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FABRICATION AND EVALUATION OF MECHANICAL PROPERTIES OF A COMPOSITE BY IN-SITU METHOD

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ABSTRACT: Aluminum alloy-based metal matrix composites (ALMMC) are widely used for sliding wear applications because of their excellent wear resistant properties. ALMMC are fabricated using method liquid state fabrication. It was found from our literature survey, there is a draw back with respect to heating temperature when heated at peaks the fabrication is failing in practice, so among stir casting methods, we are trying to apply centrifugally atomized casting method technique so that the fabrication will not collapse while heating. In the present work, aluminum alloy-7075 reinforced with various percentages of Ground nut shell particles (2.5, 5,7.5, 10 wt%) were prepared The mechanical properties which were considered for testing are Hardness, Micro structure, Strengths.

Keywords: Stir Casting, Micro Hardness, Microstructure, heat treatment etc.

INTRODUCTION: History is often marked by the materials and technology that reflect human capability and understanding. Many times, scales begin with the stone age, which led to the Bronze, Iron, Steel, Aluminium and Alloy ages as improvements in refining, smelting took place andscience made all these possible to move towards finding more advance materials possible. Progress in the development of advanced composites from the days of E glass / Phenolic redone structures of the early 1940's to the graphite/ polyimide composites used in the spaceshuttle orbiter-is spectacular. The recognition of the potential weight savings that can be achieved by using the advanced composites, which in turn means reduced cost and greater efficiency, was responsible for this growth in the technology of reinforcements, matrices and fabrication of composites. If the first two decades saw the improvements in the fabrication method, systematic study of properties and fracture mechanics was at the focal point in the 60's. Since then, there has been an ever-increasing demand for newer, stronger, stiffer and yet lighter-weight materials in fields such as aerospace, transportation, automobile and construction sectors. Composite materials are emerging chiefly in response to unprecedented demands from technology due to rapidly advancing activities in aircrafts, aerospace and automotive industries. These materials have low specific gravity that makes their properties particularly superior in strength and modulus to many traditional engineering materials such as metals. As a result of intensive studies into the fundamental nature of materials and better understanding of their structure property relationship, it has become possible to develop new composite materials with improved physical and mechanical properties. These new materials include high performance composites such as Polymermatrix composites, Ceramic matrix composites and Metal matrix composites etc. Continuous advancements have led to the use of composite materials in more and more diversified applications.The importance of composites as engineering materials is reflected by the fact that out of over 1600 engineering materials available in the market today more than 200 are composite. MMCs have the best properties of the two components, such as ductility and toughness of the matrix, wear resistance, high modulus and strength of the reinforcements.

METHODOLOGY

SPECIMEN FABRICATION

Fabrication and characterization of GROUND NUT SHELL with Al- 7075 compositeusing by stir casting process to analyze the properties of this project and should be improvingproperties in Al-7075 material by adding of various wt% GROUND NUT SHELL reinforcement material.

RAW MATERIALS:

Reinforcement:

- GROUND NUT SHELL is a white odorless crystalline powder. It is amphoteric in nature, and is used in various chemical, industrial and commercial applications.
- GROUND NUT SHELL is an excellent ceramic oxide with a very wide range of applications, including adsorbents, catalysts, microelectronics, chemicals, aerospace industry, and other high-technology fields.
- GROUND NUT SHELL combination of hardness, high temperature operation and good electrical insulation makes it useful for a wide range of applications.
- Typical applications include electrical insulators; seal faces; valve seats.
- The reinforcement of GROUND NUT SHELL with the average size of 25µm into Al-7075 matrix improves and the reinforcement
- Hard, Wear Resistant
- Resist alkali attacks at high temperature
- Good thermal conductivity
- High Strength and Stiffness

Properties of GROUND NUT SHELL

- Low density
- High strength
- Good high temperature strength (reaction bonded)

- High hardness and wear resistance
- Excellent chemical resistance

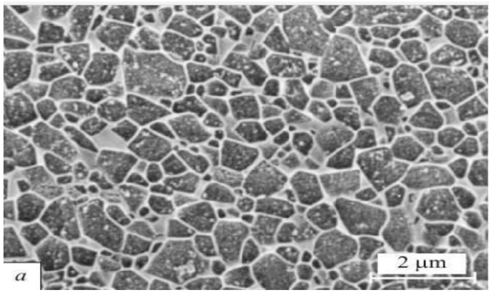


Fig 1 **GROUND NUT SHELL POWDER**

PROPERTIES

It has an ultimate tensile strength of at least 469 MPa and yield strength of at least324 MPa.More typical values are 283 MPa and 138 MPa, respectively.

Young's modulus (E): 73.1GPa Elongation (ε) at break: 12–25%Thermal conductivity (k): 121 W/(m·K) Density (ρ): 2.78g/cm³

Fig 2 Al-7075

The Chemical Composition of Al 7075 is given in below table 1

Table: 1

Elements of Al 7075	Wt %
Copper	3.8%- 4.9%
Manganese	0.3%-0.9%
Magnesium	1.2%-1.85
Chromium	0-0.1%
Zinc	0-0.25%
Titanium	0-0.15%
Silica	0.5%
Aluminium	(90.7-94.7%)

FABRICATION OF COMPOSITES: A bottom pouring stir is employed for fabrication of compositematerials. Stir Casting is a liquid state method for the fabrication of composite materials, in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring. Stir Casting is the simplest and the most cost-effective method of liquid state fabrication. Stir casting (Melt stirring) process, which is one of the liquid metallurgy techniques is used toAlMMC.

Bottom Pouring Type Centrifugally Atomized Mode Stir Casting M/C Specification

➢ Capacity	:	0.7 to 2 Kg
Furnace Temperature (Max)	:	950°c
➢ Pre-Heating of Reinforcement (Max):	:	
Stir Speed	:	100 to 1500 rpm
Die Temperature (Max)	:	350°c
Furnace Chamber	:	Organ Gas (Pure)
Operation	:	Remote Operation with Laptop

Fig 3 Bottom Type of Stir Casting.

In materials science, a **metal matrix composite (MMC)** is a composite material with fibers or particles dispersed in a metallic matrix, such as copper, aluminium, or steel. The secondary phase is typically a ceramic (such as alumina or silicon carbide) or another metal (such as steel[1]). They are typically classified according to the type of reinforcement: short discontinuous fibers (whiskers), continuous fibers, or particulates. There is some overlap between MMCs and cermet's, with the latter typically consisting of less than 20% metal by volume. When at least three materials are present, it is called a **hybrid composite**. MMCs canhave much higher strength-to-weight ratios, stiffness, and ductility than traditional materials, so they are often used in demanding applications. MMCs typically have lower thermal and electrical conductivity and poor resistance to radiation, limitingtheir use inthe very harshest environments. 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 densityand 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 fibersare coated with nickel or titanium boride.

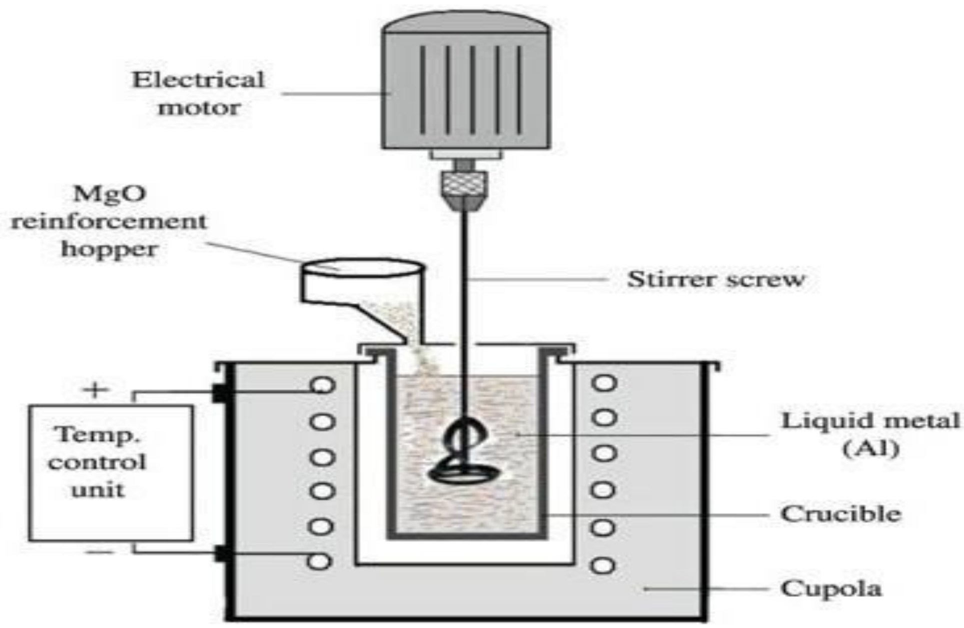


Fig 4 **Stir Casting**

HARDNESS TEST To measure micro and macro hardness of the fabricated composites, specimens of 10x10 mm are prepared and their surface was polished. An average of three samples was taken to determine the hardness of the specimens. Fig. shows Vickers micro hardness testingmachine. The basic principle, as with all common measures of hardness, is to observe a material's ability to resist plastic deformation from a standard source. The Vickers test can be used for all metals and has one of the widest scales among hardness tests shown in fig4

FIGURE5 VICKERS MICRO HARDNESS TESTING MACHINE

The Vickers hardness number (VHN) is calculated using the following formula: HV = $1.854(F/D^2)$, with F being the applied load (measured in kilograms-force) and D^2 the area of the indentation (measured in square millimeters). The applied load is usually specified when HV is cited. The Vickers hardness test method consists of indenting the test material with a diamond indenter, in the form of a right pyramid with a square base and an angle of 136degrees between opposite faces subjected to a load of 1 to 100 kgf. The full load is normally appliedfor 10 to 15 seconds.

Specifications:

- Magnification of optical projection : 70X
- Max. Test Height (mm.) : 200
- Scale least count (mm.) : 0.001
- Depth of throat (mm.) : 135
- Weight (Approx) : 70 kg
- Power Supply : 220V AC, 50Hz, 1- Phase

INVERTED METALLURGICAL MICROSCOPE To measure micro structure of the fabricated composites, specimens of 10x10 mm areprepared and their surface was polished.

Fig 6 Inverted Metallurgical Microscope Measurement

In an inverted microscope, the source for transmitted light and the condenser are placed on the top of the stage, pointing down toward the stage.

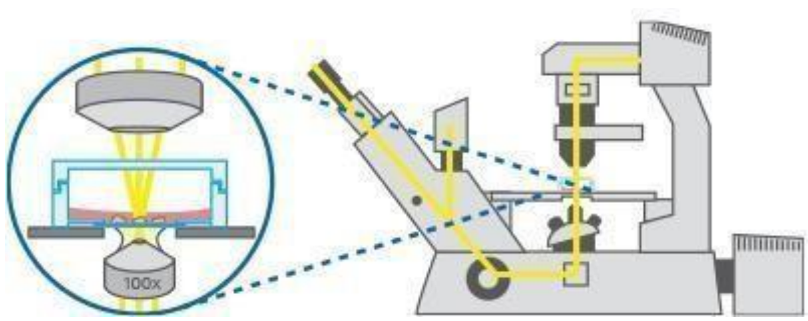


Fig 7 Principle of Inverted Microscope

The above fig 7 Inverted microscopes are used in micromanipulation applications where space above the specimen is required for manipulator mechanisms and the microtools they hold and in metallurgical applications where polished samples can be placed on top of the stage and viewed from underneath using reflecting objectives. The stage of an inverted microscope is usually fixed, and focus is adjusted by moving the objective lens along a vertical axis to bring it closer to or further from the specimen. The focus mechanism typically has a dual concentric knob for coarse and fine adjustment.Depending on the size of the microscope, four to six objective lenses of different magnifications may be fitted to a rotating turret known as a nosepiece. These microscopes may also be fitted with accessories for fitting still and video cameras, fluorescence illumination, co focal scanning and many other applications.

Specifications:

Eye piece	:	WF 10X(18mm of dia)
Objectives	:	PL 10X, 20X,40X, (Plan Achromatic), 60X, 80X, 100X.
Focusing	:	Coaxial Focusing System Mechanical stage
Stage size	:	150mm x 200mm
Illumination Unit	:	6V, 20W Halogen lamp, Adjustable brightness.

WEAR TEST Common techniques of wear measurement include using a precision balance to measurethe weight (mass) loss, profiling surfaces, or using a microscope to measure the wear depth or cross- sectional area of a wear track so as to determine the wear volume loss or linear dimensional change. Resistant to damage from normal wear or usage. Its wear-resistant partsare used to combat damage to machinery caused by high temperatures and corrosion. In a pin-on-disc wear tester, a pin is loaded against a flat rotating disc specimen such thata circular wear path is described by the machine. The machine can be used to evaluate wear and friction properties of materials under pure sliding conditions shown in fig 8

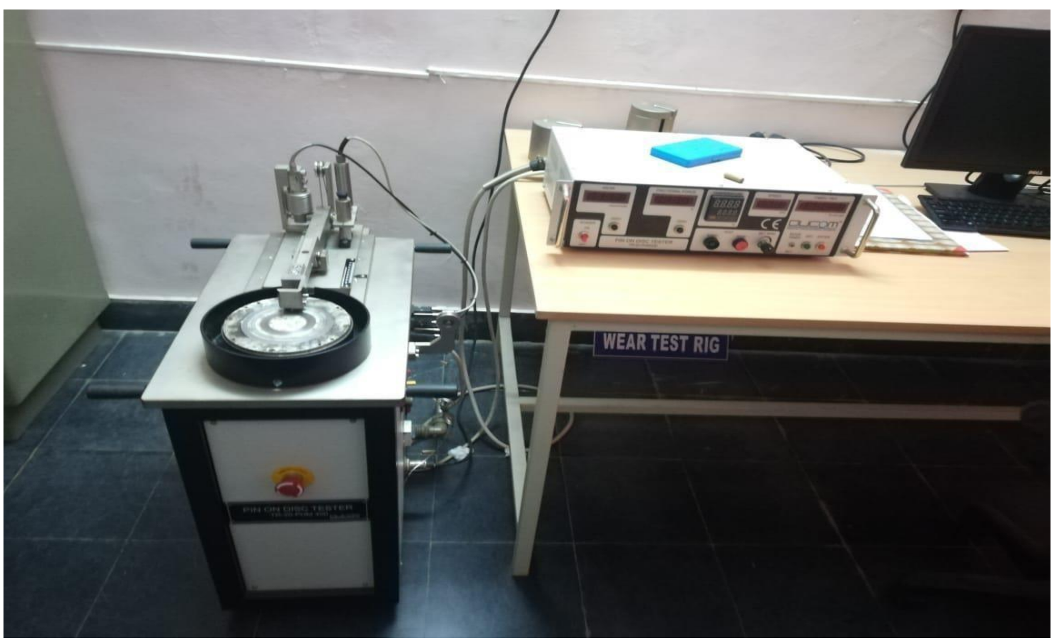


Fig 8 Pin on Disc Wear Test Machine.

Schematically, the pin on disk test is depicted in the above figure. The stationary pin is pressedagainst rotating disk under the given load. The pin can be of any shape; however, the most popular shapes are spherical (ball or lens) or cylindrical due to ease of alignment of such pins(flat pins are typically subject to certain misalignment which can lead to non-uniform loadingand difficulties for theoretical analysis) shown in above fig 9. During the test, the friction force, wear and temperature are continuously monitored.

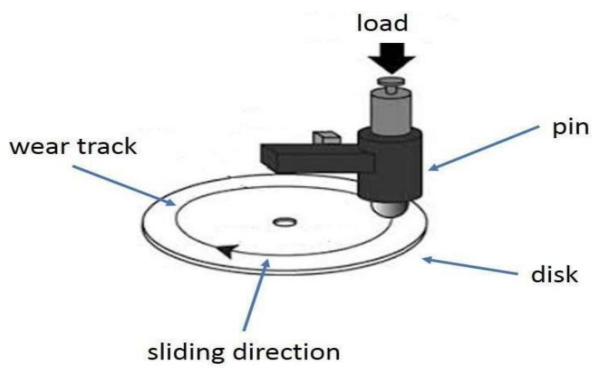


Fig 9. Schematic diagram of a pin on disk test.

A stationary pin mounted on a pin holder is brought into contact against a rotating disc ata specified speed as the pin is sliding, resulting frictional force acting between the pin and discare measured by arresting the deflecting pin holder against a load cell. The pin-on-disc sliding wear test is a commonly used tribological characterization technique to estimate the coefficient of friction and the wear mechanism of diamond films. Pins and discs were ultrasonically cleaned in ethanol and weights were measured before and after the wear test, with an accuracy of 0.1 mg.

The pin was held against the counter face of a rotating disc (EN31 steel disc) with wear trackdiameter 165 mm. The pin was loaded against the disc through a dead weight loading system.The wear test for all specimens was conducted under the normal loads of20N, 40N and a sliding velocity of 2 and 4 m/s.

Specifications:

- Load : Upto 200N
- Pin Heating Temp : 400°c
- Disc size : 165 x 8mm
- Pin holders (Dia 3mm, 4mm, 6mm, 8mm 10mm, & 12mm) Special holders to hold Pin\ Ballwith 5-micron accuracy Standard : ASTM G99

RESULTS AND DISCUSSIONS

MICROSTRUCTURE:

This property which shows the structure of element in heterogeneous distribution. Adding of ground nut shell reinforcement in Al-7075 to improve the structure of each percentage of specimen.

Fig 10 Pure Al-7075(2) Adding 2.5% GROUND NUT SHELL Reinforcement

5% GROUND NUT SHELL SHELLREINFORCEMENT

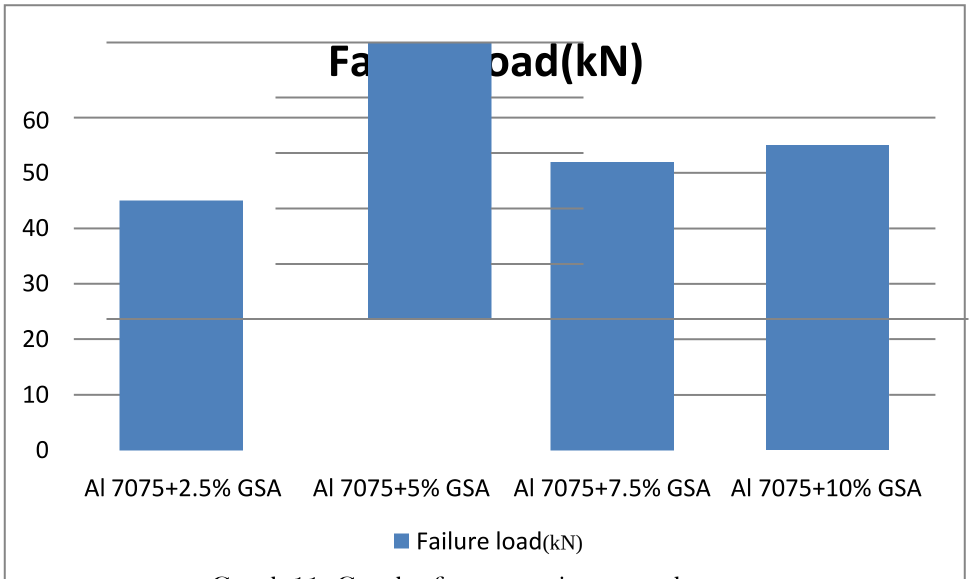
7.5% GROUND NUT REINFORCEMENT

As per above result of composites of various percentages of GROUND NUT SHELLreinforcement, it developed the structure of composite compare to pure material Al-7075, andit majorly improves in 5% and 7.5% of the specimen and regarding this result 2.5% of specimenis doesn't form the better structure because of the casting effects andit having more porosity formed in this specimen compare to 4% and 6% of composite specimen. When comparing the4% and 6% of Silicon Carbide Reinforcement, the 6% of Silicon Carbide Reinforcement gives better result than the 4%of Reinforcement which shownin fig

COMPRESSIVE STRENGTH:

The following table shows the test results of compressive strength test conducted forvarious compositions which were conducted on Universal testing machine.

S.No	Compositions	Failure load(kN)
1	Al 7075+2.5% GSA	45
2	Al 7075+5% GSA	49
3	Al 7075+7.5% GSA	52
4	Al 7075+10% GSA	55



Graph 11. Graph of compressive strength

Fig 12 Before Compression Test

Fig 13 After Compression Test

The compression test process having required specifications of specimen to test the compressive strength on Universal testing machine having a specimen sizes 20mm diameter x 40mm length of each percentage of specimen. After testing of various percentages of composite specimen is improved the strength compare to pure Al-7075 material. The fig 4.2.1 shows before testing and fig 4.2.1 shows after testing. After we tested the compressive strength, the compressive strength is improved in the 6% of GROUND NUT SHELL Reinforcement of composite specimen shows high strength.

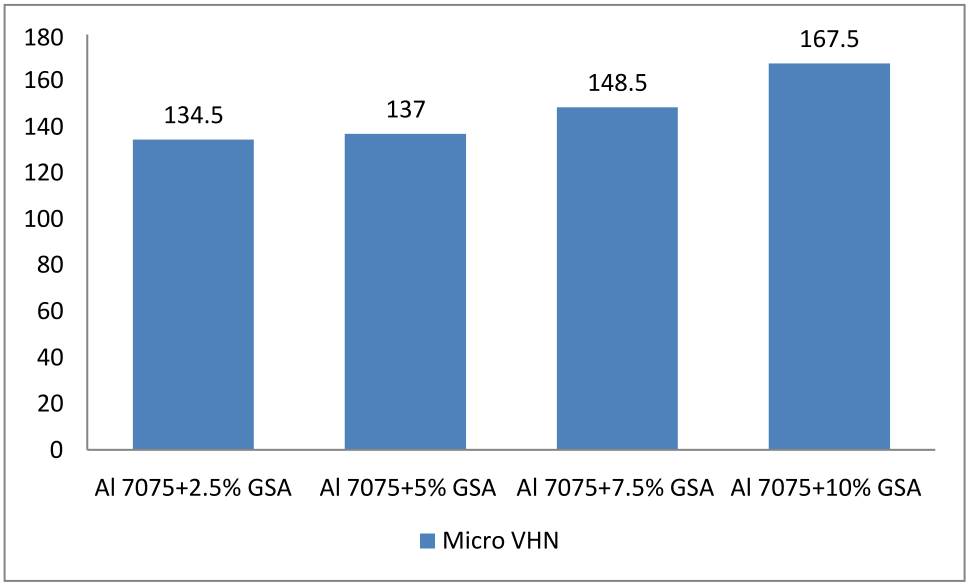
HARDNESS TEST

Fig-14. HARDNESS TEST

COMPOSITIONS	Trail-1			Trail-2			Micro VHN
	D1	D2	VHN	D1	D2	VHN	
Al 7075 + 2.5% GSA	76	48	135	79	45	134	134.5
Al 7075 + 5.0% GSA	47	75	142	68	56	132	137
Al 7075 + 7.5% GSA	85	49	154	58	87	143	148.5
Al 7075 + 10% GSA	39	93	162	76	59	173	167.5

Measurement of Hardness:

Hardness is not an intrinsic material property dictated by precise definitions in terms of fundamental units of mass, length and time. A hardness property value is the result of a defined measurement procedure. Hardness of materials has probably long beam assessed by resistance to scratching or cutting. An example would be material B scratches material C, but not material A. Alternatively, material A scratches material B slightly and scratches material Cheavily. Relative hardness of minerals can be assessed by reference to the Moh's scale that ranks the ability of materials to resist scratching by another material. Similar methods of relativehardness assessment are still commonly used today.



Graph 15. Graph of Hardness

An example is the file test where a file tempered to a desired hardness is rubbed on the test material surface. If the file slides without biting or marking the surface, the test material would be considered harder than the file. If the file bites or marks the surface, the test materialwould be considered softer than the file. The above relative hardness tests are limited in practical use and do not provide accuratenumeric data or scales particularly for modern day metals and materials. The usual method to achieve a hardness value is to measure the depth or area of an indentation left by anindenter ofa specific shape, with a specific force applied for a specific time. There are three principal standard test methods for expressing the relationship between hardness and the size of the impression, the being Brinell, Vickers and Rockwell. For practicaland calibration reasons, each of these methods is divided into a range of scales, defined by a combination of applied load and indenter geometry.

CONCLUSION

Al-7075 with GROUND NUT SHEL composite material was prepared successfully in 2.5%,5% and 7.5% weight percentage GROUND NUT SHELL reinforcement through stir casting process. Mechanical Characterization was studied on Vickers hardness, compression strength,tensile strength and microstructure behaviour of Al-7075 with GROUND NUT SHELL composite material was studied and results are summarized and given below:

The particle size of composite material &microstructure examined, the size and shape of the Al-7075 and adding of wt% of GROUND NUT SHELL develops the specimen in 4% and 6%have high distribution in material compared to Pure Al-7075. Based on results 2% of specimendoesn't form the perfect structure in composite and seems to form a high porosity property inthe composite due to casting effects. The Vickers hardness of Al-7075 with GROUND NUT SHELL composite material increaseswith increase in addition of

GROUND NUT SHELL reinforcement, this shows that the uniform distribution of GROUND NUT SHELL which reduces the internal granule space in the ALMMC. Also increases in hardness shows good physical bond between Al-7075 with GROUND NUT SHELL composite. As per result based on values this project improved the hardness property in 4% and 6% of the specimen. The Compressive Strength of Al-7075 with GROUND NUT SHELL composite material increases with increase in addition of AL-7075reinforcement; this shows the uniform distribution of GROUND NUT SHELL reduces the internal granule space in the ALMMC. Also increases in compressive strength shows good physical bond between Al-7075 with GROUND NUT SHELL composite. As per result based on values this project improved the property in 2.5% and 7.5% of the specimen.The Wear of Al-7075 with GROUND NUT SHELL composite material increases with increase in addition of GROUND NUT SHELL reinforcement this shows the uniform distribution of GROUND NUT SHELL which reduces the internal granule space in the ALMMC. Also increases in wear resistance at certain time period shows good physical phenomenon between Al-7075 with GROUND NUT SHELL composite. As per result basedon values this project improved the property in 5% and 7.5% of the specimen compare toAl- 7075. Based on result of those parameters of GROUND NUT SHELL reinforced of composite is much better than 2.5% and 7.5% of GROUND NUT SHELL composite.

FUTURE SCOPE: Based on the results, the Al-7075 with GROUND NUT SHELL composite material will have finer crystal structure so that it can be applicable for various complex situations towards the manufacturing of various complex designs. More over the stir casting techniquescan be applicable in future advanced technologies.

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