Real-Time Measurement System For Improved MetPeel Performance

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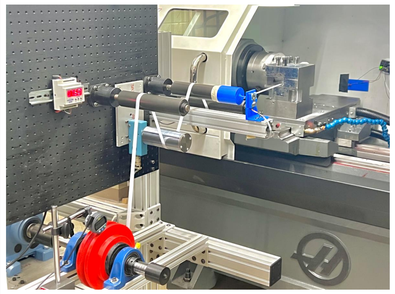
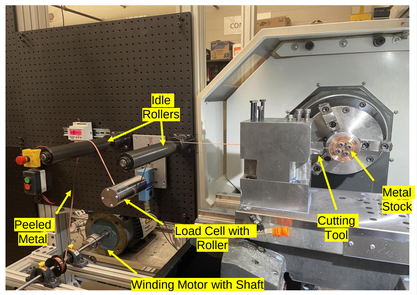
Introduction

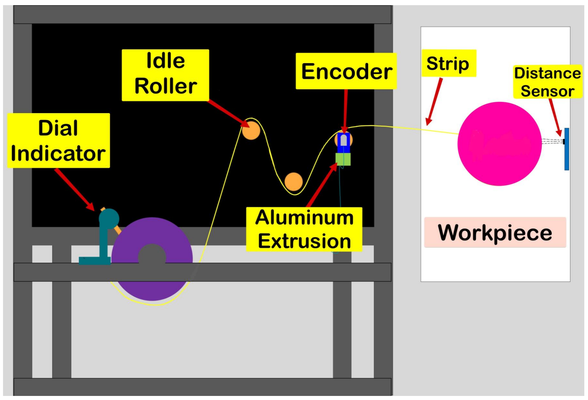
The measurable goals of this project were to create a real-time measurement system for improving the performance of MetPeel, which is a patented single-step process for producing metal strip coil in a much more energy-efficient manner compared to conventional rolling-based processes.





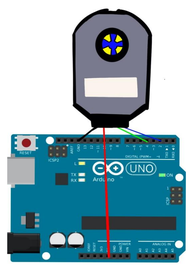
Goals

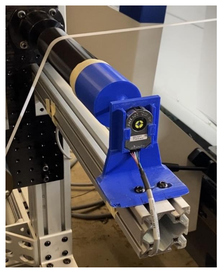
To instrument the process for real-time measurements of **strip velocity** and **workpiece diameter**.



Contributions

Process instrumentation with a AMT102 rotary encoder for real-time measurements of strip velocity; and a Pololu 4071 LiDAR sensor to monitor the reduction of the workpiece diameter during the cutting process, giving an estimate of strip thickness and coil diameter.

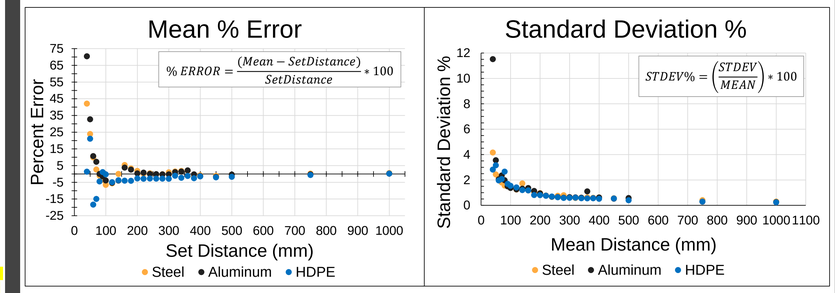




The encoder was used as a velocimeter, programmed through an Arduino Uno, mounted on an aluminum extrusion below the first idle roller.

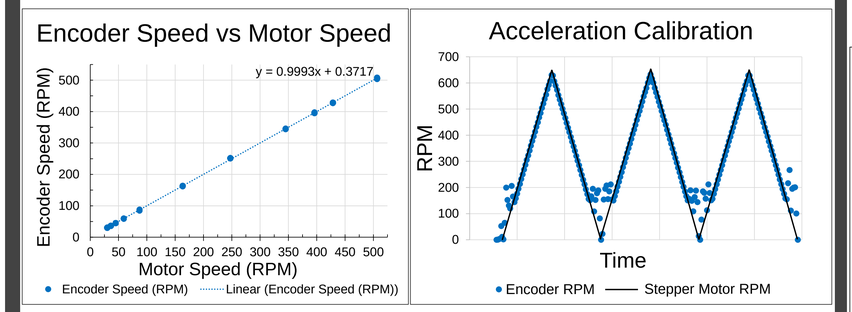
Calibration

Static and dynamic calibration was performed for both the sensors. LiDAR readings were recorded every 25 ms for objects placed at set distances for static calibration.



Mean % error (left) remained within the reported 5% after 200 mm. Standard deviation % (right) decreases below 2% as distance increases past 100 mm.

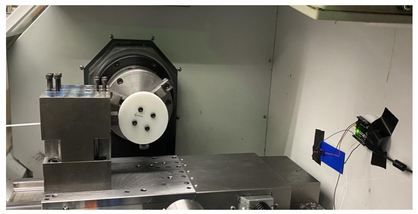
The encoder was calibrated using a stepper motor set at constant speeds and then set at a constant acceleration. The stepper motor speeds were verified using a tachometer.

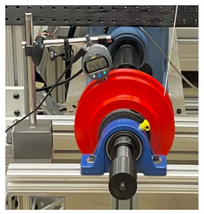


Encoder speed (left) shows a linear trend relative to motor speed, ensuring accuracy and precision during experiments. Encoder acceleration (right), follows the acceleration curve of the stepper motor closely.

Observations

Through calibration, Pololu LIDAR sensors were found to have poor detection resolution for dynamic response. However, the static response was relatively accurate, staying within the 5% error range reported by the company after 200 mm. The LiDAR sensor worked as a proof of concept, but a higher resolution broader capacity sensor could work better for the application. The AMT102 rotary encoder worked very well, remaining within a 1% margin of error during calibration.

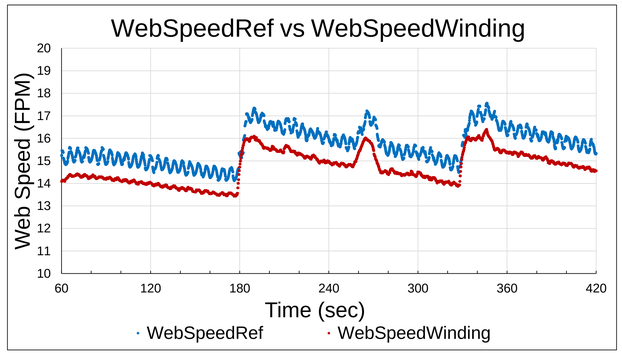




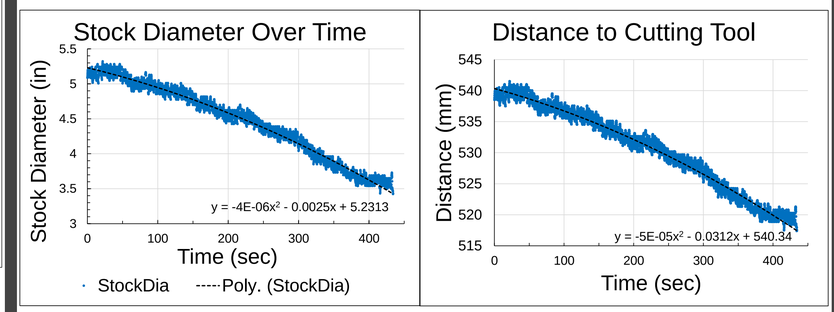
The distance sensor (left) measured the diameter of the stock. The dial indicator (right) calculated the diameter of the coiled strip.

Results

Experiments were performed on High-Density Polyethylene (HDPE) at a cutting speed of 16.4 feet per minute, with the strip coiled under a tension of 7.5 pounds, maintained by a closed loop feedback system.



The estimated velocity of the strip (WebSpeedWinding) followed closely to the real-time velocity measurement from the encoder (WebSpeedRef). The encoder readings captured the inherent oscillatory behavior in the strip speed.



The LiDAR sensor measured the distance to the cutting tool (right), showing a similar trend to the calculated workpiece diameter. The stock diameter (left) was calculated by subtracting the radius of the workpiece at the start from the distance to the cutting tool.

Summary

Using an Arduino Uno R3 microcontroller, the AMT102-V rotary encoder and Pololu LIDAR sensors were programmed to provide a real-time measurement system for MetPeel. The efficacy of this system in improving the performance of the manufacturing process was validated through a series of calibrations and experiments. The encoder showed the greatest potential to be used in a consistent application for the MetPeel process.

Acknowledgments

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