Material developments in the automotive front end

By Colin Pawsey

In recent years the modularisation of vehicle front ends has reduced the number of components, and encouraged the integration of safety, styling and engine cooling into singular modules. The driving factors in the design and manufacture of front ends are weight reduction, simplified assembly processes, and reduced complexity. Innovation in this area of automotive manufacture is continual, and one of the key developments currently is in the production of new materials, particularly lightweight plastics, which are enabling the design of ever lighter front end modules.

Weight reduction is vital to the automotive industry in light of carbon reduction targets, and replacing metal components with plastic not only reduces weight, but also offers the potential to save money through reduced production costs.

Types of plastics for front ends

Glass fibre reinforced thermoplastics that use short glass fibres to improve strength and stiffness and reduce temperatures, are well established as lightweight alternatives to metal for automotive applications. Glass fibre reinforced polypropylene is also being used for several applications, replacing metal or other plastics, such as glass fibre reinforced polyamide, in applications such as air intake manifolds. While plastics like reinforced polyamide and polyphthalamide are replacing metal components in engine cooling systems.

Long glass fibre reinforced thermoplastics, and in particular long glass fibre reinforced polypropylenes, are one of the most common types of plastics used for metal replacement due to their performance abilities and cost structures. At high temperatures of 80^{o}C upwards required for automotive applications, long glass fibre reinforced polyproplylene can be twice as effective as short glass fibre plastics. Long glass fibre plastics have been successfully used for front end modules, and have the benefit of reducing weight, reducing production costs, and reducing the number of components. A steel front end module could have as many as 25 components and weigh up to 8kg, while a long glass fibre reinforced module can have as little as 3 components, weighing just 3kg.

Carbon fibre reinforced plastics have been used in many applications in the automotive industry in the past, most notably for body shells for high end sports cars. However, the use of carbon fibre may become more widespread in the future as production is streamlined and manufacturing costs are reduced. SGL Automotive Carbon Fibres, which is a joint collaboration between the SGL group and the BMW Group, will produce carbon fibre materials for the new BMWi range, due to be launched in 2013. It will be the first time that carbon fibre materials are used in such large scale production.

The method of resin transfer moulding (RTM), is one of the reasons that carbon fibre may become a viable material for the automotive industry as it is intended to vastly reduce cycle times for component manufacture. High pressure and high speed RTM processes have been developed which can produce carbon fibre reinforced plastic automotive parts in around 3 minutes, compared to previous cycle times of around 20 minutes. Dow automotive systems has developed one such process, VORAFORCE, which is an ultra-fast cure epoxy designed for high speed RTM, and Dow have also developed a new adhesive package, BETFORCE, which can be used to bond carbon fibre parts to other materials, and offers manufacturers a complete composite solution.

Sabic STAMAX

Sabic's Innovative Plastics division has developed STAMAX, a form of long glass fibre reinforced plastic, and recently announced that it is due to increase production capacity at its manufacturing facility in Genk, Belgium. The STAMAX long glass fibre reinforced plastic offers customers a variety of properties and is well suited to the application of front end modules. The composite resins offer lighter weight to help improve fuel efficiency and reduce emissions, while offering comparable strength to steel and reduced production costs.

The properties of STAMAX composite resins provide similar stiffness performance to polyamide-steel hybrid systems, yet remove the need for steel beam reinforcement. As a result, the STAMAX reinforced plastic makes an even greater contribution to weight reduction and fuel efficiency. Indeed, according to Sabic's sustainable product scorecard an automotive front end module constructed with STAMAX reinforced plastic offers up to a 44% lower energy footprint compared to a PA hybrid alternative, from material sourcing through to end of product life. Most of this is achieved through weight saving during the vehicles lifetime. Other statistics provided by Sabic state that the production of 200,000 front end modules with STAMAX resin, as opposed to a PA hybrid solution, would save enough energy to power 14,900 homes in Europe for a year.

The STAMAX resin was used by Chang'an for the CX30 model, the first Chinese-developed vehicle with an entirely plastic front end module. The application of this module integrates 22 components into one single injection-moulded part, making the production process of the front end of the vehicle much simpler and reducing associated costs. By replacing steel in this vehicle, Chang'an were able to reduce part weight by around 40%, and overall vehicle weight by around 4kg.

Due to the increased demand for the resins, work started recently on a second production line at the Genk facility, which is expected to be operational in the second half of 2013.

Rehau front end bracket

Rehau has developed a new front end module which features a steel reinforcement with plastic over-moulding, and is using a new production process to manufacture these front ends for Mercedes for use in the new M-Class. The Sports Utility Vehicle is manufactured by Mercedes at the Daimler plant in Vance Alabama, but the initial research and development of the process was undertaken in Germany at Rehau's research centre in Bavaria. The Innovative design has been in development since 2008.

The front end bracket (pictured above), consists of a steel sheet reinforcement over-moulded with plastic. The new technology requires extremely tight production tolerances but provides several major advantages. The component is a great deal lighter, with the plastic element reducing overall weight by around 25%. Another key advantage to the bracket is that the component allows many functional elements to be integrated into the design; including such elements as the intercooler duct, the headlight modules, the screen-washer container, the horn, the anti-collision radar module, and the air intake. The bracket will also help to support the hood of the vehicle.

The Rehau plant in Alabama is currently producing up to 80,000 of these modules per year for Mercedes.

Summary

There is a drive within the automotive industry to reduce weight wherever possible in passenger cars. The European Union has set out clear targets for the reduction of carbon emissions, and manufacturers are constantly striving to produce vehicles which are more fuel efficient and which will therefore reduce emissions.

One of the key developments in weight reduction is the replacement of metal parts with plastic components, and this is prevalent in the development of new front end modules. The development of different types of plastics in recent years has opened up many opportunities for manufacturers and engineers to explore new designs to replace metal parts that previously could not be considered. New types of reinforced plastics are able to cope with very high temperatures in and around the engines of vehicles, where previously they could not. Better production processes are enabling the manufacture of thinner and lighter plastics which still retain similar properties and strength to steel, even under extreme temperatures.

Long glass fibre reinforced plastics are being used frequently in front end modules due to their excellent heat resistant properties, strength, weight reduction, and cost reduction. In comparison to steel front end modules, the use of long glass fibre reinforced plastics can result in the use of just three components rather than twenty-five, and can reduce weight by as much as 5kg.

The development of carbon fibre reinforced plastics and high speed resin transfer moulding processes may lead to the development of the use of CFRP for front end modules, bringing with it the all the performance properties associated with carbon fibre products.

Developments such as Sabic's STAMAX long glass fibre reinforced plastic, and the need to increase production capacity, show that there is a current demand amongst automotive manufacturers for these types of lightweight plastic solutions. With a 44% lower energy footprint when compared with a hybrid PA alternative, from material sourcing through to end of product lifetime, it is clear to see why there is such an appeal to these lightweight front end modules.

There is still expected to be much advancement in materials over the next decade, and today's solutions may become quickly out-dated. During this period of evolution there will be several different types of front end modules developed with a variety of materials, before industry and material standards can be realised.

Colin Pawsey's background and experience is in the water heating industry, with a focus on technical data analysis and energy efficient products for both commercial and residential sectors. He also works as a freelance journalist focusing on renewable and sustainable resources, energy efficiency, and consumer information.

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