

**Leveraging First Generation
Bioethanol Production
Workshop**

Ames Laboratory

September 25th & 2016, 2019

SüPR·2G

**Biomass Pretreatment
Reactors**

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Brief introduction



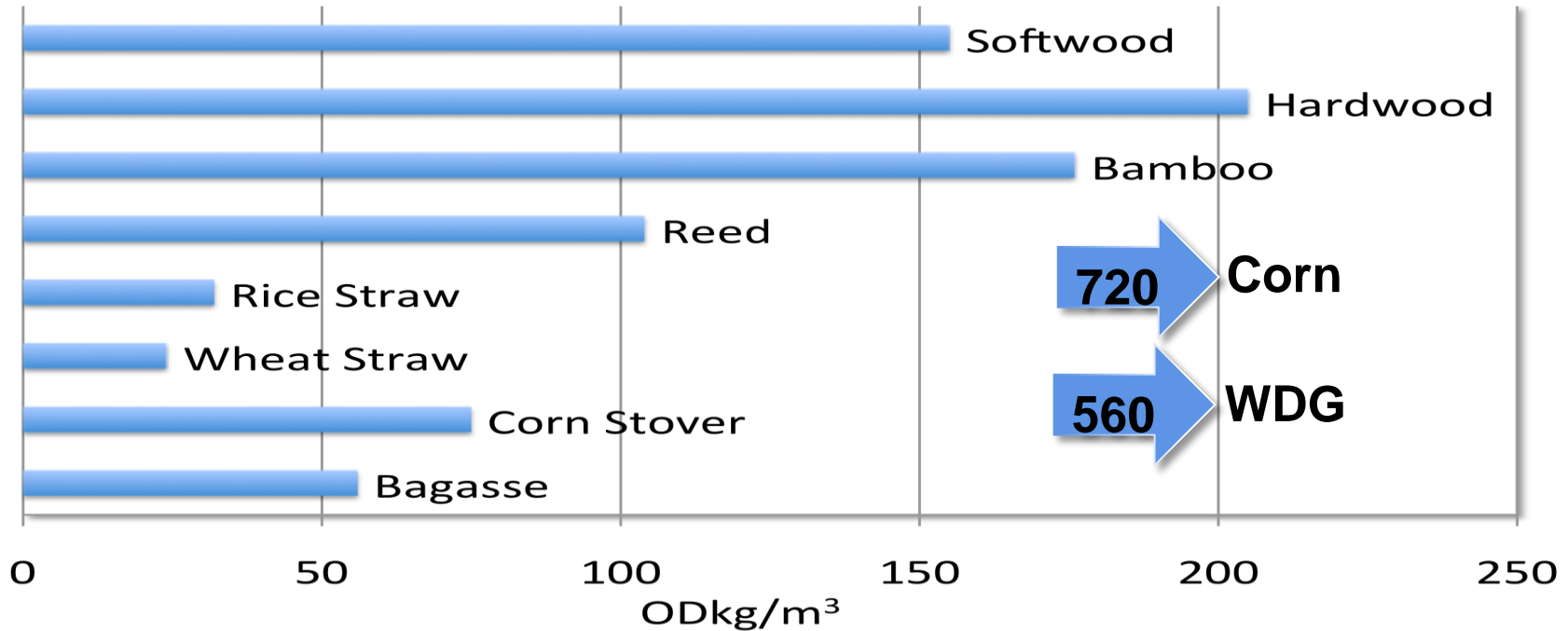
- **Circa 2007**
- **Renewable fuel & chemicals**
 - Consulting services
 - Process technology
 - Development
 - Project concept
 - Modeling
 - Design
 - Startup
 - Debottlenecking
 - Troubleshooting
 - Expert services



- **Circa 2009**
- **Equipment, systems & skids**
 - Pretreatment reaction
 - Fermentation
 - Gravity separation
 - Distillation
 - Evaporation
 - Skids
 - Lab
 - Pilot / Demonstration
 - Fully instrumented
 - Steam generation

Feedstock bulk density

High solids pretreatment reactors are sized based upon volumetric flow....not mass flow.

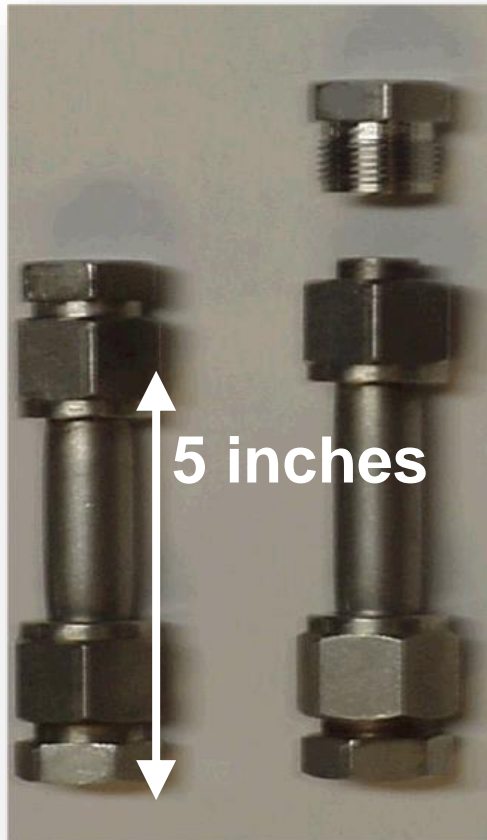


Pretreatment constraints



- High yields are critical to distribute both operating and capital costs
- Low operating costs essential to providing margin for return on capital
 - Low chemical, energy, and labor costs
 - Must be lower for overall process than for cash cows making conventional products
- Low capital costs essential to minimize exposure
 - Low cost containment, e.g., small size, low pressure, low temperature
 - Few steps, e.g., simple processes

Lab batch reactor



Batch steam gun

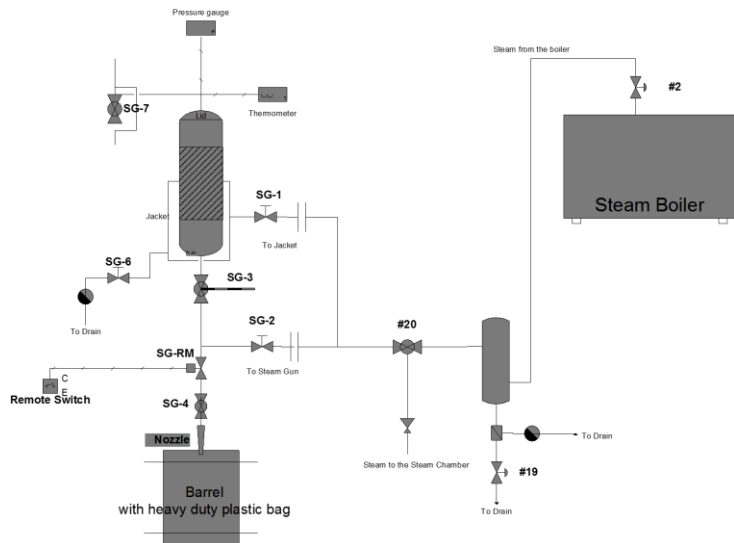
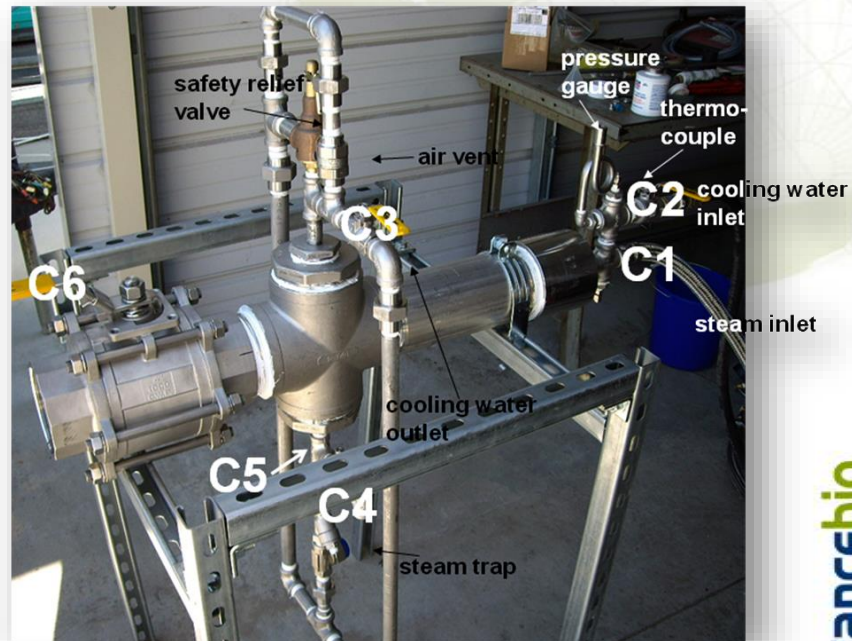


Diagram of Steam Gun

Manjot Singh and Jian Shi
12-18-2009

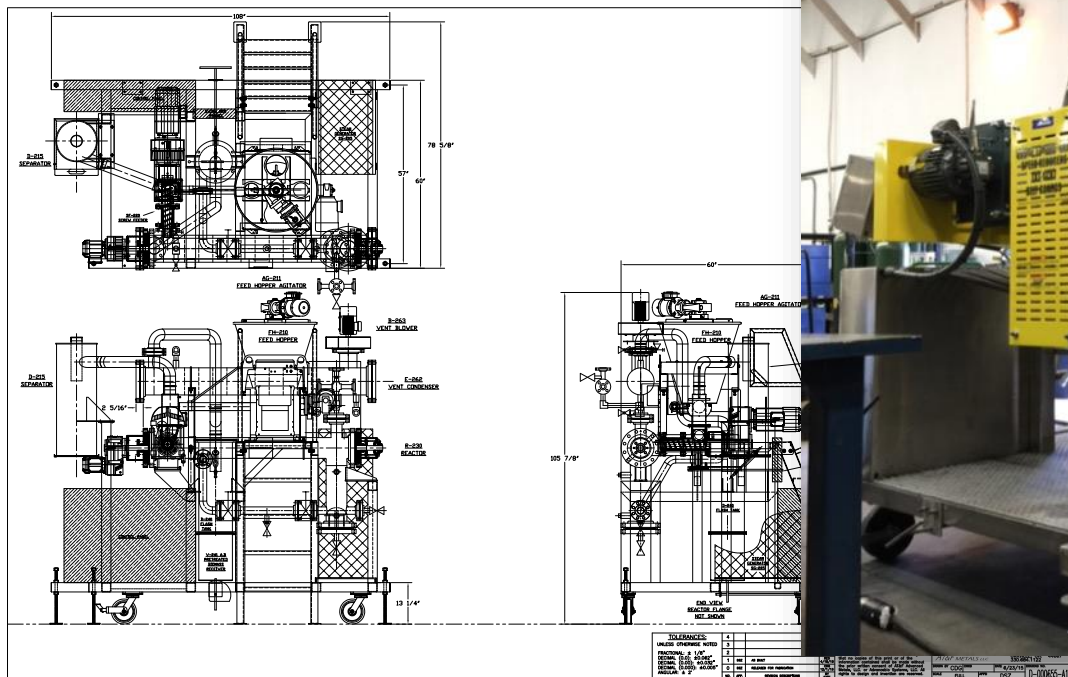


Commercial furfural reactors

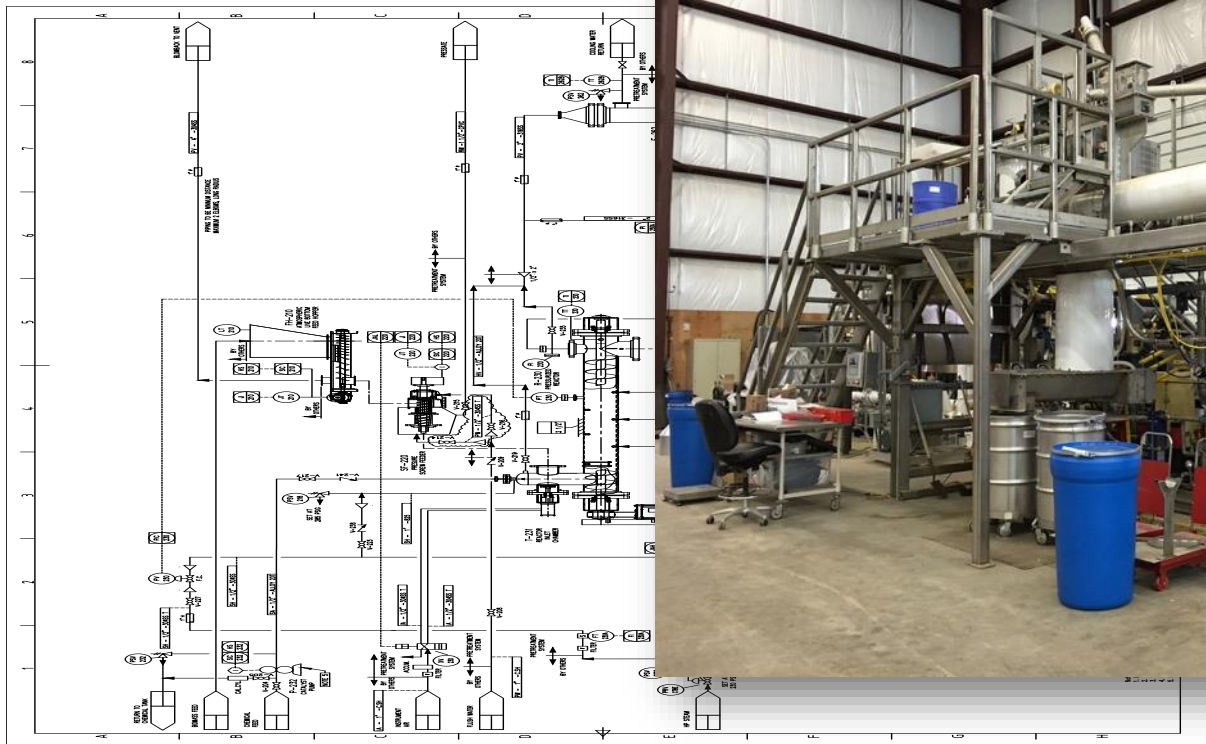


3 trains of ~ 500 tpd each

Process scale-down – 10 kg/hr



Process scale-down – 100 kg/hr



Commercial scale pretreatment

- Feedstocks

- Bulk density
- Feedstock composition
 - Corn stover, bagasse, wheat straw, switch grass, empty palm fruit bunches, wood chips, WDG.....

- Liquid solids ratio

- 20% to 60% dry matter

- Plant capacity

- Scalable
 - 10 kg/h to ~ 500 tpd

- Reaction conditions

- Reaction chemistry
 - Base, acid or organic
- Time
 - From 1 minute to 1 hour or more
- Temperature
 - Ambient to 390°F
 - Atm. to 200 psig

Gen 1.5 Horizontal screw reactor



Closing thoughts on pretreatment

- Essential to high product yields
- Has a pervasive impact on overall process and consequently overall costs
- Chemical methods to realize high yields
- Mechanical systems appropriate to pretreatment scale are required
- Important to manage pretreatment risk to commercialize cellulosic fuel technologies



Thank You

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Always remember....

*....a bad day fishing is still better than a
good day at work....*

