Team 5

Smart Camera to Measure Coil Diameter

Sponsor: ArcelorMittal

Manager: James Quaglia
Webmaster: Joe McAuliffe
Lab Coordinator: Ian Siekkinen
Doc Prep: Petros Taskas & Matt Wesolowski
Presentation Prep: Poyaun Han
Company Information

- World’s largest steel producer
- Created by Western European steelmaker Arcelor and Indian steelmaker Mittal steel in 2006
- Generates 96.3 million tons of steel in production, and ranked in the Fortune Global 500 in 2013
Executive Summary

**Problem:** Current System does not correctly measure steel coil diameter

**Solution:** Implement smart camera system with interface to correctly measure diameter of steel coil during rolling process
Customer Needs

● Accurate way to measure the diameter of a steel coil on a tension reel
  ○ Diameter needs to be accurate within an inch
● Robust measurement system
  ○ Ideally in a protected location away from the moving parts of the tensioner
● Ability to communicate the amount of steel back into the existing control systems
Current System

- 320p security camera being used
- Uses feed rate and steel gauge to calculate diameter as steel is being rolled
- Human Machine Interface is insufficient for quick use
Meet with sponsor

Complete the design for camera an install on # pickle line

Use ultrasonic sensor mounted near winding coil

Use laser to measure the radius

Design software that will measure the diameter of coil

Build a communication via TCP/IP

Installed the program on to dedicated computer

Received feedback of image processing and communicate with plant control system
Conceptual Design

● “Smart” Camera
  ○ 1080p, 30 fps, Type 1 PoE

● Ultrasonic Sensor
  ○ Max range 180 inches, sample rate up to 170 kHz, accuracy 0.25%

● Laser Sensor
  ○ Max Range 10 m, Sample rate up to 50 Hz, accuracy ± 5.0 mm
### Design Rankings

<table>
<thead>
<tr>
<th>Feasibility Criteria</th>
<th>Wt.</th>
<th>AXIS “Smart” Camera</th>
<th>Ultrasonic Sensor</th>
<th>Laser Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operational Feasibility</strong></td>
<td>30%</td>
<td>This system will work exceptionally well since it will be away from moving parts and easily accessible. It also has functions to communicate with the network and existing software. This system will be user friendly and organized due to its simplicity and standard feature.</td>
<td>This system should work moderately well since it will be close to moving parts and a dirty area.</td>
<td>This system will work poorly due to the possible reflection and its proximity to moving parts.</td>
</tr>
<tr>
<td><strong>Technical Feasibility</strong></td>
<td>30%</td>
<td>“State of the art” camera. Easily acquirable. Step by Step guide to interface with networks. Moderately easy to develop. Very easy to operate. Very easy to maintain since it will be installed overhead above a walkway.</td>
<td>Old technology with a moderately cheap sensor. Very easily acquirable. May have a few issues communicating with networks due to no pre-developed hardware or software. Moderately easy to develop. Difficult to operate. Difficult to maintain due to installation area near moving parts.</td>
<td>Moderately new technology. Moderately available. Easy to acquire. May have a few issues communicating with networks due to no pre-developed hardware or software. Moderately easy to develop. Difficult to operate. Difficult to maintain due to installation area near moving parts.</td>
</tr>
<tr>
<td><strong>Economic Feasibility</strong></td>
<td>30%</td>
<td>$1,000+</td>
<td>$200+</td>
<td>$400+</td>
</tr>
<tr>
<td>Payback period (discounted):</td>
<td></td>
<td>Initial Investment / Periodic Cash Flow</td>
<td>Payback period = 7 days</td>
<td>Payback period = 1.5 days</td>
</tr>
<tr>
<td>Payback Period = (\sum_{t=1}^{n} \frac{C_t}{(1 + r)^t} - C_0)</td>
<td></td>
<td>Detailed calculations:</td>
<td>Net present value = Getting more information.</td>
<td>Net present value = Getting more information.</td>
</tr>
<tr>
<td>Schedule Feasibility</td>
<td>10%</td>
<td>3 to 5 weeks</td>
<td>4 to 6 weeks</td>
<td>5 to 7 weeks</td>
</tr>
</tbody>
</table>

**Ranking:**
- **Wt.**: 100%
- **AXIS “Smart” Camera**: 95
- **Ultrasonic Sensor**: 79
- **Laser Sensor**: 72
Proposed Design Solution

- Use the Axis P1355-E and a dedicated Windows 7 PC to create a smart camera system
  - The camera will feed live video into the dedicated computer
  - The computer will analyze the video to find the coil diameter
    - The computer program will utilize the Sobel method to detect the edge and calculate the diameter in the image
    - The actual diameter of the coil will be calculated using the known geometry of the setup
  - The computer will then feed this value back into the existing production control system
Software Design Process

Start → Receive Desired Diameter Length variable from Production Controller → Detect Increasing Edge Frame by Frame → Desired Diameter Length? → Yes → Ping TCP/IP Address of Production Controller with "Cut Command"
# Risk Analysis

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Event</th>
<th>Tech. Performance</th>
<th>Cost</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 High</td>
<td>Program Relays false data into computer system, catastrophic failure, endanger line workers</td>
<td>Highly unacceptable, increase in chance of accident occurring</td>
<td>Budget impacted due to increase of insurance liability</td>
<td>Project pushed back maximum of one week</td>
</tr>
<tr>
<td>2 Moderate</td>
<td>Computer malfunction, line forced to stop, no steel being produced</td>
<td>Unacceptable due to loss of profit experienced by sponsor</td>
<td>Budget continually impacted for duration</td>
<td>Project affected until computer system can be reset with bug fixed</td>
</tr>
<tr>
<td>1 Low</td>
<td>During Camera installation, worker could become injured</td>
<td>Performance not greatly affected, time and profit lost</td>
<td>Budget only impacted based on injuries sustained</td>
<td>Project pushed back no more then one day until properly installed</td>
</tr>
</tbody>
</table>
Gantt Chart

Critical Tasks

- Pre Proposal
- Meeting with Dr. Deller
- ArcelorMittal Site Visit
- API Selection
- Proposal
- Software Development
- Final Site Visit
- Report
- Design Day Presentation
Budget

- Thus far, no part of the $500 budget will be used within the foreseeable future
  - Axis P1355-E Camera - Supplied by sponsor
  - Dedicated computer - Supplied by DECS
  - VAPIX (API) $215
  - Software - Supplied by DECS
    - MATLAB
    - Simulink
    - Microsoft Visual Studio
Progress Thus Far....
Conclusion

- New software written for ArcelorMittal’s steel line computer system
- Very accurate reading of steel roll diameter based on 1080P Camera monitor

Questions?