Modeling and Simulation in Smart Manufacturing

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Topics

- CESMII’s view on advanced sensing, control, platforms, and modeling (ASCPM) in Smart Manufacturing

- Smart Manufacturing requires the right data at the right time, in the right place, in the right format for human and machine actions.

- CESMII Projects have demonstrated benefits and shared methods (playbooks) in key industry verticals
Mission Strategy Role

Smart Manufacturing to drive next generation of U.S. Manufacturing Productivity and Environmental Sustainability

How

Monetize *Productivity, Precision, & Performance* at scale with **Advanced Sensing, Control, Platform, and Modeling for Manufacturing (ACSPM)**

CESMII represents the *voice of manufacturing*; engaging the smart manufacturing ecosystem through a membership model

- Manufacturers
  - Small, Medium & Large
- System Integrators & Consultants
- Machine Builders
- Technology Providers
- Academia & Labs

2017

$140M + $61M Renewal

Public Private Partnership

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SM Technology Building Blocks and Information Flow

Structured Information Models that enable movement of data-in-context and hence interoperability of components.

High Performance Computing for Data Sharing

High Performance Computing
Machine Learning
Artificial Intelligence
Leveraging HPC in CESMII

Structured Information Models that enable movement of data-in-context and hence interoperability of components

Descriptive
Diagnostic

Data Driven Models
High Fidelity Models
Reduced Order Models

High Performance Computing
Best Resources

CESMII
R&D

Manufacturer Needs
(Predictive capabilities)

Data Contextualization
Aggregation
Categorization
Pre-Processing

HPC = entire range of compute
Structured Information Models
that enable movement of
*data-in-context* and hence
interoperability of components

Parameter identification and screening
for ML and AI models

High fidelity modeling and simulation of
complex phenomena

Reduced order models for
optimization and real-time control
applications

Model Based Simulators
For dev and testing solutions

Laboratory Facilities &
Demonstration Centers

Where HPC and National Labs can Collaborate
Project Examples where Modeling and ML has been used
Smart Manufacturing in Steel Continuous Casting

ArcelorMittal, RPI, Purdue, Missouri Science & Technology University

- Data acquisition infrastructure implemented and configured for caster health monitoring
- Advanced strain measurement and 3D displacement sensors to detect liquid core in continuous steel caster developed and tested
- Digital twin for simulating caster operation developed and demonstrated for maintenance applications
- Machine learning based model developed to predict caster plugging.

Significance and Impact: Realtime sensing and predictive modeling will improve caster performance and downstream product quality. Potential impact of $90M in energy savings for steel industry from improved quality, and $2M/strand from predictive maintenance.
Smart Manufacturing for Cement

University of Louisville, Argos USA

• Lab scale kiln constructed and instrumented with burner and sensors for conducting experiments
• Multi-physics thermal and flow models developed and validated with instrumented kiln
• Machine learning model developed to predict clinker quality based on operational parameters
• Real-Time Process Assessment and Control System developed for energy optimization

Significance and Impact: Validated multi-physics predictive models will lead to optimized operating conditions contributing to up to 15% reduction in energy usage in production kilns
Smart Manufacturing in Chemical Industry

Texas A&M, Emerson, AspenTech, PSE, RPI, OSISoft, UT Austin

• Steady state and dynamic models (Digital twins) developed and validated for predicting operational behavior of Air Separation Unit (ASU)

• Surrogate models developed for ASU control application including fault detection, real-time optimization, scheduling and predictive control

• Real-time asset monitoring solution for the ASU and auxiliary equipment has been implemented

• Asset templates for ASU equipment developed

Significance and Impact: Predictive modeling and real-time monitoring for air separation units will lead to increase in operating efficiencies and energy savings worth $10M/yr for one large manufacturer, with potentially similar impact to other manufacturers with similar ASUs.
Smart Manufacturing in Composite Brake Mfg
Virginia Tech, Honeywell, University of Virginia, Penn State University, Commonwealth Center for Adv. Mfg.

- Data acquisition and platform infrastructure developed
- Computational Models for Energy Consumption and Product Quality Prediction developed & validated
- Process anomaly detection algorithm developed and validated
- Physics based and data driven prediction models developed and validated for process optimization

**Significance and Impact:** Automated process monitoring and control will lead to a reduction of 15% in energy consumption for Honeywell's CVI process
Backup