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COMPARATIVE ANALYSIS OF MECHANICAL PROPERTIES OF ALUMINIUM SILICON ALLOY PRODUCED BY SAND CASTING AND DIE CASTING

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ABSTRACT

In this work, selected mechanical properties such as tensile strength, hardness and microstructure analysis of a sand cast and die cast of aluminum silicon alloy was investigated and compared. An aluminum silicon alloy was cast using sand mould material and die mould material. The cast produced from both methods were subjected to tensile test, hardness test and microstructure analysis test. The die Al-Si cast has the hardness test of 134.5 HV while sand Al-Si 131, 9 HV. The die AL-Si cast has the yield point stress of 118 N/m^2 andsand cast was 105 N/m$^{2.}$ The microstructure analysis result showed the particle of AL-Si cast produced by die cast is more refined than the sand Al-Si cast. The hypoeutectic alloy shows a mixture structure of α –phase and fine eutectic phase of α +Si, though the hypereutectic alloys show a mixture of fine eutectic phase of α+Si and Si particles phase in which the size of particles increases with increasing silicon concentration of the alloy. The degree of refinement of the eutectic silicon increased as the silicon content of the alloy increased beyond the eutectic composition. Here, the primary silicon appears as coarse polyhedral particles. Conclusively die casting produced better Al-Si alloy than sand casting method.

Keywords: Alloys, Cast, Microstructure, Mould, Test, Properties,

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INTRODUCTION

The process of mould preparation, metal melting and the pouring of the molten metal into the moulds, in order to get the shape made by the patterns on solidification of the molten metal is known as foundry, also is the field of engineering and practice which deals with the production of castings. (Ukachi, 2002) There are variation in the mould preparations and different molding material used, when mould sand is used in mould making, the product is called Sand cast, and when the mould is made of metal is called die cast. Foundry is the mother of all industries, the eventual achievement of industries emancipation and economic self reliance in Nigeria hinge on the success of our foundry industries.

The quality of casting produced depends largely on the pattern and core boxes, its materials, design and construction. (Ukachi, 2006).Considerable economies in the cost of raw material for foundry moulds and cores for casting can be achieved by fully exploiting those sources of sand nearer to the foundry than better known and more publicized types of sand (Ukachi,2006). Though, good quality sand is essential for foundry work regardless of initial cost. The sand properties are not only determined by chemical composition, but also amount of clay, moisture content and then by the shape and size of silica grains in the sand (Kiran et al, 2011). To ascertain if sand in certain location is suitable for foundry uses, periodic sand tests are required (Ukachi, 2011). .These tests include grain shape and grain size distribution test (sieve analysis) or grain fineness test, permeability test, strength test, moisture contents test and hardness test. The information from these tests is compare to the standard values to determine the sand suitability for foundry applications (Ravi, 2006)

Aluminium is the most abundant metallic element, making up about 8% of the earth's crust and it was produced in quantity second only to that of iron (Lingberg, 2008). The principle ore for aluminum is bauxite which is a hydrous (water containing) aluminum oxide and includes various others oxides. The production process from bauxite to aluminum consumes a great deal of electricity which contributes significantly to the cost of aluminum (Campbell, 2008). There were elements such as copper, magnesium, silicon and zinc added into the aluminum to become aluminum alloy to improve the strength, hardness and fluidity (Ravi, 2006). In recently years, aluminum alloy become one of the most important engineering material in views of machinability, formability, weldablityand castablity (Lindberg, 2008).

MATERIALS AND METHODS

The materials used for sand casting and die casting processes were: wrought iron foundry sand, Aluminium scraps, powdered silicon, diesel, crucible, mold boxes, rammer, mould box, bellow, tong, sprue cutter, venting wire, tackle, water parting sand and mallet.The following processes were carried out to produce cast from sand mould. Determination of the grain size distribution, Sand casting process for sand mould production, Sand preparation, Pattern making, Mould making, Melting, Pouring, Extracting and Fettling (Kaufman, 2006)

The available sand within The Federal Polytechnic, Ado-Ekiti was packed, seived and mould into casting mould.The grain size distribution of the sand used in the production of the sand mould was determined using sieves pan. Wrought iron was melted and use to form a die mould. Aluminum scraps was purchased from local market and silicon powder were melted with the aid of furnace to about 600^0C. The molten mixture was poured to sand mouldand die mouldsimultaneously and rod like cast were produced according to the rod like pattern cavity inscribed in the pattern. The rod like or cylindrical cast were machined on lathe, milling and machines to produced tensile strength specimen, hardness test specimen and microstructure test specimen respectively. The specimens were fitted to the various machines and tensile strength, hardness test were determined and microstructure analysis were conducted. The results of the sand cast and die cast were then compared.

Plate 1.0: Mould and cavity preparation

Plate 1.1: Melting process

Plate 1.2: Clamping process

Plate 1.3: Melting process

RESULTS AND DISCUSSION

Results of Sieve Analysis of the Moulding Sands

The results of sieve analysis of the samples tested for the grain distribution of sands are presented in table below:

Table 1.0: Sieve analysis of the sand sample

S	**Siev**		**Ma**	**Soil**	**Per**	**Perc**
1	9.50	480	480	0	0	100
2	4.75	530	534	4	1.3	98.7
3	2.36	466	488	22	7.3	91.4
4	1.18	430	475	45	15	76.4
5	600	402	496	94	31.	45.1
6	425	444	496	52	17.	28
7	300	443	483	40	13.	14.7
8	150	403	436	33	11	3.7
9	75µ	427	429	2	0.6	3.03
1	Bas	162	171	9	3	0.03

Weight of container = 92g

Weight of dry soil = 392g

Weight of container + dry soil sample = 392g

Table 1.0 Present analysis of grain distribution. The characteristics shape of the sand grain is an important factor in foundry sand. The grain size distribution affects many of the sand properties. The grain analysis in table 1.0 shows high concentration, grain retained 31.3% by 600µm sieve size. Highly concentrated small grain structure enhances fine surface finish casting.

Grain foundry number is a rapid method to express average grain sizes of particular foundry sand. The fineness of foundry sand is determined by its size and distribution.

The sand particles can be broadly grouped as sand grains(large particles) and foundry sand clay. Fineness has an important bearing on the physical properties of sand grains and clay in foundry sand. Determination of fineness of foundry sand is therefore essential to serve as a guide in determining the amount of quantity of bonding material required to produce some desirable properties in new foundry sand (Shuab-Babata and Olumodeji, 2014). It is also significant to control the proportion of clay bonding material and the proper distribution of grain sizes in foundry sand.

Investigation into the mechanical properties of aluminum Silicon alloy produced through die casting and sand casting process was carried out and the following mechanical properties were determined, viz,;tensile strength, hardness and microstructure analysis of the material produced and the results are shown below .

Tensile Test Analysis

The result of the tensile strength test carried out on the Al-Si alloy cast produced by sand casting method is shown in Fig 1.0.

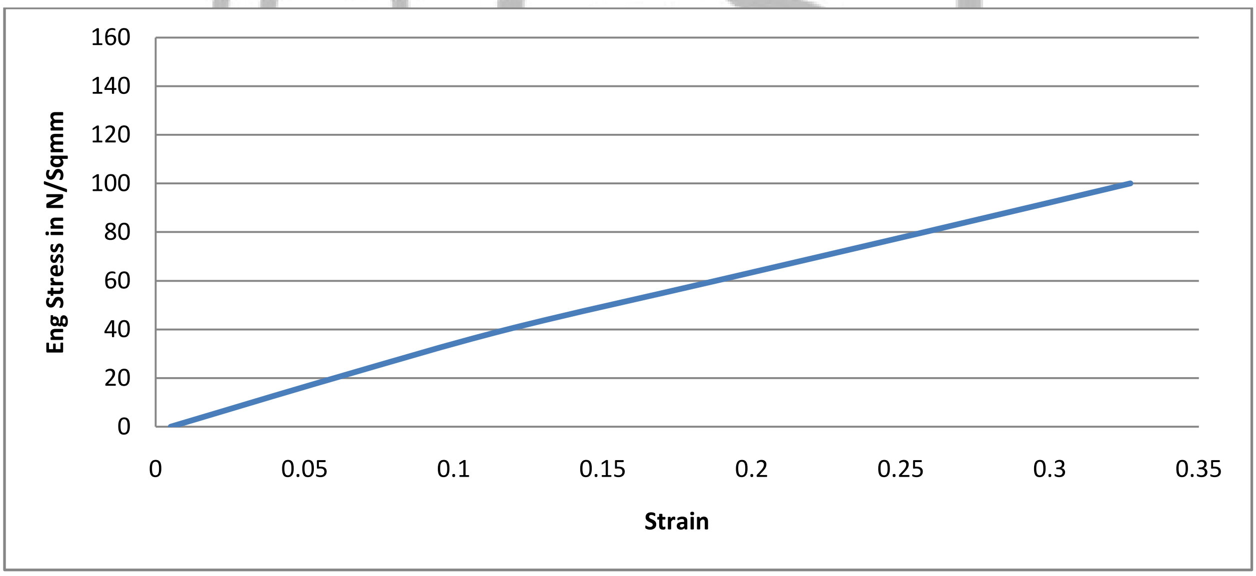


Fig 1.0:**True stress against true strain for sand casting specimen A**

For specimen A (sand cast product), the engineering stress and strain was determined as shown in figure 1.0. the yield point of the specimen has a stress value of 105N/m2 and the strain value of 0.070. the ultimate tensile point has the stress value of 122N/m2 and the strain of 0.12 and the specimen breaking point has the value of 80Nm2 as engineering stress and 0.3 as the true strain. The result show that the specimen cannot thrive well under high load especially axial loading. The area under the stress- strain curve indicates toughness (i.e energy which can be absorbed by material up to the point of rupture).

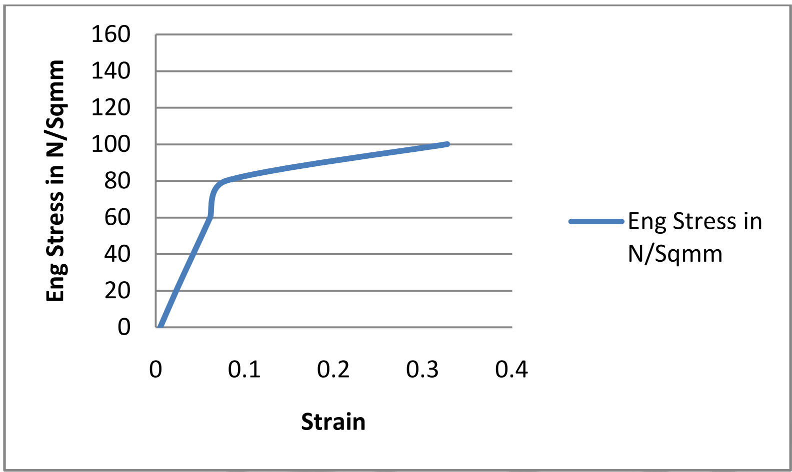


Fig 1.1: **True stress against true strain for die casting specimen B**

Fig 1.1.Shows the graph of True stress against the strain of die cast aluminum silicon alloy. The elongation is higher than the sand cast produced because the force of attraction of the molecules is higher than sand cast Al-Si alloy and the grain size is more refined. At the yield point, the engineering stress value was 118N/m2, and then strain was higher than 0.079. The breaking start almost in mm and slightly lower than the yield stress value. This shows that the material will take time to fail but when fracture occurs it will be sudden.

Hardness Test Analysis

The hardness test results for the sand cast Al-Si alloy and die cast Al-Si alloy was shown in table 1.1 using micro Hardness Tester.

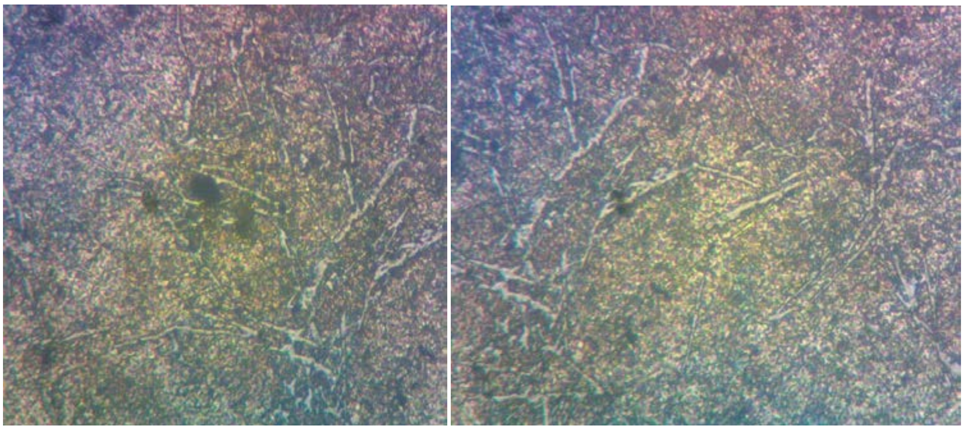
Table 1.1: Hardness test results of Al-Si alloy produced by Sand cast and Die cast

S/N	LABEL	READING 1		READING 2		READING 3		AVERAGE	
		HV HRC		HV HRC		HV HRC		HV	HRC
	Sand casting A2	132.2 0		145 0		115.5 0		131.9 0	
	Die casting B1	145.3 0		132.2 0		126.2 0		134.4 0	

LOADING 980.7mN **DEWELL**

TIME 10sec

The hardness test method as defined in ASTME- 18 is the most common used hardness test method. Hardness is resistance of metal to plastic deformation usually by indentation. However, the term may also refer to stiffness or temper or resistance to scratching, abrasion or cutting. it is the property of the metal which gives it the ability to resist being permanently deformed (bent, broken or have its shape change) when a load is applied. The greater the hardness of the metal, the greater the resistance it has to deformation. Hardness measurement can be defined as macro - micro or nano- scale according to the forces applied and the displacement obtained. Results from table 1.1 shows that Al-Si alloy produced by die casting method has higher hardness than that of Al-Si alloy produced by sand casting method because intermolecular force of attraction between the molecules is higher.



Specimen 1 Specimen 2

Fig. 1.2: Microstructures of Al-Si alloy cast produced by sand and die casting.

The goal of micro structural analysis is to develop a quantitative description of microstructure that can be used to establish its relationship to properties. Micro structural factors that have an important influence on the properties include: grain size, defects like porosity and oxides, size, shape and distribution of silicon and intermetallic particles, volume fraction of eutectic and precipitates. Efforts are always made to improve the performance of these materials by controlling the microstructure. The Al–Si casting alloys contain two principal phases: aluminum based α–Al as the phase with the largest volume fraction, acts as the matrix for the alloy, and the silicon phase, which is found largely in two forms: primary 'blocky' silicon which is die cast product is more refined and less coarsed than specimen 2 which is sand cast method. The specimen 2 is porous than specimen 1 and this account for the general weakness of sand casting method. The die casting method is better because the molecules of Aluminium and Silicon more fused thus account for high bonding. The microstructure of the alloys depends on the composition of the two primary elements.

The hypoeutectic alloy shows a mixture structure of α –phase and fine eutectic phase of α +Si, though the hypereutectic alloys show a mixture of fine eutectic phase of α +Si and Si particle phase in which the size of particles increases with increasing silicon concentration of the alloy. Fig 1.2 shows that, the degree of refinement of the eutectic silicon increased as the silicon content of the alloy increased beyond the eutectic composition. Here the primary silicon appears as coarse polyhedral particles.

CONCLUSION

The investigation of mechanical properties of Aluminium Silicon alloy produced by sand casting and die casting method has been carried out. The results of the research shows that Aluminium scraps mixed with silicon powder and produced through die casting method will meet most desirable mechanical propertiesof a good engineering materials than sand casting method. The Al-Si alloy cast produced by die casting method exhibit high tensile strength, hardness and good metallurgical composition.

In this work, some mechanical properties like tensile strength, hardness and microstructure analysis of a sand cast and die cast of aluminum silicone alloy was compared. An aluminum silicone alloy was cast using sand cast material and die cast material. The cast product was subjected to tensile, hardness and microstructure test the clay sand was used to make the mould cavity for the sand cast after sieving and addition of additive. The sand cast production has some porosity embedded whereas the die cast product has more. The stress and strain curve of the sand cast was produced. The die cast tensile test shows that the product has gradual infinitesimal increase in elasticity and the fracture occurs at 118N/m2. The hardness test of both specimen using hardness Vickers. The die cast has a value of 134.5HV and sand cast has 131.9HV, which shows the material prody through die casting material has higher impact strength compared to the same material produced through sand casting.

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