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Analysis of the Potential for New Automotive Uses of Magnesium

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This paper describes the scope of a new project, just initiated, for the Lightweight Materials Program within the Office of Transportation Materials. The Center for Transportation Research and the Energy Technology Division at Argonne National Laboratory will assess the feasibility and technical potential of using magnesium and its alloys in place of steel or aluminum for automotive structural and sheet applications in order to enable more energy-efficient, lightweight passenger vehicles. The analysis will provide an information base to help guide magnesium research and development in the most promising directions.

Vehicle weight reduction is one of the major means available for improving fuel efficiency and thereby enabling a reduction in the United States' dependence on petroleum imports. While high-strength steels, aluminum, and polymers are being used to achieve significant weight reductions in the current generation of automobiles produced in Detroit, magnesium and its alloys have been used until now in relatively small quantities, limited to die castings. Substantial weight reductions may be possible if improved magnesium alloys and forming processes are developed to enable the cost-effective use of magnesium and its alloys in sheet and/or structural forms. Magnesium alloy sheet could be used in vehicle semi-structural and structural applications, while extrusions could be used in structural applications. Currently, magnesium alloy sheet has found limited use in the aerospace industry, but the costs are too high for automotive use. The development of those alloys, innovative microstructural modifications and forming techniques, or other breakthroughs that promise to lower costs, is required for significant penetration into the automotive market.

A multidisciplinary team, including materials scientists, automotive engineers, and systems analysts, has been assembled for this project. The study will begin with a literature search to see what has been done in the past. Historical applications of magnesium alloys include various truck bodies, such as the Metrolite that used sheet and extrusions extensively, the Volvo concept car, and the Volkswagen Beetle engine, which was made of cast magnesium. The study will continue by defining the characteristics required for component parts in different types of automotive systems. Material properties and performance required for each type by the automotive industry such as stiffness, crush behavior, corrosion resistance, fatigue resistance, nonflammability, and limited explosiveness will be identified.

The properties available in magnesium and its varied alloys will be characterized, noting possible extensions to improve desired properties. The range of parts made possible by different forming methods, at room or elevated temperatures, will be identified. We will identify and assess the potential of magnesium to meet production demands involving stamping, rolling, extrusion, hydroforming, forging, superplastic forming, finish machining, assembly, and finishing. Applications involving die-cast methods will not be investigated, unless some there is some novel aspect that would enable significant new applications. The vehicle requirements and possibilities available via magnesium and its alloys will be matched up to identify potential new areas for automotive uses of magnesium. ANL will identify technical and institutional constraints hindering the use of magnesium and alloys in automotive sheet and structural forms. Production cost barriers will also be identified based on current technology.

Directions for research to help alleviate some of the barriers will be identified. Results of this study will be presented at the 1995 Automotive Technology Development Contractors' Coordination Meeting.

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