REALIZING RADICAL WEIGHT REDUCTION OF VEHICLES

To expedite THE WEIGHT REDUCTION OF VEHICLES, a unique initiative in Japan is bringing together companies, national research institutes and universities.

In the race to reduce carbon dioxide emissions from vehicles, much attention has been given to improving the efficiency of engines and employing clean fuels such as electricity and hydrogen. But an equally important approach is to reduce the weight of vehicles without compromising their structural strength or performance. While there has been significant progress in this area in past decades, president of the Innovative Structural Materials Association (ISMA), Teruo Kishi, believes there are much greater gains still to be made. "We're striving to achieve nothing less than radical weight reduction in vehicles," he says.

Established in 2013, ISMA is strategically positioned to promote innovative joining technologies and for enhancing the strength of structural materials for vehicles. A mutual benefit non-profit corporation, ISMA brings all parties in Japan to the table: industry, academia and government. Currently, 40 companies, two national research institutes, two universities, one general incorporated foundation, and 61 subcontractors (research centres, universities and company laboratories) are participating in the initiative.

But most critically, ISMA is uniquely placed to consider the big picture when it comes to materials. Often research groups and companies specialize in specific materials, but ISMA's purview is the full gamut of materials used in vehicles, including steels, aluminum alloys, titanium alloys, magnesium alloys, carbon fibres and carbon-fibre-reinforced plastics (CFRPs).

"WE'RE NOT AWARE OF ANY ORGANIZATION QUITE LIKE ISMA"

SELECTING THE BEST MATERIALS FOR CAR PARTS

As part of the Japanese government's Innovative Structural Materials R&D Project, one of the two key strategies ISMA is exploring in its quest to realize radical weight reduction in vehicles is the use of multi-material technologies. Rather than produce a car chassis from one material, the optimal material is used for each part so that the material properties match the part requirements. ISMA is using computer-aided engineering for determining the optimal materials to use.

"Multi-material design, that is, using the optimal lightweight material for each part, is playing an increasingly significant role in reducing the weight of vehicles," explains Tomoaki Hyodo, a project manager at ISMA.

It's a strategy that is already used in luxury vehicles, but steel is still the main structural component for cheaper mass-produced cars. The challenge is to bring costs down to the point where multi-material design can be used in standard cars.

One way that ISMA is seeking to reduce costs is by replacing the CFRPs used in luxury vehicles with thermoplastic CFRPs, which are cheaper to produce than conventional CFRPs. In 2017, researchers produced a thermoplastic CFRP chassis that was 10% lighter than a conventional aluminium chassis.

Another method is making high-strength, high-ductility steel sheets for automobiles, which is challenging because it means going against the general trend where material strength drops as ductility increases. Ductility is important because it makes materials easy to process during the manufacturing process. Researchers in this project have already succeeded in producing a steel sheet whose tensile strength is 2.5 times higher than conventional steel sheets, with no loss in ductility. They achieved this by just using carbon, without resorting to rare metals.

MAKING DISSIMILAR MATERIALS STICK

Using various kinds of materials in a vehicle gives rise to a new challenge: joining dissimilar materials without sacrificing structural integrity. Existing joining technologies are not suitable for joining dissimilar materials. Thus, the second strategy that ISMA is pursuing new technologies to address this.

"We're developing friction stir welding and fusion welding for joining hard-to-join materials such as ultrahigh-strength steels, including medium- and high-carbon steels and titanium alloys, and joining dissimilar materials, such as metals to thermoplastic CFRPs," says Hyodo. "We're doing this in conjunction with *in situ* observation, modelling of joining processes and evaluation of joint performance."

Another promising technology for joining dissimilar materials is adhesive joining since it can achieve structural rigidity with minimal deformation at a comparatively low process temperature. To enhance joint strength, durability and productivity with this technique, ISMA is developing new adhesives. The goals of this project are to determine the adhesion mechanism, establish a method for evaluating it, and find ways to improve bond durability.

Researchers using an automatic particle-analysis system, which accelerates the analysis and evaluation of material microstructure.

A friction stir spot joining robot.

A prototype car chassis made from thermoplastic carbon-fibre-reinforced plastic.

LOOKING TO THE FUTURE

ISMA has a vital role to play in the future push to reduce the weight of vehicles. "Individual companies can develop specific materials, but a consortium such as ISMA is essential to realize multi-material technologies and joining technologies for dissimilar materials," says Kishi. "We're not aware of any organization quite like ISMA, where different companies and industries are coming together and collaborating to develop technology in the same project."

The approach promises to realize lighter vehicles in the short to medium term. "We're developing many innovative materials, including ultrahigh-strength steel sheets, high-strength aluminum alloys, flame-resistant magnesium alloys, low-cost titanium alloys, thermoplastic CFRPs and innovative carbon fibres," says Hyodo. "Our hope is that they and new techniques for joining them will be used in light-weight vehicles in the near future." ■

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