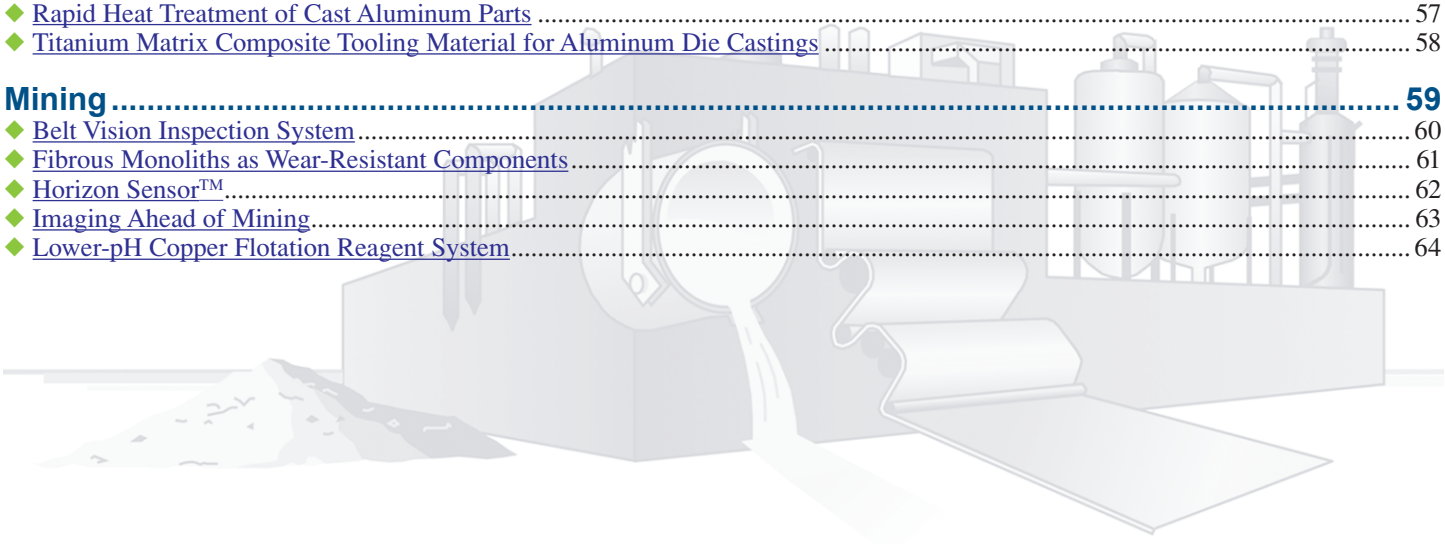
Appendix 1:
ITP-Sponsored Technologies Commercially Available



ITP-Sponsored Technologies Commercially Available

IMPACTS

ITP-Sponsored Technologies Commercially Available

IMPACTS

Aluminum

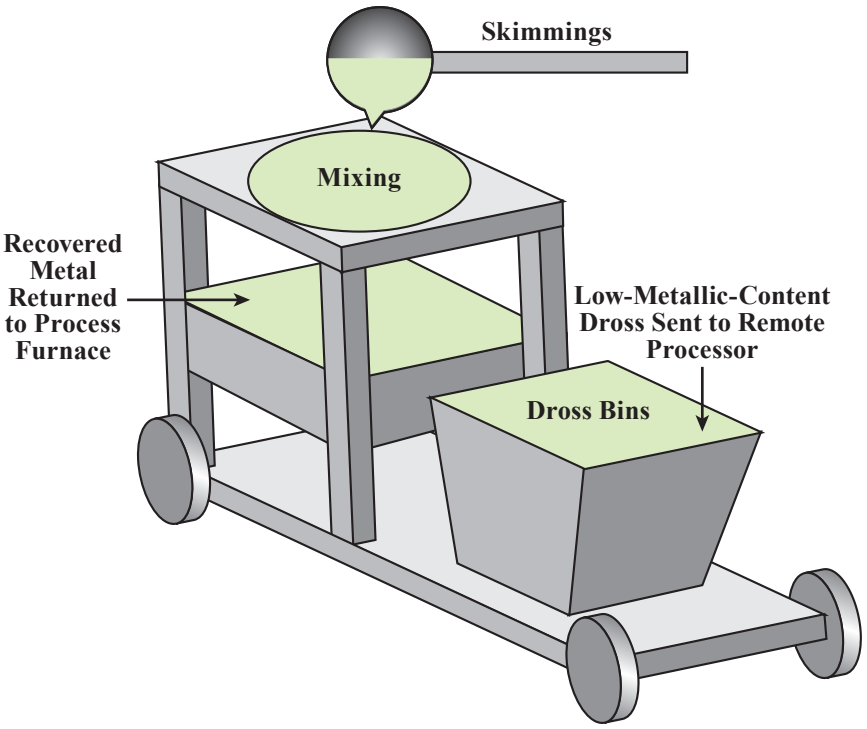
IMPACTS

Aluminum Reclaimer for Foundry Applications

Affordable Metallic Recovery System Saves Energy and Reduces Landfill Waste Streams

Aluminum foundries and melters typically generate rich metallic skimmings and drosses during industrial processes. While equipment is commercially available to recover a portion of the contained metallics from skimmings and drosses, the capital investment for the previous equipment has precluded its application with smaller melting units such as crucible or reverb melters. With assistance from ITP, Q.C. Designs, Inc., developed an improved reclaiming process specifically to recover the metallics from small quantities of dross and skim. Recent advances in the technology permit an increase in the quantity of drosses being processed and allow the recovered metal to be returned to the generating furnace in molten form, in some cases. The process has recovered as much as 80% of the contained metal at the point of generation.

In operation, the process may be run either manually, with power-assisted stirring, or with a fully automatic programmed cycle. All operations are environmentally friendly, reducing the amount of smoke and fumes normally associated with dross processing and furnace cleaning. Foundries reduce their melting losses by the in-plant recovery of drosses and their contained metals, which can then be reused directly without realloying.



Portable Aluminum Reclaimer

Overview

- Available from Q.C. Designs, Inc. (www.qcdesignsinc.com)
- Commercialized in 2001
- Twenty units installed in the United States

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.004	0.001

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.0	0.012

Applications

In-plant aluminum foundry dross and skimming recovery

Capabilities

- Processes hot dross in quantities from 10 to 500 lb.
- Allows automatic processing or manual operation.
- Features sizes for applications in different foundry installations.

Benefits

Productivity

Contributes directly to profits by decreasing melting losses. Typical compensation for dross materials from outside processors is 10% to 20% of true value because the generating foundry has to bear the costs of transportation, remelt and processing, landfill of the waste, and return of the recovered material. In-plant processing eliminates a large portion of these costs.

Waste Reduction

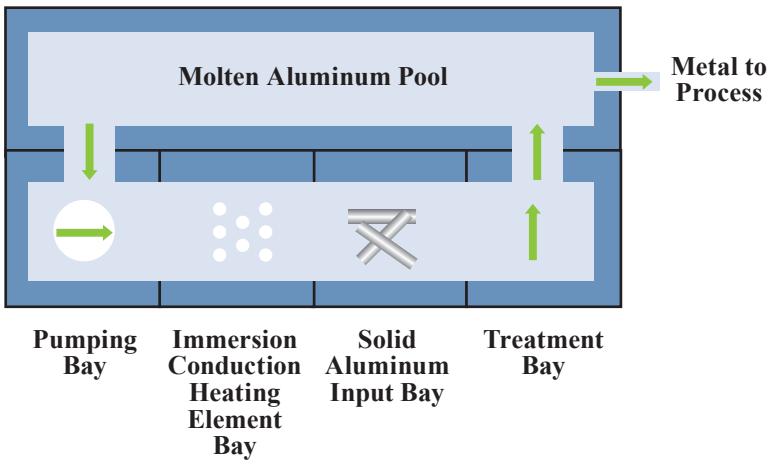
Minimizes the volume of material requiring landfilling and recovers a higher percentage (up to 80%) of metallics than current methods.

IMPACTS

New Energy-Efficient Melting Process Saves Energy and Reduces Production Losses

Aluminum melting is an energy intensive process that exhibits a 2% to 3% loss rate due to the generally open heating method for melting. A new immersion heating process, Isothermal Melting (ITM), has been developed by Apogee Technology, Inc., with support from ITP. The system uses immersion heaters in a closed loop multiple bay arrangement. Each bay contributes to an efficiency improvement. The pumping bay provides circulation that provides better mixing for purifying and alloying and more uniform temperature profiles throughout the molten pool. The heating bay is the major source of efficiency gain, where electricity is converted into heat through the immersion heaters and conducted directly to the molten metal. The heating bay raises the molten metal temperature (typically less than 90°F) just high enough to melt the solid metal being charged into the pool. Compact charging and treatment bays provide control and introduce solid charge or alloying and purifying elements in a more energy efficient manner compared with opening hearth doors and exposing the entire surface of the pool and refractory to the plant environment.

The challenge to developing the ITM system was the creation of immersion heaters that could provide the high heat flux and the chemical, thermal, and mechanical robustness required in an industrial molten aluminum environment. Apogee Technology's research program developed new materials, fabrication techniques, and quality control systems to build immersion heaters with high heat flux (approximately 70,000 Btu/hr-ft^2), approximately 5 to 10 times more than commercially available heaters. These new heater designs are based on highly thermally conductive, impact resistant ceramic coating on a metallic sheath and a highly conductive dielectric integral coupling medium between the sheath and the heat producing element. This allows heat transfer by conduction to be the dominant mode, rather than particle to particle radiation heat transfer that prevails in conventional processes. The composite refractory coating is resistant to corrosive attack by the molten aluminum, yet sufficiently thin enough to provide a high heat flux.



The Isothermal Melting System

Overview

- Developed by Apogee Technology, Inc. (www.apogeetechinc.com)
- Installed at one plant in Ohio

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.011	0.001

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.0	0.010

Applications

Can be used in aluminum melting processes and other metal melting processes

Capabilities

- Can be retrofitted to existing furnaces.
- Applies to multiple types of molten metal heating operations.

Benefits

Cost Savings

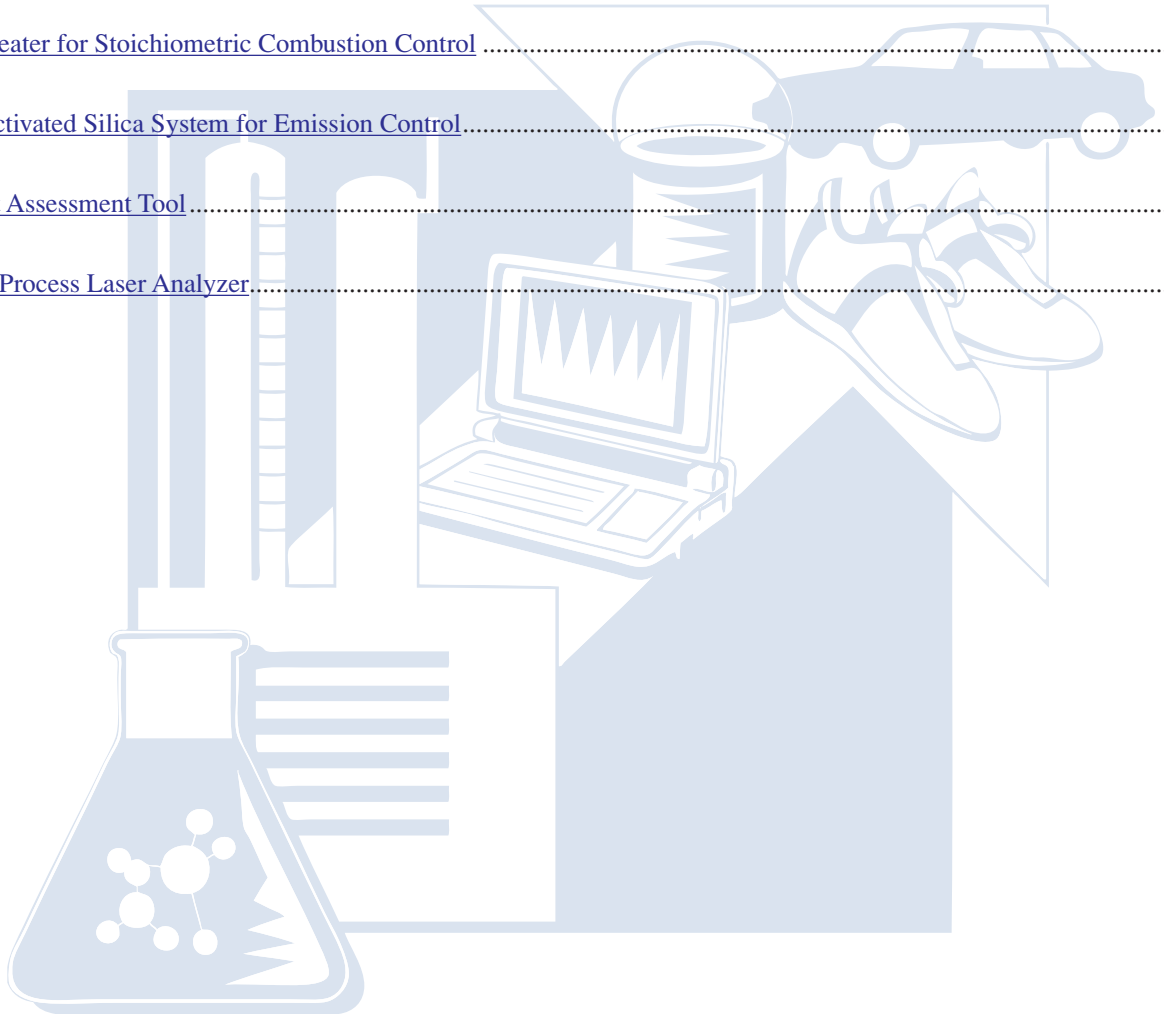
Reduces metal lost to oxidation to <1%.

Environmental Emissions Reductions

Produces zero in-plant emissions compared with natural gas process heating.

Chemicals

IMPACTS



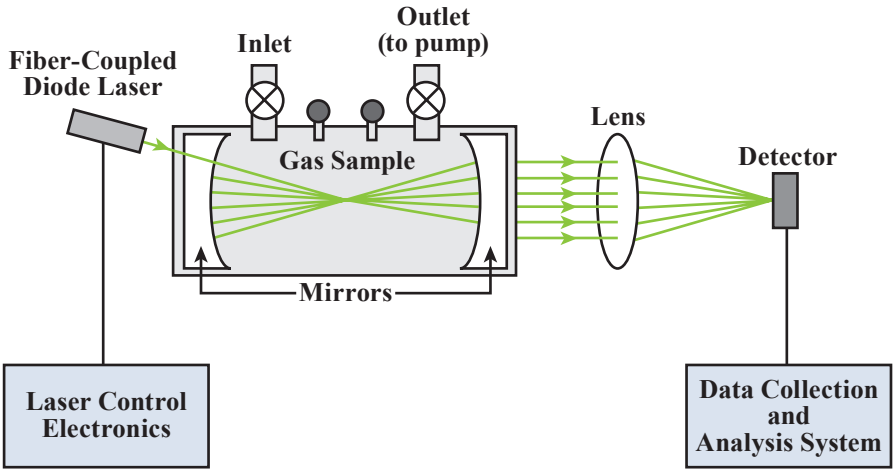
Cavity-Enhanced Gas Analyzer for Process Control

Ultrasensitive Analyzer Provides Real-Time Quantification of Acetylene and Reduces Operating Costs

Ethylene is the largest volume, largest revenue-generating organic chemical produced. Ethylene finds widespread use, serving as the building block for 50% of all organic chemicals and polymers. However, manufacturers who produce polymer-grade ethylene must constantly monitor, and if necessary, hydrogenate any acetylene that may be present in ethylene flows. Such measures are imperative because too high an increase in acetylene concentration has the potential to contaminate both the catalytic bed and the stored finished product, and if left unchecked, acetylene contamination can cost a chemical manufacturer more than $200,000 in losses per event. As a result, the ability to quickly and accurately monitor trace levels of acetylene is a critical need for ethylene manufacturers.

Los Gatos Research, in partnership with Dow Chemical and Analytical Specialties, Inc., has developed an industrial gas process control monitor that can replace gas chromatography. Through support funding provided by DOE's SBIR program, the new gas analyzer uses a patented technology having a variation of absorption spectroscopy. The new technology increases the path-length up to several kilometers of effective path using two highly reflective mirrors in the sample cavity and a diode laser that is not sensitive to alignment. The compact robust technology, Off-Axis ICOS (Integrated Cavity Output Spectroscopy), retains the sensitivity of older detection methods, while providing an absolute, accurate measurement of acetylene contamination that is fifty times faster and one-third less expensive than traditional gas chromatography.

The Off-Axis ICOS technology can be completely integrated into gas handling and computing subsystems. The analyzer is field serviceable to permit long-term deployment in the gas processing environment. Additionally, the highly reflective mirrors can be periodically replaced without any need for realignment or adjustment, which further increases the instrument's lifetime.



Cavity-Enhanced Gas Analyzer System

Overview

- Developed by Los Gatos Research in partnership with Dow Chemical Co., and Analytical Specialties, Inc. (www.lgrinc.com)
- Commercialized in 2006 with more than fifteen units in operation

Applications

Can be used to measure trace acetylene concentrations in ethylene gas flows, providing a real-time measurement of potential contamination.

Capabilities

- Provides measurements 50 times faster than conventional gas chromatography.
- Reduces the capital cost for analytical support technologies.
- Allows for the optimization of the hydrogenation reactor and minimizes product contamination.

Benefits

Applicability

Integrates into complete gas handling, sampling, and computing systems with a compact, robust design.

Product Quality

Minimizes off-specification ethylene product quality through improved process control.

Profitability

Improves raw material conversion to finished product and minimizes reprocessing and potential system contamination due to excess acetylene in the gas.

Hollow-Fiber Membrane Compressed Air Drying System

IMPACTS

New Membrane Allows Drying of Compressed Air at Lower Energy and Higher Productivity

With the support of a NICE[3] grant, a new hollow-fiber membrane for dehydrating gases has been developed by Air Products and Chemicals, Inc. The membrane has 5 times higher water vapor permeation coefficient and 25 times higher water vapor/air selectivity compared with first-generation membrane dryers. The membrane produces higher flow capacity and lower purge loss in compressed air drying, which enables high productivity and low energy consumption in drying compressed air. The membrane module contains a bundle of hollow-fiber membranes in a plastic shell with aluminum end caps. The feed air flows through the fiber bores; selective permeation of water vapor produces dry nonpermeate gas, a fraction of which is metered via a flow restrictor such as an orifice to provide a low-pressure purge gas that carries away the permeated moisture.

Compressed air is widely used as a utility in many industries and most often must be dried to avoid condensation or freezing in lines and to meet the needs of many processes. Whereas refrigerant dryers are used at pressure dew points of 35°F and desiccant dryers are used at dew points of -40°F, membranes can be used to cover the range between 35°F and -40°F. The membrane can achieve the necessary degree of drying while requiring less purge air and therefore achieves lower energy consumption than a heatless desiccant dryer. Modular membrane dryer systems with large flow capacity can be used to produce pressure dew points between 35°F and -40°F, consuming less energy than that of desiccants. Unlike desiccant systems, membrane operation is continuous, requiring only one control valve versus at least 5 valves for flow diversion/de-pressurization in the desiccant system.

Benefits

Cost Savings
Provides purge control for additional power and cost savings.

Environmental
Reduces solid waste production.

Operation and Maintenance
Operates without valves or moving parts and is maintenance-free. Requires no electrical wiring or external power and operates silently.

Overview

- Developed by Air Products and Chemicals, Inc. (www.airproducts.com)
- Commercialized in 2004
- 8913 units operating in the United States in 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.020	0.009

U.S. Emissions Reductions

(Thousand Tons, 2009)

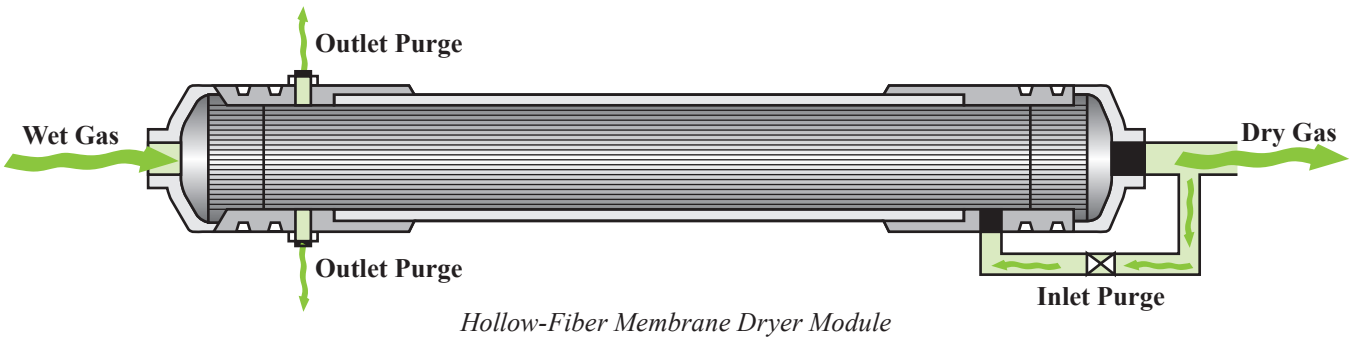
Particulates	SO_x	NO_x	Carbon
0.0	0.002	0.001	0.167

Applications

Can be used by manufacturing industries that use compressed air

Capabilities

- Is compact and lighter in weight than heatless desiccants, allowing flexibility in packaging the unit into a compressed air system.
- Is rated for operation up to 150°F and 200 psig.
- Provides excellent turndown capability, all the way down to zero feed.



Hollow-Fiber Membrane Dryer Module

Improved Methods for the Production of Polyurethane Foam

New Surfactants Result in a More Environmentally Benign Production Process

Methylene chloride, a toxic chemical that contributes to air pollution, was recently eliminated from use in the U.S. polyurethane industry. This mandated elimination did not permit production of as large a range of foam grades as was possible using methylene chloride, thus placing U.S. industry at a competitive disadvantage. Air Products and Chemicals, Inc., with financial assistance from ITP, developed new silicone surfactants enabling the efficient production of the full range of foam grades using a more environmentally benign CO_2 blowing agent. In addition to lowering toxicity, the new process uses less energy and reduces the net release of CO_2, which is implicated in global warming.

The challenges in using liquid CO_2 as a blowing agent include rapid vaporization, rapid bubble nucleation, and difficulty in maintaining fine cell structure in the foam. The new surfactants address these challenges by emulsifying the blowing agent, thereby maintaining fine cells during foaming. The silicone surfactants have achieved superior performance, resulting in finer cell structure (better yield), higher bun heights (better yield), better top to bottom physical property gradient (product consistency), and better compatibility with flame retardants.

Benefits

Productivity
Increases yield through finer foam cell structure, higher bun heights, and improved top to bottom physical property gradients.

Safety
Improves compatibility with flame retardants.

Waste Reduction
Reduces the toxicity of the process and uses the CO_2 blowing agent more effectively for reduced CO_2 release to the atmosphere.

Overview

- Developed by Air Products and Chemicals, Inc., and being used in seven plants in the United States (www.airproducts.com)
- Commercialized in 2006

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.296	0.103

U.S. Emissions Reductions

(Thousand Tons, 2009)

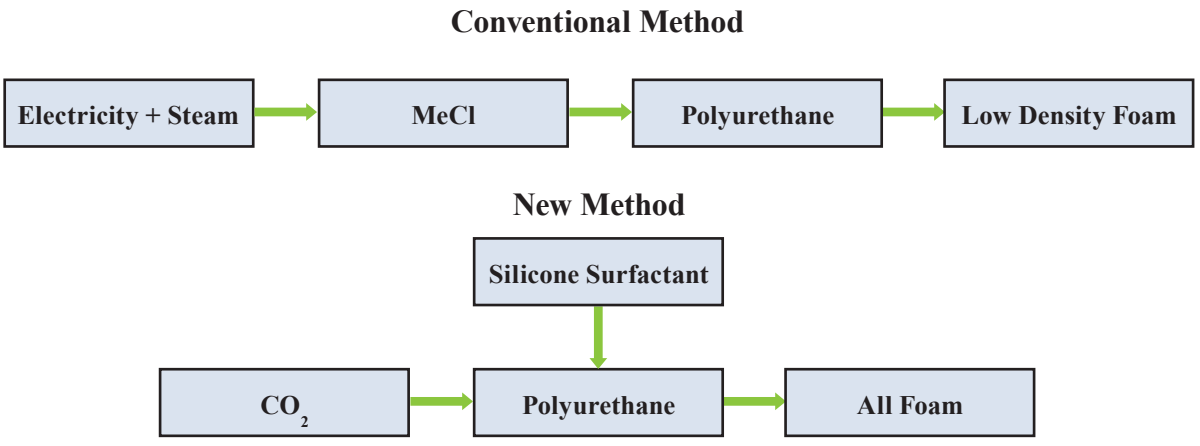
Particulates	SO_x	NO_x	Carbon
0.0	0.011	0.014	1.83

Applications

Can be used in polyurethane foam production

Capabilities

- Eliminates use of toxic methylene chloride.
- Increases foam yield through finer foam structure.
- Improves compatibility with flame retardants.



Polyurethane Foam Production

Low-Cost, Robust Ceramic Membranes for Gas Separation

IMPACTS

Innovative Ceramic Membrane Reduces Energy and Cost of Industrial Gas Separation

Ceramic membranes offer great potential for industrial gas separation. Without a ceramic membrane, gases must be cooled before separation. Unfortunately, even though ceramic membranes can improve the productivity for many reactions and separations in the chemicals and refining industries, they are costly.

Media and Process Technology, Inc., with ITP support and industrial partners Gas Control Engineering Corporation, Southern California Gas, and the University of Southern California, developed a new technology that has overcome the cost barrier by using a low-cost, robust ceramic membrane. This membrane separates gases and vapors at temperatures up to 600°C. Significant energy savings are possible because cooling prior to gas separation can be eliminated and valuable components removed from the gas stream can be recycled.

Applications are targeted toward hydrogen production, water and energy recovery from flue gas, and CO_2 removal in natural gas processing. In addition, this low-cost membrane is currently under consideration as substrate for a wide range of thin films capable of industrial gas separations and is being used commercially without the gas separating layer for a wide range of liquid phase separations.

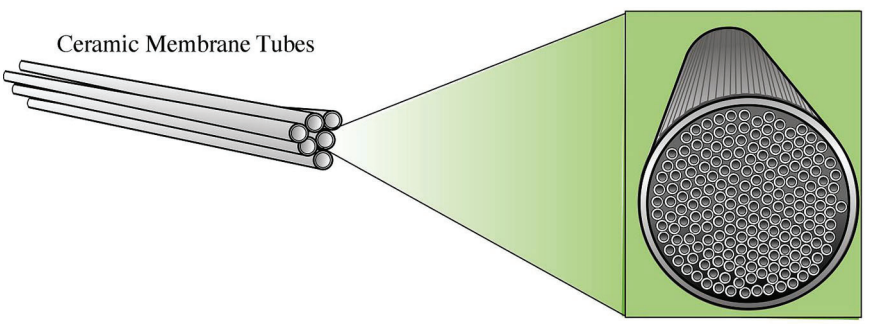
Benefits

Energy Savings

Allows gas separation at higher temperatures, eliminating the need to cool gases beforehand and therefore saving cooling energy.

Profitability and Productivity

Offers a low-cost material that reduces time and money spent for gas separation and allows valuable chemicals to be recycled rather than being disposed of.



Media and Process Technology's Ceramic Membrane Tubes and Elements

Overview

- Developed in joint venture among Media and Process Technology, Inc., Gas Control Engineering Corporation (GCE), Southern California Gas, and the University of Southern California (www.mediaandprocess.com)
- Commercialized in 2005 and being marketed by the Gas Technology Institute
- Installed in four U.S. locations for recovery of water vapor and energy, with multiple units planned for future installations.

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.043	0.016

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.002	0.254

Applications

Can be used in natural gas processing, landfill gas recovery, hydrogen production, and water and energy recovery. Liquid phase separations are also possible. Can be used as low cost substrates for deposition of various membrane layers.

Capabilities

- Separates gases and vapors at temperatures up to 600°C.
- Simplifies chemical production processes.
- Enhances conversion of chemical reactions.

Low-Frequency Sonic Mixing Technology

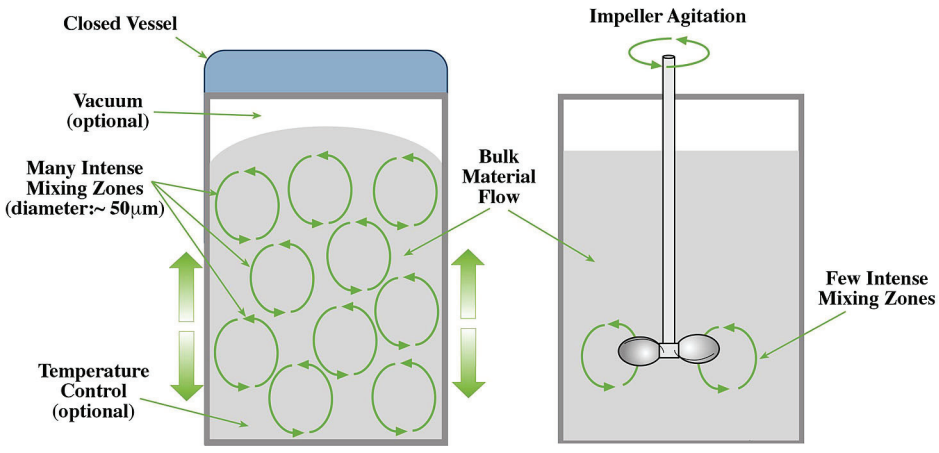
New Acoustic Mixing Technology Improves Productivity Using Low-Frequency, High-Intensity Sound Energy

Typical mixing technology uses a drive mechanism—usually an electric, hydraulic, or pneumatic motor—to rotate a shaft with one or more impellers. While many other mixer designs are available, including static mixers that do not use motors, the motor-driven mixer is the most prevalent mixing method.

Resodyn Corporation's ResonantAcoustics® mixing (RAM) technology, developed with the aid of a grant from DOE's Inventions and Innovation Program, is an improved approach to solving mixing and dispersion problems associated with conventional impeller agitation and ultrasonic mixing. Rather than mix by inducing bulk fluid flow, such as impeller agitation, RAM agitation mixes by inducing microscale turbulence through propagating acoustic waves throughout the medium. The RAM system has a lower frequency of acoustic energy and larger scale of mixing than ultrasonic agitation. Another distinct difference from ultrasonic technology is that the RAM devices are simple, mechanically driven agitators that can be made large enough to perform industrial-scale tasks at reasonable cost.

RAM introduces acoustic vibrations into liquids and slurries via the resonant vibration of a mechanical system. The impedance of the vibrating system is matched to that of the load, i.e., the process fluid. The entire system vibrates in resonance, which allows efficient energy transport to the fluid, creating small-scale eddies. Although the eddies are microscale, the entire reactor is well mixed in an extremely short time because the acoustic streaming, generated by the acoustic field, causes the microscale vortices to be distributed uniformly throughout the fluid. Multiple mixing regimes are possible by using the RAM system and the controls developed exclusively for it.

Since the commercialization of the technology, Resodyn has sold tens of laboratory-scale mixers to both U.S. and international customers and has extended the product line by adding 5-gallon and 55-gallon capacity mixers for production applications. Industries that use mixers in their production process are extremely receptive to new mixing technologies that could help improve efficiency and lower their manufacturing costs.



Resonant/Acoustics® Mixing vs. Impeller Mixing

Overview

- Developed by Montec Research, Inc.
- Commercialized in 2007
- Marketed by Resodyn Acoustic Mixers, Inc. (www.resodynmixers.com)

Applications

Can be used in a number of industries, including ceramics, biotechnology, agriculture, chemical manufacturing and processing, food, mining, municipal waste treatment, petroleum, pharmaceutical, pulp and paper, aerospace, microelectronics, and water treatment.

Capabilities

- Uses acoustic energy rather than impellers to mix gases, liquids, and slurries.
- Mixes a wide viscosity range (1cP to 100+million cP).
- Can mix in a shipping container using a LabRAM 500 ml mixer.

Benefits

Productivity

Enhances mass transport and improves reaction rates on both macro- and micro-mixing levels. Can easily tune to different frequencies, making them suitable for multiple applications, such as heat- or mass-transfer limited systems, those that expend inordinate mixing energy, or those that require mixing uniformity.

Profitability

Reduces mixing time up to 62% and competes with current mixer prices in many applications.

Membranes for Reverse-Organic Air Separations

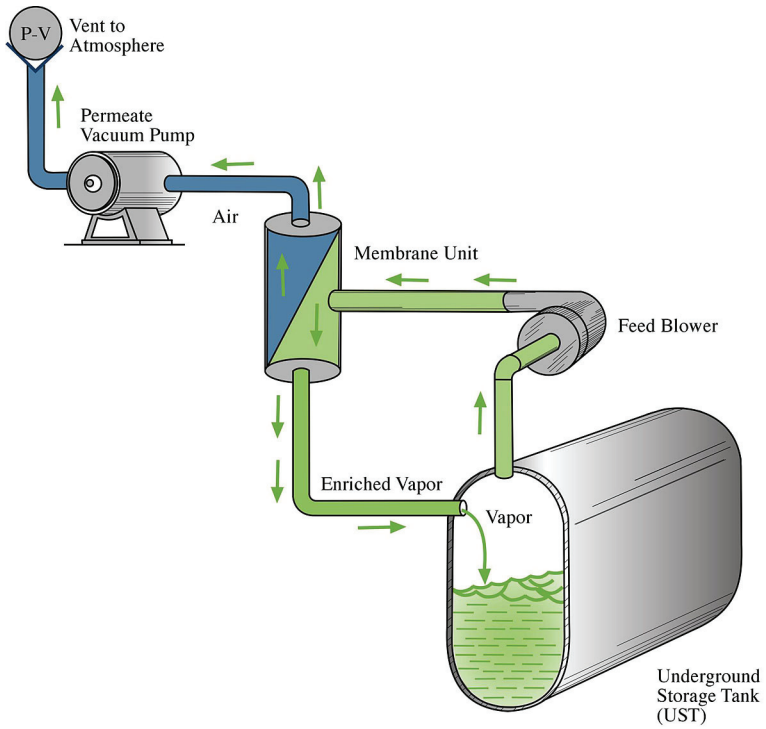
IMPACTS

New Membranes Use Reverse Separation to Reduce Pollutant Emissions

Many industrial applications need a process to separate pollutants known as volatile organic compounds (VOCs) from air in order to protect the environment and save energy. One such application is the venting of vapor from underground storage tanks (UST) used in gasoline storage and dispensing. These vapors, which can build up and create high pressure within the UST, contribute to ground-level ozone and smog upon release.

Traditional separation of VOCs uses rubber-based polymer membranes; however, these membranes are inadequate for applications requiring pressure relief by venting or low-pressure condensation of VOCs because they permeate VOCs more rapidly than air. To address this shortcoming, Compact Membrane Systems, Inc., in conjunction with project partners and support from DOE's SBIR program, has developed a novel reverse separation membrane that can be used to discharge clean air at low to slightly negative pressure, while leaving the VOCs fully contained in the fuel storage tank.

In addition to recovering the fugitive emissions from storage tanks, the system enables the UST and associated piping to operate under negative pressure while providing continuous diagnostics of the refueling system, such as storage tank structural integrity. Maintaining a slight vacuum on the UST ensures that any potential leaks within the system are contained within the tank and are not accidentally released to the environment. Continuing research and development are focused on applications where robust membranes are deployed in gas separation from both vapor and liquid streams.



Compact Membrane Systems' Vapor Recovery System

Overview

- Invented by Compact Membrane Systems, Inc. (www.compactmembrane.com)
- Commercialized in 2007

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.274	0.150

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.001	0.087	0.023	3.27

Applications

Can be used by gasoline storage and dispensing facilities, pharmaceutical processes, and fuel oil tank farms engaged in preventing the unintended release of VOCs from storage tanks.

Capabilities

- Reduces VOC emissions below the California Air Resources Board limit of 0.38 lb/month/1000 gallon capacity.
- Enables continuous monitoring of storage tank internal conditions, structural integrity, and leak-checking.

Benefits

Energy Savings

Prevents fuel vapor escape from a gasoline storage tank, thereby potentially saving 180 million gallons of gasoline per year domestically.

Environmental

Decreases VOC emissions to the atmosphere by limiting gasoline tank leakage.

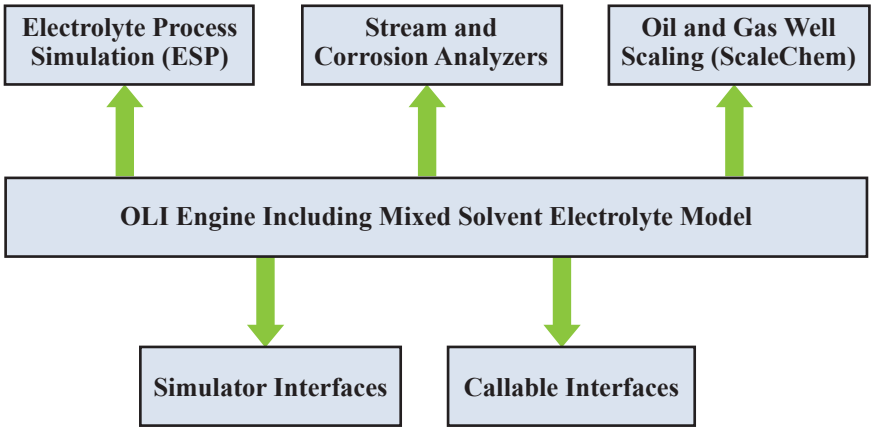
Mixed Solvent Electrolyte Model

Software Tool to Predict Solubility of Solids and Other Thermophysical Properties

With assistance from ITP, OLI Systems, Inc., developed the mixed-solvent electrolyte model, a comprehensive physical property package that can predict the properties of electrolyte systems ranging from dilute solutions to fused salts in water, nonaqueous, or mixed solvents. The model accurately predicts the solubility of solids in complex multicomponent systems, thus providing a tool for designing crystallization processes. In addition, the model predicts other properties such as vapor-liquid and liquid-liquid equilibria, densities, heat effects, viscosity, electrical conductivity, and diffusivity.

The model incorporates chemical equilibria to account for chemical speciation in multiphase, multicomponent systems. For this purpose, the model combines standard-state thermochemical properties of solution species with an expression for the excess Gibbs energy. The model can accurately reproduce various types of experimental data for systems of aqueous electrolyte solutions. Separate formulations have been developed for predicting transport properties in the same range of temperature and compositions.

The model has been implemented in OLI Systems' commercial software, including the Electrolyte Simulation Program (a flowsheet simulator), StreamAnalyzer (a desktop chemical laboratory), CorrosionAnalyzer (a tool for predicting the tendency of metals to corrode), and selected interfaces to third-party process simulation programs. In its various implementations, the mixed-solvent electrolyte model is already used by more than 50 chemical process companies that lease OLI's software.



Integration of the Mixed Solvent Electrolyte Model with OLI Software

Overview

- Developed and marketed by OLI Systems, Inc. (www.olisystems.com)
- Commercialized in 2005
- Sold 146 U.S. licenses and 128 non-U.S. licenses

Applications

Can be used to optimize crystallization and other separation processes throughout the chemical and pharmaceutical industry

Capabilities

- Predicts crystallization and other separation processes.
- Predicts solubility of solids and other thermophysical properties.

Benefits

Efficiency

Improves process control, filterability, and mixing efficiency.

Energy Savings

Substitutes crystallization for more energy-intensive process units.

Product Quality

Improves process control and product quality and minimizes lab and plant testing costs and risks (by using simulations).

IMPACTS

New Process Recovers and Reuses Nylon from Waste Carpeting Saving Energy and Costs

With a desire to keep materials out of the landfill, Shaw Industries, Inc., has incorporated a novel process developed by Honeywell International, Inc., and DSM Chemicals North America, Inc., into the largest Nylon-6 carpet recycling facility in the United States. The recovery process not only reduces the amount of carpet-based material destined for landfill, but produces virgin quality caprolactam, the monomer building block of Nylon-6 resin used to make carpet fiber.

With proof-of-principal financial assistance provided by ITP, the closed-loop depolymerization and purification process allows Nylon-6 recyclers to recover and reuse a significant percentage of the raw materials used to make carpeting while consuming less total energy compared with the conventional production of caprolactam. In addition to caprolactam recovery, the process can reclaim calcium carbonate used for carpet backing and other polymers used in carpet manufacturing for future use.

Shaw Industries' Evergreen Nylon Recycling (ENR) facility is the largest commercial-scale Nylon-6 recycling plant in the world. With the plant currently in operation, ENR is drawing from over 40 carpet collection facilities across the nation and has collectively kept over 165 million pounds of carpet out of landfills. The Cradle to Cradle™ process recovers approximately 24 million pounds of caprolactam and 35 million pounds of calcium carbonate filler and recovers up to 400 billion Btu each year.

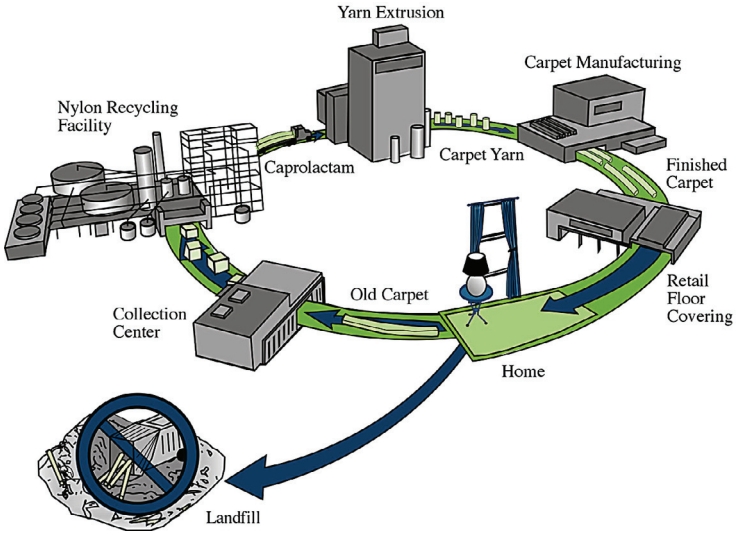
Benefits

Energy

Reduces energy consumption in the production of Nylon-6 resin and carpet fiber.

Environmental

Reduces landfilling of nylon waste carpets and other Nylon-6-based materials and reduces raw material demand for the production of Nylon-6.



Shaw Industries' Nylon Carpet Recycling Loop

Overview

- Developed by Honeywell International, Inc., and DSM Chemicals North America, Inc.
- Evergreen Nylon Recycling facility in Augusta, GA, is owned and operated by Shaw Industries, Inc. (www.shawfloors.com)
- Recycled over 165 million pounds of post-consumer carpeting since re-opening of the facility in 2007
- Produced in excess of 24 million pounds of virgin quality caprolactam in 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
1.32	0.428

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.050	6.79

Applications

Can be used to recover and reuse the primary constituents of reclaimed carpeting and carpet fibers including caprolactam, calcium carbonate, and other polymers

Capabilities

- Produces virgin quality pure caprolactam using the closed-loop depolymerization and purification system.
- Enables processing of whole Nylon-6 carpets and eliminates mechanical separation.
- Enables reuse of recovered raw materials in Nylon-6 as carpeting, fibers, and resins.

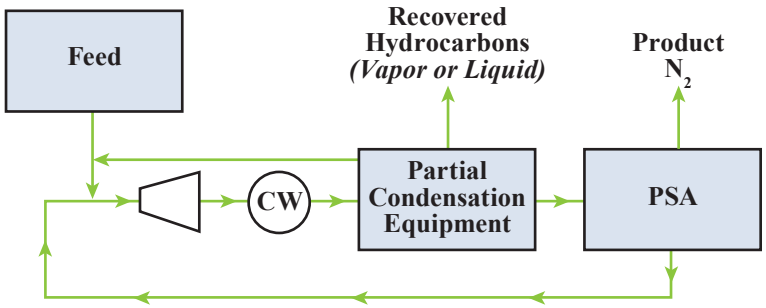
Pressure Swing Adsorption for Product Recovery

Highly Selective Pressure Swing Adsorption Technology Recovers Valuable Components from Waste Streams

Many polyolefin plant designs use a polymer degassing step to remove unreacted monomer, solvents, and additives from the product polymer fluff before it is processed in downstream pelletizing operations. When nitrogen is used as the stripping gas, the operation produces a low-pressure gas stream that typically contains nitrogen and valued hydrocarbons that can be recovered and recycled to the plant. If the gas is not processed for recovery, it is typically flared. The flaring step results in volatile organic compounds, NO_X, and CO_2 emissions. Flaring can also be costly, roughly equal to the value of the purchased nitrogen.

With assistance from ITP, Air Products and Chemicals has developed a single unit operation to recover these gases. Pressure swing adsorption (PSA) is combined with partial condensation to essentially recover 100% of the hydrocarbons from the vent gas. In addition, PSA produces a high purity N_2 stream, with nearly 100% recovery of nitrogen. The recovered nitrogen can be recycled to the stripping operation or used elsewhere in the facility. Air Products' high recovery system eliminates waste streams and therefore emissions.

In this new process, the vapor stream from the partial condensation section flows into a PSA unit. Within the PSA, specially selected adsorbent materials extract hydrocarbons, thereby refining the nitrogen to a high purity with minimal pressure drop. Over time the adsorbent material in the bed becomes saturated and must be regenerated. Lowering the pressure in the saturated bed desorbs the hydrocarbon components from the adsorbent material in the PSA. The hydrocarbons are released and recovered in a low-pressure tail gas, which is recycled back to the compressor suction so the hydrocarbons are not lost. This technology provides a significant opportunity for energy and cost savings and reduced waste.



Pressure Swing Adsorption Recovery

Overview

- Developed by Air Products and Chemicals (www.airproducts.com)
- Commercialized in 2003
- Installed in three locations in Texas

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.626	0.111

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.013	1.76

Applications

Can be used by chemical and refining industries, including polyethylene and polypropylene production processes that use N_2 for degassing the polymer fluff and for treating refinery off-gas streams. Could be adapted to recover valuable products from other waste streams throughout the industry.

Capabilities

- Recovers hydrogen, nitrogen, and hydrocarbons for reuse.
- Is flexible enough to operate using an external refrigeration source.

Benefits

Pollution Reduction

Can collect and separate for reuse exit streams from certain processes, eliminating the emissions and need for disposal. Can save energy and costs by eliminating flaring of waste streams, which is typically part of disposal.

Profitability and Productivity

Reduces operating and emission costs by eliminating flaring and increases productivity by reusing products in the feed streams.

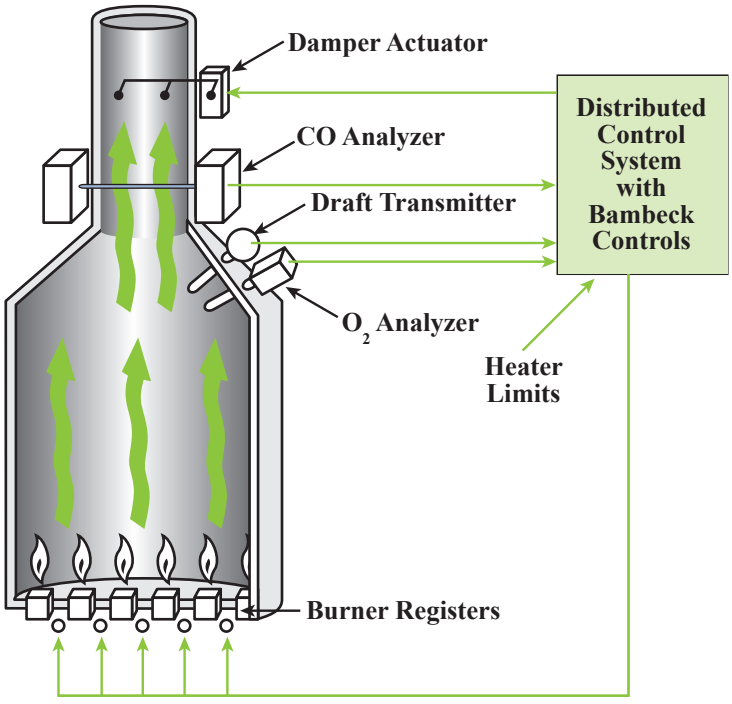
Process Heater for Stoichiometric Combustion Control

IMPACTS

An Enhanced, CO-Based, Low Excess Air Control System Saves Energy While Reducing Emissions

To heat liquids and induce chemical reactions during production processing, the refining and chemicals industries rely on process heaters and boilers that consume large amounts of fuel. Bambeck Systems and Valero Energy received a grant from ITP to demonstrate how fuel can be saved by fully automating the available air to the three types of heaters typical to a refinery. Using a Bambeck fast CO analyzer to monitor the heater flue gas, a control scheme is installed to reduce the oxygen until a small amount of CO is produced. Using this parameter in the control scheme optimizes the air needed for combustion, thereby not wasting fuel to heat unneeded air.

The three requirements to successfully implement this technology are the fast CO analyzer, a new control strategy, and operator education. The analyzer provides CO data to the existing heater control system. The current control strategy is then modified to reduce the air to the heater via the controllable entrances, including stack dampers, fans, and burner registers. When a small amount of CO is generated, the control system automatically maintains that point, changing the controllable entrances as more or less air is required as indicated by the CO analyzer. Since fuel Btu content can change rapidly, the fast CO analyzer responds to the change in demand for O_2 and, through the control system, sends commands to the dampers, fans, and registers to open or close. Because operators historically used an O_2 monitor to ensure that the combustion process has excess air, the operators need to be educated to feel comfortable seeing very low O_2 readings. The heater is safer because CO is a precursor to a combustible condition and O_2 is not. In addition, reducing the excess O_2 also reduces both NO_x and CO_2 (greenhouse gas).



Bambeck Ultra-Low Excess Air Control System

Overview

- Developed and being marketed by Bambeck Systems, Inc. (www.bambecksystems.com)
- Commercialized in 2002 with over 700 of the original technology installed
- Seven enhanced ultra-low versions installed

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
2.45	0.411

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.024	0.051	6.82

Applications

Can be used by the chemicals, petrochemicals, and refining industries

Capabilities

Monitors the unburned fuel gases and controls the amount of air available for the combustion process, providing the minimum amount needed.

Benefits

Reduced Emissions

Reduces NO_x emissions from 30% to 45% and CO_2 in proportion to the size of the heater.

Safety

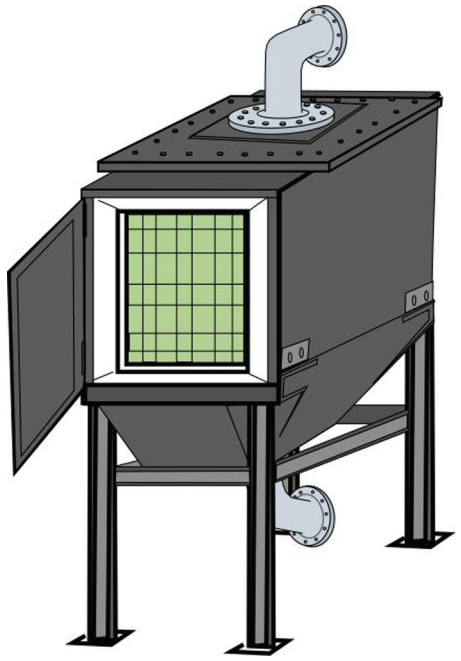
Eliminates the possibility of any dangerous combustible conditions developing in the heater.

Titania-Activated Silica System for Emission Control

Silica-Titania Composite (STC) Technology Safely and Cost-Effectively Removes Mercury from End-Box Exhaust in Chlor-Alkali Facilities

The chlor-alkali industry produces valuable chemicals such as chlorine, hydrogen, and caustic soda. In 2001, between 150 and 200 chlor-alkali facilities throughout the world used the mercury-cell process. Although this process uses the mercury in a closed-loop system, mercury is released to the environment through entrainment in byproduct streams, end-box ventilation systems, and fugitive emissions. An average of about 3 tons of mercury per year must be added to the production process at each mercury-cell facility in the United States to account for losses. The National Emissions Standard for Hazardous Air Pollutants (NESHAP) for mercury-cell chlor-alkali plants requires these facilities to drastically reduce mercury emissions from their gas-phase exhaust streams.

With assistance from ITP, Sol-gel Solutions, LLC, has developed silica-titania composite (STC) technology for removing mercury from end-box exhaust in chlor-alkali facilities. The technology focuses on the synergistic combination of adsorption and simultaneous photocatalytic oxidation to remove pollutants. STC technology can be regenerated in place, avoiding the cost and risk of continuously replacing and disposing of typical adsorbent materials such as activated carbon. Sol-gel Solutions has installed two full-scale reactors at a U.S. chlor-alkali facility. The reactors were installed in parallel so that one could operate while the other was regenerated. After a period of successful operation, an economic analysis showed the STC technology to have a lower cost per pound of mercury removed than activated carbon. In addition to applications in the chlor-alkali industry, Sol-gel Solutions is continuing efforts to commercialize the technology for indoor air purification and the coal-fired power industry.



Sol-gel Solutions' Silica-Titania Composite System

Overview

- Developed at the University of Florida
- Commercialized by Sol-gel Solutions, LLC (www.sol-gel-solutions.com)
- Two units operating at a U.S. chlor-alkali facility since 2006

Applications

Can be used in the chlor-alkali industry for removing mercury from caustic exhaust streams and in coal-fired power plants for mercury removal from flue gas

Capabilities

Uses ultraviolet light to oxidize elemental mercury to more stable mercuric oxide.

Benefits

Cost Savings

Reduces the cost per pound of mercury removed compared with activated carbon.

Safety

Eliminates the risk of disposing of mercury-laden activated carbon.

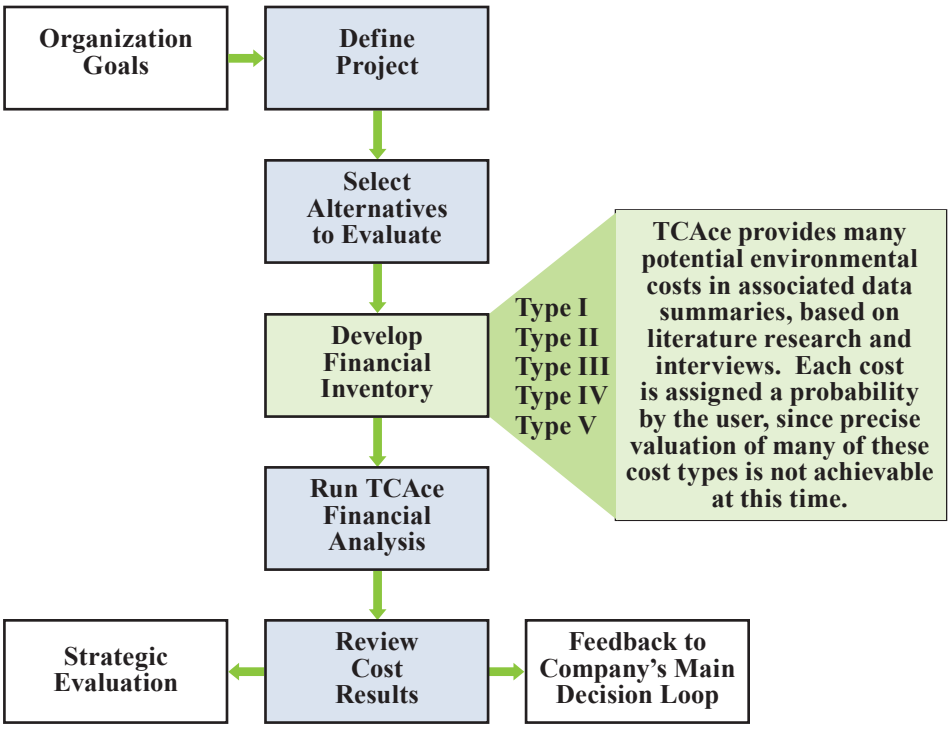
IMPACTS

New Decision-Making Software Integrates Costs into Environmental Decisions and Life Cycle Assessments

The Total Cost Assessment (TCA) methodology enables industry to include all environmental, health, and safety costs in decision-making. In particular, TCA includes contingent liabilities such as fines and cleanup costs and intangible costs such as damage to corporate or brand image and reduced employee morale. External costs, such as costs to society, can also be included in the TCA methodology. In traditional industry decision-making, environmental health and safety (EHS) assessments have been conducted separately from life cycle cost analyses. This customary separation has limited the influence and relevance of life cycle assessment for decision-making and has left uncharacterized the important relationships and tradeoffs between the economic and environmental performance of alternative decisions.

The TCA methodology was developed by an industry collaboration of ten companies led by the American Institute of Chemical Engineers (AIChE) Center for Waste Reduction Technologies (CWRT) with support from ITP and the National Business Roundtable Industrial Pollution Prevention Council.

The Total Cost Assessment Tool (TCAce), developed and sold by Sylvatica, manages the TCA process by enabling the company to use sliding ranges and probabilities to reflect the true nature of contingencies. TCAce integrates scenario case studies and sensitivity/uncertainty/risk analysis into a company's existing economic evaluation framework to enable sound decisions. It identifies all conventional, hidden, human health, and environmental impact costs, both internal and external. TCAce requires an operating system of Windows 98 or better and recommends at least a 24MB hard drive.



The Total Cost Assessment Process

Overview

- Software developed by Sylvatica of North Berwick, Maine (www.earthshift.com)
- Has sold 14 units to date: 4 in the United States and 10 internationally
- Commercialized in 2005

Applications

Can be used throughout industry in considering all the environmental and health costs associated with a business decision, such as process, project, or corporate-level investment alternatives. The software performs and addresses the following activities: estimating baseline costs, benchmarking, process development, product mix, waste management decisions, pollution prevention alternatives, remediation alternatives, environmental management, research budget allocations, materials/supplier selection, facility location/layout, outbound logistics, market-based environmental options, and public relations/lobbying.

Capabilities

- Identifies best environmental and economic options in business decision-making.
- Aligns environmental goals with good business strategies.
- Integrates internal costs and externalities into a single assessment process.

Benefits

Environmental Benefits

Selects waste management investment decisions that are environmentally sound and reduces long-term liabilities.

Profitability

Reduces manufacturing costs by integrating life cycle assessment with life cycle cost analysis and facilitating collaborative scenario planning.

TruePeak Process Laser Analyzer

In-Situ Sensors Provide Real-Time Measurements Enabling Better Control and Process Optimization

Current chemical process controls use few in-situ sensors, relying instead on analytic techniques that require sample conditioning and transport, and significant turnaround time. With few exceptions, these techniques lack speed of measurement, accuracy of measurement, sensitivity of measurement, and economical measurement. In-situ sensors can provide real-time measurements, enabling better understanding and control of the process and improving process optimization, product quality, and plant economics. Supported with a grant from ITP, Analytical Specialties, Inc., since acquired by Yokogawa Electric Corporation, has developed a system of in-situ sensing for more efficient process operation.

The system, called TruePeak, is a tunable diode laser analyzer that directly measures the concentration of O_2, H_2O, and potentially several other gasses. TruePeak measures across an infrared absorbance region, which makes it useable in high dust and corrosive environments and provides a true interference-free analysis. The system is characterized by rapid measurement (as fast as 1 second), high process pressure capability (up to 20 bar), high temperature (up to 1500°C), and no contact with the process. The system operates at the required process conditions (pressure, temperature, etc.), provides real-time or near real-time data, and significantly reduces installation and operational costs compared with currently available products.

Appropriate applications for TruePeak include combustion oxygen analysis of process heaters, furnaces, and incineration operations. The technology is also applicable to processes where reducing errors in oxygen concentration measurements can reduce plant process shutdown. The need for this technology and its measurements are driven by advances in process control systems and the need to "close the loop" in modern control systems. This rugged unit can be used in a variety of chemical process applications and can provide real-time, accurate measurements in harsh environments, which can improve process efficiency, reliability, and productivity.

Overview

- Developed by Analytical Specialties, Inc.
- Commercialized in 2004 and being sold by Yokogawa Electric Corporation (www.yokogawa.com)

Applications

Can be used for gas sensing in chemical processes

Capabilities

- Provides in-situ analysis, eliminating errors and costs associated with extractive analyzers.
- Can be used in harsh environments.

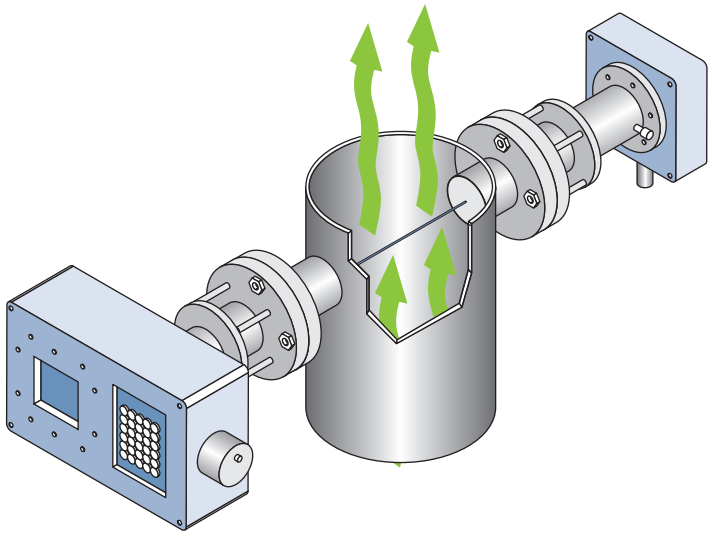
Benefits

Applicability

Operates with processes up to 1500°C and 20 bar and virtually interference-free.

Productivity

Reduces downtime for maintenance and provides near real-time measurements with improved accuracy for better control.



TruePeak Process Laser Analyzer

Forest Products

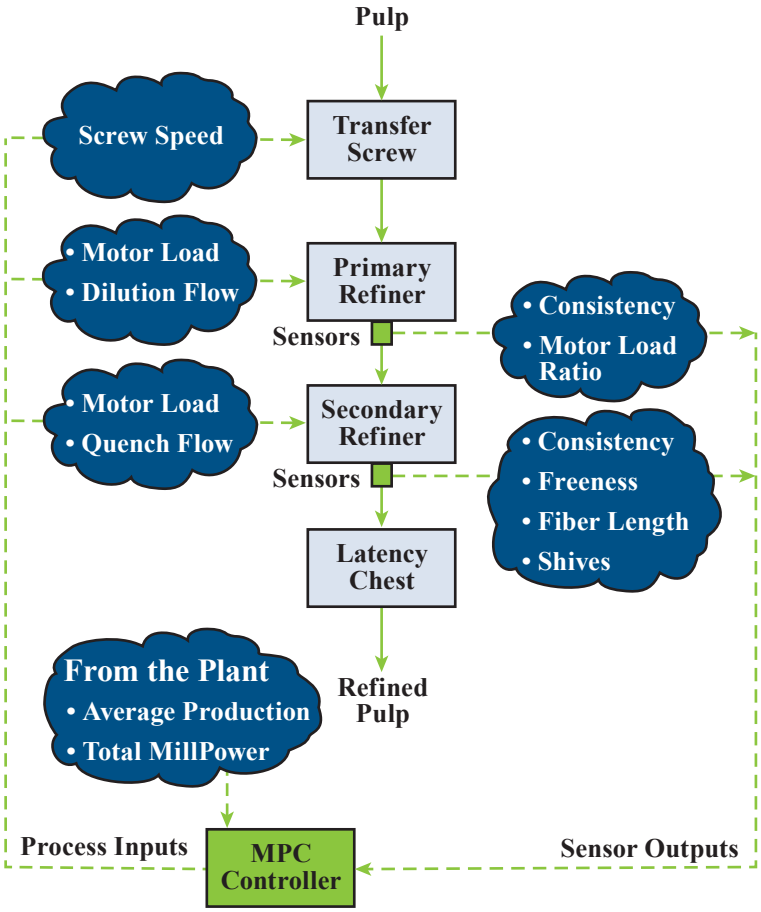
IMPACTS

Advanced Quality Control (AQC) Solution for Thermo-Mechanical Pulping

Optimal Pulping Using an Advanced Control System and Sensors

Thermo-mechanical pulping (TMP) has become the pulping method of choice for many pulp and paper mills. Electrical energy accounts for 23% of the total production cost, with over 70% of that dedicated to the TMP process. In 2001, with financial and technical support provided by ITP, Pacific Simulation assessed and implemented their AQC model-predictive controls in a TMP plant. In this demonstration, the plant realized gains in three key areas: reduced peak and specific energy consumption, reduced production line transition times, and improved freeness targets.

Commercial implementation of AQC involves coordinating advanced quality control in multiple areas of the paper mill: mainline refiners, reject refiners, screen room, and pulp quality. Sensors are used to measure controlled variable outputs for freeness, consistency, shive content, fiber length, motor load, screw speed, refiner temperature and pressure, and reject rate. The heart of the AQC system is the multivariable predictive controller (MPC) and associated software that compares "current" data against "historical" data to determine the predictive model. The MPC, coupling pulp line output with plant productivity and power consumption, can make real-time optimization changes to manipulated variables to efficiently manage pulp and finished paper quality and production capabilities while reducing specific energy consumption. The AQC Solution has been implemented on over 73 refiners in the United States, Canada, Sweden, Norway, New Zealand, and Chile.



AQC System Schematic for Pulp Refining

Overview

- Developed and commercialized by Metso Automation's Pacific Simulation in 1995
- Expanded under DOE grant in 2001
- Purchased and marketed by Metso Automation in 2004 (www.metso.com)

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
1.27	0.192

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.001	0.042	0.031	3.78

Applications

Can be used to link final product quality with the thermo-mechanical pulping process optimizing production, quality, and cost.

Capabilities

- Reduces peak and specific energy demand by matching real-time pricing from local electrical utilities.
- Reduces raw material costs by limiting the required amount of purchased Kraft pulp.
- Improves final pulp quality by optimizing refiner operation and output.

Benefits

Energy Savings

Reduces specific peak energy from 8 MW to 6.5 MW; uses an average of 125 horsepower days/ton in the plant down from 145 horsepower days/ton.

Production

Uses stock blending quality control to optimize the blend of feedstock quality and final paper grade to allow mills to match pulp quality production to the exact requirements of the paper machine on a grade basis.

IMPACTS

Innovative Technology Enables Low-Cost, Energy-Efficient Treatment of Industrial Exhaust Streams

Air quality standards are becoming more stringent for the U.S. wood products industry. Emissions of volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) (including methanol, formaldehyde, acetylaldehyde, and acrolein) during production of wood products must be tightly controlled. Conventional VOCs and HAPs emission control techniques such as regenerative thermal oxidation and regenerative catalytic oxidation require significant amounts of energy and generate secondary pollutants such as nitrogen oxides and excess carbon dioxide.

With assistance from ITP, BioReaction Industries, LLC, has developed a novel biological treatment system that integrates two types of bio-oxidation to achieve energy-efficient emissions reduction. The technology uses microorganisms to degrade air toxins without the extensive consumption of natural gas required by thermal oxidation. The process employs a three-stage treatment process for the VOC, HAP, and particulate emissions in an exhaust airstream: (1) water soluble compound and particulate removal in the bioscrubber/biotrickling filter, (2) biodegradation in the biofilm of the biotrickling filter and the sump waters, and (3) hydrophobic compound adsorption and biodegradation in the multi-layer biofilter. As of 2009, ten units have been installed across the U.S. forest products industry, with an average air flow of approximately 100,000 CFM. BioReaction Industries is also pursuing applications of the technology for the automobile industry, particularly with paint emission streams using water soluble solvents.

Benefits

Adaptability
Modular and expandable design allows for easy adjustment to meet new process flow rate requirements.

Cost Savings
Reduces the labor and materials required for maintenance compared with traditional thermal oxidation systems.

Overview

- Developed by BioReaction Industries, LLC, with technical and scientific assistance from Texas A&M University
- Commercialized by BioReaction Industries, LLC (www.bioreaction.com)
- Ten units operating in the U.S. forest products industry as of 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
1.53	0.829

U.S. Emissions Reductions

(Thousand Tons, 2009)

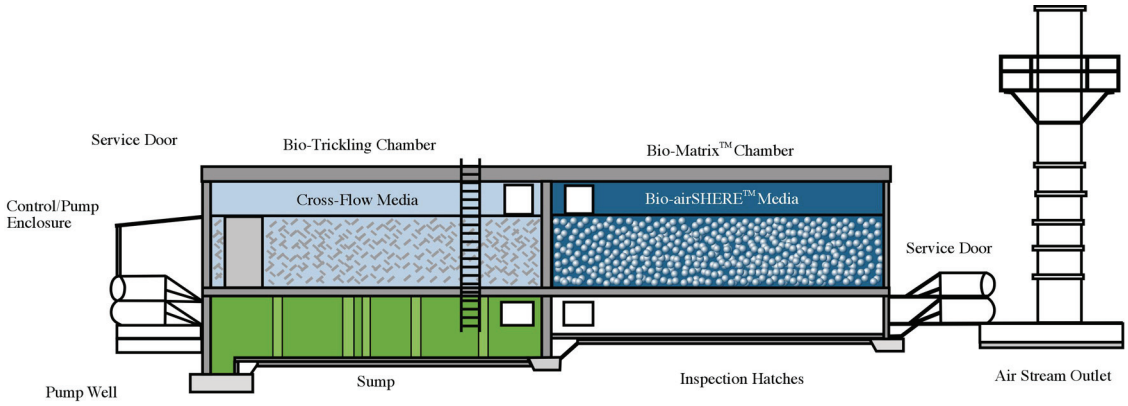
Particulates	SO_x	NO_x	Carbon
0.0	0.003	0.098	13.2

Applications

Can be used as an energy-efficient alternative to thermal oxidation of industrial process exhaust streams

Capabilities

- Enables reliable operation through control panel adjustment of temperature, humidity, fan, and pump parameters.
- Uses patented Bio·airSPHERES™ media for digestion and final breakdown of contaminants.



BioReaction Industries' Advanced Bio-Oxidation Process

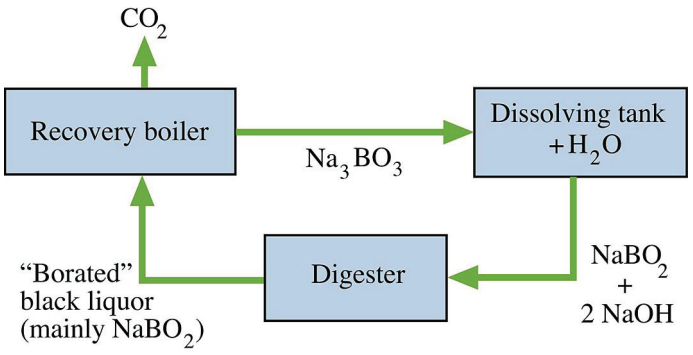
Borate Autocausticizing

New Technology Increases Energy Efficiency of Kraft Chemical Recovery Process and Causticizing

Boron-based autocausticizing is a new, cost-effective technology to recover kraft pulping chemicals. Conceptually, the technology can be used to supply part or all of the sodium hydroxide requirements of the kraft process, supplementing or replacing the lime cycle. Because the de-carbonating reactions take place directly in the recovery boiler, instead of the lime kiln, this process reduces energy consumption and increases causticizing and calcining capacities.

The technology uses sodium metaborate to react with sodium carbonate in the kraft furnace. Once the reacted salts are dissolved in the green-liquor dissolving tank, sodium hydroxide is formed, and the sodium metaborate is regenerated. The technology provides more energy-efficient hydroxide production, increases the causticizing equilibrium, and, when used in conjunction with the conventional lime cycle, increases the causticizing/calcining capacity.

Rio Tinto Minerals, with ITP support, has developed partial borate autocausticizing, which is being implemented in pulp mills worldwide to supplement conventional lime causticizing with almost no capital investment. The one U.S. application is in the P.H. Gladfelter Co. mill in Spring Grove, Pennsylvania, where it increased production by roughly 5% in 2007.



Borate Autocausticizing Process

Overview

- Developed by U.S. Borax/Rio Tinto Minerals (www.borax.com)
- Commercialized in 2004
- Installed in one U.S. plant and in several international plants.

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.035	0.000

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.0	0.0

Applications

Can be used to replace all or part of the kraft causticizing-calcining process, therefore providing supplemental lime kiln and causticizing capacities

Capabilities

- Reduces the load on lime causticizing plants, improving the performance of clarifiers or filters and reducing the extra alkali circulated in the weak wash (weak white liquor) stream.
- Reduces fresh lime usage and lime mud disposal associated with lime kiln production constraints.

Benefits

Cost Savings

Decreases the load on causticizing and lime reburning to reduce either lime purchases or kiln energy and maintenance costs.

Productivity

Increases the causticizing capacity of the mill to increase pulp production without investment in lime kilns or recausticizing equipment.

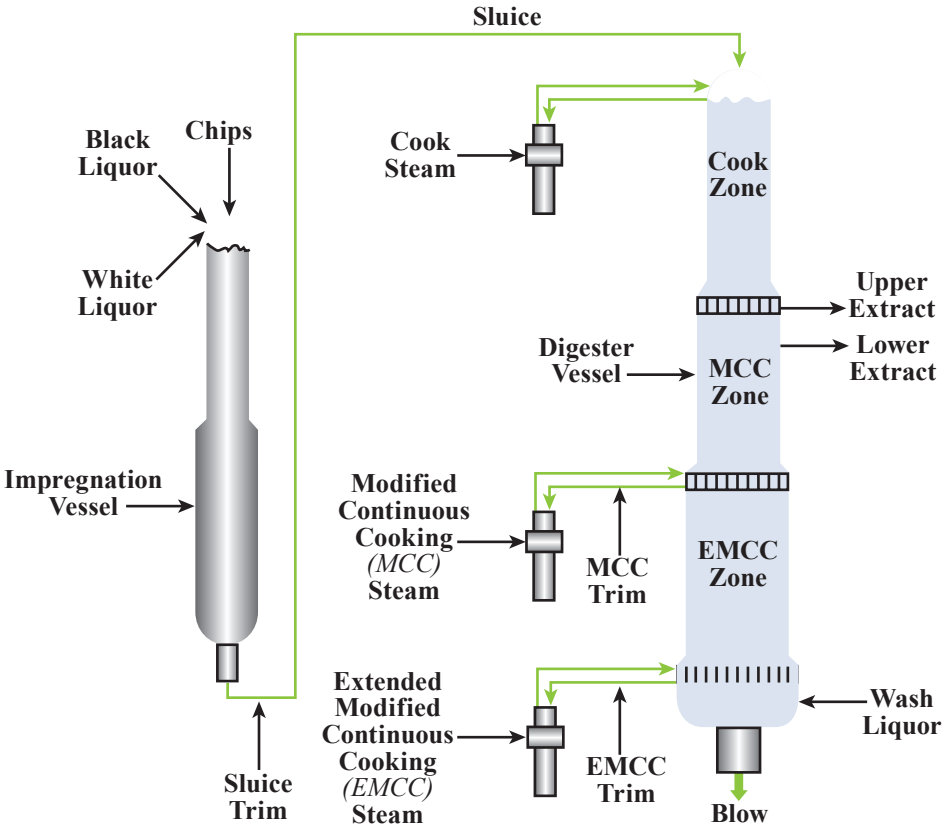
IMPACTS

Pulp Process Model Identifies Improvements that Save Energy and Improve Productivity

The pulp digester is known as the bottleneck unit in the pulp mill flow sheet because it can require 5% to 50% of typical on-line operation time, making this component of the pulping process very capital intensive. Improving digester performance can significantly reduce production losses, operating costs, and negative environmental effects while increasing paper quantity and quality. Using a computer-based model and control system for continuous digesters could regulate the pulping process, thereby minimizing mill downtime caused by digester problems and fostering continuous operation and pulp production.

Previous work conducted at the University of Delaware (UD) indicated that fundamental computer models could manage the internal conditions within the digester. The UD resolved the major challenge to designing such a model by developing a fundamental digester model that manages production rate changes and grade swings between hardwood and softwood feedstocks.

The digester's fundamental process model integrates physical and chemical properties as system "states" (i.e., points in the digester process) to track grade transitions. This model allows appropriate material, energy balance, and diffusion simulations to be calculated as various-origin chips pass through the digester. The observation and tracking of these data help identify process improvements. The model's first commercial application in a Texas mill allowed the temperature to be reduced in part of the pulping process, thereby saving 1% of the process energy.



Dual Vessel EMCC Continuous Digester

Overview

- Developed at the University of Delaware
- Commercialized in 2003
- Being marketed by IETEK (www.ietek.net)

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
9.00	0.00

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.0	0.0

Applications

Can be used in all types of pulp digesters and provides the basis for developing more model-based methods of soft sensing, diagnostics, and control

Capabilities

- Uses a computer model to evaluate the pulping process.
- Provides operational data through the model to identify process improvements.

Benefits

Environmental Impact

Minimizes the amount of chemicals used.

Productivity

Improves operator control, thus raising productivity and process reliability. Also improves system operability through rate and grade transitions.

Product Quality

Reduces pulp and paper quality variations.

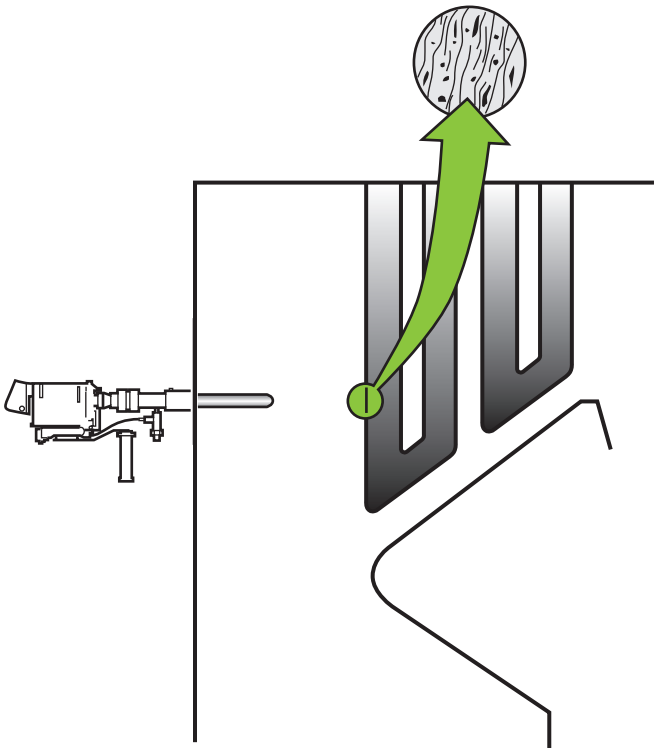
Detection and Control of Deposition on Pendant Tubes in Kraft Chemical Recovery Boilers

Advanced Imaging System Improves Boiler Efficiency, Reduces Sootblowing Costs, and Improves Operational Safety

The kraft chemical recovery boilers used for pulp processing are large and expensive and can be the limiting factor for mill capacity. Improvements in boiler efficiency with better control of deposits on heat transfer surfaces (e.g. pendant tubes) and reductions in boiler downtime (due to pluggage or slag impact) can improve boiler capacity and reduce operating costs.

With assistance from DOE's Inventions and Innovation Program, Enertechnix, Inc., has developed a hand-held infrared inspection system. Using the inspection system technology, they have also established the feasibility of and are developing a continuous integrated monitoring sootblower control system to detect and control buildup of deposits. The early detection of deposits can extend the intervals between boiler shutdowns. The resulting improved boiler operation and reduced maintenance provide energy savings and productivity improvements to the pulp processing industry.

Sootblowers use steam to clean the soot from the fire side of heat exchanger pendant tube surfaces. The hand-held inspection system has demonstrated reductions in sootblower steam use of up to 20% because the frequency of sootblower operation is reduced, sootblowers can be repositioned based on data obtained from the inspection, and sootblower malfunction can be detected. Reduced pluggage and deposition in the boiler have also led to improved heat transfer rates. The integrated observation camera and sootblower control system (under development) are expected to reduce sootblower steam usage by 30-35% and improve heat transfer efficiency by 20%.



Hand-Held Inspection System on a Kraft Recovery Boiler

Overview

- Developed by Enertechnix, Inc. (www.enertechnix.com)
- Commercialized a hand-held device in 2002
- 159 units in use in 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
7.18	1.75

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.013	1.02	0.270	38.1

Applications

Can be used by kraft recovery boilers in the pulp and paper industry and also for boilers in the coal power, cement, steel, and glass industries

Capabilities

- Produces clear video images of boiler interiors despite highly particle-laden environments.
- Produces images at distances up to 100 feet, enabling inspection anywhere in the combustion chamber including the convection pass and economizer.

Benefits

Productivity

Reduces boiler downtime through early detection of defective fixtures (tube leaks or damaged sootblower). Without shutting down the boiler, also detects slag formation at an early stage, preventing impact damage and enabling cleaning before deposits harden.

Safety

Enables early detection and elimination of sizable slag deposits on boiler internals, which can lead to severe damage and potential injury.

MultiWave™ Automated Sorting System for Efficient Recycling

IMPACTS

Advanced Sensor Detects Paper's Unique Spectral Signature at High Speed

The primary challenge in recycling paper has been to obtain raw material with the highest purity. Ideally, creating a paper stream sorted by purity would facilitate a high-quality end product, thereby saving processing chemicals and energy. Unfortunately, previous manual sorting techniques were not effective in meeting this challenge. With financial assistance from ITP, North Carolina State University, Weyerhaeuser, and MSS Corporation developed sensors for automatically sorting grades of paper from a mixed stream at high speed for more efficient recycling. Using technology developed by North Carolina State University, MSS commercialized the MultiWave™ sensor in 2006, providing proprietary full spectrum color and near infrared (NIR) spectroscopy in one compact module at scanning speeds that are more than double those of other NIR sensor systems. The new sensor also provides gloss and lignin identification.

The new sensor provides manual recycling facilities, as well as paper and plastics processors, with a solution for automated optical separation at levels not possible before. At up to 15 tons/hr, the incoming stream is uniformly fed in a single layer on high-speed conveyors at velocities of 1,200 ft/min (6 meters/sec). Besides increased speed, the sensor works in machine widths of up to 96" (2440 mm), which allows significantly higher throughput rates to be processed than any other sorting module available on the market – more than 160 ft^2 per second (15 m^2/sec).

The sensor starts the process by analyzing all items and classifying them according to specific "signatures." Then, the master computer processes the signals and fires compressed air jets. Depending on the setup, the targeted materials can be ejected together into one chute (upwards) or separately into two chutes (one upward, one downward). An auto-calibration feature ensures consistently high sorting accuracy. The result is a paper stream that is sorted by purity, thereby meeting the original challenge and reducing landfill waste.

Overview

- Developed by North Carolina State University
- Commercialized and marketed by MSS Corporation in 2006 (www.magsep.com)

Applications

Can be used for high-speed sorting of mixed recycled paper streams and gloss and lignin identification

Capabilities

- Works in machine widths up to 96 inches, up to 15 tons per hour.
- Analyzes and classifies paper type at 1,200 feet per minute.

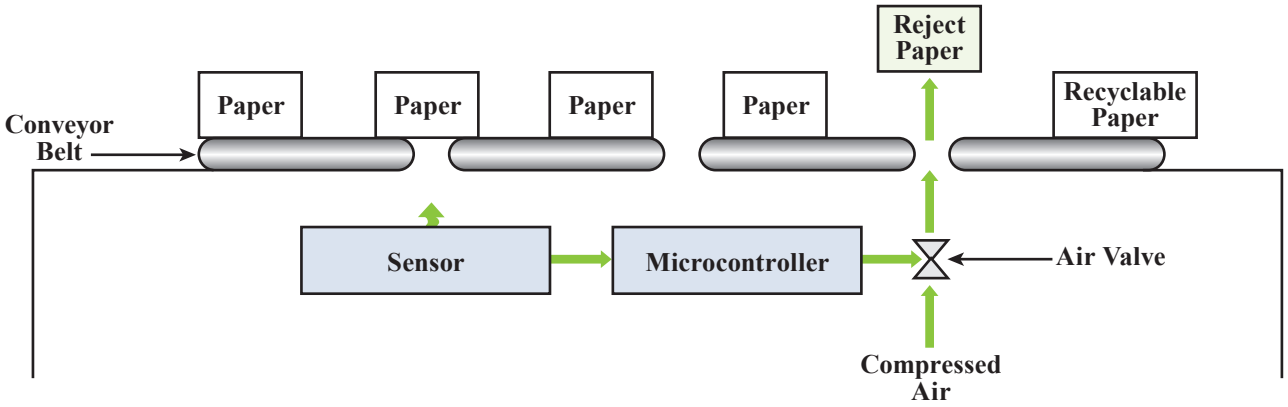
Benefits

Profitability

Sorts recycled paper using a high-speed machine instead of hand sorting.

Waste Reduction

Reduces rejected recycled pulp up to 5%.



Paper Recycling Using the MultiWave Sensor System

Screenable Pressure-Sensitive Adhesives

Improving Recycled Paper Production Energy Efficiency

Pressure-sensitive adhesives (PSAs) in recycled paper create a number of problems for the recycling process, including lost production and diminished product quality. Unlike conventional PSAs, a new adhesive material was developed at the University of Minnesota, with the assistance of ITP funding, that is effectively removed from the papermaking process during the furnish screening process. The new adhesive possesses properties that enhance its removal without impacting its performance in PSA products.

To develop the new adhesive materials, new screenable PSAs were synthesized and characterized, and performance measures were created. In addition, modified adhesive substrates were tested, and test methods were designed to gauge disintegration inhibition of adhesive labels and relative removal efficiencies of developed polymers. The new adhesives break down into larger, harder, nontacky particles that are more easily removed through conventional screening, and the cross linking reactions may be controlled through external stimuli allowing the reactions to be initiated during recycling.

The technology was commercialized in 2006 and is the industry's first 100% recyclable label. Currently, the Pinnacle Label Company is selling a portion of their labels under their recyclable label brand utilizing this technology. Using 100% recycled paper stock and a recyclable permanent adhesive, Pinnacle now has an environmentally friendly product. Pinnacle Label supplies the needs of its national customer base from its headquarters and production facility in Buffalo, New York, and other distribution centers around the nation.

Overview

- Developed by Dr. Steven Severtson of the University of Minnesota in 2000
- Commercialized in 2006 and being marketed by H. B. Fuller Company (www.hbfuller.com)

Applications

Can be used for all press-on type labels and sticker products

Capabilities

- Allows easier adhesive removal in paper recycling.
- Reduces machine downtime by reducing jams due to adhesives and reduces process chemical needs.

Benefits

Energy Savings

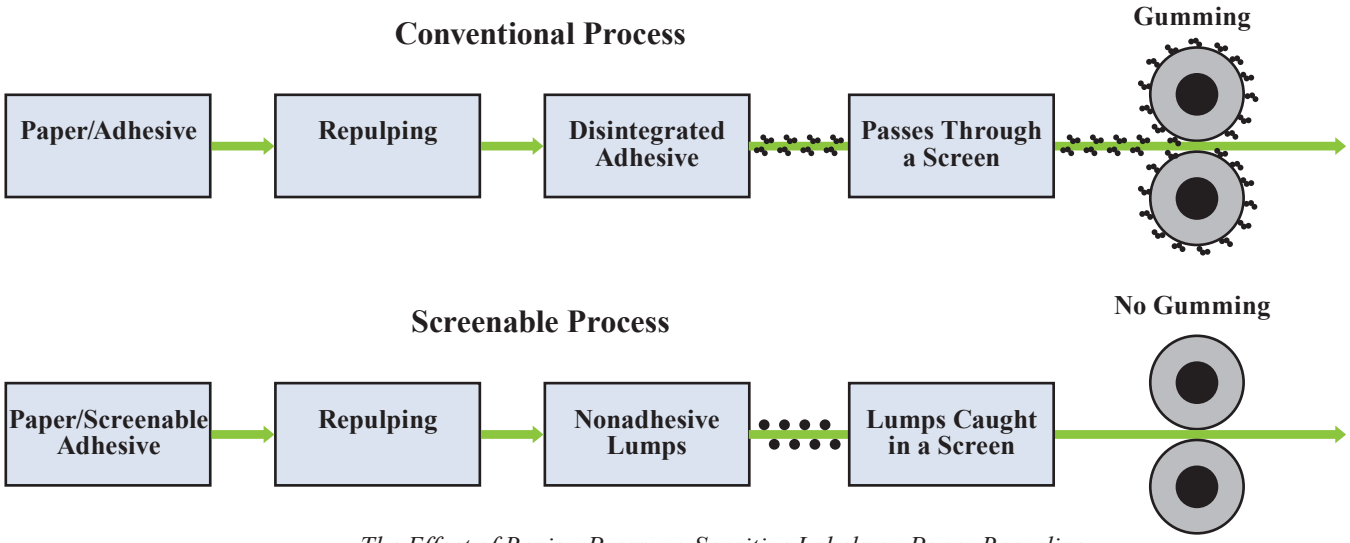
Improves the energy efficiency of recycled paper production.

Productivity

Reduces paper recycling re-manufacture processing downtime and lowers fiber loss.

Waste Reduction

Allows for the recycling of more post-consumer paper trash and reduces process chemical needs.



The Effect of Benign Pressure-Sensitive Labels on Paper Recycling

Thermodyne™ Evaporator – A Molded Pulp Products Dryer

IMPACTS

Thermodyne Evaporator–A Substantially Improved Molded Pulp Products Dryer

With assistance from DOE's Inventions and Innovation Program, Merrill Air Engineers demonstrated that its Thermodyne dryer outperforms conventional molded pulp dryers. Unlike other dryers, the Thermodyne dryer reheats water vapor released from the product being dried to create superheated steam that is directed onto the material being dried. Conventional paper dryers exhaust this liberated water outdoors, causing a large visible plume and dumping valuable heat. The Thermodyne dryer is sealed so internal vapor (moisture) cannot escape into the insulated dryer walls. The retained water vapor passes through indirect integral heaters to raise its temperature to a level that allows for substantially faster drying rates than if drying in relatively dry air. An absence of oxygen in the dryer also means the drying temperature can be higher and the retained water vapor can help protect and evenly dry the material. Fires are prevalent with standard dryers, but lower oxygen levels in a Thermodyne dryer eliminates this hazard. The released water vapor also helps control internal temperatures by mixing with the superheated steam, dropping its temperature to a more desirable level. Finally, the system recovers heat and harmful volatile organic compounds (VOCs) from the dryer's condensate, substantially reducing the amount released into the atmosphere.

Benefits

Productivity

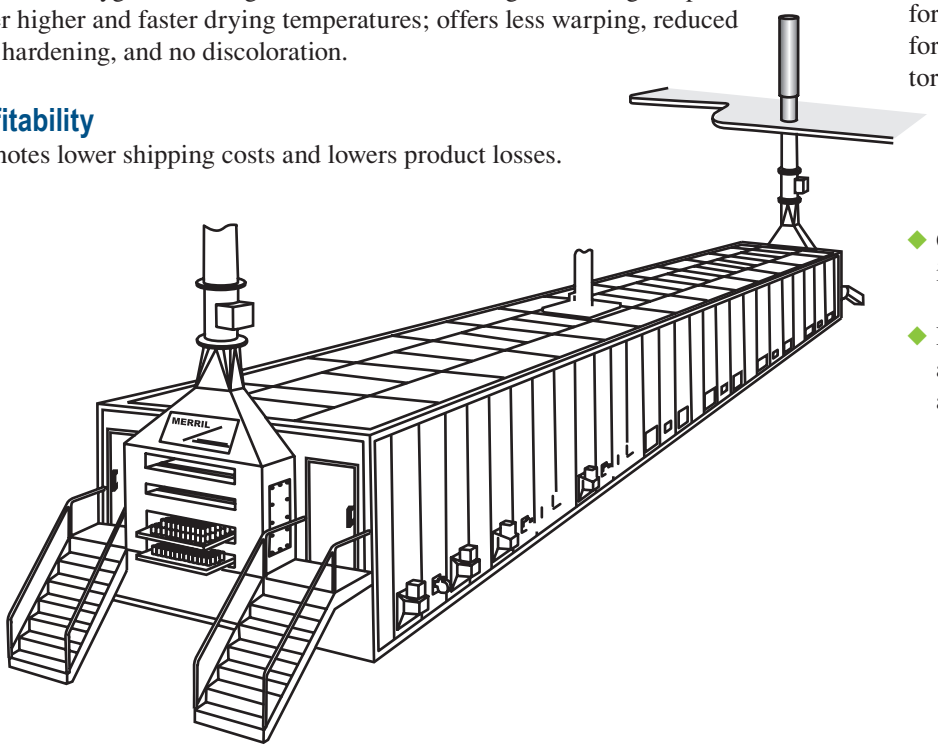
Promotes easier stacking and wrapping.

Product Quality

Suppresses oxygen, reducing the chance of scorching or burning the product under higher and faster drying temperatures; offers less warping, reduced case hardening, and no discoloration.

Profitability

Promotes lower shipping costs and lowers product losses.



Thermodyne Evaporator–A Molded Pulp Products Dryer

Overview

- Developed by Merrill Air Engineers (http://merrill-air-engineers.com/)
- Commercialized in 1997
- Two units in service in the U.S., one in Ireland, and one in Columbia

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.476	0.068

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.008	1.07

Applications

Can be used by the forest products industry for manufacturing molded fiber articles and for drying pulp, wood, cotton, cellulose, or torrefied wood and wood veneers

Capabilities

- Can replace conventional drying systems in the forest products industry.
- Handles a wide variety of forest products and can be applied to agricultural applications.

Glass

IMPACTS

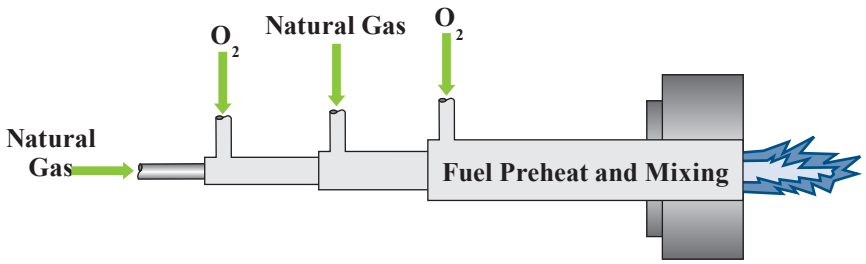
High Luminosity, Low-NO_x Burner

High-Efficiency Burner Lowers Costs and Emissions in Oxy-Fuel Glass Melters

Glass melters use combustion systems to produce molten glass. While significant progress has been made in developing oxy-fuel combustion systems, current technologies provide low flame luminosity and generate relatively high NO_x emissions in the presence of even small mounts of nitrogen in the combustion process.

With the help of a grant from ITP, Combustion Tec Inc., now Eclipse, Inc., has developed an innovative burner that increases luminosity and radiant heat transfer in high-temperature glass furnaces. The burner improves performance by modifying the fuel prior to combustion and then forming and burning soot in the flame. The burner increases heat transfer rates while decreasing flame temperatures to improve furnace production rates and thermal efficiency.

The high-luminosity, low-NO_x burner combines a preheating zone with two combustion zones. First, a small fraction of the natural gas is burned. The products of this combustion are then mixed with the main supply of natural gas, resulting in hydrocarbon soot precursors generated in an oxygen-free heating environment. Next, the preheated natural gas enters the first, fuel-rich combustion zone in which soot forms in the flame. However, most of the combustion occurs in the second, fuel-lean combustion zone. The burning soot particles create a highly luminous flame that is more thermally efficient and cooler than a typical oxy-fuel flame.



High Luminosity, Low-NO_x Burner Design

Overview

- Developed and marketed by Eclipse, Inc. (www.combustiontec.com)
- Commercialized in 2002
- Operating in seven U.S. plants in 2009

Applications

Can be used in existing and new oxy-fuel glass melters, with the largest demand currently existing in the container, fiber, and specialty glass sectors of the glass industry

Capabilities

- Can be used on new furnaces or retrofit to older ones.
- Improves furnace production rates as a result of a more than 12% increase in heat transfer rates.

Benefits

Energy Saving and Pollution Reduction

Reduces NO_x emissions from glass melters up to 50% and improves thermal efficiency up to 20% over traditional oxygen fuel burners.

Productivity

Allows cost-effective compliance with emissions regulations and provides flexibility for compliance in existing furnaces without major modifications.

Reliability

Produces a lower flame temperature and lower exit temperatures, which could extend the furnace life.

High Throughput Vacuum Processing for Producing Innovative Glass/Photovoltaic Solar Cells

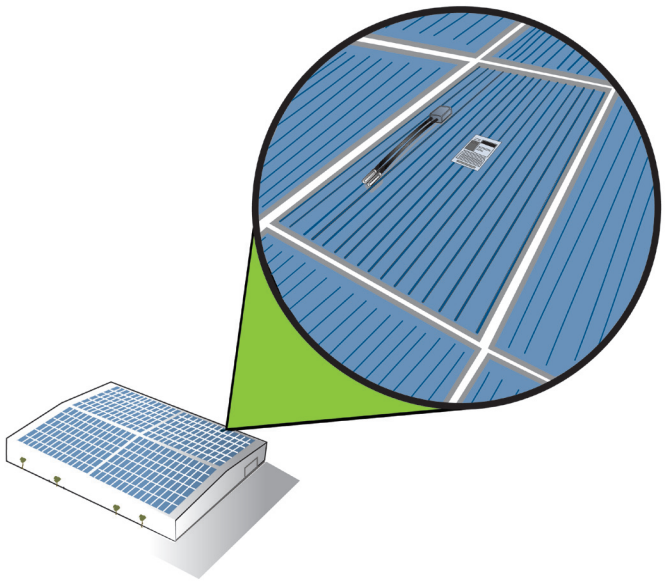
IMPACTS

Continuous Manufacturing Process Reduces Cost of Solar Power

The sun has long been known to be a boundless source of energy. More solar energy hits the earth in one hour than is used by the entire world's population in one year. Unfortunately, the high manufacturing cost of solar photovoltaic (PV) modules has prevented solar from competing with other forms of electricity generation.

With assistance from DOE's Inventions and Innovation Program, Abound Solar, Inc., has developed an improved manufacturing process for producing thin-film cadmium telluride (CdTe) solar cells encapsulated with a protective layer of glass. The manufacturing process is dry, in-line, continuous, and fully automated. A glass panel enters the semiconductor chamber every 10 seconds, and emerges from the end of the line as a complete product module in less than two hours. Abound Solar's proprietary in-line semiconductor deposition tool significantly improves PV film quality, device efficiency, device stability, and product yield. Because the semiconductor layers are applied in a single piece of equipment, capital equipment costs, factory space, and manufacturing costs are reduced. In addition, the fast cycle time increases product volume per capital dollar invested.

The Abound Solar modules are ideally suited for solar installations ranging from commercial-scale (tens of kilowatts) to utility-scale (hundreds of megawatts). Designed for use worldwide in a variety of climates, the modules perform better than crystalline silicon PV under real-world conditions such as high temperatures and low or diffuse lighting.



Abound Solar's CdTe Solar Modules on a Commercial Building Rooftop

Overview

- Developed and marketed by Abound Solar, Inc. (www.abound.com)
- Commercialized in 2009 with one facility in Longmont, Colorado, selling commercial units in the U.S. and internationally.

Applications

Can be used to produce next-generation, thin-film PV modules that deliver a low levelized cost of electricity.

Capabilities

- Produces completed solar modules in less than two hours.
- Produces thin-film CdTe PV cells that have achieved efficiencies of 12 to 13%.

Benefits

Cost Savings

Reduces costs by using continuous, high-throughput manufacturing techniques in a single piece of equipment.

Emissions Reductions

Reduces emissions of air pollutants and greenhouse gases by 92 to 98% compared with fossil-fuel-based electricity.

Environmental

Avoids disposal issues because Abound Solar pays for packaging and shipping of solar modules to be recycled at the end of their life. More than 95% by weight of each module is recycled.

Product Quality

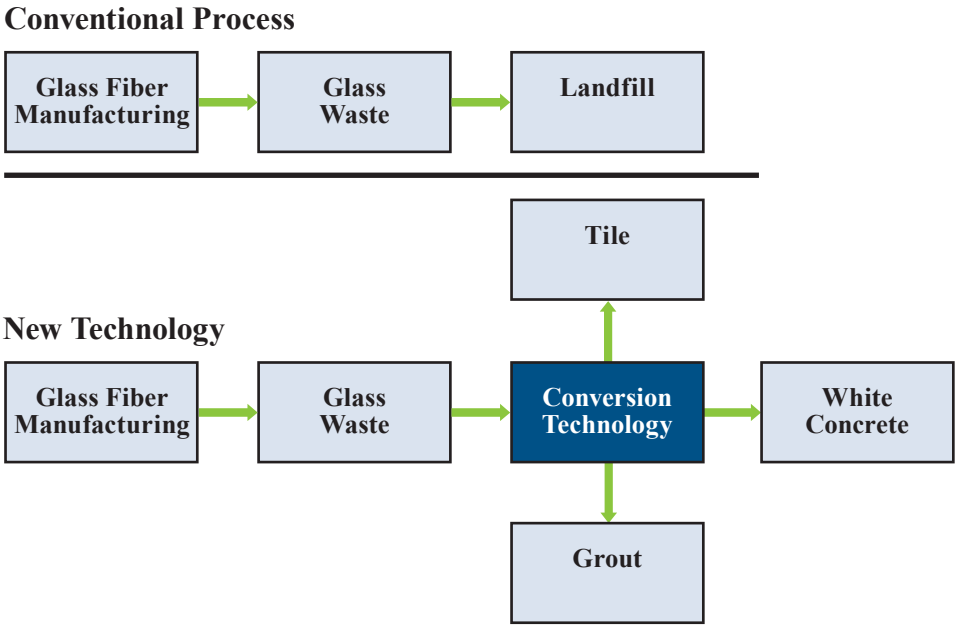
Offers a 5-year materials and workmanship warranty, with power output guarantees of 90% of nominal output during the first 10 years and 80% over 25 years.

Process for Converting Waste Glass Fiber into Value-Added Products

New Process Reduces Glass Fiber Waste Stream to Landfills

Solid wastes are generated at glass fiber manufacturing facilities. With the help of a grant from DOE's Inventions and Innovation Program, Albacem, LLC, developed a new process that converts these waste streams into VCAS™ (vitrified calcium alumino-silicate) pozzolans that can be used in cement and concrete applications. This technology can help divert up to 250,000 tons per year of discarded glass fiber manufacturing wastes for use in the concrete construction industry. This technology can also be used for processing glass fiber waste materials reclaimed from existing landfills at manufacturing facilities. Both sources can help supply over 500,000 tons per year of glass fiber waste for processing into value-added products.

In the new process, waste glass fiber is ground to a fine powder that effectively functions as a reactive pozzolanic admixture for use in Portland-cement-based building materials and products, such as concrete, mortars, terrazzo, tile, and grouts. Because the waste fiber from the glass manufacturing industry is vitreous, clean, and low in iron and alkalis, the resulting pozzolan is white and highly consistent in chemical composition. This white pozzolan is especially suited for white concrete applications, providing increased long-term strength and improved long-term durability. This new pozzolan is being manufactured and marketed by Vitro Minerals, Inc. While this additive is targeted towards white concrete applications, it can also be applied to other concrete applications where environmental benefits are desired.



Glass Waste Conversion Process

Overview

- Developed by Albacem, LLC
- Commercialized and marketed by Vitro Minerals in 2006 (www.vitrominerals.com)

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.385	0.140

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.016	2.22

Applications

Can be used for waste streams in the glass fiber industry and to replace part of the cement used in concrete

Capabilities

- Decreases water used to cure concrete.
- Imparts white color to concrete.

Benefits

Energy Savings

Decreases the amount of cement used in concrete and the amount of water needed to cure concrete while imparting white color to the concrete.

Environmental

Reduces the carbon footprint of a product when used as a cement additive.

Waste Reduction

Reduces the waste stream from current glass fiber manufacturing and reclaims glass fiber waste from old landfills.

Metal Casting

IMPACTS

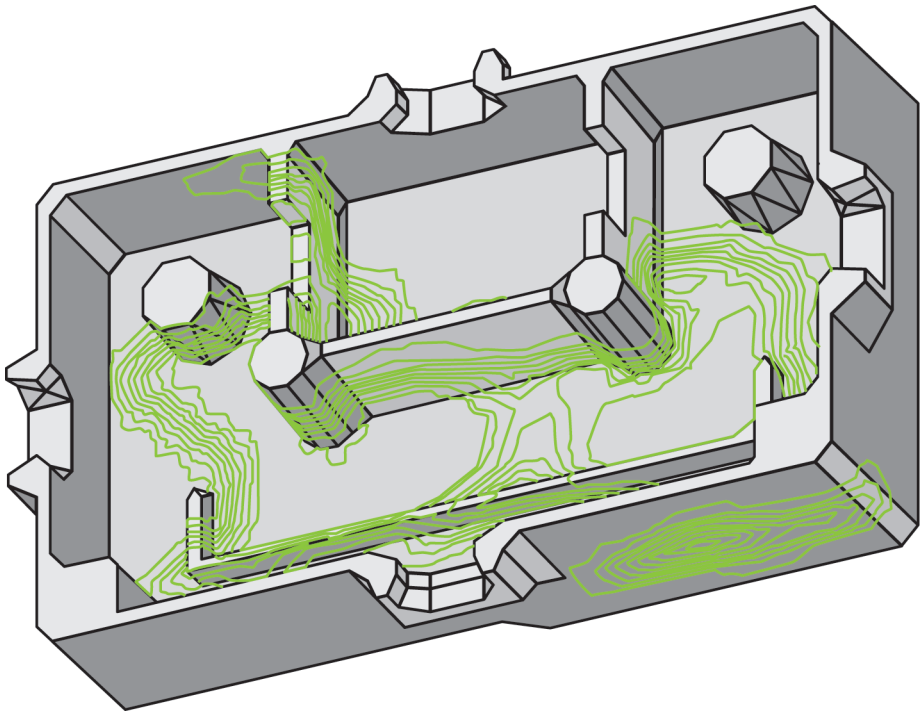
CFD Modeling for Lost Foam White Side

New Modeling Program Provides Higher Quality Lost Foam Molds

The lost foam casting process produces clean, high-quality castings with close tolerances. The most important advantage is that no cores (with binders) are required. One challenge in lost foam casting is maintaining the uniformity and quality of the expandable polystyrene (EPS) pattern. This has often been the cause of defects in casting. An estimated 80% or more of lost foam defects can be attributed to the pattern, or the so-called white side. Foam molds are complex, and beads must flow through complex passages to completely fill the mold. The process is further complicated by the expansion of the beads.

General Motors Powertrain and others in the metal casting industry have successfully used advanced computational fluid dynamics (CFD) tools to improve foundry processes. These efforts have yielded significant cost savings and improvements in the casting processes. The industry has recognized that mathematics-based tools are needed to design and build consistent, quality EPS patterns for lost foam casting.

Arena-flow, LLC, in conjunction with the American Foundry Society, ITP, and the metal casting industry, have extended existing flow modeling software to simulate the air-driven blowing of pre-expanded beads into a mold and the subsequent steaming (expansion) of beads as they form a lost foam pattern. They developed a CFD tool for improving design and development of EPS patterns for lost foam castings.



Expandable Polystyrene Pattern Volume Fraction During Filling of a General Motors Test Box

Overview

- Invented by Arena-flow, LLC, and marketed by CPFD Software, LLC (www.cpfd-software.com)
- Being used by 2 U.S. manufacturers in 3 locations

Applications

- Can be used in modeling fluid/particle applications for mold creation in the lost foam casting industry
- Can be used in analysis of other industrial fluid/particle processes, including cyclones or fluidized bed reactors

Capabilities

- Provides visualization of the mold by using CFD modeling prior to the mold creation.
- Optimizes pattern quality as affected by fill guns, beads, and tool venting.

Benefits

Productivity

Results in fewer casting defects, requires no cores, and produces higher-quality castings.

Waste Reduction

Reduces casting defects on the white side, caused by pattern difficulties.

Die Casting Copper Motor Rotors

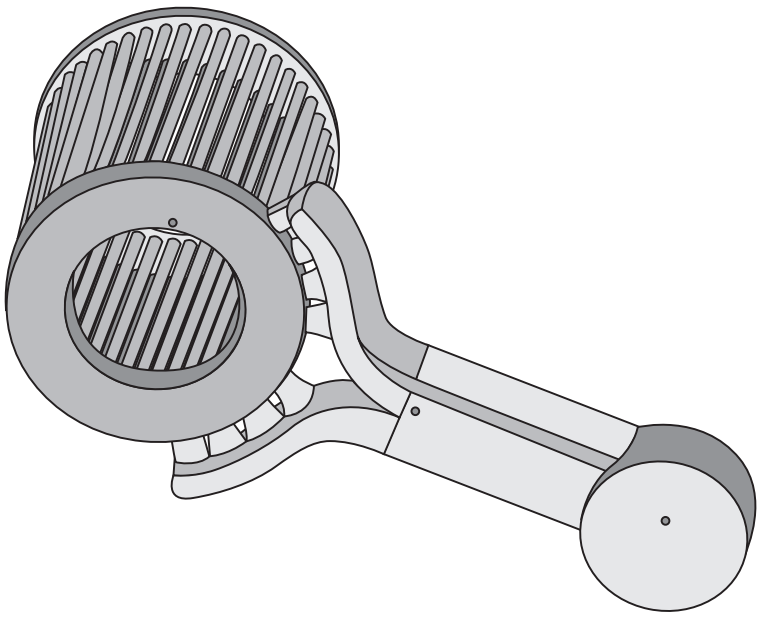
IMPACTS

Die Casting Copper Technique Improves Energy Efficiency of Electric Motors

Though it conducts electricity less efficiently than copper, aluminum is the industry's preferred fabrication material in electric induction motor rotors. Traditional tool steel casting molds suffer thermal shock, shortening mold life and increasing operating costs when used for die casting copper rotors. ThermoTrex Corporation, with the assistance of a NICE^3 grant, proposed a process for copper die casting using molds from high-temperature, thermal shock-resistant materials. The copper industry successfully tested these mold materials for copper die casting at higher temperatures (copper melts at 1083°C, aluminum at 660°C).

The copper die-casting technology developed by the copper industry is now in commercial use. The process replaces the tool steel molds used for the aluminum die casting with molds made from high-temperature die materials. In addition, the new process preheats the die inserts, reduces the temperature differential between the mold surface and the cooler interior, and avoids mold failure from thermal shock and thermal fatigue.

In 2003, SEW Eurodrive of Bruchsal, Germany, was the first company, worldwide, to bring the technology to market. A line of high-efficiency gear motors (1.1-5.5 kW) use copper rotors at a competitive price. Although traditional high-efficiency motors are larger than standard motors, gear boxes using copper rotor technology provide efficiency without increasing motor size. In 2004, FAVI S.A., a major French supplier of copper and copper alloy die castings, began offering custom-designed, copper-based rotors for squirrel-cage electric motors in sizes ranging from fractional to 100 hp. Siemens Corporation began commercial production and sales domestically in 2006 in the 1 to 20 hp range.



Squirrel-Cage Motor with Die Cast Copper Rotors

Overview

- Invented by the ThermoTrex Corporation and commercialized by the Copper Development Association (www.copper.org)
- Marketed by SEW Eurodrive, FAVI S.A, and Siemens Corp. with more than 275,000 in use in the U.S. in 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.389	0.152

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.001	0.033	0.024	2.99

Applications

Can be used in electric motors throughout U.S. industry, which account for more than 60% of all electricity use in the nation.

Capabilities

- Reduces electric motor total energy loss by 15% to 20%.
- Decreases operating costs compared with conventional motors.

Benefits

Productivity

Reduces production time and hand labor compared with former methods of producing copper motor rotors.

Profitability

Decreases operating costs compared with conventional motors.

Improved Magnesium Molding Process (Thixomolding)

Improved Die Casting Process Substantially Reduces Energy, Waste, and Operating Costs

Traditionally, die-cast molding results in product yields of 50% and creates waste – scrap, slag, and dross. The Thixomolding process, developed and demonstrated by Thixomat, Inc., with the help of a NICE^3 grant, improves product yields to 90% while eliminating waste and loss of product to melting. The process is worker and environmentally friendly and can be integrated into automated manufacturing processes to produce metal and metal/plastic assemblies.

In Thixomolding, room-temperature magnesium chips are fed through a volumetric feeder into the back end of a heated barrel that contains an argon atmosphere to prevent oxidation. Within the barrel, a rotating screw propels the material forward as the screw retracts. Resistance heaters on the outside of the barrel, arranged in 10 separately controlled zones, heat the material to the semi-solid region (approximately 560°C to 630°C). Once the magnesium is heated, the screw rotation provides the necessary shearing force to divide the dendrites from the root solid particles. This action creates a thixotropic slurry consisting of spherical solid particles in a continuous liquid matrix. The slurry is forced through a non-return valve and into the accumulation zone. When the proper amount of slurry is in front of the non-return valve, the screw proceeds forward at a speed of 1.8 to 5 m/s, forcing the metal into a preheated metal mold to produce a net or near-net shape part requiring few, if any, secondary operations. The process offers numerous cost advantages over other production methods, including higher yield, increased die life, lower utility costs, consistency of process, tighter dimensional tolerances, and improved manufacturing agility.

Benefits

Cost Savings
Reduces operating costs by 20%.

Environmental
Significantly reduces pollutant emissions and eliminates the use of sulfur hexafluoride. Eliminates slag and dross and their disposal problems.

Waste Reduction
Reduces scrap that must be recycled and subsequently reheated by 50%.

Overview

- Developed by Thixomat, Inc. (www.thixomat.com)
- 50 Thixomolding machines in use in 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.223	0.075

U.S. Emissions Reductions

(Thousand Tons, 2009)

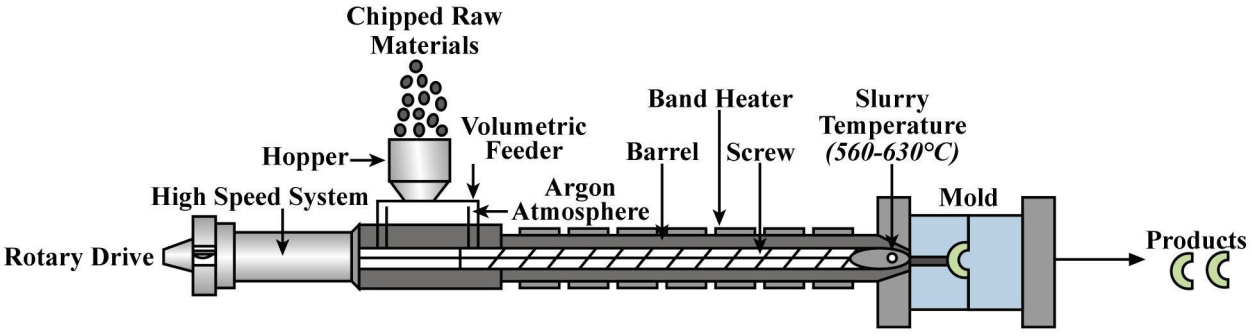
Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.009	1.18

Applications

Can be used in automotive, electronics, communications, sports, and hand tool industries

Capabilities

- Produces thinner, lighter, and stronger parts than possible with engineered plastics.
- Provides excellent dimensional stability (0.001 mm/mm), low porosity, tighter part tolerances, minimum shrinkage (0.5%), low residual stress, and virtually no component distortion.



Thixomolding Process

Improvement of the Lost Foam Casting Process

IMPACTS

Improved Process Reduces Energy Use, Waste and Emissions, While Lowering Product Defects and Costs

Casting is an energy-intensive manufacturing process within the metal casting and aluminum industries, requiring natural gas to melt aluminum and electricity to run equipment. The higher-than-acceptable faults and scrap rates in the lost foam casting process for the complex L61 engine previously resulted from the inability to control and measure refractory coating thickness and to control particle size and the shape of the unbonded sand. Remelting defective castings adds to overall energy costs, emissions, and use of resources.

The lost foam casting process starts with a foam pattern of the desired end-product made out of polystyrene beads. The foam pattern is coated with a thin refractory film and placed into dry, unbonded sand that is compacted by vibration. Molten metal, poured into the sand casting, evaporates and replaces the foam, producing a metal casting that is nearly identical to the foam pattern. The foam vapor passes through the pores in the refractory coating and the sand. This process enables the joining of several components within a single casting, thereby reducing downstream machining and assembly.

With the assistance of a NICE^3 grant and the New York State Energy Research and Development Authority, General Motors Corporation has developed tools to precisely measure dried coating thickness and pore size distribution, more accurately measure the size and shape of sand used in casting, and better understand the rheology of coatings. Rheology affects both coating thickness and uniformity on foam patterns. Coating thickness controls the permeability of gaseous expanded polystyrene by-products, which is directly related to casting defects such as porosity and folds. Therefore, measuring the rheological properties of the lost foam coating is critical to minimizing casting defects.

Benefits

Cost Savings
Reduces costs for polystyrene beads, glue, coating, sand, aluminum, cleaning media, and labor by $900,000 to $1.5 million annually.

Environmental
Reduces harmful incinerator emissions and sand waste by 2.2 to 3.5 tons annually.

Product Quality
Improves product quality 5% to 8% over conventional lost foam casting and significantly reduces scrap rates.

Overview

- Developed by General Motors Corporation (www.gm.com)
- Commercialized in 2004
- Employed at 1 General Motors casting facility

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
2.28	0.163

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.015	0.022	2.85

Applications

Can be used in metal casting and aluminum industries

Capabilities

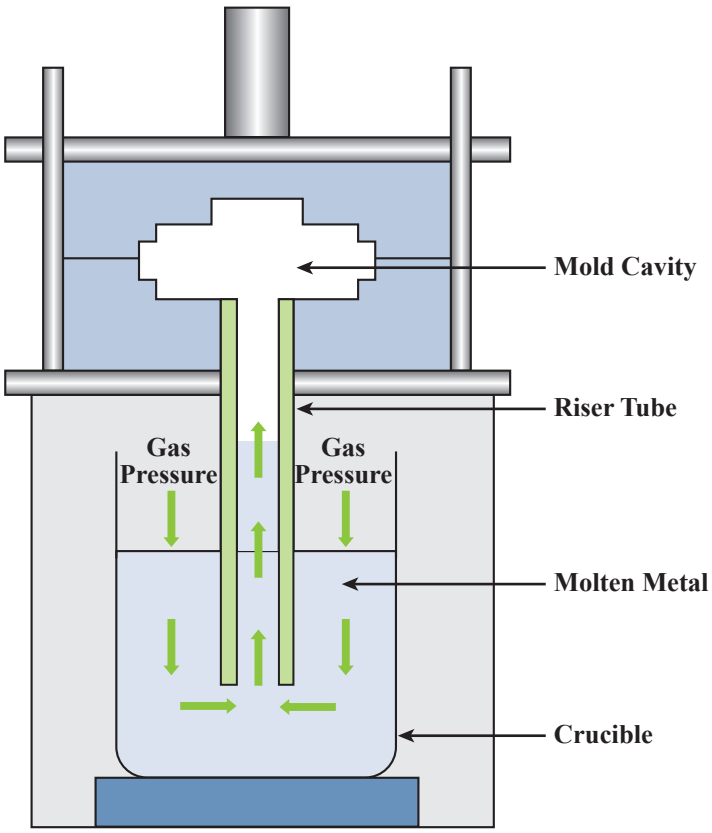
Significantly reduces aluminum and sand scrap rates during production of the complex General Motors L61 engine.

Low Permeability Components for Aluminum Melting and Casting

New Low Permeability Coating Improves Durability and Life of Aluminum Casting Components

Materials for low-pressure casting operations typically have limited lifetimes. New, optimized coatings for ceramics and refractory components have been developed by Pyrotek, Inc., Oak Ridge National Laboratory, and the University of Missouri with support from ITP. The new materials exhibit low permeability to gases for applications involving low-pressure casting and contact with molten aluminum. The products treated with this new technology will have improved coatings, functionally graded materials, and monolithics that will hold gas pressure.

The new materials include enhanced combinations of properties, including resistance to thermal shock, erosion, corrosion, and wetting. As these materials are successfully deployed in aluminum smelting and casting operations, their superior performance and durability will achieve marked improvements in uptime, defect reduction, scrap/rework costs, and overall energy savings. Initial applications of this technology, labeled "XL" glaze, include riser tubes in low-pressure die casting of aluminum products. The reduced porosity of the new ceramic coating material improves the component's air tightness, which reduces tube failures. Testing shows that the improved tube coatings increase the life of the component 3-4 times the standard, depending on the application and coating material. Additional work is underway on a castable material system that will incorporate the benefits of the "XL" coating in the cast material itself. This product is expected to increase component life by up to 7 times the standard.



Aluminum Casting Riser Tube with Pyrotek's Low-Permeability Coating

Overview

- Developed by Pyrotek, Inc. (www.pyrotek-inc.com)
- Commercialized in 2005

Applications

Can be used in aluminum casting and chemical reaction processes where riser tube and other material flow components are subject to extreme temperatures or caustic chemical streams and replacement of process components is costly and time-consuming

Capabilities

- Extends tube component life 3-4 times.
- Increases component reliability.

Benefits

Energy Savings

Eliminates reheating energy by reducing waste.

Productivity

Reduces production downtime because components have longer lifetimes.

Product Quality

Increases the life of process components.

IMPACTS

Automated In-Line Fluidized Bed Aluminum Heat Treatment System Improves Efficiency and Reduces Pollution

Arizotah Global Enterprises, LLC, in conjunction with the NICE^3 Program and the Minnesota Office of Environmental Assistance, has developed a system that reduces the time and energy required to heat treat cast aluminum components by up to 90%.

Unlike existing technologies where components are stacked in baskets and placed in a convection or vacuum furnace, this process uses a fluidized bed in a continuous process mode. Because each component is individually heated in the fluidized bed, the components reside in the bed only as long as necessary, thus reducing the process time.

The technology offers additional benefits by using microprocessor-controlled pulse-fired burners, which allow for precise temperature control that reduces rejection rates and increases product consistency. The fluidized bed also allows the casting sand that is traditionally disposed of to be captured and recycled in the fluidized bed and removed for use in new castings.

Benefits

Cost Savings

Reduces the number of personnel required for loading, unloading, and transfer and eliminates the disposal of sand contaminated with binders.

Energy Savings

Substantially increases energy efficiency, reducing heat treating energy use by up to 90%.

Product Quality

Reduces component rejection rates and improves product performance, while simultaneously reducing the amount of aluminum needed to achieve performance standards. Eliminates problems of media dispersion into the facility and volatility in the heat chamber.

Overview

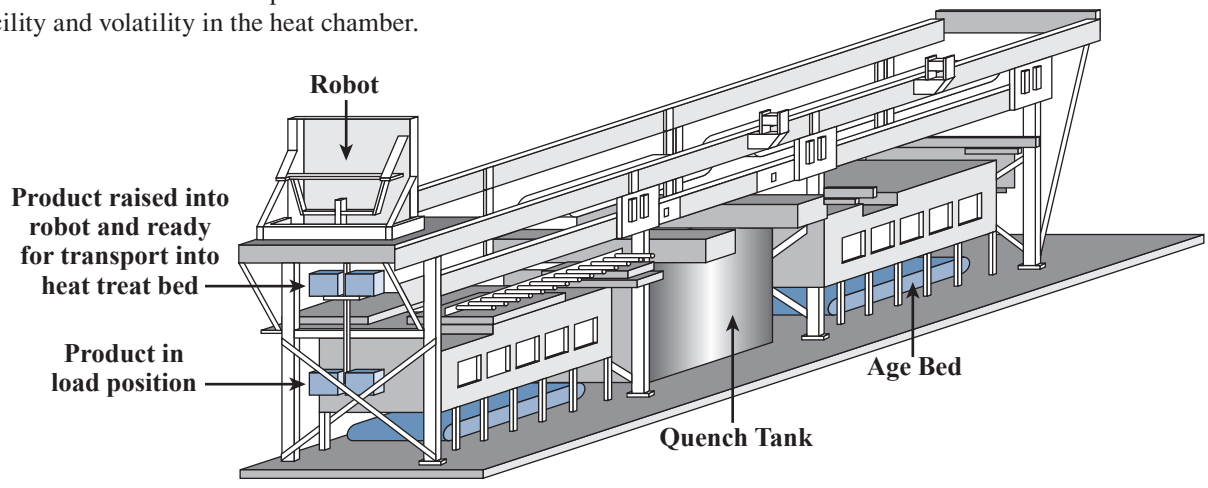
- Developed and commercialized by Arizotah Global Enterprises, LLC
- Commercialized in 2006
- 11 units operating in the United States in 2009

Applications

Can be used in the wrought and cast aluminum heat treatment industry

Capabilities

- Allows for short-cycle heat treating of aluminum castings and forgings.
- Brings the heat treating process into the production flow with the forming operation.



Automated Fluidized Bed Heat Treatment System

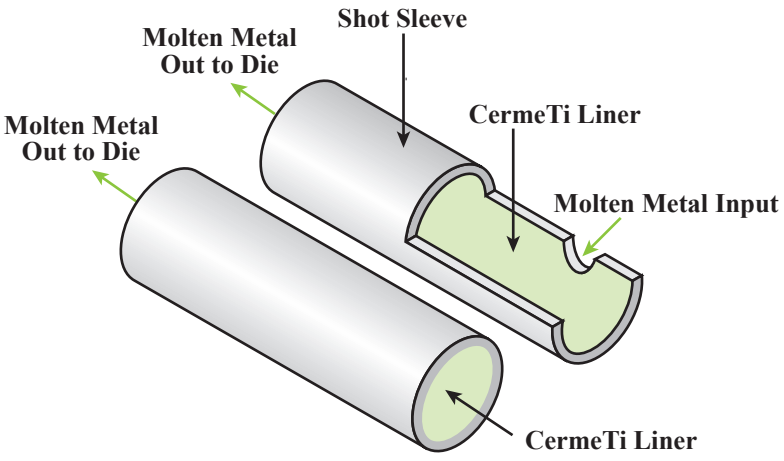
Titanium Matrix Composite Tooling Material for Aluminum Die Castings

Innovative Material Saves Energy and Extends Product Life In Aluminum Die-Casting Components

In aluminum die-casting, molten aluminum is forced under high pressure into a die cavity. First a "shot" of molten aluminum is ladled into a shot sleeve and the shot of molten aluminum is forced by a plunger through the shot sleeve into the die cavity. Shot sleeves are subject to severe conditions. For example, impingement of the shot can cause erosion at the surface across from the pour hole, and delivering and then expelling the shot can subject the shot sleeve to cyclical heating.

Currently, H-13 tool steel is used to fabricate shot sleeves and other aluminum die-casting components. However, the useful life of H-13 is limited because molten aluminum adheres (called "aluminum soldering") to the surface of the steel, eventually causing the sleeve to fail. Also, H-13 has poor resistance to heat checking, thermal fatigue, erosion, and distortion. The poor performance of H-13 results in frequent shot sleeve replacements.

With the help of a NICE^3 grant, Dynamet Technology, Inc., developed CermeTi®, a titanium-alloy metal matrix composite material that is used as a liner inserted into an H-13 shot sleeve. This new technology has significant advantages over the conventional technology, especially in its resistance to aluminum soldering and erosion. In addition, the reduced thermal conductivity of the CermeTi liner reduces heat loss during the injection phase of the casting process. Slower cooling permits the use of lower pouring temperatures (less preheat energy) or slower plunger-tip speeds (less turbulence or surface impingement problems within the die). As a result, the useful life of the shot sleeve is dramatically improved, reducing downtime, improving product quality, and saving energy.



Aluminum Die-Casting Shot Sleeves with CermeTi® Liners

Overview

- Developed by Dynamet Technology, Inc. (www.dynamettechnology.com)
- Commercialized in 2005 and being used by 35 die-cast machines in the U.S.

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.068	0.018

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.002	0.286

Applications

Can be used in metal casting applications currently using H-13 shot sleeves, including squeeze casting, conventional die-casting, and semi-solid processing

Capabilities

- Enhances thermal shock resistance through excellent resistance to aluminum soldering and lower thermal conductivity than H-13 steel.
- Reduces the tendency of premature metal solidification that impedes the flow of molten metal needed to feed the casting properly.

Benefits

Cost Savings

Reduces total process costs by 3%.

Productivity

Extends sleeve life by 4 to 10 times over H-13 steel, reduces downtime as a result of fewer shot sleeve changeovers, and enables longer plunger tip life.

Mining

IMPACTS

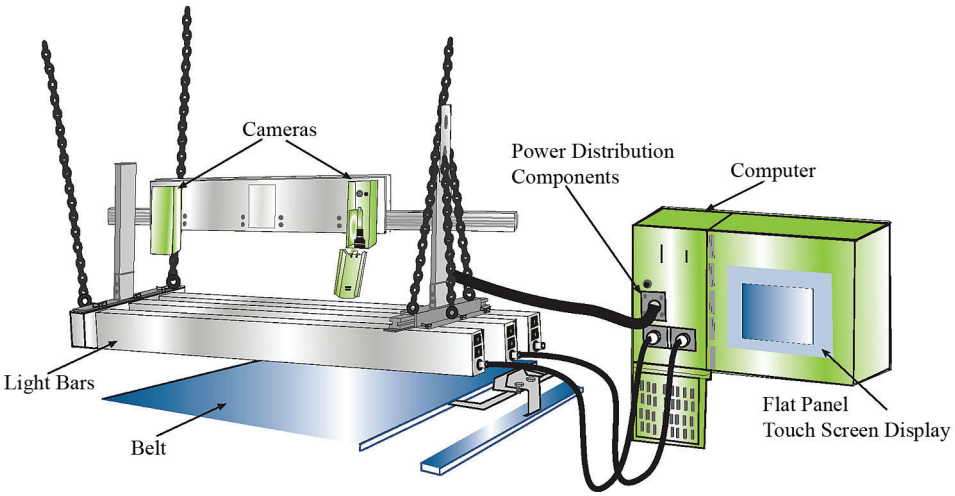
Belt Vision Inspection System

Low-Cost System Identifies Defects in Mining Conveyor Belts, Reducing Unscheduled Maintenance and Downtime

Mining operations rely on conveyor belts to move mined material from the working face of the mine to a processing plant. When a conveyor belt breaks or stops for unscheduled maintenance, production generally halts because the belt is the only cost-effective way to carry material away from the mining unit and stockpiling is typically not available at the point of extraction. Longwall mining operations can produce revenue at $1000/minute; a mainline belt break will stop production for a minimum of four hours, resulting in $240,000 of lost revenue.

The Belt Vision system, developed by the Beitzel Corporation and Carnegie Mellon University's National Robotics Engineering Consortium, with support from ITP, uses high-speed line scanning cameras and a computer system to monitor mechanical splice deterioration in moving conveyer belts. The computer system, located on the belt or a remote desktop, digitizes and records continuous imaging of the belt and splices. Mine personnel can review live or historical images several times a day with minimal effort and take action before belt splices fail. The Belt Vision system helps eliminate costly repairs to conveyor belts, keeps production running, and helps reduce costs.

The Belt Vision system's hardware consists of cameras for imaging the belt, lighting for illuminating the belt, a computer for digitizing and analyzing the camera image, a flat panel touch screen display for a local user interface, and components for power distribution. Mines using the system can measure cost savings from avoided downtime, plan maintenance effectively, review the real time splice status of beltlines more easily, and plan action items for a splice.



Components of Beitzel's Belt Vision System

Overview

- Developed by the Beitzel Corporation (www.beitzelcorp.com)
- Marketed by Pillar Innovations, LLC (www.pillarinnovations.com)
- Commercialized in 2007, with more than 10 systems used in U.S. mines in 2009.

Applications

Can be used to provide images of the belt splices to mine personnel, who evaluate these images and take action before the belt splice fails

Capabilities

- Allows mine personnel to monitor deterioration in operating conveyor belts in underground and surface mines.
- Reduces deterioration in mining conveyance systems.
- Provides a user interface for belt inspection at installation points using software that controls the cameras, collects encoder data, and captures images.
- Stores images in a database and distributes them to a web server that can be accessed on a remote computer.

Benefits

Cost Savings

Helps eliminate costly repairs to conveyor belts by finding potential problem points before the belt fails.

Productivity

Keeps production running and eliminates the need for periodic manual shutdowns to inspect the belt's condition.

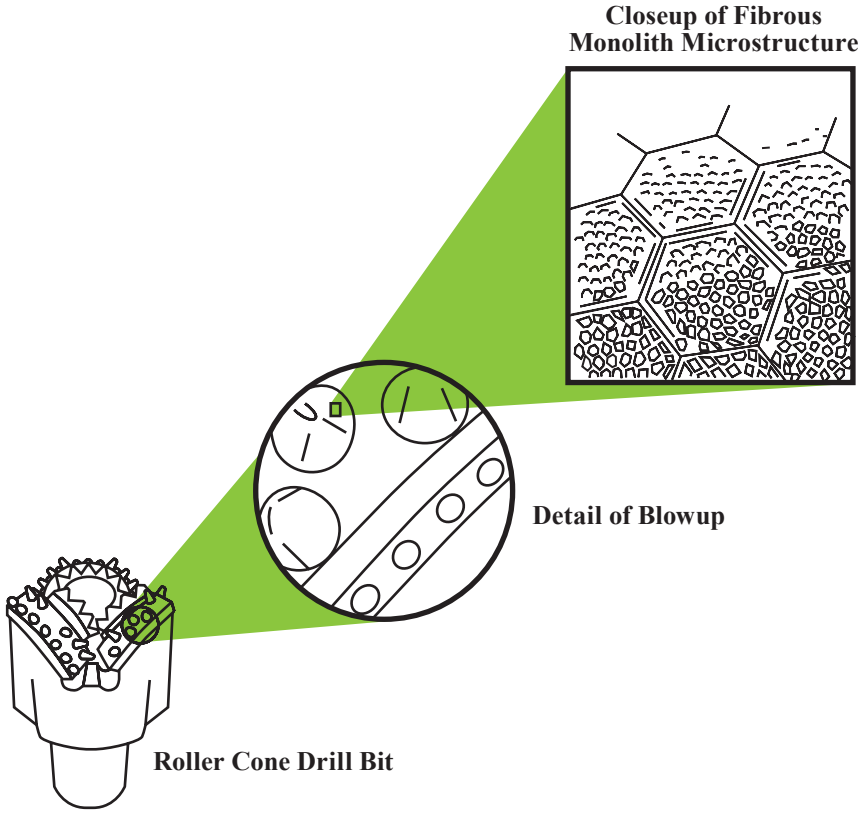
Fibrous Monoliths as Wear-Resistant Components

IMPACTS

New Composite Material Improves the Cost/Performance Ratio of Drill Bits

Advanced Ceramics Research (ACR) led a collaborative effort of component manufacturers, end users, a national laboratory, and universities to develop fibrous monoliths (FMs) for mining applications. ACR licensed the technology to Smith Bits of Houston, Texas, one of the world's largest oil and drill bit manufacturers. Smith Bits demonstrated nearly a 3 to 1 oil drilling performance increase using FM technology compared with state-of-the-art diamond-coated drill bits. ACR also started a joint commercialization program with Kyocera Corporation to apply FM technology to industrial cutting tools.

Smith Bits uses the FM composites in Cellular Diamond™ inserts for drilling and high-impact applications. FMs are produced using a simple process in which sets of inexpensive, thermodynamically compatible ceramic and/or metal powders are blended with thermoplastic polymer binders and then co-extruded to form a green fiber. The green composite fiber is extruded and thermoformed into the shape of the desired component, pyrolyzed to remove the polymer binder, and consolidated at ultra-high pressure and temperature to obtain the final FM product. The new FM manufacturing process produces ultra-hard inserts for roller cone bits.



Roller Cone Drill Bit with Fibrous Monolith Inserts

Overview

- Collaboratively developed by a national laboratory, universities, and private companies led by Advanced Ceramics Research, Inc.
- Currently licensed to Smith Bits, a subsidiary of Schlumberger, Ltd., for use on drill bits (http://slb.com)

Applications

Can be used for wear-resistant components for drilling

Capabilities

Offers very high fracture energies, damage tolerance, and graceful failure.

Benefits

Energy Savings

Reduces energy consumption by more efficient use of the drill machinery and less downtime.

Productivity

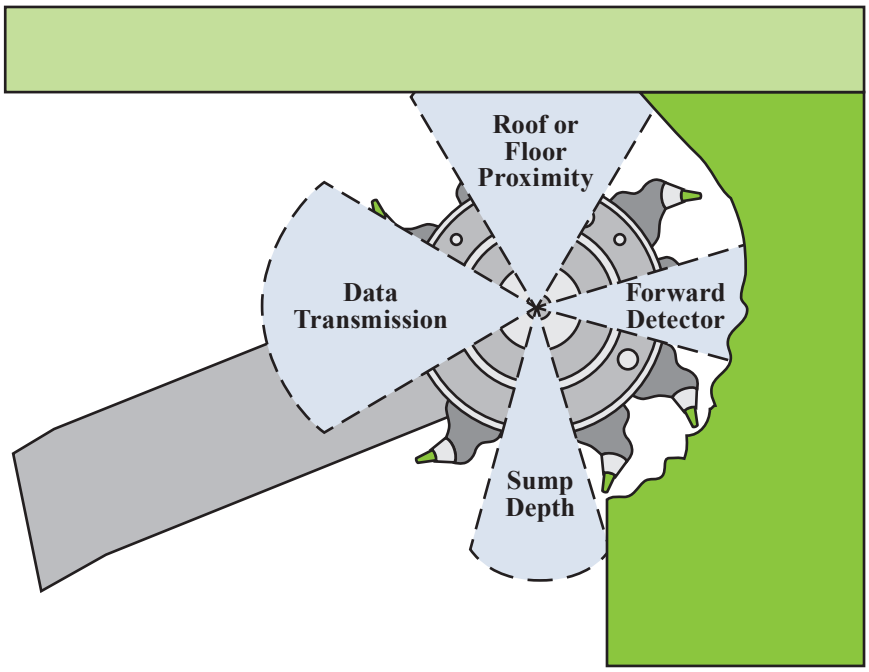
Increases the cost/performance ratio of wear materials and components and increases employee output.

Horizon Sensor™

Remote Sensing Cuts Coal and Other Minerals More Efficiently

Future mining will be from deeper and thinner seams; profiles of deep coal seams reveal multiple levels of coal and sediment strata or layers. Some of these layers contain greater levels of pollutants than others, which results in more effort to clean the coal once it is removed from the ground and more emissions when it is burned for fuel.

With the aid of ITP, Stolar Horizon, Inc., developed the Horizon Sensor to distinguish between the different layers of coal. Miners can use this technology at remote locations to cut only the clean coal, resulting in a much more efficient overall process. The sensor, located inches from the cutting bits, is based on the physics principle of resonant microstrip patch antenna (RMPA). When it is in proximity of the rock-coal interface, the RMPA impedance varies depending on the thickness of uncut coal. The impedance is measured by the computer-controlled electronics and then is sent by radio waves to the mining machine. The worker at the machine can read the data via a graphical user interface, which displays a color-coded image of the coal being cut, and can direct the machine appropriately.



Functions Performed by the Horizon Sensor Mounted on the Cutting Edge of a Continuous Mining Machine

Overview

- Developed by Stolar Horizon, Inc. (www.stolarhorizon.com)
- Commercialized in 2002
- Used in 10 different U.S. mines

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.251	0.000

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.0	0.0

Applications

Can be used in both underground and surface mining operations. Primarily used in the coal industry but is also used to mine trona and potash.

Capabilities

- Improves the quality of coal extracted from mines.
- Allows for deeper mining.
- Is used remotely for miner safety.

Benefits

Productivity

Increases productivity by reducing or eliminating the cleaning step after extraction. Allows for deeper mining, resulting in more material obtained from one location and results in longer bit life keeping the cutting bits out of rock.

Safety

Allows workers to operate the machinery away from the hazards of cutting coal, including noise, dust and gases, and coal and rock splintering and outbursts.

IMPACTS

Radio-Imaging Method (RIM™) Improves Mine Planning and Products

Coal mining is becoming more difficult as machines must extract the coal from deeper, thinner, and more geologically complex coal beds. This type of mining also includes the need to reduce risk and costs.

To address these mining issues, Stolar Horizon, with support from ITP, redesigned and improved a technology developed twenty years ago. The Radio-Imaging Method (RIM) uses wireless synchronization between a transmitter and remote imaging receiver to detect geologic formations up to 1,800 feet ahead.

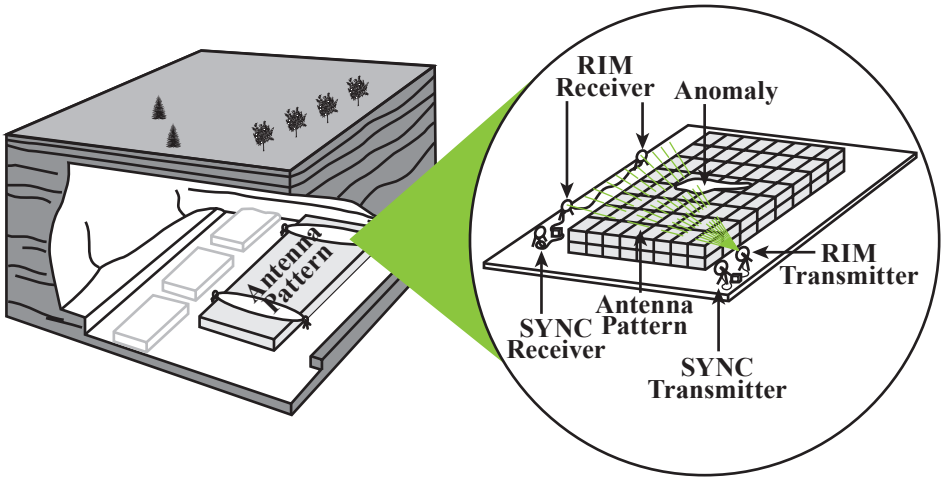
In layered sedimentary geology, a natural coal seam waveguide occurs because of the 10:1 contrast in conductivities between coal and surrounding materials. The electromagnetic wave sent by RIM through the rock reacts to these properties with a detectable change in magnitude because it is very sensitive to changes in the waveguide geology.

The information from RIM can be used to produce an image that maps out the dikes, faults, and paleochannels for more targeted mining. Areas of high signal loss represent geologic anomalies and can be imaged to high resolution using tomographic reconstructions similar to CAT scans.

Benefits

Productivity and Profitability

Reduces the risk of interrupting production because of adverse geologic conditions. When RIM is integrated into the planning of underground mining, forecasting production can improve 10 percent, which in turn increases profits.



In-Mine RIM Detection System

Overview

- Developed by Stolar Horizon, Inc. (www.stolarhorizon.com)
- Commercialized in 2002
- Used in over 20 different mines in the United States through 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
7.14	0.351

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.002	0.076	0.057	6.90

Applications

Can be used in both underground and surface mining operations. Primarily used in the coal industry but has also been used for metalliferous mining, environmental research, and civil engineering applications. Also has been used to confirm the location of old and abandoned mine works and the integrity of barrier pillars.

Capabilities

- Detects ore seams and geologic anomalies.
- Delineates ore bodies, monitors heap leaches, and detects voids in coal seams.
- Detects voids and confirms geologic anomalies.

Lower-pH Copper Flotation Reagent System

New Reagent System Improves Recovery, Reducing Energy Use and Air Emissions in the Mining Industry

In the mining industry, flotation is a process that concentrates minerals from their ores prior to metal recovery. Current practice uses slurry pHs in excess of 10, achieved by adding burnt lime (CaO). However, lime production is an energy-intensive process that releases large quantities of carbon dioxide into the atmosphere. Furthermore, lime has several undesirable properties once it is in the flotation circuit. Lime produces scaling in piping and equipment, requiring the use of descaling reagents. It flocculates fine material and may occlude fine copper-sulfide particles. Lime increases the viscosity of the mineral slurry and tends to hinder aeration, slowing flotation kinetics. In addition, the calcium ion also has been shown to decrease recoveries of lead and molybdenum-sulfides and to reduce the recovery of free gold.

A new reagent system, developed by Versitech, Inc., with assistance from DOE's Inventions and Innovation Program, recovers copper minerals at a much lower pH than conventional reagents and avoids floating pyrite. The process reduces or even eliminates both the lime used in copper flotation and the accompanying carbon dioxide. The result is immediate cost, energy, and environmental savings along with improved recovery of copper and other minerals.

Benefits

Cost Savings

Reduces annual operating costs in a 50,000 ton per day plant by $1.3 million.

Productivity

Improves mineral recovery in the mill flotation processes and decreases the amount of waste rock.

Overview

- Developed by Versitech, Inc.
- Commercialized in 2005

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
4.87	0.973

U.S. Emissions Reductions

(Thousand Tons, 2009)

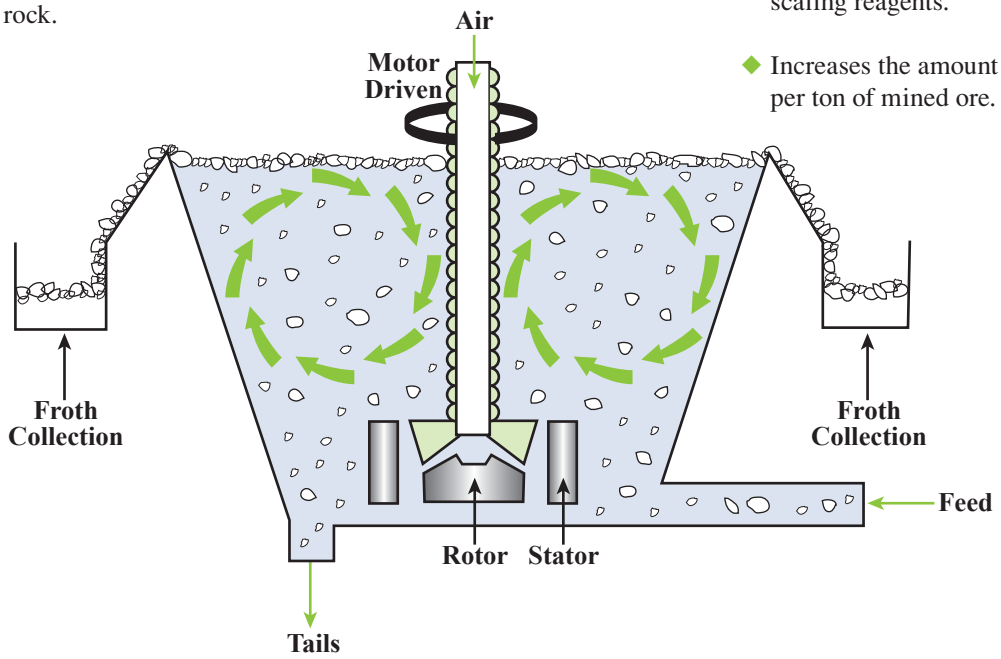
Particulates	SO_x	NO_x	Carbon
0.004	0.210	0.157	19.1

Applications

Can be used in mining processes using a lime additive in the separation process

Capabilities

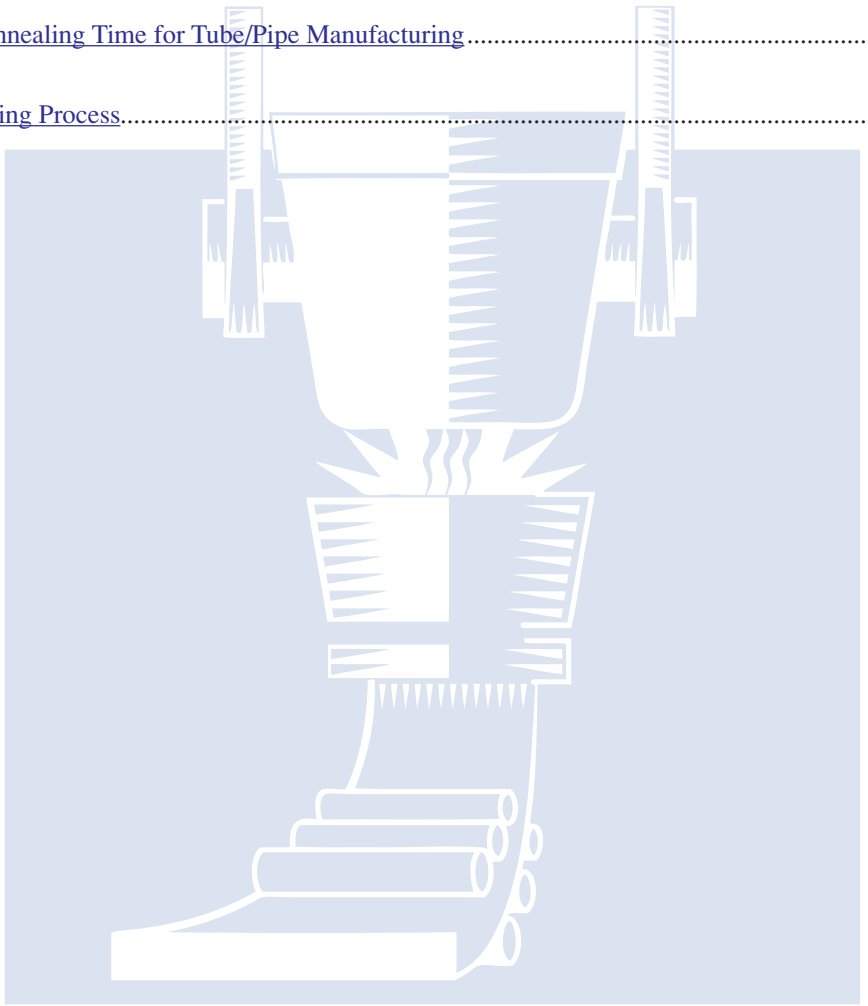
- Reduces or eliminates lime and de-scaling reagents.
- Increases the amount of copper recovered per ton of mined ore.



Copper Flotation Reagent System

Steel

IMPACTS



Aluminum Bronze Alloys to Improve Furnace Component Life

Improved System Increases Steelmaking Furnace Efficiency, Safety, and Productivity

Hoods, roofs, and sidewall systems in basic oxygen furnaces (BOFs) and electric arc furnaces (EAFs) enable effluent gases in excess of 3000°F to be properly captured, cooled, and processed prior to delivery to the environmental control equipment. Traditionally, these carbon steel components have been considered standard "repair and replace" items by the industry. During the steelmaking process, large amounts of waste heat, particulates, and waste gases are generated in the furnace. The interaction of these waste streams with the carbon steel components of the furnace can result in metal failure from erosion, corrosion, and thermal stress cracking.

With ITP support, the Energy Industries of Ohio, Oak Ridge National Laboratory, Republic Engineered Products, and Amerifab, Inc., developed and installed several components of a BOF with aluminum bronze alloy material. Replacing carbon steel components with those manufactured from aluminum bronze alloy reduces metal failure, increases productivity, improves operating safety, and reduces energy consumption in the steel making process. Additionally, slag from the steel making process does not adhere to the aluminum bronze alloy, which eliminates all cleaning time, equipment damage, and operational difficulties associated with the accumulation of slag on the skirt.

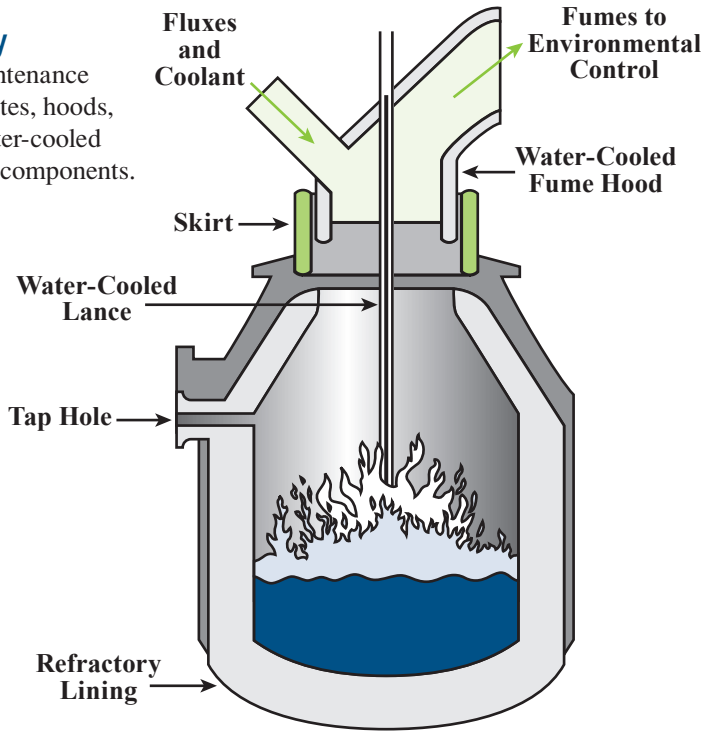
Benefits

Environmental

Reduces chance of air permit violations associated with improper skirt positioning in suppressed combustion furnaces, thereby optimizing primary capture of vessel emissions.

Productivity

Reduces maintenance on skirts, chutes, hoods, and other water-cooled steel furnace components.



Basic Oxygen Furnace Components

Overview

- Developed by AmeriFab, Inc., in 2002 (www.amerifabinc.com)
- Commercialized in 2004
- Components being used on five furnaces in Ohio and Illinois

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.074	0.010

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.001	0.162

Applications

Can be used for BOF/EAF hood, roof, and side wall systems that are exposed to aggressive heat, particulate, and corrosive waste gas from the steelmaking process

Capabilities

- Provides superior performance compared with industry standard carbon, chrome-moly, and weld overlayed steels.
- Improves production throughput and limits energy consumption by reducing forced outages and downtime due to thermal fatigue, particulate erosion, and chemical corrosion.
- Reduces issues related to slag buildup.

Automated Steel Cleanliness Analysis Tool (ASCAT)

IMPACTS

New Microscopy System Improves Steel Mill Performance and Allows Production of Higher Quality Steel

Inclusions are particles of insoluble impurities formed during steelmaking and casting operations that are entrapped during solidification of metal. Characterizing inclusions is important because of an increasing demand for cleaner steels with low inclusion (defect) content. The composition, and therefore the properties, of the inclusions can be controlled through the chemistries of the metal and slag. Controlling the properties of the inclusions allows higher quality steel to be made. However, despite the major advances in inclusion control, no rapid and accurate method is available to determine the type, size, and number of inclusions present in steel samples.

RJ Lee Group, Inc., with ITP and steel industry support, has developed the ASCAT, an inclusion analysis tool based on a highly capable scanning electron microscope combined with specially developed hardware and software. The ASCAT provides a way to understand the complicated effects of inclusions in the steel making process and on the resulting properties of steel. The instrument uses an innovative state-of-the art silicon drift detector to acquire x-ray composition information that is about an order of magnitude faster than previously used equipment. The ultimate goal is to develop the system so that analysis time is reduced to 10-15 minutes, which would enable the ASCAT to be used as an "on-line" analysis tool. The ASCAT uses "intelligent" software to emulate specialized knowledge that can be used to evaluate causes of clogging/erosion, slag treatment practices, castability, degasser circulation optimization, and slab disposition. One ASCAT system is now in use at the U.S. Steel Munhall Research and Technology Center.

Benefits

Energy Savings

Improves energy efficiency by minimizing steel rejection and subsequent remelting of the rejected steel.

Productivity

Increases production and reduces downgrades, with significant cost savings.

Product Quality

Allows for the increased production of high-grade steels and alloys.

Overview

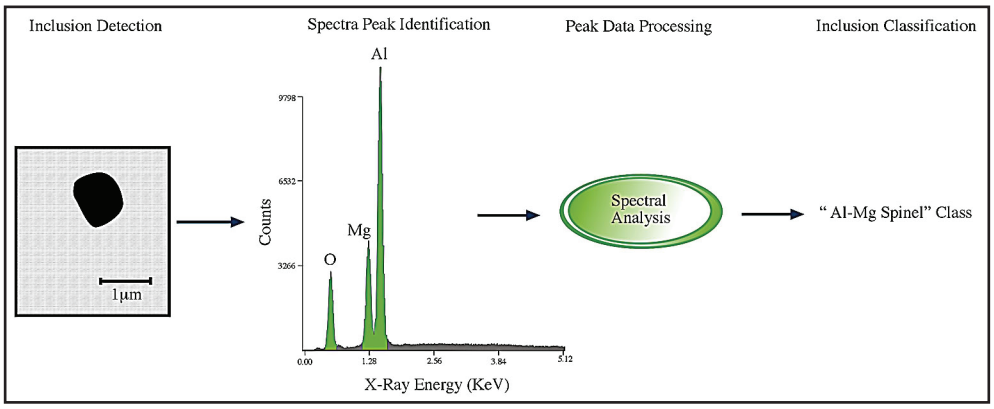
- Developed and being marketed by the RJ Lee Group, Inc. (www.rjlg.com)
- Commercialized in 2007
- Employed at the U. S. Steel Munhall Research and Technology Center

Applications

Can be used in the steel manufacturing process, including in castability of calcium treated steel; interstitial free degasser grade slag conditioning practice; tundish clogging and erosion minimization; degasser circulation and optimization; quality assessment/steel cleanliness; slab, billet, or bloom disposition; and alloy development.

Capabilities

- Collects statistically meaningful data on inclusions in a steel sample and addresses a market need to monitor the effects of inclusions in the steel making process.
- Uses fast inclusion identification software with advanced statistical algorithms to automatically sort inclusions into meaningful classifications.
- Provides intuitive graphics-based output, which can be integrated to plant control rooms and computer databases.



Classification of Steel Inclusions Using ASCAT

Electrochemical Dezincing of Steel Scrap

Dezincing of Steel Scrap Reduces Concerns of Recyclability and Waste Streams

Half of the steel produced in the United States is derived from scrap. With zinc-coated prompt scrap increasing fivefold since 1980, steelmakers are feeling the effect of increased contaminant loads on their operations. The greatest concerns are the cost of treatment before disposal of waste dusts and the water associated with remelting zinc-coated scrap.

With financial assistance from ITP, Argonne National Laboratory with Metal Recovery Technologies, Inc., and CMA Corporation (formerly Meretec Corporation) have developed a technology that separates steel scrap into dezinced steel scrap and metallic zinc. The removal of zinc from steel scrap increases the recyclability of the underlying steel, decreases steelmaking dust, and decreases zinc in wastewater streams.

The process consists of two stages: dissolving the zinc coating from scrap in a hot, caustic solution and recovering the zinc from the solution electrolytically. Through a galvanic process, the zinc is removed from the steel and is in solution as sodium zincate ions rather than zinc dust. The steel is then rinsed with water and ready for reuse. Impurities are removed from the zinc solution, and then a voltage is applied in order to grow metallic zinc via an oxidation-reduction reaction. All waste streams in this process are reused.

Benefits

Pollution Reduction

Decreases steelmaking dust released to the air as well as pollutants in wastewater streams. The process itself does not consume any chemicals, other than drag-out losses, and produces only a small amount of waste.

Productivity

Removing zinc prior to processing of scrap saves time and money in disposal of waste dusts and water. Without the zinc, this high-quality scrap does not require extra handling, blending, or sorting for remelting in steelmaking furnaces.

Overview

- Developed by Argonne National Laboratory
- Commercialized in 2003 by Meretec Corporation (now CMA Corporation) (www.cmacorp.net)
- Steel scrap sold to several dealers, steelmakers, and foundries after dezincing

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.370	0.087

U.S. Emissions Reductions

(Thousand Tons, 2009)

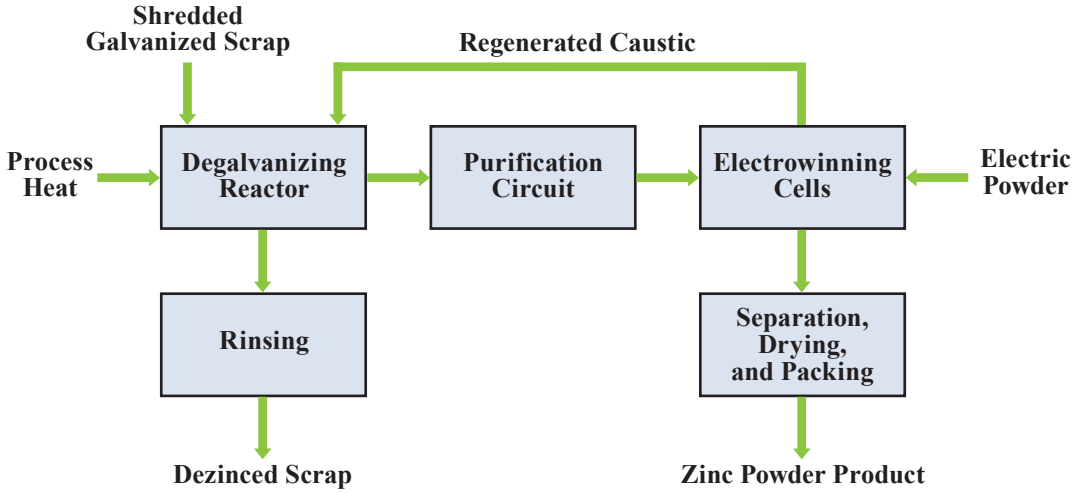
Particulates	SO_x	NO_x	Carbon
0.001	0.055	0.024	2.44

Applications

Can be used primarily in the steel and foundry industries

Capabilities

- Improves quality of steel scrap that steelmakers can use.
- Produces 99.8% pure zinc for resale.



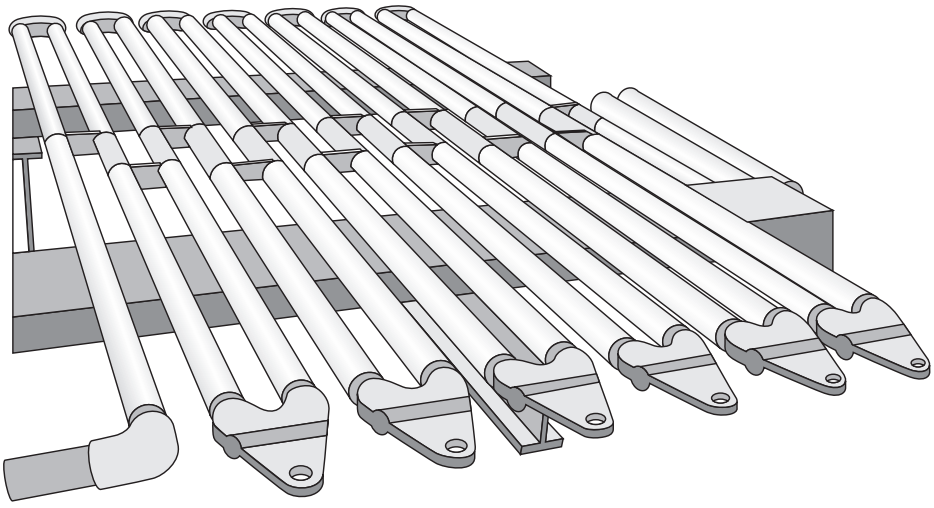
Electrochemical Dezincing of Galvanized Steel Scrap

IMPACTS

Scientific Design Methodology Used to Develop Stronger Stainless Steels for High-Temperature Applications

Cast H-Series austenitic steels are used extensively in several industries for a broad range of high-temperature applications. The H-Series stainless steels have evolved over many years of complex alloy development that added various alloying elements by trial-and-error methods. The native microstructure established in these austenitic alloys consists of dendritic structures of austenite matrix with finer dispersions of carbides. With the support of a grant from ITP, a combination of thermodynamic modeling, developed at the Oak Ridge National Laboratory, micro-structural characterization, and mechanical property measurements was used to derive composition-structure-property relationships for this class of alloys. With these relationships, Duraloy Technologies, Inc., successfully developed new alloy compositions with improved properties at higher temperatures.

The combined approach of micro-characterization of phases and computational phase prediction permits rapid improvement of a current class of alloy compositions and allows alloys to be customized across steel grades for specific applications. The results of this work increased the high-temperature creep strength and the upper-use temperature range of H-Series stainless steel material, including HP and HK alloys. Application of these new products is best suited to radiant burner tubes for annealing furnaces in the steel heat treating industry, tubes for the chemical industry, and transfer rolls and kilns for various high-temperature furnace operations. Other applications in other industries would apply where high-temperature operations are required.



Chemical Processing Coils Composed of H-Series Stainless Steel

Overview

- Developed by Duraloy Technologies, Inc. (www.duraloy.com)
- Commercialized in 2003
- As of 2009, 197 U.S. applications were operating in 10 processing plants

Applications

Can be used in the chemicals, forest products, heat treating, petrochemical, and steel industries, including burner tubes for heat-treating furnaces, transfer rolls for heat-treating furnaces, coiler drums and rolls for Steckel mills, and tubes for ethylene cracking and other processes

Capabilities

- Offers superior toughness over standard H-series steel.
- Applies to multiple heating processes.

Benefits

Energy Savings

Could save an estimated 35 trillion Btu/year and $185M/year by 2020.

Productivity

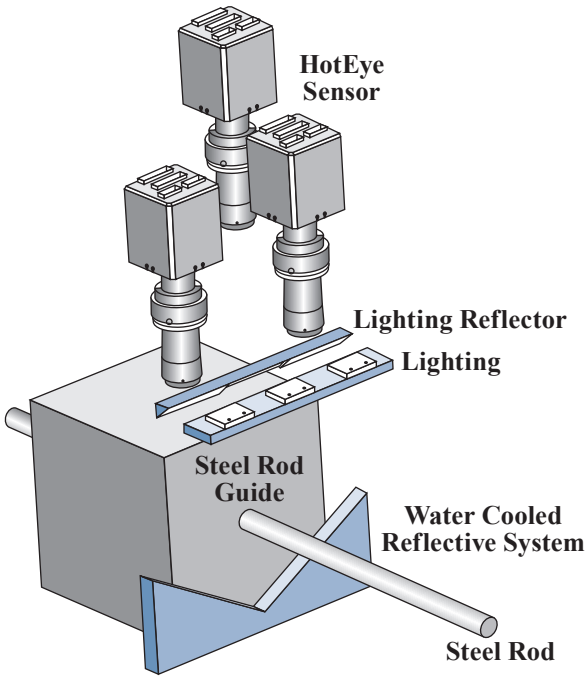
Improved process efficiencies from higher operating temperatures reduces downtime of the production equipment, reduces replacement of components, and increases productivity with reduced rejection.

HotEye® Steel Surface Inspection System

Unique Measurement System Enhances Process Control, Cuts Scrap by Half, and Saves Energy

A new inspection system, the HotEye® Rolled Steel Bar (RSB) System, has been developed and demonstrated by OG Technologies (OGT) Inc., with the help of both a NICE[3] grant and a project under the ITP Sensors and Automation Program. The HotEye RSB System is based on OGT's HotEye System and integrates it with a dynamic control plan (DCP) for hot steel processes. The HotEye System accurately and reliably measures a part's dimensions and detects its surface features, including defects, while it is still red hot, i.e., at temperatures of up to 1550°C. Current measurement systems cannot be used until the parts cool down, which results in higher scrap rates once defects are detected. The DCP classifies some defects from production and identifies their root causes and corrective actions. The DCP's effectiveness depends on instruments that can detect quantitative quality information in real-time in a hostile operating environment. The HotEye RSB System provides real-time process control to increase yields 2.5% in continuous casting and hot rolling steel mills, saving energy, improving quality, and increasing productivity.

The HotEye RSB System consists of three HotEye imaging sensors, four powerful PCs, modulating devices for the lighting system, proprietary image processing software, the software version of the steel rolling DCP, and an enclosure to protect the hardware and software from the effects of the harsh operating environment in a steel mill. The HotEye RSB System will automatically (1) inspect 100% of the surface of the product in-line; (2) identify defects as small as 0.025 mm; (3) analyze and record the size, nature, and location of the defects; (4) measure 100% of the dimensions of the product; and (5) generate process correction advice based on the DCP, while the product is at a temperature up to 1550°C and moving at a speed up to 100 m/second.



Design of the HotEye RSB Sensor System

Overview

- Developed by OG Technologies, Inc. (www.ogtechnologies.com)
- Commercialized in 2004
- Installed in five U.S. and multiple foreign steel mills in 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
8.29	0.00

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.0	0.0

Applications

Can be used in steel hot rolling mills and continued casting processes

Capabilities

- Inspects 100% of product surface on-line.
- Identifies defects as small as 0.025 mm.
- Performs inspections while the product is at temperatures of up to 1550°C and moving at 100 m/second.

Benefits

Employee Safety

Allows the inspection of parts at temperatures of up to 1550°C remotely, reducing employee burns.

Profitability and Productivity

Detects and identifies production flaws quickly and reduces the scrap rate from the process by 50%.

Laser Contouring System for Refractory Lining Measurements

IMPACTS

Optical Sensor Provides Real-Time Process Control, Resulting in Reduced Costs and Improved Performance

A suite of new robust sensors and control systems for base oxygen furnace (BOF) and molten steel transfer ladles makes possible dynamic process control and rapid assessment of the effectiveness of operations. With ITP support, Process Metrix and the American Iron and Steel Institute developed the Laser Contouring System (LCS) now being sold by Process Metrix. The LCS is a high-speed, laser-based technology that measures the refractory lining thickness of furnace vessels for manufacturing steel, copper, and aluminum. With a laser scan rate of over 8,000 points per second, the LCS provides exceptionally detailed contour resolution and accurate bath height determination. Moreover, measurement time ranges between 1 to 6 minutes or ten times faster than prior units. Quick on-line feedback eliminates downtime costs due to off-line inspection and unnecessary relining, increases equipment life, and ensures operational safety.

Contour maps of both vessel wall and bottom clearly illustrate lining thickness over the entire vessel interior. Thickness values are displayed both numerically and by color key, immediately revealing regions that might require attention. The report generator automatically prints all of the views and screens needed by the mill to make informed process decisions. New software releases, that include upgrades and feature requests from customers, are made twice annually.

Two principle objectives are emphasized in the mobile platform design: speed and simplicity. Fast measurement times are achieved using a laser-based navigation system. Working from three reflectors mounted on the building structure behind the cart, this system automatically measures the cart position relative to the BOF and reports position information directly to the LCS computer. The navigation system is completely automatic and updates 8 times per second. Process Metrix has also implemented a radio frequency (RF) link that continuously broadcasts the vessel tilt to a receiver located in the cart. The RF-link incorporates 2.4 gigahertz spread-spectrum technology for interference-free transmission. During the measurement, the RF receiver automatically reports the vessel tilt to the LCS computer. Together, the laser navigation system and RF link enable fast, error-free measurement of the vessel lining thickness. Single measurements can be made in 20-30 seconds. An entire map of the vessel interior, consisting of 4-6 measurements and 500,000+ data points, can be completed in less than 6 minutes.

Fixed position installation is available for converter and ladle applications. This type of installation, coupled with the high measurement speed of the LCS, enables measurements after every heat with little or no loss of process time.

Overview

- Commercialized in 2001 by Process Metrix (www.processmetrix.com)
- Nine units in operation at seven U.S. installations in 2009 and additional units in use overseas

Applications

Can be used for rapid measurements of vessel wall and bottom lining thickness in steel converters, ladles, electric arc furnaces, copper smelters – in short, any refractory-lined vessel that has line-of-sight optical access

Capabilities

- Is available as a mobile platform or a fixed position installation.
- Maps the entire vessel interior in less than 6 minutes.
- Provides detailed contour resolution and vessel lining thickness with over 500,000 individual contour measurements.

Benefits

Cost Savings

Saves up to $1 million per year for manufacturers.

Energy Savings

Reduces energy usage via rapid real-time measurements for process control and with no loss of process time.

Productivity

Reduces maintenance on BOF refractory via automated furnace inspection.

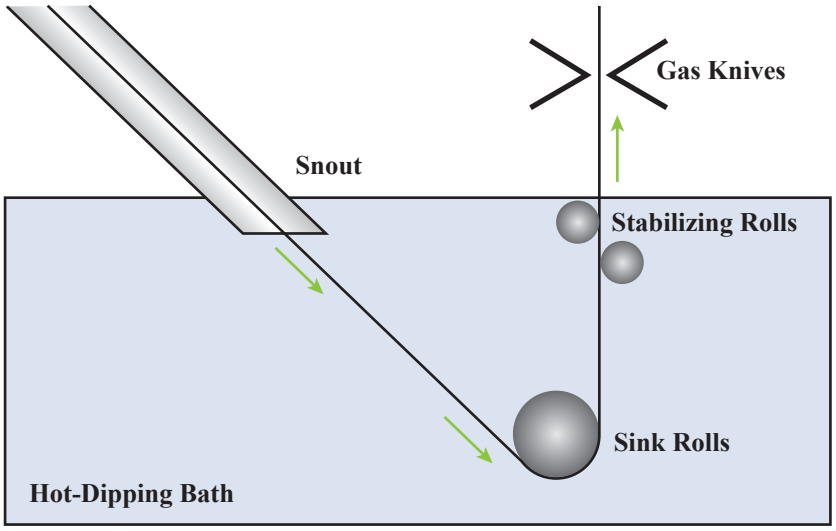
Life Improvement of Pot Hardware in Continuous Hot Dipping Processes

Improved Galvanizing Bath Hardware and Materials Result in Energy and Cost Savings

Flat-rolled surface-coated steel, including galvanized and aluminized sheet, is one of the fastest growing, most profitable sectors of the U.S. steel industry. Coating steel sheets by continuous hot dipping in a molten metal bath of zinc and aluminum is an efficient and economical method of protecting most steel sheet compositions from corrosion. However, corrosion, wear, and dross buildup on bath hardware such as bearings, sink rolls, and stabilizing rolls can lead to frequent downtime of production lines and can significantly reduce energy efficiency.

West Virginia University, with support from ITP and numerous private sectors partners, developed a new generation of bath hardware components. The components are made with several entirely new materials, such as an iron-aluminum-cobalt alloy, which provide 10 times the corrosion and wear resistance in the Zn/Al bath compared with baseline materials. The advanced bath hardware materials provide longer life in the corrosive galvanizing bath by minimizing crystal growth, corrosion attack, and bearing surface degradation, all of which can lead to surface impurities on the final product, lowering the market value of the finished galvanized steel.

Delivering new roll and bearing designs, along with bath hardware materials developed with these new alloys, has extended component life by an order of magnitude, while remaining cost effective at only 10% to 15% higher than comparable components.



Steel Sheet Manufacturing Process

Overview

- Developed by West Virginia University in partnership with numerous steel manufacturing support companies
- Commercialized in 2006 by Pyrotek, Inc. (www.pyrotek-inc.com)

Applications

Can be used to improve the life of pot hardware, which applies to the 57 continuous hot dipping process lines in the U.S.

Capabilities

- Provides up to 10 times the corrosion and wear resistance compared with baseline materials.
- Reduces the potential for bearing instability due to improved hardware alloys.
- Improves surface characteristics of sheet steel from reduced dross formation.

Benefits

Cost Savings

Reduces waste and process scrap volume by limiting the frequency of downtime in the galvanizing process.

Environmental

Reduces emissions from sheet steel manufacturing plants.

Productivity

Limits the formation of surface imperfections on the finished sheet steel.

Low-Temperature Colossal Supersaturation of Stainless Steels

IMPACTS

New Process Improves Hardness and Corrosion Resistance of Stainless Steel Components

Austenitic stainless steels in the 300 Series are the primary materials used for a very broad range of applications when corrosion resistance is needed in aqueous solutions at ambient temperatures. While austenitic stainless steels have excellent corrosion-resistance properties, they possess low hardness values and cannot be heat-treated to increase their hardness. In materials science, it has been generally understood that carbon atoms cannot be introduced into austenitic stainless steel through heat treatment without the formation of chromium carbides, which compromise the corrosion-resistant properties of the alloy. Until now, hardness and corrosion resistance have been typically regarded as tradeoffs.

With assistance from ITP and the Ohio Department of Development, Swagelok Company contributed to research using its patented heat treating process known as low-temperature colossal supersaturation (LTCSS). This process dramatically improves surface hardness without losing corrosion resistance. By contrast, the traditional methods of heat treating stainless steel promote the formation of chromium carbides that compromise the corrosion-resistant properties of the alloy. LTCSS introduces carbon atoms into the austenitic, or face-centered-cubic, crystal structure without the formation of chromium carbides. Testing has shown the carbon absorption to be about 80,000 times greater than thermodynamics and kinetics would suggest being possible. At the same time, there is evidence of improved corrosion resistance, wear resistance, and increased fatigue strength.

Swagelok Company launched their LTCSS business by forming a subsidiary, Swagelok Technology Services Co., to treat steel parts supplied by their customers. Swagelok is pursuing individual licensing of the technology.

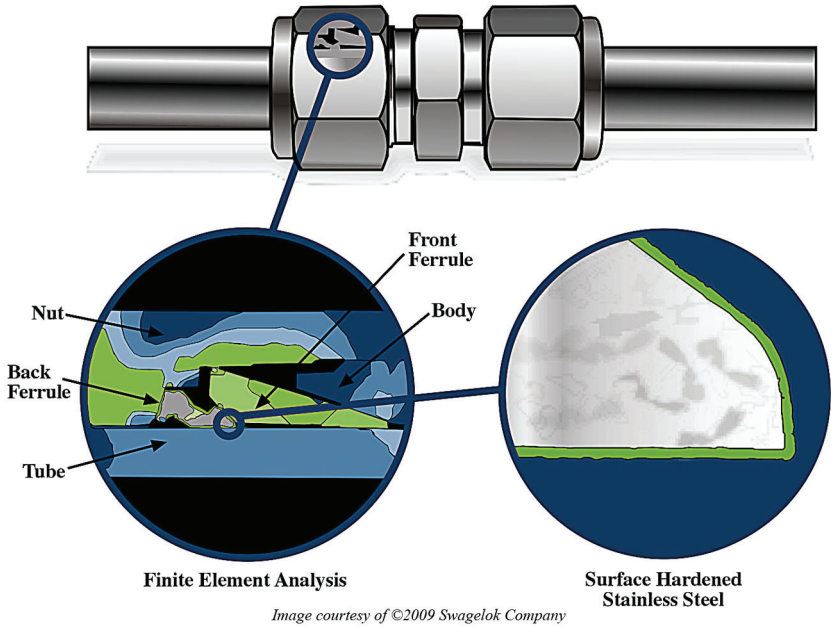


Image courtesy of ©2009 Swagelok Company

An Application of Swagelok's LTCSS to Tube Fittings

Overview

- Developed by Swagelok Company (www.swagelok.com)
- Research performed in conjunction with Case Western University, Energy Industries of Ohio, Oak Ridge National Laboratory, and Spirax Sarco, Inc.
- Used by Swagelok since 1999 and commercialized to the public in 2007
- Used by the U.S. Naval Research Lab for treating stainless steel components

Applications

Can be used anywhere stainless steel parts are used, e.g., pump and circulation equipment, industrial components, and medical devices

Capabilities

- Imparts higher hardness to stainless steel components.
- Provides nickel-like corrosion resistance for a part that will cost less than an expensive high-nickel alloy.
- Allows sheet metal to be treated and still retain its ductility.
- Treats finished components without distortion or change of dimension.
- Avoids carbide formation.

Benefits

Durability

Increases the corrosion/erosion resistance of stainless steel components to levels previously attainable only by expensive high-nickel or high-molybdenum alloys.

Product Quality

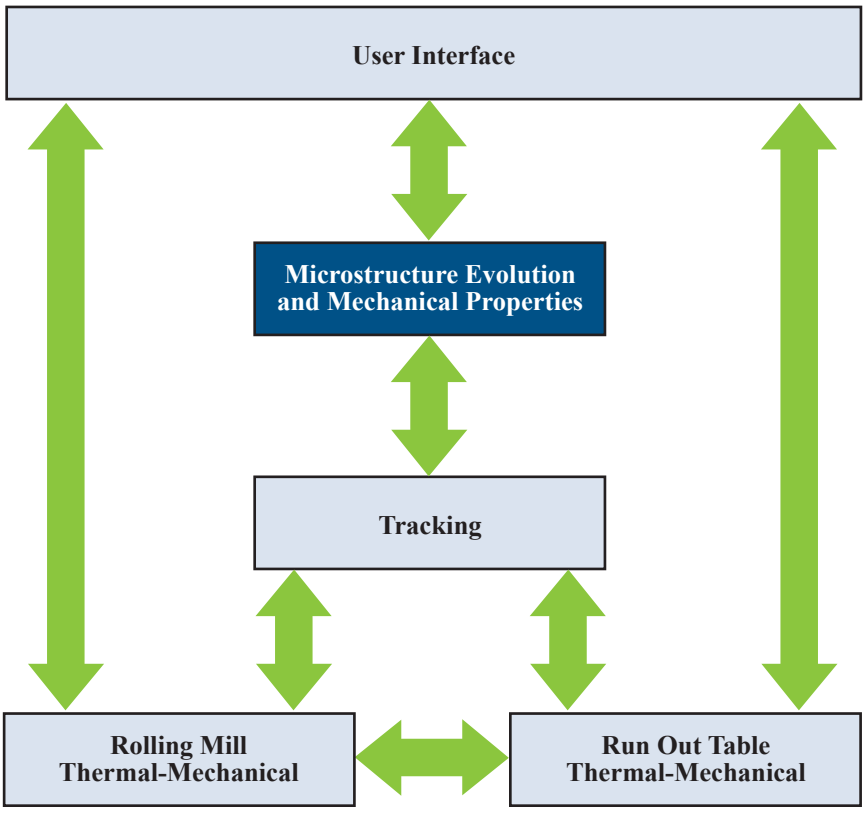
Allows ordinary stainless steels to adopt performance characteristics of more expensive alloys.

Microstructure Engineering for Hot Strip Mills

Innovative Model Provides a More Detailed Insight into Mill Operations to Reduce Costs and Improve Quality

Many hot rolled products must achieve strict strength and toughness requirements, making control of the microstructure critical. This causes these products to be difficult to make and requires many costly full production trials before the range of both chemical composition and hot strip mill processing parameters can be defined. The Hot Strip Mill Model (HSMM) is an invaluable tool to cost effectively assist in determining the optimum processing conditions to achieve the desired product properties. This model runs in an off-line mode, thereby saving many tons of wasted product that might be scrapped in trying to identify the proper mill set-up.

The HSMM also provides additional savings in grade consolidation, control optimization for new grades, and improvement of mechanical and microstructure properties for downstream processing. The model can consolidate grades by allowing the user to develop different processing setups for the same steel grade that will then achieve the various mechanical properties needed for the different finished products. The HSMM can improve on-line control optimization for new grades by using what is learned from the HSMM to help set up the on-line models so they learn faster how to optimize the processing of the new grade. And finally, processing the steel to achieve the optimum or specific microstructure attributes further improves processing of the product in downstream operations.



Components of the HSMM

Overview

- Developed by The American Iron and Steel Institute as part of its Advanced Process Control Program
- Marketed and sold by INTEG Process Group, Inc. (www.integpg.com)
- Acquired by 28 companies or universities around the world, including five U.S. steel companies

Applications

Can be used in any hot rolling mill that produces sheet or plate products (flat rolled material). The model can handle a variety of rolling mill configurations, including roughing mills, coil boxes, finishing mills, run out tables, and coilers

Capabilities

- Allows the user to easily modify the mill configuration or processing parameters to see its impact on the end results of the product being rolled (simulated).
- Can be used as a training tool, allowing operators to see the end result for different processing conditions or grades of steel.

Benefits

Competitiveness

Improves industrial competitiveness through product optimization and cost savings.

Productivity

Decreases product variability through the development of a predictive tool, which can quantitatively link the properties of hot rolled product to the operating parameters of the hot strip mills.

Shorter Spherodizing Annealing Time for Tube/Pipe Manufacturing

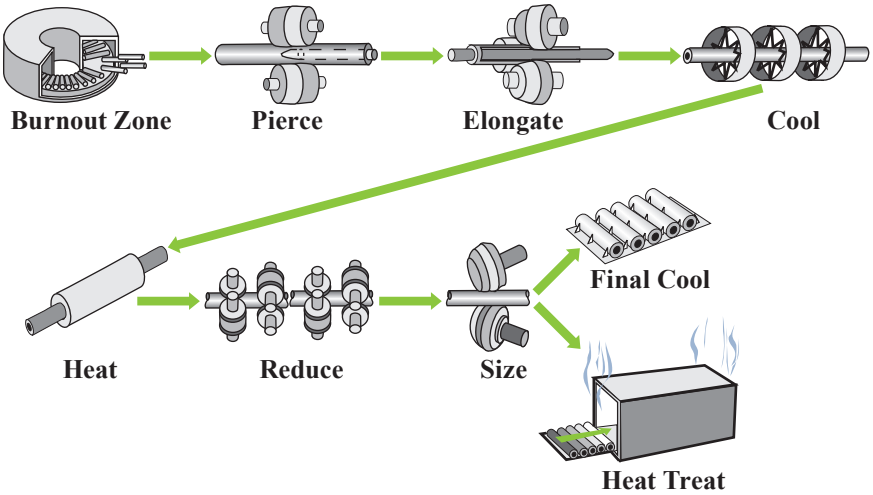
IMPACTS

New Process Results in Productivity Improvements and Energy Savings

The steel industry is working to improve the manufacturing of tubes and pipes while maintaining key steel parameters and reducing the amount of energy used in the process. The Timken Company developed an enhanced spherodized annealing cycle for through-hardened steel. This technology is a by-product of a larger ITP-sponsored project, the "Controlled Thermo-Mechanical Processing (CTMP) of Tubes and Pipes for Enhanced Manufacturing and Performance."

The spherodized annealing process changes the hard, elongated carbide particles in the steel to be spherical with a preferred diameter. The size and shape of the original elongated carbides produced by the previous hotworking process influence the ability to spherodize the carbides. The spherodized annealing process consists of heating the carbide particles to temperatures at which they form spherical shapes. This entire heating and holding cycle takes 20 to 50 hours. Various combinations of temperatures and times can be used to achieve the desired shape and distribution of the carbide spheres. In this ITP-sponsored project, experimentation was conducted to characterize the effect of the original elongated carbides and the annealing times and temperatures on the resulting spheroid size and distribution.

The experimental results helped the Timken Company shorten the annealing cycle time by 20% and condense the number of plant trials to achieve that. The result was an optimized cycle that reduced energy consumption and improved productivity while generating a quality product with the desirable metallurgical properties for forming and machining.



Tube Making Process

Overview

- Developed by The Timken Company (www.timken.com)
- Used at one U.S. steel plant in 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.138	0.008

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.001	0.133

Applications

Can be used by steel tube and pipe manufacturers and specialty metal manufacturers

Capabilities

Shortens annealing cycles and saves energy.

Benefits

Energy Savings

Reduces fuel requirements by reducing annealing cycle time by 20%.

Productivity

Increases productivity approximately 10% due to the reduced cycle time.

Product Quality

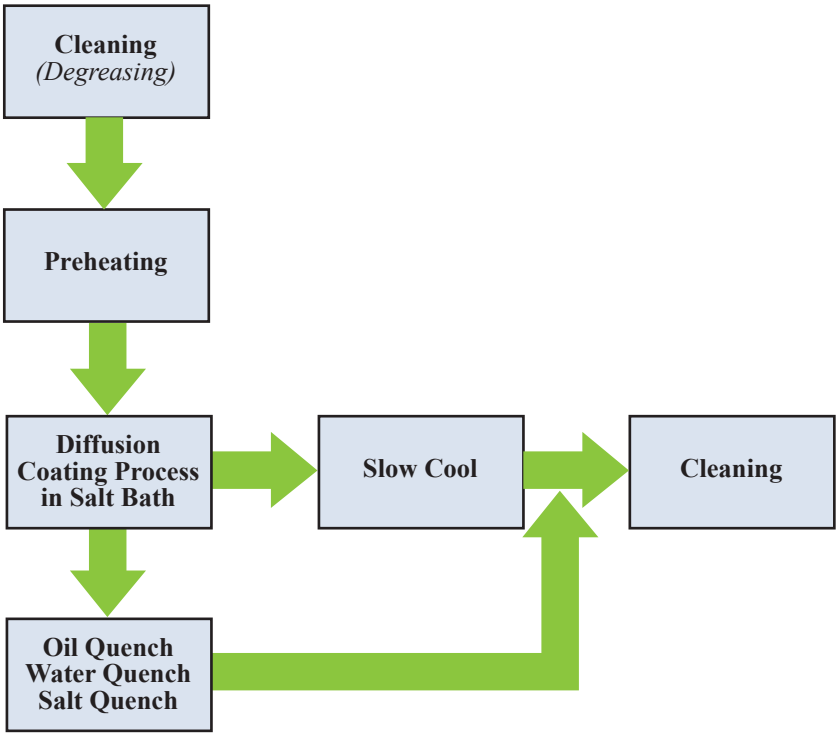
Provides the end user with steel that is easily formed and machined with the same desirable metallurgical properties.

Vanadium Carbide Coating Process

Innovative Process Enhances Wear Resistance of Metals, Saving Energy, Waste, and Costs

Traditional methods of coating steel surfaces with a layer of hard metal carbide require large capital investment, produce toxic and hazardous gases, are costly to operate, and require multiple heat-treatment steps during processing. Vanadium carbide (VC) coating technology provides a superior protective coating for steel surfaces and eliminates the need for multiple heat-treatment steps during processing, thereby eliminating harmful gas emissions.

The coating system, developed by Metlab-Potero with assistance from the NICE[3] program, is based on a thermal diffusion technology, which forms a VC surface layer that can be made up to 15 microns thick in 12 hours. Process steps include cleaning, preheating, coating, cooling, or quenching, and subsequent tempering as required. Cleaned parts are preheated and then immersed in an environmentally benign fused salt bath in an 800°C to 1200°C furnace at ambient pressure until the required coating thickness is achieved. The work piece is then removed from the furnace for quenching, slow cooling, or additional hardening and tempering. The process protects steel surfaces with a thick, well-controlled layer of VC while eliminating the need for multiple heat-treatment steps that increase energy use and the chance of production defects. Reducing the number of processing steps eliminates emissions, vacuum vessels, and the associated electrical heating system components.



Vanadium Carbide Coating Process

Overview

- Developed by Metlab-Potero (www.metlabheattreat.com)
- Commercialized in 2005

Applications

Can be used for manufactured tools and dies requiring hardened, wear-resistant surfaces

Capabilities

Increases dimensional accuracy and creates wear-resistant surfaces without multiple heat-treatment steps.

Benefits

Cost Savings

Reduces process costs by 20%.

Environmental

Reduces water usage by 20% to 50% and eliminates harmful gas emissions.

Productivity/Quality

Offers productivity gains of 10% to 30% and increases tool life 5 to 30 times compared with conventional wear-resistance methods.

Crosscutting

IMPACTS

Crosscutting

IMPACTS

Adjustable-Speed Drives for 500 to 4000 Horsepower Industrial Applications

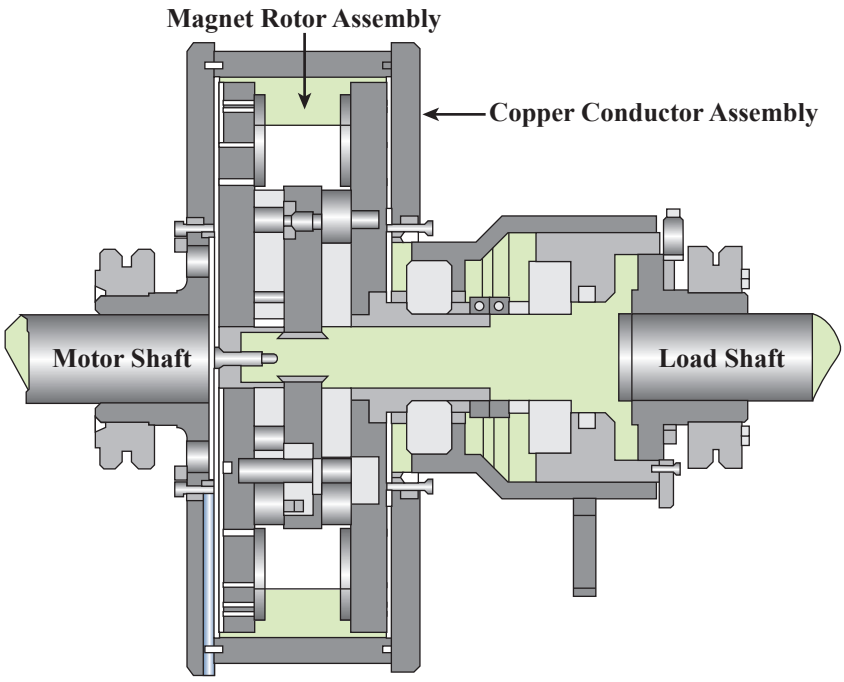
IMPACTS

New Drive System Saves Energy and Extends Variable Speed Control to Larger Motors

MagnaDrive Corporation, with assistance from the NICE^3 program and Washington State University's Cooperative Extension Energy Program, has developed a highly efficient adjustable speed drive (ASD) for various industrial applications. The MagnaDrive ASD has been successfully tested and used in industrial environments with motors up to 4,000 horsepower (hp). Over 5,000 units are currently in use in U.S. applications up to 2,500 hp, of which 72 are over 500 hp.

The ASD consists of two major components that never touch: (1) the copper conductor assembly, directly connected to the motor shaft; and (2) the magnet rotor assembly, directly connected to the load shaft. The torque is transmitted across a thin air gap that can be continuously adjusted to control the speed of the load. The actuation components are attached to the magnet rotor assembly on the load side of the ASD. Rare-earth permanent magnets are the key to the system's performance. The magnets are made of neodymium, iron, and boron (NdFeB) and retain their magnetic properties for the life of the system.

The motor is started with the ASD system in a position that places the largest air gap between the magnet rotors and the copper conductors. The motor quickly comes to full speed in an unloaded condition. The magnet rotor is then actuated to adjust the rotors closer to the conductors. As the components approach each other, eddy currents are induced, allowing a smooth transfer of torque across the air gap until the distance between the magnet rotor and the copper assembly closes to about 1/8 inch. At this point the ASD reaches its maximum efficiency of up to 99% of the torque transferred between the motor and the load.



Adjustable-Speed Drive Components

Overview

- Developed by MagnaDrive Corporation (www.magnadrive.com)
- Commercialized in 2003
- 72 large and over 5000 smaller units operating in the United States in 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
1.65	0.551

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.002	0.119	0.089	10.8

Applications

Can be used in motor driven pumps, fans, blowers, and other processing/manufacturing equipment used in industry

Capabilities

- Transfers torque from motors to driven equipment across an air gap without shaft-to-shaft physical connection.
- Permits speed control by varying the air gap spacing, thereby controlling the amount of torque transmitted.
- Eliminates the transmission of vibration across the drive due to the air gap configuration.

Benefits

Productivity

Eliminates vibration, reduces noise, tolerates misalignment, provides overload protection, extends motor and equipment life, and reduces overall maintenance and operations costs.

Product Quality

Improves product quality and optimizes process rates.

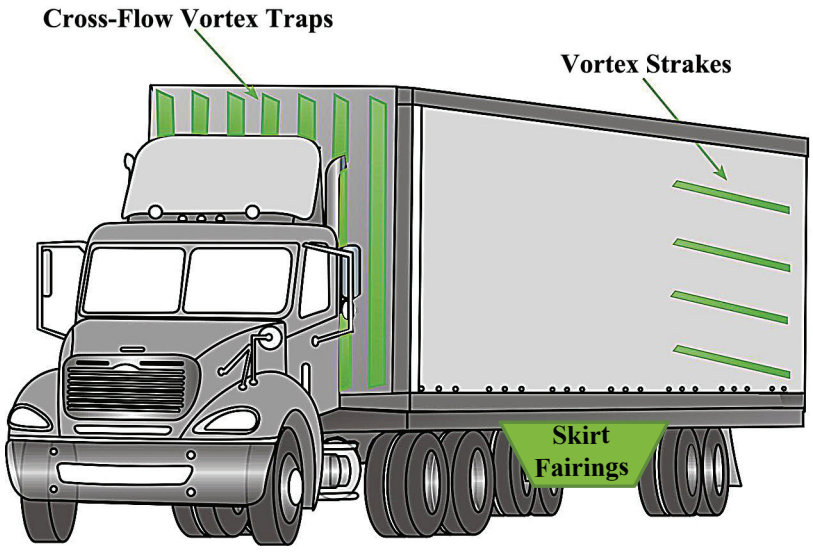
Advanced Aerodynamic Technologies for Improving Fuel Economy in Ground Vehicles

Low-Cost Aerodynamic Drag Reduction Devices for Tractor-Trailer Trucks Reduce Fuel Consumption

Heavy vehicles lose a tremendous amount of energy from wind resistance, braking, and rolling resistance. Such non-engine losses can account for about a 45% decrease in efficiency. The need for technologies to reduce these parasitic losses has gained significant attention as fuel costs have increased. The 21st Century Truck Program, an industry-government collaboration, has established an aerodynamic drag reduction goal of 20% for Class 8 tractor-trailer combinations.

With assistance from DOE's Inventions and Innovation Program, SOLUS Solutions and Technologies LLC has developed several low-cost aerodynamic devices that reduce drag and improve fuel economy for tractor-trailer trucks. In 2007 Silver Eagle Manufacturing Company began to produce and sell the SOLUS drag reduction devices. Wind tunnel and on-road testing demonstrated that these devices can provide a combined fuel savings of about 10% at 60 mph. The expected fuel savings from the inventions for an average tractor-trailer truck will exceed 2,000 gallons per year.

The geometric-based devices can be attached to the trailer's front face, sides and top surfaces, and the undercarriage. One device employs "trapped vortex" design technology to eliminate the drag due to flow in the gap region between the tractor and the trailer. The "vortex strakes" create a "boat tail" at the back of the trailer. A boat tail is a tapering protrusion mounted on the rear of a truck that reduces the aerodynamic base drag caused by the lower-pressure effect that occurs in the wake of a vehicle. The "skirt fairings" reduce drag caused by airflow underneath the trailer. The location of the aerodynamuc devices (trailer front, top, sides and undercarriage) does not interfere with door operation. Testing indicates that adding the SOLUS devices to trailers has no negative impact on either operational utility or maintenance requirements.



SOLUS Solutions and Technologies' Vortex Drag Reduction Devices

Overview

- Developed by SOLUS Solutions and Technologies LLC in 2001 (www.solusinc.com)
- Commercialized in 2007
- Currently marketed by Silver Eagle Manufacturing Company (www.silvereaglemfg.com)

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.093	0.052

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.030	0.008	1.14

Applications

Can be used for all classes of heavy tractor trailers to reduce drag and improve fuel economy

Capabilities

- Improves fuel economy of a tractor-trailer by 10% at 60 mph.
- Improves vehicle stability and handling.
- Reduces drag by up to 25% at all operational speeds.

Benefits

Profitability

Ensures low operation and maintenance costs and a return on investment in less than one year.

Reliability

Reduces wear on engine and braking assemblies and wear on the transmission.

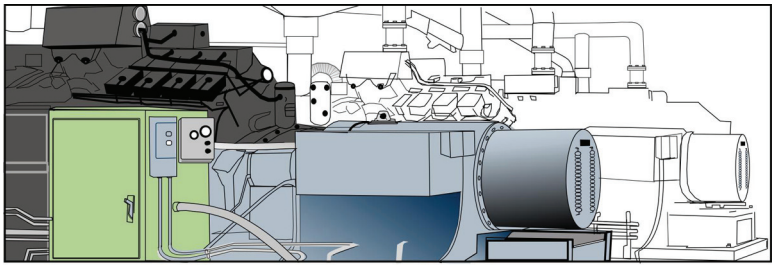
IMPACTS

Advanced Natural Gas Reciprocating Engines Increase Efficiency and Reduce Emissions for Distributed Power Generation Applications

Distributed energy (DE) technologies for on-site power generation are assuming a role of increasing importance for our nation's energy, environmental, and economic future. The use of DE technologies can lead to lower emissions and, particularly in combined heat and power (CHP) applications, improved efficiency. The reciprocating (piston-driven) engine is a widespread and well-known DE technology. Although diesel and gasoline-fueled reciprocating engines are commonly used for stand-by applications, they create significant pollution in terms of emissions and noise. The development of cleaner natural gas-fired engines is desired to address these concerns.

The U.S. Department of Energy's Advanced Reciprocating Engine Systems (ARES) program represents a cooperative effort by major engine manufacturers, DOE national laboratories, universities, and engine consultants to obtain maximum efficiency and minimum emissions from natural gas-fired reciprocating engines. The ARES program began in 2001 and consists of three phases, with each phase targeting specific progress benchmarks aimed at achieving the overall goals of the program. The program will result in engines with at least 50% brake thermal efficiency and NO_x emissions no greater than 0.1 g/bhp-hr.

Caterpillar, Inc. has successfully commercialized their G3500C and E series engines for Phase I of the ARES program. These engines employ several improvements for increased efficiency, including: advanced combustion, improved air systems, and dedicated control systems. In their current development stage (Phase II), Caterpillar is focusing on value-added after-treatment and exhaust heat recovery. Cummins, Inc. selected a lean burn approach for achieving the targets of Phase I, which culminated with the successful release of their QSK60 engine. Phase II work is centered on a stoichiometric system with exhaust gas recirculation (EGR) and a three-way catalyst with thermo chemical recuperation. Dresser Waukesha developed its Advanced Power Generation (APG) 1000 engine in Phase I, focusing on combustion/controls technologies and application of the Miller Cycle to achieve its objectives. In Phase II, Waukesha is exploring further advances in combustion, low friction technologies, and new controls technology to achieve further efficiency gains and emissions reductions.



ARES Engines

Overview

- Being developed in parallel by Caterpillar Inc., Cummins Inc., and Dresser Waukesha (www.cat.com) (www.cummins.com) (www.dresser.com)
- Commercialized since 2003 and sold by all three engine manufacturers
- Sold more than 500 engines in the U.S. and over 1600 internationally

Applications

Can be used for a wide range of distributed generation needs, including: backup to the electrical grid, combined heat and power, and combustion of landfill and digester biogases.

Capabilities

- Increases combustion quality through use of improved spark plug ignition systems.
- Reduces friction losses through modified piston rings and liners, without loss of sealing or component life.
- Reduces frequency of maintenance through use of improved control systems, resulting in lower operating costs.

Benefits

Cost Savings

On-site power generation eliminates transmission costs associated with utility-provided electricity.

Emissions Reduction

Reduces NO_x and carbon monoxide emissions.

Productivity

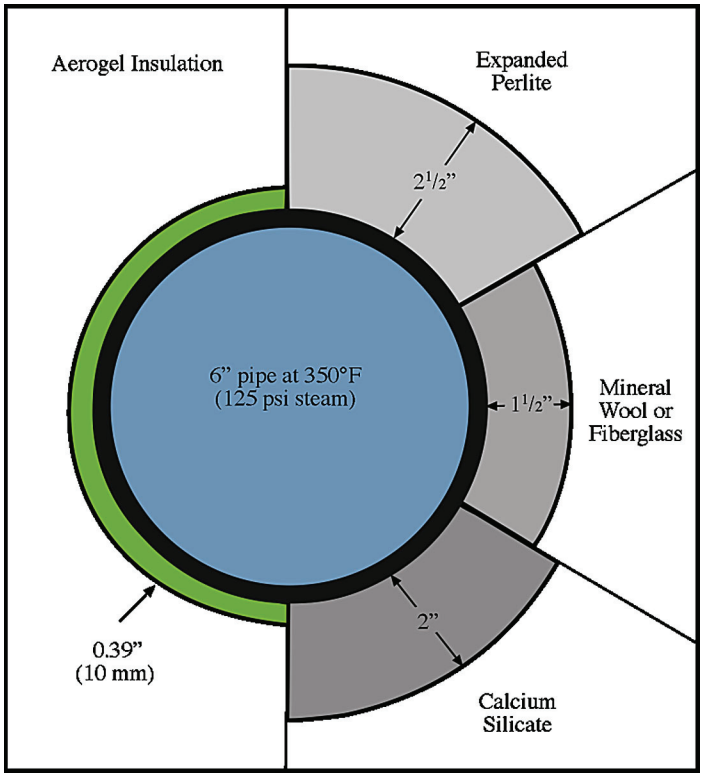
Achieves higher power density and improved fuel efficiency compared with conventional reciprocating engines.

Aerogel-Based Insulation for Industrial Steam Distribution Systems

New Efficient Insulation for Pipes Allows for the Use of Less Material with High-Temperature Durability

Thermal loss through industrial steam distribution systems accounts for a large part of total U.S. energy consumption. Traditional pipe insulation employs mineral wool, fiberglass, calcium silicate, perlite, and various foams. Annular shrouds of these materials are tightly wrapped around steam pipes and clad with sheet metal. As a highly efficient insulation material, flexible aerogel blankets can help reduce these losses when wrapped around hot piping, vessels, and equipment. This breakthrough technology provides the equivalent insulating properties of conventional insulation but with two to five times less material. A cost-effective method has been developed by Aspen Aerogels, Inc., with ITP assistance, to manufacture this industrial insulation product that has remarkable thermal performance, physical toughness, and water-resistant properties.

Aerogel has the lowest thermal conductivity of any known material. Recent processing developments allow this once boutique material to be manufactured cheaply in blanket form. The main attraction of aerogel insulation is that it significantly reduces the amount of material needed to achieve the same insulation value as bulkier traditional insulation. Aerogel is still more expensive to produce on a weight basis, but much less material is required, so the improved properties compensate for the difference in cost. Insulation designs and installation protocols were developed to allow for widespread adoption of aerogel-based pipe insulation by all industries that rely on steam distribution systems, with a focus on assemblies that are not currently cost-effectively addressed by aerogel insulation, such as large diameter, complex, and/or high-temperature pipe systems.



Thickness Comparison of Aspen Areogel's Insulation vs. Conventional Insulation with Equivalent Insulation Properties

Overview

- Developed by Aspen Aerogels, Inc., in partnership with Air Liquide USA LLC (www.aerogel.com)
- Commercially available since 2007

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.163	0.132

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.015	2.10

Applications

Can be used for industrial steam distribution systems, enhancing high-temperature durability up to superheated steam at 1200°F.

Capabilities

- Enhances high-temperature durability of industrial insulation.
- Reduces installation labor.
- Offers long-term water resistance and corrosion protection because of the aerogel's hydrophobic properties.
- Has very low thermal conductivity.

Benefits

Efficiency

Possesses a very low thermal conductivity and thickness compared with conventional insulation materials.

Material Savings

Reduces the amount of material needed to achieve the same insulation value as bulkier traditional insulation.

Autotherm® Energy Recovery System

IMPACTS

Innovative Technology Reduces Idling, Fuel Costs, and Emissions on Large Vehicles

Historically, cab interiors are kept warm when a vehicle is stationary in the winter by either installing an expensive fuel-fired heater or idling the vehicle engine to keep hot water circulating to the cab heater. According to Argonne National Laboratory, larger vehicles can consume one gallon per hour of fuel simply to operate the heater. In most vehicles once the motor is turned off, within a few minutes, the vehicle interior is too cold to occupy comfortably because the engine driven pump is no longer recirculating water to the cab heater. With assistance from DOE's Inventions and Innovation Program, Autotherm developed a system that continues to supply heat stored in the engine to a vehicle cab when the engine is turned off. The easy-to-install design allows the vehicle to stay heated for up to several hours when the vehicle is turned off, eliminating both fuel consumption and emissions from the stationary vehicle.

Once the vehicle motor is turned off, the Autotherm system operates the vehicle's existing heater using a dash-mounted system control unit and a small electric recirculating pump, which is attached to the existing engine coolant system. The system is fully automatic and can maintain cab temperature with the driver present or absent from the vehicle. Operation stops automatically when the engine coolant drops to about 95°F. The vehicle can be left securely locked, and if the driver returns within the heating period, the vehicle will be warm and snow-free.

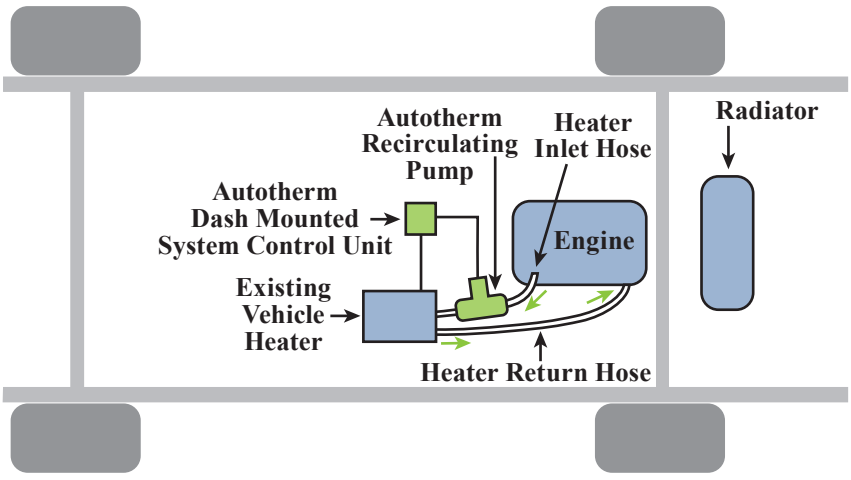
Benefits

Emissions Reductions

Reduces 100% of the emissions from an idling vehicle by eliminating the need for the engine to run to maintain cab temperature.

Profitability

Reduces operating costs and has a payback of one heating season.



Autotherm Components

Overview

- Invented by Frank Perhats in 1974 and refined using DOE funding
- Commercialized in 2003 and being marketed by the Autotherm Division of Enthal Systems, Inc. (www.autothermusa.com)
- About 1900 units installed through 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.137	0.037

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.022	0.006	0.807

Applications

Can be used in any vehicle that is prone to idling, including small to large service vehicles and semi-trucks.

Capabilities

- Maintains a vehicle's interior temperature for several hours when the engine is off by recovering energy stored in the warm engine.
- Automatically turns off when the engine coolant system drops to below 95°F.
- Alerts the driver to an approaching "low battery voltage" condition and shuts down the system before the battery is low.

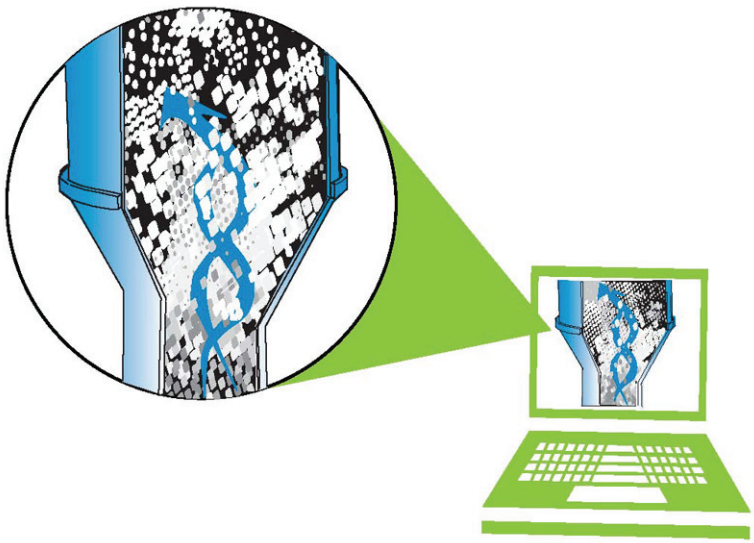
Barracuda® Computational Particle Fluid Dynamics (CPFD®) Software

Innovative Software Program Extends the Capabilities of CFD by Modeling Solid Particle Movement

Invented at the Los Alamos Scientific Laboratory in the 1950s and '60s, computational fluid dynamics (CFD) is a mathematical expression of the physics of the movements of fluids (liquids and gases). CFD computer software simulates real-world fluid-flow events, such as modeling the flow of air over an aircraft wing or predicting the flow of an oil spill in a river channel. Sand in an hour glass is said to "flow," and so for many years CFD computer codes were used to model and predict the movement of particles as well as fluids. However, because particles are solids, not fluids, modeling them as fluids is inherently limited and not completely accurate.

With assistance from ITP, a consortium of industrial partners led by CPFD Software, LLC, has developed and commercialized Barracuda CPFD software. The CPFD software models the behavior of particles as they move through process equipment. This gives industrial users the ability to design processes that are more energy-efficient and environmentally friendly.

The CPFD software is currently employed by major automotive and transportation manufacturers, as well as by major chemical, petrochemical, and power generation companies worldwide. CPFD Software, LLC, continues to expand the product's applications to meet today's critical energy challenges. These applications include making the supply of Canadian oil sands economically feasible, increasing clean coal energy production, and expanding solar photovoltaic deployment.



Industrial Process Modeled by Barracuda CPFD Software

Overview

- Developed through a collaborative effort between CPFD Software, LLC; ExxonMobil; Millennium Inorganic Chemicals, Inc.; and Sandia National Laboratories
- Commercialized by CPFD Software, LLC (www.cpfd-software.com)

Applications

Can be used in any industrial application that requires accurate modeling of complex mixing and chemical reaction processes

Capabilities

- Allows the user to model three-dimensional movement of a size distribution of particles.
- Enables simulations to run for sufficient time to achieve meaningful quasi-steady behavior and allow for scenario analyses.

Benefits

Cost Savings

Saves time and reduces waste materials by optimizing existing processes.

Emissions Reductions

Reduces emissions by identifying more ecologically friendly retrofit technologies that can be applied to existing facilities.

Energy Savings

Prevents damaging outputs and inefficient energy use by modeling complex mixing and reacting processes.

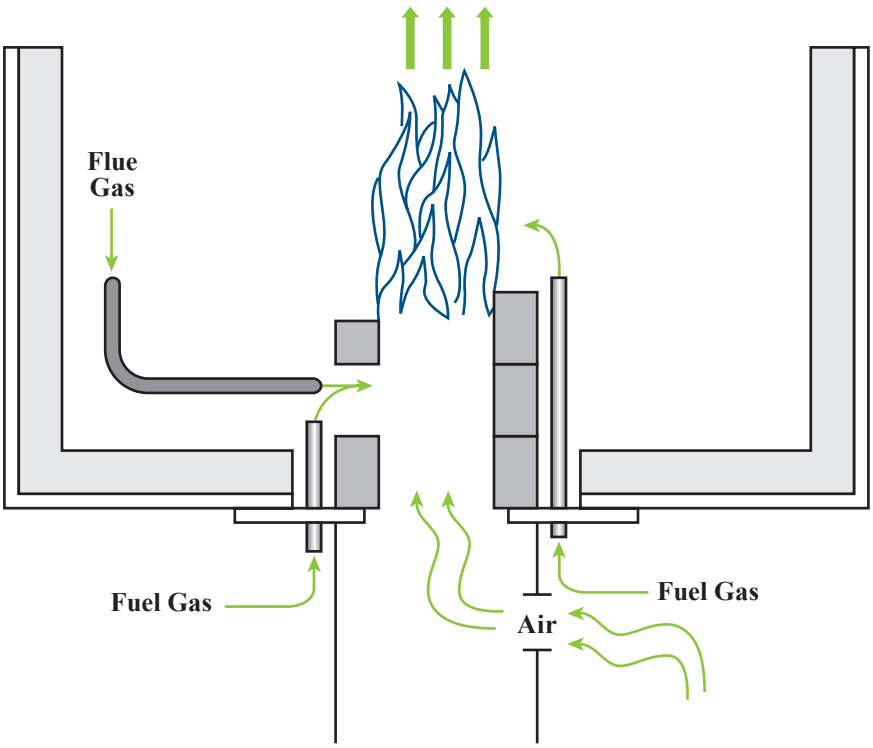
Callidus Ultra-Blue (CUBL) Burner

IMPACTS

A New Generation of Smart, Integrated Burner/Fired-Heater Systems

The refining and chemicals industries rely on process heaters to heat liquids and induce chemical reactions during production processing. Process heaters in these two industries generate over 235,000 tons of NO_x emissions annually. The chemicals and refining industries are facing more stringent environmental regulations to reduce NO_x emissions; for example, the state of Texas has ordered refiners in the Houston area to reduce NO_x emissions by 80+%.

Callidus Technologies, along with funds and resources from ITP, Gas Research Institute (GRI), and Arthur D. Little Company, developed and demonstrated an ultra-low NO_x emissions burner. The burner uses internal flue gas recirculation to reduce 80% of the NO_x emissions, with many applications achieving reductions greater than 90%. Callidus Technologies, with licensing rights from GRI, is manufacturing and marketing the Callidus Ultra-Blue Burner to the chemicals and refining industries, where potential NO_x reductions of 200,000 tons/year are possible.



Callidus Ultra-Blue Burner

Overview

- Developed by Callidus Technologies, Inc. (www.callidus.com)
- Commercialized in 2000
- Over 12,000 burner units installed by 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
95.1	26.4

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	3.09	419

Applications

Can be used in the chemicals, petrochemicals, and refining industries

Capabilities

Works with natural or forced-draft operation; refinery fuel gas, natural gas, and high and low hydrogen content; and ambient and preheated air.

Benefits

Emissions Reductions

Reduces thermal NO_x in the combustion zone by 80% to 90%.

Profitability

Eliminates or reduces the need for expensive post-combustion emission-altering equipment.

Other

Is designed to be user-friendly.

Catalytic Combustion

Advanced Catalytic Combustion System Reduces NO_X Emissions

Natural-gas-fired turbine systems currently require complex after-treatment systems to clean the exhaust of harmful emissions. Many of these emissions could be reduced by lower operating temperatures during the combustion process.

With the support and recognition from many organizations, including ITP, the California Air Resources Board, the California Energy Commission, and the U.S. Environmental Protection Agency, Catalytica Energy Systems, Inc., has developed an innovative system to reduce turbine emissions. The Xonon Cool Combustion® System uses a catalytic process instead of a flame to combust the fuel, thereby lowering the combustion temperature and significantly reducing the formation of NO_X.

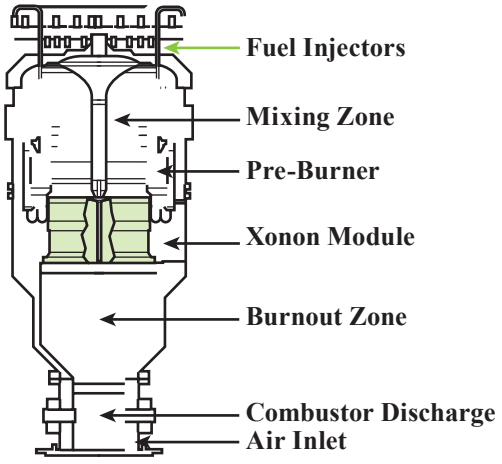
While maintaining turbine efficiency, the technology has the potential to reduce the cost associated with achieving ultra-low emissions while generating electricity with gas turbines. With the growing need for electricity generation that produces less pollution, Catalytica Energy Systems' solution provides a cost-effective method to meet air pollution control standards through pollution prevention rather than cleanup. In its first commercial installation, the NO_X output was reduced from approximately 20 ppm to well below 3 ppm.

Benefits

Emissions Reductions
Reduces air pollutant emissions from gas turbine energy generation systems.

Pollution Reduction
Avoids the need for costly or burdensome exhaust cleanup systems that use toxic reagents such as ammonia.

Productivity
Maintains turbine efficiency, demonstrating operating reliability greater than 98%.



Catalytic Combustion

Overview

- Developed by Catalytica Energy Systems, Inc.
- Has accumulated over 18,000 hours of operation on the grid in field demonstrations
- First commercial installation in 2002
- Commercially available through Kawasaki Gas Turbines-America on its M1A-13X, a 1.4-MW gas turbine as part of the GPB 15X cogeneration system (www.kawasakigasturbines.com)
- Being actively developed in partnership with GE Power Systems for its GE10, a 10-MW gas turbine, and with Solar Turbines for its Taurus 70, a 7.5-MW gas turbine

Applications

- Can be used for power generation turbine systems with low emission requirements or preferences, such as California installations, international systems, and systems with low pollution requirements
- Can also be applied to turbine generation systems with cogeneration to improve energy efficiency

Capabilities

- Can be used in a broad range of turbine sizes and will not reduce the turbine efficiency.
- Achieves emissions less than 3 ppm for NO_X and less than 10 ppm for CO.
- Uses a catalyst rather than a flame to combust fuel.

IMPACTS

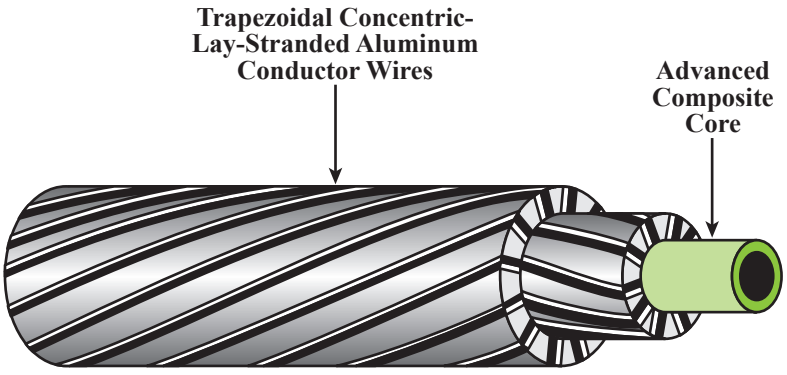
New Aluminum Conductor Composite Core Cable Increases Transmission Efficiency and Installs Easily

After nearly three years of intensive research and development, Composite Technology Corporation, in association with General Cable, introduced a new conductor type known as ACCC (Aluminum Conductor Composite Core). This new conductor uses a lighter-weight, high-strength carbon and glass fiber core embedded in a high-performance thermoset resin matrix, which is produced continuously using an advanced pultrusion process. The hybrid structural core is then helically wound with fully annealed trapezoidal-shaped conductive aluminum wires. Compared with a conventional steel core cable, the new core allows for up to 28% more conductive aluminum to be wrapped within the same outside diameter. The end product is of similar weight to conventional aluminum conductor steel reinforced cable, which allows existing structures to be used without modifications.

While the conductor was designed to perform efficiently at temperatures significantly higher than conventional steel-cored conductors, ACCC actually operates much cooler and more efficiently under equal power flow. Because the power flow capability, or "ampacity," is double that of a conventional conductor, the ACCC's improved efficiency can help reduce power generation costs and greenhouse gas emissions, while mitigating grid bottlenecks and the associated high costs of grid congestion.

The ACCC conductor's higher capacity can also improve grid reliability; if a parallel line fails, it can handle the extra current flow. When operated at higher temperatures (representing higher current flow), a normal conductor would tend to thermally expand and sag beyond safe limits – potentially grounding out to adjacent lines or structures – causing catastrophic outage. The ACCC conductor's reduced coefficient of thermal expansion prevents thermally induced line sag and would prevent that type of occurrence.

In addition to improving the weight and conductivity characteristics of utility transmission and distribution lines, the new ACCC allows for reductions in the number of structures by as much as 16% or more because of its thermal stability and 25% to 40% greater strength. The added aluminum content (~28%) greatly reduces resistance and line losses. One utility reported a reduction in line losses of approximately 35% on one of their ACCC lines, which also helped improve the overall efficiency of the system.



Aluminum Conductor Cable with Composite Core

Overview

- Developed by Composite Technology Corporation (www.compositetechcorp.com)
- Commercialized in 2005
- Over 637 miles of line installed in 10 U.S. states and much more in foreign countries

Applications

Can be used by the power industry to increase transmission efficiency and increase capacity for new and existing pathways. Is available in all the industry standard sizes ranging from 431 to 2727 kcmil.

Capabilities

- Doubles the current carrying capacity of existing transmission and distribution lines.
- Decreases the cost of new installations by reducing the number of structures required and related construction and maintenance costs.
- Resists environmental degradation and improves reliability.

Benefits

Productivity

Uses conventional installation methods and tools, allows the existing transmission and distribution structures to be used without modifications, and reduces construction costs by using fewer support structures.

Product Quality

Virtually eliminates high-temperature cable sag and will not rust or corrode or cause electrolysis with aluminum conductors or other components.

Profitability

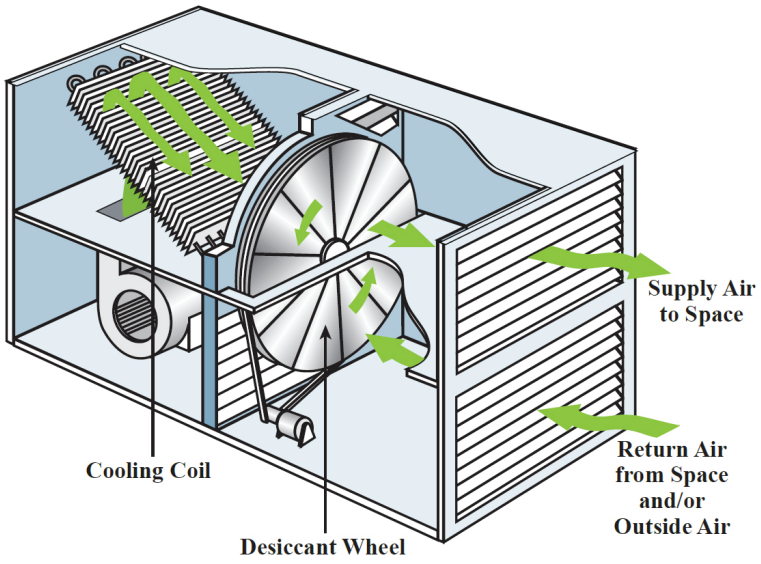
Doubles current-carrying capacity and reduces power generation and transmission costs.

Cromer Cycle Air Conditioner

New Air Conditioning System Uses Desiccant to Transfer Moisture and Increase Efficiency and Capacity

When cooling a space to a comfortable temperature, two types of heat energy must be removed: temperature-associated sensible heat and moisture-associated latent heat. An air-conditioner coil usually operates by performing about 25% moisture removal and 75% cooling. In a typical system, over-cooling must occur to meet the moisture-removal demands. These typical systems inefficiently add heat to the supply air (reheat), which consumes even more energy, to correct for the over-cooling. Latent-heat ratios often become higher than 25% in hot and humid climates, where introducing fresh air brings in significant levels of moisture, upsetting the temperature and moisture balance of interior spaces and reducing comfort levels. Excessive moisture in the air can also contribute to indoor air quality problems in buildings.

With assistance from DOE's Inventions and Innovation Program, the Cromer cycle air conditioner was developed to reduce energy consumption of the air conditioning while increasing the moisture-removal capacity of the air-conditioner coil. In the Cromer cycle air conditioner, a desiccant wheel is used to transfer moisture continuously from the supply air stream to the return air stream before the cooling coil. This transfer enhances dehumidification of the coil without significantly reducing coil temperature, improving the efficiency of the refrigeration cycle. The drier air supplied to interior spaces increases comfort and indoor air quality. Trane incorporated the Cromer cycle into a new system called the Cool Dry Quiet (CDQ™) desiccant dehumidification system. The first CDQ systems were sold in 2005 and by the end of the year 30 units had been installed, primarily in hospitals and museums. In 2006, Trane began to market the CDQ in roof top units and in applications for package units.



Trane Cromer Cycle Air Conditioner

Overview

- Developed by Charles Cromer of the Solar Engineering Co.
- Commercialized in 2005
- Being produced and marketed by Trane (www.trane.com)

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
1.13	0.458

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.002	0.099	0.074	9.00

Applications

Can be used in commercial, industrial, or residential HVAC systems needing dehumidification down to 25°F dew points

Capabilities

- Reduces the amount of cooling, eliminating reheat used in many systems to dehumidify, and improves the efficiency of the cooling needed by maintaining higher evaporator coil temperatures than standard systems.
- Requires minimal maintenance of the desiccant wheel for the life of the air conditioning system.

Benefits

Productivity/Comfort

Improves humidity control for more comfortable working or living environments, resulting in improved productivity.

Waste Reduction

Avoids the need for stand-alone dehumidification equipment or dedicated outdoor air units; uses return air to regenerate the desiccant versus the high-temperature heat used with other desiccant systems.

Electrochromic Windows – Advanced Processing Technology

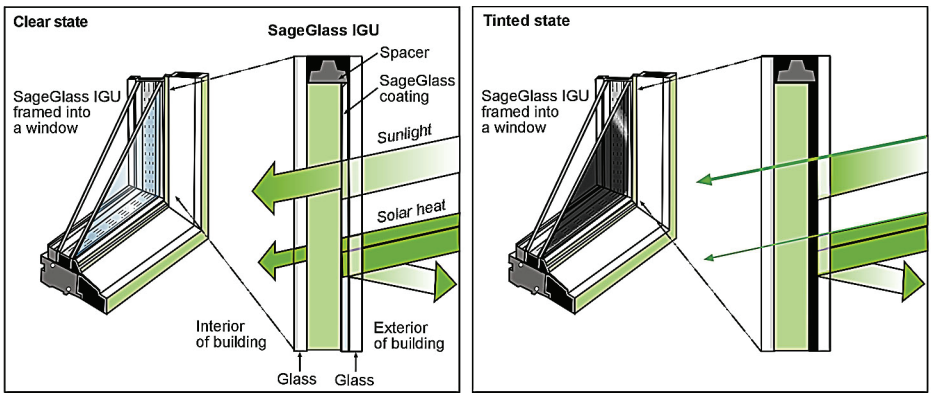
IMPACTS

'Smart Glass' Technology Reduces Solar Heat Gain in Buildings

Windows are often the most inefficient part of a building envelope and are responsible for heat loss in cold months and solar heat gain in warm months. Sunlight entering a home can increase cooling loads by up to 20%. In some instances, glare from the sun can make it difficult to see a computer or other LCD screen, requiring the blinds to be pulled, negating the benefits of natural light. Sunlight can also fade furniture, carpets, and drapes, increasing building owners' maintenance costs.

SAGE Electrochromics, Inc., with assistance from DOE's Inventions and Innovation Program, developed SageGlass® product technology to create windows and skylights that switch from clear to dark with the push of a button. Within 5-10 minutes, the electrochromic (EC) glass completely changes, depending on the size and temperature of the pane. The variable tint feature of the glass prevents glare, fading, and heat gain without the loss of a view. Without the drawbacks of traditional glass, this technology allows architects the freedom to design with daylighting, creating well-lit, comfortable buildings.

This EC glass modulates light transmission and solar heat gain by sending an electrical charge through the glass. The glass is made up of five separate layers of ceramic materials; when voltage is introduced, the glass lightens or darkens as needed. The electricity used to operate 1,500 square feet of SageGlass window is less than a 60-watt light bulb. The glass can be altered manually via a wall switch or as part of an integrated building management system so that windows can be programmed to tint depending on input from timers, motion sensors, or similar controls.



SAGE Electrochromics' SageGlass Window Operation

Overview

- Developed by SAGE Electrochromics, Inc. (www.sage-ec.com)
- Commercialized in 2003

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.002	0.001

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.0	0.023

Applications

Can be used in any building with windows or skylights, including homes and large public buildings; is particularly appropriate for hospitals, schools, libraries, data centers, clean rooms, etc.

Capabilities

- Reduces solar energy by up to 81% in its fully tinted state.
- Prevents sunlight from damaging artwork, furniture, and carpet.
- Reduces glare so windows do not have to be shaded or blocked.

Benefits

Adaptability

Can be configured to operate by a wall switch or as part of a building's automation system and is appropriate for both residential and commercial applications.

Energy Savings

Reduces annual cooling loads in commercial buildings by 20% and peak electricity demand in most of the United States by 19% to 26%.

Energy-Conserving Tool for Combustion-Dependent Industries

MultiGas™ Analyzer Provides On-Line Feedback Resulting in Lower Energy Use and Emissions

Using a NICE[3] grant, Advanced Fuel Research (AFR), Inc., has developed and demonstrated a new system to improve continuous emissions monitoring (CEM) and on-line process tuning of combustion-dependent systems such as boilers and turbines.

Many existing combustion-monitoring techniques are unable to effectively and efficiently monitor all combustion gases, including difficult-to-separate hydrocarbons such as formaldehyde and emission control reactants such as ammonia. Typical CEM systems monitor a limited number of gases using an expensive collection of single-gas analyzers. These systems require a temperature-controlled room and a substantial ongoing investment to maintain operation and calibration of the facility.

The new multi-gas analyzer technology is portable, low-cost, and energy-efficient and combines advanced Fourier transform infrared spectroscopy with advanced electronics and software. This system provides CEM and on-line feedback for operational tuning of combustion-based industrial processes. The system allows for real-time measurement of criteria emissions and pollutants, including pollutants that are not usually monitored such as formaldehyde and ammonia. The improvements in dependability and efficiency and the lack of need for expansive temperature-controlled space result in lower operations, energy, and labor costs.

Benefits

Environmental

Measures criteria and hazardous air pollutants that are not typically monitored on-site in real-time, such as formaldehyde and ammonia.

Productivity

Reduces maintenance and performance verification time, resulting in labor savings of up to 80%.

Overview

- Developed by Advanced Fuel Research, Inc.
- Commercialized in 2001
- Manufactured and sold by MKS Instruments (www.mksinst.com)
- 73 units operating in the U.S. in 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.022	0.006

U.S. Emissions Reductions

(Thousand Tons, 2009)

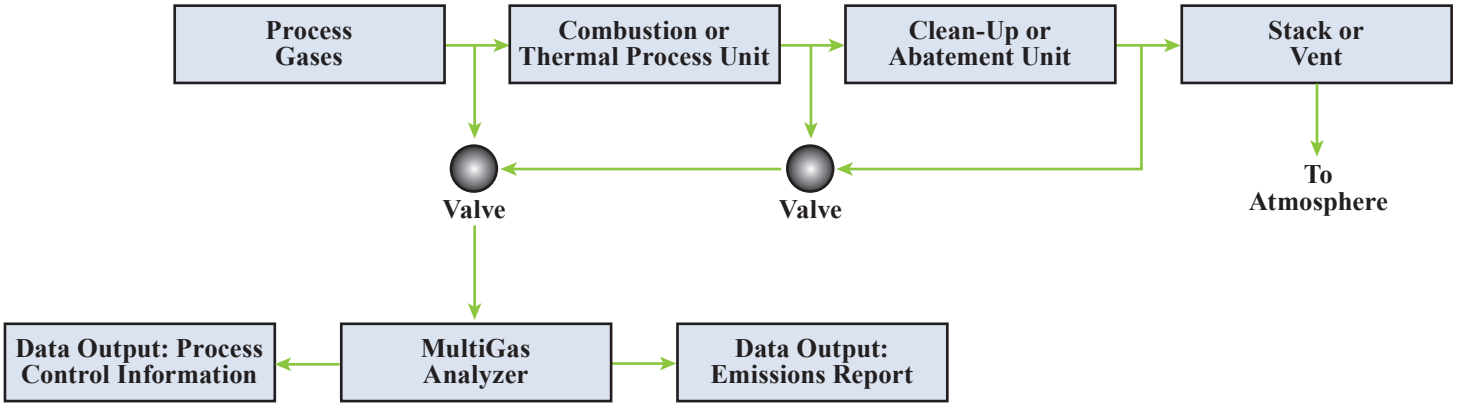
Particulates	SO_x	NO_x	Carbon
0.0	0.001	0.001	0.112

Applications

Can be used in systems and processes requiring combustion of fuels in engines, boilers, incinerators, and turbines

Capabilities

- Achieves higher combustion efficiencies through closely monitored and controlled combustion.
- Reduces emissions through verified efficient operation.



MultiGas Analyzer System

Fiber-Optic Sensor for Industrial Process Measurement and Control

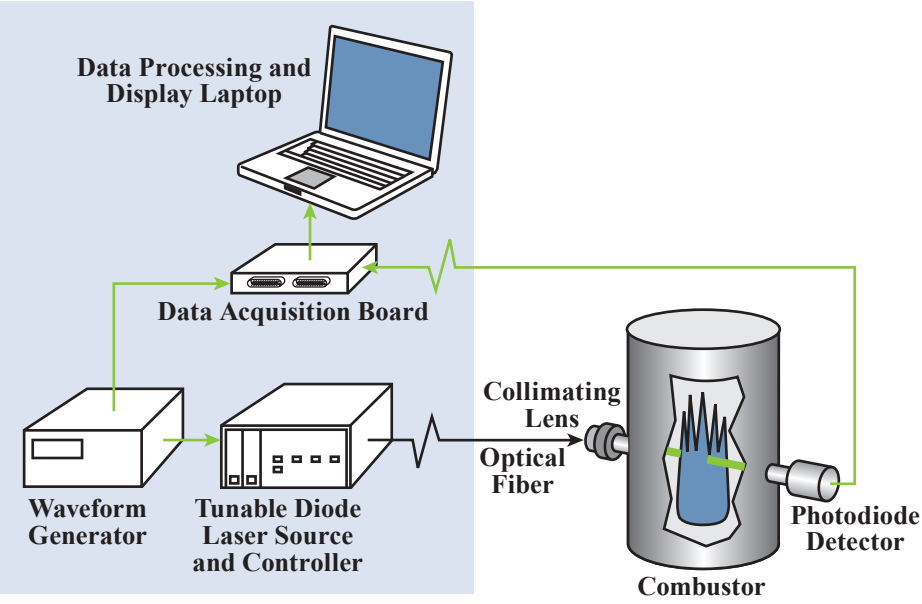
IMPACTS

Reliable Advanced Laser Sensor Helps Control High Temperature Gas Combustion

Through a marketing agreement with MetroLaser Inc., Bergmans Mechatronics LLC is offering the LTS-100 sensor to the aerospace and industrial markets. This new sensor will help reduce the cost and improve the performance of traditionally difficult temperature measurements. A separate marketing agreement with LaVision GmbH of Germany has been entered into in which a version of this sensor is marketed to the pharmaceutical industry for leak detection.

Many existing industrial process sensors have limited accuracy in applications involving highly corrosive gases at elevated temperature and pressure because they require extractive sampling systems that introduce variations in the temperature, pressure, and composition of the probed gases. Moreover, sampling systems introduce a lag resulting in >1-10 second response times, require frequent servicing, and may be subject to unexpected failures because of their complexity. Using advanced tunable diode laser absorption spectroscopy (TDLAS) sensors for closed-loop process control affords a direct, quantitative measure of the species concentration in the probed region. In addition, by monitoring two or more transitions, the temperature along the optical path can also be determined.

Near-infrared diode lasers are attractive light sources for sensing applications because they are rapidly tunable, small and lightweight, low-cost, efficient, and robust. They operate at near-ambient temperatures and produce narrow bandwidth radiation over a broad wavelength range. These on-line sensors can be combined with process optimization control strategies to significantly improve plant throughput, increase product quality, and reduce energy consumption and waste.



LTS-100 Processing Unit

Overview

- Developed by MetroLaser Inc., Irvine, CA
- Commercialized in 2003
- Being provided as a service in the United States by MetroLaser (www.metrolaserinc.com)
- Applying a derivative of this technology as a leak detection system for pharmaceutical production lines

Applications

Can be used in coal-fired power plants to achieve accurate real-time temperature measurements, in solid propellant combustion to enhance the capabilities of the next generation of solid-fuel vehicles, and in leak detection for pharmaceutical production

Capabilities

- Monitors high-temperature gas combustion in process control applications.
- Monitors vacuum leaks in pharmaceutical vials using non-intrusive measurements.

Benefits

Profitability

Reduces maintenance costs and minimizes slag buildup heat-transfer losses in coal-fired power plants by precisely controlling furnace temperature and startups.

Reliability

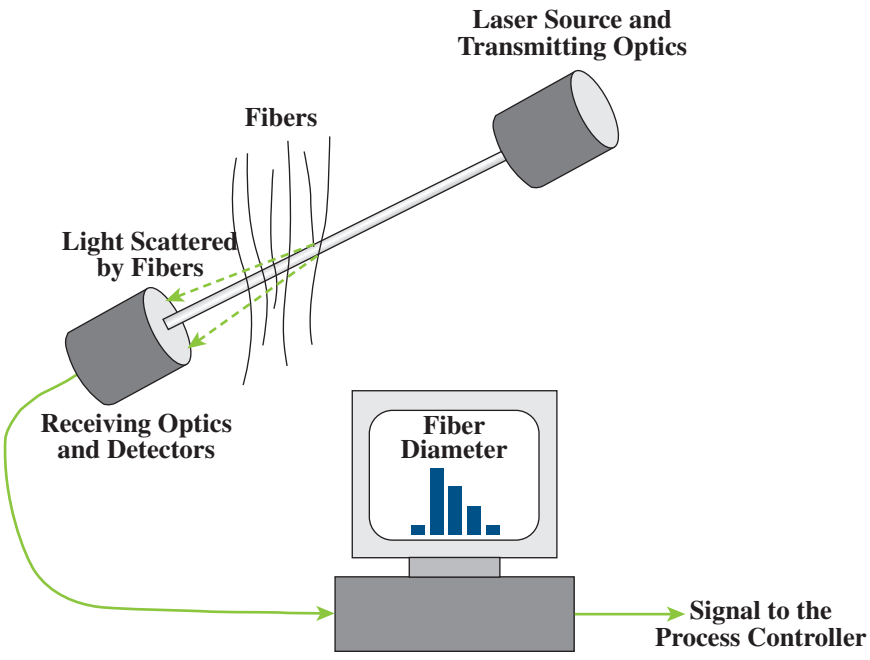
Performs measurements regardless of vibration, flame luminosity, temperature, pressure extremes, and particle interferences.

Fiber Sizing Sensor and Controller

Revolutionary Optical Technology Provides Rapid Measurement of Large Samples of Fiber Diameters

Fiber size (or denier) has a significant effect on the performance of fiber-based products, such as filters, insulation, and composites. Fiber samples are generally characterized by optical or electron microscopy. Flow resistance of a sample of fibers (e.g., by the Micronaire™ technique) is also used to estimate the mean fiber size. However, these methods require sampling and are time consuming, and microscopic measurements are usually based on a small number of fibers selected from an image of a collection of fibers and may not be statistically reliable. Rapid measurement of fiber size, based on a large sample, is desirable for quality control of fiber-based products, development of new fiberizing processes, or basic research on fiber generation. With assistance from DOE's Inventions and Innovation Program, Powerscope, Inc., developed FibrSizr™, which provides rapid measurements for both on-line and off-line fiber characterization. The sample size is large and usually consists of hundreds of fibers.

FibrSizr consists of a laser instrument developed for the accurate real-time and in-situ determination of fiber diameter distributions. This device can be used to monitor nonwovens and glass fibers during production and to rapidly measure fiber size distribution in a web sample. This technique is applicable across a wide range of polymers, production methods, and fiber sizes.



Fiber Sizing Sensor/Controller Using Ensemble Laser Diffraction

Overview

- Developed and commercialized by Powerscope, Inc., in 2004 (www.powerscopetech.com)
- Completed sales, lease arrangements, and contract measurements for several major U.S. fiber manufacturers

Applications

Can be used in off-line and on-line process control of fibers on a variety of production/treatment methods such as meltblown, spunbond, meltspun, carded, chemical bonded, needlepunched, spunlaced, stitchbonded, thermal bonded, and rotary fiberizing

Capabilities

- Offers a new model that uses violet laser, instead of red laser, for better resolution of fine fibers as small as 0.7 micron in mean size.
- Provides a detachable transmitter and receiver for applications with limited physical access.
- Covers a wide range of fiber sizes (denier) and fiber densities using adjustable laser power and detector gain.

Benefits

Energy Savings

Eliminates events, such as sudden shutdowns, which result in waste of energy and material, by close monitoring of the process.

Pollution Reduction

Minimizes release of pollutants such as CO_2 from the pertinent combustion processes by operating the fiberizers at near optimal conditions.

Product Quality

Measures and controls fiber size distribution, which is a critical element in producing nearly all value-added fiber products.

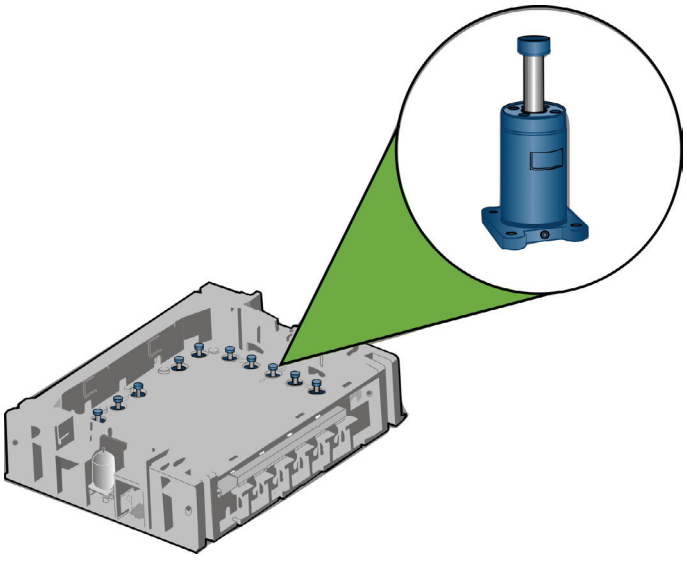
Force Modulation System for Vehicle Manufacturing

IMPACTS

Novel Technology Enables Energy-Efficient Production of High-Strength Steel Automotive Parts

Recent U.S. automobile sales show a growing demand for more fuel-efficient and environmentally-friendly vehicles, including hybrids. The U.S. auto industry is pursuing at least two parallel paths to address these market evolutions. The first path involves design changes in the engine plant, such as improved internal combustion engines, hybrids, and alternate fuel engines. The second method focuses on changes in the materials used to build vehicle frames and bodies, thereby reducing weight and improving fuel efficiency. Researchers have found that work-holding capabilities in excess of 600 tons are required to form the higher strength steels. Conventional press systems with nitrogen-based cylinders suffer from excess shock loading and an inability to control individual cylinders. A system is needed that offers improved vehicle component forming capability under heavy loads.

With assistance from DOE's Inventions and Innovation Program, Metalforming Controls Corporation has developed Force Modulator™ cylinder technology. The Force Modulator system is built around a series of interconnected hydraulic cylinders. Each cylinder has a proprietary control device that allows for changing resistance throughout the stroke. In short, stroke tonnage can be controlled at any point in the stroke. This capability allows each cylinder to start with virtually no resistance tonnage (the equivalent of pre-acceleration), increase tonnage rapidly to set the bead, and decrease tonnage during part formation. Any other tonnage profile is also possible. When the press upstrokes, the initiation of system re-pressurization and the timing of re-pressurization allow the piston and binder return to be controlled. This system also allows for zone control. If required, the tonnage profile of each cylinder can be independently controlled, allowing press operators to increase or decrease tonnage at each point on the binder ring. Zone control is exerted through the control device found in each cylinder.



Metalforming Controls Corporation's Force Modulator Hydraulic Cylinder System

Overview

- Developed and marketed by Metalforming Controls Corporation (MCC). (http://www.mfcontrols.com)
- Commercialized in 2009, with 1 cushion unit operating in the U.S. and multiple units operating internationally.

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.017	0.017

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.005	0.003	0.357

Applications

Can be used in the stretch-forming of standard and high-strength steel components for lightweight vehicle frames and bodies.

Capabilities

- Uses a die-mounted hydraulic cylinder system, which allows a soft hit, tonnage control throughout the press stroke, and a controlled return during the press stroke.
- Reduces shock loading of presses by 20% or more compared with conventional nitrogen-based systems.

Benefits

Energy Savings

Reduces the amount of work required by the compressor via regenerative use of the working fluid's potential energy.

Product Quality

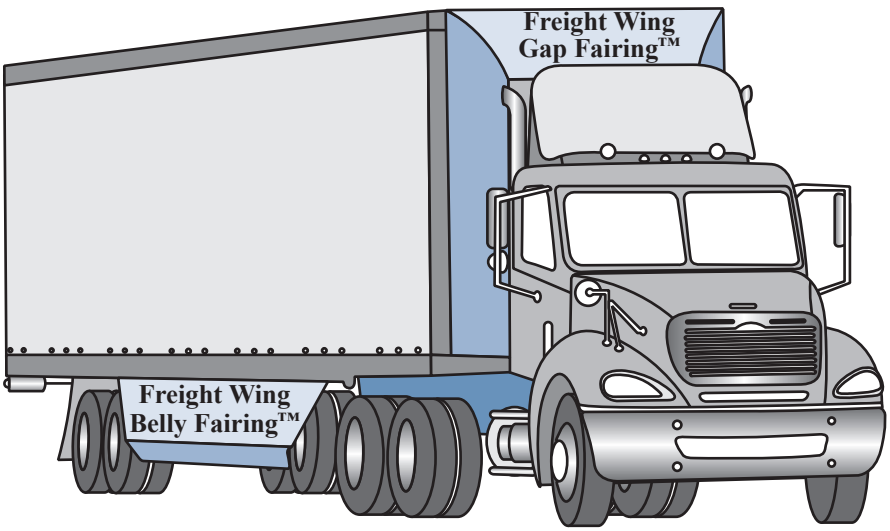
Produces high-strength steel components, which reduce vehicle weight and increase safety.

Freight Wing™ Aerodynamic Fairings

Innovative Aerodynamic Fairings Minimize Drag on Box-Shaped Semi-Trailers

A great deal of scientific research has demonstrated that streamlining box-shaped semi-trailers can significantly reduce a truck's fuel consumption. However, significant design challenges have prevented past concepts from meeting industry needs. Freight Wing, Inc., was formed to improve the fuel efficiency and profitability of trucking fleets through innovative aerodynamic devices. Freight Wing was initially funded through a grant from DOE's Inventions and Innovation Program to develop rear-fairing technology and has since expanded the company's products to a complete line of aerodynamic solutions. Their initial research focused on developing a practical rear fairing that would not interfere with the truck's operation and on investigating other means to reduce aerodynamic drag on box-shaped semi-trailers. Freight Wing market research soon revealed that the industry was not very interested in the rear fairing because that area is extremely prone to damage and durability is a primary concern. Consequently, the company has since focused on developing designs for front or gap fairings and undercarriage or belly fairings.

Freight Wing generated prototypes of all three fairing designs with their manufacturing partner, ASAP Metal Fabricators, in early 2004. In May 2004, Freight Wing tested all three fairing prototypes at the independently owned Transportation Research Center (TRC) in East Liberty, Ohio. TRC tested the fairings using the industry standard Society of Automotive Engineers/ Technology & Maintenance Council (SAE/TMC) J1321 fuel consumption procedure Type II test. A 7% fuel savings was demonstrated on trailers equipped with all three fairings. The product was marketed starting in the fall of 2004, and soon thereafter the company made its first sale of two belly fairings. Additional research was conducted to develop second-generation designs using different materials and aerodynamic concepts. The resulting second-generation belly fairing product produced a 7.4% fuel savings alone in SAE tests and in fleet operation. Partnerships with major trailer manufacturers have been developed to offer Freight Wing products on new trailers with factory installation. In 2009, 2,883 fairings were sold, demonstrating a significant increase in product demand and industry acceptance of the technology.



Freight Wing Fairings Installed on a Semi-Trailer

Overview

- Developed and marketed by Freight Wing, Inc. (www.freightwing.com)
- Commercialized in 2004
- Currently used by over 400 trucking fleets in the United States and Canada

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.711	0.493

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.004	0.286	0.076	10.7

Applications

Can be used on trucks or semi-trailers to reduce the effects of aerodynamic drag

Capabilities

- Reduces aerodynamic drag on semi-trailers.
- Retrofits on existing or new semi-trailers.

Benefits

Energy Savings

Reduces fuel consumption by 7% with use of second-generation belly fairing alone.

Emission Reduction

Reduces emissions of combustion products, including particulates, SO_X, NO_X, and CO_2.

Functionally Graded Materials for Manufacturing Tools and Dies

New Material Processes Improve the Performance and Lifetime of Tools and Dies

Tools, dies, and process equipment currently used in the metal casting, forging, and glass manufacturing industries are generally composed of thick-sectioned monolithic H13 or other tool steels. Although the starting materials are relatively inexpensive, the conventional tool manufacturing process results in low material yields, significant machining time, long lead times, and high overall cost. When the dies contact either hot/molten metals or glass, as appropriate, significant degradation of the surfaces occurs due to soldering, heat checking, and/or physical erosion. Damaged dies lead to part surface imperfections, dimensional tolerance issues, high part reject rates, and die repair downtime.

With assistance from ITP, Carpenter Powder Products, Inc., has developed functionally graded materials (FGM) to produce more robust tools and dies. The techniques of laser powder deposition and solid-state dynamic powder consolidation result in FGM tools and dies with increased wear resistance and superior performance at elevated temperatures.

Functionally graded materials provide many benefits to the industrial process user. The tools and dies perform better, which leads to shorter process cycle times and a reduction in waste scraps from parts manufacturing. In addition, FGM parts have a longer lifetime than traditional tools and dies, which reduce replacement costs.

Benefits

Adaptability
Allows properties of functionally graded tools to be customized to meet the requirements of a particular application.

Cost Savings
Increases tool and die lifetimes, thereby reducing the cost to replace parts.

Waste Reduction
Reduces scrap and waste in tool and die parts manufacturing.

Overview

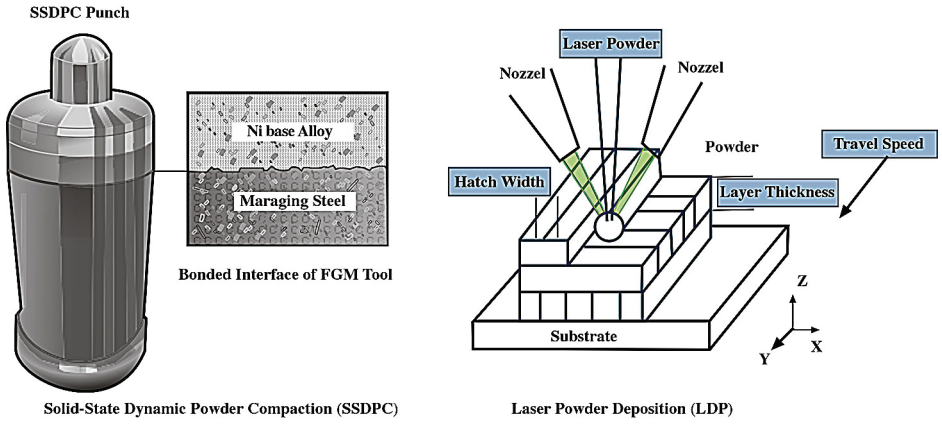
- Developed by Carpenter Powder Products, Inc. (www.cartech.com)
- Commercialized in 2007
- Used by multiple U.S. metal forging and die casting companies in 2009

Applications

Can be used in the aluminum, forging, glass, metal casting, and steel industries

Capabilities

- Improves elevated-temperature properties of tools and dies.
- Reduces die surface degradation.
- Increases wear resistance and dimensional stability of tools and dies.
- Reduces process cycle times.



Two Manufacturing Processes Used to Produce FGM Tools

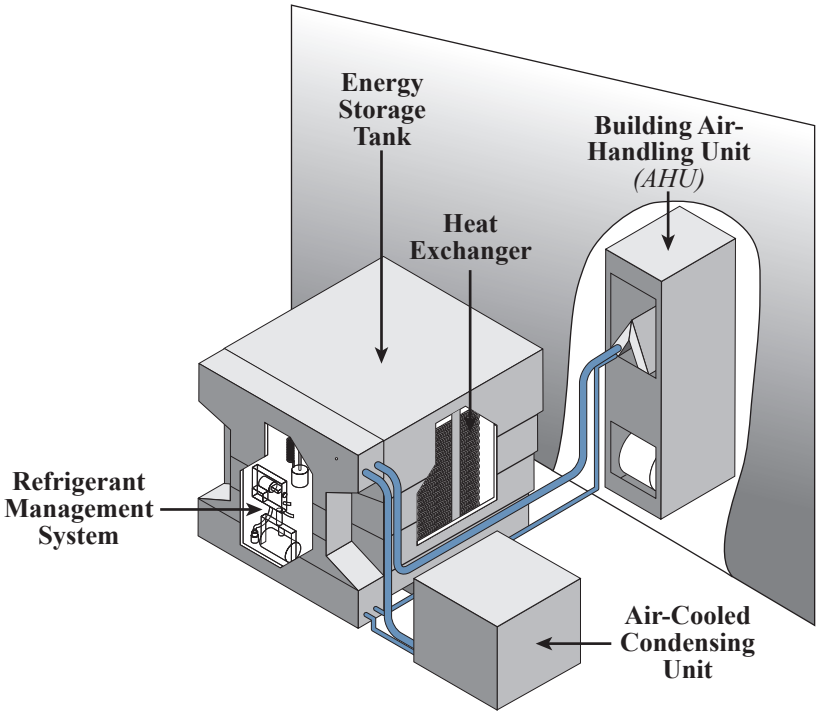
Ice Bear® Storage Module

Thermal Energy Storage for Light Commercial Refrigerant-Based Air Conditioning Units

The Ice Bear® storage technology was initially developed by Powell Energy Products, with assistance from DOE's Inventions and Innovation Program and commercialized by Ice Energy®, Inc. The Ice Bear storage module was engineered to complement new or existing air conditioning (AC) equipment to shift energy use from peak to off-peak periods. The Ice Bear unit is designed for use with rooftop or split system AC equipment. The Ice Bear unit with an air-cooled condensing or rooftop unit operates during off-peak hours to store energy as ice. During peak daytime cooling, the Ice Bear unit functions as the condenser, circulating ice-condensed refrigerant with a low-power refrigerant pump. Total energy use is only 300 watts to provide 7.5 tons of cooling for 6 hours.

The Ice Bear unit consists of a heat exchanger made of helical copper coils placed inside an insulated polyethylene storage tank filled with normal tap water, a patented refrigerant management system, a low-power refrigerant pump, and the CoolData® controller. To provide AC, the Ice Bear uses a low-power pump to circulate refrigerant to the evaporator coil in the air handler. By using the condensing or rooftop unit to produce ice during the night and the refrigerant pump to supply condensed liquid refrigerant to the evaporator coil during the day, the Ice Bear effectively transfers the majority of load requirements to nighttime hours or levels energy loads. In both of these applications, the Ice Bear reduces humidity levels, which helps meet indoor air quality standards.

The Ice Bear unit is designed to meet retrofit, replacement, and new construction requirements in commercial or industrial AC applications.



Ice Bear Storage Module

Overview

- Base technology developed by Powell Energy Products, Inc., and patents acquired by Ice Energy, Inc. in 2003
- Commercialized by Ice Energy, Inc. in 2005 (www.ice-energy.com)

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.003	0.001

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.0	0.018

Applications

Can be used in conjunction with 3.5-to-20 ton AC units in markets such as small to big-box retail, industrial, data centers, office buildings, restaurants, banks, fire stations, libraries, schools, and community centers

Capabilities

- Shifts 95% of AC load from peak to off-peak periods.
- Offers energy storage capacity of 45-ton/hr, up to 7.5 tons of cooling for 6 hours.

Benefits

Cost Savings

Substantially reduces electrical bills in load-shifting applications where peak and off-peak price differentials exist by reducing demand by 95%.

IMPACTS

Redesigned Diesel Engines Improve Heavy Truck Fuel Economy

The KIVA computer model resulted from the efforts of a diesel engine working group formed in 1979 as part of DOE's Energy Conservation and Utilization Technologies (ECUT) Division's Combustion Technology Program. The goal of this activity was to guide the development and application of diagnostic tools and computer models. Under the guidance of DOE and the Cummins Engine Company, the multidimensional KIVA model was developed to help engine designers overcome some of the technical barriers to advanced, more fuel-efficient engines.

KIVA allows designers to see the effects of alterations to engine geometry without actually building the engine. Cummins Engine Company has used KIVA to make piston design modifications and other modifications to diesel engines for heavy trucks. In a cooperative effort with DOE, Cummins has also improved engine breathing, pulse-preserving manifolds, and turbocharger design. Cummins has improved the diesel engine sufficiently to increase the mileage by nearly one-half mile/gallon. With millions of trucks and buses currently on the road, this improvement in engine efficiency yields a significant savings in fuel.

Energy savings from this development are based on the number of trucks (class 7 and 8) powered by Cummins engines. This value, multiplied by the savings per mile and the number of miles driven per year, results in the estimated annual energy savings.

Benefits

Competitiveness
Helps the U.S. automotive industry strengthen its competitive position relative to Europe and Japan.

Productivity
Reduces time required from engine design to production.

Waste Reduction
Optimization in engine performance considerably reduces emissions, including unburned hydrocarbons.

Overview

- Developed by Los Alamos National Laboratory, Sandia National Laboratories, Southwest Research Institute, and others
- Commercialized in 1991
- First used by Cummins Engine Company to redesign diesel engines for improved energy efficiency

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
1160	16.3

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.122	9.47	2.52	355

Applications

Can be used in visualizing the effect of design changes on engine performance, in assessing engine ability to use alternative fuels or reduce emissions, and in optimizing engine operation to reduce emissions

Capabilities

- Simulates precombustion fluid motion, chemical kinetics, flame propagation, and combustion dynamics in engines.
- Investigates airflow and diesel spray characteristics nonintrusively.

In-Situ, Real Time Measurement of Elemental Constituents

New Laser System Provides Real-Time Measurements for Improved Product Quality Control

A probe uses laser-induced breakdown spectroscopy (LIBS) to determine the elemental constituents in ferrous and non-ferrous metals, ceramics, or glass. This probe measures continuously and in-situ at any point in the melt, thus providing spatial and temporal real-time data. The probe uses a pulsed (5-10 ns duration) Nd:YAG laser at 1064 nm that is focused, through a fiber-optic cable. In the molten aluminum application, the probe is immersed into the melt, generating high-temperature plasma consisting of excited neutral atoms, ions, and electrons. Any chemical compounds present in the sample are rapidly separated into their constituent elements. The laser-generated plasma is allowed to cool several microseconds after the laser pulse, and then a spectrometer collects and disperses optical emissions from neutral and ionized atoms. The line radiation signal provides the concentration of each element present.

The probe has several applications in the ferrous and non-ferrous metals, ceramics, or glass industries. For example, the probe can be used for in-line alloying to measure chemical content during a pour and for continuous and semi-continuous furnace operations to minimize the current practice of off-line sampling and measurement. In other applications, the probe can perform in-line monitoring of impurity removal from the melt, such as removing magnesium from molten aluminum, and can provide real-time data to validate computer simulations and model furnaces.

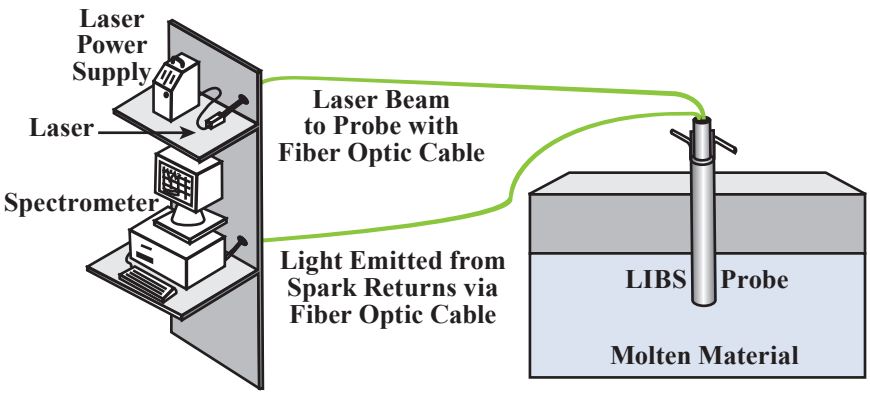
Benefits

Product Quality

Providing data for use in a feedback control loop to control the furnace operation in real time increases product quality.

Productivity and Profitability

Eliminates the aluminum and steel furnace idle time now required for off-line measurement of melt constituents. The payback has been shown to be less than one year.



Example of LIBS System Applied to Molten Material

Overview

- Developed and marketed by Energy Research Company (www.er-co.com)
- 5 units installed in the U.S., with 3 units currently operating.

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.927	0.000

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.0	0.0

Applications

Can be used to identify elemental constituents in ferrous and non-ferrous metals, ceramics, and glass melts during the fabrication process; to identify elemental constituents of wet or dry, solid or gaseous raw materials via close non-contact; and to characterize coal sample constituents to determine coal quality

Capabilities

- Measures aluminum melt constituents with 5% accuracy and a 0.002% minimum detection limit.
- Monitors trace alkali metal content in electronic glass compositions.
- Analyzes material being conveyed prior to processing, potentially eliminating energy use and emissions from using "off-spec" material.

Materials and Process Design for High-Temperature Carburizing

IMPACTS

New Class of High-Performance Carburized Steels Saves Energy and Increases Productivity

Various project partners have integrated an optimization of process and materials that will enable a broad usage of high-temperature carburization. The unique capabilities of high-temperature carburizing were exploited to access new levels of steel performance, including the distortion-free, high-performance gear and bearing materials for the transportation sector. Emphasis was placed on creating a new class of thermally stable, ultra-durable, deep case-hardened steels that could ultimately extend case hardening to tool and die steels. Case hardening would enable major productivity gains in the forging, forming, and die casting of aluminum and steel.

With assistance from ITP, a consortium of project partners used their carburization simulation tools and fundamental calibration data to gain reliable control of high-temperature carburizing of their new class of high-performance gear steels. One of the partners, QuesTek Innovations LLC, used the technology to successfully commercialize the new gear steels by demonstrating both higher gear performance and acceptably reduced manufacturing variation.

Benefits

Energy Savings
Reduces the U.S. annual energy consumption for carburizing.

Environmental
Reduces greenhouse gases compared with conventional gas carburizing technology.

Productivity
Reduces scrap and eliminates the need for hard chromium plating in many applications; offers increased durability and higher performance when it replaces conventional steel.

Overview

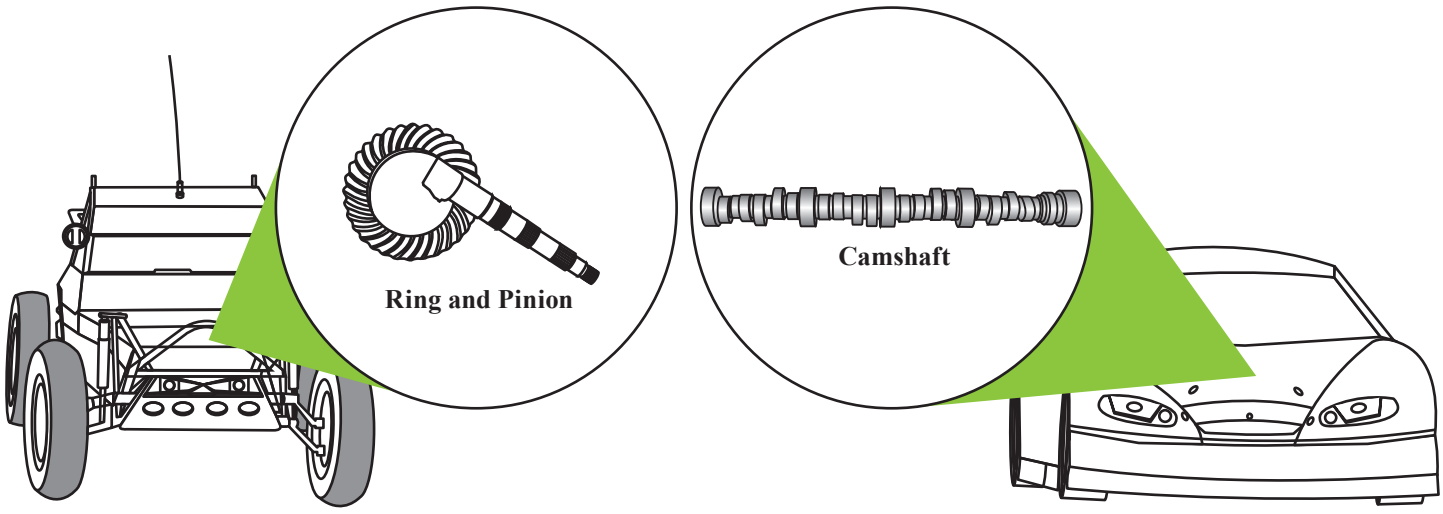
- Developed by a consortium of project partners including the Center for Heat Treating Excellence, Metal Processing Institute – Worcester Polytechnic Institute, Northwestern University, and QuesTek Innovations LLC
- Commercialized by QuesTek in 2003 (www.questek.com)

Applications

Can be used in high-performance gear and bearing applications for the transportation sector and in new deep-case applications, that include ultra-durable die materials for forging and forming of steel and aluminum and for die casting of aluminum

Capabilities

- Establishes sufficient control of high-temperature carburizing to greatly expand applications.
- Creates a new class of steels with particular emphasis on novel deep-case applications.
- Demonstrates accelerated materials and process development through the emerging technology of computational materials design.



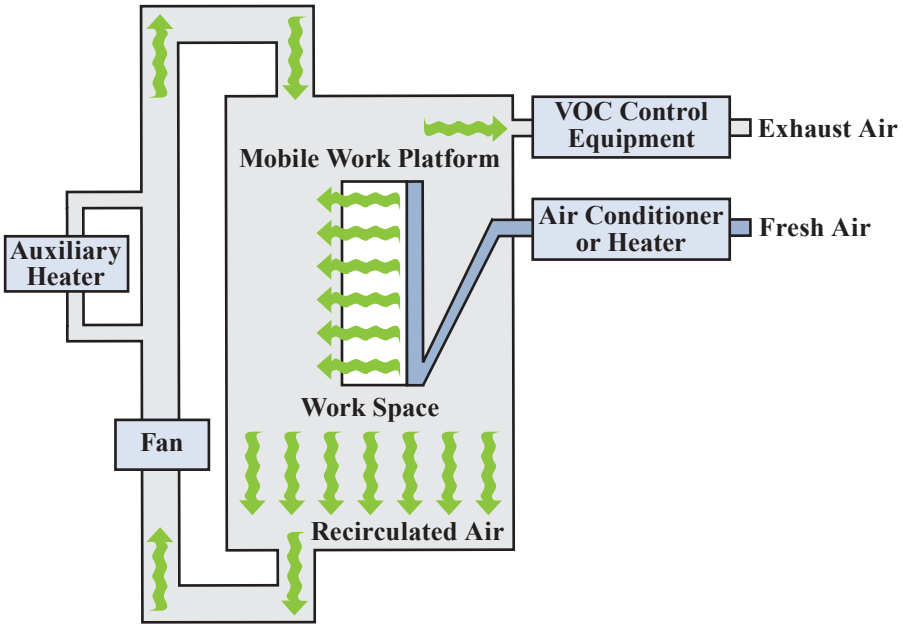
New Gear Steel Products Created Using High-Temperature Carburizing

Mobile Zone Optimized Control System for Energy-Efficient Surface-Coating

New Surface-Coating Ventilation System Reduces Air Pollution and Energy Use

Volatile organic compounds (VOCs) are released during the application of spray coatings in paint enclosures, exposing workers to toxins, creating air pollution emissions, and creating fire or explosion hazards. To meet safety and environmental regulations, paint booths are usually ventilated with 100% outside air, which is then heated or cooled to maintain useable work temperatures. Ultimately, the amount of ventilating air entering the spray booth (usually expressed as cubic feet per minute) determines the energy usage and scale of the pollution problem.

A new spray booth technology developed by Mobile Zone Associates, with the help of a grant from the EPA and DOE's Inventions and Innovation Program, greatly reduces the amount of energy needed to heat and cool ventilation air during surface coating operations by reducing the quantity of ventilating air consumed. The Mobile Zone system separates the human painter from the contaminated air of the spray booth by providing the painter with a separate, mobile work platform or cab during spray coating operations. The cab is flushed with fresh air, while the rest of the spray booth uses recirculated air. The design meets OSHA regulations and National Fire Protection Association (NFPA) guidelines. Excluding robotic painting operations, the Mobile Zone installation is the only successful example of substantial ventilating air reduction in the United States and possibly the world. It represents superior process containment and is a first step before consideration of air-to-air heat exchange or VOC pollution-control equipment. The technology is currently being used by the U.S. Army at Fort Hood, Texas, for consideration of system wide use.



Air Flow in Paint Spray Booth with Mobile Zone System

Overview

- Developed by Mr. Clyde Smith and Mr. William Brown of Mobile Zone Associates (www.mobilezonepaintbooth.com/aboutus.html)
- One installation operating in the United States in 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.059	0.007

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.001	0.001	0.120

Applications

Can be used to apply sprayed surface coatings to chairs, tables, motorcycles, tractors, railroad cars, aircraft, and other painted products in either side-draft or down-draft booths

Capabilities

Reduces the ventilation, heating and cooling requirements by directing a sufficient, but small, amount of fresh air to the painter and recirculated air to the remaining unoccupied space within the spray booth. Meets existing OHSA, EPA, and NFPA standards for worker conditions.

Benefits

Productivity/Product Quality

Maintains or improves production speed and quality.

Profitability

Reduces the size of heating, cooling, and pollution control equipment between 60% and 98%, which offers significant savings in associated capital and energy costs.

Nanocoatings for High-Efficiency Industrial Hydraulic and Tooling Systems

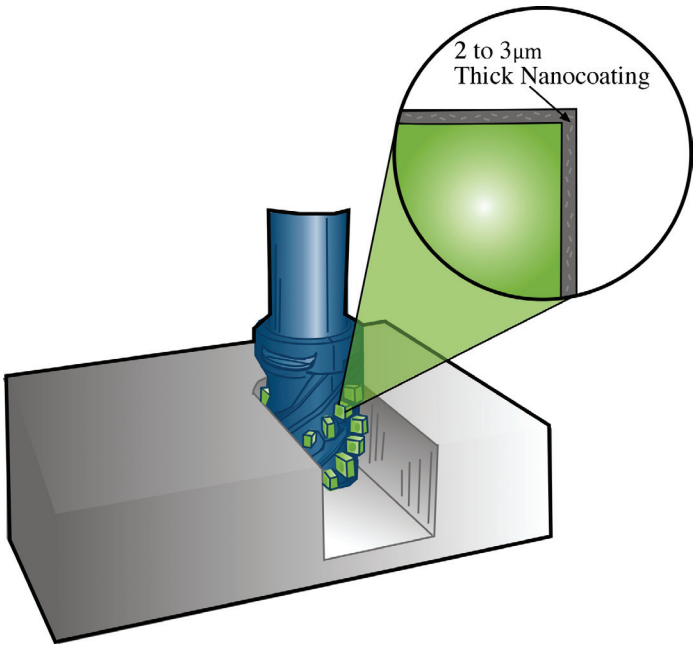
IMPACTS

Surface Coatings Enhance Wear Resistance of Metals, Saving Energy and Increasing Component Life

Industrial energy efficiency is directly linked to the wear and degradation of materials used in processing applications such as pumps and tooling components. The preferred route to minimizing wear is to apply a protective, hard coating to contacting surfaces so that the surfaces generate less friction and resist wear. With lower friction between contacting surfaces, less energy is required to overcome frictional forces during start-up and operation, thereby increasing energy efficiency. While the energy savings per component may be modest, substantial cumulative benefits are possible due to the large number of pumps and machining tools currently in operation.

With assistance from ITP, Eaton Corporation is developing a new family of "superhard" (greater than 40 GPa) composites in which the hardness is derived from microstructural engineering of the constituent phases. The coatings combine high hardness with a low coefficient of friction and have been shown to substantially reduce tool wear in lathe turning tests. This project is focusing on materials degradation resistance for two distinct industrial applications: tooling systems and industrial hydraulic components.

Widespread use of the new superhard coatings will increase energy efficiency through diminished friction losses and increased seal reliability in hydraulic pumps. Further savings are possible through an extended lifetime of optimum cutting performance in machine tooling. Increased system reliability coupled with decreased downtime and replacement costs also results in economic benefits. Environmental benefits include reduced pollutant leakage through pump seals and reduced emissions due to increased equipment energy efficiency.



Eaton Corporation's Nanocoatings Protecting the Blades of an Aerospace Industry Titanium Machining Tool

Overview

- Developed by Eaton Corporation, in partnership with Greenleaf Corporation, Oak Ridge National Laboratory, and Iowa State University. (http://www.eaton.com)
- Commercialized in 2009 and being sold by New Tech Ceramics, Inc.

Applications

Can be applied to any metal surface where increased wear resistance and reduced friction are desired, including industrial and mobile hydraulics, cutting and grinding tools, and mechanical seals used in pumps and compressors.

Capabilities

- Increases operating efficiency of hydraulic systems.
- Reduces heat loss from sliding friction along mechanical interfaces
- Improves wear performance and extends component life.

Benefits

Durability

Reduces friction along mechanical interfaces, thus reducing wear associated with extended service time.

Emissions Reduction

Reduces pollutant leakage and emissions by improving pump seal performance and increasing the equipment efficiency.

Productivity

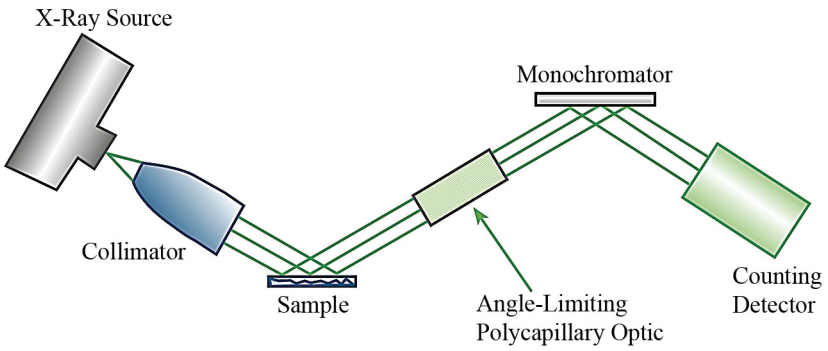
Enhances torque response in hydraulic motors. Reducing torque at startup yields greater power density, minimizing the necessary motor size.

Portable Parallel Beam X-Ray Diffraction System

New, Low Power System Reduces Energy Consumption and Improves Process Efficiency

Real-time, nondestructive, in-line measurements of material properties are needed for process control in metallurgical manufacturing. With ITP support, X-Ray Optical Systems, Inc., developed the X-Beam®, a portable x-ray diffraction (XRD) system that can be used to identify structural phases, determine grain size, and measure stress and texture of materials in line. XRD is widely used in laboratories to determine these material properties, but conventional XRD techniques usually cannot be used for in-line monitoring because they require sophisticated sample preparation, weigh hundreds of pounds, require water cooling, and consume several kilowatts of power (8 to 24 kW).

The X-Beam provides real-time material characterization capability, is portable, weighs no more than 50 pounds, and uses about 50 watts of power. The X-Beam uses polycapillary x-ray optics to collect x-rays over a large solid angle from a low-power x-ray source and to form an intense quasi-parallel beam. This system eliminates the problem of misalignment and provides significantly more diffraction intensity than current Bragg-Brentano XRD systems. The parallel beam geometry also eliminates the instrument error functions that contribute to asymmetric peak shape broadening: flat specimen, axial divergence, sample displacement, and sample transparency.



X-Ray Optical System's Parallel Beam XRD Process

Overview

- Developed by LTV Steel Technology Center and X-Ray Optical Systems, Inc.
- Commercialized in 2007
- Marketed by X-Ray Optical Systems, Inc., with over 180 units sold worldwide (www.xos.com)

Applications

- Can be used wherever elemental analysis is required, including protein crystallography
- Can be used by industrial sectors, including steel, aluminum, cement, pharmaceutical, and semi-conductor

Capabilities

- Provides continuous in-line monitoring of phase, grain size, grain orientation (texture), and residual stress of steel.
- Provides real-time, nondestructive, in-line measurements of material properties using XRD or x-ray fluorescence.

Benefits

Energy Savings

Uses 90% less energy then the standard rotating anode x-ray system and operates without a water cooling loop.

Portability

Decreases measurement system weight compared with the current XRD systems (from 200 to 1,000 kg to 20 kg) and volume from the current 2 m^3 to 0.04 m^3.

Productivity

Allows process control in the steel, pharmaceutical, nano-material, and plastics and polymer industries.

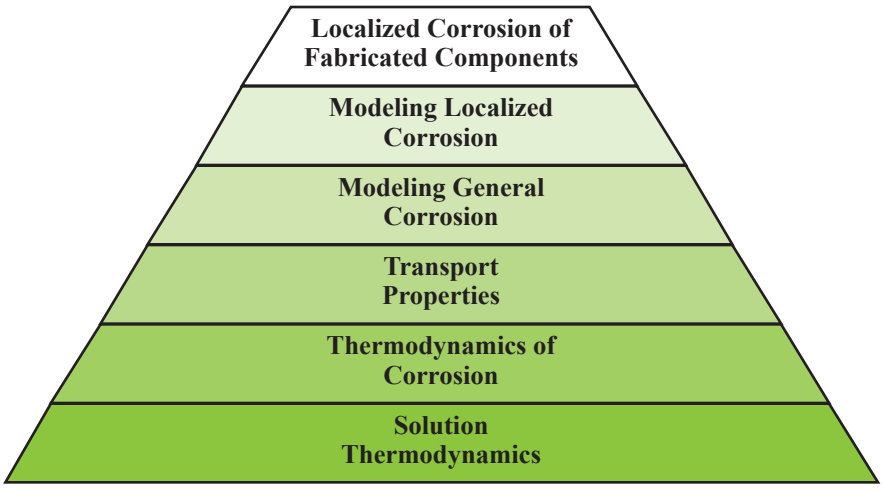
Predicting Corrosion of Advanced Materials and Fabricated Components

Corrosion Prediction Software Tool Facilitates Selection and Development of Corrosion-Resistant Alloys

Based on the fundamental understanding of corrosion phenomena, OLI Systems, Inc., with assistance from ITP, developed the CorrosionAnalyzer, a methodology that simulates the electrochemical reactions and associated physical processes responsible for corrosion at the metal/aqueous solution interface. The simulation methodology predicts the susceptibility of fabricated components to localized corrosion as a function of alloy composition, fabrication procedures, and external environmental conditions.

To predict the occurrence of localized corrosion, the system relies on the computation of the corrosion and repassivation potentials as functions of solution chemistry and temperature. The corrosion potential is calculated from a mixed-potential model that has been verified by calculating corrosion rates in mixed acids and corrosion potential as a function of pH and concentration of oxidizing species. The repassivation potential is calculated from a separate model that quantitatively considers competitive processes at metal/salt film/solution interfaces in the limit of repassivation. This model has been shown to be accurate for reproducing the repassivation potential for mixtures containing both aggressive and inhibitive ions. The combined predictive methodology has been extensively validated for engineering alloys using both laboratory and plant data.

This system combines fundamental understanding of mechanisms of corrosion with focused experimental results to predict the corrosion of advanced, base, or fabricated alloys in "real-world" environments encountered in the chemical industry. Users are able to identify process changes, corrosion inhibition strategies, and other control options before costly shutdowns, energy waste, and environmental releases occur. These innovative corrosion mitigation measures can be tested in a virtual laboratory without risking the plant. The "useful remaining life" can be predicted based on operating experience and projected operating conditions so that catastrophic failures can be avoided and well-planned corrosion control and maintenance actions can be proactively scheduled.



Structure of Corrosion Prediction Model

Overview

- Developed and marketed by OLI Systems, Inc. (www.olisystems.com)
- Commercialized in 2005
- 45 companies leasing the CorrosionAnalyzer in the United States and 54 outside the United States

Applications

Can be used in industries where fabricated components are exposed to corrosive environments, including chemicals, forest products, and petroleum industries

Capabilities

- Predicts the tendency of alloys to corrode as a function of environmental conditions.
- Predicts the tendency for localized corrosion and corrosion damage as a function of time.

Benefits

Efficiency

Reduces waste and environmental damage, and improves risk management.

Energy Savings

Reduces process losses, improves thermal efficiencies due to more optimum design of components, and reduces heat transfer losses attributable to corrosion and corrosion by-products.

Productivity

Improves component life and reduces unscheduled downtimes.

Process Particle Counter

New Particle-Size and Concentration Monitor Leads to Efficient Use of Lower-Quality Fuels

While both gas turbines and power-recovery expanders used in petroleum power generation are efficient energy-conversion devices, fuel quality limits the application of these technologies. Widely available low-cost fuels generally contain more contaminants, which can lead to system fouling and wear as well as downtime for repair and cleaning. Without continuous monitoring for particulate contamination and feedback control, systems must be set for unknown conditions, so the more-efficient gas turbines and power-recovery expanders are not installed or, if installed, operate at lower efficiency.

With assistance from ITP and a grant from DOE's Inventions and Innovation Program, Process Metrix LLC developed a real-time laser-optical process particle counter/sizer (PPC). The PPC can be used as a short-term or automated long-term sensor and control system for dust monitoring of expanders/gas turbines and process stacks. The PPC uses optical technology with fixed alignment to provide a continuous, real-time, robust, standalone particulate monitor that allows expanders and gas turbines to operate closer to optimum conditions. Such conditions improve efficiency while protecting turbines, allowing use of lower-quality fuels.

Benefits

Durability
Protects turbines from high particulate concentrations that lead to blade wear.

Emissions Reductions
Decreases emissions by improving power-generation efficiency.

Energy Savings
Could save 20 billion Btu of natural gas per installation annually.

Productivity
Allows high-efficiency turbines to be installed in more applications and reduces production downtime from failures caused by particulate contamination.

Overview

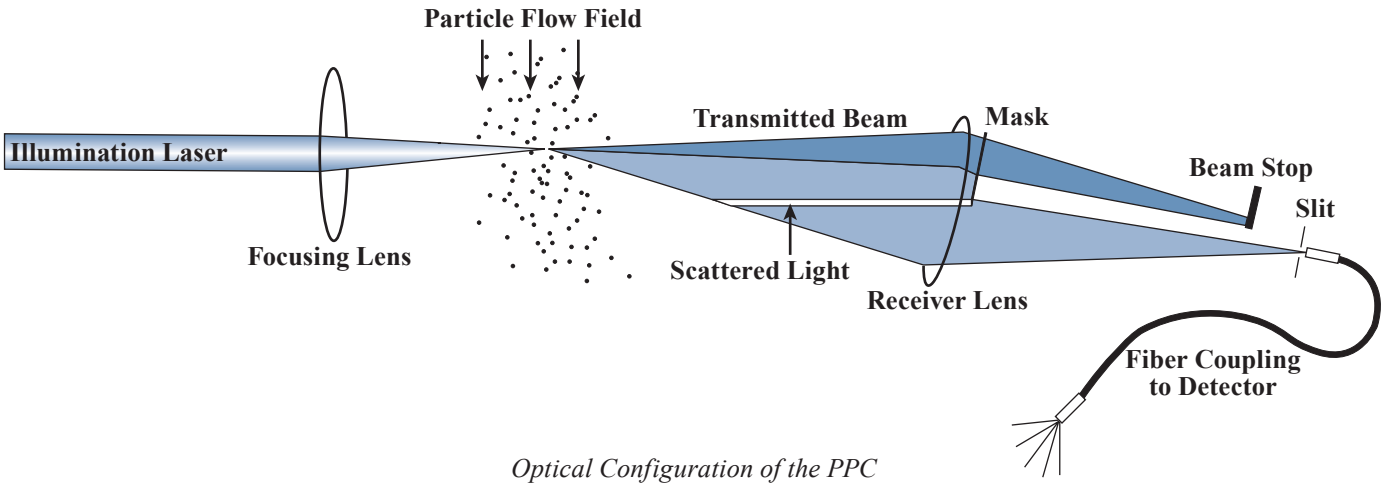
- Developed and being marketed by Process Metrix, LLC (formerly Insitec) (www.processmetrix.com)
- Commercialized in 2004
- Fifteen units being used in the United States in 2009

Applications

Can be used in petroleum power generation both for existing power-recovery expanders and in situations where power-recovery expanders have not been used because of unreliable fuel quality and return on investment concerns

Capabilities

- Monitors gas-phase particle contamination at low concentration using single particle counting.
- Measures size, concentration, and velocity of gas particles in real-time.
- Operates in-situ at industrial high temperatures/pressures.
- Uses diffraction light scattering with minimum shape and refractive index sensitivity.



Optical Configuration of the PPC

Pulsed Laser Imager for Detecting Hydrocarbon and VOC Emissions

IMPACTS

Advanced System Safely and Effectively Detects Leaks and Emissions Without Requiring an Air Sample

With assistance from DOE's Inventions and Innovation Program, LaSen, Inc., developed the Airborne Lidar Pipeline Inspection System (ALPIS®). ALPIS is a helicopter-based, mid-infrared, Differential Absorption Lidar system that detects leaks in natural gas and hazardous liquids pipelines. The laser beam is transmitted downwards from the sensor to illuminate the area above and around the buried pipeline. When the laser beam passes through an emitted plume of hydrocarbon gas, some of the beam's energy is absorbed (i.e., removed from the beam) by the gas molecules in the plume. As a result, the amount of light reflected from the ground back towards the sensor is diminished. The amount of attenuation is measured by special detectors inside the sensor and can be used to determine the intensity of gas in the beam's path. This basic principle is at the heart of laser-based gas detection systems.

ALPIS is operated at a safe distance of 50 to 150 meters above the inspection site. Once a volatile organic compound (VOC) is detected, the GPS coordinates are recorded and an estimate of the leak size and a high resolution video image of the location are simultaneously recorded and delivered to the customer the day after the inspection flight. This remote capability provides better information for response teams to effectively maintain their pipeline. LaSen is offering ALPIS as a service to U.S. pipeline companies.

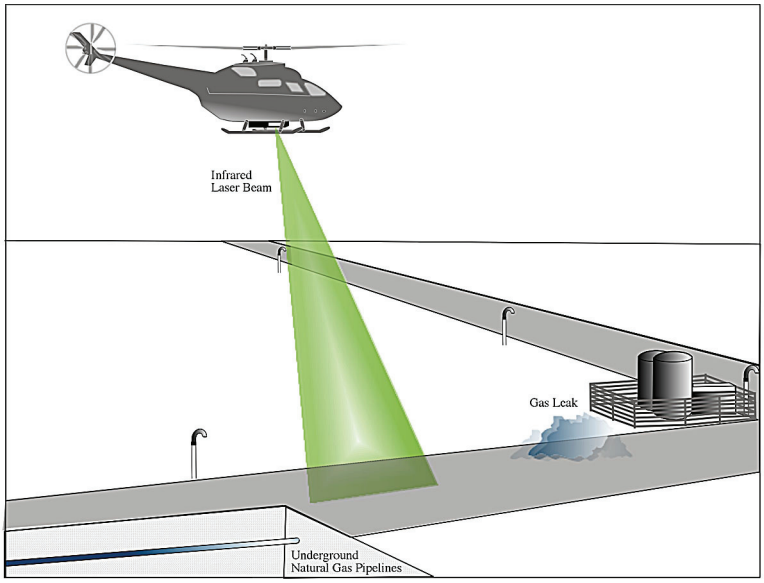
Benefits

Efficiency

Delivers complete survey results on a secure online database, which includes GPS coordinates of the indications, maps, and digital and satellite imagery of the right-of-way within 1 to 12 hours of inspection.

Safety

Offers a safe, fast and reliable remote detection system that eliminates human error and uses an eye safe laser.



LaSen's ALPIS Used to Detect Underground Pipeline Leaks

Overview

- Developed and being offered as a service by LaSen, Inc. (www.lasen.com)
- Commercialized in 2005
- Currently used by 17 major U.S. oil and gas companies

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
1.77	0.360

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.042	5.72

Applications

Can be used in the oil and gas industry to monitor and maintain the integrity of their pipeline systems from the wellhead to the end user

Capabilities

- Inspects over ten times faster compared with ground surveys.
- Provides high sensitivity in remote hydrocarbon detection.
- Provides easy access to rough terrain and private land.
- Provides high-resolution digital photography of the entire survey route.
- Provides real time detection of benzene, propane and other volatiles.

Simple Control for Single-Phase AC Induction Motors

New Motor Controller Reduces Noise and Increases Efficiency

A new approach to electric motor control removes the need for complex, high-frequency, high-voltage digital controllers that are motor and application specific. With the help of a grant from DOE's Inventions and Innovation Program, Opto Generic Devices, Inc. (OGD), developed an optical programmable encoder and controller combination that offers continually adaptive/variable-speed, optimized commutation, dynamic vector control, real-time feedback, application tuning, and signal enhancement for operating AC motors. Based on this technology, OGD's subsidiary, OGD V-HVAC, Inc., developed a new technology, the Adaptive Climate Controller (ACC), using optical programming that controls single-phase motors. While this controller has many uses with small motors, its most common applications provide climate control and healthy indoor air quality with energy efficiency, noise reduction, relative humidity control, and moisture control for mold abatement. Air filtration systems function more effectively with gradually changing air flow than with abrupt off-on fan cycling that accelerates harmful particles and organisms through mechanical and electronic filters.

In addition to providing a second, analog input for low DC voltage, the factory-supplied temperature sensor provides feedback for the controller to maintain temperature in the human comfort zone by gently mixing room air to avoid the extremes of cold air near the floor and warm air near the ceiling. If comfort demands suddenly change, such as when additional people enter a classroom or conference room, the ACC ramps up airflow as the mechanical system supplies heated or chilled air at temperatures above or below the human comfort zone, responding quickly to the changing room needs. Gradually ramping up fan speeds, instead of turning fans on fully whenever the thermostat calls for heated or chilled air, conserves energy by using only the electrical and thermal energy necessary to satisfy the demand. In systems such as fan coils, where thermal energy is transferred from heated or chilled coils into the air, the ACC enhances thermal energy exchange from the coils as it gradually ramps down fan speed in response to the actual supply air temperature as it settles into the setpoint temperature even after the thermostat has closed the valve that brings in heated or chilled water. Thus, the coil thermal energy transfer with the room continues even after the water valve has closed, allowing for additional electrical savings in chillers and fuel savings in boilers.

Benefits

Ease of Installation

Allows control upgrades to be easily installed on existing systems within minutes.

Energy Savings

Adaptively varies air flow to only what is needed.

Product Quality

Reduces noise for workers or occupants in businesses, hospitals, hotels, schools, etc.

Overview

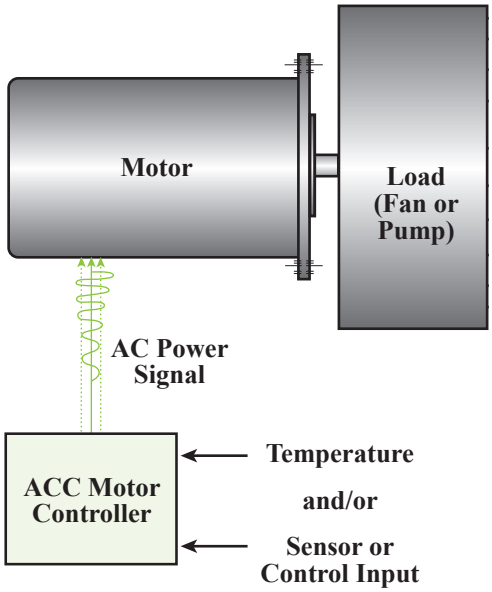
- Developed by Opto Generic Devices, Inc. (www.ogd3.com)
- Commercialized in 2005 with thousands of installed units

Applications

Can be used to control small single-phase motors up to 240 V_{AC} and 10 amps full load, including HVAC and other system motors found in data centers, hospitals, residences, hotels, nursing homes, schools, and other institutions. Also can be used to control fan coils, packaged terminal air conditioners, unit ventilators, and exhaust fans.

Capabilities

- Accepts one or two analog inputs, including, but not limited to, temperature and low DC voltage from a sensor or building management system.
- Adaptively varies motor speed for the discharge air flow across fan coils to control indoor climate.
- Reduces system noise.



OGD Electric Motor Control

Solid-State Sensors for Monitoring Hydrogen

IMPACTS

New Sensors Rapidly and Accurately Detect Hydrogen, Improving Industrial Safety and Efficiency

Molecular hydrogen, H_2, is a combustible gas that is produced in large quantities by many industries and has a broad range of applications. When H_2 is an undesirable contaminant, a monitor must be able to detect concentrations on the order of parts per million (ppm). In other cases a monitor must be usable in nearly pure hydrogen. Although gas chromatography and mass spectrometry are widely used for detecting H_2, these methods require bulky, expensive equipment.

Using solid-state technology developed at Sandia National Laboratory, H2scan LLC is now commercializing hydrogen-specific sensing systems that can detect hydrogen against virtually any background gases. These hydrogen-sensing devices can detect hydrogen in 1 to 10 seconds, thus allowing the devices to be used in control systems. Currently, H2scan offers three hydrogen-sensing system configurations: a hand-held portable leak detector, a fixed-area monitoring system, and an in-line real-time concentration analyzer.

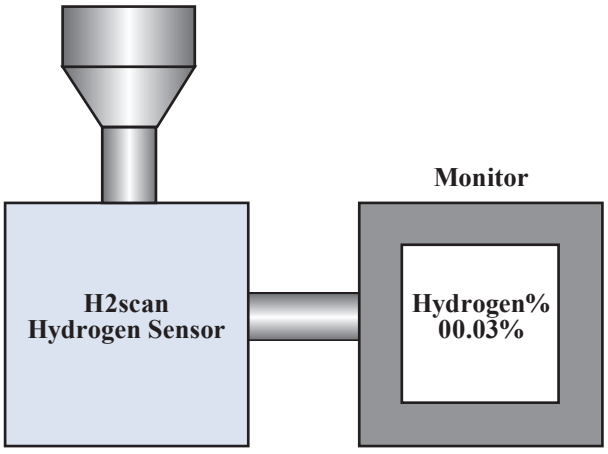
The advantages of the H2scan hydrogen sensors are in their operating parameters. The sensors have a low hydrogen sensitivity of about 5 ppm in air and less than 1 ppm in nitrogen. They are hydrogen specific with no cross-sensitivity to other gases. The upper range of the sensor is 100% with an extremely fast speed of response. They operate between -40°C to 150°C, making them attractive for virtually all sensor applications.

Benefits

Energy Savings
Saves substantial energy by avoiding improper monitoring.

Productivity
Detects hydrogen in 1 to 10 seconds, which is suitable for interfacing to control systems. Using the device to monitor hydrogen in feedstock of a refinery feed hydrogen/carbon monoxide facility could improve overall performance by up to $250,000 per year per plant.

Profitability
Can be mass-produced, making them much less expensive than competing sensors. Small sensor dye produces a system that is much smaller than traditional sensors.



H2scan Hydrogen Monitoring System

Overview

- Developed by Sandia National Laboratory and H2scan LLC (www.h2scan.com)
- Commercialized in 2003
- 2600 units sold through 2009

Applications

- Monitoring trace levels of H_2 in high-purity feed gases for chemical processes
- Monitoring hydrogen production from methane and refinery offgases, where hydrogen is often mixed with CO
- Monitoring hydrogen levels in transformer oil to detect when the oil starts breaking down
- Measuring the hydrogen given off from lead acid batteries due to overcharging to stop a buildup of hydrogen and reduce the threat of either a fire or explosion
- Monitoring and control of hydrogen, which are crucial to obtain the correct molecular-weight distributions in the gas-phase polymerization of polyethylene and polypropylene
- Analyzing fugitive hydrogen emissions in ambient plant environments or in materials subjected to high-energy radiolysis, which is crucial for safety in those environments
- Measuring hydrogen levels to control the efficiency of fuel cell reformers

Capabilities

- Can be used over a wide range of hydrogen concentrations with minimal interference from other gases.
- Provides rapid response time of 1 to 10 seconds, allowing the sensors to be used for process control.

SpyroCor™ Radiant Tube Heater Inserts

Unique Twisted Design of Ceramic Insert Saves Energy for Metal Heat-Treating Furnaces

Radiant tube heaters are typically used in metal heat-treating furnaces. The heaters are long tubes, often in a U shape, which have natural-gas fired burners at one end of the tube (the burner leg) to produce a flame and heated gas that flows through the tube to produce heat for conditioning metals (e.g., strengthening them or otherwise changing some of their properties). In a traditional radiant tube, the burner leg releases 30% more energy than the exhaust leg because of convection and radiation heat transfer in the burner leg.

With the help of a grant from DOE's Inventions and Innovation Program, STORM Development LLC and Sycore, Inc., optimized the SpyroCor, a ceramic (silicon-carbide) insert for the exhaust leg of the tube heater. The patented twisted design of the SpyroCor produces nonturbulent, high convection flow that produces the highest possible rate of uniform heat transfer. As a result, the SpyroCor reduces heat loss and the energy demands of the process or application by 15% to 20%. A typical furnace contains 10 radiant tubes, which use an average of 3 SpyroCors per tube. Through 2009, 472 furnaces have been equipped with SpyroCors for a savings of 7.46 trillion Btu.

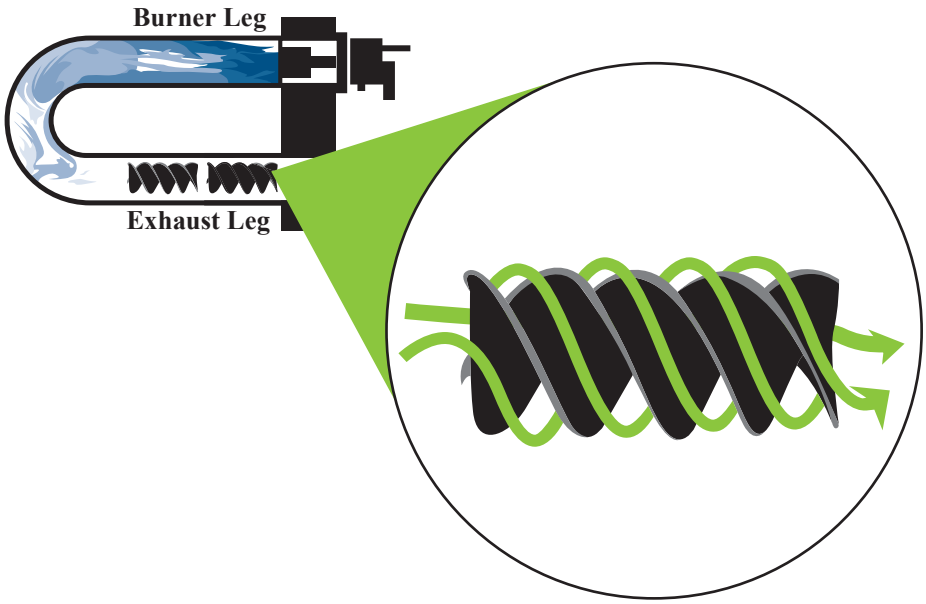
Benefits

Ease of Installation

Can be quickly and easily inserted into existing heater tubes without overhauling the entire furnace.

Productivity

Allows the furnace user to increase the amount of metal treated for the same amount of energy used or to reduce the amount of energy used for the same output.



SpyroCor Installed in a Radiant U-Tube Heater

Overview

- Developed by STORM Development LLC and SyCore, Inc.
- Commercialized and being marketed by Spinworks LLC (www.spin-works.com)
- Sold more than 17,000 units through 2009

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
7.46	2.24

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.262	35.6

Applications

Can be used in radiant tube heaters typical in metal heat-treating furnaces that use natural gas burners or in industrial radiant tube space heaters

Capabilities

- Produces nonturbulent, high convection flow in the radiant tube.
- Doubles the amount of surface area available for heat transfer.
- Balances the heat transfer throughout the radiant tube, allowing more energy to be available to the load.

Three-Phase Rotary Separator Turbine

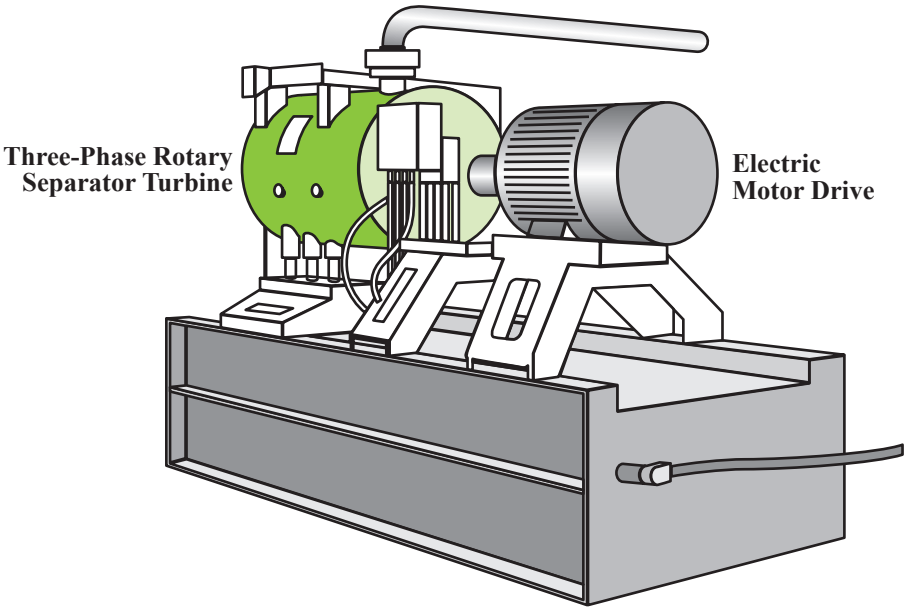
IMPACTS

New Turbine Efficiently Separates Gas, Oil, and Water While Generating Electricity from Waste Energy

Using a NICE[3] grant, Douglas Energy Company and Multiphase Power and Processing Technologies (MPPT) demonstrated a three-phase rotary separator turbine (RST3) at a land-based production field and on an offshore production platform. The device introduces a highly efficient and compact method for separating gas, oil, and water during production operations, while generating substantial power from previously wasted process energy.

Traditional oil and petroleum separator systems use a centrifuge or gravity separator. The centrifuge system requires outside energy to power the motors that propel a centrifugal drum, where oil and water are separated. After separation occurs, solids remain inside the drums and require costly periodic cleaning. The gravity separators use huge vessels that rely on gravity to perform the separations. However, the separations are often incomplete and require secondary energy-consuming systems.

The RST3 effectively separates solid waste, oil, gas and water, while harnessing expansion energy from the pressure reduction that occurs after the oil, gas, and water mixture is brought to the surface from offshore wells. This creates a clean power source that accelerates the rotating portion of the RST3 unit, where the mixture is separated more efficiently than by traditional methods. The new process often creates net energy for other offshore oil platform operations, reducing the need for electricity produced from natural gas turbine generators.



Three-Phase Rotary Separator Turbine

Overview

- Developed by Douglas Energy Company Inc.
- Commercialized in 2003 with 2 units previously operating in the U.S.
- Currently being revamped by Dresser-Rand Group, Inc. (www.dresser-rand.com)

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.036	0.000

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.0	0.0

Applications

Can be used to replace traditional separation technologies used in petroleum and chemical industries

Capabilities

- Creates its own source of clean shaft power, reducing electrical input requirements.
- Weighs 10 times less than a typical gravity three-phase separator and has a much smaller footprint.

Benefits

Cost Savings

Substantially reduces the size and cost required for offshore platforms, enabling a low-cost production system for marginal oil and gas fields and increasing supply.

Environmental

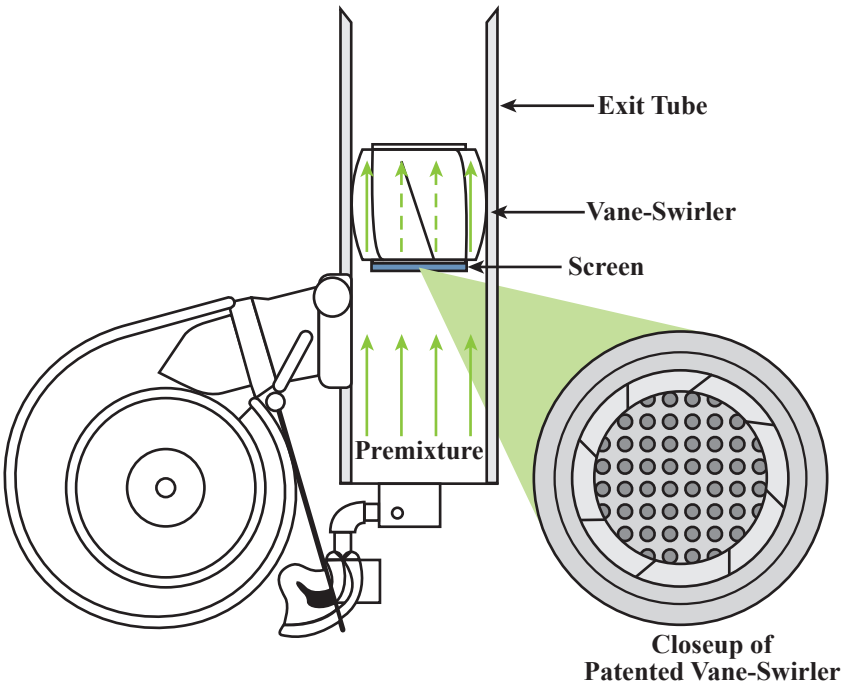
Purifies the process water without adding harmful chemicals commonly used in traditional separators.

Ultra-Low NO_x Premixed Industrial Burner

Reduction of Burner NO_X Production with Premixed Combustion

Industries that are dependant on combustion processes are faced with more stringent environmental regulations to reduce NO_X emissions. Some states require NO_X emissions reductions as great as 90% for chemical and refining industries. The recently developed M-PAKT™ Ultra-Low NO_X Burner uses lean premixed combustion gases and low swirl flow of combustion gases to achieve NO_X emissions levels <10 ppm (an NO_X reduction of 80% to 90%).

The research for this technology originated at Lawrence Berkeley National Laboratory with funding from the DOE Office of Science Experimental Program and ITP. This new burner's distinct characteristic is a detached flame that is lifted above the burner, providing the capability for more complete combustion with less emissions. This burner concept can be applied to a wide range of combustion systems including furnace and boiler applications, gas turbines, and liquid process heaters for the chemical and refining industries. The burner can be operated with natural gas, biomass gas, and pre-vaporized liquid fuels. The burner is scalable and simple in design with no need for costly materials for manufacturing and installation. Maxon Corporation has licensed the technology for industrial process heaters used in many industrial baking and drying ovens. Applications have also been successfully tested in smaller-diameter domestic heater units.



M-PAKT Ultra-Low NO_X Burner Installation

Overview

- Developed by LBNL with two patents issued
- Installed in the U.S. and overseas
- Technology licensed to Maxon Corporation and sold as the M-PAKT burner (www.maxoncorp.com)
- Over 1280 burners estimated to reduce NO_X by over 1.418 million pounds in 2009

Applications

Can be used on a wide range of combustion systems: furnaces and boilers, chemical and refining industry process heaters, and gas turbines

Capabilities

Reduces thermal NO_X in the combustion zone.

Benefits

Adaptability

Burns different gaseous fuel types and blends. Can be scaled to different sizes of units and adapted to different orientations and sizes of various flue configurations.

Low Cost

Offers low cost for manufacturing compared with traditional low NO_X solutions because the components are simple and are made from conventional materials.

Pollution Reduction and Energy Efficiency

Typically reduces NO_X to less than 10 ppm without compromising energy efficiency.

Ultrananocrystalline Diamond (UNCD) Seal Faces

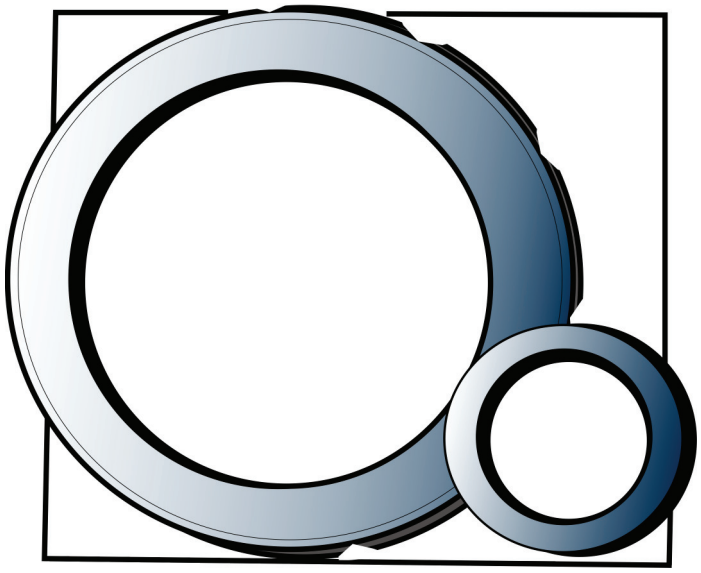
IMPACTS

New Diamond Coatings Reduce Friction and Improve Performance of Mechanical Seals

Mechanical seals are used to reduce friction and prevent product leakage in a variety of industrial rotary equipment such as pumps and mixers. Traditional seal ring pairs employ a hard material such as silicon carbide (SiC) and a soft material such as carbon to achieve the best possible hardness and friction-resistant properties. However, these seals exhibit significant wear in extreme environments such as abrasive slurry pumping. In addition, heat generated from friction between the two ring faces quickly leads to seal failure. An improved material is needed to address these concerns and improve seal performance.

Advanced Diamond Technologies, Inc., with assistance from ITP, has commercialized Utrananocrystalline Diamond (UNCD) technology to improve mechanical seals. Using a patented chemical vapor deposition process, thin UNCD coatings are applied to the seal face of a silicon carbide ring. Unlike commercially available diamond-like carbons, UNCD is a phase-pure (sp3) diamond-bonded carbon. The unique microstructure, comprised of nanometer-sized diamond grains, results in seals with exceptionally low friction, superior wear resistance, and chemical inertness.

UNCD provides a solution for applications requiring a metal-to-metal seal face combination that risks dry run damage. UNCD faces that are paired with silicon carbide have shown tolerance for dry running in conventional ANSI pumps, whereas conventional hard pairs generated so much heat that seal failure quickly occurred. UNCD provides improved wear resistance over SiC, enabling seals to last longer in applications involving abrasive slurries, other erosive environments, or poor lubricating conditions. The exceptionally low friction results in a cooler face temperature, making UNCD suitable for temperature-sensitive media. The chemically inert, corrosion-resistant surface is ideal for handling food and pharmaceutical chemicals where media contamination and the reduction of friction-generated reactions at the seal face are critical.



Advanced Diamond Technologies' UNCD Seal Faces

Overview

- Developed by Argonne National Laboratory, with assistance from John Crane, Inc., and Advanced Diamond Technologies, Inc.
- Commercialized in 2008 and sold by Advanced Diamond Technologies, Inc. (www.thindiamond.com)

Applications

Can be used in a wide variety of industrial pumping applications, especially in harsh environments involving high wear and poor lubrication

Capabilities

- Improves wear resistance compared with silicon carbide seal faces to increase seal life when handling abrasive slurries or other erosive fluids.
- Increases energy efficiency by reducing friction between seal faces.
- Reduces seal face temperature to allow hard faces to be used when pumping thermally sensitive media.

Benefits

Cost Savings

Reduces operation and maintenance costs from process downtime when worn-out seals are replaced.

Durability

Enables dry running of metal-to-metal seal faces where conventional hard seal pairs fail due to excess heat generated from friction.

Versatility

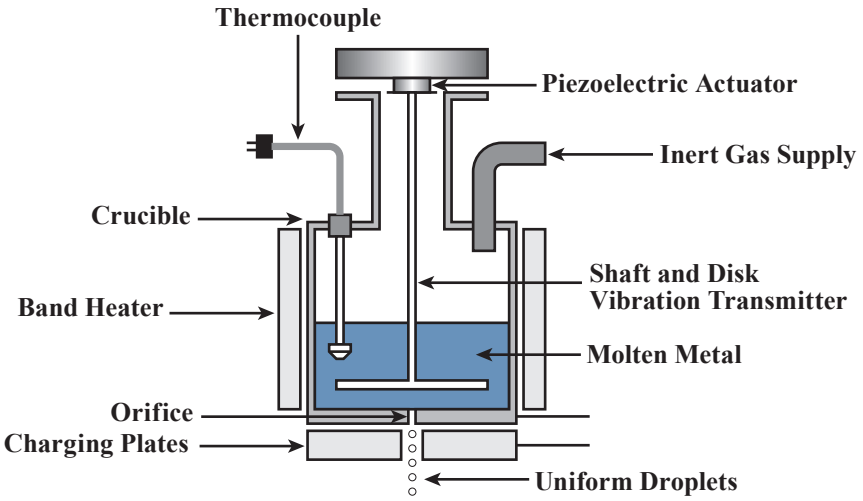
Enables sensitive food, biological, and pharmaceutical media to be handled because of the corrosion-resistant, chemically inert diamond surface.

Uniform Droplet Process for Production of Alloy Spheres

New Process Allows High-Quality Production of Uniform Alloy Droplets

The Uniform Droplet Spray (UDS) process is a nongas atomization process that uses the concept of controlled breakup of a laminar jet to produce uniform alloy droplets with identical thermal histories. This controlled breakup is similar to that used in ink-jet printing technology and produces monosized droplets. The droplets are solidified along a path that produces a desired microstructure. Unlike other methods for producing thermal sprays, the spray parameters in this process are fully decoupled and, therefore, permit materials processing under conditions inaccessible by conventional thermal spray processes.

With support from ITP, Oak Ridge National Laboratory, the Massachusetts Institute of Technology, and Northeastern University have developed this process that is now being commercialized for various applications. With appropriate engineering, novel particulate materials can be produced at reasonably high production rates and low capital and operating costs. Currently, the major commercial use is to produce micro-solder balls for Ball-Grid Array electronics packaging; the balls are used for manufacturing and assembling electronic products.



Uniform Droplet Spray Process

Overview

- Developed by Oak Ridge National Laboratory, the Massachusetts Institute of Technology, and Northeastern University
- Currently licensed to two U.S. and four Japanese firms who are exploring the Ball Grid Array application (www.cooksonsemi.com and www.indium.com)

Applications

Can be used in the integrated circuit packaging industry with potential applications for use as a filtering media in the chemicals and petroleum industries

Capabilities

- Offers high quality production of uniform alloy droplets.
- Saves significant time and energy over traditional methods relying on cutting and milling operations.

Benefits

Product Quality

Produces uniform alloy droplets.

Profitability

Reduces labor costs compared with traditional cutting and milling operations.

Quality Control

Increases quality control because of the consistency of solder ball production.

Uniformly Drying Materials Using Microwave Energy

IMPACTS

System Uses Microwave Energy to Dry Materials Uniformly at Half the Cost and Half the Emissions

Industrial Microwave Systems LLC, with assistance from a NICE[3] grant, successfully demonstrated and commercialized an innovative system that uses microwave energy to dry materials. Traditionally, microwave-drying systems have scorched the portions of materials that were close to the radiation source, while materials further from the source remained moist. This result is due to a primary characteristic of microwave energy—it attenuates as it leaves its point of origin, creating hot spots across the materials being dried. This characteristic has kept microwave drying from becoming the drying technology of choice.

This new technology addresses these traditional problems by using a rectangular wave-guide. This guide is slotted and serpentined to maximize the exposure area of materials as they pass through the system. A number of wave-guides can be cascaded to form a system that dries an entire piece of fabric or other material.

Benefits

Energy Savings

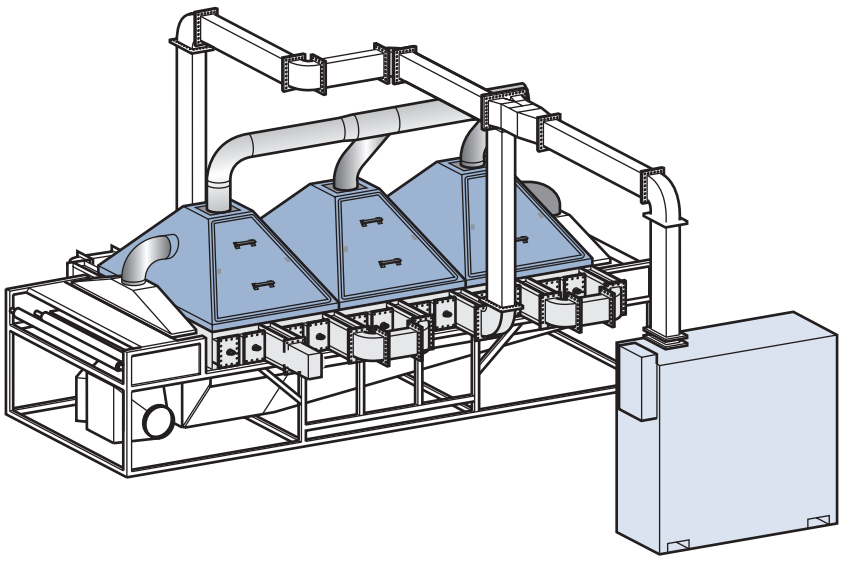
Reduces natural gas heating requirements by 20% to 50%, saving up to 12 billion Btu/year for a typical plant.

Pollution Control

Reduces greenhouse gas emissions by approximately 50%, with 68% of the particulates eliminated.

Productivity and Profitability

Reduces drying stress because of no contact drying and lowers maintenance costs because of fewer movable parts.



Microwave-Drying System

Overview

- Developed by Industrial Microwave Systems LLC (www.industrialmicrowave.com)
- Commercialized in 2000
- Currently operating at 7 facilities in the United States and 3 in foreign countries
- Being tested in five U.S. demonstration units

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.211	0.024

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.001	0.003	0.400

Applications

Can be used in the production of fabrics; agricultural and pumpable food products; industrial filters and insulation; medical dressings; paper products; geotextiles, carpeting, and roofing materials; and personal hygiene products such as diapers

Capabilities

- Provides efficient and uniform drying of materials continuously fed through the drying system.
- Works with existing systems to reduce conventional natural gas or electric drying needs.
- Reduces microwave leakage with the use of choke flanges.

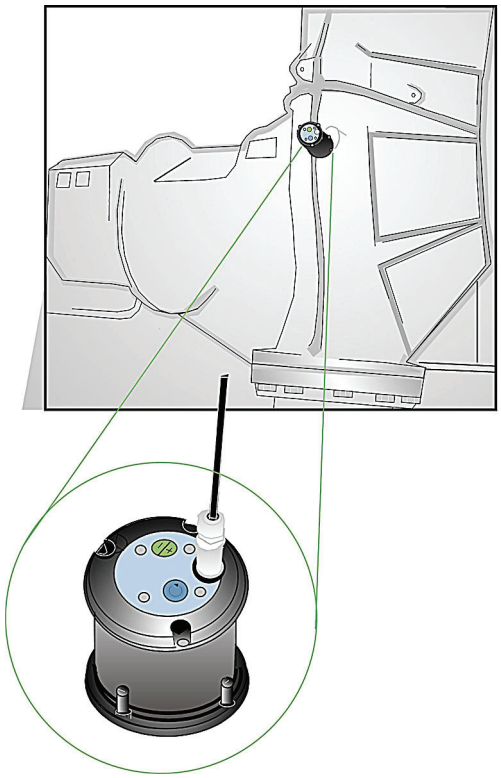
Vibration Power Harvesting

New Technology Captures Freely Available Vibration Energy to Power Wireless Sensors

The industrial market for wireless sensors is growing rapidly but is constrained by implementation costs and compatibility with existing wireless networks. Typical wireless sensors and transmitters depend on batteries, which require periodic maintenance to change the battery. Maintenance costs for battery use in wireless sensor applications are estimated at $80 to $500 per replacement, including labor, which exceeds the sensor's cost.

With assistance from an SBIR grant, KCF Technologies, Inc., has developed vibration power harvesting devices that eliminate the need for battery change. Available as part of KCF's Power Harvesting Demonstration Pack, the device converts vibration energy to regulated DC power, supplying sufficient power to the wireless sensor for up to 15 years without needing any maintenance time or expenses. The technology is not overly sensitive to vibration frequency, amplitude, or other environmental characteristics.

KCF Technologies' innovation was recognized with a "Best of Sensors Expo" Award in 2008. The harvester-powered sensor was honored as one of the most promising and exciting technologies on display out of nearly 200 products at the annual Sensors Expo & Conference in Rosemont, Illinois. These devices are expected to greatly expand the use of wireless sensors throughout U.S. industry.



KCF Technologies' Vibration Power Harvesting Unit Installed on a Large Motor

Overview

- Developed by KCF Technologies, Inc., in 2006 (www.kcftech.com)
- Commercialized in 2007
- Formed strategic partnerships with Johnson Controls, Omega Piezo Technologies, Pennsylvania State University, and RLW, Inc.

Applications

Can be used wherever wireless sensor networks are deployed, including refrigeration and HVAC systems, pulp processing and paper printing, condition-based maintenance, and power generation facilities

Capabilities

- Increases data transmission capabilities for wireless sensors in high-vibration settings.
- Is compatible with existing wireless sensors.
- Enables sensor placement in infrequently accessed locations.

Benefits

Cost Savings

Eliminates downtime and costs associated with battery maintenance.

Safety

Expands sensing capabilities for machinery and equipment to increase safety and security.

Wear Resistant Composite Structure of Vitreous Carbon Containing Convoluted Fibers

IMPACTS

New Composite Material Improves Motorcycle and Automotive Performance and Saves Energy

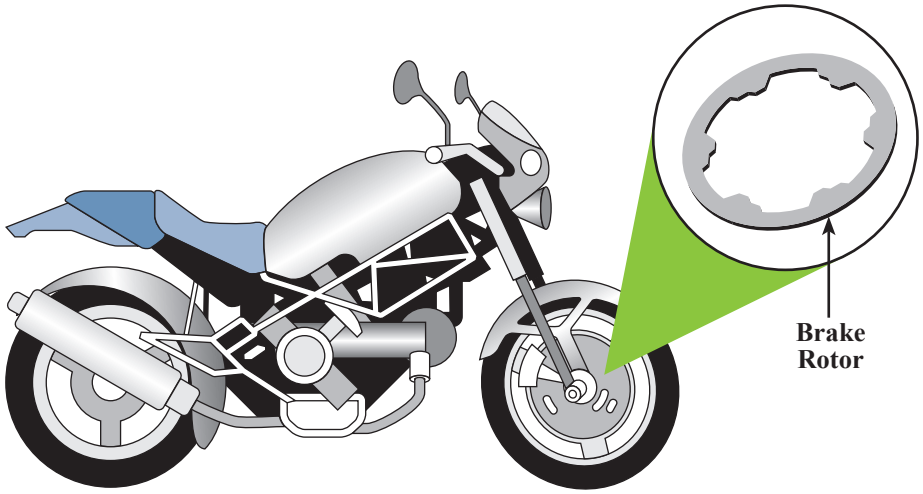
MRCC, Inc., and Starfire Systems, Inc., created a novel method for manufacturing a carbon composite material consisting of a vitreous silicon/carbide matrix containing carbon fibers. The new manufacturing method provides additional strength and applies metal fibers of high-thermal conductivity to aid in processing. The graphite fiber-reinforced ceramic matrix complex (CMC) operates at high temperatures and is resistant to acids, bases, and organic solvents in seal configurations. The final product can be cut into electrical contacts, mechanical seals, brakes, pumps, vanes, engine parts, and implanted prosthetics with better wear resistance, lower fade, and higher electrical conductivity than competing materials.

The funding to develop this technology was jointly provided by the United States Air Force and DOE's Inventions and Innovation Program and was used to test lighter-weight composite material and aircraft brakes. Although Starfire continues to work with the aircraft brake companies, the motorcycle and automotive brake industry has shown stronger interest in the technology. In automotive and motorcycle brakes, the lightweight material reduces the amount of energy required to accelerate the vehicle, reducing fuel consumption, and increasing the acceleration rate. The improved fuel consumption is most noticeable in "stop and go" driving where brakes are continually being applied.

Benefits

Product Quality
Offers unusual wear resistance without lubrication.

Profitability and Productivity
Results in fewer replacements and lower costs due to longer life of the composite material; can use generally available methods to machine the products.



Starfire Systems' Motorcycle Application

Overview

- Developed by MRCC, Inc., and Starfire Systems, Inc.
- Commercialized in 2006 and being marketed by Starfire Systems (www.starfiresystems.com)
- Currently being used in motorcycle and automobile brake rotors

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.007	0.002

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.001	0.0	0.052

Applications

Can be used in the motorcycle and automotive industries and potentially the aircraft and electric rail industries

Capabilities

- Provides metal-reinforced carbon composite that operates at high temperatures.
- Offers resistance to acids, bases, and organic solvents in seal configurations.
- Increases wear resistance, lowers fade, and produces higher electrical conductivity than competing materials.

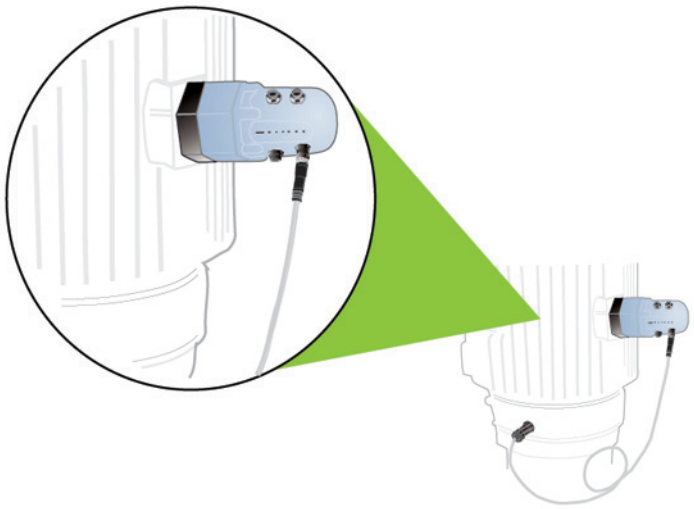
Wireless Sensors for Condition Monitoring of Essential Assets

New Technology Provides Cost Savings and Flexibility for Monitoring Motor-Driven Industrial Equipment

Conventional permanent systems for monitoring industrial electric motor-driven assets (pumps, fans, compressors, etc.) suffer from the complexity and costs associated with running the necessary hardwiring for signal and power. Monitoring is especially difficult in remote locations or areas of a plant where access is hazardous. The traditional alternative to permanent systems is a hand-held portable monitoring strategy. However, using technicians in the field can be both costly and time-consuming and valuable monitoring information can be lost between data collection trips through the plant.

With assistance from ITP, GE has developed a wireless condition monitoring solution to economically monitor the performance of motor-driven equipment assets. The Essential Insight.mesh™ solution contains all the hardware necessary to deploy 16 dynamic points of reliable and secure wireless monitoring throughout a plant and can be expanded to thousands of points throughout a site. A sensor mesh network enabled through wireless sensor interface module nodes provides this rapid deployment and flexibility. Each sensor node supports four input ports that can be any combination of vibration transducers or thermocouples.

The Essential Insight.mesh system allows equipment anomalies to be detected with clear diagnostic messaging. The package allows the user to configure collection rates to obtain information daily for general long-term trending and more often for static data transmissions. Advanced options include the availability of a dual power source for the sensor nodes. Power is available from a battery or from energy harvester technology. Energy harvester technology is an innovative new feature that allows the machine's vibration itself to serve as a power source via a miniature moving-coil generator. In addition, users can select magnetic or conventional threaded mounting studs for the sensor nodes.



Essential Insight.mesh Wireless Sensor Transmitting Data from Critical Motor

Overview

- Developed by GE.
- Commercialized in 2008 by GE Energy (www.ge-energy.com/bentlywireless)

Applications

Can be used across all industries that employ motor-driven process equipment

Capabilities

- Allows the user to configure the rate of data acquisition.
- Allows a greater volume of data to be collected for analysis and interpretation compared with conventional systems.
- Provides information critical to maintaining high productivity and preventing costly equipment failure.

Benefits

Adaptability

Can be powered via battery or energy harvester technology, which uses a machine's vibrations as the power source.

Cost Savings

Reduces outage times and the number of unplanned outages, thereby lowering the costs of these events.

Safety

Increases safety by remotely monitoring assets in areas that are unsafe for humans to enter.

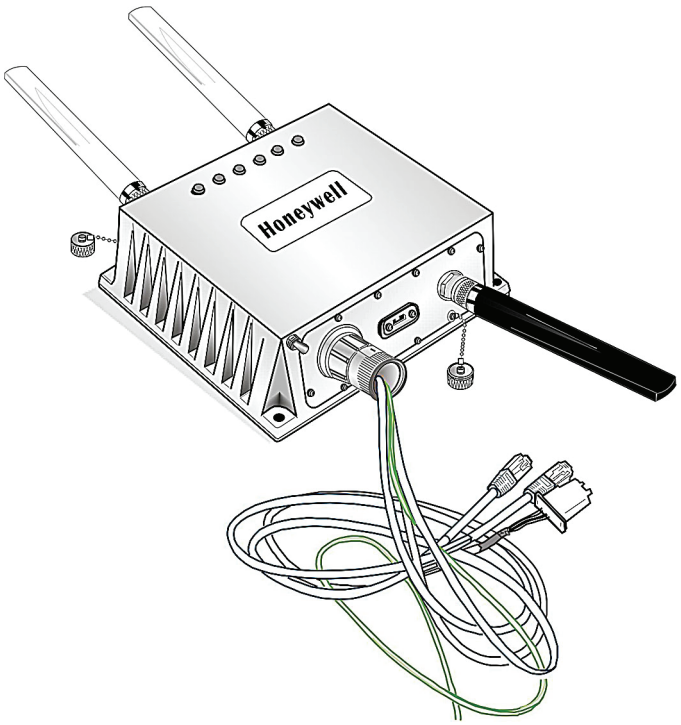
Wireless Sensors for Process Stream Sampling and Analysis

IMPACTS

Advanced New Wireless Sensor Meets Demanding Requirements of Industrial Production Lines

Sensing and controlling manufacturing present unique problems with effective sampling in harsh environments and with real-time control. The demanding requirements of industrial control of manufacturing processes need to be met while maintaining maximum security, battery life, and reliability. Wireless sensors for sampling and analyzing process streams allow monitoring in remote locations, but research is needed to determine how they satisfy the key considerations of operational reliability, sustained performance in harsh environments, invulnerability to interference, security, bandwidth efficiency, and other factors that are critical for the ultimate wide-spread deployment of robust wireless sensor networks in manufacturing.

With ITP support, Honeywell International, through its Wireless Sensors for Process Stream Sampling and Analysis project, developed and successfully commercialized a wireless system that meets all the operational considerations. The critical component of this production line measurement and control system is the Frequency Hopping Spread Spectrum board. In addition to production line measurement and control, the technology's anticipated low cost will enable wireless sensors to be used to determine energy and environmental-related process parameters that are not traditionally monitored. Industrial power and cogeneration plants can use the sensors to balance generation demands, operational efficiencies, and regulatory constraints. By implementing these sensors with advanced energy solutions, plants can reduce heat and power production costs, increase effective boiler operation range, reduce flue gas emissions, optimize production capacity utilization, extend production asset's life, and reduce maintenance.



Honeywell International's Wireless Sensor

Overview

- Developed by Honeywell International
- Commercialized and marketed by Honeywell International in 2007 (www.honeywell.com)
- Sold about 2000 to 4000 units in the United States in 2009

Applications

- Can be used for process control and monitoring in remote locations and for monitoring equipment health

Capabilities

- Provides cost-effective sample validation.
- Is certified for use in hazardous environments.
- Collects additional process and equipment health data.
- Is easily installed.

Benefits

Profitability

Offers low cost and easy deployment, increasing the number of measurements that can be used to improve process efficiency. Minimizes the energy needed to heat or cool down a process resulting in energy and cost savings.

Reliability

Has been tested extensively in severe production environments such as steel mills.

Versatility

Allows remote installation without running additional wires.

Other Industries

IMPACTS

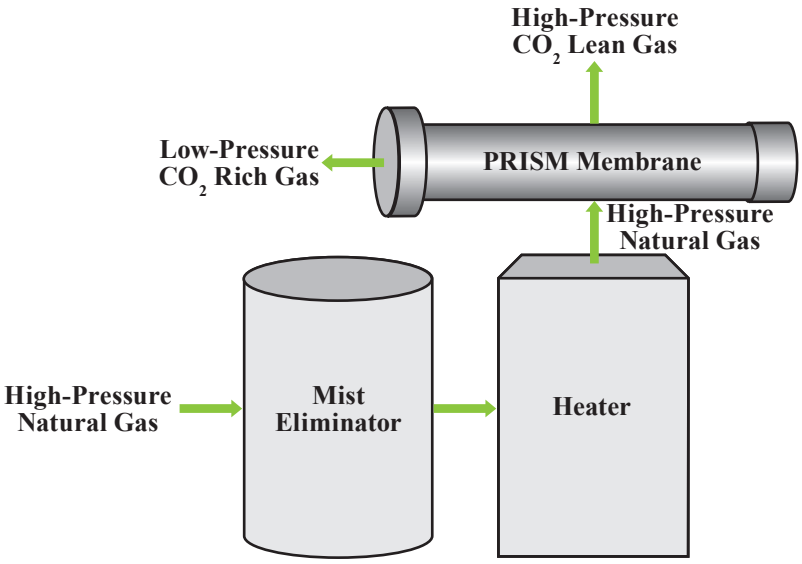
Advanced Membrane Devices for Natural Gas Cleaning

New Membrane Cost Effectively Upgrades Sub-Quality Natural Gas

Carbon dioxide (CO_2) is a common impurity that must be removed in natural gas to improve the gas's heating value or to meet pipeline specifications. Hydrogen sulfide (H_2S) often prohibits natural gas from being used to generate power and drive compressors at remote locations such as oil and gas production sites. Production companies are faced with choosing among shutting in a well, overhauling engines frequently, or dealing with logistical challenges associated with routing other fuels to the site.

With ITP support, Air Products & Chemicals, Inc., through its Advanced Membrane Devices project, developed and successfully commercialized PRISM® membranes for upgrading sub-quality natural gas. These semi-permeable polymeric membranes can be used as gas scrubbers for natural gas, removing CO_2 and H_2S from natural gas.

PRISM membranes, based on simple process designs, provide a low-cost alternative to traditional amine systems that are used to upgrade natural gas. The membranes can also be used as a bulk-removal device to minimize the size of an amine system. The benefits become even more pronounced as the industry produces natural gas from very remote locations. Fuel-gas conditioning systems that incorporate PRISM membranes provide oil and gas production companies with an economical solution to an otherwise often enormous problem. The membrane device can be used to make low-grade natural gas with high CO_2 and H_2S content into a pipeline-grade gas for domestic and industrial consumption.



Example CO_2 Removal Process Using the PRISM Membrane System

Overview

- Developed by Air Products & Chemicals (www.airproducts.com)
- Commercialized in 2001
- 110 CO_2-removal units operating in the United States in 2009

Applications

- Recovers CO_2 from associated gas in enhanced oil recovery programs
- Removes acid gas from natural gas
- Separates nitrogen from air while also yielding an oxygen-rich byproduct
- Separates hydrogen from process gas

Capabilities

Reduces impurities to allow natural gas to meet pipeline specifications.

Benefits

Environmental Quality

Avoids use of any hazardous chemicals such as amines, which can cause environmental complications.

Ease of Installation

Offers lightweight and compact units, thus facilitating their transportation and installation.

Profitability

Is ideal for remote locations with limited utilities and sour natural gas.

Reliability

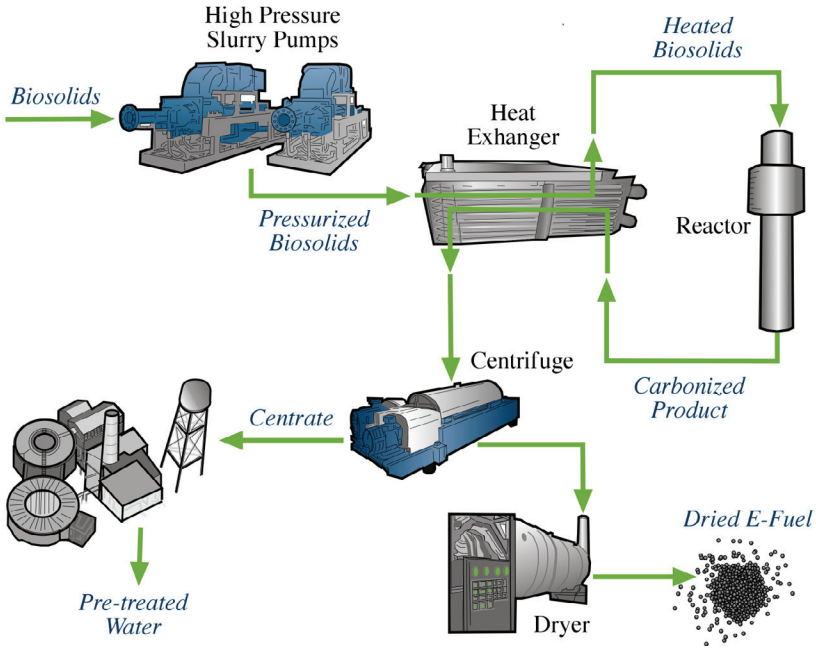
Requires no moving parts, reducing maintenance costs.

IMPACTS

New Process Converts Wet Biosolid Wastes into an Energy-Dense Solid Fuel

The United States annually produces more than 8 million tons of municipal sewage sludge (MSS) and 250 million tons of municipal solid waste (MSW). Much of this waste is sent to landfills, which increases strain on the environment. In addition, the landfilling of waste solids eliminates a source of high-fuel-value feedstock, which could be used to reduce the combustion of fossil fuels. A process is needed to efficiently convert waste biosolids into an energy-dense renewable feedstock.

With assistance from DOE's Inventions and Innovation Program, EnerTech Environmental, Inc., has developed a new method for creating fuels from wet biosolids. The SlurryCarb™ process is a patented technology that converts biosolids into a renewable fuel called E-Fuel. The process subjects biosolids to pressure and heat in an anaerobic environment, breaking the hydrocarbon molecules down into light gases and carbon-rich residual solids. The carbonization process also removes chlorine and slag compounds, resulting in the high-energy, renewable E-Fuel. The solid fuel can be injected with less than 20% excess air into a pulverized coal boiler and is cleaner to burn than most coals. The E-Fuel product is an alternative to fossil fuels and has combustion characteristics similar to lignite or sub-bituminous coal. The fuel has a heating value of 6,500-8,000 Btu/lb in dry form and is suitable for use in cement kilns, gasification and co-firing processes, and coal-fired burners.



Flow Diagram of EnerTech's SlurryCarb Process

Overview

- Developed and marketed by EnerTech Environmental, Inc. (http://enertech.com)
- Commercialized in 2009 at the Rialto SlurryCarb facility in Rialto, California.

Applications

- Can be used to convert MSS, MSW, agricultural products, industrial sludge, animal manure, and other organic materials into a renewable fuel substitute for coal.

Capabilities

- Converts ~ 270,000 wet tons of biosolids per year into ~ 60,000 tons per year of renewable, carbon-rich E-fuel.
- Produces boiler-ready E-fuel with a heating value of 6,500-8,000 Btu/lb in dry form.
- Integrates with current wastewater treatment systems or operates as a standalone facility.

Benefits

Emissions Reductions

Uses carbon sequestered by living plants and human-generated waste, thereby recycling CO_2 and producing nearly zero net greenhouse gas emissions.

Waste Reductions

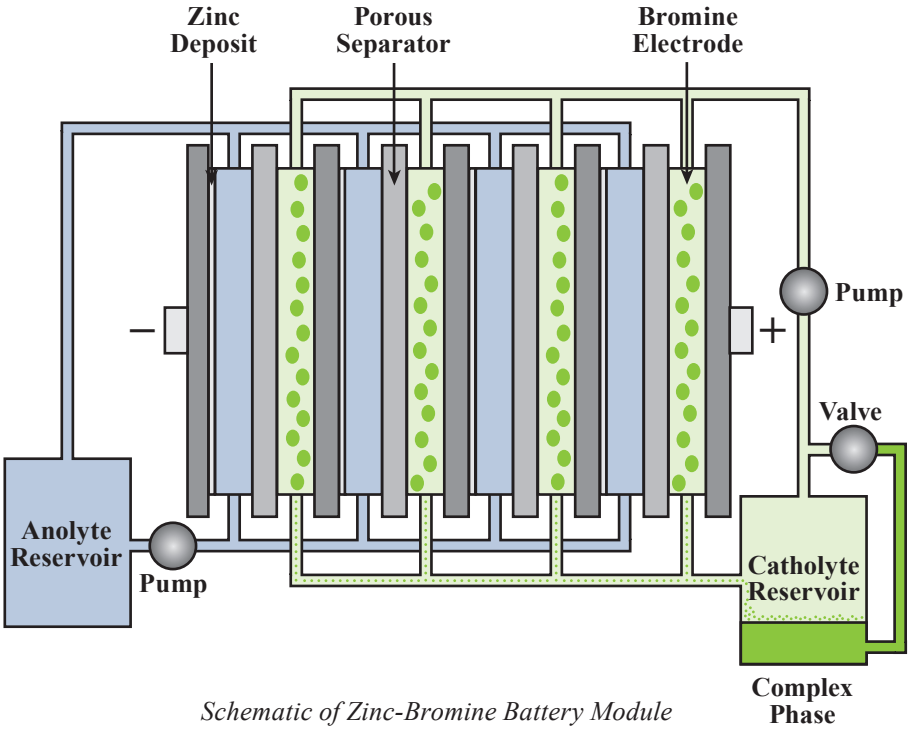
Reduces the amount of municipal, industrial, and agricultural waste sent to landfills.

Deep Discharge Zinc-Bromine Battery Module

Long-Lasting Electrical Energy Storage Module Allows Off-Peak Power Generation

Electricity consumption during peak demand can overload utilities, forcing them to acquire more generation, transmission, and distribution capacity to meet customer demand. Also, the available generation, transmission, and distribution capacity is not fully used most of the time because peak loads need to be met even though the amount of time they are used is limited. Equipment running at low loads (less than full capacity) is less efficient. ZBB Energy Corporation, with financial assistance from DOE's Inventions and Innovation Program and another EERE Program, has developed a longlasting, high-energy density zinc energy storage system (ZESS) module that can store energy generated during off-peak hours for use during peak hours. This provides the additional capacity during peak times without adding new generation, transmission, and distribution infrastructure and increases the overall operational efficiency of the complete electrical system or industrial plant.

The ZESS regenerative fuel cell consists of an electrochemical reactor through which electrolyte is circulated from external storage tanks and where the electrodes do not take part in the chemical reaction and thus are not degraded or consumed over time. Power characteristics of the ZESS can be modified by changing the electrolyte composition. The ZESS is made from cost-competitive materials, which reduce manufacturing and disposal costs compared with traditional battery types. The battery modules offer up to 3 times the energy density of lead-acid batteries. They can be 100% discharged thousands of times with minimal degradation of round-trip charge/discharge efficiency. The capacity rating of a ZESS battery module remains constant over the service life (20+ years), but the charge required to achieve the rated capacity degrades consistently (1 to 2% efficiency loss/year) with typical (daily) usage. The 'active electrode' layer in the cell stacks is what 'wears out' requiring the periodic (5+ year) replacement of the module's cells stacks.



Schematic of Zinc-Bromine Battery Module

Overview

- Developed by ZBB Energy Corporation (www.zbbenergy.com)
- Commercialized in 2006

Applications

Can be used for power control and energy storage in renewable and remote-area power systems.

Capabilities

- Allows storage of off-peak electricity for use during peak hours.
- Achieves up to 100% battery discharge with no damage.
- Achieves shorter recharge times; 4 to 5 hours vs. 8 to 12 hours for lead-acid battery.

Benefits

Adaptability

Adapts to various system configurations to suit application; 25 MW to 2 MW power output and 50 MWh to 8 MWh energy storage capacities.

Cost Savings

Achieves cost savings by eliminating liquid fuel use off-grid or during grid outages, by integrating renewable power sources or stored off-peak power to supplement power demand during peak hours.

Operation and Maintenance

Requires no maintenance and can be fully discharged indefinitely with no damage.

Pollution and Waste Reduction

Requires only the recyclable cell stack to be replaced which eliminates disposal and cost concerns that are associated with lead-acid batteries.

High-Intensity Silicon Vertical Multi-Junction Solar Cells

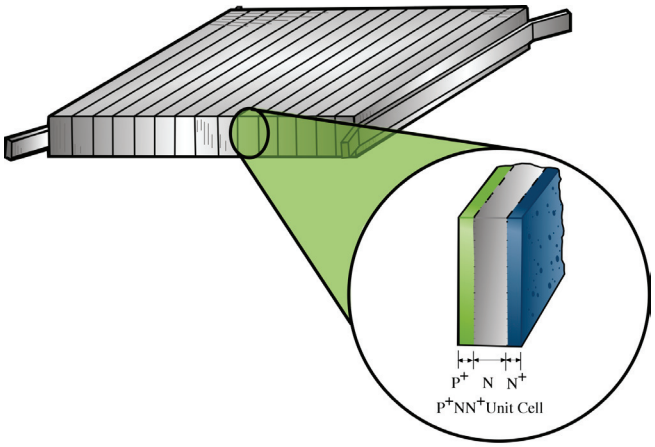
IMPACTS

Improved Solar Cell Reduces Cost of CPV Systems

Solar photovoltaic (PV) technologies accounted for less than 1% of the nation's energy supply in 2009, despite their environmental benefits compared with electricity generation from combustion of fossil fuels. The high capital cost and low efficiency of PV systems are key barriers that prevent the technology from being widely adopted. Conventional flat PV panels also require large surface areas to generate a significant amount of electricity, making them less desirable in applications where ground or rooftop space is limited.

The efficiency and cost of solar PV can be improved with concentrating photovoltaic (CPV) systems, which use mirrors or lenses to concentrate sunlight on the solar cells. To maximize the cost-effectiveness of CPV systems, the solar cells must be low-cost, durable, and designed to perform well under high sunlight intensity. With assistance from DOE's Inventions and Innovation Program, GreenField Solar Corporation developed the PhotoVolt™ solar cell for use in its StarGen™ CPV system. The PhotoVolt is a series-connected array of silicon unit cells with vertical junctions and contacts. This configuration optimizes current collection and minimizes sheet resistance, current crowding, and blockage of illumination. The PhotoVolt has an extremely durable electrical, thermal, and mechanical configuration, which enables high packing densities with easy interconnecting of electrical output leads in high-power-density systems. The series connection of silicon unit cells provides high-voltage, low-current operation for optimum compatibility with most power processing loads. An active cooling system in the StarGen solar concentrator removes heat from the PhotoVolt cells, thereby increasing cell efficiency and capturing solar thermal energy.

Designed for operation at high intensities, the PhotoVolt uses 1/1000th of the silicon semiconductor used in conventional flat PV panels for a given power output. This innovation significantly reduces both the installed price and levelized cost of electricity of solar energy systems. The PhotoVolt cell's design simplicity and use of widely available silicon (instead of other semiconductor materials) enables high-volume production at low cost.



GreenField Solar Corporation's PhotoVolt Solar Cell

Overview

- Developed and marketed by GreenField Solar Corporation. (http://greenfieldsolar.com/)
- Commercialized in 2009 with 15 U.S. commercial installations.

Applications

Can be used to provide electrical and thermal energy for utilities and large commercial applications.

Capabilities

- Produces up to 1.5 kW of electricity and 15,000 Btu/hr of thermal energy per StarGen system.
- Uses a sun-tracking parabolic array of mirrors to concentrate high-intensity sunlight on PhotoVolt cells.
- Operates at a sunlight intensity of 300 to 900 times greater than conventional flat PV panels.
- Facilitates use of "dense array" CPV design approach by offering side contacts and high-voltage output, and avoiding the need for bypass diodes.

Benefits

Cost Savings

Reduces costs by using 1/1000th of the silicon semiconductor used in conventional flat PV panels for a given power output.

Emissions Reductions

Reduces consumption of electricity generated from combustion of fossil fuels.

Versatility

Can be used in ground-mounted and roof-mounted deployments.

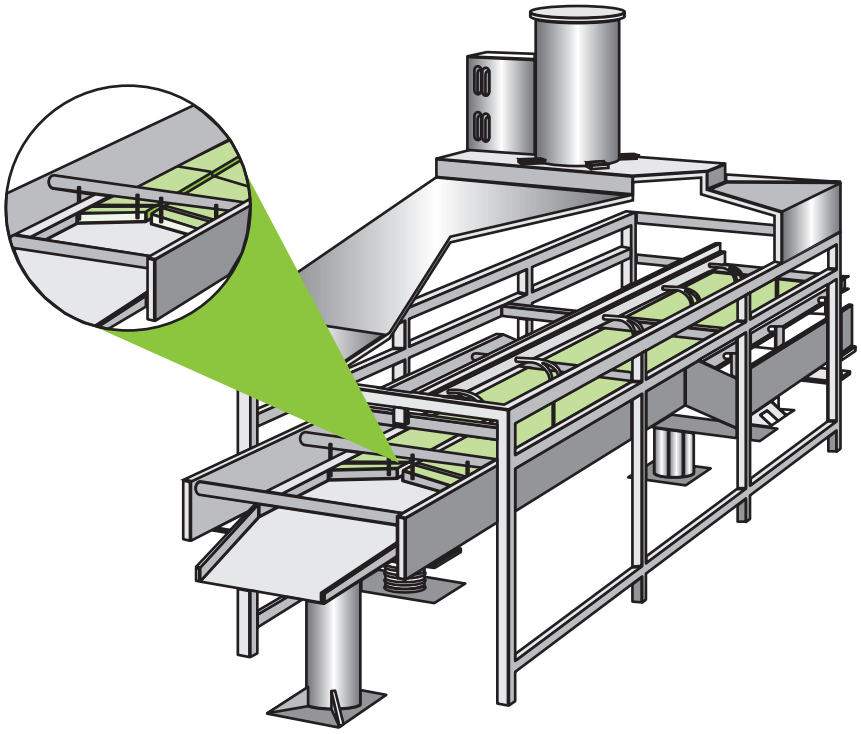
Long Wavelength Catalytic Infrared Drying System

New Infrared Drying System Removes Moisture More Efficiently Without Heating Surrounding Air

Conventional drying systems for wood particulates, typically in the form of sawdust or chips, currently employ a rotary drum dryer that shoots a raw flame through a 20' to 30' rotating drum while tumbling the wood product. Product scorching and air emission problems, particularly with carbon, NO_X, and volatile organic compounds (VOCs), are prevalent because the rotary drum operates at up to 1,000°F.

An infrared drying system was developed by Catalytic Drying Technologies, Inc. (CDT), with the support of a DOE NICE^3 grant. The long wavelength catalytic infrared drying system uses infrared energy from 3 to 7 microns to transfer energy directly to the water, activating it to a gaseous form at temperatures from 135°F to 220°F. Highly efficient and tightly controlled infrared radiant energy is delivered to the product as it travels along a conveyor engineered to uniformly expose the product to the radiant energy.

A large prototype unit was constructed and tested with sawdust, wood chips, and a variety of agricultural products. The CDT system was proven to dehydrate forest and agriculture products efficiently. A conveyance system distributes the product evenly throughout the dryer to achieve consistent drying. While equipment costs are comparable to conventional heating systems, life-cycle costs are reduced. However, the CDT system can greatly reduce drying/heating times using flameless catalytic infrared energy, resulting in smaller equipment or more throughput (or both). Reducing the moisture content with infrared drying by transferring energy directly to the moisture instead of heating the air and surrounding metal structure requires less energy, reduces air emissions and dries the product more thoroughly than conventional drying.



Catalytic Infrared Drying System

Overview

- Developed and marketed by Catalytic Drying Technologies, Inc. (www.catalyticdrying.com)
- Commercialized in 2005
- Two units operating in the U.S. in 2009 in a rice drying facility and a powdered egg production plant

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.012	0.003

U.S. Emissions Reductions

(Thousand Tons, 2009)

Particulates	SO_x	NO_x	Carbon
0.0	0.0	0.0	0.046

Applications

Can be used by various industries such as forest products, agriculture, chemical processing, brewing and distilling, animal products, and horticulture

Capabilities

- Uses infrared energy from 4 to 7 microns to transfer energy directly to water.
- Drives off water at temperatures from 135°F to 220°F.
- Avoids the need for direct flame, which could damage the product.

Benefits

Cost Savings

Reduces operating and life-cycle costs compared with conventional dryers.

Productivity

Reduces residence time in the dryer and the amount of scorched (wasted) product.

Plant Phenotype Characterization System

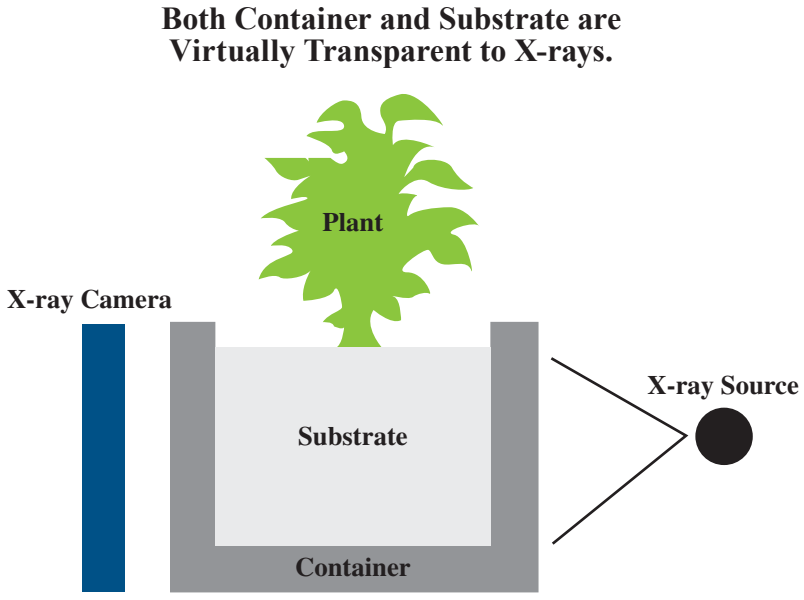
IMPACTS

New X-Ray Technology Accelerates Plant Research

The ability to analyze plant root structure and function in a timely, cost-efficient manner is critical to meeting DOE Biomass Program goals. Plant root characterization technologies traditionally cannot handle high throughput. Additionally, it has been difficult to analyze the same plant more than once due to destructive analysis methods.

With funding from DOE's Inventions and Innovation Program, the Phenotype Screening Corporation has developed a high-throughput, high resolution, and non-destructive system to image and characterize plant roots. The effect of the application of this technology will be to accelerate progress in a wide range of genetic improvement programs, including biomass feedstock (poplar, switchgrass, corn, and soybeans). Research acceleration may produce overall improvements in the range of 30%.

The system is based on low-voltage digital x-ray radiography, used with special growth substrate material, plant containers, and image processing algorithms. Low-density polymer substrates and containers are used because they are suitable for low energy x-ray radiographic imaging. The project will primarily enable "output trait" and "value-added trait" improved products.



Non-Invasive Root Characterization System

Overview

- Developed by Phenotype Screening Corporation (www.phenotypescreening.com)
- Commercialized in 2006
- Used by universities and other research organizations

Applications

Can be used in noninvasive root characterization studies to compare different plants' growth or a single plant's growth over time. Stressors may be introduced to see how the plants react; detailed analysis and characterization can show traits that can't be seen by the unaided eye.

Capabilities

- Allows detailed plant root measurements without destroying the plant.
- Can be customized to allow varied studies.

Benefits

Productivity

Accelerates research by about 30%, contributing to reduced research time and costs, and therefore higher productivity.

Waste Reduction

Allows measurements to be made on the same plant so fewer plants have to be grown to conduct an analysis, using less growing medium, water, and plant containers.

Plastics or Fibers from Bio-Based Polymers

Plastics from Renewable Resources Offer Significant Commercial and Environmental Benefits

Each year, 60 billion pounds of thermoplastics are produced from imported and domestic oil to make industrial and consumer products. Because oil is an increasingly limited resource with negative impacts on the environment, reducing dependence on oil in all areas is important, including product manufacturing.

Polylactide (PLA), derived from annually renewable bio-based resources, can be used in place of petroleum-based thermoplastics in many applications such as compostable packaging, film, and fibers for apparel, carpeting, and other fabrics while greatly reducing CO_2 emissions. With financial assistance from ITP, the National Renewable Energy Laboratory (NREL) along with Cargill Dow LLC and the Colorado School of Mines, developed and refined a process to use PLA in manufacturing. Substituting PLA for petroleum-derived polymers reduces fossil energy use by 62% to 68%. Projections are that 10% of the U.S. nonrenewable plastics packaging can be replaced with polylactide polymer.

This project assisted in expanding the PLA market by developing two new processing technologies. Both technologies yield semi-crystalline PLA particles that have improved physical properties. Other project tasks helped to better understand the relationship between polymer molecular structure and physical properties, which is useful information for improving process control.

Benefits

Energy Savings and Pollution Reduction

Consumes up to 68% less energy in the form of fossil resources compared with producing products from petroleum. Emits less CO_2 than petroleum-based products because the carbon comes from plants that extracted CO_2 from the atmosphere.

National Security

Reduces the nation's dependence on foreign resources and oil to produce necessary products such as clothing, food packaging, and carpets.

Overview

- Developed by NREL with Cargill Dow LLC and Colorado School of Mines
- Commercialized in 2003
- Produced at Nature Works LLC's Blair, NE facility with a capacity of 300 million pounds per year (www.natureworksllc.com)

U.S. Energy Savings

(Trillion Btu)

Cumulative through 2009	2009
0.124	0.018

U.S. Emissions Reductions

(Thousand Tons, 2009)

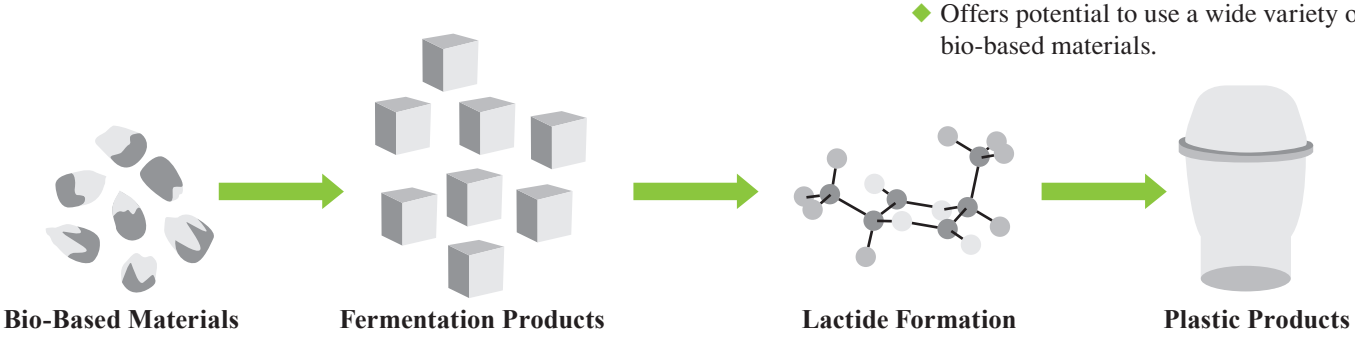
Particulates	SO_x	NO_x	Carbon
0.0	0.011	0.003	0.394

Applications

Can be used by plastics and textile industries, replacing certain packaging, films, and fibers used for apparel, carpeting, and other fabrics

Capabilities

- Competes in a market based on price and performance, with a better environmental profile than today's plastics.
- Currently could replace 10% of packaging with PLA, with more research being conducted to infiltrate the market further.
- Offers potential to use a wide variety of bio-based materials.



Process for Producing Plastic Using Renewable Resources