Kelvin Erickson Missouri University of Science and Technology

ELECTRICAL ENGINEERING GRANT

Two undergraduate students, Makeda Beyene and Chris Eichholz, started the "Development of a Steel Continuous Annealing Line Simulation" project as their capstone senior design project. They made some progress and have successfully developed a simulation of the first part, the heat section, but more work remains.

The major impediment was figuring out how to use Mimic to structure the simulation and to then to configure it to communicate to the simulated programmable logic controller (PLC).

In addition, the overall approach to the simulation needed to be modified because of the way the Mimic furnace simulation block worked. The steel strip passes through multiple heat zones. Each zone is a furnace. The proposal split and combined the heat output from each zone furnace to transfer the heat to the sheet steel stream. The approach was "reversed" to split and combine the steel stream through each furnace.

The students did eventually get it to work and simulate the heat section of the annealing line, reading the PLC-generated valve positions, and writing the simulation-generated temperatures. The steel strip alloy, width and gauge were set to values for which ArcelorMittal provided a complete set of process measurements for which to test the simulation. With all combustion air valves set to their maximum value (fully open) and the gas valves set to the valve to maintain the proper air-fuel ratio, the temperature of the steel strip at the output of the heat section is about 800°C, which is close to what is measured in the actual system.

However, the current simulation needs a few changes. A number of assumptions were made about the configuration of the recuperators that use the furnace flue gas to preheat the combustion air. Basically, the heat exchanger representing a recuperator was configured with parameters so the simulated temperatures were "in the ballpark" to the actual measurements. The team was unsuccessful in obtaining this information from ArcelorMittal before the end of May.

The students overcame major hurdles in the project. Simulation of all of the heating-related sections should be very similar to the heat section. The only major unknowns are the cooling parts.

A new team of senior design students should pick up from where Makeda and Chris took the project and I expect they will finish. If a senior design group does not take this project, then I will pay an undergraduate or graduate student to finish the project by June 2019. ✦

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Makeda Beyene and Chris Eichholz, two undergraduate students, began their capstone senior design project, "Development of a Steel Continuous Annealing Line Simulation," in 2017. While development of the simulation is complete, additional data is required to refine the simulation.

The overall approach to the simulation needed to be modified because of the way the Mimic furnace and heat exchanger simulation blocks worked. In most sections, the steel strip passes through multiple heat zones. Each zone is basically a furnace (set of burner tubes) and a heat exchange between the set of radiant heat tubes and the steel strip. The original proposal split and combined the heat output from each zone furnace to transfer the heat to the sheet steel stream. The approach was "reversed" to split and combine the steel stream through each furnace. The "C" blocks combine multiple steel streams and the "S" blocks split the steel streams combined at the zone input. The Mimic blocks used to implement zone 2 of the heat section are shown in two parts. Mimic has two sets of blocks, regular blocks and advanced blocks. A sheet defined for regular blocks cannot contain advanced blocks and vice versa.

Dr. Erickson met with Carlos Forjan and York Tung of ArcelorMittal on 30 May 2019. The running CAL3 simulation was demonstrated on a laptop computer running Mimic and Mimic was interacting with an emulated ControlLogix processor.

The model documentation will be submitted as a paper to the AISTech 2020 conference. A research proposal is planned to be submitted to ArcelorMittal to continue this work in the following aspects:

1. Verify the gas jet cool section when in cooling mode. We did not have data for which to verify this part of the simulation.
2. Refine aspects of the simulation that were estimated: radiant heat tube mechanical data, recuperator mechanical data, cooling zone water-to-air mechanical data. The mechanical data values used for the heat exchanger blocks that implemented these parts of the simulation were estimated and adjusted so that the zone temperatures were close to the values of the provided data sets.
3. Add input/output points to the simulation so that the full programmable logic controller (PLC) program can be demonstrated. This task includes adding the infrared (IR) measurements of the steel strip between sections to the simulation, as well as the discrete input/output points.
4. Determine if the iFIX human machine interface (HMI) can use the open platform communications (OPC) driver to communicate to an emulated PLC processor. ArcelorMittal has already determined that the IO driver currently used by the iFIX HMI cannot communicate with an emulated PLC processor. Without this change to an alternate driver, the Mimic simulation is not useful for operator training.
5. Investigate how to modify the simulation to work with different steel gauge and widths. The gauge and width determine the surface area and volume for the steel strip in the furnace and heat exchanger blocks, of which there are about 100 in the simulation. For the current version of Mimic, these values are set as constants in the appropriate fields of the blocks, which means more than 200 parameters must be changed for each scenario. A programmatic way of changing the values of these fields for a given gauge and width would be very useful, as the alternative is to manually change the 200 parameters. ✦