Metal Injection Molding of Wing/Flaperon

BAE Systems, NCDMM, U.S. Army and Polymer Technologies

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United States Army
Army Material Command (AMC)
Research, Development and Engineering Command (RDECOM)
Aviation and Missile Research, Development and Engineering Center (AMRDEC)
Engineering Directorate (ED)
Manufacturing Science and Technology Division (MST)
Redstone Arsenal, Alabama
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and the

National Center for Defense Manufacturing and Machining (NCDMM)
Latrobe, Pennsylvania
Mark F. Huston – Executive Director (724) 539-8132
Polymer Technologies Inc

• Started under the name of PTI in 1941. Was spun-off into Polymer Technologies Inc in 1987 to pursue value added, specialty work.

• Occupies 93,000 sq feet. Capable of expansion to 143,000 if needed

• Employees- 95
What is Metal Injection Molding?

Metal Powders + Binder = Injection molding Feedstock

Blending → Sintering → Debinding of Molded Parts → Injection Molding
150 ton tie-bar-less Injection Molding Machine at PTI
AVS Batch Furnace at PTI

High Vacuum, all metal hot zone for clean rapid cycles

Hydrogen, Argon, Vacuum cycles to 1450°C
Hydrogen Pusher Furnace at PTI

• High Production Rate Furnace
• 144” Preheat, 72” high heat, 96” cooling
• Fully instrumented
  • (H₂ and N₂ mass flow meters, etc)
• 1650°C (~3000°F) operating temperature

CM Furnace for continuous production
RR195 Backing Plate
MIM 316L
17-4PH Stainless Steel Snap Ring

Flying Bomb Housing

Demonstrated ability to flow and fill long thin parts having detail
316L, 17-4PH and 4340 Components

Simple and Complicated shapes can be formed easily
Tungsten Alloy Components

Balls

Flyweights
PTI MIM has identical microstructure as traditional process.
Complex Geometry and Co-Sintered Joints
As-Sintered 17-4PH MIM Wing
Closer view showing cavity on bottom
View through Nacelle
As-sintered 17-4PH Flaperon
Closer view of back - As-sintered 17-4PH Flaperon
Phase I - Task I  Component Review -cont

17-4PH MIM Microstructures
HIPed, standard H1025 H.T.

Edge of 5/8 inch dia bar

$R_c = 38$
$Cu = 3.8$

Center of 5/8 inch dia bar

$R_c = 38$
$Cu = 3.8$

Proper Control of Sintering Atmosphere Including Carbon Potential Allows for Uniform Properties in Thick Components
Phase I - Task I  Component Review - cont

Average 17-4PH H1025 Tensile Data

<table>
<thead>
<tr>
<th></th>
<th>YS(ksi)</th>
<th>UTS(ksi)</th>
<th>El(%)</th>
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<tbody>
<tr>
<td>MIM</td>
<td>153</td>
<td>165</td>
<td>12</td>
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<tr>
<td>Wrought</td>
<td>159</td>
<td>164</td>
<td>13</td>
</tr>
<tr>
<td>Cast</td>
<td>151</td>
<td>160</td>
<td>11</td>
</tr>
</tbody>
</table>

Notes:
unHIPed
C-0.03
0xy-0.06
TD-99%

PTI MIM on Full size ASTM bars

PTI MIM Tensiles are commensurate with Wrought specimens
Tensile Comparison with Aerospace Wrought Data

HIPed H1025 17-4PH

PowderFlo Tensile Data is Equivalent to Aerospace Wrought Processed Material
• MIM exceeds cast in all conditions

• MIM exceeds wrought in HIPed condition

MIM exceeds target goals of this program
### Typical Dimensional Tolerances

<table>
<thead>
<tr>
<th>Feature</th>
<th>Best Possible</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle</td>
<td>0.1°</td>
<td>2°</td>
</tr>
<tr>
<td>Density</td>
<td>0.2%</td>
<td>1%</td>
</tr>
<tr>
<td>Weight</td>
<td>0.1%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Linear Dimension</td>
<td>0.05%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Absolute Dimensions</td>
<td>0.04 mm</td>
<td>0.1 mm</td>
</tr>
<tr>
<td>Hole Diameter</td>
<td>0.04%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Hole Location</td>
<td>0.1%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Flatness</td>
<td>0.1%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Parallelism</td>
<td>0.2%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Roundness</td>
<td>0.3%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Perpendicularity</td>
<td>0.1% or 0.1°</td>
<td>0.2% or 0.3°</td>
</tr>
<tr>
<td>Avg. Surface Roughness</td>
<td>0.4 µm</td>
<td>2 µm</td>
</tr>
</tbody>
</table>

Summary-Injection Molding at Polymer Technology

● Advantages of MIM
  ● Cost Reduction-potentially 50% for the wing/flaperon
  ● Component Flexibility
  ● Ability to combine parts
  ● Reduced Cycle Times, WIP
  ● Ability to produce novel materials ability to reduce processing steps

● Advantages of MIM at PTI
  ● Large components
  ● Rapid Cycle time
  ● Excellent properties in full scale components