International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** V **Month of publication:** May 2019

DOI: https://doi.org/10.22214/ijraset.2019.5540

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

Evaluation of Mechanical Behavior of LM25/TiB_2/B_4C Metal Matrix Composite

K. Aishwarya Lakshmi[1], B. Rajeswari[2]
[1]Department of Manufacturing Engineering, Government College of Technology, Coimbatore.
[2]Department of Manufacturing Engineering, Government College of Technology, Coimbatore.

Abstract: This paper is about the study of metal matrix composite reinforced with TiB_2 and B_4C. This paper presents an overview of Al-TiB_2- B_4C MMC on aspects relating to the mechanical characteristics such as hardness, wear, tensile and microstructure characteristics and also its applications. Aluminium alloys are widely used for commercial applications in the transportation, construction and in many other industrial areas. Nowadays main focus is given to Aluminium as matrix material because of its unique combination of corrosion resistance, low electrical resistance due to these properties they find good application in naval vessels manufacturing. Al-TiB_2- B_4C Metal matrix composite is formed by stir casting method. With TiB_2 as reinforcement addition, the properties of LM25 aluminium can be greatly improved. It improves the strength of the aluminium. This combination of metal matrix composite is widely used in manufacturing cylinder heads, liners, pistons, brake rotors and in many automobile applications due to its improved properties. Comparative study for all the said composites is done with respect to yield strength, tensile strength, hardness, impact strength and compressive strength.

I. INTRODUCTION

Metal matrix composites are a group of materials that are incorpated with various reinforcing phases which may in the form of particulates, whiskers or continuous fibers. Over the last few years researchers and manufacturers have greater interests in Metal matrix composites due to their unique mechanical and physical properties. Metal matrix composites has higher strength, high stiffness, high thermal conductivity, low density, high strength to density ratio etc.,

Aluminium matrix composites is becoming a good base material in many applications since they possesses higher resistance to wear and improved strength. While considering the reinforcement type ceramics such as SiC, Al_2O_3, TiC, TiB_2, B_4C, Graphite are more commonly preferred. Many methods are available for fabricating Aluminium matrix composites with ceramic reinforcements. Two such important methods are stir casting and powder metallurgy. The simpler and easier method is liquid state processing i.e Stircasting. Stir casting is of two types namely Ex Situ and In situ methods. In insitu method the particles are synthesized within the melt and in the ex situ method the particles are added externally.

II. MATERIAL SELECTION

Aluminium is a predominant metal with typical alloying elements namely Copper, Magnesium, Manganese, Silicon, Strontium and zinc. The two main classes of Aluminium are Casting alloys and Wrought alloys. Other main classes of Aluminium alloys are 1XXX, 2XXX, 3XXX, 4XXX, 5XXX, 6XXX, 7XXX, 8XXX series. In this present work LM25 alloy is selected and the elemental composition is given in Table 1.

Table 1: Chemical Composition of LM25

Chemicals	Contribution %
Copper	0.1 max.
Magnesium	0.20 to 0.60
Silicon	6.5 to 7.5
Iron	0.5 max.
Manganese	0.3 max.
Nickel	0.1 max.
Zinc	0.1 max.
Lead	0.1 max.
Tin	0.05 max.
Titanium	0.2 max.
Aluminium	90.45

LM 25 Aluminium alloy belongs to 4XXX series. It is widely used in casting and as filler materials. LM25 has excellent fluidity, is good for castings that has to be leak tight, LM25 can avoid problems due to hot tearing. LM25 is mostly used in the manufacture of wheels, cylinder blocks, heads and other engine body castings. Castings of LM25 aluminium alloy are standardized in the as cast (M) condition, the precipitation treated condition, the solution treated condition, stabilized condition and in fully treated condition.
Titanium Di boride (TiB_2) is chosen as the ceramic reinforcement, which is a hard material, has high strength, has high wear resistance at elevated temperatures, has high elastic modulus and high compressive strength. TiB_2 is more commonly used in armour weapons such as ballistic armours and in aluminium smelting process.
Aluminium oxide at constant 5% level in powder form is used. It is used in various chemical, industrial and commercial applications. Pure alumina finds wide range of applications in orthopaedic implants, as substrates in electronics industry. Here LM 25 aluminium alloy metal matrix composite reinforced with weight fractions of 0, 3, 4, 5 % of TiB_2 and 5% of Al_2O_3 were produced using stir casting and the experimental plan for this paper is as shown in Table 2

TABLE 2: Experimental Plan

Sample No.	Melting temperature (°C)	Reinforcement preheat Temperature (°C)	Reinforcement (%)	
			Al_2O_3	TiB_2
1.	600	200	-	-
2.	675	250	5	2
3.	700	300	5	3
4	750	350	5	4

III. FABRICATION OF LM25 / TiB_2 / B_4C

For preparing metal matrix composite LM25 / TiB_2 / Al_2O_3 liquid state processing of stir casting process is selected. Stir casting equipment is shown in figure 1. Initially 2000 gm of LM25 (Brick shaped) Aluminium is melted in a graphite crucible at 900◦C near to its liquid temperature in an electric furnace under argon gas atmosphere. This composite synthesis is done in 10Kg capacity furnace. LM25 is melt and for each casted sample about 474gm of LM25 (may vary in each sample) in which 3,4,5% of TiB_2 at constant 5% level of B_4C is added and stirred mechanically using an impeller driven by an motor. TiB_2 and B_4C reinforcement powders are heated in reinforcement preheater. These powder reinforcement particles are added into the furnace by manual powder addition. For uniform mixture of the reinforcements and molten LM25 stirring is done for 15mins. Then the molten mixture is poured into pre heated die with 250mm and radius 15mm as shown in figure 2.

Figure 1: Stir Casting Equipment

Figure 2: Preheated Die

The casted samples of 250mm height of different proportions are then machined separately for testing tensile strength, hardness, wear rates and microstructure analysis. The weight proportions of the four samples are as shown in the table 3.

Table 3: Reinforcement Proportions of 4 Samples

Sample No.	LM25 (gm)	B_4C (gm)	TiB_2 (gm)
1	474	-	-
2	482.16	22.23	23.84
3	485.37	22.23	31.80
4	488.58	22.23	39.75

IV. MECHANICAL TESTS

A. Tensile Test

The important properties that can be measured when a sample is tensile test are elongation at yield, Yield stress, Load at break, elongation at break, load at peak in an universal tensile testing machine as shown in figure 3. The specifications of the standard tensile test sample is shown in the figure 4(a), and the samples machined according to the tensile test standards are shown in the figure 4(b).

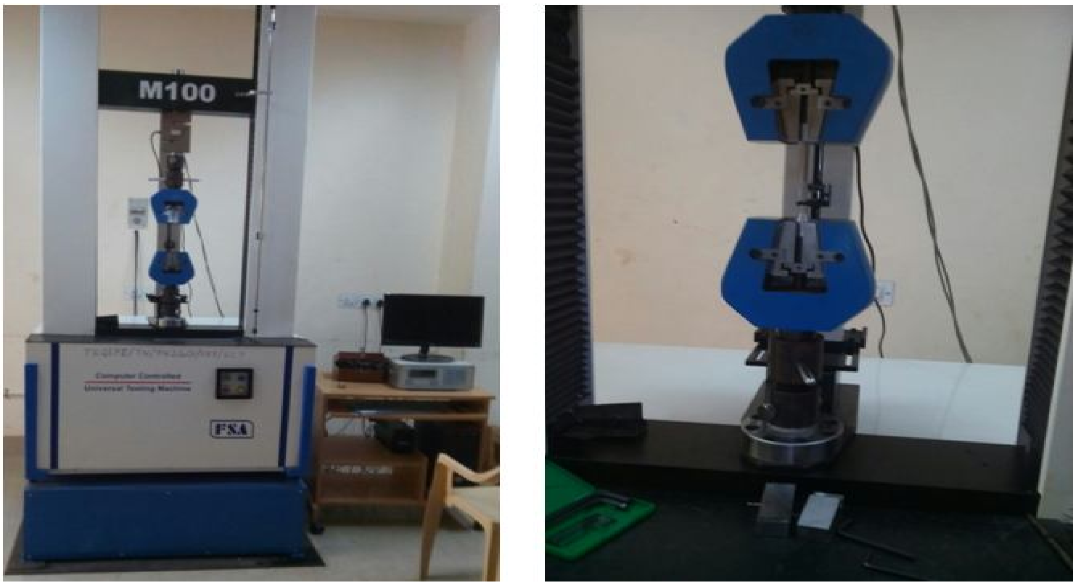
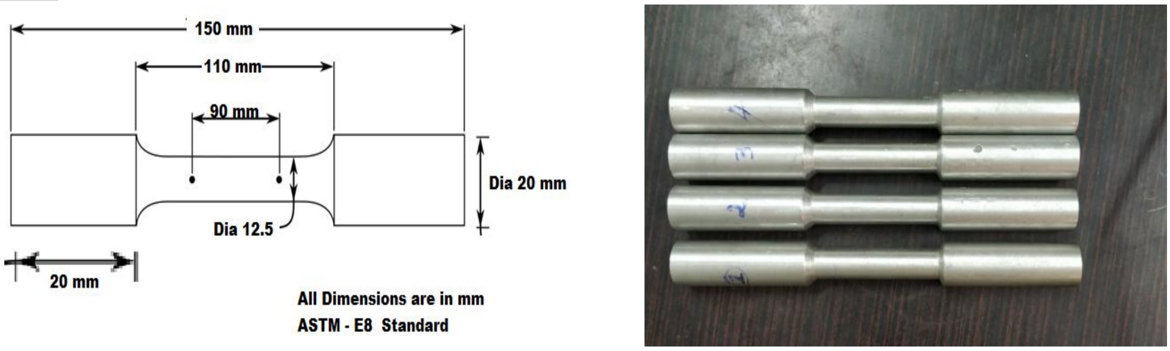


Figure 3: Tensile Test Machine Holding The Sample



(a) (b)

Figure 4. (a) Specifications of the standard tensile test sample (b) Machined Samples

It has been observed that the addition of TiB_2 particles improved the tensile strength of the composites. Tensile test results of the samples (1,2,3,4) are as shown in table 4 below:

TABLE 4. Tensile test results

Sample No	Samples	Tensile Strength (Mpa)
01	LM25	227.820
02	LM25 + B_4C (5%) + TiB_2(3%)	232.452
03	LM25 + B_4C (5%) + TiB_2(4%)	240.556
04	LM25 + B_4C (5%) + TiB_2(5%)	270.105

B. Dry Sliding Wear Test

Wear rates of the samples machined as per ASTM G99 05 as shown in Figure 5 standards were calculated using weight loss method tested on Pin On disc apparatus. An approximately strain gauged friction detecting arm holds and loads the specimen vertically on a rotating steel disc as shown in Figure6. After running through a fixed sliding distance at specific time, the specimen was removed, cleaned with acetone, dried and weighed to determine the wear rate. Table 5 shows the wear loss rate of the samples. Figure 7 shows the graph between Wear rate Vs Time.

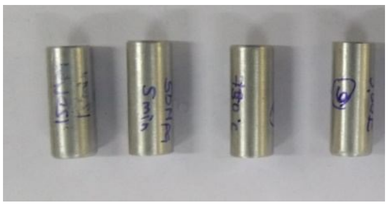


Figure 5: Wear Test Samples

Figure 6: Pin-On-Disc Apparatus

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

TABLE 5. Wear test results

Sample No	Load (kg)	Speed (rpm)	Time (min)	Initial weight (gm)	Final weight (gm)	Change in weight (gm)
01	2	500	5	6.115	6.103	0.014
02	2	500	5	6.847	6.838	0.009
03	2	500	5	6.956	6.948	0.008
04	2	500	5	6.232	6.227	0.003

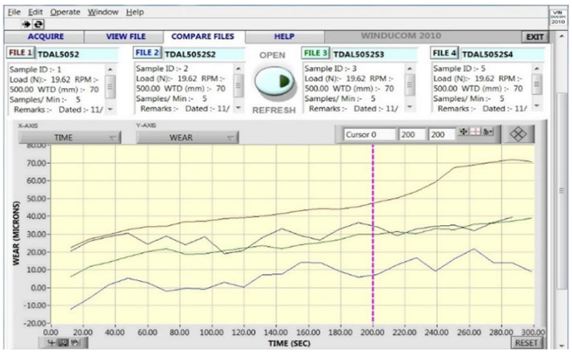


Figure 7. Wear Rate Vs Time

It can be seen that addition of reinforcements such as B_4C and TiB_2 into LM25 matrix resulted in lesser wear rate. The hybrid composite exhibited superior wear resistance when compared with base alloy.

V. MICROHARDNESS TEST

Microhardness tests were carried out using Vicker's microhardness test on the polished samples of ASTM G99 05 standards using a 1/16 inch diameter diamond indentor pressed on the sample for a specific period of time as shown in Figure 8. Table 6 shows the Vicker's microhardness test values.

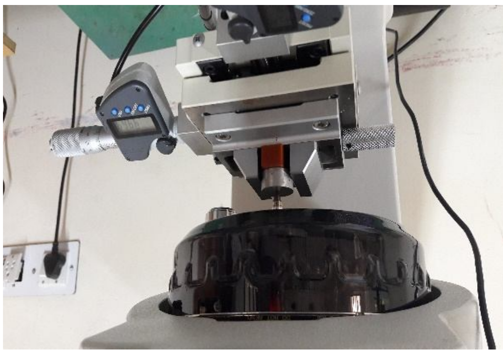


Figure 8: Vicker's MicroHardness Tester

TABLE 6. Vicker's Microhardness Test Results

Sample No.	Trial 1 [HV]	Trial 2 [HV]	Trial 3 [HV]	Indentation Depth	Average [HV]
1	122.4	121.8	132.6	3.7mm	125.6
2	152.3	147.8	145.8	3.9mm	148.6
3	165.4	163.7	159.8	4.3mm	162.9
4	179.2	181.8	186.6	4.7mm	182.5

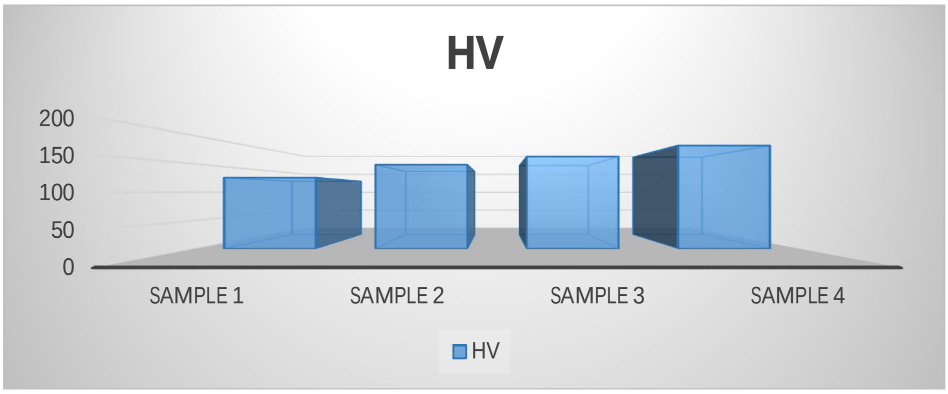


Figure 9: Hardness test Results

Hardness test results compared in Figure 9 indicate that the variation of hardness in the locations due to the uncertainty of reinforcement particles presence at the indentation location. The sample 4 with combination of 5% Boron Carbide and 5% Titanium diboride with remaining LM25 is having higher hardness and base alloy has the lower hardness because of the absence of the reinforcement particulates.

VI. CONCLUSION

In this current study, development and characterization of LM25 alloy based metal matrix composite reinforced with titanium diboride and Boron Carbide is carried out. The following conclusions were drawn from the experimental results:

A. With increase in TiB_2 levels, the tensile strength of base LM25 alloy had greatly improved.
B. From wear analysis carried out on Pin on disc apparatus, it is evident that wear rate of the fabricated Metal matrix composite decreases with increasing levels of TiB_2 tested at 2kg load levels.
C. Micro hardness test results revealed the improvement in hardness levels due to increase in Titanium Di Boride levels.

Composite having 5% B_4C and 5% TiB_2 and 90% LM25, combination fabricated at melting temperature 700°C and reinforcement pre-heat temperature 900°C has higher hardness and superior wear resistance compared to other combinations. This hybrid composite can be explored for use in applications where higher wear resistance is required.

VII. FUTURE SCOPE

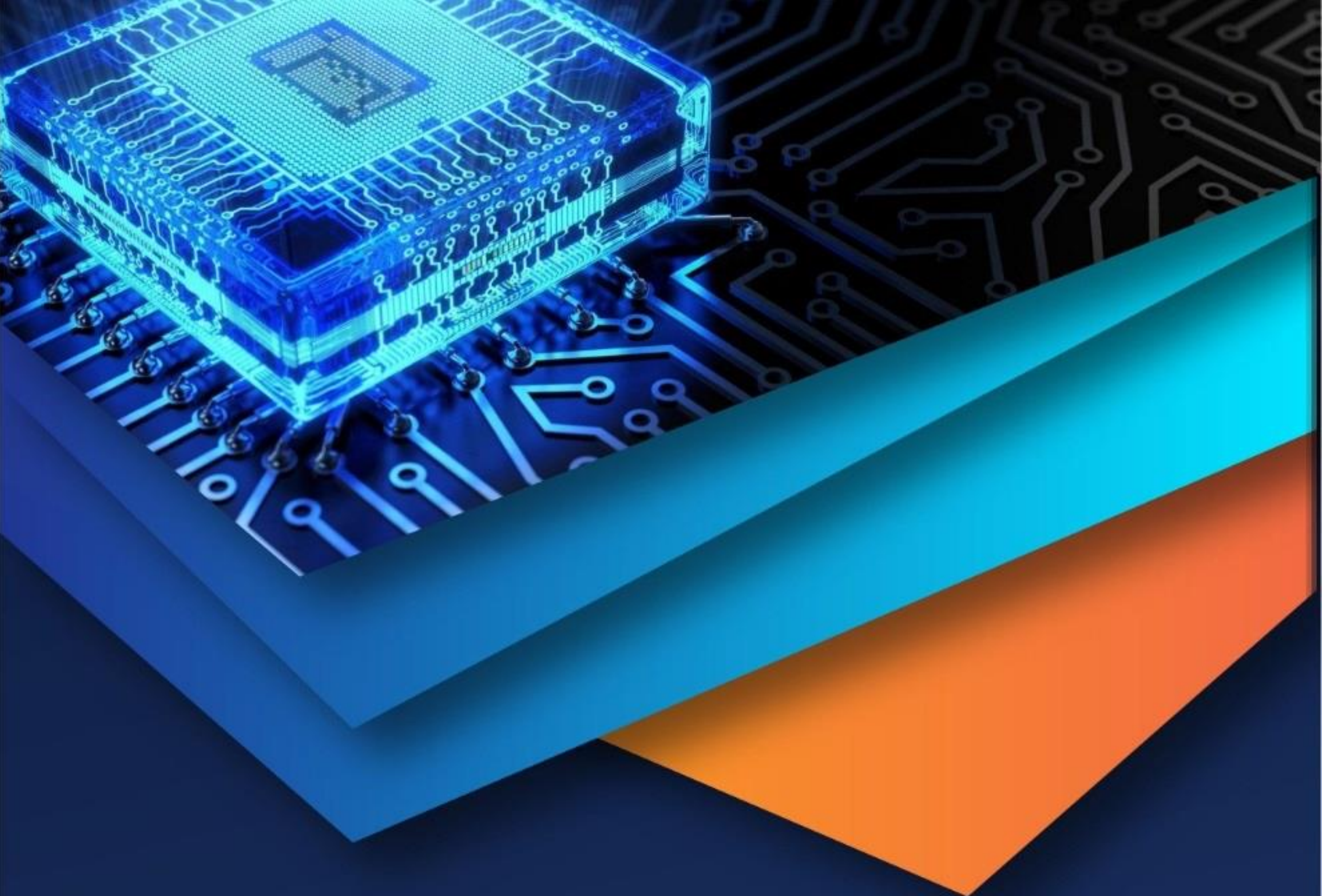
This project is focused in increasing the hardness and wear resistance of the aluminium alloys. The following may be adopted in future to explore further possibilities to improve the above properties.

A. The process parameters like stirring speed, stirring time, die pre-heat temperature, can be varied and can be optimized by any optimization technique.
B. The percentage of reinforcements can be varied.
C. The same process parameters and percentage of reinforcements can be carried out using squeeze casting or vacuum casting method.

REFERENCES

[1] S.Suresh, N.Shenbaga Vinayaga Moorthi, 2012, “Aluminium-Titanium Diboride (AlTiB2) Metal Matrix Composites: Challenges and Opportunities”, Elsevier Ltd, Procedia Engineering, 38 (2012) 89-97.
[2] Elango, BK Ragunath, 2013, “Tribological behavior of Hybrid (LM25 Al+ SiC+ TiO2) Metal Matrix Composites, Elsevier Ltd, International conference on Design and Manufacturing, Procedia Engineering 64(2013) 671-680.
[3] J.Dinesh, G.Mohammad Ashraf, N.Radhika, 2016, “Fabrication and Characterization of Al LM25/ TiB2 in-situ composites”, ARPN Journal of Engineering and Applied sciences, Vol11, No9, ISBN 1819-6608.
[4] R.Surendran, Dr.A.Kumaravel, S.Vignesh, 2014, “Tribological Behaviour of LM25 Aluminium Alloy Reinforced with Nano Aluminium oxide”, IOSR Journal of Mechanical and Civil Engineering, Volume 11, Issue 3 ver VI (May-June 2014), PP 01-07.
[5] A.Silpenyuk, V.Kuprin, Yu.Milman, 2006, “Properties of P/M Processed particle reinforced composites specified by reinforcement concentration and matrix to reinforcement particle size ratio”, Elsevier Ltd, Acta materials journals, 157-166.
[6] Mehdi Rahmanian, Nader Parvin, Naser Ehsani, 2011, “The effect of production parameters on microstructure and wear resistance of powder metallurgy Al-Al2O3 composite”, Elsevier Ltd, Materials and design 32 (2011) 1031-1038.

[7] Govindan Karthikeyan, 2016 “Dry sliding wear behavior of stir cast LM25/ZrO2 Metal matrix composites”, International Journal of Engineering research and advanced technology, Vol 02, 312-317.
[8] L.Bolzoni, N.Hari babu, 2015, “Refinement of the grain size of the LM25 alloy (A356) by 96Al-2Nb-2B master alloy”, Elsevier Ltd, Journals of Material processing technology 222, 219-223.
[9] Shanawaz patil, Robinson P, Madhu BP, 2018, “Investigation of mechanical properties of LM25 alloy reinforced with silicon carbide and Activated carbon”
[10] Dhanasekaran R, 2017, “Study of hardness of aluminium LM25 Composite”, International Journal of Engineering research and advanced technology, Volume 03, Issue 5, May 2017.
[11] Jun Hu, et al., “Ultrasonic dynamic impact effect on deformation of aluminum during micro-compression tests” Journal of Materials Processing Technology, S09240136(2018)30126-2.
[12] Jahangiri. A, et al., “The effect of pressure and pouring temperature on the porosity, microstructure, hardness and yield stress of AA2024 aluminium alloy during the squeeze casting process” Journal of Materials Processing Technology Volume 245, July 2017, Pages 1-6.
[13] Vipin K. Sharma, et al., “Effect of flyash particles with aluminium melt on the wear of aluminium metal matrix composites” Engineering Science and Technology, an International Journal, Volume 20, Issue 4, August 2017, Pages 1318-1323.
[14] Mohsen SAEEDIKHANI, Mehdi JAVIDI, Sareh VAFAKHAH, “Anodising of 2024T3 aluminium alloy in electrolyte of sulphuric− boric−phosphoric mixed acid containing cerium salt as corrosion inhibitor” Trans. Nonferrous Met. Soc. China 27(2017) 711−721
[15] Guoping Liu, et al., “Effect of T6 heat treatment on microstructure and mechanical property of 6101/A356 bimetal fabricated by squeeze casting” Materials Science & Engineering S0921-5093 (2017) 30542-7.
[16] Jianbin Zhu & Hong Yan, “Fabrication of an A356/fly-ash-mullite interpenetrating composite and its wear properties” Ceramics International Volume 43, Issue 15, 15 October 2017, Pages 12996-13003.
[17] Tania Garrido, et al., “Tailoring soy protein film properties by selecting casting or compression as processing methods” European Polymer Journal 85 (2016) 499–507.
[18] Teng Liu, et al., “An investigation into interface formation and mechanical properties of aluminium–copper bimetal by squeeze casting” Materials & Design Volume 89, 5 January 2016, Pages 1137-1146.
[19] Teng Liu, et al., “Microstructure and Mechanical Properties of Overcast 6101– 6101 Wrought Al Alloy Joint by Squeeze Casting” Journal of Materials Science & Technology Volume 32, Issue 4, April 2016, Pages 298-304.
[20] Hashem F. El-Labban, et al., “Preparation and characterization of squeeze castAl–Si piston alloy reinforced by Ni and nano-Al2O3 particles” Journal of King Saud University - Engineering Sciences Volume 28, Issue 2, July 2016, Pages 230-239.
[21] Jie Liu, et al., “Synergism between cerium nitrate and sodium dodecyl benzene sulfonate on corrosion of AA5052 aluminium alloy in3 wt.% NaCl solution” Applied Surface Science 389 (2016) 369–377.
[22] R.G. Guan, et al., “Microstructure and properties of squeeze cast A356 alloy processed with a vibrating slope” Journal of Materials Processing Technology 229 (2016) 514–519.
[23] Bhasker Soni, Somnath Biswas, “Evaluation of mechanical properties under quasi-static compression of open-cell foams of 6061-T6 Al alloy fabricated by pressurized salt infiltration casting method” Materials Characterization, S10445803(2016)30375-8.
[24] H. C. Ananda Murthy, Somit Kumar Singh, “ Influence of TiC particulate reinforcement on the corrosion behaviour of Al 6061 metal matrix composites” Advanced Materials Letters 2015, 6(7), 633-640.
[25] Matej Vesenjak, et al., “Dynamic compression of aluminium foam derived from infiltration casting of salt dough” Mechanics of Materials S0167-6636(2015)00221-5.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY