
NREL H2/FC Manufacturing R&D Workshop

Automation Status

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Presentation Overview

- Brief Introduction
- DOE / NREL – Review & Discussion
- Automation Platforms
- Automation Processes
- Automation Considerations of the Manufacturer
- Manufacturer and the Supplier
- Three (3) Automation Programs Following these Guidelines
 - Automotive Component Manufacturing
 - Medical Manufacturing
 - Membrane Electrode Assembly Manufacturing
- Hypothetical Fuel Cell Manufacturing Platforms

Professional Bio

- Automation Technician – Mobil Chemical
- Senior Applications Engineer – Allen Bradley
- Regional Sales Manager – Hansford Manufacturing
- Sales Manager – Progressive Machine and Design (PMD)
- Independent – SPERK LLC

- BS – Mechanical / Industrial Engineering - RIT
- MS – Computer Integrated Manufacturing – RIT
- Robotics Industries Association (RIA) Member
 - Membership Committee member

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Fuel Cell

Proton Exchange Membrane (PEM) and Solid Oxide Fuel Cell (SOFC) Manufacturing Lines and test equipment that include the following processes:

- Laser Cutting and Welding
- Web Handling – Roll to Roll
- Electrode Thickness Measurement
- Annealing
- Die Cutting and Temperature Welding
- PEM Test Stands
- Solid Oxide Fuel Cell (SOFC) Test Stands
- Membrane Stacking

Battery

Advanced and traditional battery manufacturing, assembly and test systems that include the following processes:

- Ultrasonic Welding
- Battery Filling and Electrical Performance Test
- Laser Welding
- Tab Forming
- Soldering and Lead Trimming
- Automated Dispensing
- X-ray



Wind

PMD has built components for the wind industry focused in the following areas:

- Blade Manufacturing
- Tower component design and detailing
- Tower component machining and fabrication
- Tower component assembly tools and fixturing for sub-assembly
- Automated welding cell for high volume components

Solar

PMD has Solar process experience in the following areas:

- High precision multi-part solar assemblies
- Chip Placement – high speed and high precision
- Curing
- Flat glass material handling
- Assembly Material Handling
- Electrical connectivity
- Final assembly

DOE / NREL – Review & Discussion

- Discuss the status of automation for fuel cell systems and component manufacturing.
 - Pick and Place
 - Semi-continuous
 - Continuous / Automated
- **Fuel Cell Manufacturing is not much different than other assemblies or products being manufactured today.**
- **Manufacturing platform (material handling and integrated processes) is highly dependant on the needs of the Manufacturer.**

DOE / NREL – Review & Discussion

Obtain the recommendations of fuel cell manufacturers for accelerating and driving down the cost of fuel cell manufacturing through automation.

- What are the key technical or process barriers that inhibit adoption of highly automated production methods?
- What specific process or automation technologies, if any, should the Department of Energy focus on to assist in decreasing cost and increasing quality of these fuel cell systems?
- **Make all Fuel Cells the same.....Standardization of designs and common materials**
- **Working with manufacturing experts who will help develop cost effective automation solutions, that will meet current production needs, are scalable and flexible.**

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- Lean Cells

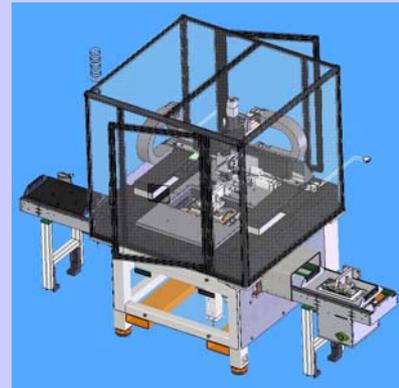


Automation Platforms

- Cam Driven Chassis



- Robotic Systems



Automation Platforms



- Indexing Dials



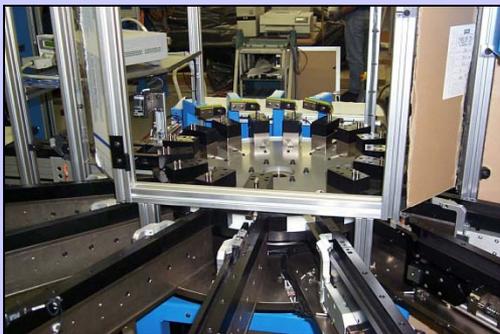
- Power and Free Conveyors



- Web Handling Systems



Automation Processes



Automation Considerations of the Manufacturer

- Production Volumes (short term and long term)
- Program Timeline
- Product Migration
- Manufacturing Locations
- Areas of Risk or Process Concerns
- Assemble the Manufacturing Team (inclusive of R&D, Manufacturing, Operations, Safety, Procurement)
- Develop a Budget

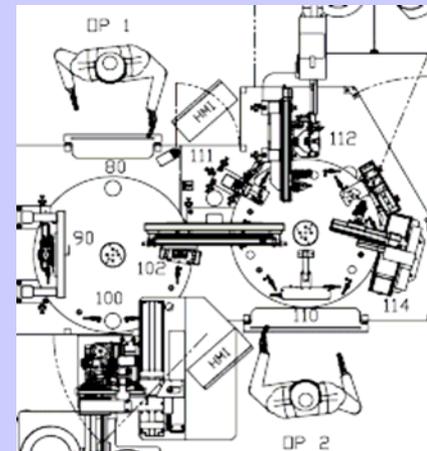
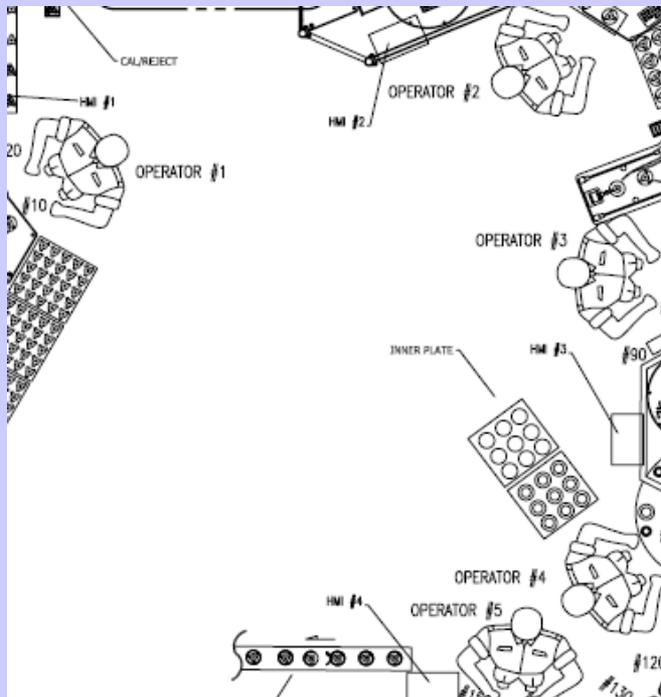
Manufacturer and the Suppliers

- Bring what information you have, and more importantly, share what you don't know.
 - Drawings
 - Parts
 - Processes (tested and untested)
 - Quality and Reliability
- Work to find a partner.....not always the lowest price
 - Who has experience with various automation solutions and processes
 - Who can help minimize handoffs and reduce dedicated tooling
 - Leverage relationships with process component providers
- Test the supplier
 - Ask for supporting documentation
 - Risk Mitigation - Proof of Process (PoP)
 - Visit the supplier during the PoP
- Sign on with the Supplier with long term interests in mind.

Automotive Component Manufacturing

- Product was still in design while system was being designed
- PoP activities were completed by customer
- Sacred materials and assembly processes defined and agreed upon
- Quality and reliability requirements dictated process solutions (press force and distance)
- Three (3) models ran on first system, Eight (8) models in total to date
- Volume projections low for first two years
- Significant increase in volumes 3+ years
- Initial System was the Automation Platform that future models would be built on
- Secured firm pricing for process equipment for two years (three programs)

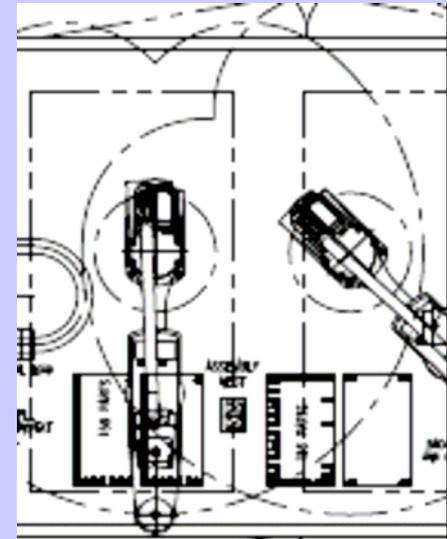
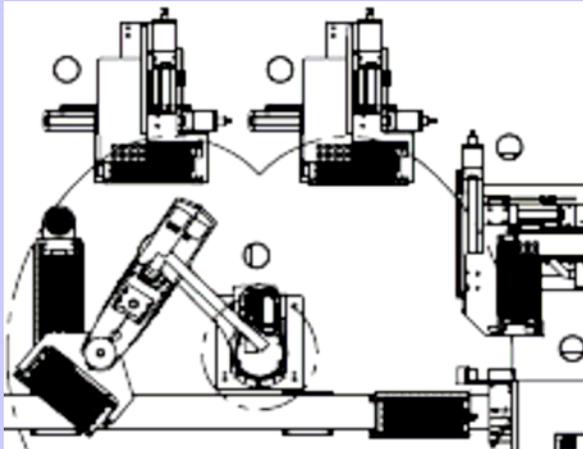
Automotive Component Manufacturing



Medical Manufacturing

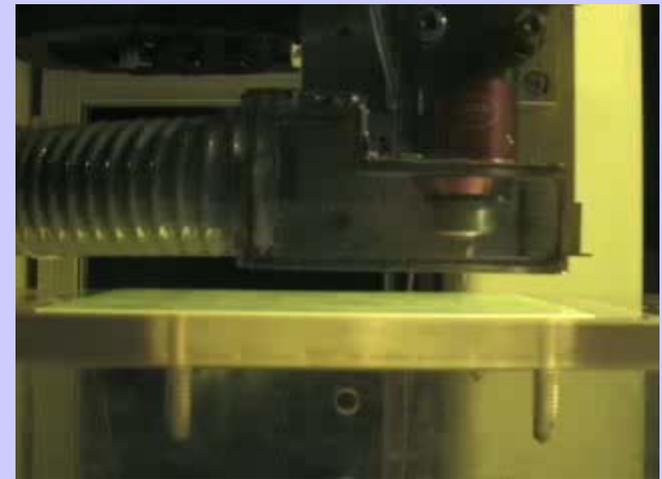
- Two (2) Proof of Process Activities for Risk Mitigation
 - PoP #1 – Confirm the proposed solution would work
 - PoP #2 – Confirm proposed cycle time, preliminary tooling design and incoming part formats
- Worked with chosen robot supplier for consignment (FREE) robot for PoP activity
- Robot manufacturer simulated robot motions and performed cycle time analysis of all robots.

Medical Manufacturing



Membrane Electrode Assembly Manufacturing

- Great example of doing it right
- Proof of Process Activities for Risk Mitigation
- Detail User Requirement Specification

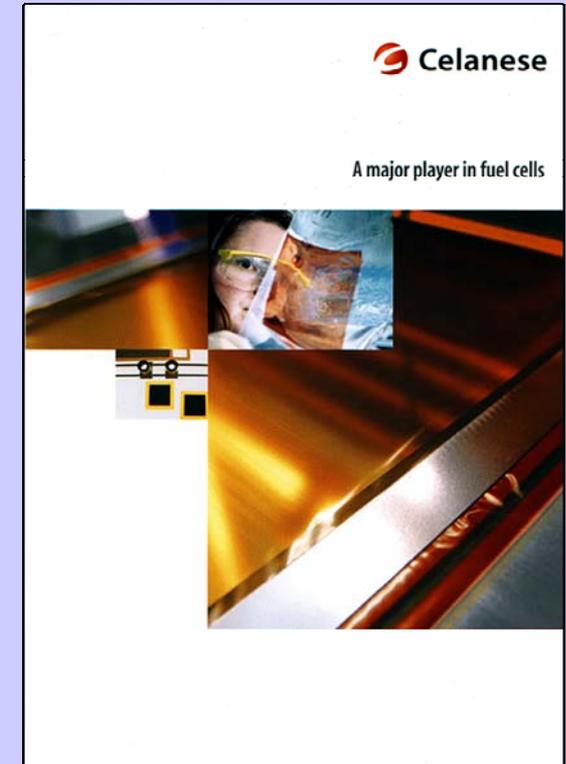


Membrane Electrode Assembly Manufacturing



First Automated Pilot Plant

- Commissioned in Frankfurt Germany 2002



Membrane Electrode Assembly Manufacturing



Second Automated Manufacturing Line

- Commissioned in Somerset New Jersey 2009



BASF Opens State-of-the Art Production Facility for Fuel Cell Components in Somerset, New Jersey

May 6, 2009

Fuel cell technology enables the efficient and alternative energy supply for numerous consumer products and applications.

FLOHAM PARK, N.J. (May 6, PRNewswire) – Fulfilling its leadership position in the development of energy management solutions, BASF today announced it has officially opened its BASF Fuel Cell production facility in Somerset, New Jersey. The modern facility uses advanced production and automation technologies to fabricate ready-to-use high-temperature Membrane Electrode Assembly (MEA) units – the heart of the fuel cell. In a MEA, hydrogen and air react to water generating electrical power and heat. The proprietary and innovative BASF products are marketed under the brand name Celtec(R) and will enable the fuel cell industry to meet the current and growing challenges of future energy supply.

BASF's tradition of materials innovation and commitment to sustainable development continues with this advancement from BASF Fuel Cell. The novel MEA developed by BASF is opening new horizons for system builders as it contains the world's first commercially available high temperature membrane for fuel cells that allows operating temperatures in the range of 320 to 380 F (160-200 degrees C). This innovation, with the unique ability to run without any humidification, has therefore a considerable advantage over other Polymer electrolyte membrane (PEM) fuel cell technologies, including a far simpler system and tolerance to impurities in hydrogen and air.

Celtec(R) high-temperature MEAs are used in numerous product applications, e.g. private home electricity and heat supply units providing electricity and hot water at unprecedented efficiencies or backup-systems to ensure electrical power.

"BASF has made a decisive breakthrough in fuel cells with the development of the high-temperature MEA," said Dr. Andreas Klemmer, Research Executive Director and Member of the Board of Executive Directors of BASF at the inaugural event. The aim of the world-class Somerset, New Jersey facility is to meet the current and growing demand from customers. Future enhancements and refinements of BASF's proprietary MEA product in conjunction with system developments by our alternative energy partners will make fuel cell energy realistic, affordable and widely available.

The most immediate challenge facing developers is to develop a highly reliable and cost-effective fuel cell system for practical applications. The key factor in achieving this is for the system to have as few components as possible. Conventional low-temperature fuel cell systems, which operate at a maximum of 115 F (30 degrees C) need a large number of ancillary units, a complex control and hydration system as well as a reformer with a hydrogen gas purification unit to function. Fuel cells equipped with BASF's high-temperature Celtec(R) MEA are tolerant to impurities in the hydrogen gas; they can be cooled by the air and do not have to be hydrated with water. This eliminates the need for air humidifiers, water pumps, sense valves and cleaning systems.

"Thanks to the proprietary Celtec(R) MEA from BASF, fuel cell systems now need substantially fewer components and this translates into cost savings for our customers," said Dr. Horst-Tore Land, CEO, BASF Fuel Cell, Inc. The development of the high-temperature MEA enables our customers to manufacture commercially viable fuel cell products.

About BASF Fuel Cell GmbH

BASF Fuel Cell GmbH is a supplier of materials for fuel cells and reformers. The company is a leading supplier for high-temperature membrane electrode assemblies, developed and commercialized in the Celtec(R) product line. Additionally, a broad variety of catalysts for fuel cells and reformers is covered by the product line Selectra(R). BASF Fuel Cell continues the fuel cell activities of BASF, Engender and PEI(EA). For further information go to www.basf-fuelcell.com

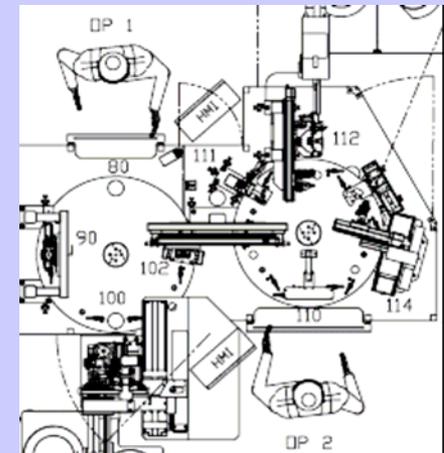
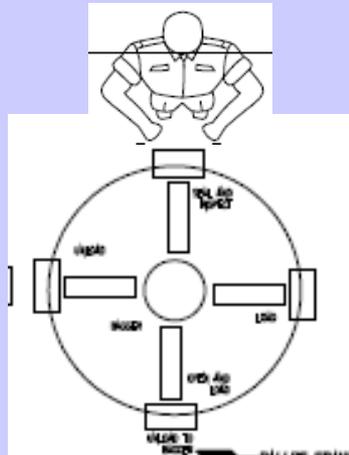
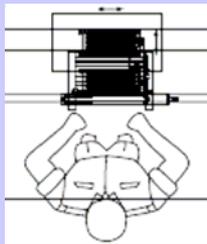
BASF - The Chemical Company: We don't make a lot of the products you buy. We make a lot of the products you buy better.(R)

BASF Corporation, headquartered in Floham Park, New Jersey, is the North American affiliate of BASF SE, Ludwigshafen, Germany. BASF has more than 13,000 employees in North America, and had sales of approximately \$11.5 billion in 2008. For more information about BASF's North American operations, or to sign up to receive news releases by e-mail, visit www.basf.com/na

BASF is the world's leading chemical company. The Chemical Company's portfolio ranges from chemicals, plastics and performance products to agricultural products, fine chemicals, as well as oil and gas. As a reliable partner, BASF helps its customers in virtually all industries to be more successful. With its innovative products and intelligent solutions, BASF plays an important role in finding answers to global challenges, such as climate protection, energy efficiency, nutrition and mobility. BASF has approximately 37,000 employees and posted sales of more than euro 62 billion in 2008. BASF shares are traded on the stock exchanges in Frankfurt (BSE), London (BFA) and Zurich (ZAX). Further information on BASF is available on the internet at www.basf.com

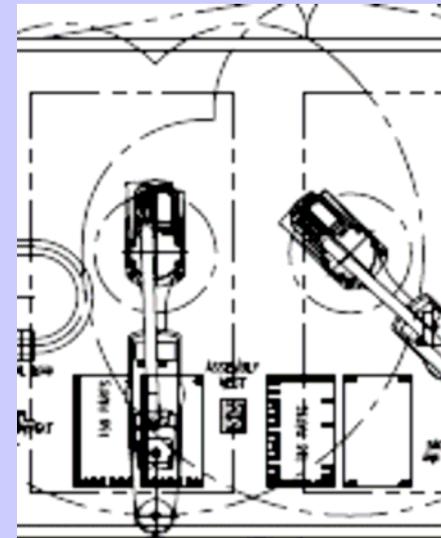
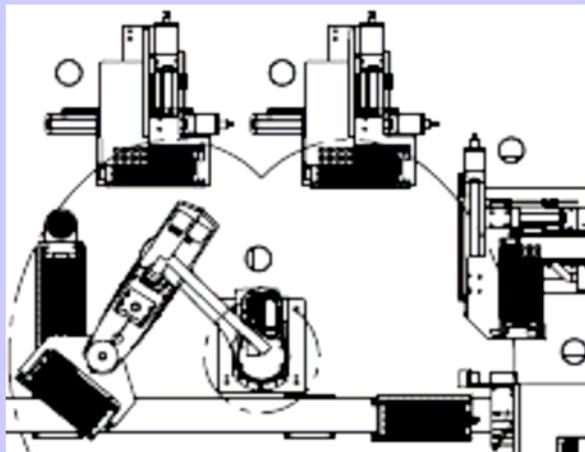
Hypothetical Fuel Cell Manufacturing Concepts

- Stacking – low model mix



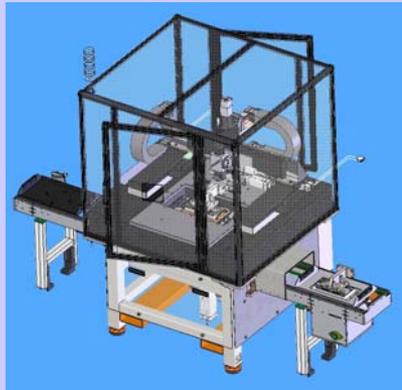
Hypothetical Fuel Cell Manufacturing Concepts

- Stacking – high product mix



Hypothetical Fuel Cell Manufacturing Concepts

- Stack Assembly



Thanks for listening.

Got Questions?

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