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Automobile Bodies By Advance Material With Light Weight

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Abstract - *This contribution illustrates the important role modern material technology plays in automobile development. The manufacture of lightweight automobiles is driven by the need to reduce fuel consumption to preserve dwindling hydrocarbon resources without compromising other attributes such as safety, performance, recyclability and cost. Materials development plays an important role against this background, since significant weight decrease is made possible through the substitution of high density materials and more precise adjustment of material parameters to the functional requirements of components. The great substitution of conventional materials used in the automotive industries. This paper provide some basic knowledge of structure and properties, mechanical properties and applications of Aluminum based metal foam, Natural Fibers, ULSAB AVC Steel and Magnesium Alloys in the automobiles.*

Key Words: *— ULSAB-Ultra Light Steel material selection, automobile material, AVC–Advance Vehicle Concept*

1. INTRODUCTION

The research and development of ecological technologies for vehicle is increasingly important for the automotive industries. It is seen as one of the greatest trend of this century to conserve the natural resources and minimize the air pollution. One of the ways to achieve this is by reducing the weight of the vehicle therefore lowering the rate of fuel consumption and air pollution.

As a result, In automotive industry reduction in consumption and emissions remains the greatest technological challenge for the automotive industry [1]. Reducing weight by 100 kg leads to fuel savings of 0.35 l/100 km and 8.4 g CO2/km with gasoline engines if taking into account an adjustment of the gear shifting without a change in elasticity and acceleration values due to the lower weight [1].

Ultimate driving performance can be achieved by fulfilling these requirements and, in addition, by providing an individual driving experience, i.e. experiencing agility, engine power, elasticity in speed changes and corner handling. These high demands on automotive engineering can only be met through the appropriate use of advanced material technologies.

A lightweight body achieved by combination of three lightweight design fig.(1) categorized into lightweight engineering, lightweight manufacturing and weight reduction through material selection.

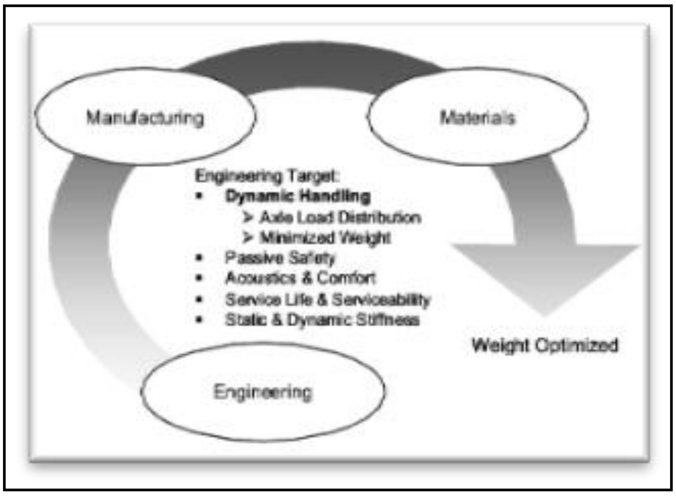

Fig. 1– Light Weight Design Approach [2]

The major issues last decades change in materials usage in motor vehicles can summarized as follows:

1.1 Environmental constraints:

Materials with high stiffness and strength properties for ex. allow highly efficient lightweight load bearing structures produced . The net moulding allow greater design freedom in producing complex shapes for improved aerodynamics, reducing fuel consumption.

1.2 Economic demands and Performance enhancement

The increasing need recycle or reuse material put additional constraints on motor vehicle manufacturers due to Extended warranty periods and increase the demand for the vehicles. This achieved through improved quality and processing materials.

2. ALUMINUM

Aluminum has already established itself in the car industry for many years. Its low density and high specific energy absorption performance and good specific strength are its most important properties. Aluminum is also resistant to corrosion and can be easily recycled in its pure form. Due to its lower Modulus of elasticity, it cannot substitute steel parts on a one-for-one basis. Therefore, those parts need to be engineered to achieve the same mechanical Strength. However, using aluminum still offers potential for weight reduction. Aluminum is used for body structures, closures and exterior attachments such as crossbeams, doors or bonnets.

Pure aluminum bodies have been developed and implemented. They are used for luxury cars, such as the Audi A8, and some niche vehicles, such as the BMW Z8, because of their comparatively high material and production costs. Nevertheless, aluminum offers advantages and possibilities will play an increasingly important role for the car industry in the future [3].

2.1Mechanical Properties Of Aluminum

➢ **Compressive Deformation Behavior:** The significant attributes of metal foams is their characteristic non-linear deformation behavior [4]. The light-weight Construction efficient absorption of deformation energy are important. In automotive applications, the crush energy absorption behavior of metal foams due to high strain rate deformation is important in designing vehicles for optimum crashworthiness.

➢ **Crash Energy Absorption:** Metal foams offer great potential in applications systems requiring crash energy absorption. The characteristic shape of metal foam allows absorption of large amounts of energy at a relatively low stress level. A comparison of the typical energy absorption behavior of a fully dense elastic solid with that of porous metal foam [4] .

➢ **Vibration Damping:** Control of vibration characteristics is very important for automotive applications. As the auto industry greater use of aluminum for weight reduction, this more critical due to the inferior vibration damping behavior of aluminum compared to steel and cast iron. The damping capacity of test panels of aluminum sheet and aluminum foam sandwich (AFS) was measured over the frequency range of 100 to 500 Hz [4].

2.2 Applications Of Aluminium Based Metal Foams In Automobiles

Characteristics of Metal Foam: Ultra-lightweight aluminum foams possess unique micro structural physical applications [4]:

- Ultra-lightweight materials with high degree homogeneous closed-cell porosity.
- High stiffness-to-weight and strength-to-weight ratios.
- Ability to absorb energy from impact, crash, and eplosive blasts.
- Vibration damping and sound absorption.
- Fire resistance and thermal insulating properties.
- Metal foams are readily recycled.

3. COMPOSITE MATERIAL

Research and industrial development explores new ways to create greener and environmentally friendlier chemicals and materials for a variety of applications. Fibers can be classified into two main groups: manmade and natural [3]. Natural fibers have the potential to reduce vehicle weight . the use of natural fibers can minimize harmful pollutants, and their eventual breakdown is environmentally benign. Natural fibers emit less CO2 when they break down than is absorbed during plant growth. Fiber-producing crops are easy to grow [5] .

3.1 Mechanical Properties Of Natural Fiber Composites

The mechanical properties of a natural fiber composite materials depends on the fiber orientation, fiber volume fraction, fiber geometry, the nature of the matrix and mainly on the adhesion between fiber and the polymer matrix. Natural fibers generally have poor mechanical properties compared to their synthetic counterparts.

Table shows the mechanical properties of some natural and synthetic fibers. The fiber volume fraction plays a significant role in deciding the mechanical properties of natural fiber composite materials. The augmented percentage of fiber content in the composite improves the mechanical properties of the material. In addition, the maximum volume fraction is governed by the fiber orientation and packaging arrangement of fibers [6].

The second main factor affecting the performance of natural fiber composite material is fiber matrix interface strength [9]. The interface serves transfer of applied loads to the fibers via shear stresses over the interface between the fiber and matrix. In general, strong interfacial adhesion delivers high strength. Interfacial strength is essential if stresses are to be transferred properly to the fibers and to provide the necessary function. Weaker interfacial adhesion causes fiber pullout and energy absorption through particular the mechanism of failure. Interfacial bond between the matrix and the fiber determines the effectiveness of stress transfer the mechanism.

Table -1: Mechanical Properties Of Fibers As Compared To Conventional Polymers

Fiber	Specific Gravity	Elongation (%)	Tensile strength (MPa)	Young's Modulus (GPa)
Fibers (Reinforcement)				
Cotton	1.5-1.6	7.0-8.0	287-800	5.5-12.6
Jute	1.3	1.5-1.8	393-773	26.5
Flex	1.5	2.7-3.2	345-1035	27.6
Hemp	1.5	1.6	690	70.8
Ramie	1.5	1.2-3.8	400-930	61.4-128
Sisal	1.5	2.0-2.5	511-635	9.4-22.0
Coir	1.2	30.0	175	4.0-6.0
Viscose (cord)	-	11.4	593	11.0
Softwood (Craft)	1.5	-	1000	40.0
E-Glass	2.5	2.5	2000-3500	70.0
S-Glass	2.5	2.8	4570	86.0
Aramide (normal)	1.4	3.3-3.7	3000-3500	63.0-67.0
Carbon	1.4	1.4-1.8	4000	230.0- 240.0
Polymers (resins/matrices)				
ABS	1.05	10	55	2.8
Polycarbonate	1.22	100	62	2.3
Nylon	1.12	29	66	3.5
Polyethylene	0.95	30	28	1.04
Polypropylene	0.9	200	35	0.83
Polystyrene	1.05	15	35	20.76
Epoxy Resin	-	6.2	32	0.5

Adapted from: Alireza Ashori [8]

3.2 Application Of Natural Fiber Composites In Automobiles

Natural fibers from plants such as Jute, Coir and Sisal are easily available & have high strength as well and can be effectively utilized for light & medium load bearing applications. Thus, the inherent properties of natural fibers can satisfy the requirements of automobile industries especially in weight reduction [8].

Door linings in 'Ford Mondeo' are made of a mixture of kenaf fiber and polypropylene resin [9]. This leads to a reduction of 5 to 10 % of door weight. The ability of plant fibers to absorb large amounts of humidity leads to an increased comfort that cannot be reached with synthetic materials.

Higher performance applications are achieved with the inside panels of the Mercedes-Benz E-Class [10]. The fiber materials previously used for the inside panels are replaced by a plant fiber-reinforced material consisting of a flax/sisal fiber mat embedded in an epoxy resin matrix. A remarkable weight reduction of about 20% is achieved, and the mechanical properties, important for passenger protection in the event of an accident, are improved.

4. STEEL

The vehicle body structures employ the unique advantages of advanced steel grades, which provide heightened strength with excellent part forming. ULSAB-AVC vehicle body structure uses 100 percent high-strength steel grades, of which over 80 percent are advanced high-strength steels. These steels are combined with advanced manufacturing and joining technologies to achieve the structurally efficient designs and safety features found in ULSAB-AVC concepts.

ULSAB-AVC features a full spectrum of the latest steel technologies, including tailor welded blanks, tailored tubes, advanced joining techniques and tube and sheet hydro-forming.ULSAB-AVC raises automotive steel design to new levels of mass and performance optimization through extensive use of ultrahigh strength steels and advanced high strength steels (AHSS) in vehicles designed to satisfy transformation induced plasticity (TRIP), complex phase (CP), and the martensitic (Mart) steels. Higher-strength steels currently account for 80% of the body of a European premium-class car such as the BMW 7er-series, introduced in 2001.In parallel with the enlarged use of this material, the yield stress of high strength steels has been improved over the years, realizing 220 megapascals (MPa) up to 1,200MPa. Today, higher-strength steels are used more frequently in smaller vehicle segment as well[11].

The family of steels based on multi-phase microstructures provides a remarkable combination of strength and formability not available in conventional grades.

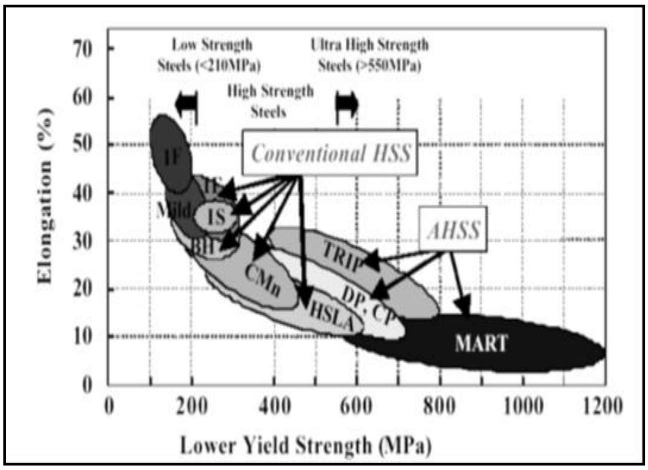

Fig -2 : Strength-Formability Relationships For Mild, Conventional HSS And Advanced HSS Steels [11].

4.1 Mechanical Properties Of Steel

The steel grades utilized in the ULSAB-AVC body structure and generalized mechanical properties are provided in The majority of grades utilized in the ULSAB-AVC are AHSS grade.

Table -2: Steel Grades For The ULSAB-AVC Body Structure Concept Design [12]

Product	YS MPa	UTS MPa	Total EL (%)	n-value1 5-15%	R -bar	k-value2 MPa
(flat sheet, as shipped properties)						
BH 210/340	210	340	34-39	0.18	1.8	582
BH 260/370	260	370	29-	34	0.13	1.6 550
DP 280/600	280	600	30-34	0.21	1.0	1082
Mart 950/1200	950	1200	5-7	0.07	0.9	1678
Mart 1250/1520	1250	1520	4-6	0.065	0.9	2021
Mart 950/1200	1150	1200	5-7	0.02	0.9	1550

- YS and UTS are minimum values, others are typical vaues
- Total EL % - Flat Sheet (A50 or A80), Tubes (A5)
- 1n-value is calculated in the range of 5 to 15% true strain,
- 2K-value is the magnitude of true stress extrapolated to a true strain of 1.0. It is a material property paramet quently used by one.

5. MAGNESIUM ALLOYS

Magnesium alloys meet the demand for a combination of low specific weight, good machinability and handling, an interesting characteristic profile, and high recycling potential. Mg has a competitive specific modulus (stiffness) and is being used in applications for which stiffness is the design criterion, e.g., transmission cases & transfer cases. In strength-driven designs, Mg has the advantage of much greater specific yield strength and has found applications in instrument panels, beams & brackets. Magnesium is the eighth most common element. It has a good ductility, better noise and vibration dampening characteristics than aluminum and excellent cast ability.

5.1 Advantageous Properties :

- Lowest density of all construction metals at 1.8 g/cm3; light construction parts possible
- High specific strength (strength/density ratio)
- Excellent casting ability; steel dies may be used
- Good machining ability (milling, turning, sawing)
- Improved corrosion resistance with high-purity (HP) alloys.
- High damping properties
- Good weld-ability under inert gases
- Integrated recycling possible .

Magnesium alloys have two major disadvantages for the use in automotive applications; they exhibit low high temperature strength and the relatively poor corrosion resistance. The physical properties of Mg are given in the Table 3 [13].

Table -3: Properties of Magnesium [13]

Crystal structure	**Hexagonal Closed Packed structure (H.C.P)**
Density at 20°C (g/cm3)	1.74
Coefficient of thermal expansion 20–100°C (×106/C)	25.2
Elastic modulus or Young's modulus of elasticity (106 Mpa)	44.2
Tensile strength (Mpa)	240
Melting point (°C)	650

5.2 Application Of Magnesium Alloys In Automobiles

For automotive applications it is important that the development of new casting alloys addresses creep resistance and cost effectiveness [14]. Under this aspect Mg-Al-Si, Mg-Al-RE, Mg-Al-Ca, Mg-Al-Sr and quaternary combinations of them are very promising new systems for high pressure die casting and Ca, Sr and RE additions are also studied for gravity or low pressure castings. These new alloys have already high temperature properties comparable to common aluminum alloys. A comparison of the performance of an oil pan made from the new magnesium MRI153M alloy and from aluminum A380 alloy revealed that the magnesium alloy performed similar and had the better damping properties [15].

Automotive applications require also good ductility for many components; especially energy absorbed in the case of an accident is a very crucial issue. One direction in the alloy and process development for wrought alloys is to optimize the energy absorption of the material [13]. The Nevertheless components require preferentially higher strength than ductility.

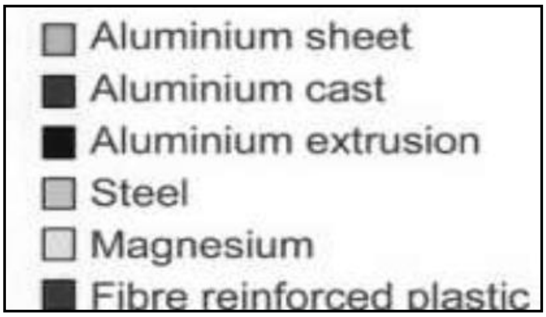

Fig -3(a) :Material of Car Body[6]

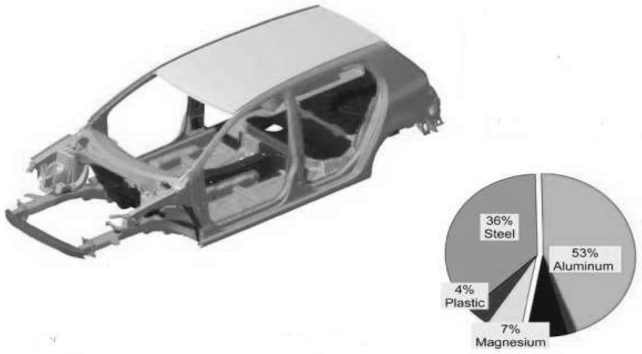

Fig-3(b) : super light car with materials[6]

In fig.[a , b] consisting a material and car body manufactured with different materials. The fig.(a) represent material used in car body. The fig(b) represent the material percentage used in car body structure. This fig.[a,b] represent the material in a automobile structure.

6. CONCLUSION

This paper presents a review of the previous papers based on the advance materials that can be utilized for the future vehicle to reduce the weight of the vehicle. Researching the historical development of products, in this case automotive vehicles from a materials perspective, is a rich source of ideas for future designs.

Lightweight engineering provides the basis for weight optimization. Once the load path is defined, the optimum weight distribution of the vehicle can be broadly determined in order to prioritize those areas of the vehicle that would benefit most from the application of more expensive materials within the boundaries of the set value proposition cost relationship. Additionally, the data from lightweight engineering provides the basis for matching material properties to meet the needs of localized load path conditions of individual sub-systems and components. The selection of the appropriate materials results in the optimized configuration of the lightweight vehicle.

This paper has demonstrated the feasibility of researching retrospective product development from a materials perspective, mapped against forecasts, increases the quality of future design decision-making and the probability of successful new product introduction. There are significant data available on a lot of products in the form of marketing reports. These can be compared against forecasts published in trade literature. The information can then form the basis of strategic plans for new product development.

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