Industry
Steel
Metals

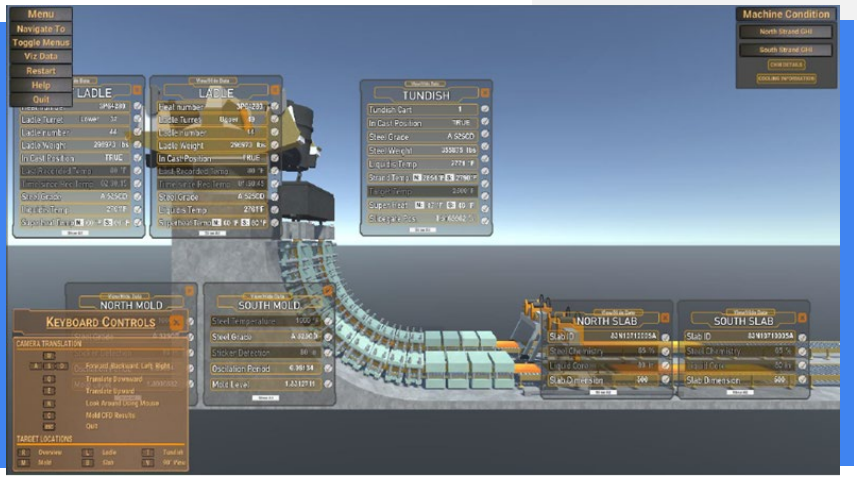
Technologies
Sensing
Machine Learning
Predictive Modeling

Solutions
Asset Performance
Quality Improvement
Energy Efficiency

CESMII
THE SMART MANUFACTURING INSTITUTE

PROJECT CASE STUDY

Smart Manufacturing in Steel Continuous Casting: Production of Zero-Defect Slabs



PROJECT LEAD

ArcelorMittal

PROJECT TEAM

Rensselaer Polytechnic Institute (RPI), Missouri University of Science and Technology, Purdue University Northwest

PROJECT OBJECTIVE

The goal of this project is to improve steel slab quality and continuous caster productivity using Smart Manufacturing (SM) methodologies and technologies, thereby reducing the overall energy intensity of existing steelmaking and casting operations.

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Smart Manufacturing Technologies Improve Steel Casting Processes

BENEFITS TO OUR NATION

- A 0.2% improvement in yield (from the reduction of steel slab defects) will result in an annual savings of $90 million for the US steel industry.
- A 2.68 PJ of energy savings per year is equivalent to ~ 22 million gallons of gas savings, enough to power ~ 70,000 American homes for a year.
- Predictive maintenance tools alone could save at least $2 million per caster strand per year (there are hundreds of strands in the US).

BENEFITS TO INDUSTRY

The outcome of this project is expected to trigger a paradigm shift (e.g., from quality-by-inspection to quality-by-design) in how preventive maintenance is done, how product quality is evaluated and how dispositioning of products is performed in real time.

The project contributes to CESMII's energy reduction and energy productivity goals. The project delivers data analytics and process modeling tools via the Smart Manufacturing Innovation Platform™ (SMIP). Specifically, metal manufacturing engineers will learn to develop machine learning tools and techniques that reduce equipment down-time, improve product quality and increase process yield in an industry beset with poor data quality and non-stationarity of data.

PROJECT DESCRIPTION

TECHNICAL APPROACH

- Extend and scale-up the in-house Caster Health Monitor (CHM) application into the Smart Manufacturing platform for predictive tools
- Develop real-time hybrid predictive models for slab defects and quality
- Build an interactive interface of a digital twin prototype of the continuous casting process for shop-floor deployment
- An ArcelorMittal dataset was used to model the workflow of analyzing a real-world industrial dataset and to compare several different machine learning techniques

ACCOMPLISHMENTS

- Developed off-line prototype pilot caster digital twin.
  - Main Caster Overview
  - Caster Health Monitor
  - Cooling Overview
- Developed optical fiber sensors to detect caster and mold process data
- Developed flexible parser for raw data.
- Developed detailed tutorials documenting the entire workflow of industrial data analytics.

DELIVERABLES

- Installed and tested new advanced sensors in the pilot caster
- Completed, delivered and validated an enhanced version of the Caster Health Monitor application as a true predictive maintenance tool
- Developed and delivered caster health monitor analytics tools (e.g., improved breakout system, plugging prediction, etc.) and predictive maintenance tools (e.g., roll gap data analytics, pinch roll failure analytics, etc.)
- Delivered hybrid model (data-driven + physics-based) for slab defect and quality prediction for integration and deployment within a digital twin framework for real-time shop floor use
- Development and shop floor deployment of the pilot caster digital twin
- Delivered tutorials for predictive modeling, fault detection, and sensor fusion

REUSABLE OUTCOMES / SM MARKETPLACE

- Continuous caster digital twin for maintenance application
- Fiber optic strain and displacement sensing system for high temperature manufacturing environments
- Caster health monitoring and predictive model

RESULTS

~22 M/yr

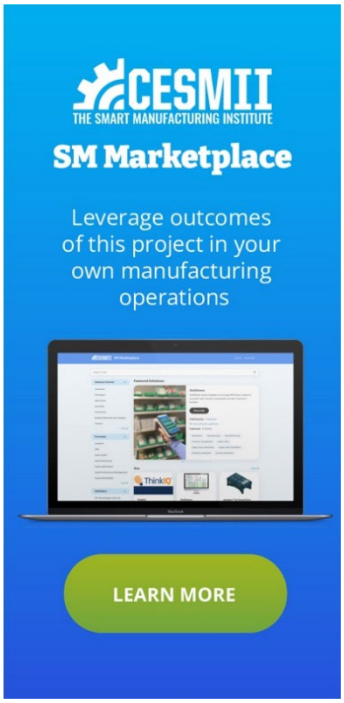
Potential annual gallons of gas savings through defect reduction and other process improvements.

~$90M/yr

Potential savings for the US Steel industry from the reduction of steel slab manufacturing defects.

~$2M/yr

Potential savings per caster strand by reducing equipment down-time.



PROJECT DETAIL
Budget Period: B4
Submission Date: 01/14/2022
Sub-Award (contract) Number:
4550 G WA302
SOPO: 237

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