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EFFECT OF REINFORCEMENT PARTICLES ON PROPERTIES OF ALUMINIUM BASED COMPOSITES BY STIR CASTING: A LITERATURE REVIEW

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ABSTRACT

This review considers the most significant utilize and applications of aluminium because of its superior properties like low density, electrical, ductility and thermal conductivity. At first, the necessary properties are recognized, after which, the review explores aluminium and its significance in the industrial application with its limitations. Metal matrix composites fabricated by different methods are the better replacement for aluminium. Among these all methods, stir casting was considered as the most promising route because of some superior advantages than others. In this review we included the effect of different reinforcement particles on mechanical, optical and physical properties of many of the researchers.

Keywords – Aluminium, Composites, Matrix, Reinforcement, Stir Casting.

I. INTRODUCTION

In an era of cutting-edge developments, where many fields have reached the pinnacle of success, the field of material science is not an exception [1]. The development of MMCs (Metal Matrix Composites) can be considered a mile stone in this field. MMCs are materials consisting of two phases. The continuous one is called Matrix & discontinuous one is called reinforcement [2, 3]. The Matrix retains the reinforcement & reinforcement improves overall properties of the matrix [2]. MMCs are of two types: Mono composites wherein only one reinforcement is used & Hybrid composites wherein more than one reinforcement is used [1]. MMCs have widespread applications in automotive, defense & aerospace industries owing to their low density, high specific strength & modulus, excellent wear resistance, higher service temperature, better physical & mechanical properties compared to conventional materials [4, 5].Amongst lot many MMCs, the Aluminium MMCs have attracted special attention, aluminium has properties such as low weight, it`s density is one-third that of copper, it has good ductility & electrical & thermal conductivity [2, 6]. Besides, aluminium has good machinability & workability. Thus it becomes easy to manufacture any shape & pattern [2, 7].Some of the methods used for manufacture of MMCs are stir casting (Liquid Metallurgy), squeeze casting, powder metallurgy, spray casting, landride technique etc.[1,8]. Out of these techniques, stir casting is used on a large scale, since conventional composites fabrication route on be used & thus, final cost is minimized [1, 9]. Comparative evaluation of different techniques is as follows [1, 9]:-

Stir casting: - It allows wide range of shapes & size up to 900 kg. Its metal yield is greater than 90%. It is least expensive among other methods & causes no change to the reinforcement.

Squeeze casting: - It allows only limited shapes with low metal yield, and causes severe damage to the reinforcement.

Powder Metallurgy: - It allows wide range of products but with restricted size. The metal yield is high, but this method results in reinforcement fracture and is expensive.

Spray casting: - It allows limited shape, but large size. The metal yield is medium & the method is expensive.

Landride Technique: - Allows limited and only pre-formed shapes with restricted size and is expensive.

Thus stir casting comes across as the most economical and promising method. This paper aims to bring into picture various reinforcements used and the results and effect of these reinforcements on properties of MMCs.

II. STIR CASTING

There are abundant methods recently available for producing MMCs, Such as diffusion banding, powder metallurgy, stir casting, pressure infiltration and spray deposition [10].

Amongst these methods stir casting is considered as most simple, flexible & Acceptable to large quantity production. It is also an attractive method because final cost of product is reduced as it allows a conventional metal processing route [11]. This liquid metallurgy technique proves to be most economical technique of all available routes for MMCs production [12]. It involves continuous stirring of molten metal and reinforcement particle in a certain portion and pouring it in a mould cavity.

III. ALUMINIUM ALLOY

A number of cast grades are used in industrial application but aluminium A356, A359 and A6061 are the most promising grade.

3.1 Aluminium A6061

A6061 has properties like good thermal conductivity, low density, easy to process, good castability and weldability [13]. It also has high corrosion resistance and it is used in construction side, automotive and marine applications [14]. The chemical composition and properties are given in the table 1 and table 2

Table 1 Chemical composition of A6061 and by Weight percentage [15]

Element	Mg	Si	Fe	Cu	Mn	Cr	Z	Ti	Al
%wt	1.2	0.8	0.7	0.4	0.15	0.35	0.25	0.15	Bal

Table 2 Properties of Aluminium A 6061 [16]

Properties	**Value**
Youngs Modulus	69 Gpa
Ultimate tensile Strength	290 MPa
Yield strength	240 Mpa
Thermal Conductivity	152 W/mK
Microhardness	44 VHN
Macrohardness	38 BHN
Elongation	8. %
Density	2.7g/cm3

3.2 Aluminium A356

A356 is widely used in industrial application. It has properties like excellent castability, corrosion resistance and good mechanical properties and it has low production rate, fast machinability and good recyclability [17]. The chemical composition and properties are given in the table 3 and table 4.

Table 3 Chemical composition of A356 [17]

Element	Si	Mg	Cu	Fe	Ti	Al
% wt	7.08	0.41	0.06	0.09	0.13	Bal

Table 4 Properties of A356 [18]

Properties	**Value**
Density	2.67 g/cc
Tensile Strength	234 MPa
Hardness	79.2BHN
Melting point	557-613 C
Thermal Conductivity	151 W/mc
Coefficient of thermal expansion	21.5*10^6 /C
Specific heat capacity	963 J/KgC

3.3 Aluminium A359

Aluminium alloy A359 has the higher value of wear resistance than the other Al alloys. It widely used in number of application like automobile, aerospace and electronic industries [19]. The chemical composition and properties are given in the table 5 and table 6.

Table 5 Chemical composition of A359 [19]

Element	Si	Fe	Cu	Mn	Mg	Zn	Ti	Al
% wt	10.22	1.39	0.30	0.47	0.11	0.38	0.17	86.97

Table 6 Properties of A-359 [20]

Properties	**Value**
Hardness	74 Vickers hardness number.
Density	2.6-2.7 g/cc.
Tensile Strength	330 MPa
Yield strength	255Mpa
Elongation	6%.

IV. EFFECT OF REINFORCEMENT ON PROPERTIES

4.1 Effect of reinforcement on mechanical properties

4.1.1 Effect on hardness

M.B. Harun et al [15] observed that, as the volume fraction of fly ash particles was increased in A-Si-Mg alloy, the hardness of the composite was reduced. This indicated high porosity in the composite. N.E. Elzayady et al [21] marked a slight increase in Vickers Hardness value of A356-3%Albite MMC. The hardness of unreinforced alloy was 73 HV while that of the MMC was found to be 76 HV. Ramesh et al [22] on the other hand, observed 47% increases in BH value of the MMC. It was found that this contradiction was because of large sized particles and hence existences of large surface area. The results are shown in below fig [21]. Y.P. Lim et al [17] marked that 0.1wt% Ti and 0.02wt% B increase the hardness of A356 from 19.4 HRA to 21.62 HRA. After that, that the contents of Ti & B were kept constant and yttrium was added from 0.1 to 0.3 wt% and hardness observed was 21.1 HRA, 22.6 HRA and 23.88 HRA respectively. M.N. Wahab et al [23] noted that the hardness of Al-10%AlN is as high as 94 HV as compared to 44 HV of pure Al alloy.

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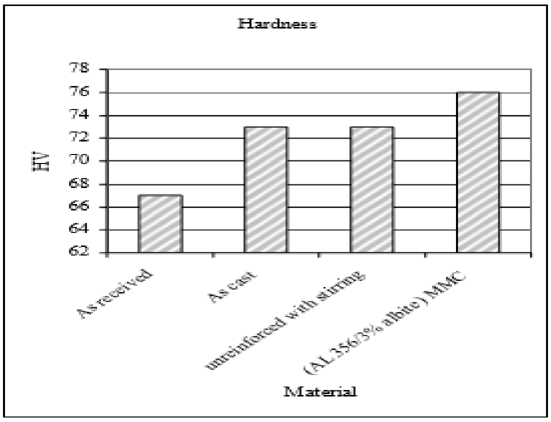


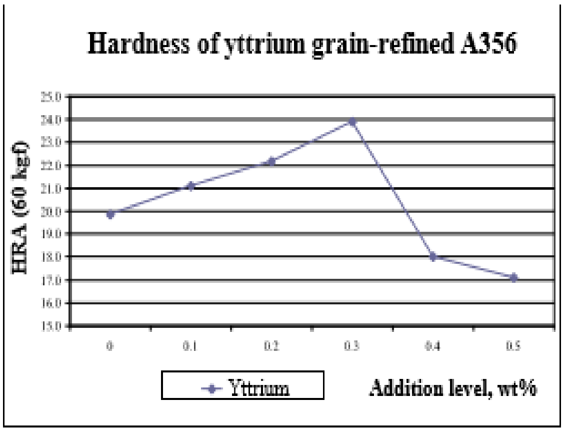
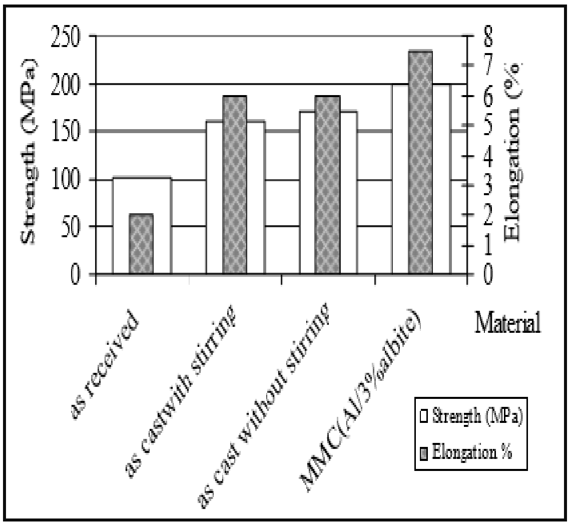


Fig 1 Hardness of albite reinforced MMCs [21]

Fig 2. Hardness of yttrium grain-refined A356 [17]

4.1.2 Effect on tensile strength

K.L. Meena et al [24] marked that as the wt% of SiC is increased in Al-SiC composites, the tensile strength increases from 217.5 MPa with 5% SiC to 235 MPa with 15% SiC. N.E. Elzayady et al [21] observed that the ultimate tensile strength of Al-Albite MMC increased from 102.5 MPa for commercial A356 alloy to 200 MPa with 3% Albite addition [21]. Y.P. Lim et al [21] marked that the original A356 alloy which has a tensile strength of 123.49 MPa increases to 148.29 MPa on addition of 0.2 wt% yttrium & 173.40 MPa on addition of 0.3 wt% of yttrium [17].



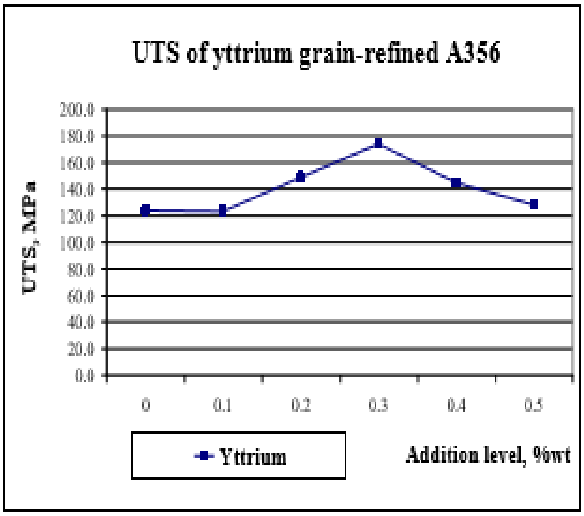


Fig 3 UTS of albite reinforced MMCs [21]

Fig 4 Hardness of yttrium grain-refined A356 [17]

It was also observed that further addition of yttrium does not increase the tensile strength, instead the tensile strength decreases to 144.52 MPa & 127.92 MPa for 0.4wt% & 0.5 wt% of yttrium respectively. Muhammad Jokhio et al [23] reported that the tensile of MMC reinforced with 2.5% Al2O3 increases as compared to un-reinforcement alloy. This is because, the Al2O3 particles refine the grain size of aluminium casting composites by nucleating the fine grain size during solidification process.

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4.1.2 Effect on percentage elongation

Y.P. Lim et al [17] reported when TiB is added to A356, with 0.1 wt% Ti & 0.02wt% B, the ductility does not improve appreciably. If only changes from 0.064 to 0.069. But with addition of 0.1 to 0.5 wt% yttrium the value reached to a maximum of 0.076. N.E. Elzayady et al [21] studied the elongation of Al-3% Albite MMCs. It was noted that elongation changed from 2% to 7.5% with Albite addition. Ramesh et al [22] who used coarse particularly (of Albite) in his study reported a decrease in ductility of the MMC.

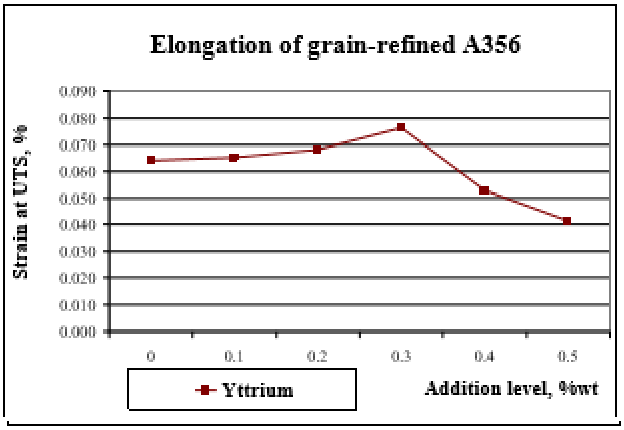

Fig 5 Elongation of grain-refined A356 [17]

4.2 Effect of reinforcement on physical properties

The observation made by F. Akhlaghi showed [25] the variation of porosity with Sic content in composites of SS & SL which is shown in figure.

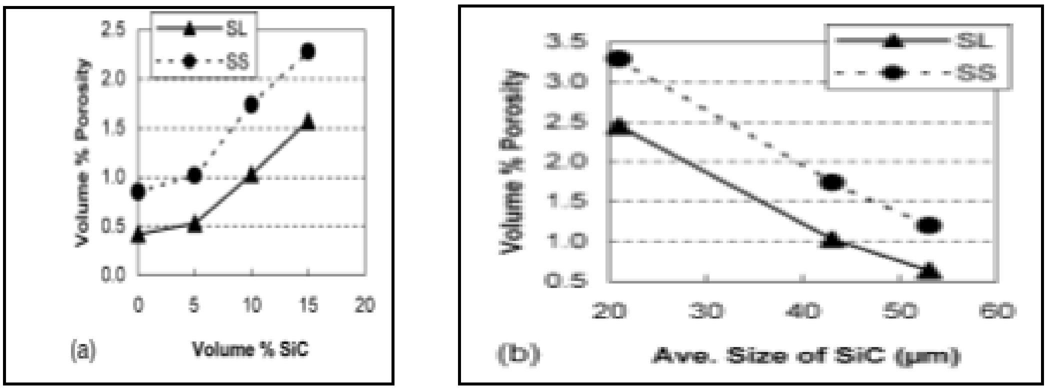

Fig 6 (a) Vol. % Porosity v/s vol. % SiC (b) Vol. % Porosity v/s Avg. size of SiC

It was observed that by taking 43μm SiC particles, there was increased in volume % porosity corresponding to an increased in volume % SiC incorporated. Following graph showed that by taking fixed content of SiC particles (10% volume) porosity of SS & SL composite sample decreased when the size of SiC particles were increased.

4.3 Effect of reinforcement on optical properties

Madeva Nagaral et al [13] observed that, if 6%wt Al2O3 reinforced with 6061 Al, particles get uniform distribution, and 9%wt. Al2O3 reinforced with 6061Al, there was agglomeration of particles.
B. Ashok Kumar et al [14] observed that if 6061 Al reinforced with 5%,10%,15%,20% of AlN ,there was uniform distribution of AlN, and there was no cracks and porosity in the castings.

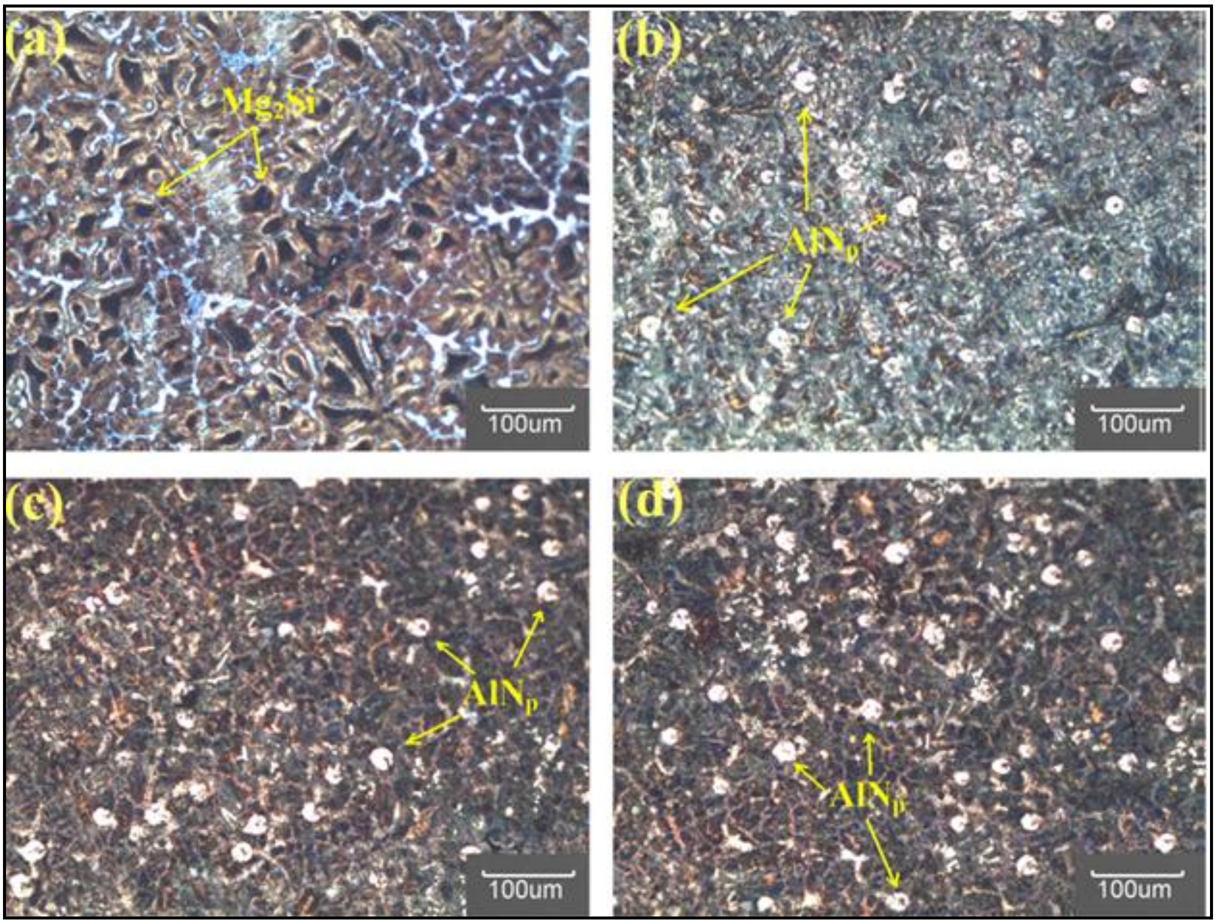

Fig 7 Microstructure of composites reinforced with AlN_p of particle size 100 µm

M. B. Harun et al [15] observed that if Al was reinforced with 10% fly ash and 15% SiC ,there was homogeneous distribution of the particles, there was agglomeration observed when reinforced of Al with 15% fly ash. Y. P. Lim et al [17] observed that, the addition of 0.1 to 0.5wt% of yttrium microstructure was refined potently. When there was more amounts added of yttrium the grain boundary became narrow. And the melting point was increased by the addition of yttrium. V. C. Uvaraja et al [26] observed that the reinforcement distribution was uniform while Al6061 and Al7075 were reinforced with Sic and B4C.

V. CONCLUSIONS

For unique application in, defence, automobile military and general engineering applications aluminium should have achieved definite properties like high stiffness, high hardness and high tensile strength. These properties can be achieved by manufacturing aluminium based composites by a number of techniques like stir casting, powder metallurgy and compocasting etc. So this literature covers the different routes and the effect of different ceramic particles on mechanical properties of aluminium. And from the literatures of different researchers we got to know that mechanical, physical and optical properties improve appreciably with increase in different reinforcement particles.

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