

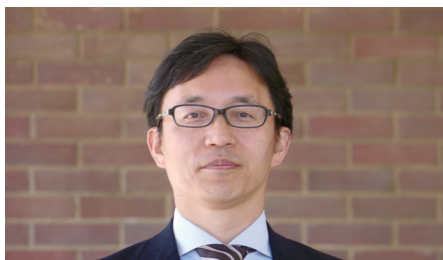
Weight Reduction for Energy Efficiency and Higher Speed



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Increasing the running speed of trains not only increases energy consumption but also tends to increase vibration and noise since the force applied on the tracks will also increase. As such, it becomes increasingly necessary to reduce the weight of the car body to achieve higher running speed of trains while controlling energy consumption, noise, and vibration. Here, we introduce two different approaches that are intended to reduce the weight of the car body.

Use of light-weight metals



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Most modern trains use stainless steel and aluminum alloy for the body structure. While some weight reduction has already been achieved by using aluminum, i.e., light metal, we could expect to further reduce the weight if we are able to use magnesium whose density is about two thirds of that of aluminum.

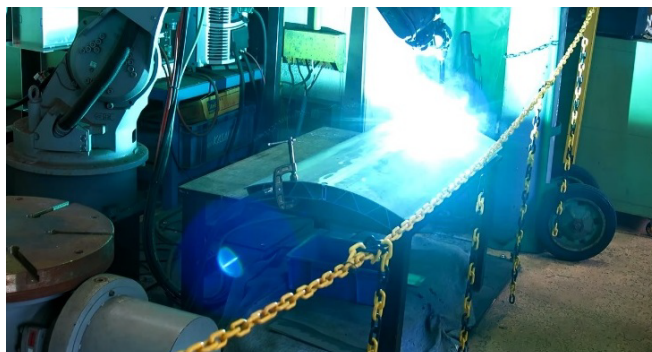
The advantage of using magnesium is not limited to its light weight – magnesium is abundant in the earth’s crust, and thus it is relatively easy to get. However, one of the problems is that magnesium can be flammable. Thus, we have developed a noncombustible magnesium alloy, by

adding calcium to typical magnesium alloys, for use in car bodies. We have successfully tested the new material to verify that it is noncombustible up to an ambient temperature of 600°C. The test was performed by directly heating a plate of the noncombustible magnesium alloy. Typical magnesium alloys catch fire at this temperature.

To use the material for the car body structure, various types of sheet metals and sections of different cross-sectional profiles are required. While sheet metals and sections are mainly produced by extrusion, it is generally the case that sections are more difficult to produce than sheet metals. We have successfully produced



MIG welding by an automatic welding machine

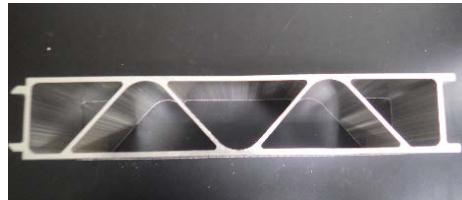


MIG welding of roof structure

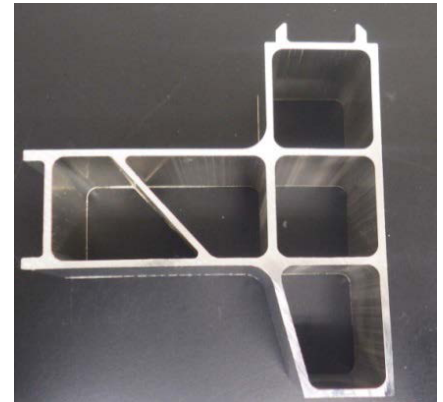
noncombustible magnesium alloy sections to nearly the desired cross-sectional profile to be used for various types of car body structural members. This was achieved by optimizing various parameters such as the symmetry of cross sections, deformation resistance during extrusion, and so on.

The next step was to develop the bonding technology to assemble and join the section members to form a structure. We have tested the MIG (Metal Inert Gas) and FSW (Friction Stir Welding) methods, which are used for welding aluminum alloys to form car body structures, and found that the MIG welding method can produce similar bonds as in the case of aluminum alloys. On the other hand, we have not yet developed a FSW method that can achieve the same level of bonding as with aluminum alloys, as defects are easily produced in bonding areas. Accordingly, further studies are required on the new magnesium alloy material in terms of the basic material data, assembly and working techniques, and bonding techniques.

We have produced a small half section model structure of a car body, by combining the material technology with a number of techniques in production and bonding of various structural members. In particular, we have successfully bonded hollow sections of magnesium alloy to



Section material for floors and walls



Section material for side beams

the intended size using the MIG welding method. Although this result cannot be directly applied to actual vehicles, this model is considered a step towards the practical use of noncombustible magnesium alloys on vehicles. While we have to study and verify a number of things before the practical use, we will continue our efforts to develop and accumulate more techniques aiming to further reduce the weight of rolling stock.

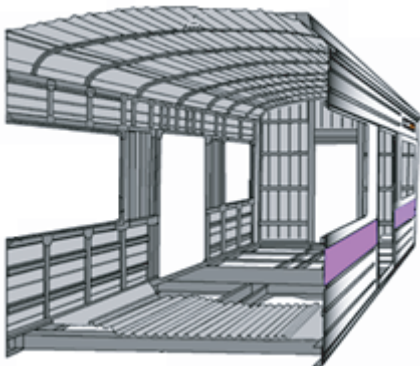
Applying new body structures and design methods

To achieve a higher running speed of trains, weight reduction of the car body is required. On the other hand, to keep

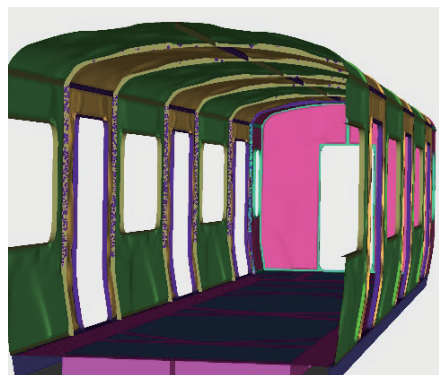
passengers comfortable, it is also necessary to enhance the rigidity of the car body. However, since that generally leads to weight increase, it becomes a difficult problem to satisfy the weight reduction and rigidity requirements at the same time.

Conventional vehicles have a framed structure. In this, the side posts, transverse beams, and other members are joined together to make a discontinuous structure. Also, the large number of parts and complicated structure tend to make it difficult to reduce weight and increase rigidity. To solve the problem, we have developed an idea using press forming to make an integral structure of concavo-convex shapes for a light weight and less deformable body structure. To form the new body structure, we have established a rational design method using the structural optimization technique. As a result, a new body structure using press forming has been proposed.

As it is difficult for conventional design concepts to derive proper concavo-convex shapes according to the load applied to the body, a new structural optimization technique has been established. We have verified that a press formed car body can be designed to increase the rigidity and decrease the weight compared to the conventional car bodies that are based on a frame structure.



Conventional vehicles are structurally so complicated that it is not easy to reduce their weight and increase their rigidity.



A light weight and less deformable body is realized with an integral structure of concavo-convex shapes shell by press forming.