

Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Embedded Thermal Sensor for an Injection Molding Nozzle

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Client: Orbis Corporation, 206 Plastic Lane, Monticello, Iowa, 52310, <http://www.orbiscorporation.com/>

Contact(s):

- Heather Wegner, Continuous Improvement Engineer, heather.wegner@orbiscorporation.com, 319-558-6678
- Greg Kemp, Maintenance Manager, greg.kemp@orbiscorporation.com

1 PROBLEM STATEMENT

Orbis products are having an issue with quality because the temperature of the melt flow is inconsistent. We must find a solution to measure the real time temperature of the resin as it passes through the nozzle. This will allow Orbis to detect issues before the products are produced.

Business Case Statement

- A. The temperature within the injection molder is not being monitored reliably or captured in real time. The inconsistency from these factors causes products are created with lower qualities. The main issue is that not knowing the real-time temperature of the plastic, since controlling this temperature would allow for better quality control. Placing a thermal sensor in the nozzle of the injection molder would allow the operator to observe variations in the temperature, in real time, and adjust machine parameters accordingly to ensure a higher quality product.
- B. The temperature variations have the potential to affect all of the products that Orbis produces.
- C. The problem initially occurs because of the inconsistent quality of the resin. Different melt temperatures from batch to batch of resin cause a need for real-time temperature monitoring.
- D. Installing a thermal sensor will help to reduce future quality issues with Orbis products.
- E. Orbis and its customers care about the quality of the products. This will help to reduce low-quality products, which will help Orbis save money and ensure customers receive higher quality products.

2 GOAL STATEMENT

- A. Our goal was to find a way to read the plastic melt flow temperature inside the nozzle of an injection molding machine in real time.
- B. We will measure our success of this project by being able to get a temperature reading of the plastic for each shot that goes through the machine. Then being able to adjust the machine's parameters when the quality of the product is not satisfactory.
- C. Respond to all questions below with specificity (point B above), if feasible). What were the:
 - o The parameters that we worked with were, our solution needed to measure the the temperature in real time, be safe, withstand 27,500 psi, and can withstand 500 degrees
 - F. With our solution we will save the company and estimated \$288 a day on products that they were losing before to overheated or underheated and saving them time so they can run more products through their machines. It will also help them understand better how/when the temperature changes.
- **Main Objective(s) and Specific Objectives**
 - o (1) Design an embedded thermal sensor that meets all client criteria and constraints:
 - Produce real-time material temperature
 - Sensor placed on the back of nozzle to avoid interference with the mold
 - Safe to operate
 - 27,000 internal psi
 - 500 degrees Fahrenheit
 - 1 year lifetime
- **Rationale**
 - o Orbis will be able to produce higher quality shipping containers
 - o Orbis will be able to pay off the investment within 2 months

3 PROJECT PLAN/OUTLINE

A. Methods/Approach

- Reference Material(s)
 - We obtained the specs about the heat transfer lines and the possibility of tapping into the nozzle from product handout from Synventive and by speaking with Desmond Crowley, an employee at Synventive.
 - We researched the specs of the sensor and found it able to withstand 500 degrees Fahrenheit and 27,500PSI from an engineer with Nordic Sensors.
 - We obtained the financial information to do a cost analysis from Greg Kemp.
- **Data collection:**
 - We collected data from the nozzle and sensor manufacturers, and Orbis to help find the best options for each option that would produce a safe, accurate, and timely reading.
 - We did research on each option to ensure they would be within the constraints of the injection molding system.
- **Skills:**
 - We had to analyze all physical constraints (pressure, temperature, obstructions) to provide a feasible, practical and safe solution.
 - Statics was beneficial to do a stress analysis on the threaded end of the sensor.
- **Solutions:**
 - We evaluated each option based on real-time capability, safety, cost, ease of implementation, user training, and lifetime.
 - Our main focus on finding a solution was the real time temperature capability and the safety in operating.
 - The solution that we have proposed fits the criteria that were given to us by Orbis. The embedded sensor will measure real-time temperature, withstand the internal constraints of the nozzle, has one year lifetime, and will be safe to operate.
- **Organization:** We communicated with Orbis on a weekly basis by email. We also met with them once and had a phone call with them as well.
 - Each week we talked about what we need to accomplish for the upcoming week and then we split responsibilities up evenly from there.
 - Our major milestones during this project were, contacting Orbis and truly getting a grasp on what our project was, finding different possible solutions to the project, talking to Jake Behrens who showed us that embedded sensors are possible, getting the nozzle we have cut and drilled/tapped.
 - Throughout the project, we had setbacks from the client not getting back to us in a timely manner. We dealt with this by continuing with our project in another area until the client got back to us. We also sent multiple emails to the client to get their attention.

B. Results/Deliverables

- o Complete technical drawings and instructions for installation, give these drawings and instructions to Orbis and finally give the final report to Orbis.
- o Yes, they are consistent with the project objective and scope.
- o We did not get as much done as we would have liked, such as, we would have liked to have put a sensor into a nozzle, but we have a solution for the problem.
- o Our recommendations are to implement the embedded sensor into all 12 of their machines and utilize the Solo Temperature Controller to read and record the data.
- o The next steps for Orbis to take would be to implement our solutions into their plastic injection molders.

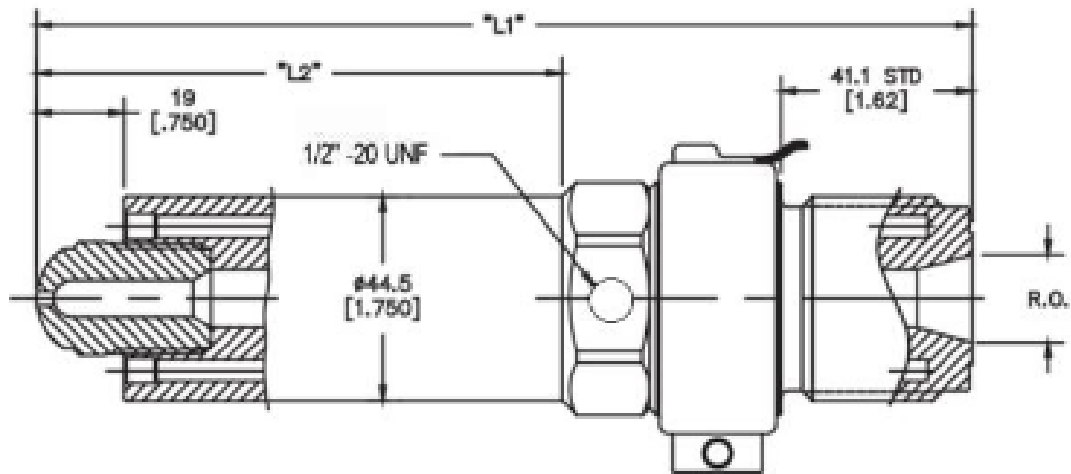
4 BROADER OPPORTUNITY STATEMENT

- A. This project is not meant for the average person. This project is focused on material that is specific to companies or institutions that use injection molding machines.
- B. This project does not address needs or provide solutions for the Big Challenges such as feeding the world.
- C. The problem this project focuses on can be experienced with any business or facility that uses an injection molder and needs to know the real-time temperature of the plastic within the nozzle.
- D. Outside of industries that use injection molding machines, there would not be any need for this project's solution.
- E. Competitors addressing the same issue of this project are implementing an injection molding machine with a temperature sensor already installed on the machine when purchased.
- F. Companies are extremely willing to alleviate this problem as it saves them a considerable amount of time and reduces the amount of scrap created by their system.

5 PROJECT SCOPE

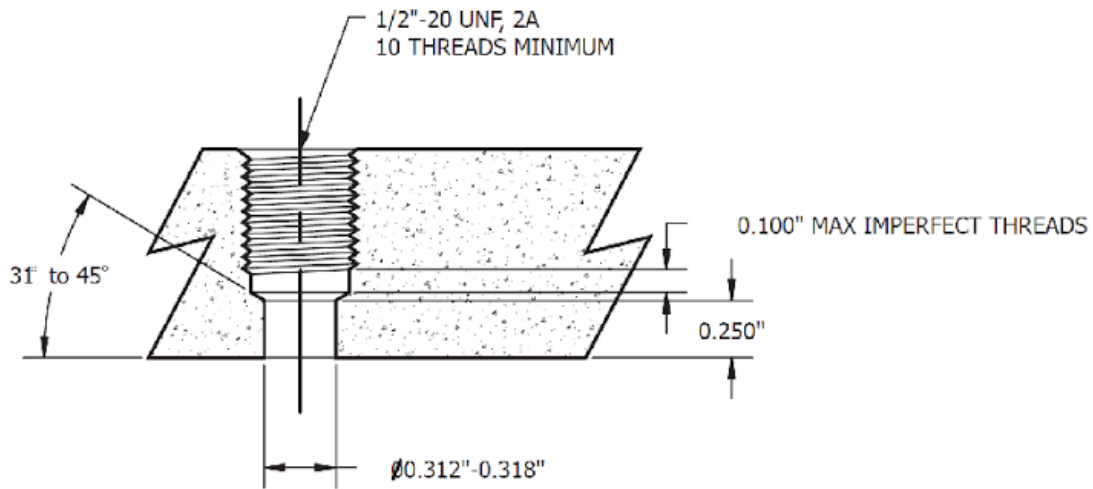
- A. We focused on finding the temperature of the melt flow within the nozzle. We began by looking at the sensing options that may work for Orbis. We analyzed each option to ensure the best results for Orbis. After choosing the embedded sensor, we developed the documentation to implement the sensor and controller for the unit.
- B. We collaborated with the Continuous Improvement and Maintenance departments throughout the process.

6 GRAPHICAL ABSTRACT

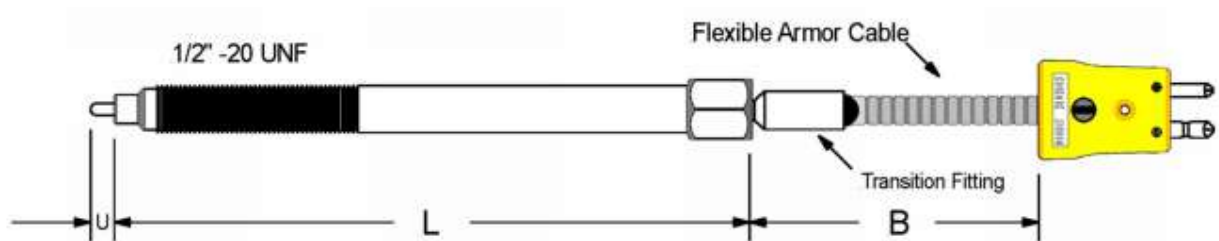


Above is a technical drawing of an injection molding nozzle with a hole location shown on the nozzle base. The hole shown above is to be drilled and then tapped as a $1/2'' - 20$ UNF hole.

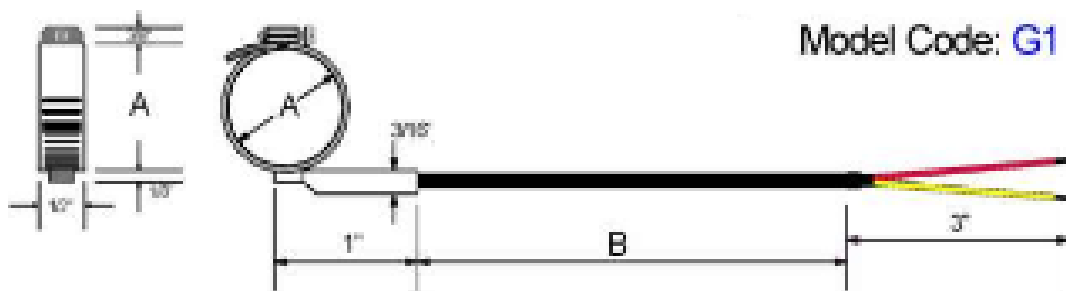
7 APPENDIXES



1. Above is a sectional view of the $1/2''-20\text{ UNF}$ hole placed into the injection molding nozzle.



2. Nordic Sensor's K1 Thermal Sensor - This project's chosen solution.



3. Nordic Sensor's External Thermocouple



4. Raytek's RAYCI1B10L Infrared Sensor

	Embedded Sensor
Sensor	\$96
Controller	\$130
Installation (including labor)	\$208
Cost per Machine	\$434
Machines	12
Total	\$5,208
Simple Payback Period (Days)	18.08

5. Cost Analysis

Possible Solutions		Embedded Sensor	Infrared Sensor	Upgraded Thermocouple
<u>Criteria</u>	<u>Wt.</u>	1	2	3
Real Time Capability	40%	5	1	1
Safety	20%	3	5	5
Ease of implementation	10%	3	3	5
User Training	10%	3	1	5
Cost	10%	3	1	3
Lifetime	10%	3	3	3
Weighted Score	1	3.8	2.2	3.0

6. Decision Matrix