Background

Introduction

Perrigo is a self-care and pharmaceutical manufacturing company founded in Allegan, Michigan. The company has been creating quality products for over 130 years. Perrigo’s Plant 7 uses compressed air in their manufacturing processes for quality purposes and to orientate products on the packaging line. Inefficient use of compressed air at Perrigo leads to an increase in cost and waste of energy.

Air Knives

Air knives are used to deliver compressed air in a continuous laminar flow pattern. The exit air velocity can be used to shear away moisture or particulates without mechanical contact. Figure 1 illustrates an air knife used in Perrigo’s manufacturing facility.

Pharmaceutical Applications for Air Knives

• Movement of bottles along line
• Inverting bottles
• Removal of debris before labeling

Design Alternatives

Air Flow

1. Non-Invasive

Using ultrasonic technology, non-invasive flow meters calculate flow rate by utilizing ultrasonic signals to measure differences in transit times of opposing signals. The difference in transit time allows for flow calculation. No cutting of pipe required for installation.

2. Invasive

Using thermodynamic and heat transfer principles, invasive flow meters determine mass flowrate by using thermometers or calorimeters to measure heat loss to the flow. Installation required into pipeline.

Line Autonomy

1. Infrared Proximity

Composed of an infrared LED and an optical sensor. Detects the presence or absence of received light and converts detection to an electrical signal which can control a mechanical device.

2. Through-beam Ultrasonic

Composed of a transmitter, to release audible ultrasonic sound waves, and a receiver, to detect the sound waves. When an object passes through and interrupts the ultrasonic sound waves, the sensor is triggered to produce an action.

3. Paddle Level Switch

Paddle sensors run based on the flow of bottles through the production line. The force of moving bottles physically moves the paddle arm from the “on” to “off” position.

4. Safety Light Curtain

Consists of parallel infrared beams between an emitting bar and receiving bar. When an object breaks the curtain of light, an electronic signal is generated.

Selected Design

Airflow meter

The meters were evaluated based on the following criteria: cost, accuracy, quality and safety assurance, ease of installation, feasibility of system integration, and ease of data acquisition.

Aventics’ invasive IO-Link flow sensors were chosen to measure the flowrate through Perrigo’s air knives in packaging line 424. The sensors use calorimetric measuring principles by measuring the cooling effect of the air flowing on the heated probe.

Implementation

Airflow Meter

Two Aventics IO-Link flow sensors were installed directly into each of the air knives’ poly feed piping. Each flow meter was uninstalled and reinstalled daily to collect data in all five air knives. All installation was handled by Perrigo and came at no cost to the project.

Line Autonomy

Line autonomy was completed by installing infrared proximity sensors in tandem with pneumatic valves at each of the five air knives. The proximity sensor was installed above the production line with the pneumatic valve integrated into the poly air supply line, as shown in Figure 3. The infrared proximity sensors installed by Perrigo were from internal stock.

Ladder Logic, based in conditional formatting, was used for communication between the sensors and valves. If a bottle was detected by a sensor, a signal was sent from the computational system to open the pneumatic valve. If the sensor detected no object, a signal was sent to close the valve.

Data Analysis

After purchase and install of two Aventics IO-Link flow sensors into line 424, the team collected data through all five air knives over the course of one 24-hour workday. Table 1 illustrates average flow measurements before autonomy implementation.

After effectively integrating line autonomy into all five air knives, the team performed the same data collection process to determine flow reduction. Table 2 illustrates average flow measurements after autonomy implementation.

Economics & Conclusion

Economic Justification

The team calculated the payback period based on overall savings implications from flow reduction. Table 3 provides a price breakdown for purchases made for the project. All purchases were made prior to payback period calculation because the team did not have access to the needed calculations.

Recommendations

Moving forward, Perrigo should collect more comprehensive data to represent true air flow in their system. Due to time constraints, the team could only measure air flow for 24 hours in each respective air knife. Similarly, Perrigo should track and use real-time energy consumption and air flow discharge data for the machines involved in the air compression process. This will enable Perrigo to derive a dynamic cost of compressed air based on system fluctuations. Lastly, Perrigo should integrate autonomy into air knives across all manufacturing lines and plants. The team’s calculations show that expansion of air knife autonomy can lead to significant savings.

References


Table 1: Initial Flow Readings Through Air Knives.

<table>
<thead>
<tr>
<th>Air Knife 1</th>
<th>Air Knife 2</th>
<th>Air Knife 3</th>
<th>Air Knife 4</th>
<th>Air Knife 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Flow (L/min)</td>
<td>122.2</td>
<td>241.4</td>
<td>51</td>
<td>58.3</td>
</tr>
<tr>
<td>Average Flow (cfm)</td>
<td>1.7</td>
<td>4.6</td>
<td>1.3</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Average Total Flow (cfm) 14.0

Based on the calculated data, line 424’s air knife flow was reduced by 34%. Figure 4 shows hourly flow in cubic feet per minute before and after autonomy implementation.

Table 2: Post-Autonomy Implementation Flow Readings Through Air Knives.

<table>
<thead>
<tr>
<th>Air Knife 1</th>
<th>Air Knife 2</th>
<th>Air Knife 3</th>
<th>Air Knife 4</th>
<th>Air Knife 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Flow (L/min)</td>
<td>48</td>
<td>131.4</td>
<td>57</td>
<td>58.3</td>
</tr>
<tr>
<td>Average Flow (cfm)</td>
<td>1.7</td>
<td>4.6</td>
<td>1.3</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Average Total Flow (cfm) 14.0

Figure 3: Proximity Sensor Implementation in Line 424.

Figure 4: Graphical Representation of Air Flow Before and After Autonomy Implementation.