Development of Magnesium Powder Metallurgy Alloys

Paul Burke and Georges J. Kipouros

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Materials Engineering Program
Process Engineering and Applied Science
Dalhousie University
1360 Barrington St., Halifax, NS, B3J 2X4

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Outline

• Introduction
• Objective
• Methodology
• Experimental Procedure
• Results
• Conclusions
• Acknowledgments
Introduction

Aluminum

Magnesium
Introduction
Powder Metallurgy

- Blending
Powder Metallurgy

- Compaction
Powder Metallurgy

• Stages of sintering
  » Point contact (A)
  » Initial stage (B)
  » Intermediate stage (C)
  » Final stage (D)
Research on Mg P/M

- Utilizing rapid solidification to produce unique alloys and fine grain structures
- High strain rate superplasticity
- Investigation of mechanical properties and formability

- Canned powder hot extrusion
Objective

• Determine optimum conditions for the industrially dominant uni-axial die compaction process to produce magnesium alloy components via powder metallurgy
Methodology

- Choose alloying elements
- Powder characterization
- Experimental design
  - Compaction pressure
  - Sintering temperature
  - Sintering time
  - Quench temperature
Methodology

• Characterize samples
  – Dimensional change
  – Density
  – Hardness
  – Microstructure
  – Chemical composition
  – Tensile properties
Experimental Procedure

Blending

Compacting

Sintering
Experimental Procedure

• Alloy - AZ31 (3% Al, 1% Zn)
  – Determine optimum process conditions

• Pure Magnesium
  – Fundamental sintering behaviour
Experimental Procedure

• Pure Mg
  – Sieve powder into similar size categories
  – Compact with isostatic and uniaxial press
  – Sintering time and temperature
Experimental Procedure

- AZ31

- Experimental plan constructed to allow analysis with design of experiments (DOE) principals
  - Compaction Pressure
    - 300, 400, 500 MPa
Experimental Procedure

• Sintering Temperature
  – 500, 550 and 600ºC

• Sintering Time
  – 20, 40, 60 minutes

• Quench Temperature
  – 375ºC and 450ºC
### Results - Pure Mg

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Mg</td>
<td>98.6 %</td>
</tr>
<tr>
<td>MgO</td>
<td>1.32 %</td>
</tr>
<tr>
<td>Other</td>
<td>0.08 %</td>
</tr>
</tbody>
</table>

![Micrograph of Mg material with dimensions 200 μm](image-url)
Results - Pure Mg

- Green sample, 500 MPa compaction
Results - Pure Mg

• 500 MPa compaction, sintered 500ºC for 30min
Results - AZ31

- 500 MPa compaction, sintered 550°C for 20min, quenched 450°C
Results - AZ31

Experiment Number

Hardness (HRH)

- Theoretical Density
- Hardness
Results

- Quantitative EDS shows presence of Carbon and Oxygen in samples

<table>
<thead>
<tr>
<th>Element</th>
<th>Weight%</th>
<th>Atomic%</th>
</tr>
</thead>
<tbody>
<tr>
<td>C K</td>
<td>15.03</td>
<td>25.62</td>
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<tr>
<td>O K</td>
<td>8.40</td>
<td>10.75</td>
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<tr>
<td>Mg K</td>
<td>72.26</td>
<td>60.87</td>
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<tr>
<td>Al K</td>
<td>3.17</td>
<td>2.40</td>
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<tr>
<td>Zn K</td>
<td>1.14</td>
<td>0.36</td>
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<tr>
<td>Totals</td>
<td>100.00</td>
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</tr>
</tbody>
</table>

- X-Ray analysis of pure Mg samples shows no other elements
Conclusions

• Magnesium P/M has great potential

• Use of uni-axial die compaction relates to industrial applications

• Mechanical properties of ~90% dense PM samples similar to wrought product
Acknowledgments

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