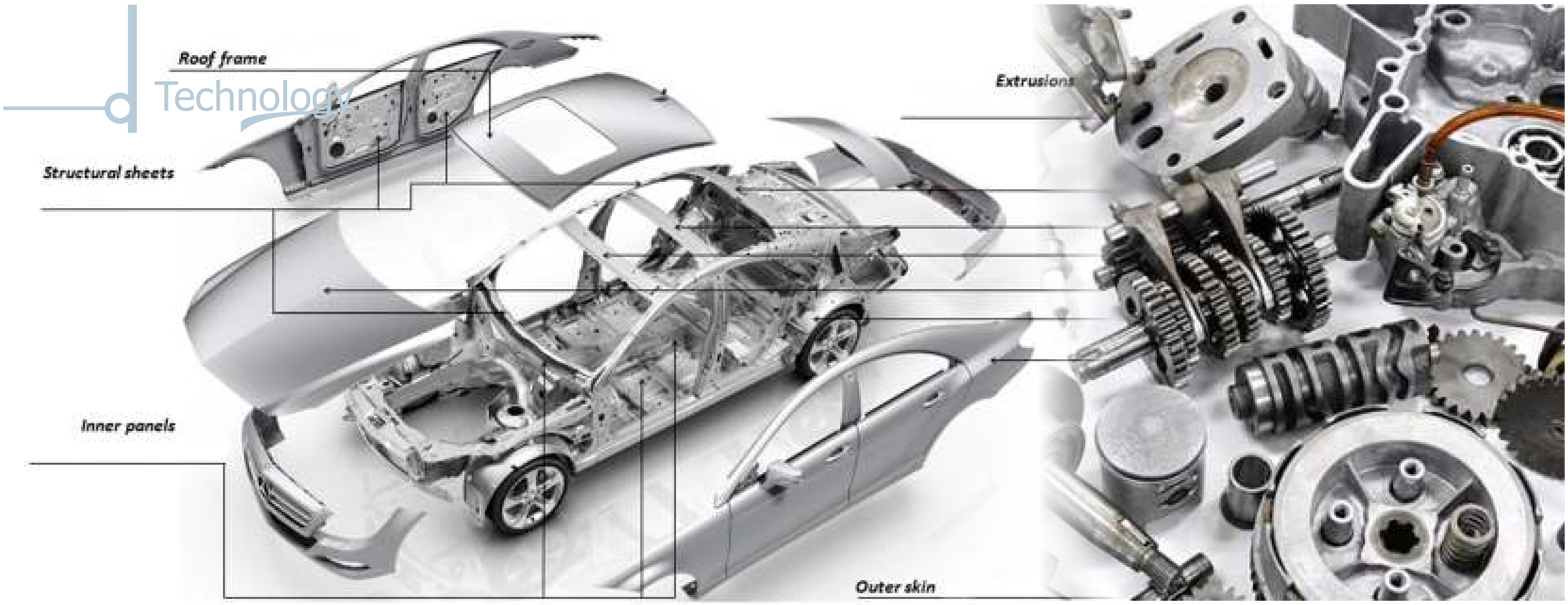

Aluminium and Magnesium Alloys for Automotive Applications

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Dramatic improvements in aluminium alloys have occurred since they were first introduced in the 1920s. These improvements are a result of increasing understanding of chemical composition, impurity control and the effects of processing and heat treatment, micro structural characteristics and properties.

The attractiveness of aluminium alloys is that it they are relatively low cost, lightweight metals which can be heat treated to fairly high-strength levels and are one of the most easily fabricated of the high-performance materials, which usually correlate directly with lower costs. In addition, well known performance characteristics, known fabrication costs, design experience, and established manufacturing methods and facilities, are just a few of the reasons for the continued confidence in aluminium alloys that will ensure their use in significant quantities for Disadvantages of aluminium alloys include a low modulus of elasticity, rather low elevated-temperature capability (<130 °C), and susceptibility to corrosion in high - strength alloys.

Classification of Aluminium alloys

Aluminium (Al) is the predominant metal and typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminium is used for wrought products, for example rolled plate, foils and extrusions. Cast aluminium alloys yield cost-effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminium alloy system is Al–Si, where the high levels of silicon (4.0–13%) contribute to give good casting characteristics. Aluminium alloys are widely used in automobiles, engineering structures and components where light weight or corrosion resistance is required.

Several investigators found that aluminium alloys containing both Zinc and Magnesium developed substantially higher strengths than those containing either of the alloying elements added singly, and significantly higher strengths were obtained from these alloys.

The need to reduce fuel consumption and emissions has sparked intense interest in light weight vehicle construction. Indeed, the amount of aluminium used in European cars has increased from less than 50 kg on average in 1980 to well over 130 kg in 2005.

Applications of Aluminium alloys

In the use of Al alloys for car bodies, initially the predominant role was given to 2036-T4, a copper based alloy and 5182-O, a magnesium based alloy by most car producers both in America and Europe.

Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti
5182-O	0.20	0.35	0.15	0.2-0.5	4.0-5.0	0.10	0.25	0.10
5754-O	0.40	0.40	0.10	0.50	2.6-3.6	0.30	0.20	0.15
5030-T4	0.25	0.40	0.50	0.20	3.5-5.0	0.20	0.10	0.10
2036-T4	0.5	0.50	2.2-3.0	0.1-0.4	0.3-0.6	0.10	0.25	0.15
6009-T4	0.6-1.0	0.50	0.15-0.60	0.2-0.8	0.4-0.8	0.10	0.25	0.10
6010-T4	0.8-1.2	0.50	0.15-0.60	0.2-0.8.	0.6-1.0	0.10	0.25	0.10
6016-T4 (Ac-120)	1.0-1.5	0.50	0.20	0.20	0.25-0.6	0.10	0.20	0.15

Table 1

Using these alloys the required rigidity of car bodies was achieved by mounting 20%-40% thicker Al sheets as compared to the usual mild steel sheets. The 2036 alloy is heat – treatable (hardenable by aging) and it was used for outer body parts, while 5182 sheets due to their particular surface relief developed during Lüdering (due dynamic strain aging) were rather suitable for inner body elements. The 5182 alloy is non-heat-treatable, and hardenable by the Mg solute as well as by deformation.

Composition of Aluminium alloys used for Panel Applications is given in Table 1.

Magnesium is the lightest of all the engineering metals, having a density of 1.74 g/cm3. It is 35% lighter than aluminium (2.7 g/cm3) and over four times lighter than steel (7.86 g/cm3). 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. Because of this property, denser material, not

only steels, cast iron and copper base alloys, but even aluminium alloys are replaced by magnesium-based alloys. The requirement to reduce the weight of car components as a result of legislation limiting emission has created renewed interest in magnesium.

Magnesium is also an important alloying element in Aluminium alloys and Al-Mg alloys work as substitutes especially for reduction of weight of the cars.

Properties of Mg, Al and Fe are given in Table 2 below.

Weight reduction of 100 kilograms represents a fuel saving of about 0.5 litres per 100 kilometres for a vehicle. High-strength steels, aluminium (Al) and composites are already being used to reduce weight, but additional reductions could be achieved by greater use of low-density magnesium and its alloys. Reduction in weight can be obtained by a combination of innovative

Automotive Components Suitable for Casting	
Car Unit	**Component**
Brake System	Brake calipers, master cylinder
Fuel Supply System	Fuel rails, petrol collectors, diesel engine pump
Engine and Suspension	Engine block, suspension arms, belt cover, pulleys, pistons
Steering System	Power-steering valve box, clutch, cylinder, wheels

Table 3

structural design and increased use of lightweight materials. Currently, the average vehicle in North America uses 0.25 % (3.8 kg) magnesium and 8% (120 kg) aluminium.

A lightweight part made of magnesium on a car may cost more than that of Aluminium, but Mg cost compensates for Al cost due to reduction in fuel and CO2 emission.

Most of the available magnesium is still used for alloying aluminium and only about 34% is directly used for magnesium parts, which can be divided into casting applications (33.5%) and wrought materials (0.5%).

Volkswagen was the first to apply magnesium in the automotive industry on its Beetle model, which used 22 kg magnesium in each car of this model.

Figure 1 Figure 2

Cast aluminium pistons and transmission housings

Figure 3

Aluminium cast Car engine

Figure 4

Ford F150 Pickup Truck.

(25 % of curb weight is Al.)

Figure 5

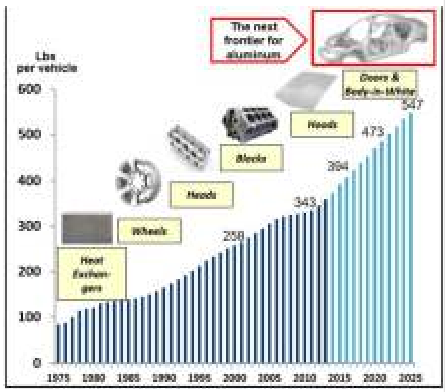
DC rear axle cradle

Figure 6

BMW fabricated wheel

(source: http://marketrealist.com/2015/12/auto-industrys-aluminum-usage-increasing/)

Accelerating Aluminum use in Automotives



Trend

Physical properties of Mg, Al, and Fe			
Property	**Mg, (Magnesium)**	**Al, (Aluminium)**	**Fe, (Iron)**
Crystal structure	HCP	FCC	BCC
Density at 20°C (g/cm3)	1.74	2.70	7.86
Coefficient of thermal expansion 20–100°C (×106/C)	25.2	23.6	11.7
Elastic modulus (106 Mpa)	44.126	68.947	206.842
Tensile strength (Mpa)	240 (for AZ91D)	320 (for A380)	350
Melting point (°C)	650	660	1536

Table 2

References-
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