Journal of Manufacturing Engineering, September, 2013, Vol. 8, Issue. 3, pp 175-177

CORROSION BEHAVIOUR OF EUTECTIC ALUMINIUM CENOSPHERE COMPOSITES

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ABSTRACT

Fly ash is a particulate waste material formed as a result of coal combustion in power plants. The use of fly ash as a filler or reinforcement for aluminum alloys is therefore, very desirable from an environmental standpoint. In light of the above, the paper summarizes the development of 12% Silicon eutectic aluminium composites by stir casting route and analyzes the corrosion behaviour of the composite to sea water for a period of 35 days. Based on varied percentages of cenospheres used six compositions of the composite are prepared and evaluated for corrosive properties and hardness.

Key words: *Al-Si Eutectic Alloy, Immersion Corrosion and Censopheres*

1. Introduction

Aluminium – silicon alloys are a variety of materials which have found large scale applications in the area of automobile and aerospace industries. To name a few, these materials have led to applications like pistons, cylinder blocks and cylinder heads. Eutectic Al – Si alloys is one of the most common alloys in the non - heat treated condition for automotive engines because of its good mechanical properties, high strength to weight ratio, wear resistance and low coefficient of expansion[1]. Al 12-Si eutectic is commonly used in as commercial filler materials for brazing aluminium alloys. [2]. The mechanical properties of Al- Si alloy can be further improved by the addition of suitable reinforcements to the matrix. When the modifying elements are added, the eutectic silicon phase becomes a very fine and fibrous silicon network resulting in an additional improvement to the alloy mechanical properties [3,4]. The reinforcements thus added can be in the form of particulates, whiskers or fibers. In the recent years, usage of ceramic particle- reinforced metal matrix composites is steadily increasing because of their advantages like isotropic properties and the possibility of secondary processing facilitating fabrication of secondary components.[5] The increasing attention in offering various environmental friendly products has recently focused on the use of fly ash in strengthening metal alloys. The cenosphere fly ash which consists of hollow particles can be used for the synthesis of ultra light weight composite materials due to its significantly low density, while the precipitator or solid fly ash can improve properties of selected matrix materials, including stiffness, strength and reduce density [6].

It is reported by other researchers that a higher tensile strength and hardness for Al-4.5% Cu alloy fly ash based composites [7]. It is also reported that the hardness and the tensile strength of the Al Si alloy increases with an increase in the percentage of fly ash particulates [8]. The influence of silicon content of the aluminium alloys on the wear resistance has been very well documented and eutectic alloys are reported to have better wear resistance than those of hypoeutectic and hypereutectic alloys [9].

A detailed investigation into the literatures have revealed that work has been carried out in evaluation of wear and other mechanical properties of Al – Si alloys with suitable reinforcements. However, corrosion behavior of Al – Si eutectic alloys with the incorporation of fly ash has not been reported.

In this investigation, an attempt has therefore been made to study the influence of cenospheres of fly ash on the static corrosion behavior of the composites.

2. Experimental Procedure

The matrix material chosen for the current work is Al –Si eutectic alloy. The composition of the alloy is as shown in table 1. The reinforcement used in the current investigation is cenospheres.

Table 1: Composition of the matrix alloy chosen for study

Si	Fe	Cu	Mn	Mg	Zn	Al
11.8-12.3	0.30	0.002	0.58	0.070	0.019	Balance

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The content of this manuscript has been presented in 3rd International Conference on Recent Advances in Material Processing Technology (RAMPT'13)

2.1 Melting procedure

The cleaned metal ingots are heated to a temperature of 800-850^{0}C by placing in a graphite crucible. A filament winding type of induction furnace is used. A degassing agent in the form of Hexamethyelene di amine is added during the melting period. Magnesium is added in small quantities to improve the wet ability of the reinforcement particles with the base matrix. Cenosphere particles are then preheated and added to the molten metal and then continuously stirred by using a mechanical stirrer for a predetermined time. The cleaned metal moulds are then prepared by bolting together each part tightly so that no leakage of aluminium takes place. The melt with the reinforcement was then poured into the preheated metal moulds. The pouring temperature was maintained at 600^{0}C. The melt was then allowed to solidify in the moulds. To compare the properties the base alloy was then cast in the same procedure.

2.2 Speciemen preparation and testing

The test specimens were prepared by machining from the cylindrical bar castings. The specimens for microstructure studies were polished with a one micron diamond paste. The samples for the microscopic examination were etched with Kellers reagent as an etchant. The specimens were washed with distilled water followed by acetone and then dried thoroughly.

2.3 Hardness test

Hardness tests were performed on the cast composites to know the effect of the reinforcement in the matrix material. The polished samples were tested using Vickers microhardness testing system. A load of 1 N for a period of 10 seconds was applied on the specimens. The hardness was determined by recording the diagonal lengths of the indentation produced. The test was carried out at five different locations and then the average value was taken as the hardness for the cast composites [10]. The test was carried out as per ASTM E384-11e1.

2.4 Corrosion studies

The corrosion behaviors of the cast samples were studied by static immersion corrosion test to measure the weight loss. Cylindrical specimens of the composites and the pure metal were weighed before and after immersion in 3.5% sodium chloride solution. The immersion corrosion test was conducted as per standards ASTM D-6943-10 on the samples and weight loss for thirty five days were estimated. After the time duration of thirty five days the samples were cleaned with distilled water, rinsed with acetone , dried and weighed. Corrosion rates were computed using the equation

Corrosion rate = 534W/DATmpy

Where 'W' is the weight loss in mg, 'D' is the density of the specimen in gm/cm^3, 'A' is the area of the specimen in sq-inch and T is the exposure time in hours [11].

3. Results and Discussions

The samples were designated as shown in table 2 after careful casting and machining process

Table 2: Sample Designation

Sl. No.	Sample Designation	Sample Chemical Composition
1.	Al-Si-0	100 % Aluminium- Silicon , 0% Cenosphere
2.	Al-Si-2	98% Aluminium- Silicon, 2% Cenosphere
3	Al-Si-4	96% Aluminium- Silicon, 4% Cenosphere
4	Al-Si-6	94% Aluminium- Silicon, 6% Cenosphere
5	Al-Si-8	92% Aluminium- Silicon, 8% Cenosphere

3.1 Hardness test results

Fig 1 shows the gradual increase in hardness of the samples with an increasing content of cenospheres. The increase in hardness is expected because of the presence of ceramic reinforcements which are very hard and act as movement of dislocations within the matrix and exhibit greater resistance to indentation [12].

Table 3: Variation of Hardness with Increasing Content of Cenospheres

Sample Designation	Hardness (Vickers)
Al-Si-0	37
Al-Si-2	40
Al-Si-4	45
Al-Si-6	51
Al-Si-8	59

3.2 Corrosion studies

Immersion test was conducted on all the samples as designated in Table 1. The samples were immersed in a solution of 3.5% sodium chloride for thirty five days and the weight loss was measured. The results of the weight loss experiments as a function of corrosion time *t* are shown in fig 3. It is seen from the table that the samples with increasing percentage of cenospheres have poor corrosion resistance as compared to the unreinforced counterparts. Cenosphere particles lead to an enhanced pitting corrosion of the cenosphere composite in comparison with unreinforced matrix. The enhanced pitting corrosion of cenosphere composite is associated with the introduction of nobler second phase of cenosphere particles and higher silicon content formed as a result of reaction between aluminium and silica [13].

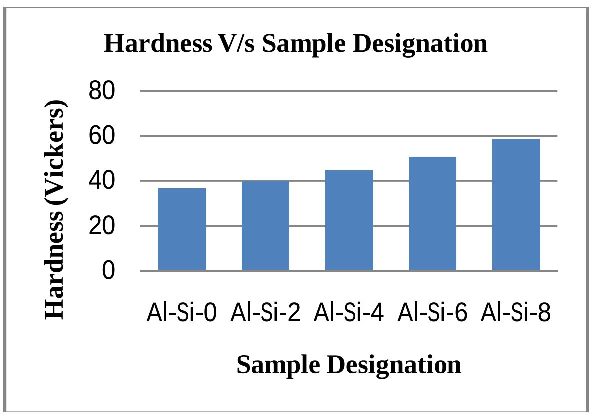

Fig. 1 Graph of Hardness V/s Sample Designation

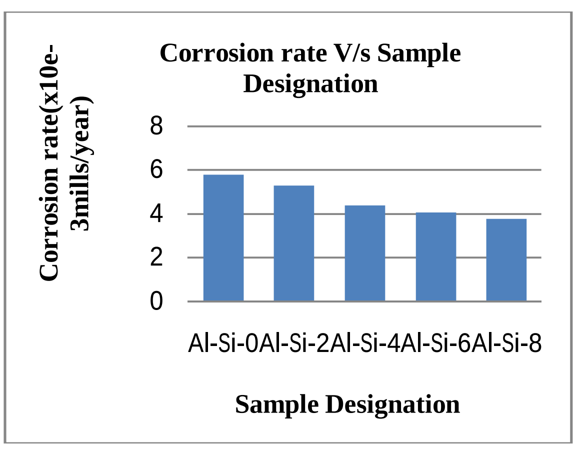

Fig. 2 Variation of Corrosion Rate with Increasing Content of Cenospheres.

4. Conclusions

i. Samples having 8% of cenospheres have shown good improvement in hardness due to the presence of a hard reinforcement of cenospheres.

ii. Immersion corrosion studies have shown that there is a decrease in the corrosion resistance of the samples with an increasing content of the cenospheres.

iii. The increase in the pitting corrosion is attributed to the presence of a nobler second phase of fly ash particles.

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