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Improving the Tribomechanical Properties of B₄C/MWCN Treinforcement with Aluminium Matrix Composite

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ABSTRACT: In the present study, Aluminium 7075 alloy, B₄C and Multiwall carbon nanotube (MWCNT) composites were fabricated with the stir casting process. Aluminium matrix composites found many applications in aerospace and structural engineering. In this investigation, B₄C nanoparticle is fixed as 10 wt% and MWCNT are varied from 5, 10 and 15 wt%. Microstructural, Mechanical and Tribological behaviour of composites were investigated. It is found that with an increase in reinforcement content uniform dispersion of particles is found. The density of composites is decreased due to the volatile nature of reinforcement particles. The tensile strength is considerably increased by increasing wt% of MWCNT content. The wear resistance of the composites increased significantly by increasing the MWCNT content. The hardness of composites is increased with increase in reinforcement content. Dominant wear mechanisms for Al, B₄C and MWCNT composites were determined to be the formation of a mechanical mixed layer on the surface of samples.

KEYWORDS: Hybrid metal matrix, B₄C, MWCNT

I. INTRODUCTION

A material is a substance (mostly a solid, however other condensed phases also included) that is proposed to be used for different applications. More number of materials is available in the world and they can be found in all the places starts from buildings to spacecrafts. Generally, materials can be divided into two categories and they are crystalline and non-crystalline. The examples are metals, polymers and ceramics. Advanced and new materials that are being developed include nanomaterials, semiconductors, biomaterials etc. The materials are divided based on their era as follows; Stone Age followed by Bronze Age, iron Age and at last Steel Age. Formerly it originates from the manufacturing of ceramics and its recognized derivative metallurgy. The oldest form of applied science and engineering is may be termed as material science. Current material science developed straightforwardly from metallurgy. Major changes happened in the late 19th century and hence the importance of understanding the behaviour of materials evolved. When, scientist Gibbs proved that there is a relation between the physical properties of the material to the thermodynamic properties related to atomic structure.

The product of the space race is the main elements of modern materials science i.e. the understanding and engineering of silica, metallic alloys and carbon materials used in the manufacture of space vehicles make possible the exploration of space. The field has become wider to include every class of materials, including magnetic materials, biological materials, ceramics, semiconductors, polymers, medical implant materials and nanomaterials. Materials are divided into groups, in order that brain can handle its complexity to identify the material. It can also be classified according to their structure, applications and properties. Based on the atoms bound together, the materials are classified

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as metals, semiconductor, ceramics and polymers. A composite material (also called a composition material or shortened to composite, which is the common name) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure, differentiating composites from mixtures and solid solutions.

II. MATERIALS AND METHODS

Aluminum alloy 6061 reinforced with silicon carbide and Multiwall carbon nanotube (MWCNT) particulate was employed as the workpiece material. The stir casting process has been used to fabricate Al-SiCpMMC plates. The MWCNTs have been selected as the additive for performing NPMEDM experiments. The three materials fully surveyed and properties in the materials shown in Table 1

Table 1 Properties of Materials

Material	Aluminium(7075)	Boron carbide	MWCNT
Properties	<ul style="list-style-type: none"> • Tempering • Tensile strength (more than 280 mpa) • High corrosion Resistance • Yield strength (more than 140 mpa) 	<ul style="list-style-type: none"> • Semiconductor • Good chemical resistance • Good nuclear properties • Low density 	<ul style="list-style-type: none"> • Hardness • Tensile strength • Electrical conductivity • Thermal conductivity and expansion

An alloy is a combination of metals or metals combined with one or more other elements. For example, combining the metallic elements gold and copper produces red gold, gold and silver becomes white gold, and silver combined with copper produces sterling silver. Elemental iron, combined with non-metallic carbon or silicon, produces alloys called steel or silicon steel. The resulting mixture forms a substance with properties that often differ from those of the pure metals, such as increased strength or hardness. Unlike other substances that may contain metallic bases but do not behave as metals, such as aluminium oxide (sapphire), beryllium aluminium silicate (emerald) or sodium chloride (salt), an alloy will retain all the properties of a metal in the resulting material, such as electrical conductivity, ductility, opacity, and luster. Alloys are used in a wide variety of applications, from the steel alloys, used in everything from buildings to automobiles to surgical tools, to exotic titanium-alloys used in the aerospace industry, to beryllium-copper alloys for non-sparking tools. In some cases, a combination of metals may reduce the overall cost of the material while preserving important properties Table 2.

Table 2 Combination of Materials

Sl. No.	Aluminium(7075)	Boron carbide	MWCNT
1	99%	1%	-
2	98.5%	1%	0.5%
3	98%	1%	1%
4	97.5%	1%	1.5%

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Molding or moulding (see spelling differences) is the process of manufacturing by shaping liquid or pliable raw material using a rigid frame called a mold or matrix. This itself may have been made using a pattern or model of the final object. A mold or mould is a hollowed-out block that is filled with a liquid or pliable material such as plastic, glass, metal, or ceramic raw material. The liquid hardens or sets inside the mold, adopting its shape. A mold is the counterpart to a cast. The very common bi-valve molding process uses two molds, one for each half of the object. Articulated moulds have multiple pieces that come together to form the complete mold, and then disassemble to release the finished casting; they are expensive, but necessary when the casting shape has complex overhang. Piece-molding uses a number of different molds, each creating a section of a complicated object. This is generally only used for larger and more valuable objects.

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 is the simplest and the most cost effective method of liquid state fabrication. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies.

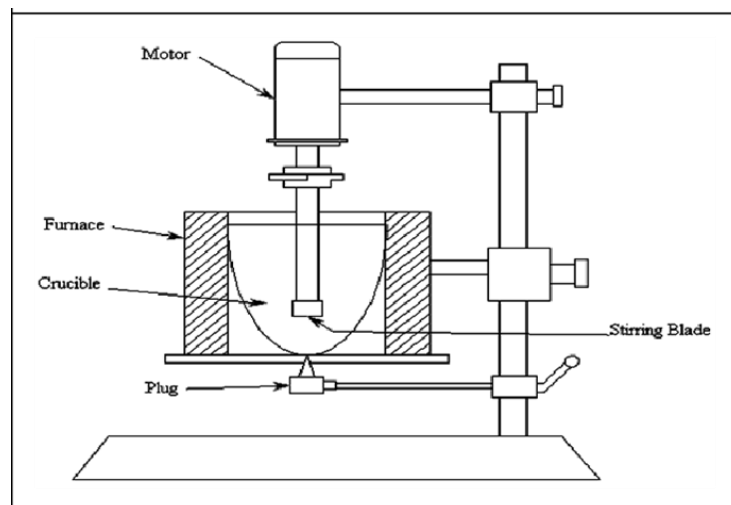


Fig.1 Stir casting Process

III. TESTING

Metal testing is a process or procedure used to check composition of an unknown metallic substance. There are destructive processes and nondestructive processes. Metal testing can also include, determining the properties of newly forged metal alloys. With many chemical-property databases readily available, identification of unmarked pure, common metals can be a quick and easy process. Leaving the original sample in complete, re-usable condition. This type of testing is nondestructive. When working with alloys (forged mixtures) of metals however, to determine the exact composition, could result in the original sample being separated into its starting materials, then measured and calculated. After the components are known they can be looked up and matched to known alloys. The original sample would be destroyed in the process.

Tensile testing, also known as tension testing, is a fundamental materials science and engineering test in which a sample is subjected to a controlled tension until failure. Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-

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hardening characteristics. Uniaxial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic materials. Some materials use biaxial tensile testing shown in fig 2.



Fig.2 Computerized UTM

The flexural strength would be the same as the tensile strength if the material were homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibers are at the largest stress so, if those fibers are free from defects, the flexural strength will be controlled by the strength of those intact fibers. However, if the same material was subjected to only tensile forces then all the fibers in the material are at the same stress and failure will initiate when the weakest fiber reaches its limiting tensile stress. Therefore, it is common for flexural strengths to be higher than tensile strengths for the same material. Conversely, a homogeneous material with defects only on its surfaces might have a higher tensile strength than flexural strength shown in fig 3.



Fig.3 Flexural Testing Machine

Wear is the damaging, gradual removal or deformation of material at solid surfaces. Causes of wear can be mechanical or chemical. The study of wear and related processes is referred to as tribology. Wear in machine elements, together with other processes such as fatigue and creep, causes functional surfaces to degrade, eventually leading to

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material failure or loss of functionality. Wear of metals occurs by plastic displacement of surface and near-surface material and by detachment of particles that form wear debris. The particle size may vary from millimeters to nanometers. This process may occur by contact with other metals, nonmetallic solids, flowing liquids, solid particles or liquid droplets entrained in flowing gasses. The wear rate is affected by factors such as type of loading, type of motion, temperature, and lubrication, in particular by the process of deposition and wearing out of the boundary lubrication layer. Depending on the tribosystem, different wear types and wear mechanisms can be observed shown in fig 4.



Fig.4 Wear Test Machine

IV. CONCLUSION

The composite is successfully prepared through stir casting process and the uniform dispersion is verified through the optical microscopic image. The increase in the mechanical property is observed, as the wt. % of B₄C and MWCNT particles increase in the composite. This type of composite materials are mainly used in aerospace and automobile applications.

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