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DIGITAL TRANSFORMATION FOR STEEL MANUFACTURING GRANT

The Smart Ladle project combines process data sampling and deep learning algorithms to create an artificial intelligence (AI)-based tool to help a ladle metallurgy furnace (LMF) operator to make real-time process decisions. By developing quantifiable relationships between the casting temperature and various factors during the ladle refining process, predictions can be made for upcoming casting temperatures, to make adjustments to steel temperature at the LMF station prior to the casting stage of the production process.

Steel Dynamics Inc. – Flat Roll Group Butler Division (SDI) was chosen as the site for developing and testing. The process features ladle pre-heating, electric arc furnace (EAF), LMF, casting and maintenance/repair.

The Smart Ladle software uses data samples from the ladles and casters in the meltshop and, after parsing the data into a data structure, uses them to train a neural network that can create correlations. Connecting data the operator may already be aware of and data that may be more "hidden" can provide predictions for the temperature behavior of the steel in the ladle to ensure experienced operators have the information they need to make process decisions.

The data structure has 25 inputs made up of the current and previous ladle/caster data and three outputs: predictions of the temperature loss of ladle steel between the last LMF temperature sample and the ladle open at the caster, the midpoint tundish temperature value, and the slope of the tundish temperature profile after intermixing occurs.

The Smart Ladle project as a whole was worked on almost entirely by students. The main work was developed by a graduate researcher pursing a master's degree in electrical and computer engineering. The project was also used as a capstone project for two senior-level electrical and computer engineering undergraduate students. The students participated in the regular project meetings and worked with industry data to develop a subset of the project. Both the graduate and undergraduate students participated in the site visits to SDI Butler Division, tours of the ladle and caster production lines, and in-person meetings with those who would be working with the Smart Ladle in practice.

Through the course of development, students in the electrical and computer science fields have been exposed to steel industry concepts and have been given insight into the ample opportunities for applying software and machine learning concepts to steel manufacturing, as well as have been given insight into many types of steel industry career opportunities.

Dr. Zhou worked with industry mentor Yury Krotov, casting manager, Steel Dynamics Inc. – Flat Roll Group Butler Division.