



A Review on Use of LM Based Aluminium Alloys in Automobile Components

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Abstract: Aluminium alloys are light weight and more corrosion resistance than stainless steel. In Recent years Al-Si alloys gained much importance because of their component usage has increased significantly in automotive, aerospace and marine applications. The reason is due to the addition of Si content, increase in alloy properties like reduction in scrap losses more intricate design thickness, with high quality castings and Strength to weight ratio have been observed. Cost is also the other major parameter in using aluminium in automotive industry. In this paper a brief attempt has been made on Al-Si especially LM series alloys used in automotive structure and components along with LM based composites their preparation methods properties and applications are discussed

Keywords: Aluminium, LM Alloys, automotive applications

1. INTRODUCTION

Now a days for most of the engineering applications Metal matrix Composites (MMC's) are the major materials as their strength, and other mechanical properties shows improvement over the conventional materials. The new materials are developed from the conventional materials either by the intrinsic or the extrinsic modification [1]. In intrinsic modification, only minor alloying changes are carried out. In extrinsic modification, external reinforcements are added to the parent material to alter its properties in order to meet the specific design requirements. The composite materials are extrinsic modification. The modification is usually done to improve the properties of the existing materials [2].

Aluminum is considered as one of the most predominant matrix material considering its properties like high strength, low density, durability, machinability, availability and relatively lower cost as compared to other competing materials [3]. Aluminium castings are widely used in automotive applications like engine blocks, cylinder heads, pistons, wheels and suspension components. Aluminum- silicon alloys are widely used in MMCs because of their light weight, good mechanical characteristic and abundance etc. The benefits by adding silicon is increasing fluidity, reducing cracking, and improving feeding to minimize shrinkage porosity, Corrosion resistance leads to many automotive, marine and aerospace applications[4].

There are a wide variety of LM alloy usage in automotive power train, chassis and body structure. In automotive powertrain, aluminium castings have been used at most in pistons, then in cylinder heads, also in manifolds and transmission. In chassis applications, aluminium castings are used for wheels, brackets, brake pads, suspension, steering parts and in strident panels. Aluminium is used for body structures, closures and exterior attachments such as crossbeams, doors or bonnets. Recent developments shows that weight of the body can be reduced by 30% of vehicle weight the substitution of steel by aluminium. The cost and price stability is its biggest obstacle for this application. So based on the commercial purpose LM series aluminium cast alloys are preferred than Designated alloys [5]. Benefits of using LM alloys like easy cast ability, Cost effective process by making sand castings. Alloys with low thermal expansion Intricate and thin wall castings can be done. The applications and relative percentages for permanent mould and sand casting is shown in Fig.1 [6].

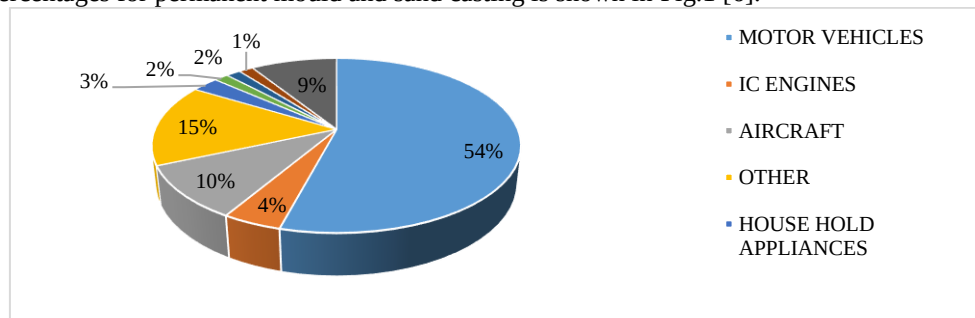


Fig. 1. Permanent mould, sand casting & high pressure die castings of all aluminium castings

Source: "Introduction to aluminium metallurgy", R.N. LUMLEY, CSIRO Light Metals Flagship, Australia
From Fig 1. it was observed that Automobile applications are the major contribution of Aluminium cast alloys.

II. LM Series Aluminum alloys

Among Various Al alloys, LM Series alloys has gained momentum recently and therefore a brief review is provided on LM based cast alloys and their Metal matrix composites in improving their properties for thermal applications in the following table 1 [7]

Table 1. LM Based Composites for Automotive Applications

Alloy	Applications	Properties
LM 4 LM 6	Marine, Automobile, Aerospace industries	- corrosion resistance, casting properties - Mechanical properties increased by heat treatment
LM 13	used for piston which undergoes thermal stresses.	- good wear resistance - machinability
LM 24	Die castings components in engineering applications	- good mechanical properties - high resistance to corrosion
LM 25	used for wheels, cylinder blocks and heads, and other engine and body castings	- good corrosion resistance, - Improved thermal properties and high Strength by heat treatment
LM26	piston and piston rings	- good wear resistance - Thermal resistance - Machinability.
LM28	Used in Piston alloy	Lower coefficient of thermal expansion.
LM29 LM30	unlined die cast cylinder blocks	- low expansion - Excellent wear resistance.

The LM 13, LM 26, LM 28, LM 29 and LM 30 are extensively used in automobile components. LM 26 is used as an alternate to LM13. The experimental investigation was carried out on a series of automobile structural cast aluminium alloys, for characterization. The potential for mechanical performance was compared with the respective conventional alloys for structural applications. Their chemical compositions are tabulated below [7]

Table 2 Chemical Composition (%) Of Aluminium Casting Alloys
(Alloying elements are given in ranges; Impurities are single figures and are the maximum)[4]

Alloy	Cu	Mg	Si	Fe	Mn	Ni	Zn	Pb	Sn	Ti
LM 4	2.0 - 4.0	0.2	4.0 - 6.0	0.8	0.2 - 0.6	0.3	0.5	0.1	0.1	0.2
LM 6	0.1	0.1	10.0 - 13.0	0.6	0.5	0.1	0.1	0.1	0.05	0.2
LM 13	0.7 - 1.5	0.8 - 1.5	10.5 - 13.0	1	0.5	1.5	0.5	0.1	0.1	0.2
LM 24	3.0 - 4.0	0.3	7.5 - 9.5	1.3	0.5	0.5	3	0.3	0.2	0.2
LM 25	0.2	0.2 - 0.6	6.5 - 7.5	0.5	0.3	0.1	0.1	0.1	0.05	0.2
LM 26	2.0 - 4.0	0.5 - 1.5	8.5 - 10.5	1.2	0.5	1	1	0.2	0.1	0.2
LM 28	1.3 - 1.8	0.8 - 1.5	17.0 - 20.0	0.7	0.6	0.8 - 1.5	0.2	0.1	0.1	0.2
LM 29	0.8 - 1.3	0.8 - 1.3	22.0 - 25.0	0.7	0.6	0.8 - 1.3	0.2	0.1	0.1	0.2
LM 30	4.0 - 5.0	0.4 - 0.7	16.0 - 18.0	1.1	0.3	0.1	0.2	0.1	0.1	0.2

From the above table it is seen that the major dominating alloy element in LM series aluminium cast is silicon (Si). Increasing of silicon content influence the mechanical properties and Thermal properties by age hardening process. The effects of other alloying elements in LM cast alloys improves corrosion resistant and wear properties. The mechanical properties of LM alloys are listed below in table 3. The values shown are typical ranges for sand and chill cast test bars produced to the requirements of B.S.1490 and for 6 mm diameter die cast bars

Table 3 LM Alloys and Their Properties

Alloy	LM4	LM 6	LM 13	LM 24	LM 25	LM 26	LM 28	LM 29	LM 30
Properties									
Density (g/cm ³)	2.75	2.65	2.7	2.27	2.68	2.8	2.68	2.65	2.73
Thermal conductivity(W/mK)	0.29	0.34	0.28	0.23	0.36	0.25	0.26-0.29	0.24-0.27	0.32
Tensile Stress(N/mm ²)	140 -170	160-190	170-200	180	130-150	210	170	120	275
% Elongation in 50 mm	2-3	5	0.5	1.5	2	1	0.5	0.5	1
Hardness (BHN)	65 - 80	50-55	100-150	85	55-65	90-120	90-130	100-140	170
Modulus of Elasticity (x10 ³ N/mm ²)	71	71	73	71	71	71	82	88	82
Coeff. of Thermal Expansion (µm/m-C)	21*e ⁻⁴	20*e ⁻⁴	19*e ⁻⁴	21*e ⁻⁴	22*e ⁻⁴	21*e ⁻⁴	175*e ⁻⁴	165*e ⁻⁴	18*e ⁻⁴

III. Literature Review on LM Alloys and Composites

The detailed works related to LM Series alloys in view of preparation methods, properties, uses, and their Innovations are summarized in Table 4

Table 4. Preparation Methods And Properties of LM Based Composites

MMC	PREPARATION METHOD	PROPERTIES	METHOD AND SPECTROSCOPY	FINDING/ APPLICATION	REF
LM13 and LM28 cast aluminum alloys	Alloys prepared by controlled melting and casting followed by heat treatment (T6)	machining characteristics such as cutting forces, cutting temperature, number of chip per gm. and surface roughness , to study the influence of metal cutting parameters such as cutting speed and feed rates on machining characteristics	melt-treated and heat-treated alloys were investigated for machining characteristic at different cutting speeds	1. Cutting temperature was found higher in machining of LM28 alloy than LM13 alloy due to higher hardness 2.Heat treatment of LM28 alloy reduced the surface roughness 3. LM28 alloy produced higher number of chips per gm. than the LM13 alloy due to higher hardness and lower ductility	8
LM13 aluminium/10wt% TiS2 composite	centrifugal casting method	Hardness evaluation, dry sliding wear test, signal-to-noise ratio analysis	Taguchi's L16 orthogonal array design. Parameters considered were load, sliding velocity, sliding distance and distance from outer periphery of the composite, varied for four levels.	Analysis of variance shows that the distance from the outer periphery has the major impact on the wear behavior of the composite The worn out surface of the particle rich region reveals lesser wear rate which is observed by SEM.	9
LM13 Al alloy-reinforced with garnet particulates	liquid metallurgy technique	Heat treatment, aging and corrosion testing	The weight loss method was used and the corrode was 1 M HCl solution at room temperature	Solution heat treatment at 525° C followed by artificial aging at 175° C was found to improve the corrosion resistance of every specimen tested	10
LM13 alloy for the matrix and SiO ₂ of 150 µm as particulates with different percentages	stir casting method	Tensile test, Hardness and Wear tests	Micro Vickers hardness tester Wear properties were evaluated using pin-on-disc wear testing machine	wear properties are considerably improved ,Tensile strength is increased up to 12 wt.% of silica. Hardness increased with increased wt.% of 9 of silica after that decreased	11
LM13/B4C/Gr Hybrid Metal Matrix Composite	Stir Casting method	strength, hardness, and wear resistance	optical microscopy	Greater wettability of the boron carbide particles with the LM13 alloy is the reason for the homogeneity	12
LM13 alloy	squeeze casting process	micro-hardness(VH), tensile strength(Rm), and density(ρ)	good mechanical properties on LM13 by varying squeeze pressure(P), molten temperature(Tm) and die emperature(Td).by Taguchi experimental design L9 orthogonal array was used to determine the signal to noise ratio	From the ANOVA analysis, the most significant parameters were identified as squeeze pressure and die preheating temperature	13
LM13/MgO particulates Composite	stir casting technique	Heat Treatment, Hardness Test, Tensile and Compression Test	artificial ageing at 164° C Brinell hardness tests Universal Testing Machine	Addition of MgO particulates enhances extreme rigidity of Aluminum LM13 alloy altogether enhances the compressive strength	14
LM25/SiC/Al ₂ O ₃ hybrid metal matrix composites	fabricated using liquid metallurgy route	hardness , tensile strength and Wear characteristics	Universal Testing Machine (UTM) Vicker's micro hardness tester	Composites with 30 wt.-% of reinforcement have higher tensile strength and hardness than LM25 base alloy.	15

			Pin-on-disc tribometer	Wear rate of composites decreases with increase in wt-% of reinforcement	
LM24 Composite Alloy Reinforced with Cu-CNT Nano fillers	ultrasonic cavitation and high pressure die casting to form as-cast tensile specimens	ultimate tensile strength and yield strength,	SEM Analysis	increment to both ultimate tensile strength and yield strength, with a corresponding decline in elongation, Interestingly, no significant difference in properties were found with an increase in the CNT content	16
Al-Si (LM 6) alloy	die casting method	three cutting parameters: cutting speed, feed rate and depth of cut	Taguchi analysis is employed (ANOVA) is also applied to identify the most significant factor.	optimal parameter combination is found that depth of cut is the most significant factor for the machining and maximization of MRR Feed rate is the most significant factor for the minimization of the roughness	17
Al-Garnet Composites	stir casting route	Micro hardness and wear behavior of composites.	effect of particle size on the microstructural features observed by SEM analysis	the wear resistance increased considerably from 10 to 15 wt.% of garnet	18
(ZA-27) alloy composites reinforced with garnet particles	liquid metallurgy technique	wear test	A pin-on disc wear testing machine	wear loss increased with increase of reinforcement in load and sliding speed wear resistant will increase with increase in garnet content	19
LM25/ZrO ₂ metal matrix composites	stir casting technique	wear test	Pin-on-disc Tribometer	wear loss decreases with an increase in the Percentage of ZrO ₂ The wear loss increases with an increase in load from 10 to 30 N for all samples The coefficient of friction of the LM25/ZrO ₂ metal matrix composites decreases with an increase in ZrO ₂	20

From the above survey it is evident that LM 13 and LM 26 alloys are widely used in engine application especially in piston arrangements for internal combustion engines because of good corrosion resistant properties and high strength at elevated temperatures. Increasing Si content in both the alloys shows Increase in machinability property. However machinability of LM26 is slightly superior to that of LM13. High strength and hardness at elevated temperatures (250 °C) make the alloys suit for I.C engines.

IV. Recent Works on LM 26 Alloys

Chintan Davda , Dhruv Patel[21] has taken LM-26 alloy to study its Precipitation behavior by Ultrasonic velocity measurement and Digital Rockwell hardness testing machine on ageing at dissimilar times and temperatures by varying aging conditions were studied and compared with those of other cast alloys

A. Pavan Kumar et al[22] has studied LM 26 reinforced with Al/RHA/RM hybrid Composites prepared by optimizing the Parameters Stirring time, stirring speed, and weight fraction predicted by Taguchi technique in Stir casting procedure and their effect on mechanical properties are also Predicted and the optimum level for good tensile strength.

H. R. Ghan, S.D.Ambekar[23] performed experiment to investigate the effect of machining parameter on surface roughness ,material remove rate and machining time of LM26 Alloy in Optimizing milling and turning parameters to find out its mathematical model and validation done by ANOVA, Taguchi Design of Experiments and concluded that better surface finish characteristics obtained during milling, and better material removal rate or optimum machining time during turning.

Sanni Dev, Amit Aherwar[24] performing the experiment to investigate the physico-mechanical properties such as density, void fraction, micro hardness and tensile strength of Porcelain Filled Aluminum LM26 Alloy prepared

by stir casting technique and concluded that The density decreases with increase in the porcelain weight, void fraction decrease up to 0.36 for 6wt%porcelain filled. The hardness increased up to 10% tensile strength increased up to 6wt%porcelain addition

Avdhoot Y. Vadghule *et al*[25] has performed the experiment on newly developed MMC of Aluminum LM26 as the base metal. Reinforcement particles used are Silicon Carbide (SiC) and Tungsten Disulphide by Stir casting and investigated its Tribological Properties on friction testing by pin-on-disk apparatus for determining wear rate, and found that the effect of sliding velocity on this material is negligible.

V. Conclusions

Aluminium MMC's (LM Based) have unique mechanical and corrosion resistances properties by reducing component weight thereby improving the engine performance. Hence LM Series alloys are used as automotive materials. The microstructure, hardness, wear resistance and Thermal resistance have made these LM based aluminium alloys unique. They can be prepared by various methods such as stir casting, liquid metallurgy and die casting methods, each and every method enhanced the required properties depend on the specific requirements and applications. From this above published findings, it is concluded that LM based aluminium alloys are encouraged in ongoing development of the MMC technology for automotive engine applications, including engine blocks also in selective strengthening of the cylinder region

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