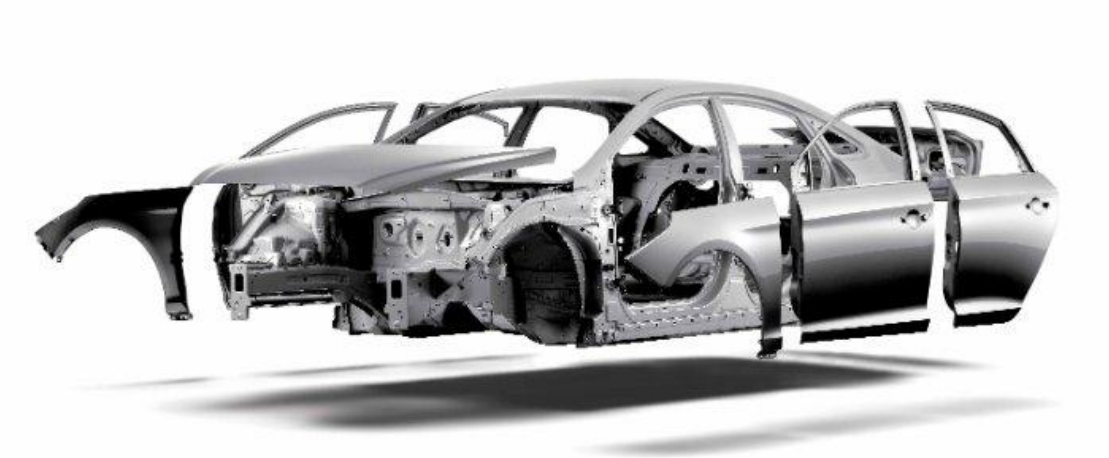
Lecture 5

Criteria of car selections



The choice of materials for a vehicle is the first and most important factor for automotive design. There is a variety of materials that can be used in the automotive body and chassis, but the purpose of design is the main challenge here. The most important criteria that a material should meet are lightweight, economic effectiveness, safety, recyclability and life cycle considerations. Some of these criteria are the result of legislation and regulation and some are the requirements of the customers. However, some of these criteria may be conflicting and therefore the optimization comes into business here.

In the beginning we start with explaining each criterion and then continue to introducing several materials and where they can be used.Requirements of the materials in automotive design

2.1Lightweight

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As there is a high emphasis on greenhouse gas reductions, reduction of emission and improving fuel efficiency this criterion is most important one for an automotive company. Lightweight materials can improve fuel efficiency more than other factors. Experiments reveal that 10 percent of weight reduction can lead to 6 to 8 percent improvement in fuel usage. Weight reduction can be obtained by three ways:

Replacing materials of high specific weight with lower density materials without reducing rigidity and durability. For example replacement of steel with aluminium, magnesium, composites and foams.

Optimizing the design of load-carrying elements and exterior attachments so as to reduce their weight without any loss in rigidity or functionality.

Optimizing the production process, such as reducing spot welding and replacing new joining techniques.

But the single main obstacle in application of lightweight materials is their high cost. Yet the weight reduction is still the most cost-effective means to reduce fuel consumption. The weight reduction versus the price increase by replacing steel by aluminium or magnesium for some of the parts is

2.2**Economic effectiveness**

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One of the most important consumer driven factors in automotive industry is the cost, that determines whether any new material has an opportunity to be selected for a vehicle component. Cost includes three components: actual cost of raw materials, manufacturing value added, and the cost to design and test the product.

Aluminum and magnesium alloys are certainly more costly than the currently used steel and cast irons. Since cost may be higher, decisions to select light metals must be justified on the basis of improved functionality. Meanwhile the high cost is one of the major obstacles in use of the composite materials.

2.3Safety

The ability to absorb impact energy and be survivable for the passengers is called “crashworthiness” of the structure in vehicle. At first two concepts in automotive industry should be considered: crashworthiness and penetration resistance. In the more accurate definition of crashworthiness, it is the potential of absorption of energy through controlled failure modes and mechanisms. However, penetration resistance is concerned with the total absorption without allowing projectile or fragment penetration.

2.4Recycling

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The most important concerns in industeries such as automotive, are ‘protection of resources’, ‘reduction of CO2 emissions’, and ‘recycling’. There are some guidelines in European Union and Asian countries about this issue. While the United States has not issued any regulations concerning automotive end-of-life requirements.

For example, in the UK, around two million vehicles reach the end of their life each year and these vehicles are concidered as hazardous waste untill they have been fully treated. When a consumer decides not to use a vehicle anymore, there are following options available:

Sell the whole vehicle to another user.

Disassemble the vehicle.

Remanufacture the vehicle.

Recycle the vehicle for materials.

Dispose the vehicle to a landfill.

Materials

3.1Steel

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The main factors of selecting material specially for body is wide variety of characteristics such as thermal, chemical or mechanical resistance, ease of manufacture and durability. So if we want to choose a material with these characteristics, Steel is ther first choice. There was many developments in irons and steels over the past couple decades that made the steel more light-weight, stronger, stiffer and improving other performance characteristics. Applications include not only vehicle bodies, but also engine, chassis, wheels and many other parts. Iron and steel form the critical elements of structre for the vast majority of vehicles, and are low-cost materials.

The past several years have seen steady increases in the use of high-strength steels that are referred to as high-strength, low-alloy steels. These materials formed the basis of Ultralight Steel Auto Body (ULSAB). The ULSAB car body demonstrated a 19% mass reduction in a body structure that had superior strength and structural performance. Comparable mass reductions nad othere benefits were achieved for doors, hoods, decklids, and the hatchbacks.

The prime reason for using steel in the body structre is its inherent capability to absorb impact energy in a crash situation.

3.2Aluminium

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There are a wide variaty of aluminium usage in automotive powertrain, chassis and body structure. Use of aluminium can potentially reduce the weight of the vehicle body. Its low density and high specific energy absorption performance and good specific stregth are its most important properties.

Aluminium is also resistance to corrosion. But according to its low modulus of elasticity, it cannot substitute steel parts and therefore those parts need to be re-engineered to achieve the same mechanical strength, but still aluminium offers weight reduction.

Aluminium usage in automotive industry has grown within past years. In automotive powertrain, aluminim castings have been used for almost 100% of pistons, about 75% of cylinder heads, 85% of intake manifolds and transmission. For chassis applications, aluminium castings are used for about 40% of wheels, and for brackets, brake components, suspension, steering components and unstriment panels. Aluminium is used for body structures, closures and exterior attachments such as crossbeams, doors or bonnets.

Recent developments have shown that up to 50% weight saving for the body in white (BIW) can be achieved by the substitiution of steel by aluminium. This can result in a 20-30% total vehicle weight reduction.

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The cost of aluminium and price stability is its biggest obstacle for its application.

3.3Magnesium

Magnesium is another light metal that is becoming increasingly common in automotive engineering. It is 33% ligher than aluminium and 75% lighter than steel/cast iron components. Magnesium components have many mechanical/physical property disadvantage that require unique design for application to automotive products. Although its tensile yield strength is about the same, magnesium has lower ultimate tensile strength fatigue strength, and creep strength compared to Aluminium. The modulus and hardness of magnesium alloys is lower than aluminium and the thermal expansion coefficient is greater.

Magnesium alloys have distinct advantages over aluminium that include better manufacturability, longer die life and faster solidification. Also magnesium components have higher machinability.

Because of its too low mechanical strength, pure magnesium must be alloyed with other elements. The most common alloying elements for room temperature applications is Mg-Al-Zn group that contains aluminium, manganese, and zinc.

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3.4Advanced composite materials

Fibre reinforced composites offer a wide range of advantages to the automotive industry. It has the potential for saving weight offered by their low density. Component designs can be such that the fibres lie in the direction of the principal stresses, and amount of fibre used is sufficient to withstand the stress, thus optimising materials usage.

3.5Carbon-fibre epoxy composite

Most recently, the most of the racing car companies much more rely on composites form whether it would be plastic composites, Kevlar and most importantly carbon-fibre epoxy composition. It is because the composite structures is the high strength/low weight ratio. The most common materials used for racing cars are carbon (graphite), Kevlar and glass fibres. Epoxy composites have been the first choice in Formula 1 car industeries and other race cars.

3.6Glass-fibre composites

Glass fibre is being used mostly for the sports car which includes Formula 1 cars. It is lighter than steel and aluminium, easy to be shaped

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and rust-proof. And more important factor is that it is cheap to be produced in small quantity.

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