

# Advance Automobile Material for Light Weight Future – A Review

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## ABSTRACT

Research into 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. This white paper will outline the materials suitable for the application for the light weight vehicles, which are in the development stage and will be a great substitution of conventional materials used in the automotive industries.

This paper seeks to 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.

**Keywords**— AVC—Advance Vehicle Concept, GJ/t-Giga Joule per ton, HP-High Purity, ULSAB-Ultra Light Steel for Automotive Body.

## 1. INTRODUCTION

The research and development of ecological technologies for vehicle is becoming 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, several approaches have already been accomplished by the automotive industry. The reduction in consumption and emissions remains the greatest technological challenge for the automotive industry [2]. Reducing weight by 100 kg leads to a fuel savings of 0.35 l/100 km and 8.4 g CO<sub>2</sub>/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 [2].

A lightweight body can be achieved through any combination of three different approaches to lightweight design (figure 1), categorized into lightweight engineering, lightweight manufacturing and weight reduction through material selection [16].

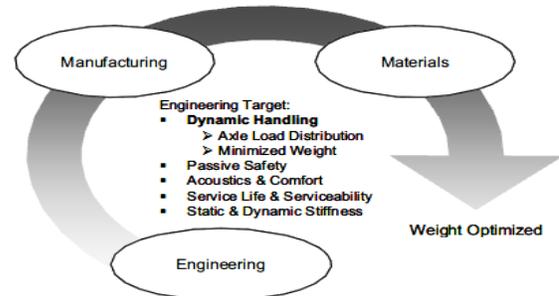


Fig. 1 – Light Weight Design Approach [16]

The major issues faced over the last decades that have influenced change in materials usage in motor vehicles can be summarized as follows:

### ➤ Environmental constraints:

One way of reducing exhaust emissions from motor vehicles is by reducing their fuel consumption. Fuel consumption can be improved by increasing the thermodynamic efficiency of the engine but significant gains can also be achieved by reducing the weight of the vehicle and its aerodynamic drag. To achieve a weight reduction, higher performance materials are required. Materials with high specific stiffness and strength properties for example allow highly efficient lightweight load bearing structures to be produced. Similarly, materials with enhanced processing capabilities, such as near net molding allow greater design freedom in producing complex shapes for improved aerodynamics, further reducing fuel consumption.

### ➤ Economic demands and Performance enhancements:

The increasing need to recycle or reuse materials has put additional constraints on motor vehicle manufacturers. The easy disassembly of motor vehicles places greater importance on the use of separate components that can be easily maintained and/or replaced. This puts up the initial cost of the motor vehicle but over the life cycle of the vehicle the cost of ownership goes down. Extended warranty periods for vehicles have increased demands on component reliability and environmental resistance. To achieve these aims, materials have to possess predictable long-term performance retention. This has been achieved through improved quality of materials and materials processing.

## ALUMINUM

Metal foams with high levels of controlled porosity are an emerging class of ultra-lightweight materials that are receiving increased attention for both commercial and military applications [1]. Aluminum metal foam materials, which can be fabricated into a variety of functional geometries, offer significant performance advantages for weight-sensitive applications. Metal foams exhibit high stiffness-to-weight and strength to weight ratios, and thus offer potential weight savings. They also have the ability to absorb high amounts of energy during compressive deformation for efficient crash energy management.

### STRUCTURE AND PROPERTIES OF ALUMINIUM METAL FOAM

It is known that foam properties strongly depend on the pore structure. Various constitutive laws have been suggested for the characterization and modeling of this relationship [14]. However, aluminum foams are dramatically different from polymeric foams: polymeric foams generally have a regular microstructure, whereas metallic foams are highly disordered with a wide dispersion of cell size and cell shape.

The following three characteristics provide a 3-dimensional design space to a foam material from which a wide range of material properties can be attained [15]:

1. Pore Size
2. Relative Density
3. Base Material

Foam pore size defines how finely the raw material of foam is divided. Accordingly, the foam pore size directly affects nominal ligament length & cross section size, and pore diameter. In turn, these micro-structural features influence specific surface area, fluid flow resistance, and electromagnetic transmission or absorption.

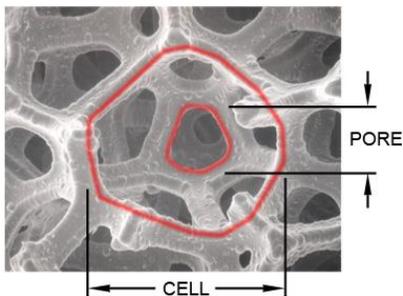


Fig. 2 – Foam Structure [15].

While pore size controls the number and nominal size of the foam ligaments, the relative density controls the ligament cross-section shape and actual size.

The properties of the base material determines all of the physical properties of the resulting foam such as melt temperature, specific heat, coefficient of thermal expansion, strut hardness, oxidation limits and chemical reactivity. In combination with the Relative Density parameter, the base material selected to be foamed affects mechanical properties such as modulus, crush strength, electrical conductivity, and thermal conductivity.

## MECHANICAL PROPERTIES OF ALUMINUM FOAM

**Compressive Deformation Behavior:** One of the most significant attributes of metal foams is their characteristic non-linear deformation behavior [1]. This attribute lends itself to applications in which both lightweight Construction and 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 for applications in systems requiring crash energy absorption. The characteristic shape of metal foam compressive stress-strain curves, with a nearly constant plateau stress, 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 is shown in Figure 3. The foam can absorb much more energy than the dense solid for a specified peak stress level. (At a specified strain level, the dense solid can absorb more energy than foam, but this is not a realistic condition for practical crash energy management.) [1].

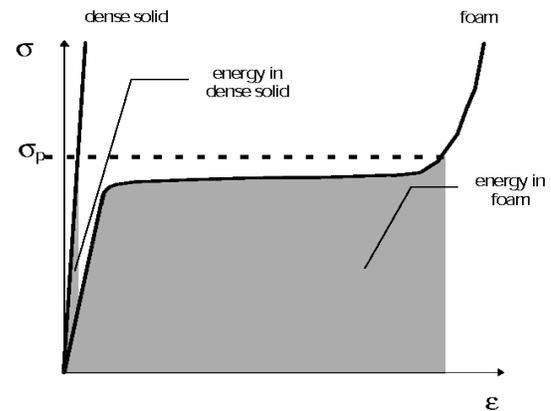


Fig. 3 – Comparison of energy absorption behavior via compressive deformation for foam and dense solid [1].

**Vibration Damping:** Control of vibration and NVH characteristics is very important for automotive applications. As the auto industry moves toward greater use of aluminum for weight reduction, this becomes even more critical due to the inferior vibration damping behavior of aluminum compared to steel and cast iron. The damping behavior of aluminum foam sandwich panels has been studied by 'Karmann GmbH' in collaboration with the Technical University of Dresden, Germany. The damping capacity of test panels of aluminum sheet, steel sheet, and aluminum foam sandwich (AFS) was measured over the frequency range of 100 to 500 Hz. As shown by the results in Figure, the aluminum foam sandwich panel showed significantly better damping behavior than either the aluminum or steel sheets, especially in the frequency range 50-400 Hz [1].

### APPLICATIONS OF ALUMINIUM BASED METAL FOAMS IN AUTOMOBILES

**Characteristics of Metal Foam:** Ultra-lightweight aluminum foams possess unique micro structural characteristics and physical

properties that make them attractive for automotive, as well as other applications:

- Ultra-lightweight materials with high degree of homogeneous closed-cell porosity.
- Foam microstructures tailor-able over the range 40 to 80% porosity.
- High stiffness-to-weight and strength-to-weight ratios
- Ability to absorb energy from impact, crash, and explosive blasts.
- Vibration damping and sound absorption.
- Fire resistance and thermal insulating properties.
- Metal foams are readily recycled.

The characteristics and materials properties exhibited by Aluminum foams suggest numerous potential automotive applications of foam structures:

- Firewalls and rear kick-up panels
- Floor panels
- “A” and “B” pillars
- Energy absorbing bumpers
- Side-impact door intrusion bars
- Front crash rails
- Space frame components and roll bars
- Blast mitigation panels in military vehicles

Potential applications of metal foams include light weight cores for sandwich panels, shells and tubes where the foam can increase the resistance to local buckling, increase the impact resistance, and improve the energy absorbing capacity of the structure [1]. This latter property offers potential uses in transportation applications where, for example, foam-filling of hollow sections in automotive components, such as door intrusion beams and side rails, may reduce damage and injuries resulting from impact accidents because it deforms plastically under impact and with essentially no spring back, preventing further damage. Other important advantages of using aluminum foams include high fire resistance, insensitivity to cold / hot weather and humidity, and ease of recycling.

Therefore, in designing with metallic foams as energy absorbing fillers, mechanical properties are needed for strain rates corresponding to those created by impact events.

With regard to energy absorption, it is possible to engineer a controlled deformation into the crash zone of vehicles with maximum impact energy dissipation. Possible applications include elements for side and front impact protection. Metal foam-filled hollow profiles present interesting deformation behavior and failure mode during buckling. In general, foam filling leads to higher deformation forces when profiles are bent and to higher energy absorption when profiles are axially crushed. Potential applications can be in bumpers, underside protection of trucks, A- and B-pillars, or other elements subjected to buckling or large

deformation. Sound absorption and heat insulation are also important consideration in the automotive industry in the selection of material. If the sound absorbing element also be the heat resistance than it will be very helpful in reduction the weight of the vehicle; existing polymer foams or a combination of materials, such as polymer foams and aluminum sheets may not be desirable due to their poor heat resistance and recyclability. Elements incorporating aluminum foam may improve these properties to meet the design criteria [1].

## 2. COMPOSITE MATERIAL

Much academic 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 [4]. Natural fibers have the potential to reduce vehicle weight (up to 40% compared with glass fiber, which accounts for the majority of automotive composites) [5], while satisfying increasingly stringent environmental criteria along with offering the greater added value, sustainability, renewability and lower costs. Much less energy is used in growing, harvesting, and preparing natural fibers than in producing glass fiber. The energy of plant fibers has been estimated as some 4 GJ/t, compared with around 30 GJ/t for glass fiber [5], which has to be drawn from a melt at several hundred degrees Celsius, using raw materials obtained through energy-intensive mining. Production of glass (or carbon, aramid, etc.) fibers releases CO<sub>2</sub> into the atmosphere, along with NO<sub>x</sub> and SO<sub>x</sub> gases and dust, which can be a health hazard. Dust and fragments are generated when recycling conventional plastic composites by grinding them down, and remain an issue during disposal either to landfill or by incineration. In contrast, the use of natural fibers can minimize harmful pollutants, and their eventual breakdown is environmentally benign. The environmental impacts that remain can be reduced by choosing crops and farming methods that economize on fuel, fertilizer, and pesticide, together with efficient extraction and treatment systems. Natural fibers emit less CO<sub>2</sub> when they break down than is absorbed during plant growth. They are non-irritating and nonabrasive, and do not blunt manufacturing tools or processing equipment. Fiber-producing crops are easy to grow and could take up marginally used agricultural capacity in developed and under developed countries.

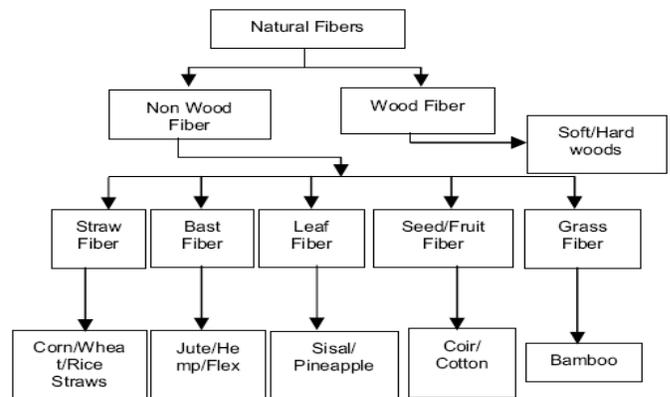


Fig. 4 - Classification of Natural fibers [6].

## STRUCTURE AND PROPERTIES OF NATURAL FIBERS

The structure and chemical composition of natural fibers varies significantly and depends on the source and many processing variables. However, some generalizations are possible. Natural fibers are complex, three-dimensional, polymer composites made up primarily of cellulose, hemicelluloses, pectin's, and lignin [7]. Figure 5 shows the structure flax fiber. The fiber morphology is one of the most important parameter influencing the properties of fiber and their composites.

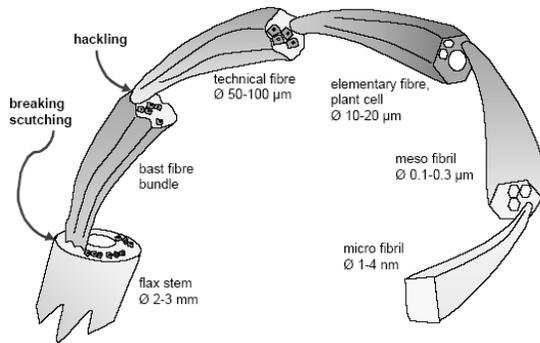


Fig. 5 – Structure of Flax fiber [7].

The quality and type of natural fibers affects the reinforcing efficiency of the composites. Natural lignocelluloses fibers are themselves composites that consist of a framework of crystalline cellulose in a matrix consisting mainly of lignin and polysaccharides [8]. Several other components such as inorganic salts, waxes, etc. are also present in smaller quantities. The properties of the fibers are thus dependent on the characteristics, quantity and orientation of the reinforcing element, crystalline cellulose [9]. The degree of polymerization of the crystalline cellulose is an important factor that influences fiber strength and modulus. In addition, there are many other factors affecting the natural fiber properties.

## 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 [8].

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 mechanism of failure. Interfacial bond between the matrix and the fiber determines the effectiveness of stress transfer mechanism from the matrix to fiber when the matrix tends to crack under load [10]. Hence, with higher interfacial bonding, tensile strength improves and fiber may not crack. This suggest that a high degree of tensile strength of the fiber is not required if interfacial bonding is the limiting factor. Normally, interfacial bond is a combination of adhesion, friction between the fibers, matrix as well as mechanical interlocking [11].

TABLE I  
 Mechanical properties of fibers as compared to conventional polymers

Fiber	Specific Gravity	Elongation (%)	Tensile strength (MPa)	Young's Modulus (GPa)
<b>Fibers (Reinforcement)</b>				
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
<b>Polymers (resins/matrices)</b>				
ABS	1.05	10	55	2.8
Polycarbonate	1.22	100	62	2.3
Polyetherimide	0	-	105	2.8
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 [3]

## 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. The specific mechanical properties of natural fibers are comparable to those of traditional reinforcements. Thus, the inherent properties of natural fibers can satisfy the requirements of automobile industries especially in weight reduction [3]. Hence they can be a good replacement of non-renewable synthetic fibers.

Presently many vehicle research and development are concentrated to work on renewable and biodegradable plant fibers. The light vehicle (SUVs) segment interiors have already replaced glass fibers with plant fibers. This reduces the cost and vehicle weight. The gross vehicle weight reduction not only depends on structures and frames but also depends on small accessories [3]. The change of

these accessories not only reduces the weight but also reduces the cost.

Door linings in 'Ford Mondeo' are made of a mixture of kenaf fiber and polypropylene resin [13]. 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. Aside from this kind of developments, fundamentally new applications have not been realized in recent years.

Higher performance applications are achieved with the inside panels of the Mercedes-Benz E-Class [12]. 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.

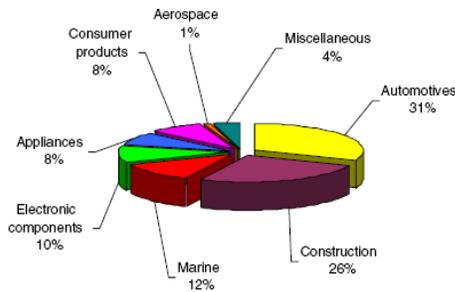


Fig. 6 – Wood plastics used in the Yr. 2002 [4].

From the figure 6, we can say wood plastics i.e. natural fiber composites are being used in a large number of applications in automotives, constructions, marine, electronic and aerospace.

### 3. 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 the most advanced manufacturing and joining technologies to achieve the structurally efficient designs and safety features found in ULSAB-AVC concepts.

The ULSAB-AVC is the most recent addition to the global steel industry's series of initiatives offering steel solutions to the challenges facing automakers around the world today. It succeeds ULSAB [25, 26], ULSAC [27] and ULSAS [28]. The ULSAB-AVC concepts revolutionize the kinds of steels normally applied to vehicle architectures, as well as demonstrating cutting edge steel vehicle design. In addition to extensive use of advanced steels, 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 ultra high strength steels and advanced high strength steels (AHSS) in vehicles designed to satisfy future environmental and crashworthiness mandates.

### GRADES AND PROPERTIES OF STEEL

High strength steels are those steels with yield strengths from 210–550 MPa; ultra-high strength steels are defined as steels with yield strengths greater than 550 MPa. The yield strengths of advanced high strength steels overlap the range of strengths of HSS and UHSS. The range of yield strengths and ductility for the AHSS grades is shown in Figure 7. The principal differences between conventional HSS and AHSS are due to their microstructures. AHSS are multi-phase steels, which contain martensite, bainite and/or retained austenite in quantities sufficient to produce unique mechanical properties. Compared to conventional micro-alloyed steels, AHSS exhibit a superior combination of high strength with good formability. This combination arises primarily from their high strain hardening capacity as a result of their lower yield strength (YS) to ultimate tensile strength (UTS) ratio.

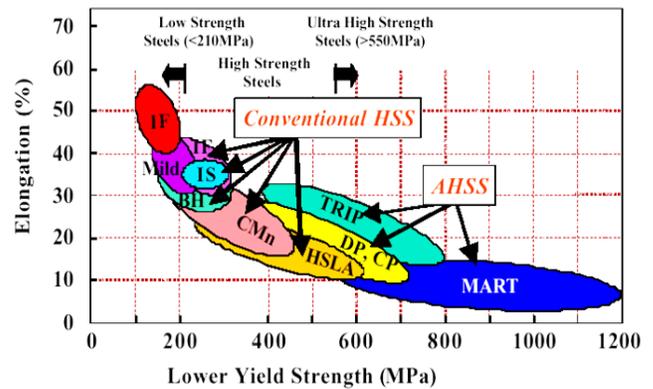


Fig. 7 - Strength-Formability relationships for mild, conventional HSS and Advanced HSS steels [24].

For conventional steels, reduced formability is one of the consequences when selecting steels with higher strength levels. To overcome this, recent steel developments, which can facilitate further light weighting of automotive structures, have targeted this phenomenon. The family of steels based on multi-phase microstructures provides a remarkable combination of strength and formability not available in conventional grades.

The multi-phase AHSS family includes dual phase (DP), transformation induced plasticity (TRIP) and complex phase (CP), products. Figure 7 shows the relative tensile strengths and formability (measured by total elongation) of conventional strength steels such as mild (Mild) and interstitial free (IF) steels; and conventional HSS such as carbon-manganese (CMn), bake hardenable (BH), isotropic (IS), high strength IF (IF) and high strength low alloy (HSLA). Figure 1 also shows advanced high strength steels (AHSS) such as dual phase (DP), transformation induced plasticity (TRIP), complex phase (CP), and martensite (Mart) steels.

### MECHANICAL PROPERTIES OF STEEL

The steel grades utilized in the ULSAB-AVC body structure and generalized mechanical properties are provided in Table 2. The majority of grades utilized in the ULSAB-AVC are AHSS grades.

TABLE II  
 Steel grades for the ULSAB-AVC body structure concept design [29]

Product	YS (MPa)	UTS (MPa)	Total EL (%)	n- value1 (5-15%)	r- bar	k-value2 (MPa)
<b>(flat sheet, as shipped properties)</b>						
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
IF 300/420	300	420	29-36	0.20	1.6	759
DP 300/500	300	500	30-34	0.16	1.0	762
HSLA 350/450	350	450	23-27	0.14	1.1	807
DP 350/600	350	600	24-30	0.14	1.0	976
DP 400/700	400	700	19-25	0.14	1.0	1028
TRIP 450/800	450	800	26-32	0.24	0.9	1690
DP 500/800	500	800	14-20	0.14	1.0	1303
CP 700/800	700	800	10-15	0.13	1.0	1380
DP 700/1000	700	1000	12-17	0.09	0.9	1521
Mart 950/1200	950	1200	5-7	0.07	0.9	1678
Mart 1250/1520	1250	1520	4-6	0.065	0.9	2021
0 DP 280/600	450	600	27-30	0.15	1.0	1100
DP 500/800	600	800	16-22	0.10	1.0	1250
Mart 950/1200	1150	1200	5-7	0.02	0.9	1550

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

### FEATURES OF STEEL (ULSAB-AVC)

Currently the fastest growing material in automotive applications, is relatively new to vehicle design and is significantly different from the conventional steel it replaces. Its light weight capability results from its unique combination of strength and ductility. These attributes stem from complex composite structures of several different steel phases, each with unique material properties.

- 21 to 25% reduction in body-in-white weight,
- 9% reduction in curb weight,
- 5.1% reduced fuel consumption,
- 5.7% reduced life cycle GHG emissions (CO2 equivalent) and,
- Little or no increase in manufacturing costs.
- Mass savings of 25% over the benchmark at no cost penalty

- 80% improvement in tensional rigidity
- 52% improvement in bending rigidity
- Meets all mandated crash requirements
- 58% improvement in first body mode

### 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.

#### Advantageous Properties [17]:

- Lowest density of all construction metals at 1.8 g/cm<sup>3</sup>; 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

### STRUCTURE AND PROPERTIES OF MAGNESIUM ALLOYS

Magnesium is the lightest of all the engineering metals, having a density of 1.74 g/cm<sup>3</sup> [17]. It is 35% lighter than aluminium (2.7 g/cm<sup>3</sup>) and over four times lighter than steel (7.86 g/cm<sup>3</sup>). The physical properties of Mg, Al and Fe are given in Table.

Magnesium is the eighth most common element. It is produced through either the metallothermic reduction of magnesium oxide with silicon or the electrolysis of magnesium chloride melts from seawater. Each cubic metre of the sea water contains approximately 1.3 kg (0.3%) magnesium [17, 19]. It has a good ductility, better noise and vibration dampening characteristics than aluminium and excellent castability [20]. Alloying magnesium with aluminium, manganese, rare earths, thorium, zinc or zirconium increases the strength to weight ratio making them important materials for applications where weight reduction is important, and where it is imperative to reduce inertial forces. Magnesium alloys have two major disadvantages for the use in automotive applications; they exhibit low high temperature strength and a relatively poor corrosion resistance. The physical properties of Mg are given in Table 3 [17].

TABLE III  
 Properties of Magnesium

Crystal structure	HCP
Density at 20°C (g/cm <sup>3</sup> )	1.74
Coefficient of thermal expansion 20–100°C (×10 <sup>6</sup> /C)	25.2
Elastic modulus [Young's modulus of elasticity] (10 <sup>6</sup> Mpa)	44.2
Tensile strength (Mpa)	240
Melting point (°C)	650

The use for transmission cases and engine blocks requires temperature stability up to 175°C and in some cases even 200°C for engine blocks. The new high temperature resistant alloys are under further development and testing. Few alloys are already available in the market (e.g. MRI, modified AE and AJ alloy systems) [19][20]. These alloys contain mostly aluminium for good castability and strontium, calcium and/or rare earth elements for better high temperature stability.

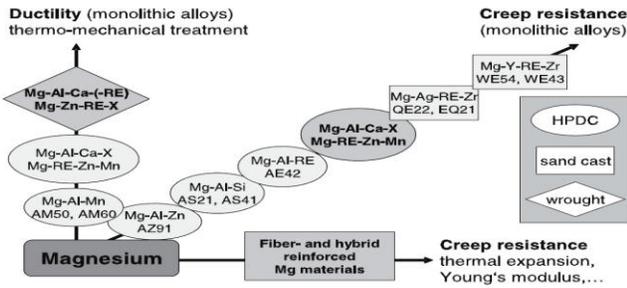


Fig. 8 - Directions of alloy development to improve the performance of Magnesium components.

#### 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 [20]. 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 aluminium alloys. A comparison of the performance of an oil pan made from the new magnesium MRI153M alloy and from aluminium A380 alloy revealed that the magnesium alloy performed similar and had the better damping properties [23].

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 optimise the energy absorption of the material [17]. Nevertheless other components require preferentially higher strength than ductility. Thus alloy development follows various requirements and certain alloy groups can be identified to provide certain properties (Fig.).

Standard parts made of magnesium alloys are: instrument panel, support frame, seat frame, steering wheel core parts, steering wheel frames, cylinder block heads, transmission cases, clutch housings, lower crank cases, intake manifolds, brake and gas pedals. Some magnesium alloy applications in the automotive sector are given on a car model in Fig.. From the figure it is seen that 22% to 70% weight reduction is possible for automotive components by using Mg alloys instead of alternative materials.

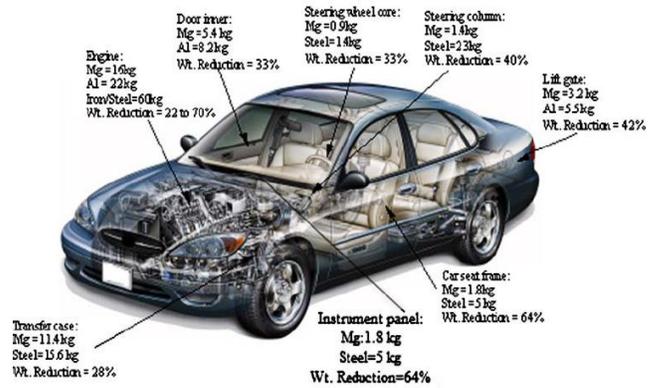


Fig. 9 - Some automotive components made of Mg alloy and obtained weight reduction[17].

#### 4. 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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