HPC4Materials – Opportunities & Challenges

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October 12, 2017
Safe, reliable and efficient power management solutions

Electrical Sector
Products

Systems and Services

2015 Sales: $7.0B
33% of sales
Providing safe and efficient electrical solutions from generation through distribution and control

2015 Sales: $5.9B
28% of sales

Industrial Sector
Hydraulics

Aerospace

2015 Sales: $2.5B
12% of sales
Solutions for the world’s most demanding power needs

2015 Sales: $1.8B
9% of sales
Mission critical, safe, and reliable solutions

Vehicle

2015 Sales: $3.7B
18% of sales
Leader in fuel economy and emissions reduction
A portfolio designed to meet your power management needs.
Technology-driven organic growth opportunities are uncovered from emerging regulations and policies

- Grid modernization: renewables, resilience, cybersecurity
  - Distributed hardware and controls
  - Power electronics
  - Microgrids

- Transportation electrification and efficiency
  - Hybrid and electric vehicles
  - Alternative combustion strategies
  - Light weighting and sustainability
National labs are our innovation partners
Microstructure control in Additive Manufacturing
Maximize Strength and Minimize expensive post-processing

• **Initial HPC program**: Phase Field modeling of microstructural evolution in Ti-6Al-4V during laser based AM powder bed fusion process

• **Ultimate goal**: Merging microstructure prediction with advanced fracture mechanics to predict fatigue life of additive parts

• **HPC challenge**: predict fatigue life of parts - predict hardness and porosity size from process physics
Predicting material properties for arc “barriers”

Avoid or direct - materials in extreme environments

**HPC challenge:** predict materials properties (a) to avoid issues with cables and splices and (b) at extremely high temperatures and pressures to effectively direct arcs to reduce extensive testing.
Joining of Dissimilar Metals and Additive Parts
No More Nuts, Bolts and Screws

• **Problem**: A wide range of geometries can be additively manufactured with novel materials - Joining is a challenge
  - Wrought-to-Additive metals
  - Additive-to-additive

• **Joining methods**:
  - Spot and Linear friction stir welding (solid state)
  - Electron beam and laser welding

• **HPC challenge**: Predictably simulate liquid & solid state welding of a broad range of materials combination of dissimilar and additive metals such as super alloys, titanium and aluminum alloys.
Heat transfer in extreme conditions

*Complicated mix of geometries, materials and kinetics*

- **Problem**: Combustion controls strategies are increasingly complex with emerging CO2 and NOX regulations, driving need for increased level of fidelity and speed in valvetrain models.

- Sodium filled valves are used for effective heat transfer for certain applications but are difficult to model due to fluid motion and complex boundary conditions.

- **HPC challenge**: predict temperature distribution in valve stem and valve head in extremely challenging environments.
High Power Density Hydraulic Systems

*Increase materials strength for low cost systems*

- **Problem**: Available engine bay space in off highway machines is shrinking with addition of engine after treatment systems.

- 2X smaller hydraulic components are needed to *package* within the machine, but capable of the same performance and power. Power density is limited by strength of materials through hydraulic system.

- **HPC challenge**: Increase material strengths through laminations, topology, composite techniques (or other) to uncover common, low cost materials and systems approach.
Opportunities for widespread HPC utilization
Must be cost effective & faster than current methods and transition

• The HPC program offers expertise we do not have. We want HPC national lab teams to work on important programs.

• Lab subject matter experts directly interacting with company during proposal process is essential to creating high-value proposals.

• *Speed is critical* in contracting and execution. Short form CRADA approach is excellent. Rapid program design is well-thought out to demonstrate value.

• **HPC methods must ultimately be cost effective** compared to our current experimental or modelling approaches.

• *We suggest a more formal, well-defined way to follow up on program results.* Need help to understand how to transition and calibrate so that HPC results are validated with experimental data and models modified for various applications.