A Study of the Efficiency and Consistency of Various Types of Mold Heating in LSR Injection Molding

Greg Murrer
Doug Natalie
4/11/14
Introduction

• Study Purpose
  – Consistency, Efficiency
  – Energy Consumption

• LSR Injection Molding
  – Differences

• 3 different 8-Run DOE
  – Type of Heating (Oil, Water, Cartridge)
  – Factors
    • Part Thickness, Cycle Time, Mold Temperature
Heating Methods

• Oil
  – Regal Oil Temperature Controller
  – Max Temp: 260 °C
  – Caused Disorder

• Water
  – SC Standard
  – 11.4 Liters per minute
  – Max Temp: 200 °C

• Cartridge
  – 900 Watt
  – 4 per plate
  – Hot Runner controller
Frisbee Disk Mold

• Custom Design
  – Recycled Plates
• Oil, Water Heater Plate
Frisbee Disk Mold

- Cartridge Heater Plate
- Air Ejection with Spring Pullback
  - Semi-auto
- Priamus Cavity Temperature sensor
Study Method

• 3 DOE’s
  – 10 Parts per Run
  – Adequate Time to Stabilize
  – Different for Each Heating Method

• Part Thickness
  – Core Change

<table>
<thead>
<tr>
<th>RUN</th>
<th>A</th>
<th>C</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A-</td>
<td>C-</td>
<td>G-</td>
</tr>
<tr>
<td>2</td>
<td>A-</td>
<td>C-</td>
<td>G+</td>
</tr>
<tr>
<td>3</td>
<td>A-</td>
<td>C+</td>
<td>G-</td>
</tr>
<tr>
<td>4</td>
<td>A-</td>
<td>C+</td>
<td>G+</td>
</tr>
<tr>
<td>5</td>
<td>A+</td>
<td>C-</td>
<td>G-</td>
</tr>
<tr>
<td>6</td>
<td>A+</td>
<td>C-</td>
<td>G+</td>
</tr>
<tr>
<td>7</td>
<td>A+</td>
<td>C+</td>
<td>G-</td>
</tr>
<tr>
<td>8</td>
<td>A+</td>
<td>C+</td>
<td>G+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor Label</th>
<th>Description</th>
<th>MINUS (-)</th>
<th>PLUS (+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Part Thickness (cm)</td>
<td>0.0762</td>
<td>0.254</td>
</tr>
<tr>
<td>C</td>
<td>Mold Temperature (°C)</td>
<td>150</td>
<td>160</td>
</tr>
<tr>
<td>G</td>
<td>Cycle Time (Sec)</td>
<td>47</td>
<td>57</td>
</tr>
</tbody>
</table>
Hot Oil Energy and Temperature Representative Graph

Time (s)

Temperature (°C)

Power (kW)
Hot Water Energy and Temperature Representative Cycle

Temperature (°C)

Power (kW)
Cartridge Heater Energy and Temperature Representative Cycle
Interactions

- B = Part Thickness and Temperature
- E = Cycle Time and Temperature
Results

Total Energy Used During Each 80 Part Study

- **Water**: 3.7368 kWh
- **Oil**: 8.0657 kWh
- **Cartridge Heaters**: 1.5080 kWh
• **Results**

![Bar Chart]

**Insulated water Comparison**

- **Cartridge**: 1.5080
- **Original Water**: 3.7368
- **Insulated Water**: 3.1270

**Kwh**
• **Results**

![Bar chart showing the comparison of matched line length for different materials. The chart compares Oil, Original Water, and Matched Water. Oil has the highest Kwh reading at 8.0657, followed by Matched Water at 4.0587, and Original Water at 3.7368.]
• **Results**

![Bar Chart](chart.png)

- **1000 Parts**
- **Heating Method**
  - Cartridge
  - Water
  - Oil
- **Cost ($)**

Cost ranges from 0 to 15 dollars.
### Other Observations

#### Heating Method Comparisons

<table>
<thead>
<tr>
<th>Method</th>
<th>Set-Up Time (mins)</th>
<th>Heating Time Up To Stabilization (mins)</th>
<th>Cool Down Time (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>12</td>
<td>32</td>
<td>14</td>
</tr>
<tr>
<td>Oil</td>
<td>12</td>
<td>42</td>
<td>20</td>
</tr>
<tr>
<td>Cartridge</td>
<td>44 (with wiring)</td>
<td>38</td>
<td>65</td>
</tr>
</tbody>
</table>

#### Controller Set Point Comparisons

<table>
<thead>
<tr>
<th>Method</th>
<th>Controller Temperature (150 °C)</th>
<th>Controller Temperature (160 °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (1 to process)</td>
<td>171.7</td>
<td>185</td>
</tr>
<tr>
<td>Insulated Water (1 to process)</td>
<td>165</td>
<td>176.7</td>
</tr>
<tr>
<td>Water (2 to process)</td>
<td>165</td>
<td>177.2</td>
</tr>
<tr>
<td>Oil (2 to process)</td>
<td>190.6</td>
<td>204.4</td>
</tr>
</tbody>
</table>
Average of the Cavity Temperature Ranges Across Individual Runs

<table>
<thead>
<tr>
<th>Heating Method</th>
<th>Max Temp Range</th>
<th>Min. Temp. Range</th>
<th>Average Temp. Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cartridge Heaters</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Degrees (°C)
**Conclusion**

- Oil is clearly the most inefficient
- Cartridge Heaters are the most efficient
- Water had the easiest set up and was the most consistent
Future Work

- Insulation of the water heating lines to see if it can be improved
- Matching the line length of water and oil tests
A Study of the Efficiency and Consistency of Various Types of Mold Heating in LSR Injection Molding

Greg Murrer
Doug Natalie
12/9/13