ASSESSMENT OF MECHANICAL AND TRIBOLOGICAL PROPERTIES OF ALUMINIUM METAL MATRIX COMPOSITE BY CENTRIFUGAL CASTING

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ABSTRACT

Aluminium 7075 alloy constitutes a very important engineering material widely employed in the aircraft, aerospace and automotive industry for the manufacturing of different parts and components. It is due to its high strength to density ratio that it a sought after metal matrix composite. Functionally graded materials (FGMs) are materials that possess variance in properties across the geometry of the material. They are a class of materials developed from the existing knowledge of material alloying.The functionally graded aluminium metal matrix prepared by centrifugal casting.Aluminium 7075 taken as base metal and titanium dioxide ,silicon nitride is used as reinforcement.In this project, mold preheating temperature ranges 250–350 °C, centrifugal speed kept between 500 rpm, pouring temperature in the range of 740–760 °C having reinforcement particle of weight percentage, with an average particle size of 40- 50 µm yield the maximum of hardness and wear resistance.Using the linear regression model, an effort has been made to optimize the material and process variables to get enhance the mechanical properties.This project delivers a detailed review of the influence of material and process variables on the micro structure, mechanical characteristics of functionally graded aluminium material (FGMs) produced by the centrifugal casting method from previous studies. Also, the basic principle and classification of centrifugal casting to produce FGMs are illustrated.The various mechanical and tribological characteristics of FGM like hardness , micro structure examination and wear rate of the specimen were tested.Work is done to develop the functionally graded materials for wear and thermal based application like piston and exhaust valves in Automobile industries.

1.INTRODUCTION:

Functionally Graded Materials (FGMs) are composite materials which are designed to present a particular spatial variation of their properties.This is usually achieved by forming a compound of two or more components whose volume fraction changed across a certain direction. Properties are better than the sum of their constituents.Discussion of the basic principles behind the fabrication of continuous FGAMCs through the centrifugal casting method, and their types, processing, and strengthening mechanisms are highlighted. The classification of ceramic reinforcement particles based upon their uses in the processing of FGAMs through the centrifugal casting technique, and also their effect on mechanical and wear properties are discussed in-depth with the material and process parameters are described.The optimization of various material and process variables to improve mechanical properties, mainly tensile strength, and hardness is presented in. Discussion about the future scope and current research gaps are done.

1.2 FUNCTIONALLY GRADED MATERIALS:

FGM as an interface layer to connect two incompatible materials, can greatly enhance the bond strength.FGM and interface can be used to reduce the residual stress and thermal stress.FGM can be used to connect the materials to eliminate the stress at the interface and endpoint stress singularity.FGM not only enhances the strength of the connections but also reduce the crack driving force

1.3 ALUMINIUM 7075:

7075 aluminium alloy (AA7075) is an aluminium alloy, with zinc as the primary alloying element.Al7075 high yield strength (>500 MPa) and its low density make the material a fit for applications such as aircraft parts or parts subject to heavy wear.7075 aluminium alloy can be further improved by how it is strengthened using a process known as heat-treatment, sometimes referred to as “tempering.” This method uses high heat (300-500 ºC) to reconfigure the metal’s crystal structure to strengthen its overall mechanical properties, and can literally make-or-break a material.Hence it was chosen as the base metal.

1.4 TITANIUM DIOXIDE:

Titanium dioxide (TiO_2) are recognized of being lightweight and having very high tensile strength , high corrosion resistance, and an ability to withstand extreme temperatures.They are available in the form of micro crystals or microdots having a high surface area.And they are used as reinforcements.

1.5 SILICON NITRIDE:

Another reinforcements with which the work done is Silicon Nitride.Its properties include high strength, toughness and hardness, excellent wear resistance, corrosion resistance to many acids and alkalis and outstanding thermal shock resistance.

2. CENTRIFUGAL CASTING METHOD:

The centrifugal method of casting FGM uses a spinning mold in casting of the materials rather than using gravity force. The mold is mounted on a rotational shaft while the melt is poured into it and allowed to solidify while the mold is still rotating.The geometry of the FGMs produced centrifugal method (CM) is limited to cylindrical shapes and the types of gradients formed are limited due to the parameters involved in the formation of those gradients, namely, material densities and applied centrifugal force. Furthermore, the denser particle reinforcement tends to move towards the outer wall of the cast during the rotation of the mold.The difference in the densities of the melt and the reinforcing particle results in a particle concentration gradient which is observed in the solidified FGM processed from CM.The speed of rotation is 500 rpm.The centrifugal force of casting done is 411.2 m / s².

FINAL PRODUCT

3. COMPOSITION OF SPECIMEN:

SPECIMEN NO	SPECIMEN 1	SPECIMEN 2	SPECIMEN 3
Weight of aluminium 7075 in grams	**970**	**970**	**940**
Weight % of aluminium 7075	**97%**	**97%**	**94%**
Weight of silicon nitride in grams	**0**	**30**	**30**
Weight% of silicon nitride	**0%**	**3%**	**3%**
Weight of titanium dioxide in grams	**30**	**0**	**30**
Weight % of titanium dioxide	**3%**	**0%**	**3%**
Total weight in grams	**1000**	**1000**	**1000**
Total weight %	**100%**	**100%**	**100%**

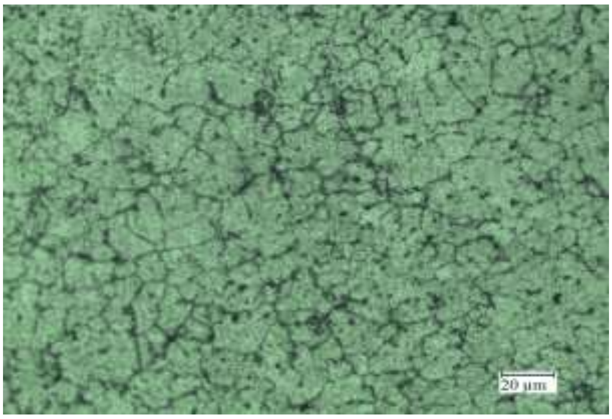
Table 1: Composition of specimen

4. MICROSTRUCTURE TEST:

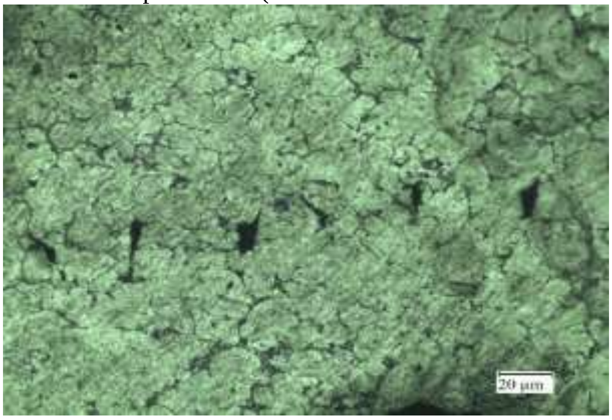
Most metals at different stages of their processing life and heat treat conditions exhibit a specific micro structure that can be evaluated to see if: the material was heat treated as required; to investigate if the raw material was processed and produced per quality standards; or to simply find out why a material is not responding to specific applications or machining operations.

4.1 OPTICAL MICROSCOPY:

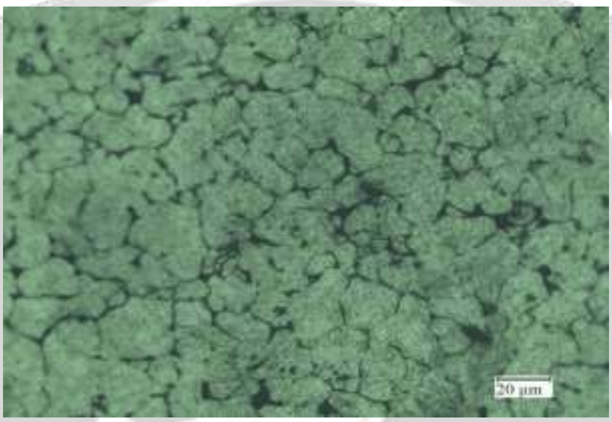
With optical microscopy, the light microscope is used to study the micro structure; optical illumination systems are its basic elements. For materials that are opaque to visible light (all metals, many ceramics and polymers), only the surface is subject to observation, and the light microscope must be used in a reflective mode.



Micro structure of specimen 1 (aluminium 7075 and titanium dioxide)



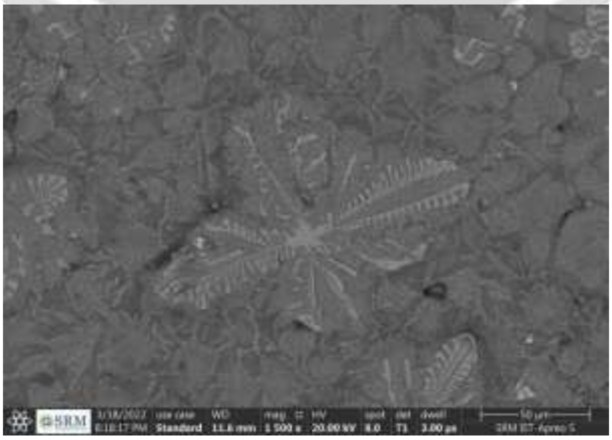
Micro structure of specimen 2 (aluminium 7075 and silicon nitride)



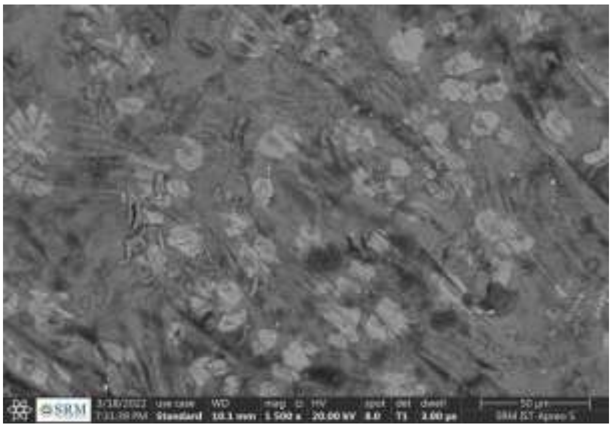
Micro structure of specimen 3 (aluminium 7075 and silicon nitride, titanium dioxide)

4.2 HR - SEM TEST:

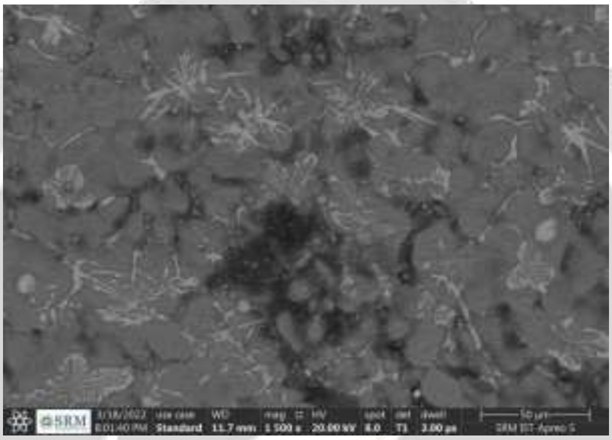
HR - SEM Test is done on the specimen samples to study about the composition and distribution of the specimen by test examining different parts of the same specimen.Particular features of interest are (1) Grain size (II) phases present (III) Chemical homogeneity (IV) distribution of phases (V) Elongated structures formed by plastic deformation.



SEM image of Specimen 1(Aluminium 7075 & titanium dioxide)



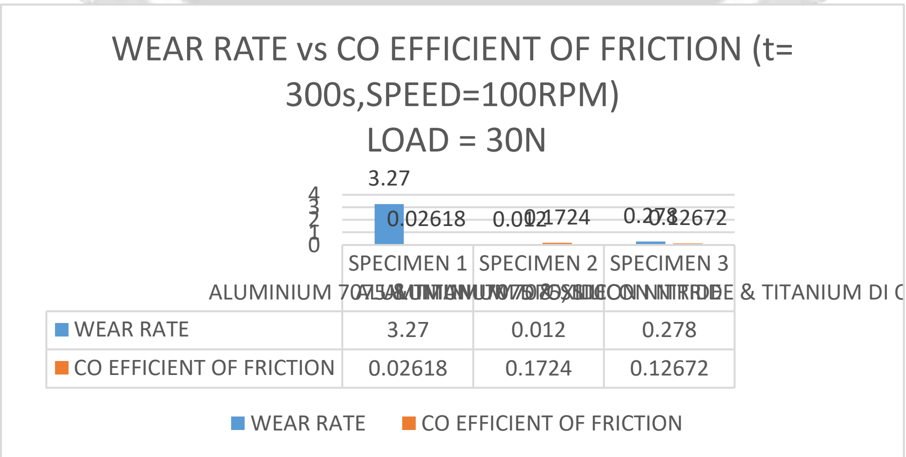
SEM image of Specimen 2(Aluminium 7075 & Silicon nitride)



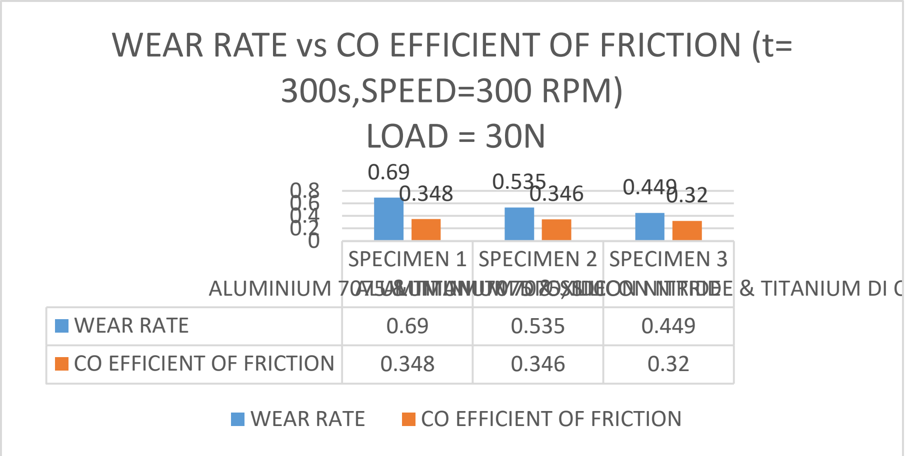
SEM image of Specimen 3(Aluminium 7075 & Titanium dioxide,silicon nitride)

5.WEAR TEST:

A process of interaction in the surfaces or a face of bonded solid which is working to loss parts from dimensions solid during working in its environment can be defined as a wear without or with losing of material. In the results in the wear standard tests, the removing of part from volume of the test sample can be used to expression the wear formals of the wear test.The wear test at 100 rpm,300 rpm,500 rpm of time period of 300 seconds by applying different loads is done with the specimens and the results are taken.



wear rate vs co efficient of friction (t= 300s)
load= 30N



wear rate vs co efficient of friction (t= 300s)
load= 30N

6.CONCLUSION:

Thus, we have fabricated the three hollow cylindrical specimens of functionally graded materials.The specimens are fabricated using centrifugal casting.In hardness test the specimen Al7075 + Titanium dioxide shows more hardness when compared to other two specimens.At 100 rpm , 30 N specimen 2 (Al7075+Silicon nitride) shows the lowest wear rate.At 300 rpm,30N specimen 2 (Al7075+Silicon nitride) shows the lowest wear rate . At 500 rpm,10N specimen 1 (Al7075+Titanium dioxide) shows the lowest wear rate.Inspection of its micro structure is done using optical microscopy and Scanning electron microscopy(SEM).Thus the FGMs produced by the project can be used for higher hardness and wear based applications.

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