Magnesium Research in the Automotive Lightweighting Materials Program

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February 27, 2008
Why Magnesium?

- Atomic Number 12, Group IIA
- Natural Occurrence
  - Ores (dolomite, magnesite, serpentine, and carnallite)
  - Chloride (sea water, underground brines and salt deposits)
- Abundance
  - Eighth most abundant element in the Earth’s crust
  - Sea water contains 12 billion pounds per cubic mile
- Metallic magnesium produced by
  - Electrolysis of MgCl₂
  - Thermal Reduction of MgO
- Lightest Structural Metal
  - ~30% less dense than Al
  - ~80% less dense than Fe
- High Strength to Weight ratio
- Excellent Damping Capacity
- Reduced Manufacturing Cost Compared to Other Materials
Magnesium Use in Automotive Applications—Past, Present, Future

- 1920’s - Dow Chemical produced Demonstration Trucks with Mg Sheet and Extruded Components
- 1930’s to 1960’s – VW used > 40lbs of Mg, primarily in transmission and air-cooled engine
- 1952 – Stamped Mg Corvette Hoods
- 1955-1965 – International Harvester produced 6300 Metro-Light Trucks Containing Mg Sheet and Extrusions
- 1998 - Ford PNGV Demonstration Vehicle Contained 87 lbs of Mg Components
- 2003 - Ford F150 Mg Radiator Support/Carrier

Between 30 and 40 components weighing ~ 300 lbs. have been approved for use by OEMs at various times. Over the last 15 years magnesium use has grown at a rate of ~12% per year.

But

In 2004 the average amount of Magnesium used by Big 3/NA was 12lb/vehicle compared to 260 lbs. of plastic, 280 lbs. of Aluminum, and 2150 lbs of steel and cast iron.

Why?
Barriers to Increased Use of Mg in Automotive Applications

1. Perceived High Cost
2. Difficult to Form at Room Temperature
   – HCP crystal structure
3. Variable Quality of Die Castings
4. Corrosion
   – Galvanic Corrosion
   – General Corrosion
5. Fastening and Joining, especially to other materials
6. Recyclability
7. Relatively little R&D on Mg Alloys and Processing During the Last 50 Years
8. Few Industrial Champions and No Full Service Tier 1 Suppliers
Strategy for the Future

• The Automotive Lightweighting Materials Program, in cooperation with the United States Automotive Materials Partnership and the FreedomCAR Materials Technical Team, seeks to achieve FreedomCAR Goals
  – 50% Mass Reduction
  – Affordable Cost
  – Increased Use of Recyclable/Renewable Materials
  – Comparable Safety and Performance

• The OFCVT Multi-Year Program Plan, the FreedomCAR Materials Roadmap, and the USAMP Magnesium 2020 Strategic Vision have all developed intermediate and long term goals and research objectives.

• Based on identified needs, specific strategies have been put into place to overcome technical barriers.

• Specific research needs include:
  – Affordable creep resistant and corrosion resistant magnesium alloys
  – Improved processes for producing high integrity castings
  – Large magnesium cast structures
  – Mg-based metal matrix composites
  – Fastening and joining technologies
  – Durable protective coatings or corrosion mitigation
  – Low-cost formable sheet materials and forming technologies
  – Low-cost, high-strength energy absorbing extrusions and forgings
  – Methods of processing recycled magnesium
Examples of Past/Current Efforts to Support Mg Technology Development Through DOE Funded Projects

• Structural Cast Mg Development (SCMD)

• Magnesium Powertrain Cast Components (MPCC)

• High Integrity Mg Automotive Castings (Hi-MAC)

• Mg Front-End R&D (MFERD)

• Warm Forming Mg Sheet