ELECOMP CAPSTONE
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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO™

Extruder Zone Heating and Cooling Control with PLC

TEKNOR APEX

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Project Motivation

Teknor Apex produces plastic using extruders. The extruders consist of various components like zones, heaters, cooling system, and a die. The extruder heats raw plastic compounds to a temperature up to 400º F. The extruder then pushes the material through a die to be cut to specifications. The method of controlling the temperature zones have become dated and much less accurate over time compared to newer extruders today. Maintaining control over the temperature of each zone is important for product quality and electrical efficiency where a +/- 10º F difference makes quality control more difficult, produces off-grade product from burning of product and poor mix quality and costs money. We seek to develop a standard method of controlling each zone, dropping the difference to +/- 1º F of all the extruders in use, new or old. This would help Teknor Apex optimize temperature settings to run more efficiently on each production line.

Key Accomplishments

PLC Communication: Communication with the PLC (Programmable Logic Controller) **(Fig. 2)** was established by creating a static IP and updating the firmware over ethernet. The connection with the PLC was made through an ethernet switch, making a small local network. The PLC was then given a static IP on the URI Wi-Fi for remoting in more

PID and PIDE Simulations: A simulation program was created using ladder logic and implemented a PID loop. The simulation took the set point and the current temperature and the PID output how much to turn the heat on which was then proportional to the current temperature. The simulation will then be applied to the barrel **(Fig. 4)**. The same thing was done in the Function Block Diagram for the PID-E.

Pseudo Temperature Integral Control: Implementing P_TempIntg and P_HeatCool in function block diagram to automatically set the gains and be controlled manually. The simulations could be flipped between automatic and manual control of the control variable.

Server Computer Setup: A spare computer was set up to act as a central remote networking server computer. It was installed with the Rockwell Studio 5000 and Inductive Automation Ignition server software that we needed to complete our project. This was set up and equipped with the means for us and our TD's to collaborate on our progress and store it in a central location that we would be able to remotely access from anywhere outside of campus. **(Fig. 1)**

Zone Tag History Graphs: One aspect of our data collection is to have an interface that is easy to see patterns and events on **(Fig. 3)**. An Ignition tool was made so that it would read a SQL database for a zone's data and display trends in an easy to view and interactive graph and table for each zone in an extruder.

Automated Zone History Report Publishing: Ignition scripts that trigger whenever a new job order or plastic batch is started would compile the data from the last batch and is able to save the report as a PDF or send it over email.

Ignition Interface: This task involved creating a user-friendly interface through Rockwell's Ignition. This in conjunction with the PLC allowed communication to each other to display valuable information to the operator. The interface had to be operator friendly using well contrasting color schemes without confusing the operators.

Ignition Revamp: This task came at the end of the semester when we consulted our TDs. The task involved revamping the Ignition main screen to more easily identify specific changes to it. This task also involved revamping how the zones acquired data from the PLC. The data was also created neatly for use with Teknor Apex. This allowed for work to be done on the main screen to easily expand the zones if need be. This would work for extruders of various sizes in Ignition.

Ignition Alarms: The Ignition interface can include various alarms for the operators to take notice to. The more necessary alarms like overheating were put into place first, with easy expandability in mind for the rest of the alarms. These alarms are a very crucial and necessary component with any operation.

Test Bench: The barrel was stood up on steel plates to allow access to its water inlet and outlet. It was also prepped for heating and insulation. A water pump used for cooling was connected and tested.

Wire Diagrams: Some simple wiring diagrams were created in AutoCAD to represent some of the components we would have used. After uploading the basic wiring diagrams into AutoCAD, they were modified to represent our setup.

Anticipated Best Outcome

The Anticipated Best Outcome was four control loops implemented in ladder logic and a HMI design for an extruder zone. A database to record and store temperatures and alarms written in python. Additionally, electrical schematics, Ladder Logic, Data types, HMI Templates, Ignition and Python scripting were necessary. All design choices were for one zone but considered scale up and machine learning compatibility. Implementation should be achievable on different models and ages of equipment. It should also be able to control the heating and cooling of a zone to within one-degree Fahrenheit. The user also needs to be able to wire multiple zones together efficiently.

Project Outcome

We did not meet the Anticipated Best Outcome because we were not able to fully realize the test bench. This did not allow us to acquire real data to be further processed.

Figures

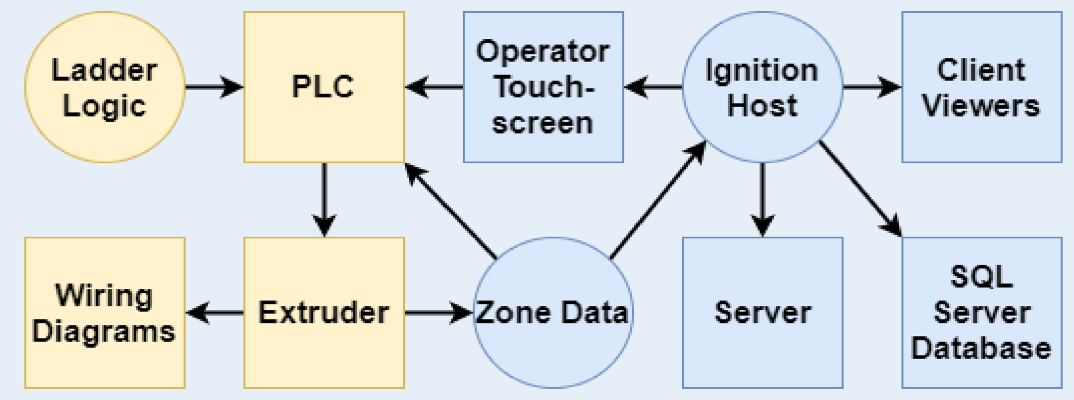

Fig. 1 - A block diagram of how the parts of the system function together.

Fig. 2 - Programmable Logic Controller with, from left to right, the Processor and the Ethernet card.

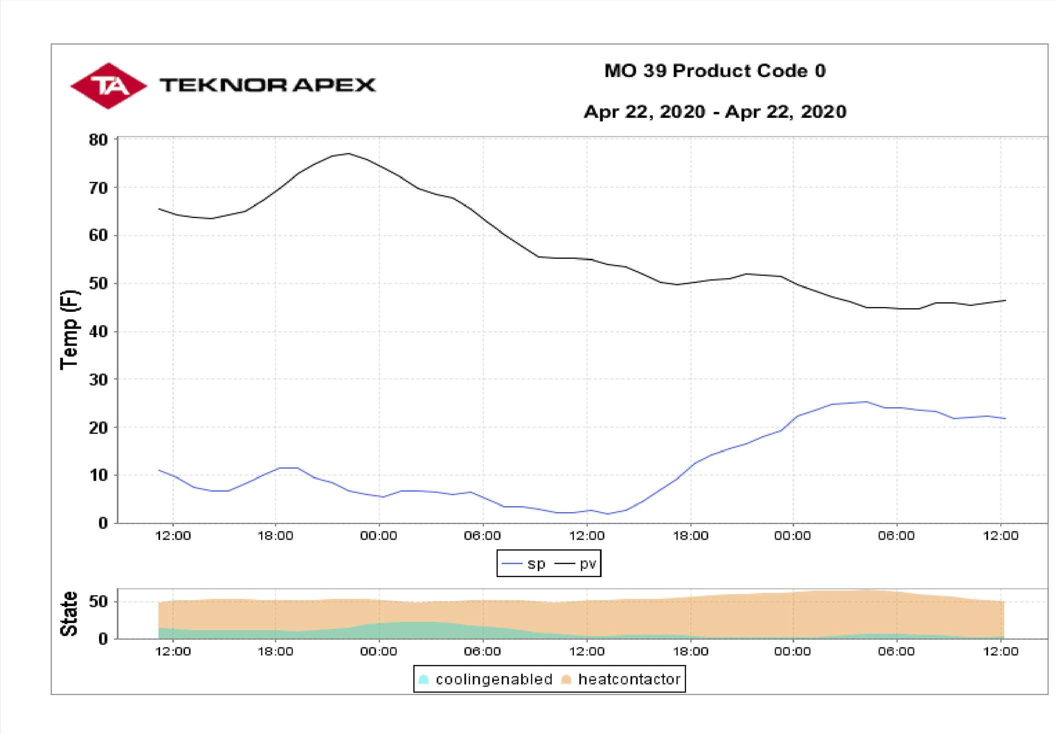

Fig. 3 - Historical Graph for a temperature zone.

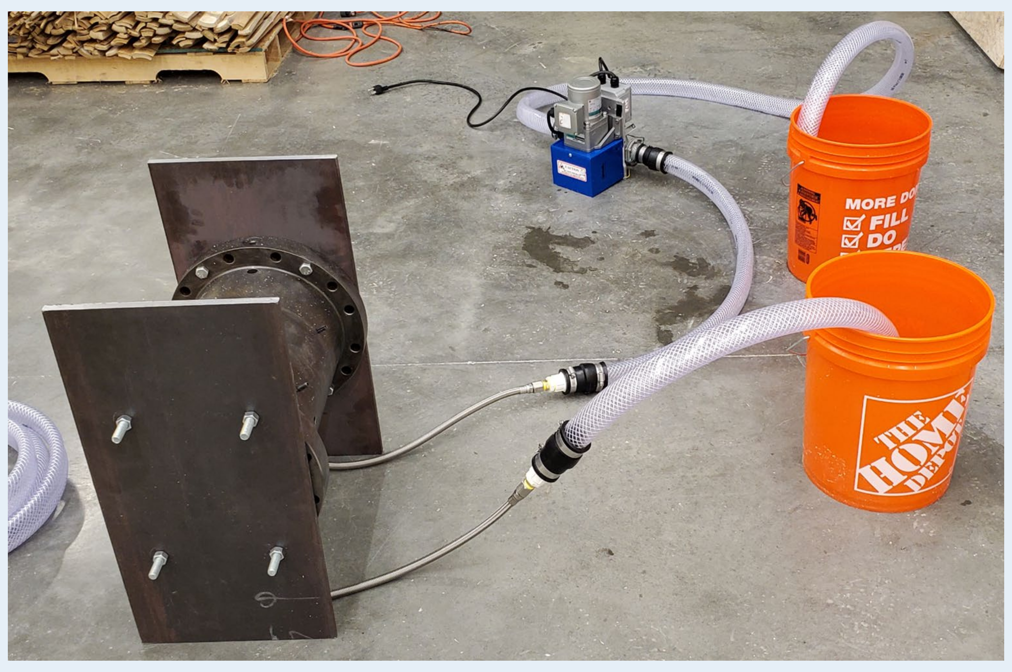

Fig. 4 - Zone with attached cooling system.