An analysis of public policy issues and how they affect MRS members and the materials community...

PNGV to Develop Materials to Reduce Auto Weight

The Partnership for a New Generation of Vehicles (PNGV) is a collaborative effort between the domestic automakers and the U.S. government to develop new automotive technologies. A major focus of this program is the development of a mid-size family automobile which exhibits up to three times the fuel economy of present vehicles but offers the same performance, ride, and comfort at the same cost to the customer. To achieve this goal aggressive targets for powertrain thermal efficiency, rolling resistance, aerodynamic drag, and vehicle weight must be met.

A well-established relationship between fuel economy and weight has led to the aggressive goal for PNGV to reduce vehicle weight by up to 40%. To meet this goal, target mass reductions for the various subsystems of the vehicle have been established. Because many of the powertrain alternatives under consideration have more components than the current integrated-circuit engine powertrain, the potential for weight savings may be limited. Thus in order to reach the overall 40% goal, the weight targets for the body and chassis call for reductions of 50% (or more). Substantial use of lightweight materials is clearly the way to achieve this goal.

In general, lightweight materials are those whose strength to density and/or stiffness to density ratios are greater than those of the conventional material used in a given application. Current automobile production employs an increasing amount of lightweight materials, such as high-strength steel, aluminum alloys, magnesium, and polymer composites. The potential for achieving large weight reductions through the use of an optimum combination of these and certain advanced materials is well-recognized. However, all of the lightweight materials, except perhaps for high-strength steels, share major disadvantages: raw material and/or manufacturing costs are higher than those for current materials, there is little or no high-volume infrastructure, and recycling technologies may need to be developed. Thus it is necessary to identify the candidate lightweight materials for each vehicle application and conduct research programs aimed at establishing comprehensive technical feasibility and reducing the costs to affordable levels.

Materials developments are being coordinated by a PNGV Materials Tech Team and many of the research projects are conducted by the United States Automotive Materials Partnership (USAMP); the membership of these groups overlaps. A process has been developed to identify, initiate, and conduct the materials research and development programs necessary to achieve the PNGV goals. The process starts with workshops at which vehicle systems engineers work with materials specialists to develop a list of possible lightweight materials which might be used in each specific application. For each material, tables are developed listing challenges which must be overcome in order for that alternative to be technically and economically viable. This is done collaboratively by vehicle and materials engineers. Existing USAMP and government (e.g., Department of Energy, National Institute of Standards and Technology, National Aeronautics and Space Administration, and Department of Defense) projects are listed against each issue along with information about timing, funding, specific deliverables, and an estimation of the degree to which the project will resolve the issue. The vehicle/materials engineers then assign priorities to the issues which are not being sufficiently addressed by current research projects.

With the mandatory and high priority research needs having been identified, the next step is to initiate appropriate R&D projects which may be carried out by USAMP, government laboratories, suppliers, and universities individually or collaboratively. This begins with supplier workshops at which experts representing all parts of the technical community (automobile companies, suppliers, government, and academia) discuss the challenges and ideas for overcoming them. "White papers" each presenting an idea for R&D to resolve a specific challenge are solicited from the workshop attendees (others are also welcome to participate). The white papers are evaluated by experts from USAMP and by government and industry members of the Materials Tech Team. Those who submitted ideas judged to be responsive to the challenges are encouraged to start, or continue, the R&D proposed. Also, although it has no budget to fund research, the Tech Team will endorse worthwhile proposals to funding agencies and assist in identifying funding opportunities.

Vehicle Structure: From among many alternatives, vehicle engineers and materials scientists selected stamped aluminum and carbon-fiber reinforced plastic as the most promising choices for achieving 50% or greater weight reduction. Prototype vehicles approaching or exceeding this goal have already been built and tested. Among the critical challenges for both of these concepts are handling high material costs and developing and validating high-volume manufacturing technology. Two workshops were held to discuss these and other challenges and more than 100 white papers were received and evaluated.

Although it is unlikely that the PNGV goal of 50% weight reduction for the body structure can be attained with steel, lesser, but still worthwhile, weight savings are possible with optimized designs. The Materials and PNGV Vehicle Engineers Teams are working with supplier groups to develop and evaluate two new design concepts for an ultralightweight steel body structure.

Chassis Materials: Cast and wrought aluminum, magnesium, polymer composites, and steels will be studied for many chassis and powertrain applications. Titanium alloys and metal matrix composites (aluminum or magnesium reinforced with ceramic particles or whiskers) will be desirable alternatives for a smaller number of applications in which their performance advantages over other materials may justify their (usually) higher cost. Based upon the most optimistic weight estimates for a number of different components, it seems that the target of 50% weight saving can be met. Cost and the lack of high-volume manufacturing technology are among the many barriers. These and other challenges were discussed at a workshop attended by over 200 participants. Ideas suggested in white papers are expected to lead to R&D projects to overcome most of the barriers, at least for some of these materials.

Powertrain Materials: Each of the PNGV teams responsible for developing powertrain components has members representing several materials disciplines. The members have been asked to identify the needs and opportunities for innovative materials. For example, in order to operate at high enough temperatures a gas turbine will need to employ ceramic components. The Materials Tech Team will then help initiate the R&D projects necessary to enable the use of these materials.

In order to meet the PNGV goals the vehicle is likely to contain a mix of materials different from current vehicles in which steel and cast iron are dominant.

ANDREW M. SHERMAN

***Andrew M. Sherman** is Leader of the PNGV Materials Tech Team at Ford Motor Company.*