Extruder Temperature Control

Extruder Zone Heat and Cool with PLC Control

ELECOMP Capstone Design Project 2019-2020

Sponsoring Company:

Teknor Apex Company
505 Central Avenue
Pawtucket, RI 02861
https://www.teknorapex.com

Company Overview:

When Alfred Fain founded a small Rhode Island tire store in 1924, at the time no one could have predicted how Teknor Apex would become an international custom compounder sought out by companies around the world. After a nearly hundred-year journey that's carried us through acquisitions and expansion, we now have nine U.S. locations, as well as operations in Belgium, Singapore, Germany, and China.

Throughout this global expansion Teknor has remained a privately held company, and today Fain's grandson sits at the helm, maintaining the family's tradition of fostering deep customer relationships. These relationships are what allow us—together—to deliver customized compound solutions and help you create better products.

Every day around the world people come into contact with Teknor Apex products.
From bottles to boots to junction boxes, ear buds to garden hoses to toys and decks, specifiers and processors of products call on Teknor to be their trusted polymer partner. That trust is something we've earned by continually delivering custom solutions that meet or exceed our customers' requirements—and expectations.

Our status as the most dependable material science company in the industry is due to our talented Teknor teammates, as well as our unique infrastructure that offers unrivaled material testing and quality control. With six specialty divisions and almost a century of expertise, we have the capability to deliver highly tailored solutions, no matter the customer, supplier, or product.
Our application development engineers and sophisticated analytical and technical labs enable us to continue to develop new products to solve your most challenging problems.

Technical Director(s):

Brendan O'Reilly
Director of Corporate Engineering
boreilly@teknorapex.com
+1 (401) 642-3434

Mickey Monarch
Corporate Engineering Manager
mmonarch@teknorapex.com
+1 (401) 642-3595

Project Motivation:

Teknor Apex uses extruders for all of our production. These extruders are made up of barrels or zones and a screw. These extruders must heat raw materials to upwards of 400^{o} F. Once the process is underway, each zone must then remove heat from the process. The company has grown a great deal over its 90 year history and the methods of controlling these temperature zones have become fragmented. They have also become less accurate. This inefficiency costs millions in utility bills. Furthermore, new opportunities in AI and machine learning stand to help to company become more efficient than ever before, but require large amounts of data. This data must be structured in a standard way across the company in order to scale quickly and apply solutions globally.

Maintaining tight control over the temperature of each zone is very important for our process, both in product quality and electrical efficiency. If a particular zone operates at +/- 10^{o} F, then the extruder is both heating and cooling too much. This makes quality control more difficult, produces off-grade product, and costs money. We seek to develop a standard method of controlling each zone such that the temperature is controlled to +/- 1^{o} F. This would save the company millions and pave the way towards the greater efficiency gains of Machine Learning.

Machine learning is best applied in manufacturing for defect detection and optimization. With a large amount of data over time, and a well-defined problem to solve, a well-developed AI model can transition a company from chasing a problem after it's happened, to preventing it from happening at all. Inaccurate zone temperature control causes burning of product and poor mix quality. If we have a standard method of controlling each zone and collecting data on the temperature and the product quality downstream, we can create process profiles for each line and each product. This would allow us to determine exactly what temperature settings, heat up rates and cool down rates allow each product to run most efficiently on each production line.

Anticipated Best Outcome:

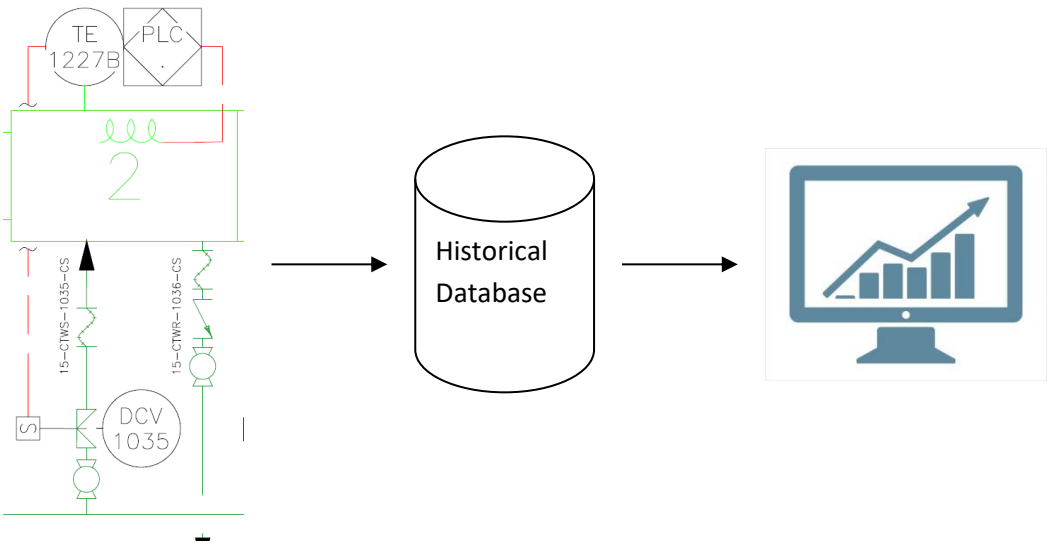
The anticipated best outcome is a fully realized set of PLC code, HMI design, and data base design for one temperature zone on an extruder. This would include electrical schematics, Ladder Logic, Function Block, Data types, HMI Templates, python scripting, and SQL scripting. All design choices should consider scale up and machine learning compatibility. Ideally a method of integrating the solution across multiple production lines with limited cost and downtime would be provided.

Project Details:

Overall system concept:

Each Extruder zone is comprised of a barrel with integrated hydraulic cooling and an electric heating element. It has a J type thermocouple to monitor temperature. The cooling is controlled with a single solenoid valve that cycles on and off as cooling is required. The heat is controlled in a similar fashion but electrically with a Solid State Relay. The first challenge will be to select an IO platform to connect these components to a PLC. Next a PLC platform must be chosen and a combination of ladder logic and function block will be written to control the zone. A UI must be designed such that an operator can view the zone temperature and change the set point. The UI must also provide a data trend of the temperature over time. To provide this trend, historical data acquisition must be designed and implemented as well.

Block Diagram:



Hardware/Electrical Tasks:

Identify all IO points for each zone (solenoid, SSR, thermocouple)

- Choose IO platform to integrate with various production lines
- Draw wiring diagrams for proposed solution
- Write Ladder Logic and Function block to control the zone
    - Access PIDe vs TempIntegral vs Thermostat control
    - Access Ladder logic vs Function block implementation
- Tune code for in process temperature control
- Write code for startup temperature control (rapid heat up)

Firmware/Software/Computer Tasks:

- Design HMI Template and Screen for single zone in Ignition using python and Java
    - Consider indirect addressing for scale up
    - Consider historical data acquisition
- Design charts for zone process data
    - Store temperature, heat on and cooling on
    - Store product code and control number
- Design historical database
    - Consider machine learning in the future
    - Consider scale up

Composition of Team:

The team will be comprised or 2 electrical engineers and 1 computer systems engineer, working with Teknor Apex engineering.

Skills Required:

Electrical Engineering Skills Required:

- Ladder logic
- Function block
- Understanding of Thermocouple functionality
- Understanding of Digital IO
- Allen Brandley PLC platforms
- Temperature control
- Ethernet and TCP/IP
- AutodCAD Electrical

Computer Engineering Skills Required:

- Python
- Java
- MSSQL
- Ethernet TCP/IP
- Inductive Automation Ignition
- Structured Data
- User Interface design

Anticipated Best Outcome's Economic Impact on Company's Business:

Teknor Apex hopes the URI team will provide a well-tested and documented package of ladder logic, function block, UI templates, wiring diagrams and Databases that can be scaled across each zone and each production line. This would allow us to copy paste working code in each PLC and Ignition gateway with great efficiency. Furthermore it would put us in a strong position to leverage data moving forward.

Broader Implications of the Best Outcome on the Company's Industry:

With standard code implementation and machine learning Teknor Apex hopes to become a market leader in advanced computing practices on the production floor. Being able to precisely track product issues to their source will allow us to produce quality product for our customers more easily. In the future, Machine learning will enable us to prevent these problems from ever happening. Combining these efforts will save the company millions of dollars.

Increased production efficiency lowers our company's carbon footprint across the board. Not only by lowering the amount of electricity we use, but by limiting the amount of times we have to make a product twice. The plastics industry is at the center of great debate about the environmental impact humans have on our world and Teknor Apex is committed to being a responsible contributor to our society.

By researching and developing advanced bio-plastics, installing solar panels at multiple production facilities and conducting efficiency projects with utilities, Teknor Apex has already put great effort advancing how we produce. We hope that increasing efficiency on the production floor will help further our progress towards this goal even more.