ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 16, April 2017

Study on hardeness and Microstructure of Aluminum alloy -Silicon carbide composite prepared by stir casting and squeeze casting process

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***Abstract*- The technological progress allowed aluminium alloys to approach the minimum of required mechanical properties in various structural applications. Shipbuilding is one of the most sought field of application in which alluminium alloys provided minimum of required mechanical properties provided by low carbon steel. The focus of this work is to increase confidence in the design ability and safety of the ship structural parts made by under the extreme loads that the ships could be subjected to in hazardous sea conditions. Aluminium and its alloys were assessed as a possible replacement for steel, due to a high corrosion resistance and a potential of considerable weight saving, as its density is almost three times lower than the density of steel , as such an attempt has been made to study viability of best process method in aluminum alloy based composite casting. The aim of the work was the evaluation of hardness and microstructure of aluminium alloy - Silicon carbide made by two different methods of castings such as stir casting and squeeze casting.**

Keywords – Composite, Corrosion, Aluminium alloys, Silicon carbide

I. INTRODUCTION

In day-today world there is a need for the development of the advanced engineering material for the use of varied engineering application. In order to meet such kind of demand the MMC (metal matrix composites) are considered as a reliable resource. Composite material is considered to be one of the most essential solutions for these requirements. Over the ultimate thirty years composite substances, plastics and ceramics had been the dominant rising substances. The extent and variety of packages of composite materials have grown steadily, penetrating and conquering new markets relentlessly. Modern composite substances constitute a widespread share of the Engineering materials market starting from everyday merchandise to state-of-the-art applications [1]. While composites have already confirmed their worth as light-weight materials, the modern challenge is to make them fee-effective. The efforts to produce economically appealing composite additives have led to numerous innovative production strategies presently being used in the composites industry. It is apparent, mainly for composites, that the development in production era alone isn't always enough to triumph over the fee hurdle. It is important that there be an included attempt in design, material, system, tooling, pleasant guarantee, manufacturing, or even program management for composites to emerge as aggressive with metals. Composites are now appreciably getting used for rehabilitation/ strengthening of pre-present structures that must be retrofitted to cause them to seismic resistant, or to restore harm resulting from seismic pastime. Unlike traditional substances (e.g. metal), the properties of the composite material may be designed considering the structural components. The design of a structural issue the usage of composites entails each material and structural design. Composite houses (e.g. Stiffness, thermal growth and so on) can be numerous constantly over a large range of values below the manipulate of the dressmaker [2]. Careful selection of reinforcement kind enables completed product characteristics to be tailored to

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nearly any specific engineering requirement. While the usage of composites could be a clean desire regularly, cloth selection in others will depend upon elements which include running lifetime necessities, variety of gadgets to be produced (run duration), complexity of product form, viable financial savings in meeting fees and at the revel in & abilities the fashion designer in tapping the premiere capability of composites [2]. In a few times, first-class effects may be accomplished via the usage of composites in conjunction with conventional substances. Structural steel is a traditional material used over one hundred fifty years in the shipbuilding enterprise due tofirst rate mechanical residences and low manufacturing expenses. Due to the increasing call for building the bigger ships, designers needed to look for opportunity materials to be able to lessen the load of ships. Aluminum and its alloys had been assessed as a probable alternative for steel, because of a excessive corrosion resistance and a capacity of huge weight saving, as its density is sort of 3 instances lower than the density of metal (2.73g/cm^3 for aluminum vs. 7.85 g/cm^3 for metal). Finally, the technological progress allowed aluminum alloys to approach the minimal of required mechanical homes in shipbuilding furnished by using low carbon metal. Those points had a decisive position in considering aluminum alloys as a promising material for marine packages. Steel and aluminum ships, like another dynamically loaded metal structure, will always have the capability tofatigue and crack. The favored approach for dealing with that is through prevention, with careful design looking for to keep stresses underneath the fatigue strength through the usage of thicker fabric, expansion joints, and soforth, and prudent detailing removing pressure concentrations by rounding corners, awesome openings, etc. Yet, in spite of those efforts, over the life of a vessel we can assume a few cracking, in particular for excessive performance vessels along with warships.

In [4] Silica carbide modified carbon cloth laminated C–C composites were successfully joined to lithium–aluminum–silicate (LAS) glass–ceramics using magnesium–aluminum–silicate (MAS) glass–ceramics as interlayer via vacuum hot-press approach. The study findings revealed that the average shear power of C–C/LAS joints achieves 21.01 MPa and the joints are apt to fracture along the SiC/MAS interface. The high retention of mechanical homes at 800ºC makes the joints to be potentially used in a large temperature variety as structural components. In [5] studied in order to fabricate non-stop carbon fiber-bolstered aluminum alloy matrix composites, numerous infiltration techniques consisting of gasoline strain infiltration, CVD-infiltration, and ultrasonic infiltration strategies were developed. Among these methods, the ultrasonic infiltration technique is the handiest. In this take a look at, the results of ultrasonic power, the diameter of the hollow of the horn, fabricating velocity, and magnesium content material on the convenience of infiltration are investigated. As the consequences, both an ultrasonic strength of two hundred W and the addition of greater than 2.Four mass% Mg are quintessential to infiltrate molten aluminum alloy into a PAN-based totally M40J carbon fiber package, which has 6000 filaments. Contrariwise, the tensile power and relative electricity (ROM ratio) of the obtained composites reduced from 1100 MPa (0.7) at each 2.Four and 4.7 mass% Mg contents to 800 MPa (0.5) at 10 mass% Mg content. Whereas in [6] studied the effect of ultrasonic vibration at the solder ability of a 30 vol% Al2O3 reinforced Al–Cu alloy matrix composite in an air ecosystem changed into investigated. The results confirmed ultrasonic vibration gave the liquid filler an extremely good capacity to unfold at the non-wetting base metallic in both drop formation and soldering checks. Wetting become improved via removing the oxide film from the bottom steel, during which preceding diffusion of the filler elements within the composite material generating partial melting performed an critical position. The joint energy increased appreciably with soldering time, attaining a price identical to that of the filler metallic after three s of ultrasonic vibration. The use of ultrasonic soldering is a likely strategy to the problems in becoming a member of aluminum alloys fantastically bolstered with ceramic composites.

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There are various literatures available for AA 5083 reinforced with SiC and their properties but very few researchers concentrate on finding the corrosion performance of the composites using through stir casting. This study, concentrate to overcome the research gap that is to perform the corrosion resistance for the said alloy and the same is compared with squeeze casting also. Hence, the present study aims to To develop the composite AA 5083 reinforced with SiC at 2% and 4% using through stir casting squeeze casting and tofind the mechanical properties of the composites and to compare the corrosion performance for the composites.

II. Experimental Work

In the present study experimental work is done stir casting and squeeze casting.

A. Stir casting

In general stir casting of MMCs entails producing a melt of the selected matrix fabric, accompanied by using the creation of a reinforcing cloth into the melt, acquiring a appropriate dispersion through stirring The next step is the solidification of the melt containing suspended composites to obtain the favored distribution of the dispersed phase in the solid matrix The schematic diagram of this method is as proven in Fig. 1. In composites produced with the aid of this approach, particle distribution will trade notably relying on process parameters at some point of each the melt and solidification stages of the system The addition of particles to the soften substantially modifications the viscosity of the melt, and this has implications for casting procedures. It is vital that solidification arise before considerable settling has been allowed to take place.

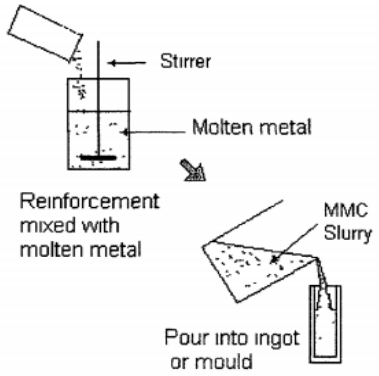

Fig. 1. Schematic diagram of Stir casting

The technique is usually earned out at two distinct levels of temperature of the melt, beyond the liquid us temperature or at the soften temperature maintained in the in part strong range of the alloy. The technique regarding the latter range of temperature is known as the compo casting procedure and it is very powerful in making forged composites with better particle content material.

Fig. 2. Stir casting poring (Bottom)

The reinforcement composites are brought steadily while stirring keeps at a regular fee According to Nishida [7], a good way to get proper incorporation, the addition charge desires to be decreased with a decrease in size of the composites Lee et al [8]

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brought particles at 4-5g/hour, and Salvo [9] takes approximately 5-10 min's to include silicon carbide particles into the soften In a few cases the particle were introduce through a nitrogen fuel movement. The reinforcement composites used normally are one in every of two sorts both in as acquired condition, or heat-dealt with (artificially oxidized) Oxidation has take area at 1000°C for 15 hours in air at 1100°C for 12 hours or one and 1/2 hours, and at 850°C for eight hour Additionally, gasoline absorbed at the floor of SiC, which became prepared in air, can be removed with the aid of preheating at a positive temperature for a sure period of time For example composites had been heated to 554°C for one hour, 850°C for 8 hours, or on the temperature of 900°C, 799°C and 1100°C.

B. Squeeze casting

Squeeze casting is a process that has been hired for making merchandise with better houses and close to net shapes. In the squeeze casting process, a molten metal is solidified underneath an applied strain in the course of solidification, which results in a high cooling fee and temperature gradient. Compared with the traditional HPDC manner, the squeeze casting has a number of advantages, such as low density of porosities, warmth treatability, consistency and soundness of mechanical residences. The key of the squeeze casting process is to control the processing parameters. In [10] author had studied the consequences of squeeze casting parameters at the macrostructure of the LM13 (Al-1013 massp.CSi) alloy. They stated that the multiplied carried out stress resulted inside the smaller grain length and the reduced pouring or die temperature rendered the same effects.

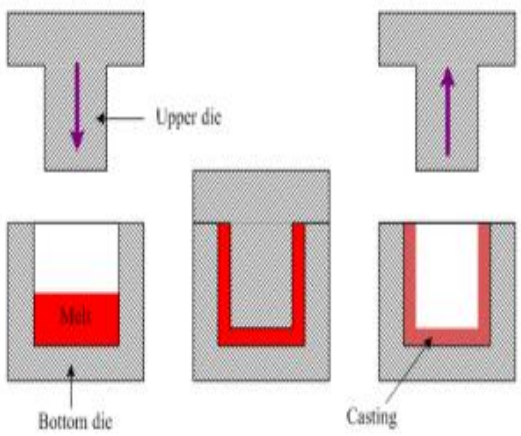

Fig. 3. Schematic diagram of Squeeze casting

In Mg alloys, AZ91 (Mg- 8.98 mass% Al-1.02 mass% Zn) alloy, AM50 (Mg- 5 mass% Al-0.Four mass% Mn) alloy and RZ5DF (Mg-4.2 mass% Zn- 1 mass% RE) alloy had been investigated within the squeeze casting [11]. In [12] carried out the impact of grain size of the RZ5DF alloy and located that the growing implemented pressure inside the squeeze cast promoted speedy solidification and nice grains.

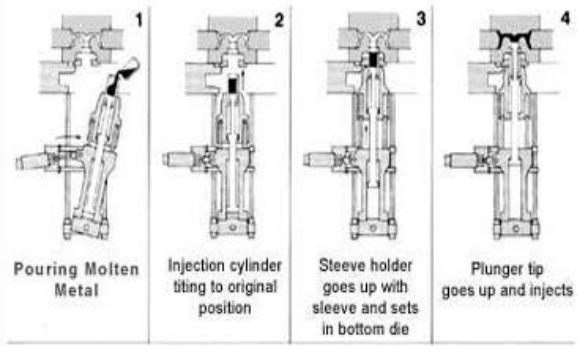

Fig. 4. Squeeze casting poring

But they didn't display the microstructure of the samples solidified under distinctive pouring and die temperatures. In reality, the macrostructure as well as the soundness and indoors nice of squeeze castings are influenced by means of more parameters except

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the carried out pressure, consisting of the soften extent and quality, the duration of the applied stress, die temperature, pouring temperature and time put off before strain application. Therefore, a majority of these parameters are required to be optimized for each person alloy device and casting. Molten steel is poured into a metallic mildew or die cavity with one-1/2 of the die squeezing the molten steel to fill within the intended hollow space beneath strain. Fiber strengthened casting with SiC or Al_2O_3 fibers jumbled in metal matrix have been efficiently squeeze solid and commercially used to supply automobile pistons. However, squeeze casting is restrained best to shallow component or component with smaller dimensions.

III. Result and Discussion

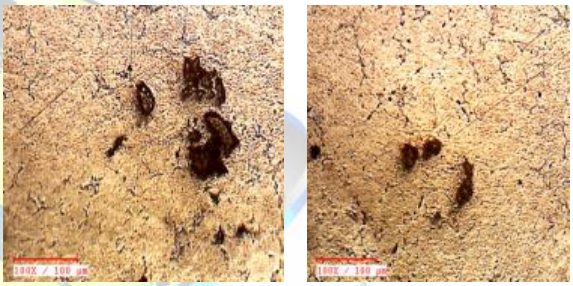
The alloy involved in this Squeeze and Stir casting process is Aluminum alloy. The pre-dominant potentials in selecting aluminum are in its lightness and corrosion resistance. Al-5083 alloy consists of magnesium as principle alloying element with bits of manganese and chromium in it. As a end result for the reason of its excessive resistance to corrosion with high strength, as a result it's miles extensively utilized in ship building and stress vessels etc.

Table 1. Chemical properties of AA-5083

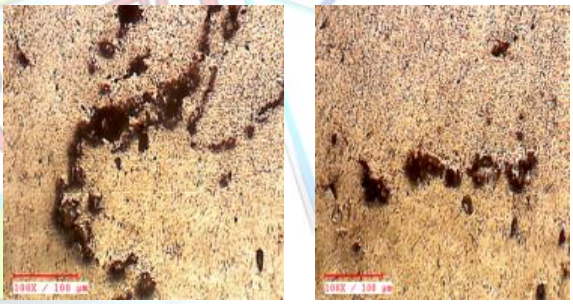
Element	Percentage present
Aluminum (Al)	Balanced level
Magnesium (Mg)	4.00-4.90
Manganese (Mn)	0.40-1.00
Iron (Fe)	0.40
Silicon (Si)	0.0-0.40
Titanium (Ti)	0.05-0.25
Chromium (Cr)	0.05-0.25
Total	0.0- 0.15

A. *Microstructure Analysis*

Microstructure observation revealed clustering and non homogeneous distribution of SiC particles in Aluminum matrix and Porosities were observed in which the porosities increase because of SiC reinforcement in Aluminum metal matrix ceramic composites and the particle size is found to be around 75 µm. . Christo Ananth et al.[3] discussed about E-plane and H-plane patterns which forms the basis of Microwave Engineering principles.



(a)



(b)

Fig. 5. Comparison of Squeeze and Stir Casting for 2% Sic (Sample 1) (a represents squeeze casting and b represents Stir casting)

Fig. 5a represents AA5083 – 2% Sic based composite prepared by squeeze casting. Fig. 5b represents AA5083 –Sic based composite prepared by stir casting. The figure: 5a and 5b it is inferred that distribution of the Sic particles are even and more particles are observed some area. Some diffusion layer and some inter metallic compounds observed along the periphery of SiC particles. The grains are

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Available online at www.ijartet.com

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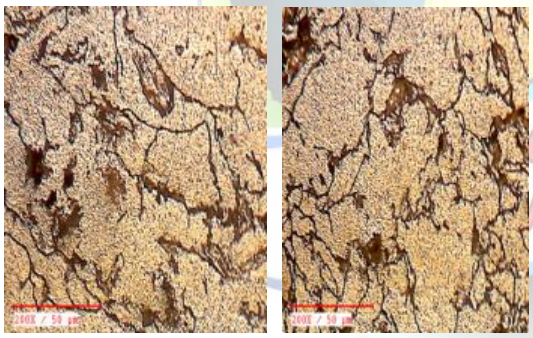
finer and no solidification cracks observed. Grains are formed along the presence of SiC particles. The microstructure is homogenous. Whereas Fig. 5b represents Stir casting in which distribution of the composites are even and some agglomeration are also noticed. Some diffusion layer and some inter metallic compounds are also observed along the periphery of SiC particles.

(a)

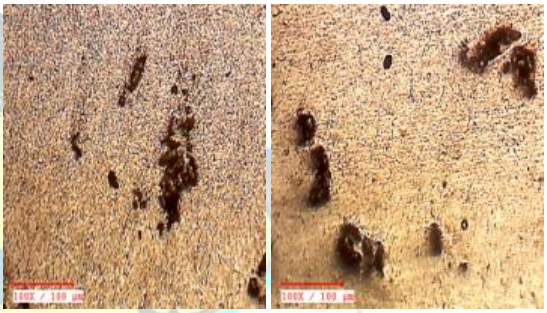


(b)

Fig. 6. Comparison of Squeeze and Stir Casting for 4% SiC (a represents squeeze casting and b represents Stir casting)

Fig. 6a represents AA5083 – 4% Sic based composite prepared by squeeze casting. Fig. 6 b represents AA5083 –4% Sic based composite prepared by stir casting.

(a)



(b)

Fig. 7. Comparison of Squeeze and Stir Casting for 2% Sic (SAMPLE 2)(a represents sequeeze casting and b represents stir casting)

Fig. 7a represents AA5083 – 6% Sic based composite prepared by squeeze casting. Fig. 7b represents AA5083 –6% Sic based composite prepared by stir casting. The micro structural analysis's depicts that the Sic particle distribution are uniform in most of the areas and I some areas it was found agglomerated. As the Sic particles experienced extreme loading in squeeze casting process it was found that the ceramic particles are found distorted grain structure in composite prepared by squeeze casting as compared to stir casting process.

B. Hardness Test

Vickers Hardness is a totally popular take a look at,that is characterized via a rectangular based diamond pyramid indenter, exactly ground to a standard shape with 136 ranges among opposite faces and used to go away a mark in metal underneath an exactly carried out force with the aid of taking care to avoid effect:

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TABLE 2. HARDNESS TEST VALUES SQUEEZE CAST COMPOSITE

S. No	Sample	Hardness			
1	AA 5083 + 2% SiC Squeeze Casting	87	89	88	88
2	AA 5083 + 4% SiC Squeeze Casting	95	93	94	94
3	AA 5083 + 6% SiC Squeeze Casting	97	95	95	96

TABLE 3. HARDNESS TEST VALUES OF STIR CAST COMPOSITE

S. No	Sample	Hardness			
1	AA 5083 + 2% SiC Stir Casting	82	79	76	76
2	AA 5083 + 4% SiC Stir Casting	88	90	88	89.0
3	AA 5083 + 6% SiC Stir Casting	96	87.1	95	96

The hardness test was carried out using Micro Vickers Hardness Tester with a testing load of 10 grams to 1 Kg Load. The table 2 and table 3 depicts the hardness values of stir cast and squeeze cast composite aluminum alloy – silicon carbide composites fabricated by stir casting and squeeze casting process. The results shows that the hardness values of squeeze cast composite is higher than the stir casting process. It is well pronounced in the results that the higher the compaction of casting led to increase in hardness values.

IV. CONCLUSION

The Aluminium alloy – Silicon based composite was prepared by stir casting and squeeze casting procees with varying percentage of ceramic particle in metal matrix.

1. The increase in ceramic particle shows higher hardness values.

2. The higher the compaction experienced by the composite during squeeze casting process led to enhanced hardness values in squeeze cast composite as compared to stir cast composites.

3. It was well observed in microstructure that compaction experienced by the composite during squeeze casting process led to distorted ceramic particle .

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