

the Energy to Lead

DRY SOLIDS PUMP COAL FEED TECHNOLOGIES

DOE/NETL Cooperative Agreement DE-FE0012062

- > **Timothy Saunders, Program Manager**
- > DOE Gasification and C&CBTL Workshop
Morgantown, WV
August 10, 2015

Program Background

US Department of Energy (DOE) funded AR to develop:

- **“A commercial solids pump as soon as possible”**

Recognizing:

- **Need for gasifier commercial solids pump capable of 500-1,000 PSI injection**
 - **To reduce capital cost of Integrated Gasification Combined Cycle, Coal-to-Chemical and Coal-to-Liquid gasification based plants**
- **GTC analysis shows significant gasification growth to 2030 and beyond**
 - **Electric utilities in EPRI “Coal Fleet” voted solids feeding as # 1 priority for successful commercialization of gasification plants**
 - **Opportunity represents several 100’s solids pumps**

Target date for availability of commercial pumps around 2017

Program Objectives

Overall:

- Develop a solids pump that meets AR “Compact Gasifier” requirements
 - 1200 psi, 400 TPD (demonstration)
- Develop a solids pump meeting commercial gasification industry requirements
 - 500 psi, 600 TPD

Current Program :

- Design, develop, manufacture and test a prototype solids pump capable of “Commercial scale” feed rate
- Test prototype to allow design optimization for commercial solids pump

Future:

- Manufacture and supply a solids pump for commercial validation
- Commence production of solids pumps for commercial sale

Program Technical Approach

- **Design prototype at “commercially defined” size**
 - 400 TPD Nominal, 600 TPD Maximum
- **Utilize commercial components to maximum extent possible**
- **Utilize a manufacturing integrator for ensuring machine produceability**
- **Evaluate and test with commercially selected and supplied feed-stocks:**
 - Initially Illinois #6 and Powder River Basin coals,
 - Then lignite, Pet Coke and coal/biomass blends

Coal Feed Testing Program

To validate commercial-scale feeding system for gasifier demonstration plant

Feed Distribution System (Completed)

- Capability tested at 600 TPD (2010)



**Ultra-dense flow transport
(no plugging)**



**Flow splitters
(uniform distribution)**

Solids pump (Underway)

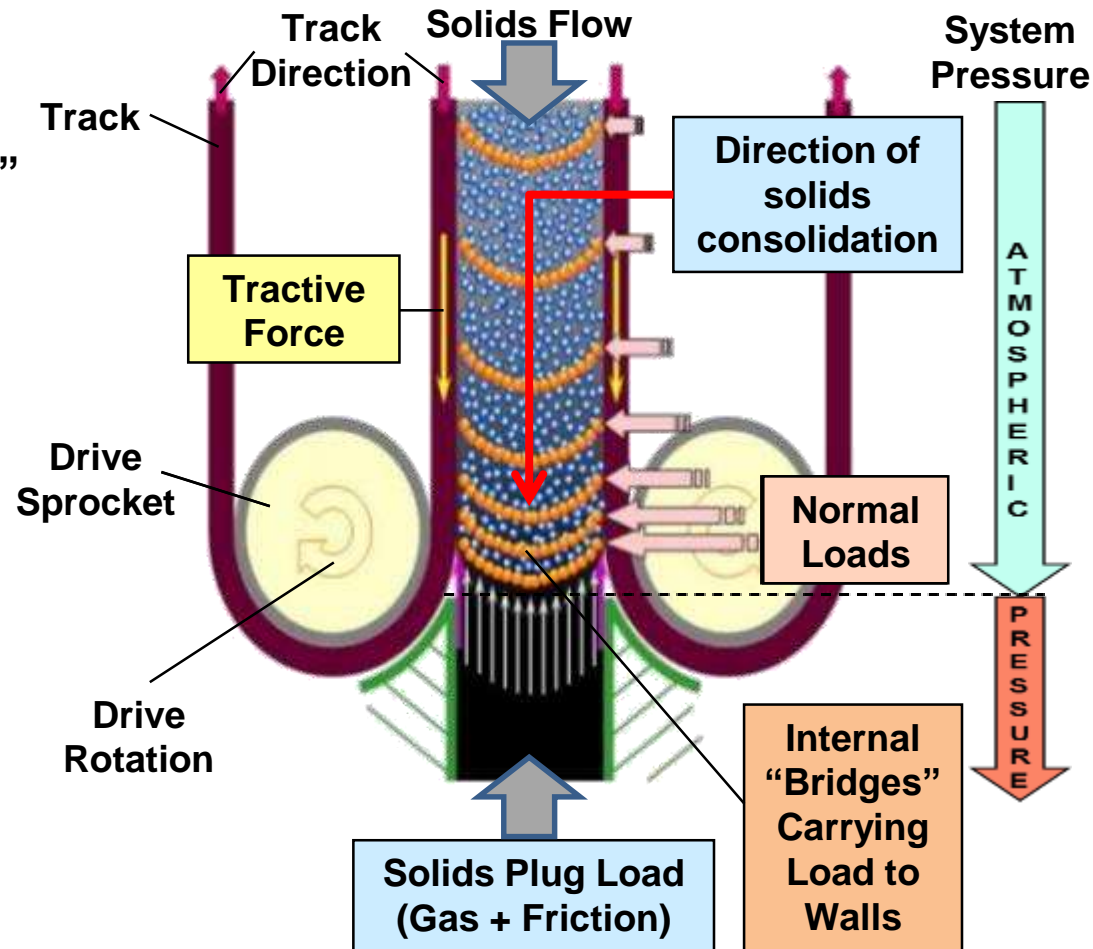
- Discharge 400+ TPD at 1,200 psi
- Standard “Utility” grind PSD
- Testing multiple feed-stocks



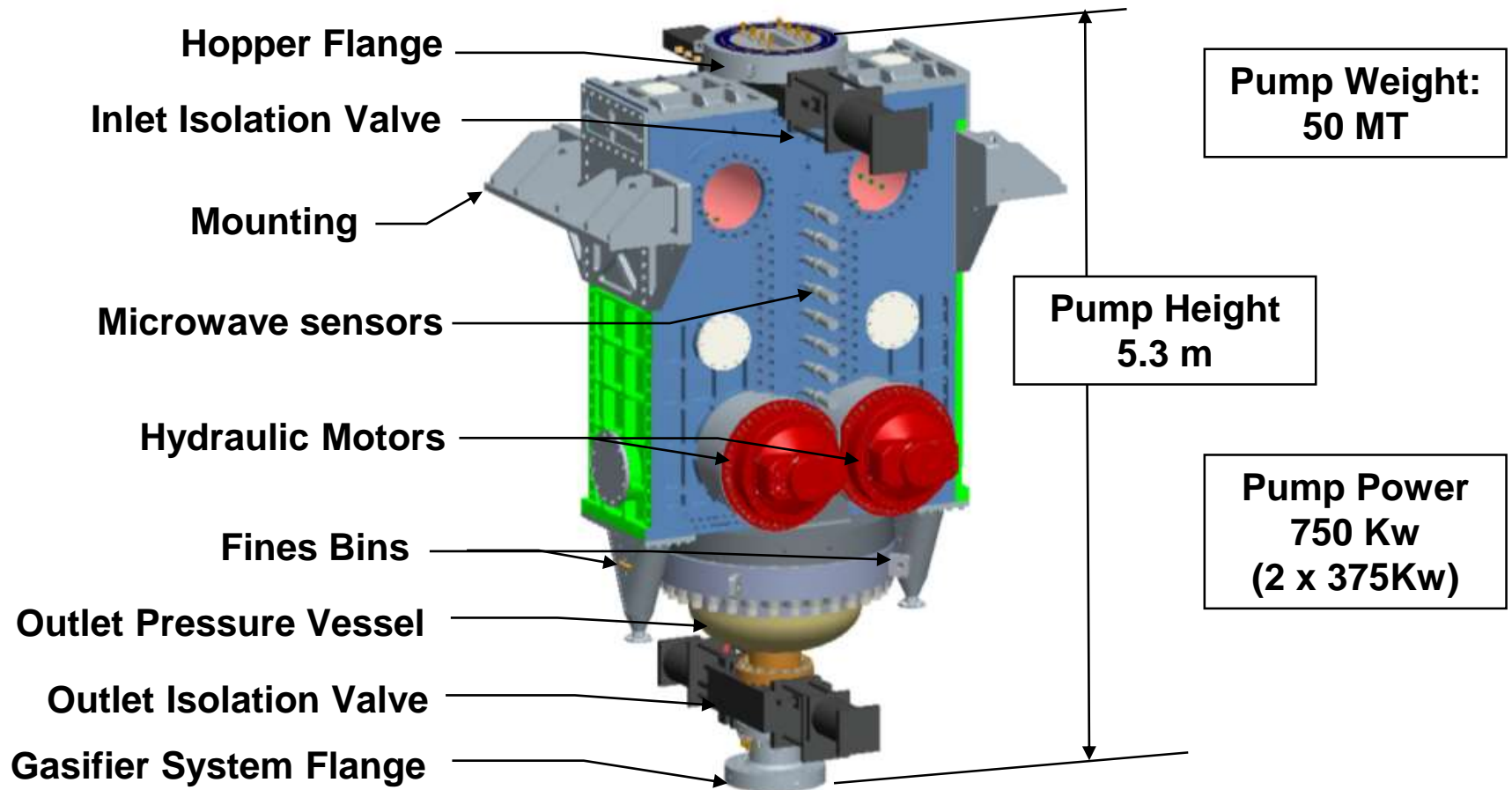
**Pump
(accurate injection)**

Pump Operation

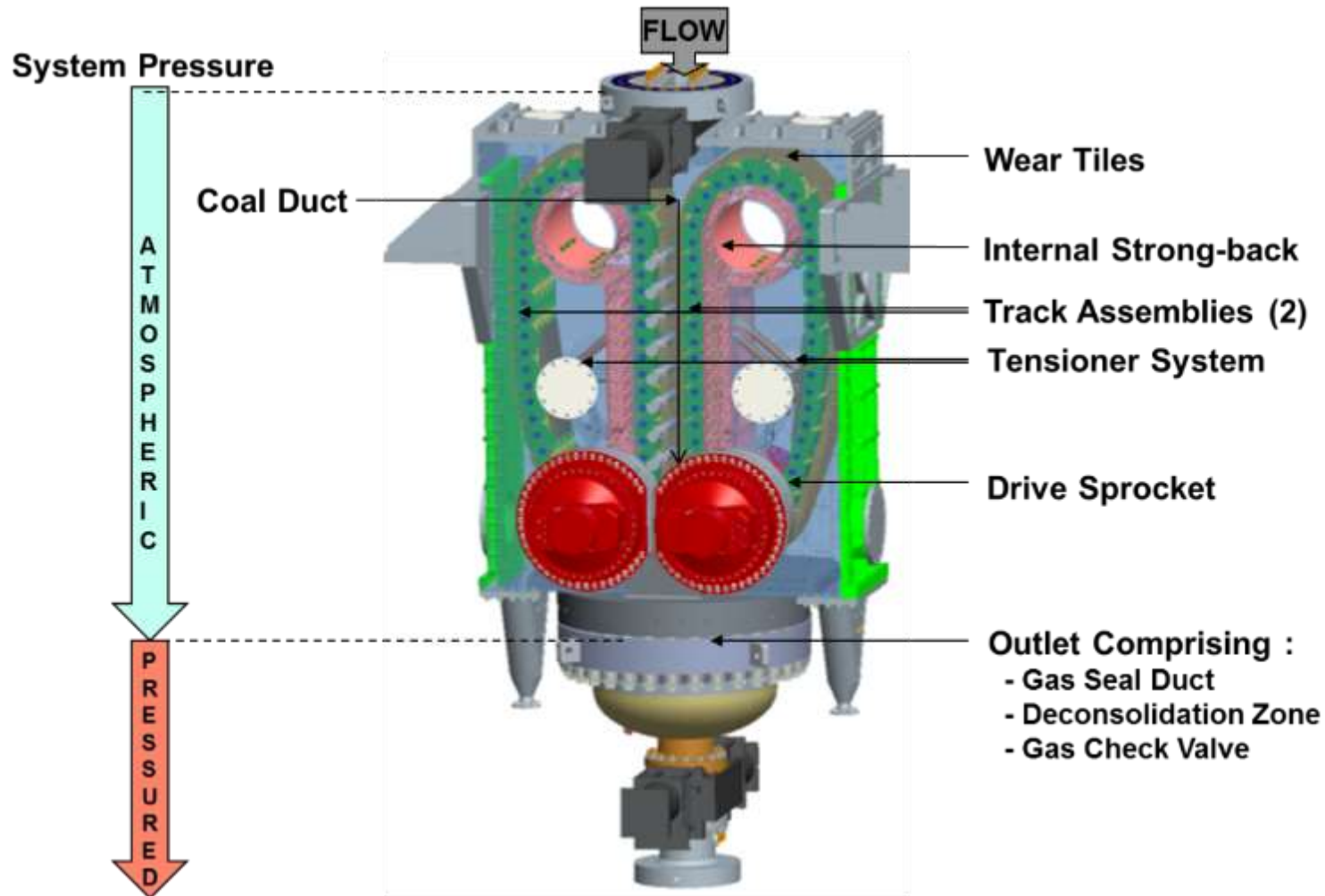
- “Caterpillar” track moving walls forming parallel sided duct
- Operation based on “solids lock-up” physics which achieved coal injection into 1,000 PSI in prior DOE-funded tests
- Design uses “solids plug” gas seal also proven in prior DOE-funded research
- “Linear” concept offers advantages over rotary solids pump:
 - Higher energy efficiency
 - Simply scalable to large capacities
 - Feed material flexibility



Prototype Pump Configuration



Pump Internal Components



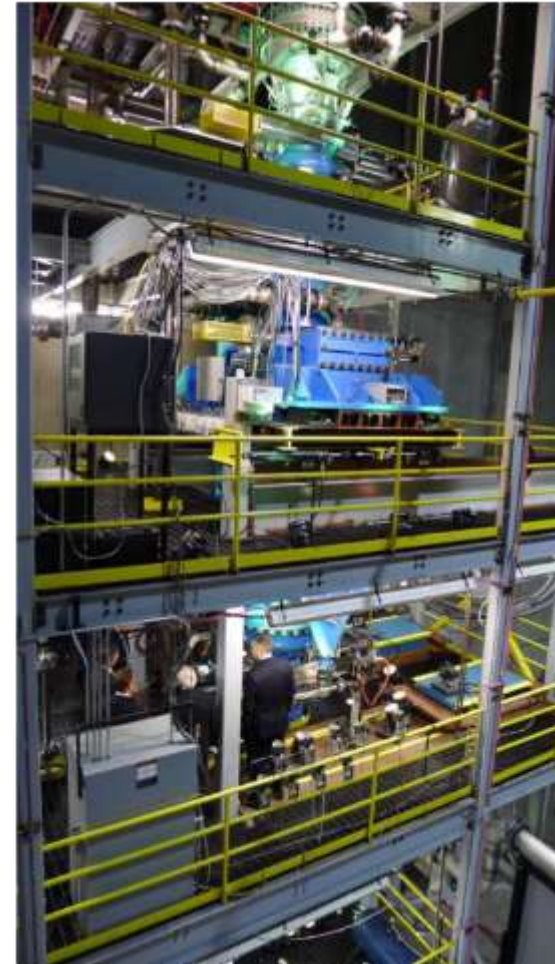
Pump Manufacture & Installation



Pump Installed in EERC Test Stand



Pump installed in the Test Stand



Prototype Testing

- **Shake-down testing initiated 2012**
 - Validated controls system and mechanical operation and characterization
 - Confirmed fundamental operating criteria
 - Identified performance limitations on certain components
- **Modified select internal components for improved performance 2013**
 - Fines sealing around moving components
 - Component clearance reductions for gas seal improvement
 - Fines clearing and removal system upgrades
- **Pump start-up and operation procedures developed**
- **DOE contract concluded end 2013**

Coal Feed Technologies, CFT Program

Follow-on CFT program agreed with DOE with completion late 2016

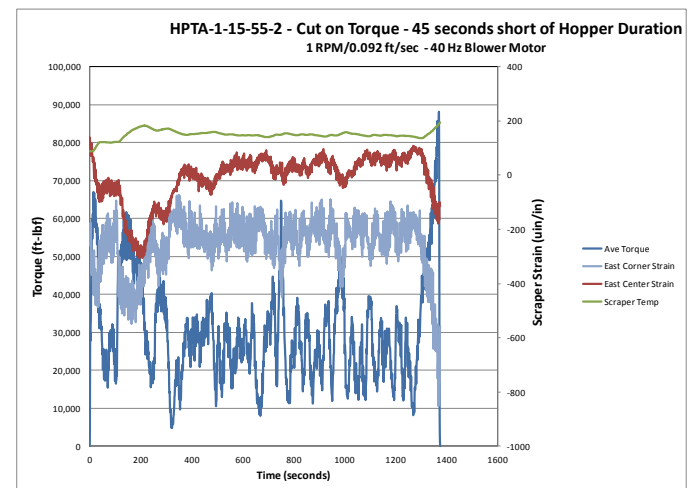
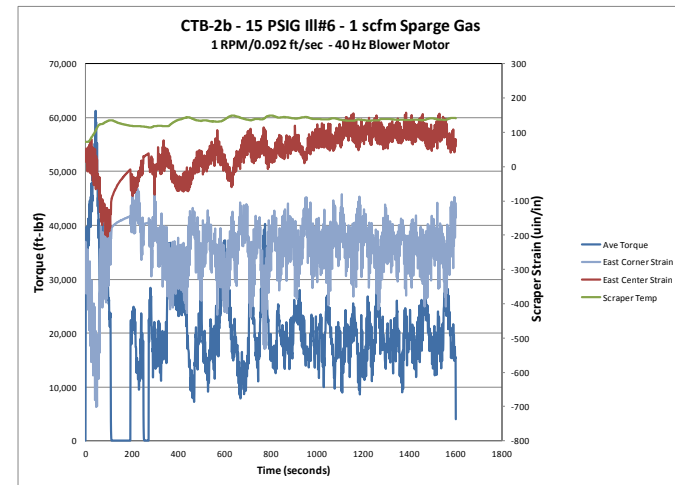
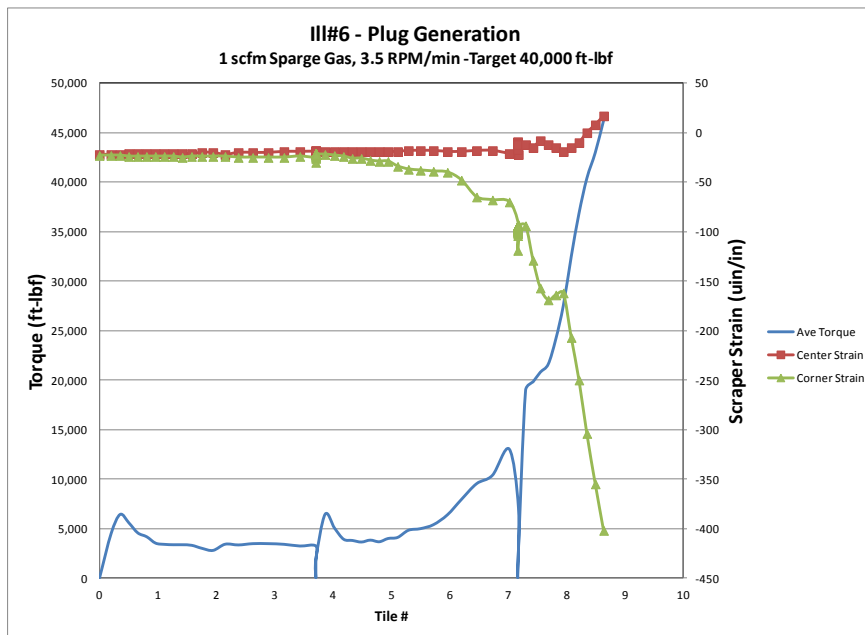
Target 500 hours of prototype operation addressing:

- **Short-term testing at pressures up to 300 PSI**
- **Performance mapping tests to understand and control upset conditions**
- **Additional feedstock tests to validate pump operation with wider range of fuels**
- **Long duration testing at pressures up to 1200 PSI**
- **Define prototype component modifications for commercial pump design**

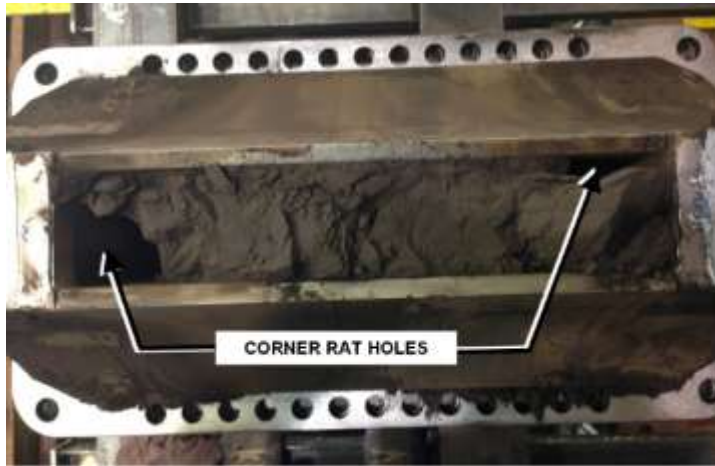
CFT Program Prototype Testing

Testing undertaken to confirm:

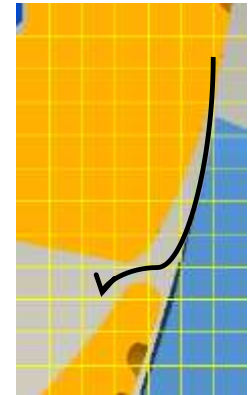
- Pump loading and seal plug formation
- Seal plug permeability/leakage
- Feeding at 50 t/hour into 100 psi



CFT Prototype Operational Issues



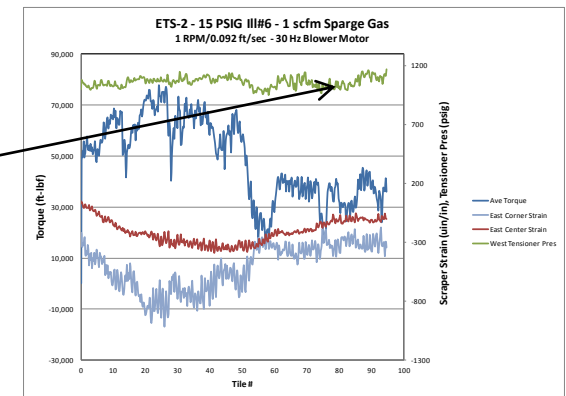
Coal consolidation impacted by flow discontinuity



Tile-to-Tile Leak paths



Coal accumulation on drive sprockets affects track trajectory



CFT Program Initial Results

Pump fundamentals demonstrated in CFT Prototype testing at EERC:

- Plug consolidation to density of 60 lb/ft³ repeatable
- Motor torque required – 80,000 ft-lbf
- Static plug sealed 300 psig for planned 30 minutes
- Dynamic extrusion against 55 psig for 27 minutes at 51 TPD

Coal plug delivered against gas pressure of 97 psig

Issues limiting prototype performance:

- Coal transition irregularities from dynamic to stationary zones disrupting seal
- Leakage between tiles and casing impacting track trajectory
- Plug generation beyond optimum location in flow path causing high torque

Prototype feed pressure capability and feed rate shown limited

The most effective solution to these challenges sought

Semi-scale Program

Prototype pump size, weight - has been a challenge for development:

- One year to design, build, install and test initial component modifications
- Development at full scale found schedule and cost prohibitive

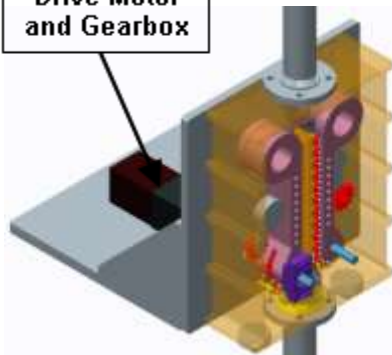
Options to accelerate development evaluated:

- Small-scale pump built and tested successfully
- Semi-scale pump program selected, approx. 1/15th scale
- Design and SOA SLM manufacture undertaken

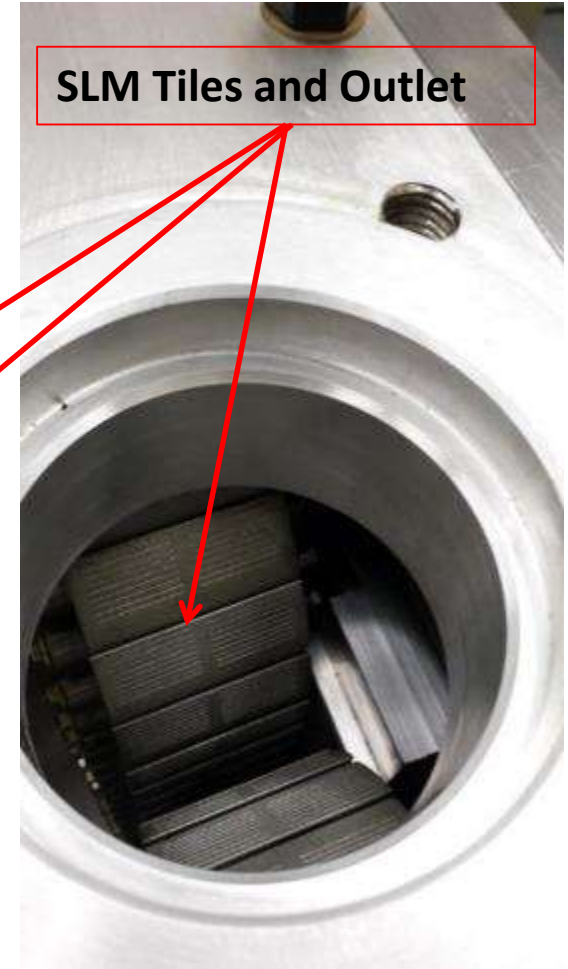
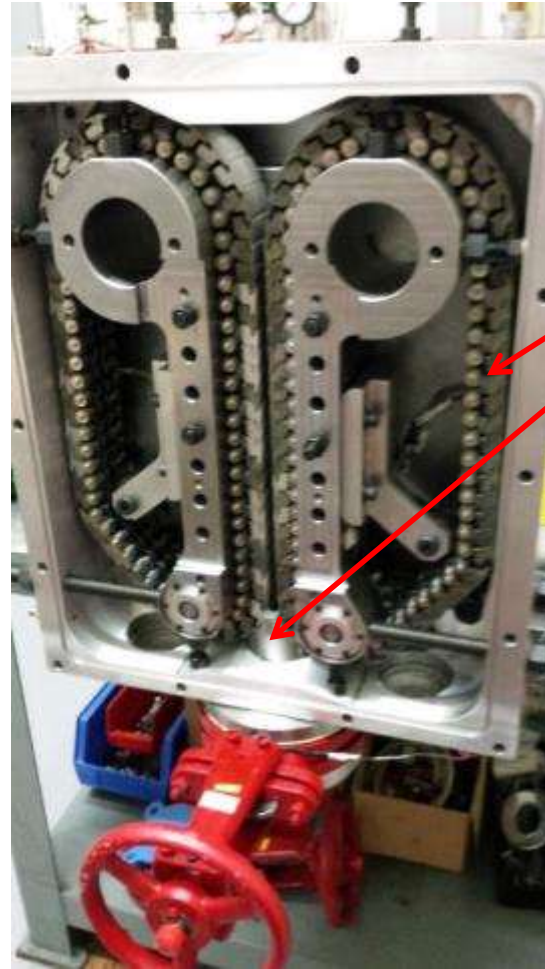
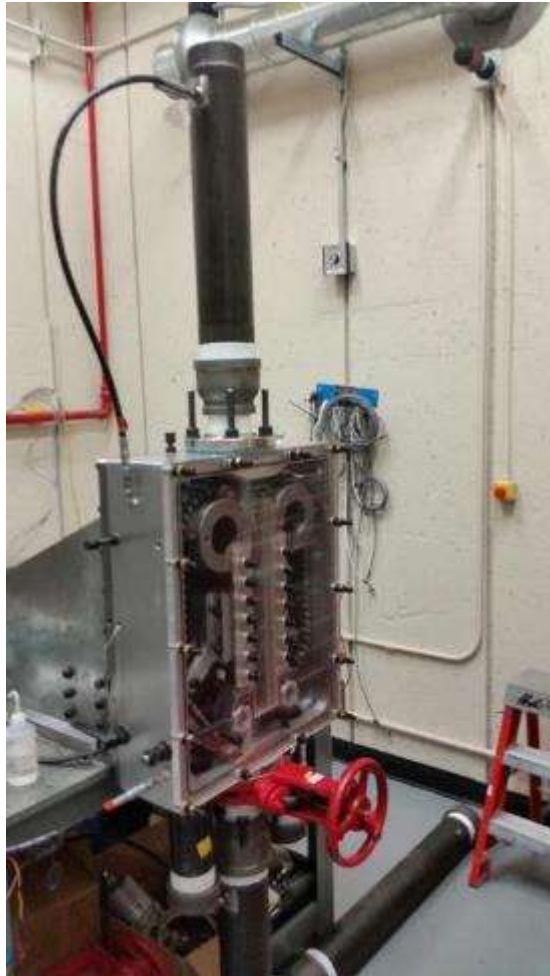
Standard conveyor chain
with attached tiles



Drive Motor
and Gearbox



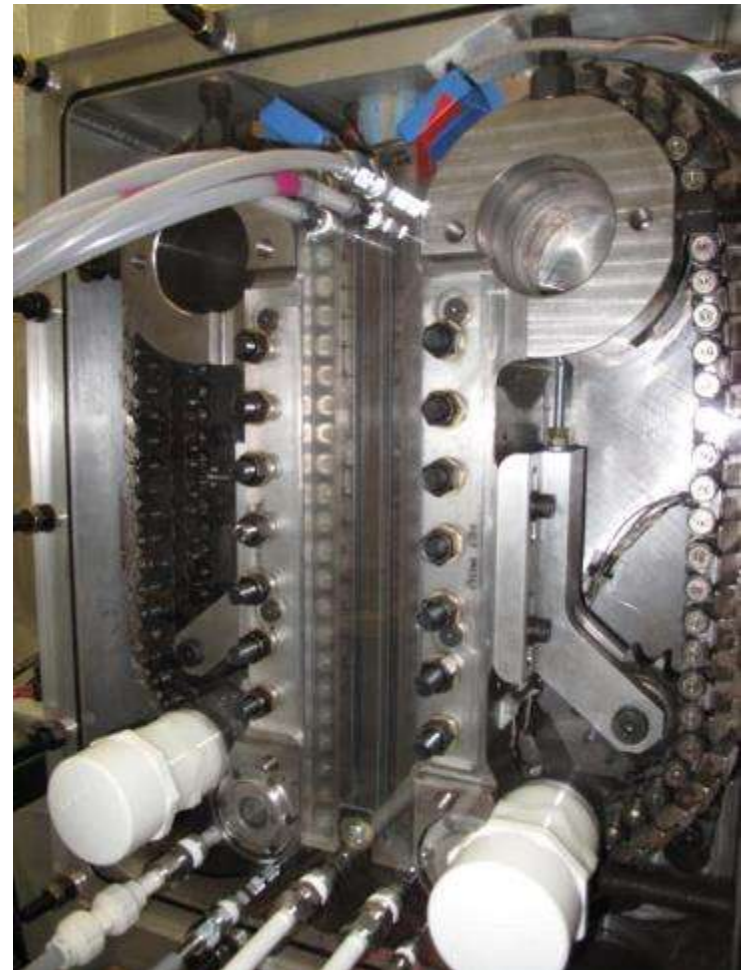
CFT Semi-scale Rig in Test



CFT Semi-scale Initial Testing



Initial Tile-sidewall Leakage Addressed by Side Seals and Vacuum Clearing Ports



CFT Semi-scale Initial Test Results

- **Reliable coal flow into pump by active hopper confirmed at semi-scale**
- **Coal lock-up in active pump duct confirmed**
- **Consolidated and repeatable coal plug in outlet confirmed**
- **Drive system modification in work to allow low-speed track operation**
- **Second generation SLM tiles to improve seal performance in manufacture**
- **Additional SLM scraper configurations in manufacture**
 - **SLM allows low-cost manufacture of complex components quickly**
- **Data acquisition system sensor mod's for lower than expected loads**

- **Commencing pressure testing (150 PSI max) shortly**

Turning Raw Technology into Practical Solutions



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