MANUFACTURING TECHNOLOGY AND MATERIALS

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Introduction

The choice of materials to be used in vehicle manufacture depends on many factors, including demand and supply, effectiveness, recyclability, weight, safety and their strength. In the past, vehicle construction was done using iron and steel. These components required a lot of time in their processing coupled with the high cost of accessing these materials and their production. These materials are also heavy, hence given a lower performance when used in vehicles that require higher performance such as race cars. These materials have since been substituted for lighter, high performance materials such as aluminium and composites. These materials are also durable and possess high specific strength/stiffness properties.

Question 1

Carbon fibre composite materials are increasing being used in automotive applications to replace more traditional metallic components.

a) Discuss the advantages of carbon fibre reinforced polymers with respect to their mechanical & specific properties in replacing traditional metallic's in vehicle body structural applications. Include in your discussion issues associated with anisotropy, how such issues can be addressed, and the consequential effect on mechanical properties. (30marks)

Composites reinforced with fibre offer many advantages to the automotive industry. The material has been popular because of its most recognised benefit that the potential for saving of weight made

possible by their low density. The consequence of reduced weight is that it could lead to reduced fuel consumption coupled with the economic and environmental benefits that come with it. Nonetheless, the following are the array of other economic benefits:

The designs of components are such that the fibres lie in the places of principal stresses, the amount of the fibre used is sufficient to withstand the said stress, hence optimizing the usage of materials. This provides an advantage, especially for the racing car applications where load impact and coupled with principle stresses come into play. The fabrication and designs can be done in such a way that the components are moulded in one process, hence reducing the cost of manufacturing (Zhao and Gou, 2009).

Fabrication of composites can be very easy because it requires a temperature that does not exceed 473k at low pressure; this again has economic implications for the costs of production. Its excellent resistance to corrosive factors and other chemical reactions helps the manufactures extend the lifetime of the individual vehicle components and the whole of the vehicle.

Particularly, car manufacturers are relying upon Carbon-fibre epoxy composites. This is because the structure of these materials is high while incorporating low density, which improves performance of racing cars. The car manufacturers also revealed that they are moving research further in the development of different composites into complex but high performance structures manufactured using pre-impregnated materials. These materials are impregnated using with high temperature epoxy resin. Most of these components are lightweight for maximum weight/strength ratio to give necessary support in areas where bonding, bolting or drilling structures is

needed. Studies done on composites prove that epoxy resins allow structuring of composite materials with thermal and mechanical performances higher than that of metal structures (Parr et al 2003).

Conclusively, carbon fibre reinforced polymers yield a greater advantage over the conventional methods in car manufacture. This is because of their low density yet strong properties capable of optimum performances as compared to the traditional materials which were both heavy and expensive. In respect to this, fibre from carbon has impressive and unique properties that favour manufactures. This is arrived at after analysing the relationship between density and its young modulus. It has low density as compared to that of steel. Carbon has 30% extra stiffness as compared also to fibreglass. The application of carbon is also attributed to its economic and technical benefit. To arrive at the stiffness of carbon, material properties and components are considered. With due advantages associated with carbon, its major problem is making thin sheets when applying to isotropic layup. Carbon has little competition in regard to weight which is a critical factor in motor vehicle industry.

b) How do the high production rates required for many standard classes of vehicles correspond to use of the such composite materials with respect to their processing characteristics when such materials are supplied in the form of pre-preg that must be vacuum bagged and autoclave moulded (30 marks)

These two methods of production can be explained as follows;

Moulding is done by layering sheets of carbon into a mould in the shape of a finished product. Its alignment is chosen in a way so as to

maximize the strength and stiffness of the final product. It is then filled with epoxy resin and air-cured, which results in a corrosion resistant, strong and stiff but light material. The part used in the less critical areas of the vehicle are made by putting a cloth over a mould with epoxy preimpregnated into the fibres (pre-preg) or painted on it (Poweleit, 2001).

Parts used in high performance areas use moulds that are vacuum bagged and autoclave moulded. This is because small air bubbles in the material can reduce the strength of the material. This is done when producing one or two copies of the material per day since its time consuming. A carbon mould is waxed and polished before the resin and the fabric is applied, it is then pulled and set aside to harden. Application of resin to the fabric can be done in two ways, these are a) manual method where a two-part resin is mixed, then applied, and it is then laid in the mould and put in a bag. The other is made by blending: the mould and the dry fabric are put inside a bag whilst the vacuum pulls the resin through a tiny tube into the bag. b) Dry lay-up method, where a carbon fibre material already impregnated with resin is put on the mould in a fashion similar to that of adhesive film. The product is then put in a vacuum to dry then vacuumed to remove the air molecules.

From the above explanations, it is clear that the processing of pre-preg using these two methods takes a lot of time. The fact that only two parts can be produced in a day does not give efficiency to the work done. In essence, a complete production of a car might even take a month and considering the amount of work put in, there is less efficiency in the use of this method. The method therefore runs at a high cost and in the end there is a high cost of production. The processes above do not make use of the new technology and

hence they are labour intensive. The increased cost of labour will in turn increase the cost of production (Woisetschlaege, 2001).

Question 2

"Some niche vehicle manufacturers are currently moving away from carbon fibre components for their medium production volume vehicle structures because of long processing times needed for high integrity carbon fibre composite components" Discuss.

Carbon-fibre-reinforced plastic (CFRP) technology has been used as a perfect combination of strength and required weight. Its difficulty in using automated methods in its production means that there is a low volume of production at a high price, which creates an opportunity for the use of aluminium. A case in study of Ferrari concludes that it is better to use aluminium in its production because the use of aluminium allows automation hence an increase in the volume of production. Though some other automobile companies still use carbon-fibre in the production of their models, the firms insist that they can do better with the use of aluminium at an increased volume of production per day. This is because the production speed using carbon prohibits the use of the time and labour intensive pre-impregnated carbon-fibre cloth in favour of a process that injects resin into the cloth after being placed into a mould. The use of excess material in this high-volume carbon-fibre manufacture technique the weight-saving potential of the material is not realized. The low-rate technology used in manufacture using composites does not reach the potential of producing the right number of automobiles per day and hence a move in the direction of aluminium (Poweleit, 2001).

Aluminium allows the use of the current technologies and is therefore suited to increasing production volumes, though there has to be an absolute optimization in the use of the material. A number of alloys are made to be used in specific parts of the car. Heat treatment is also essential to right deforms of the front and rear crash boxes. In the past, the use of steel was preferred because of its strength and good energy absorption, but is a heavy metal and hence does not produce the required results of the car because it will affect its polar moment of inertia.

Conclusively, the use of carbon-fibre composites is reducing because companies want to use non-labour intensive production, which is not only slow but also expensive. Various vehicle manufacture companies are moving to the use of aluminium that allows for the use of new technologies that increase the quality of production and the volume of production (Zhao and Gou, 2009).

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