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Experimental Investigation of Mechanical and Tribological properties of Aluminum Metal Matrix Composite (MMC) Reinforced with Alumina (Al_2O_3) using powder metallurgical process

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ABSTRACT: This project aims at the processing of aluminium metal matrix composites (MMCs), reinforced with alumina (Al_2O_3) and analyzing the mechanical and tribological behavior manufactured by powder metallurgy method. Metal matrix composites are extensively used in various components of industrial and research equipment because of their superior material properties like high stiffness to weight ratio, high strength to weight ratio, high impact strength and fracture toughness while compared to the conventional materials. Due to the concepts of high strength to low weight ratio, Al was extensively applied in aircraft engine and wings. Even if Al has higher hardness, higher strength, excellent wear resistance, and high-temperature corrosion protection. It is the order of the day to further enhance the properties for increasing its usage and applicability. The sintered compacts have been prepared by incorporating Al_2O_3 particles to aluminium metal matrix in different weight fractions (10%, 15%, 20%, and 25%). The mechanical and tribological properties of these compacts have been studied in detail for assessing the effectiveness of the adopted fabrication technique. This method is an effective way to change the properties of the materials as required in different directions.

KEYWORDS: Metal Matrix Composites, sintered Compacts, strength, Powder Metallurgy Technique.

I .INTRODUCTION

Advances in material science have prompted development of new materials having distinctive properties. Graded green compact has a place with this pattern. The design of metal matrix composites can be enhanced by integrating the concept of graded materials to produce engineering materials with tailored contradictory properties that suit multifunctioning components. Similarly, graded materials are made from a mixture of metals and ceramics and are characterized in a way that composition of each one and the volume fraction of materials are changed gradually whereas, Composite material made up of one or more materials combined in solid states with distinct physical and chemical properties. Composite material offers a wonderful combination of properties that totally different from the individual base materials and also are lighter in weight. Wood is a composite material from nature which consists of cellulose in a matrix of lignin. These materials or conventional graded structures will fail under extreme working conditions through a process called delamination (separation of fibers from the matrix) led to damage of component. This can happen for example, in high temperature application where two metals with different coefficient of expansion are used. The case of graded laminates is achieved by forming very thin layers of laminates. Graded structures used in structural components so as to optimize the responses of structures undergoing severe loadings, thermal effects due to complex environments. The concept of briquettes was developed by researchers in Japan in the mid 1980s in which the

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transition between different materials is made gradually. That time the aim was to fabricate the aircraft body's material with improved thermal resistance and mechanical properties by gradually changing compositions to withstand severe temperature gap (about 1000^0C) in between the inside and the outside of a plane project.

Graded structures can be seen in nature, in bio tissues of animals, such as bones and teeth, and plants. Dental crowns represent excellent examples of functionally graded structures. They require a high wear resistance outside and a ductile inner structure for reasons of optimal fatigue and brittleness combination.

II. LITERATURE REVIEW

S. Pradeep Devaneyan et.al in his research thesis "on the Mechanical Properties of Hybrid Aluminum 7075 Matrix Composite Material Reinforced with SiC and TiC Produced by Powder Metallurgy Method'' has investigated that the Mechanical behavior of aluminum 7075 reinforced with Silicon Carbide (Sic) and Titanium Carbide (Tic) through powder metallurgy route. Enhanced mechanical properties have been obtained with 90% of Al 7075, 4% of Tic, and 8% of Sic composition in the composite. In his experiments the higher value of micro hardness was 52.12 HV which can be obtained with 90% of Al 7075, 4% of Sic, and 8% of Tic.

Ahmed Sahib Mahdi et.al in his thesis, "Effect of compaction pressure on mechanical of aluminium particles sizes AA6061 AL Alloy through powder metallurgy process" Focused on mechanical properties of aluminium particles in which our groups of particle size were chosen (25, 63, 100, mix) µm. Each group has compacted by three specimens for several of compacted pressure (5, 7, 9) tons, the results shows that the compression strength increase with increasing compaction pressure for all groups. Micro-hardness has been getting the large value of the mix group (61HV).

Arindam Ghosh and Subrata Chatterjee in their research thesis, "Effect of Al_2O_3 Content and Process Variables on Structure and Properties of Al-Al_2O_3 Compacts" presented that compaction increases with increasing compacting pressure and decreases with increasing alumina content. Maximum density achieved is 93% for pure aluminium compacts and decreases to 85% for Al-20 wt% alumina compacts. Grain growth of aluminium particles is noticed in the compacts after sintering at 773 and 873 K.

G. Pitchayyapillai, et.al (2016) in their research article "Al6061 Hybrid Metal Matrix Composite Reinforced with Alumina and Molybdenum Disulphide" an attempt has been made to investigate the wear rate of Al6061 hybrid metal matrix composite reinforced with the hard ceramic alumina (4, 8, and 12 wt. % of Al_2O_3) and of solid lubricant of molybdenum disulphide (2, 4, and 6 wt. % of MoS2) is fabricated by using stir casting method and presented the mechanical behavior, tribological behavior, and machinability behavior.

III.EXPERIMENTAL WORK AND INVESTIGATION

3.1 Powder materials

(A) Pure Aluminum powder (98%)

Chemical composition of Aluminum

Element	Si	Fe	Mn	Mg	Ti	Al
Weight. in %	0.41	0.15	0.023	0.38	0.016	Bal

(B) Alumina (Al_2O_3)

3.2 Specimen Size and Specifications:

For this purpose of study four sample sizes were considered each of size ø8.5mm and thickness of 14.45mm. For each sample four specimens are fabricated at 290MPacompaction pressure. Therefore all together sixteen specimens are fabricated.

Sample size is 55×8.5mm

Specimen size is 14.45×8.5mm

4 Samples have to be fabricated for each composition and totally 16 composites are to be prepared for experiments.

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Specimen No.	Composition Of Specimens
1.	$90\%Al + 10\%Al_2O_3$
2.	$85\%Al + 15\%Al_2O_3$
3.	$80\%Al + 20\%Al_2O_3$
4.	$75\%Al + 25\%Al_2O_3$

Table1. Composition of specimens in weight fractions

3.3 Experimental procedure:

In this work, we have fabricated metal matrix briquettes of alumina with aluminum matrix by powder metallurgy based on cold compaction technique. The mixed powder materials are placed in the mixing chamber. The mixing chamber is rotated with live center of a lathe machine at lowest speed for an half an hour clockwise and in anticlockwise direction for through mixing of powders.

Blending powder mixtures were compacted in a cylindrical-diameter compaction dye. Based on the relationship between green density and compaction pressure of the Al alloys, the compaction pressure of the samples was chosen to be 17KN and compacted in compression testing machine (CTM, 100KN) for 60 sec under a uniaxial pressure of 17 KN. After the making of total specimens completed, taken them to finding out the length, diameter and on the digital micrometer. Compacted samples were sintered for 1hr 40 minutes at 520ºC under vacuum with a heating rate of 60ºC/min.

Fig 1: Compression and ejection block Fig 2: Compacting guides and followers

Fig 3: Compaction under CTM

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Fig 4: Sintering in Tubular furnace

Fig 5: Specimens of four different compositions

IV.RESULTS & DISCUSSIONS

4.1 Compression strength:

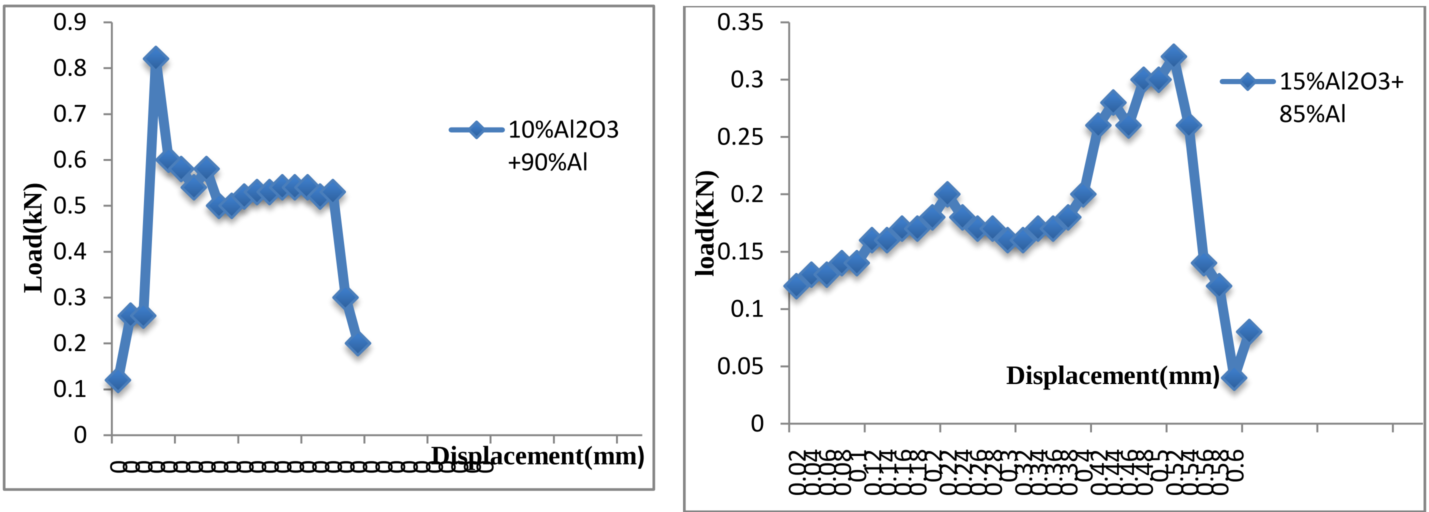

Fig 6 &7 : Load Vs Displacement Graph for Specimen 1st and 2nd samples

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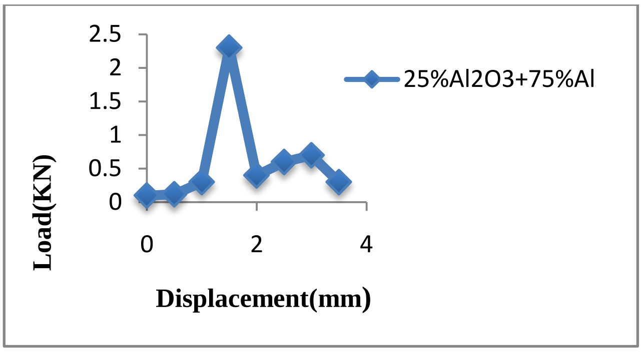

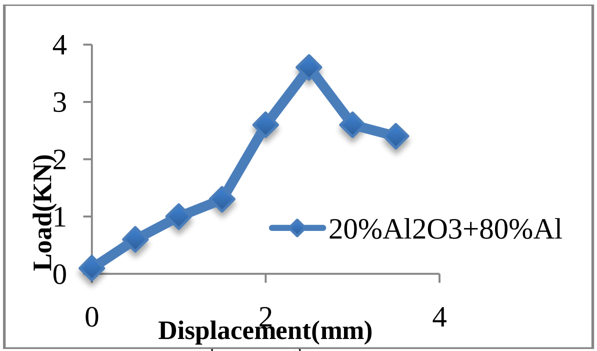

Fig 8 &9 : Load Vs Displacement Graph for Specimen 3rd and 4th samples.

It is observed that specimen with 25wt% alumina has a maximum compression strength of 58.4N/mm^2 is obtained at peak load of 3.63KN and displacement of 2.43mm for maximum load of 600KN.

4.2 Determination of hardness metal matrix composites

Fig 10: Brinell hardness equipment   Fig 11: Indents on Specimens

Sl.No	Composition of specimens	Ball diameter(D) mm	Impression diameter(d) mm	Hardness(HB)
1	90%Al+10%Al_2O_3	3	2.2	41.4
2	85%Al+15%Al_2O_3	3	2.1	46.2
3	80%Al+20%Al_2O_3	3	1.9	58.5
4	75%Al+25%Al_2O_3	3	1.9	58.5

Table 2: Hardness values of specimens

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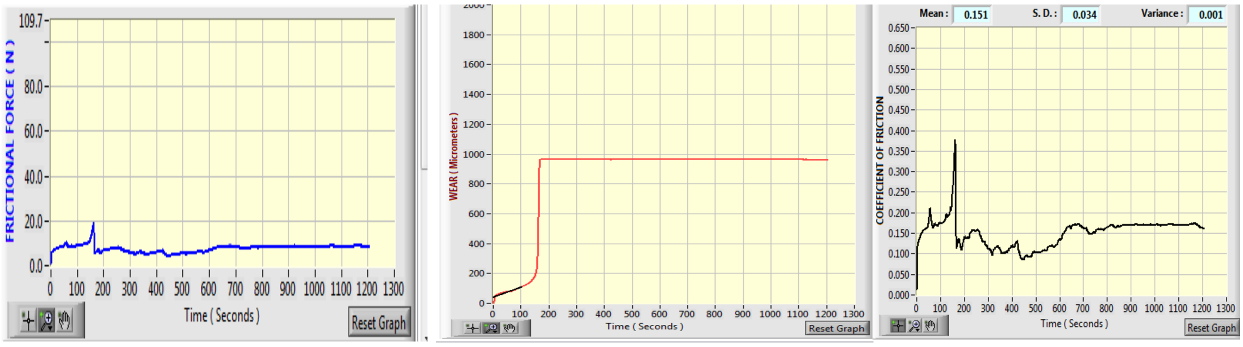
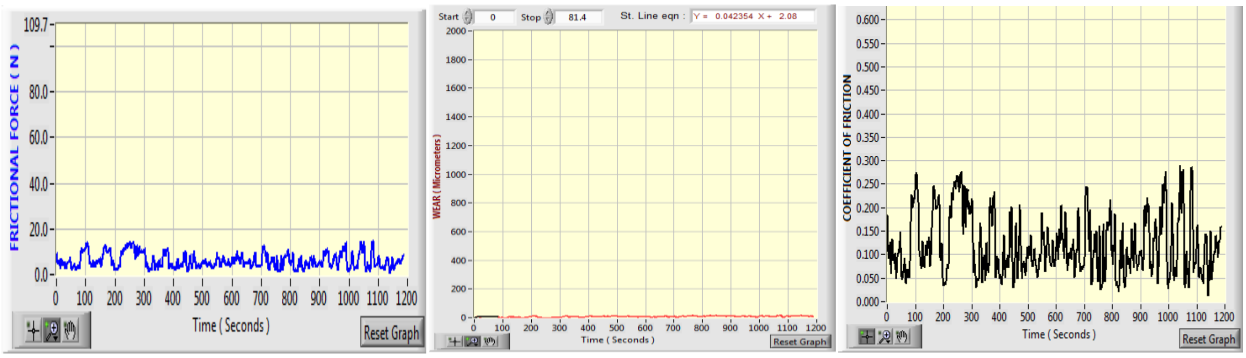
4.3 Determination of coefficient of friction by using Wear test equipment

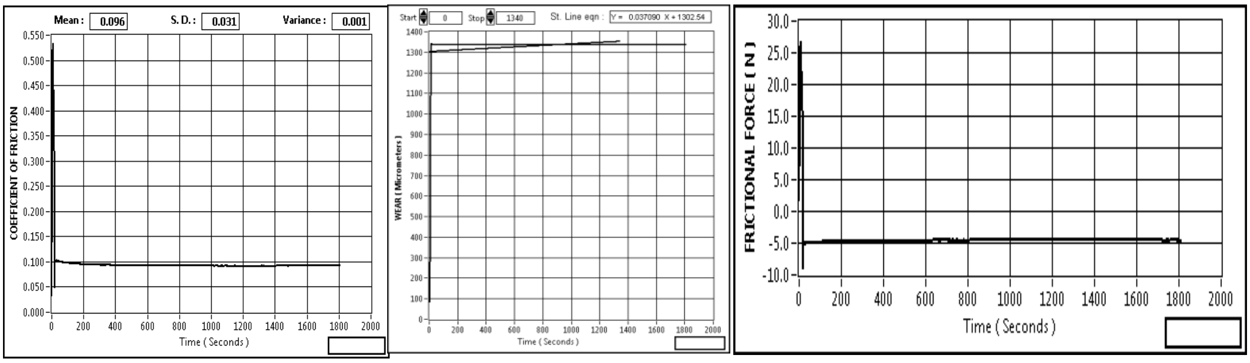
Specimen 1: 90%Al+10%Al_2O_3



Specimen 2: 85%Al+15%Al_2O_3



Specimen 3: 80%Al+20%Al_2O_3



V. CONCLUSION

1. Aluminium Metal matrix composites with different weight proportions of alumina (Al_2O_3) are fabricated successfully.
2. Compression strength on composites have done successfully and it is observed that the matrix with composition of 75%Al + 25%Al_2O_3 attained a maximum compression strength of 58.41N/mm^2 of all the remaining composites.
3. Hardness test on the composites have done successfully and it was found that specimen of two different compositions 75%Al+25%Al_2O_3 and 80%Al+20%Al_2O_3 reinforcement having higher hardness of 58.5 HB highest among other reinforcement. Hardness of material with goes on increasing with percentage of Al_2O_3.
4. Wear test of composites have done successfully by using pin on disc wear test apparatus (TR 201) and found out that highest coefficient of friction is 0.151 at frictional force 20N having the wear rate of 973 mm of 90%Al+10%Al_2O_3 composition.

REFERENCES

1. On the Mechanical Properties of Hybrid Aluminium 7075 Matrix Composite Material Reinforced with SiC and TiC Produced by Powder Metallurgy Method. S. Pradeep Devaneyan, R. Ganesh, and T. Senthilvelan.
   Received 23 July 2016; Revised 20 October 2016; Accepted 8 December 2016; Published 23 January 2017.
2. Al6061 Hybrid Metal Matrix Composite Reinforced with Alumina and Molybdenum Disulphide. G. Pitchayyapillai, P. Seenikannan, K. Raja, and K. Chandrasekaran.
   Received 1 September 2016; Accepted 12 October 2016.
3. Wear Behavior of Aluminium Metal Matrix Composite Prepared from Industrial Waste. L. Francis Xavier and Paramasivam Suresh.
4. Mukesh kumar, Randeep singh "enhancement of mechanical properties of aluminium based metal matrix composite reinforced silicon carbide" international journal of technical research (ijtr) vol. 4, issue 2, jul-aug 2015.
5. Himanshu Kalaa, K.K.S Merb, Sandeep Kumarc "A Review on Mechanical and Tribological Behaviors of Stir Cast Aluminum Matrix Composites". 3rd International Conference on Materials Processing and Characterization (ICMPC 2014).
   Received 21 November 2015; Revised 13 January 2016; Accepted 24 January 2016.
6. Gaurav Mahajan, Nikhil Karve, Uday Patil, P. Kuppan* and K. Venkatesan "Analysis of Microstructure, Hardness and Wear of Al-SiC-TiB_2 Hybrid Metal Matrix Composite "Indian *Journal of Science and Technology, Vol 8(S2), 101-105, January 2015*
7. Processing techniques for functionally graded materials. B. Kieback, A. Neubrand, H. Riedel. Institute für Werkstoffwissenschaft der TU Dresden, Mommsenstrae 13, 01062 Dresden, Germany.
8. Arindam Ghosh and Subrata Chatterjee "Effect of Al2O3 Content and Process Variables on Structure and Properties of Al-Al2O3 Compacts". Received 1 November 2013; revised 10 December 2013; accepted 30 December 2013.