



MANUFACTURING

**Creating an ecosystem to support US manufacturing
adoption of High Performance Computing**

IDC HPC User Forum 2016

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HPC4Mfg Director
Deputy Program Manager for Energy, LLNL**

US Manufacturing has been slow to adopt technology



Industries need to leverage modern technology to survive

Blue Gene Q supercomputer



LLNL



ORNL

HPC has been shown to have a positive impact on innovation in manufacturing



LBNL

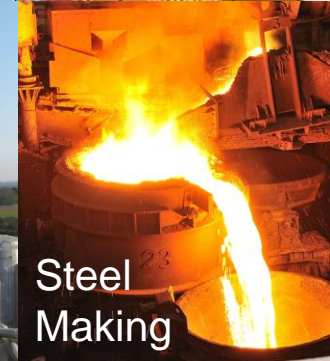
Who can help?

What data is needed? How do I use it?

What tools are available?

How can it help me?

What is HPC?



Bridging the divide can impact economic competitiveness

The Advanced Manufacturing Office's HPC4Mfg Program partners the national labs and the manufacturing industry

Increase energy efficiency and advanced clean energy technology

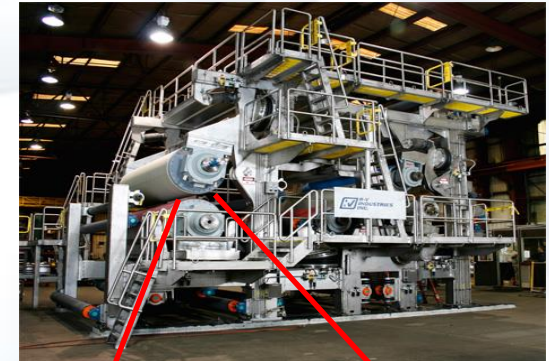
- LLNL leads the program, with LBNL and ORNL partnership
- Phase 1 projects: HPC impact demonstration
 - AMO funds < \$300K to laboratories; industry 20% in-kind
 - Project duration < one year
- Phase 2 projects: HPC adoption
 - Some mix of industry, consortium, government funding
 - Project duration: multiple year
- Streamlined private-public partnership execution
- Share what is learned
- Build HPC Manufacturing community



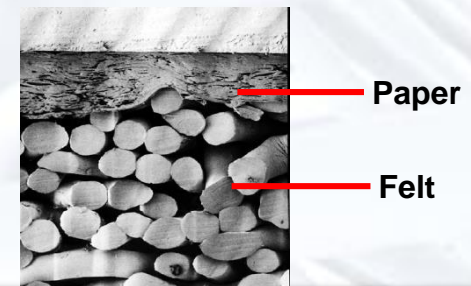
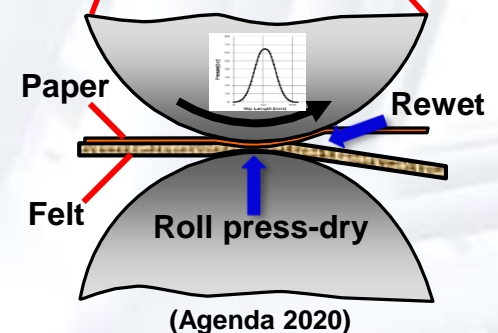
Energy Intensive Example: Paper Manufacturing

Reducing energy in paper-making could save 80 trillion BTUs per year

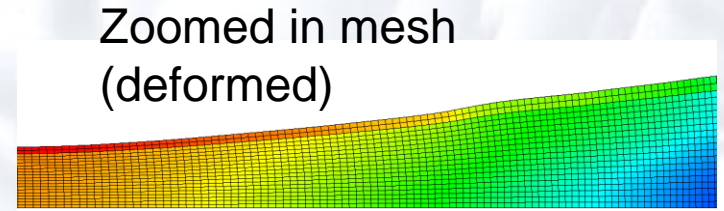
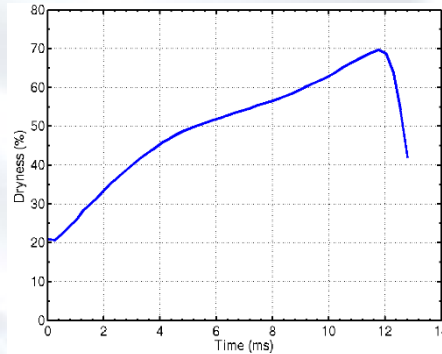
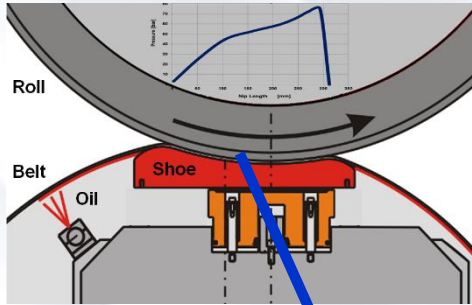
- Industry partner: Agenda 2020—paper-manufacturing consortium
- Rewetting of paper pulp after pressing: widely considered leading contributor—3rd largest—to energy intensity of paper making
- LLNL and LBNL developing coupled-physics simulations
 - Determine how water flows through porous paper pulp during, after pressing process
 - The two approaches are continuum and pore-based models
- New press designs could reduce energy consumption by up to **20% (80 trillion BTU, in \$240M—400M annually)**



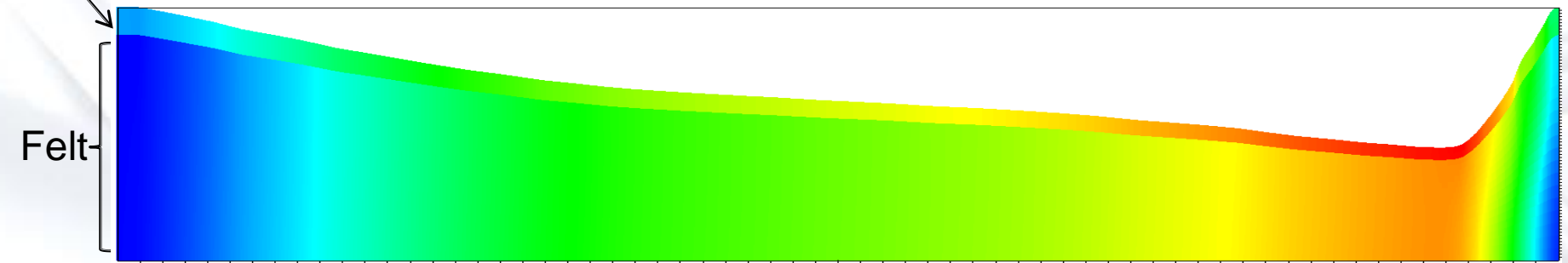
<http://www.rvii.com>



Initial modeling results show deformation and dryness of paper as it traverses rollers in continuum model



Deformed paper/felt in the press nip



312 mm

Pseudocolor
Var: dryness



Models of deformation and dryness of compressed paper/felt can be used to optimize drying

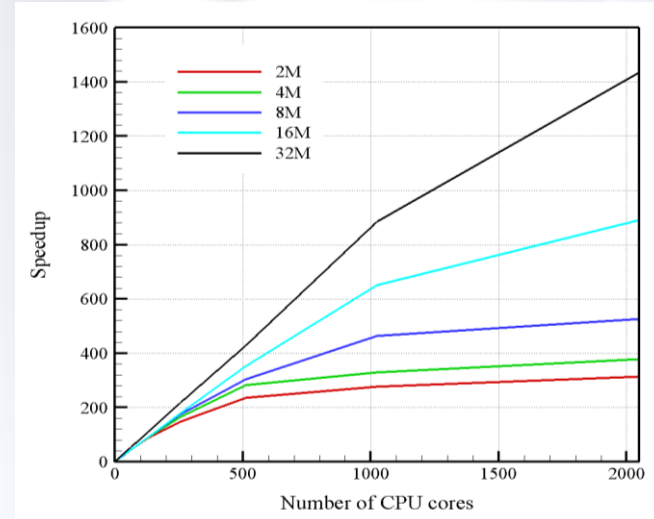
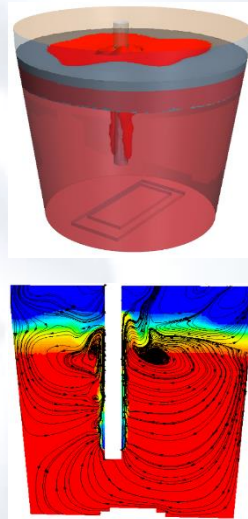
Energy Intensive Example: Steel Manufacturing

Reducing coke usage in steel-making could save \$80 million per year

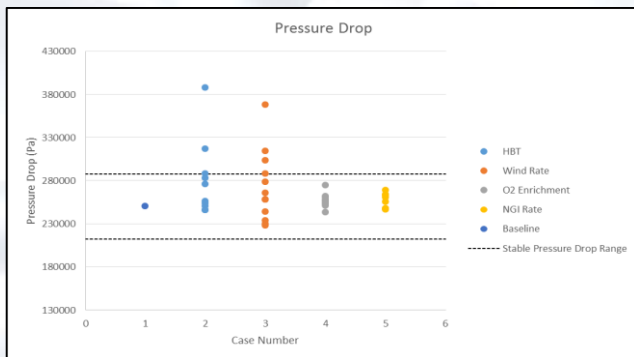
- Industry partner: Purdue Calumet (steel-manufacturing consortium)
- Carbon – rich natural gas and coke used in large quantities in steel production
- Molten iron production optimization will reduce carbon loads to environment and process costs
- LLNL improves blast furnace models:
 - Runs complex reactive flow simulations through coke, iron ore particles
 - Simulations identify furnace conditions with reduced coke utilization
- Optimized blast furnace processes could save **\$80 million/year** industry-wide by reducing coke consumption



1000X improvement in computational speed, parametric studies to reduce coke consumption



StarCCM models decrease computational time 1000X for ladle mixing showing pure molten steel on bottom and slag on top



Parametric studies of blast furnace will help reduce coke usage, especially in partial-capacity production runs

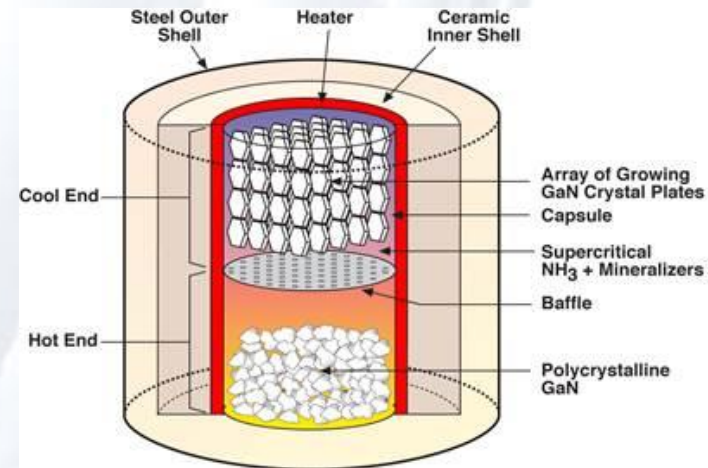
Example: Energy-efficient Lighting

Scaling up a new GaN process could yield 20% cheaper LED lighting and new power electronics

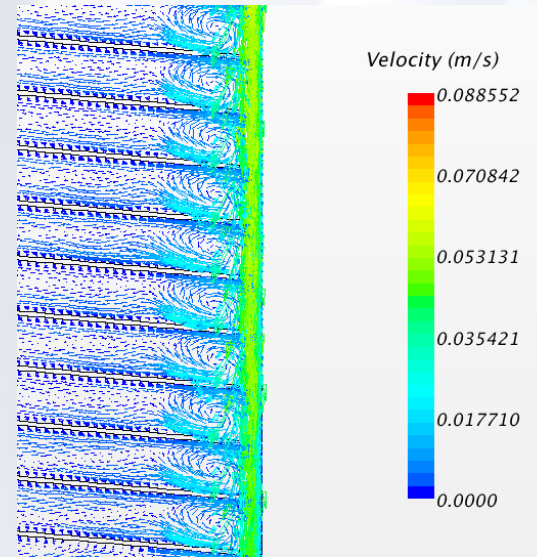
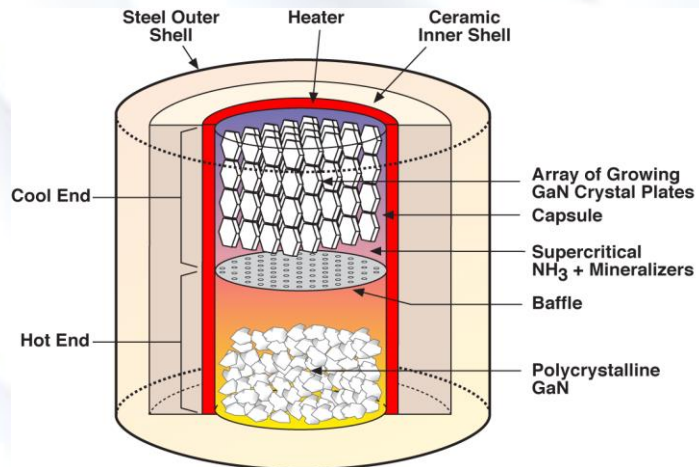
- Industry partner: SORAA
- Scale-up of GaN crystal growth technology could
 - Reduce production costs of highly efficient, high-brightness LED lighting **by 20%**
 - **Enable development of next-generation** power electronics for renewables
- LLNL is modeling chemistry of ammono-thermal crystal growth to assist process scale-up
- New high-fidelity model will save years of trial-and-error experimentation typically needed to facilitate large-scale commercial production



SORAA[®]
Simply Perfect Light[™]



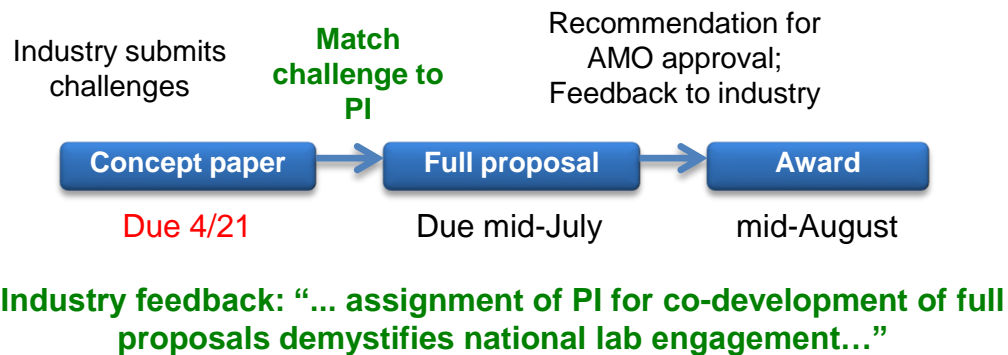
Models have been developed to determine the flow within the ammono-thermal reactor



- Recent higher-fidelity simulations show more complicated flow structure compared to previous work
- Result is improved predictions of local temperatures and flow velocities within reactor
- Now optimizing uniform growth of GaN with these new results

How HPC4mfg Operates

Projects awarded by 2-step peer-reviewed solicitation



Communication is key

- Seek out potential partners
- Broadcast solicitation to industry
- Link lab PI to submitter to co-develop proposal
- Feedback to all submitters

Technical Merit Review Committee

- Partner labs and AMO representatives
- Heavy focus on **nation-wide** impact to energy efficiency and clean energy technology industry-wide
- Diverse portfolio of projects

The HPC4Mfg Program is now running at steady state

Status after 1 year

- Selected 5 seedlings
- Awarded \$3M from inaugural solicitation
- Issued current \$3M solicitation
- Established summer internships at labs
- Identified first Phase II project

Future

- Solicitation twice a year
- Industry Day
- Building community
 - Continued lab outreach to industry
 - Students, professors, industry interns
 - Other lab partners as program grows



Carbontec Energy Corporation



Recent projects address diverse challenges

Process Optimization

- Energy reduction of industry spray drying technology
- Highly scalable multi-scale FEA simulation for efficient paper fiber structure
- Tailoring microstructure in laser powder bed fusion manufacturing process
- Numerical simulation of fiberglass drawing process
- Development of reduced glass furnace model to optimize process operation
- High-fidelity model of coupled flow and mechanical deformation of porous paper web
- Modeling the E-Iron nugget process
- The virtual blast furnace



AGENDA
2020
TECHNOLOGY
ALLIANCE

Carbontec Energy Corporation



GLOBALFOUNDRIES®

Design Improvement

- Computation design and optimization of ultra-low power device architectures
- Massively parallel multi-physics multi-scale large eddy simulations of a fully integrated aircraft engine combustor and high-pressure vane
- Microstructural modeling and control in laser-powder bed additive manufacturing
- Study Fluid Behavior Inside an ammono-thermal gallium nitride reactor using CFD



New Computational Tools

- Materials engineering tools for optimizing strength of forged Al-Li turbine blades
- Integrated predictive tools for customizing microstructure and material properties of AM aerospace components
- Open-source tools for weld prediction



EWI
We Manufacture Innovation



**United Technologies
Research Center**

Challenges remain

- Target outreach to industries not yet at the table
- Ensure HPC becomes part of the fabric of manufacturing after the one-year project
- Build the ecosystem that supports HPC in manufacturing
 - Access to cycles
 - Access to talent
- Leverage infrastructure to other areas of Energy and other labs



Questions?

Additional information at
HPC4Mfg.org

Questions can be sent to

HPC4Mfg@llnl.gov

peg@llnl.gov

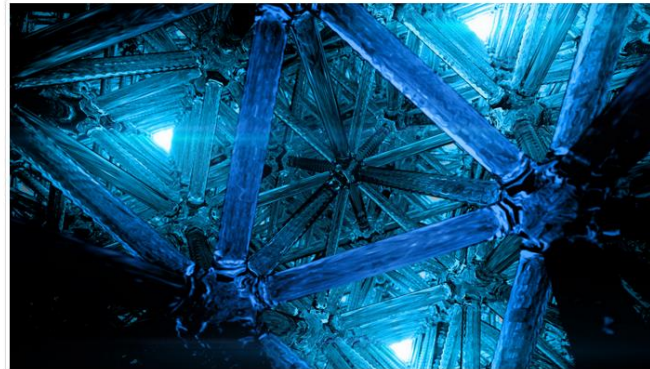
LLNL-PRES-815462

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HPC4Mfg

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High Performance Computing for Manufacturing HPC4Mfg Accelerating Innovation



By using high performance computing combined with advanced manufacturing and additive manufacturing, researchers can design and build new devices and materials with unique physical and microstructural properties. Shown above is a computer rendering of an octet truss that was produced by microstereo lithography and has high stiffness and low density. The structure was designed from mechanical theory.

Accelerating Innovation

By harnessing world-class computing and tapping in to the expertise of scientists at U.S. Department of Energy (DOE) National Laboratories, high performance computing (HPC) can advance innovation in U.S. manufacturing. Lawrence Livermore National Laboratory (LLNL) is leading a new program to advance clean energy technologies and increase energy efficiency while reducing risk of HPC adoption for U.S. manufacturers. Lawrence Berkeley and Oakridge National Laboratories are partners in the program. The DOE Advanced Manufacturing Office (AMO) within the Energy Efficiency and Renewable Energy (EERE) Office sponsors this Program.

HPC4Mfg Brings Value to Industry

National laboratory experts in advanced modeling, simulation and data analysis collaborate with industrial partners on project teams to address manufacturing challenges that will aid in decision making, optimize processes and design, improve quality, predict performance and failure, quicken or eliminate testing, and/or shorten the time of adoption of new technologies.

Infusion of advanced computing expertise and technology into the manufacturing industry is aimed at advancing innovative new clean energy technologies and reducing energy and resource consumption to be competitive in the worldwide market. Successful projects will enable significant nation-wide impact to

News

[Spring 2016 HPC4Mfg Solicitation Now Open](#)

[HPC4Mfg Program and Solicitation Announcement](#)

[Webinar slides](#)

[\\$3M portfolio of awards announced](#)

[HPC4Mfg Program announcement](#)

Contact

For additional information on the HPC4Mfg Program, email hpc4mfg@llnl.gov.

Partner Laboratories





**Lawrence Livermore
National Laboratory**

HPC4Mfg infrastructure was designed for expansion

Other DOE offices are interested in leveraging the program for their missions

- Execute projects under current infrastructure or stand up “franchise” programs to support other offices
- Expand DOE partner labs



Leverage established infrastructure for savings and industry recognition



Execute within industry sector on behalf of DOE office mission

New methods of transportation, new fuels, tech explosion...

Systems integration: many smaller companies provide solution pieces

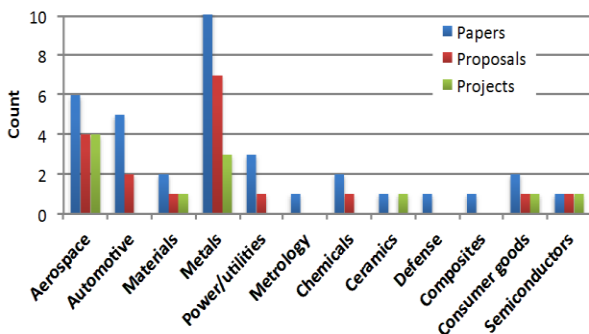
Program metrics

Project	Core hours (M)
SORAA	0.5
PUC	0.2
Agenda 2020	0.1
Carbontec	9.5
Eaton	0.3
PPG Industries, Inc.	1.0
LIFT	36.0
GE	1.0
GE	10.5
ZoomEssence, Inc.	0.5
PPG Industries, Inc.	0.1
United Technologies Research Center	0.9
Ohio Supercomputer Center	
The Procter & Gamble Company	6.0
Globalfoundries	40.0
PUC Phase II	32.9

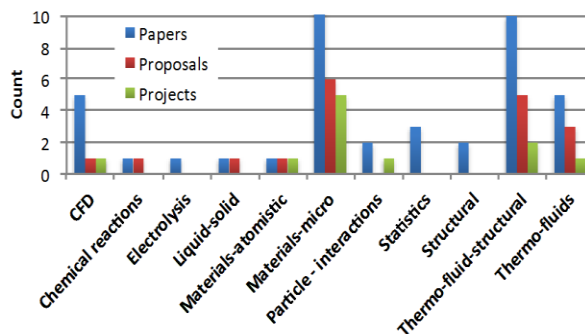
Primary HPC Systems

Lab	System	Nodes	Cores	Description
LLNL	Vulcan	24,576	393,216	IBM Blue Gene/Q; PPC A2
	Cab	1,296	20,736	Intel Xeon E5-2670
ORNL	Titan	18,688	560,640	Cray XK7; Opteron 6274
	EoS	736	11,776	Cray XC30; Intel Xeon E5-2670
LBNL	Edison	5,576	133,824	Cray XC30
	Cori 1	1,630	52,160	Cray XC; Intel Haswell

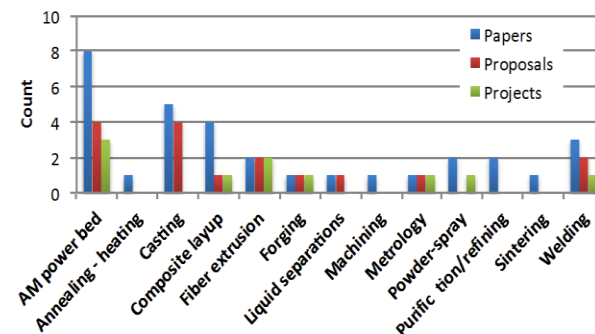
Industry Distribution



Discipline Distribution

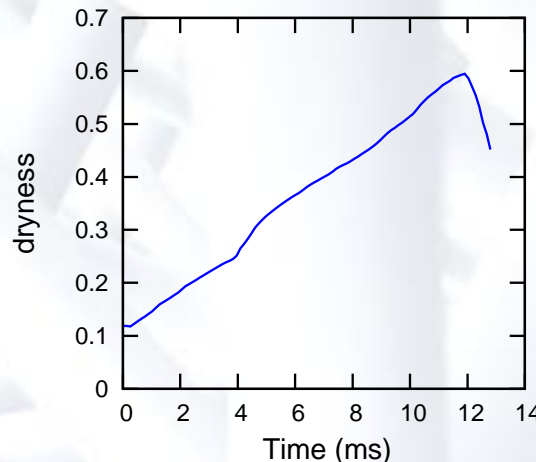
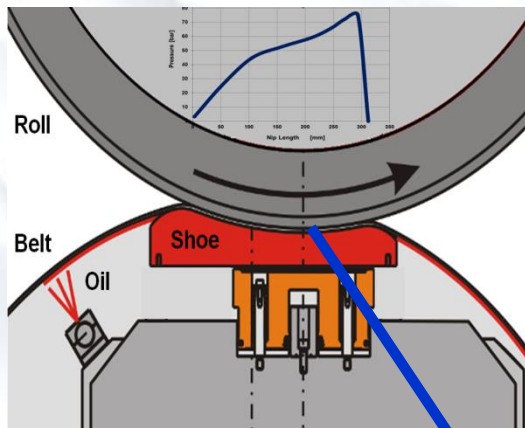


Process Distribution



Agenda2020 Consortium: Models of deformation and dryness of compressed paper/felt can be used to optimize drying

- Rewetting of paper pulp following pressing-is widely considered to be a leading contributor to the energy intensity of paper making (3rd largest).
- LLNL and LBNL researchers are developing coupled-physics models to simulate paper dewatering and rewet at the pressing section.
- New press designs could reduce energy consumption by up to 20% (80 trillion BTU, in \$240M - \$400M annually).



Pore-scale felt
CT imaging and modeling

