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INFLUENCE OF PROCESS PARAMETERS ON HARDNESS AND IMPACT ENERGY IN SAND CASTINGS OF ALUMINIUM ALLOY

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ABSTRACT

Casting is a manufacturing process to develop a product according to the customer needs and satisfaction. Now days various types of casting processes used in industries. Among these casting processes, sand casting is one of the processes which is used for both ferrous and nonferrous materials. Aluminum (LM6) plays a major role in automobile, manufacturing, nuclear and marine industries. In this experimental investigation, pit furnace is used to melt the material and product is made by sand casting methods. the work is based on the effect of various variables on hardness of sand-casting of Al LM6 alloy and graphite powder. The Tensile test, impact test specimen is calculated by Ultimate tensile testing machine and hardness of test by using the Brinell hardness tester. to investigate and optimize of various process parameters on LM6 alloy and graphite powder properties. Sand Casting is prepared according to the investigate the effect of parameters on aluminum alloy with the graphite powder of material hardness and tensile, impact. With the help of graphs and tables it is observed. The material properties of the specimen are values increases or decreases of the material in hardness and impact, tensile test after the testing report

1.0 INTRODUCTION

Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Casting materials are usually metals or various cold setting materials that cure after mixing two or more components together; examples are epoxy, concrete, plaster and clay. Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods.

Metal Casting

In metalworking, metal is heated until it becomes liquid and is then poured into a mold. The mold is a hollow cavity that includes the desired shape, but the mold also includes runners and risers that enable the metal to fill the mold. The mold and the metal are then cooled until the metal solidifies. The solidified part (the casting) is then recovered from the mold. Subsequent operations remove excess material caused by the casting process (such as the runners and risers). Plaster, concrete, or plastic resin

Casting process simulation

Casting process simulation uses numerical methods to calculate cast component quality considering mold filling, solidification and cooling, and provides a quantitative prediction of casting mechanical properties, thermal stresses and distortion. Simulation accurately describes a cast component's quality up-front before production starts. The casting rigging can be designed with respect to the required component properties. This has benefits beyond a reduction in pre-production sampling, as the precise layout of the complete casting system also leads to energy, material, and tooling savings. The software supports the user in component design, the determination of melting practice and casting methoding through to pattern and mold making, heat treatment, and finishing. This saves costs along the entire casting manufacturing route.

Sand Casting

Sand casting, also known as sand molded casting, is a metal casting process considered by using sand as the mold material. It is comparatively cheap and adequately refractory even for steel metalworks use. A suitable bonding agent (usually clay) is mixed or occurs with the sand. The mixture is moistened with water to develop strength and plasticity of the clay and to make the aggregate suitable for molding. The term "sand casting" can also refer to a casting produced via the sand-casting process. Sand castings are produced in specialized factories called foundries. Over 70% of all metal castings are produced via a sand-casting process.

Material and Properties

Aluminum Alloy LM6:It is an aluminum alloy, with zinc as the primary alloying element. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability. It has lower resistance to corrosion than many other aluminum alloys, but has significantly better corrosion resistance than the 2000 alloys. Its relatively high cost limits its use.LM6 aluminum alloy's composition roughly includes 5.6–6.1% zinc, 2.1–2.5% magnesium, 1.2–1.6% copper, and less than a half percent of silicon, iron, manganese, titanium, chromium, and other metals. It is produced in many tempers. The first LM6 was developed in secret by a Japanese company, Sumitomo Metal, LM6 was eventually used for airframe production in the Imperial Japanese Navy.

Material Properties

Table 1.1. Mechanical properties of AL LM6 alloy

Mechanical Properties	Metric
Ultimate Tensile Strength	60-70 (N/mm^2)
Tensile Yield Strength	160-190 (N/mm^2)
Shear Strength	120 (N/mm^2)
Elongation	5%
Modulus of Elasticity	$71*10^3$ (N/mm^2)
Impact resistance	6 Nm

Materials - 1. Aluminum alloy LM6+ Gr 6%
2. Aluminum alloy LM6 + Gr 8%
3. Aluminum alloy LM6 + Gr 10%

Raw Materials

Fig 1.1. Aluminum alloy LM6

Fig 1.2. Graphite powder

Objectives

- The present study involves the development of hybrid metal matrix composite reinforced with particulate Graphite and Al LM6 by sand casting method.
- Weight fraction of 6%, 8% and 10% of graphite is reinforced with base Aluminum Alloy LM6 matrix.
- The fabricated aluminum alloy was solution treated and then precipitation treated for T-6 condition.
- Casted composite and heat treated composite machined carefully to prepare specimens for hardness and tensile strength as per the ASTM standards

2.0 LITERATURE REVIEW

M.K. Surappa et al [1] Metal matrix composites (MMCs) constitute an important class of design and weight-efficient structural materials that are encouraging every sphere of engineering application. There has been an increasing interest in composites containing low density and low-cost reinforcements. With the increasing demand of light-weight materials in the emerging industrial applications, fabrication of aluminum-boron carbide with fly ash composites is required.

J.W. Kaczmar et al [2] With the increasing demand of light-weight materials in the emerging industrial applications, fabrication of aluminium boron carbide composites is required. In this context aluminium alloy - boron carbide composites were fabricated by liquid metallurgy techniques with different particulate weight fraction (2.5, 5 and 7.5%). Phase identification was carried out on boron carbide by X-ray diffraction studies. Microstructure analysis was done with scanning electron microscope.

R.M. Mohanty, K. Balasubramanian [3] This research article aims to develop lightweight Aluminium - Boron carbide composites and evaluate the mechanical properties with effect of addition of calcium carbide particles. Objective of this research is to fabricate and testing the mechanical properties of Aluminium metal matrix composites with Boron Carbide and Calcium Carbide reinforcements at different volume proportions.

K.H.W. Seah, J. Hemanth, et al [4] Accuracy was tested using simulations at various proportions of mode-I and mode-II. The strength of the composite structure exhibiting progressive delamination's could be predicted using these models. Their experimental results proved the above. Gbasouzor Austine Ikechukwu,

M.A. Belger, P.K Rohatgi [5] have tested and studied fatigue failure of brittle Aluminum under repeated varying forces and fluctuating loads on a fatigue testing machine. By repeatedly varying forces, the specimens were tested. Two tests were performed on them. First test was done under the ultimate strength of the material. Stress applied in the second test was less than used in the first test.

3.0 EXPERIMENTAL DESIGN AND STEUP

Al LM6 hybrid metal matrix is fabricated by sand casting method. It is an attractive and economical casting technique which allows conventional metal processing route.

Al LM6 melted above 850 ºC in a graphite crucible and the reinforcements were preheated up to same temperature for proper mixing. Preheated graphite was mixed in the metal slurry manually at 850 ºC. The molten metal poured in preheated moulds and allowed to cool. Casted metal matrix was machined to remove cluster formation on the surface and then cut into required dimension by using fan-saw cutting machine.

3.1. Casting Process

Fig 3.1: Raw material heated at furnace

The pit furnace was used to melt the alloy to a temperature of approximately 800-900 degrees Celsius. The molten alloy was then poured into the mold cavity via a gating system designed to maximize casting quality and yield. After the molten metal got solidified, it was allowed to cool down to the room temperature for a predetermined length of time before shakeout

Fig 3.2: Heated up to 850^{0}C

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Figure: 3.3 Patterns

Fig 3.4: Mixing the powders

Fig 3.5: Pouring the molten metal

Later the gating system was removed from the casting and recycled as scrap/return. Secondary cleaning operations were performed to remove any excess sand adhered to the casting surface. Lastly, parting line, flash and gating marks were removed in the grinding operation. The casting thus obtained was subjected to machining operation for the preparation of test samples like tensile test specimen impact strength specimen and hardness test specimen too.

Fig 3.6: After pouring the molten metal

Casting components

Fig 3.7: At composition Aluminum alloy LM6+ Gr 6%

Fig 3.8: At composition Aluminum alloy LM6 + Gr 8%

Fig 3.9: At composition Aluminum alloy LM6 + Gr 10%

Turning is performed on a lathe by rotating a part against a stationary cutting tool to center and turn in diameter. This is a required step for all round specimens including tensile, stress rotating beam and fatigue specimens, since rough-cut test specimens are usually square in shape. In addition to further refining specimen dimensions, the turning process reduces the gage length and threads the ends when required by fixturing on test machines

Figure: 3.10 coolant on turning operation

Final Doumble Shape according to ASTM standards

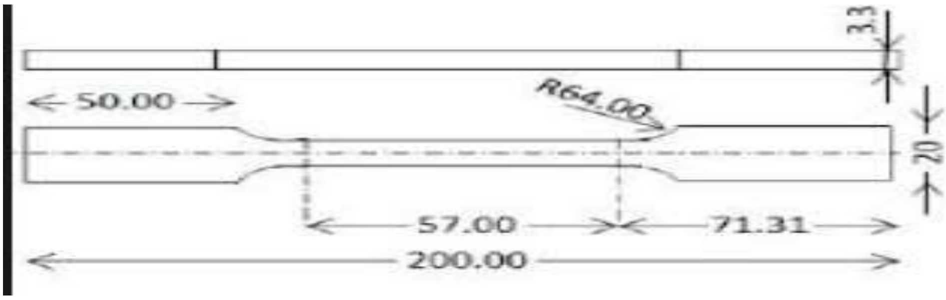

Fig 3.11: Specimen Aluminum Alloy

4.0 RESULTS AND DISCUSSION

4.1. Tests Conducted

Tensile Test

Type of test – Tensile

Machine Model – TUE-C-600

Fig 4.1: Tensile machine

Tensile testing, also known as tension testing is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under normal forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area.

Brinell hardness test method

Brinell hardness, is defined in ASTM E10. Most commonly it is used to test materials that have a structure that is too coarse or that have a surface that is too rough to be tested using another test method, e.g., castings and forgings. Brinell testing often use a very high-test load (3000 kgf) and a 10mm diameter indenter so that the resulting indentation averages out most surface and sub-surface inconsistencies.

Sample: 1

Fig 4.2. sample material of AL LM6

Sample: 2

Fig 4.3. Tensile test specimen

Sample: 3

Fig 4.4. Impact test specimen

Tensile test results:

Table 4.1. Tensile test values of Al LM 6 material

Samples	Ultimate tensile strength (N/mm^2)	Elongation (%)	Yield stress (N/mm^2)
Al+Gr6%	125.081	4.280	108.310
Al+Gr8%	125.025	3.920	109.759
Al+Gr10%	122.639	3.460	104.010

Graphs

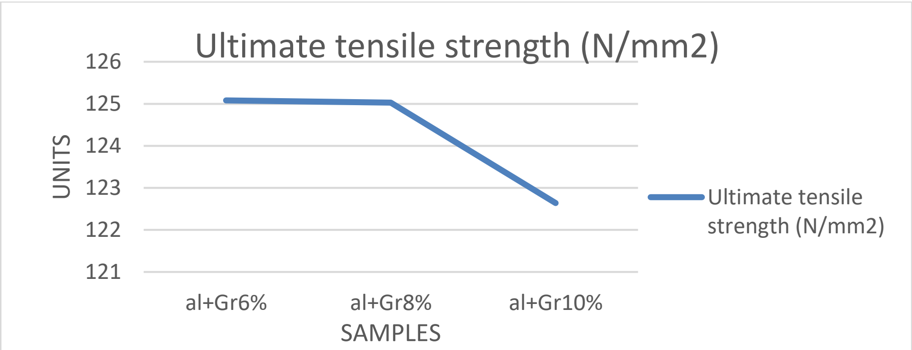

Fig 4.5. Ultimate tensile strength of Al LM 6

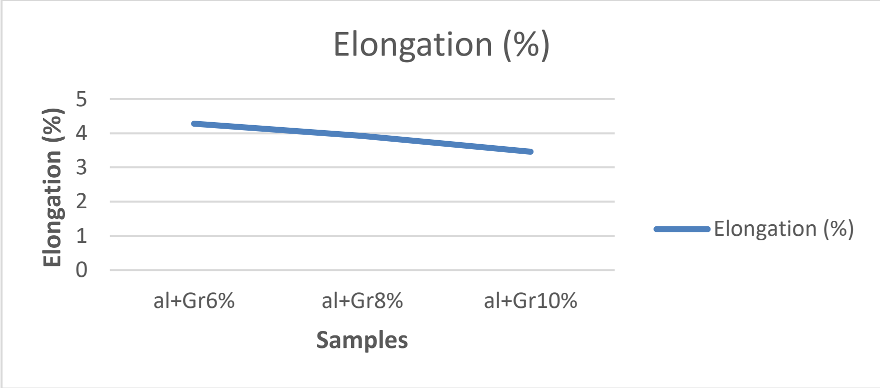

Fig 4.6. Elongation of Al LM 6

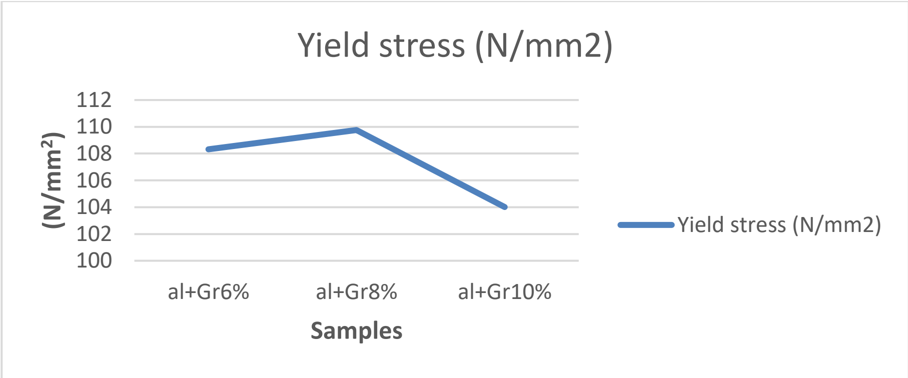

Fig 4.7. Yield stress of Al LM 6

Hardness test results

Table. 4.2. Hardness test results of Al LM 6

Samples	**Observed values in BHN**			
	Impression 1	**Impression 2**	**Impression 3**	**Average**
Al+Gr6%	62.4	61.8	61.8	62.00
Al+Gr8%	68.8	68.8	68.2	68.60
Al+Gr10%	62.4	63.0	63.0	62.80

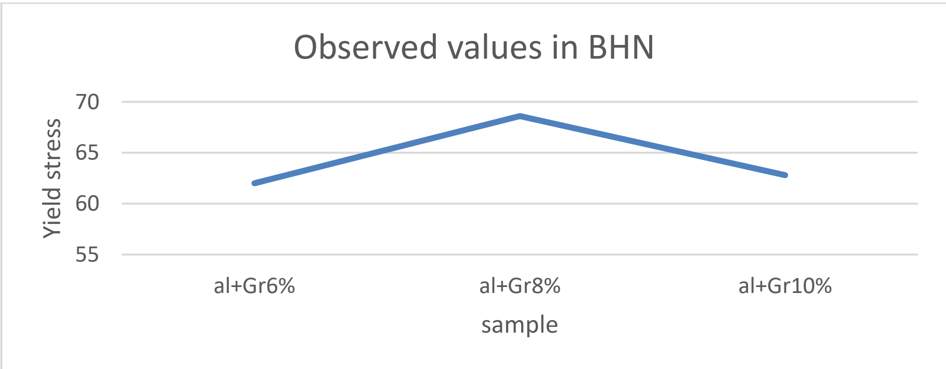

Fig 4.9. Observed values in BHN of Al LM 6

Impact test values

Table 4.3. Impact test values of Al LM6

Sample	Observed values (Joules)			
	Impact 1	Impact 2	Impact 3	Average
Longitudinal Direction	8	0	0	8
	8	0	0	8
	10	0	0	10

It is clear from hardness, impact strength and the tensile strength shows a decreasing and increasing trend with the rise in the grain fineness number of the sand. This may be attributed to the reason that large number of fines are available with a sand of high AFS number. These fines settle during compaction and mold substantial, resulting in reduced voids at the shell mold surface layers. Due to the compact voids in the sand mixtures, there is decrease in the heat transfer coefficient. It is clear that the aforementioned mechanical properties (Hardness and Impact Strength) decreasing and the increasing trend with in the humidity content. Permeability of molding sand is decreased by increasing the humidity content which further hinders the mechanical properties.

At the same time, it is the Impact Strength is first to some extent decrease by increasing the clay content but further increases by increasing the clay content but fig shows the effect of clay content on impact strength is almost negligible. Regular increment in tensile strength of casting, as the mold strength is increased by increasing the moisture content also grain fineness number is a big factor in this assignment.

CONCLUSION

In this thesis, considers the potential of use AlLM6 with Graphite metal matrix composite (MMC) with particular reference to the aerospace industry. Initially, the required properties are identified, after which, the work explores pure aluminum and its importance in the industry along with its limitations.

- In this project, we are fabricated specimens at different compositions they are: Aluminum alloy LM6+ Gr 6%, Aluminum alloy LM6 + Gr 8 % and Aluminum alloy LM6 + Gr 10%
- LM6 MMC fabricated by sand casting method effectively. The experimental study reveals the enhanced mechanical properties hardness, tensile strength and impact strength.

The hardness improved by adding reinforcements to the base alloy. The addition of Gr particles improved the hardness and the improved wear properties results by the addition of Aluminum alloy LM6S +Gr. Further the mechanical properties enriched by heat treatment. Hardness and tensile strength improved by Aluminum alloy LM6 + Gr 6 %.

REFERENCES

1. M.K. Surappa, P. K. Rohatgi, Preparation and properties of cast aluminium-ceramic particle composites, Journal of materials science, 16(1981), p 983-993.
2. J.W. Kaczmar, K. Pietrzak, W. Wlosinski, The production and application of metal matrix composite materials, Journal of material processing technology, 106(2000), p 106:58-67.
3. R.M. Mohanty, K. Balasubramanian, S.K. Seshadri, Boron carbide-reinforced aluminum 1100 matrix composites: fabrication and properties, Materials science and engineering, 498(2008), p 42-52.
4. K.H.W. Seah, J. Hemanth, S.C. Sharma, Mechanical properties of aluminium/quartz particulate composites cast using metallic and non-metallic chills, Materials and design, 24(2003), p 87-93.
5. M.A. Belger, P.K Rohatgi, N. Gupta, Aluminum composite casting incorporating used and virgin foundry sand as particle reinforcements, solidification processing of metal matrix composites-Rohatgi honorary symposium, TMS Annual Meeting (2006), p 95-104
6. S. Sulaiman, M. Sayuti, R. Samin, Mechanical properties of the as cast quartz particulate reinforced LM6 alloy matrix composites, Journal of materials processing technology, 201(2008), p 731-735.