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Mechanical Characterization of Hybrid Metal Matrix Compositions

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***Abstract* – This thesis, considers the potential of use Aluminum alloy 7075 And 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. Using these limitations, MMCs were recommended as a possible replacement for aluminum and it is seen that the exact set of properties depend on certain factors. In this paper hardness and tensile strength experiments have been conducted by varying mass fraction of graphite (6%, 8%, and 10%) with Aluminum7075. The Rockwell cum brinell hardness testing method was used to determine hardness ,impact and universal testing machine is used to find the tensile properties for different compositions of aluminum 7075-graphite particulate metal matrix composite.**

***Keywords* – B21A1, H22A and H23A, F20C, F22C, C32B ,NSX and MMCs etc.**

I. INTRODUCTION

A metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal necessarily, the other material may be a different metal or another material, such as a ceramic or organic compound. When at least three materials are present, it is called a hybrid composite. An MMC is complementary to a cermet.

1.1 Composition

MMCs are made by dispersing a reinforcing material into a metal matrix. The reinforcement surface can be coated to prevent a chemical reaction with the matrix. For example, carbon fibers are commonly used in aluminium matrix to synthesize composites showing low density and high strength. However, carbon reacts with aluminium to generate a brittle and water-soluble compound Al_4C_3 on the surface of the fiber. To prevent this reaction, the carbon fibers are coated with nickel or titanium boride.

1.2 Material

1.2.1 Aluminum Alloy 7075

7075 aluminum alloy 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 mach inability. 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.

7075 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, some of which are 7075-0, 7075-T6, 7075-T651.

Aluminum alloy The matrix material is chosen as 7075 Aluminum alloy and it is highly dense, corrosion resistance and very soft ductile material belonging to the boron group of chemical elements. The typical compositions of 7075 Al-alloy.

1.3 Graphite

Graphite (/ˈɡræfaɪt/), archaically referred to as plumbago, is a crystalline form of the element carbon with its atoms arranged in a hexagonal structure. It occurs naturally in this form and is the most stable form of carbon under standard conditions. Under high pressures and temperatures it converts to diamond. Graphite is used in pencils and lubricants. Its high conductivity makes it useful in electronic products such as electrodes, batteries, and solar panels.

1.4 Sand casting

Fig .1. Cope and Drag box.

II. LITERATURE REVIEW

Microstructure analysis of aluminum boron carbide with addition of fly ash by using powder metallurgy technique.[1]Metal matrix composites (MMCs) constitute an important class of design and weight-efficient structural materials that are encouraging every sphere of engineering applications. 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. In this context aluminum - boron carbide with flyash composites were fabricated by powder metallurgy techniques with different particulate composition of B4C (10%,20%&30%).Microstructure analysis was done with scanning electron microscope. With the increase the amount of the boron carbide, the density of the composites decreased whereas the hardness is increased. The ultimate compressive strength of the composites was increased with increase in the weight percentage of the boron carbide in the composites. Key words: Aluminium alloy, Boron carbide, flyash, powder metallurgy, SEM, Mechanical properties.

Fabrication and mechanical properties of aluminum-boron carbide composites[2]With the increasing demand of light-weight materials in the emerging industrial applications, fabrication of aluminiumboron 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%).

III. EXPERIMENTAL INVESTIGATION

3.1 Material Properties

Table –I: Chemical Properties of Aluminum Alloy 7075.

Aluminum, Al	86.5-91.5%	86.5-91.5%
Chromium, Cr	0.18-0.28%	0.18-0.28%
Copper, Cu	1.2-1.9%	1.2-1.9%
Iron, Fe	<=0.12%	<=0.12%
Magnesium, Mg	1.9-2.6%	1.9-2.6%
Manganese, Mn	<=0.06%	<=0.06%
Other, each	<=0.05%	<=0.05%
Other, total	<=0.15%	<=0.15%
Silicon, Si	<=0.10%	<=0.10%
Titanium, Ti	<=0.06%	<=0.06%
Zinc, Zn	5.2-6.2%	5.2-6.2%

Table -II: Graphite material propertites.

Property	Commercial graphite
Bulk Density (g/cm^3)	1.3-1.95
Porosity (%)	0.7-53
Modulus of Elasticity (GPa)	8-15
Compressive strength (MPa)	20-200
Flexural strength (MPa)	6.9-100
Coefficient of Thermal Expansion (x10^{-6} °C)	1.2-8.2
Thermal conductivity (W/m.K)	25-470
Specific heat capacity (J/kg.K)	710-830
Electrical resistivity (Ω.m)	5x10^{-6}-30x10^{-6}

Ford offers a Metal Matrix Composite (MMC) driveshaft upgrade. The MMC driveshaft is made of an aluminum matrix reinforced with boron carbide, allowing the critical speed of the driveshaft to be raised by reducing inertia. The MMC driveshaft has become a common modification for racers, allowing the top speed to be increased far beyond the safe operating speeds of a standard aluminum driveshaft.

Honda has used aluminum metal matrix composite cylinder liners in some of their engines, including the B21A1, H22A and H23A, F20C and F22C, and the C32B used in the NSX.

3.2 Casting

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.

3.3 Sand casting

Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. The term "sand casting" can also refer to an object produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 60% of all metal castings are produced via sand casting process.

Molds made of sand are relatively cheap, and sufficiently refractory even for steel foundry use. In addition to the sand, a suitable bonding agent (usually clay) is mixed or occurs with the sand. The mixture is moistened, typically with water, but sometimes with other substances, to develop the strength and plasticity of the clay and to make the aggregate suitable for molding. The sand is typically contained in a system of frames or mold boxes known as a flask. The mold cavities and gate system are created by compacting the sand around models called patterns, by carving directly into the sand, or by 3D printing.

IV. EXPERIMENTAL PROCEDURE

4.1 Materials-

- Aluminum alloy 7075+ Gr 6%
- Aluminum alloy 7075+Gr 8%
- Aluminum alloy 7075 +Gr 10%

4.2 Aluminum alloy 7075

Fig .2 . Materials of Aluminum alloy 7075.

Fig.3. Raw material heated at furnace.

Fig .4. Heated up to 850^{0}C

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Fig5: Pattern

Fig.6. pouring the molten metal.

Fig .7. composition Aluminum alloy 7075+ Gr 6%.

Fig. 8. Composition Aluminum alloy 7075 + Gr 8%.

4.4 Machining Process for Doumble Shape

Fig.9. Final Doumble Shape according to ASTM standards.

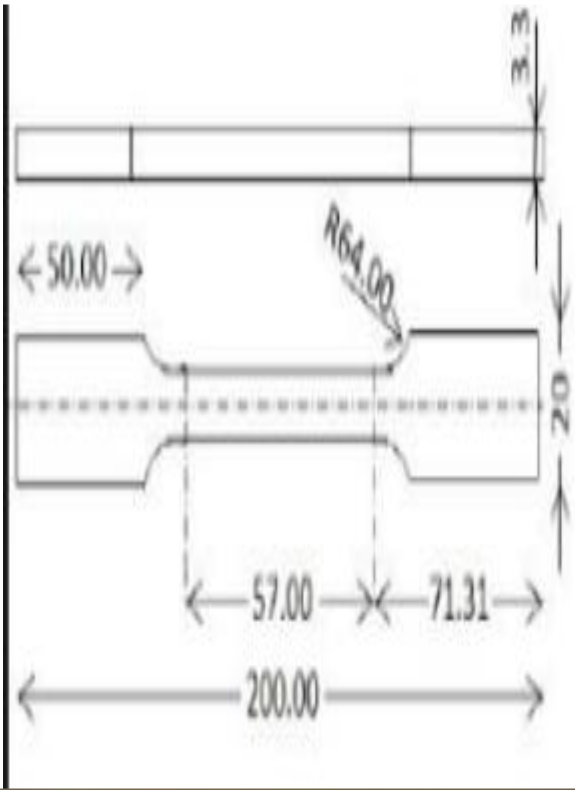


Fig .10. Universal testing Machine(UTM)

Fig .11. Tensile Test.

V. RESULTS AND DISCUSSION

Fig.12. Sample 1.


Fig .13.Sample 2.


Fig .14. Sample 2.

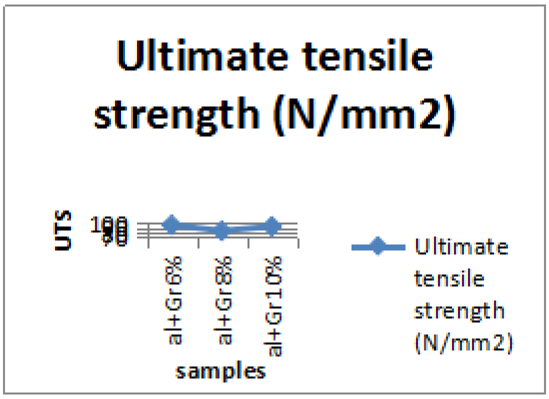
Fig.15. Test Report for Sample 1.

Fig .16. Test Report for Sample 2.

5.1 Tensile test results tables

Samples	Ultimate tensile strength (N/mm^2)	Elongation(%)	Yield stress (N/mm^2)
al+Gr6%	95.328	5.2	64.13
al+Gr8%	83.307	9.6	54.181
al+Gr10%	92.446	6.2	58.800

5.2 Results Graph



5.3 Hardness test results

Hyderabad Engineering Labs

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MATERIAL TESTING SERVICES

METALLURGICAL, NDT & BUILDING (CIVIL) MATERIALS

HARDNESS TEST REPORT

Work Order No : HEL/20/14265 | Work Order Date
Test Report No | Test Report Date

Customer Name & Address: | Sample No
| Sample Received Date
| Tested Date
| Sample Stamped As

Ref.No: | Ref. Date:

Machine Details | Test Details
Name | Test Procedure
Model No/Srl.No | Type of Hardness
Calibration on Date | Indentor
Calibration Due Date | Load Applied : 250 Kgf

Material Identification: | Material Specification:

Sl.No	Location	Observed Values in HBW 5 mm / 250			
		Impression 1	Impression 2	Impression 3	Average
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Specified Values:	--			

Result :
Remarks : 1.These Results pertains to the samples received at our lab.

Verified By: Witnessed By: For HYDERABAD ENGINEERING LABS

Authorised Signatory
ULR No:

Fig .17. Hardness test.

5.4 Hardness test results table

Samples	BHN
al+Gr6%	47.23
al+Gr8%	47.61
al+Gr10%	47.63

Al7075 hybrid metal matrix is fabricated by sand casting method. It is an attractive and economical casting technique which allows conventional metal processing route.

Al 7075 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.

5.5 Tests Conducted

1. Tensile Test:
Type of test — Tensile
Machine Model — TUE-C-600
2. Hardness Test:
Test Reference — IS 1586:2000
Type of Hardness — HRC
Machine Model — 2008/073, MRB 250
Sample ID — Hardness Test at Weld Zone
3. Impact Test

VI. CONCLUSION

The potential of use Al7075 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.

fabricated specimens at different compositions they are : Aluminum alloy 7075+ Gr 6%, Aluminum alloy 7075 + Gr 8 % and Aluminum alloy 7075 + Gr 10%

Al7075 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 Al+Gr. Further the mechanical properties enriched by heat treatment. Hardness and tensile strength improved by Aluminum alloy 7075 + Gr 6 %.

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