Re-design of Controlled Cooling Boxes—Team 1

Overview
The ArcelorMittal Steelton plant is in need of an improved controlled-cooling box system to adequately cool its manufactured rails in order to diffuse remaining hydrogen. The current eight box system is over 40 years of age and performing maintenance is difficult due to weather and crane damage, and a confined space limitation. The current burner system is inefficient, does not provide system feedback, and cannot reach the necessary heating range of 725-1200°F, especially during the winter. Without proper cooling, the hydrogen in the rails cannot completely diffuse, resulting in shatter crack development and ultimately catastrophic failure.

Objectives
The objective is to redesign the four major subsystems of the controlled-cooling box consisting of natural gas burners, materials, structure, and automated feedback control. An additional goal is to improve system efficiency and durability while considering maintenance and crane operations. Deliverables include CAD drawings, feedback control diagrams, a burner model, and a bill of materials.

Approach
- Performed general research on hydrogen diffusion, and the controlled-cooling process. Reviewed patents on cooling processes and performed benchmarking on Siemens cooling beds.
- Visited the Steelton plant to see current system and conduct interviews with ArcelorMittal employees to learn about project history.
- Generated customer needs using information gathered from site visit and interviews. Established target specifications.
- Generated concepts for sub-functions and used concept combination table to create eight designs. Used screening matrix and Pugh concept scoring matrix to choose primary and secondary design.
- Determined efficiency of burner. Performed heat transfer analysis to determine heat input required by the burner as well as the temperature decay of the controlled-cooling process at steady-state.
- Performed time value of money calculations for current and redesigned systems’ natural gas costs.
- Developed automated feedback system for burner and crane motion detection.
- Fabricated four prototypes. The final, beta prototype was constructed for the Project Showcase.
- Created Bill of Materials and CAD drawings of system.

Outcomes
- Natural gas cost savings of $303,000 or by 55%, over a 40 year lifetime as a result of this project
- Maintenance door improves ease of maintenance and inspection, resulting in fewer shutdowns while ensuring the safety of employees
- Improved burner system improves efficiency while reducing emissions
- Inner structure with replaceable blades improves durability and encourages preventative maintenance to be performed
- The project’s unique rolling lid system decreases degrees of motion required for crane operator when loading and unloading rails
- Motion detectors on boxes aid in loading rails while reducing damage to box walls
- Automation provides valuable system feedback to Utilities Coordinator
- Water repellent insulation maintains high performance when raining