iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** IX **Month of publication:** September 2021

DOI: https://doi.org/10.22214/ijraset.2021.38199

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue IX Sep 2021- Available at www.ijraset.com

Experimental Investigation on Surface Roughness and Metal Removal Rate of Aluminium 2024 Alloy

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Abstract: The purpose of this work is to investigate experimentally the surface roughness and MRR while machining of aluminium 2024 alloy which is prepared by powder metallurgical technique. Aluminium 2024 alloy prepared with different composition such as Pure Al, 1.5 W% of Mg and 2-6 % of Cu powders. Powders are blended with ball milling machine according to the composition required and specimens are prepared in square shape die (25*25mm) by applying uniaxial load of 200Mpa. The sintering process was performed at 594 ^{0}C for 60 min and cooled at room temperature. SEM and XRD analysis was carried out to know various characteristics like green density, dimensional changes during sintering, sintering density, mechanical properties and microstructures. Finally the Surface roughness and MRR during machining with CNC milling machine at different depth of cuts was also evaluated.

Keywords: Aluminium 2024 alloy, surface roughness, MRR, SEM and XRD analysis

I. INTRODUCTION

Aluminium alloys can be categorized into a number of groups based on the particular material's characteristics such as its ability to respond to thermal and mechanical treatment and the primary alloying element added to the aluminium alloy. When we consider the numbering / identification system used for aluminium alloys, the above characteristics are identified. The wrought and cast aluminium have different systems of identification. The wrought system is a 4-digit system and the castings having a 3-digit and 1-decimal place system. Aluminium 2024 is heat-treatable aluminium alloy with copper as the primary alloying element. It is used in applications requiring high strength to weight ratio, as well as good fatigue resistance. It is weldable only through friction welding, and has average machinability.

Due to poor corrosion resistance, it is often clad with aluminium or Al-1Zn for protection, although this may reduce the fatigue strength. In older systems of terminology, 2XXX series alloys were known as duralumin, and this alloy was named 24ST. 2024 aluminium is an alloy that is often used in the aerospace industry.

Each alloy contains a specific percentage of alloying elements that imbue the base aluminium with certain beneficial qualities. In 2024 aluminium alloy, these elemental percentages are 4.4% Cu, 1.5% Mg, and 0.6% Mn, nominally. This breakdown explains why 2024 aluminium is known for its high strength because copper, magnesium, and manganese greatly increase the strength of aluminium alloys. This strength comes at a disadvantage, however; the high percentage of copper in 2024 aluminium greatly reduces its resistance to corrosion. There are usually trace amounts of impurity elements (silicon, iron, zinc, titanium, etc.), but these are only purposefully given tolerances as-per the buyer's request. Its density is (2.77g/cm^3), which is slightly higher than pure aluminium (2.7g/cm^3). 2024 aluminium is machined very easily and has decent workability, allowing it to be both cut and extruded if need be.

II. METHODOLOGY

The customer may be satisfied only if the quality of the product is up to the mark. Product should be produced within the lead time and with sufficient accuracy according to the customer demand. For a powder metallurgy aluminum alloys mainly accuracy and near-net shape parts are important criterion to justify the products. The texture of the production part is given by material removal rate (MRR) and Surface Roughness (SR) should be maximized and minimized respectively to get the good product quality. The powder metallurgy products to provide the shape of the elements in the desired geometry, dimensional accuracy and surface finish. The production industries facing lot of challenges to increase the productivity without compromising the product quality. Hence, the conventional production methods is replaced by powder metallurgy techniques to adequate Material Removal Rate and less in Surface Roughness. The main objective of the present work is to prepare an Al2024 alloy using powder metallurgical technique, to identify microstructure with SEM analysis, to examine crystal structure with XRD analysis and finally to examine the machinability of Al2024.

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III.EXPERIMENTATION

The present work is done according to the following steps, the elements were taken in the weight percentage of parent material. Initially Ball milling is performed to get required shape and size of the element. The square die is used to get the shape of the material (i.e.25mm*25mm). The manual processing is performed to get required shape and size of the materials. 10 ton hydraulic press is used to compact the materials. Sintering is performed the compact specimens of the materials. Material Removal Rate is measured the sintered specimens. Material chemical compositions are analyzed by using EDAX. Atomic structures are finding by using XRD. Tally Surface Roughness tester is used to get Surface Roughness values.

The following powder form raw material is used to produce the Al 2024 alloy.

Aluminium (Al) powder, with 98% purity, Copper (Cu) with 99.0% purity and Magnesium (Mg) purity is 99.8%.

The chemical composition of material was taken as the weight percentage of the parent material. As show in the below tables.

Table 1: Chemical composition of materials

SAMPLE	COMPOSITION
1	Pure Al
2	Al-1.5%Mg
3	Al- 1.5%Mg - 2%Cu
4	Al- 1.5%Mg -3%Cu
5	Al- 1.5%Mg -4%Cu
6	Al- 1.5%Mg -5%Cu
7	Al- 1.5%Mg -6%Cu

Table 2. Material weights

Sample No and Composition	Aluminium(g)	Copper(g)	Magnesium(g)
S1: Pure Al	11.8125	0	0
S2: Al-1.5 Mg	11.5395	0	0.1757
S3: A l-1.5% Mg - 2% Cu	11.4641	0.2376	0.1782
S4: A l-1.5% Mg - 3% Cu	11.4256	0.3589	0.1795
S5: A l-1.5% Mg - 4% Cu	11.3865	0.4820	0.1807
S6: A l-1.5% Mg - 5% Cu	11.3469	0.6068	0.1820
S7: A l-1.5% Mg - 6% Cu	11.3067	0.7334	0.1834

IV.SEM ANALYSIS

The scanning electron microscope (SEM) is used for chemical composition analysis the images are as shown below.

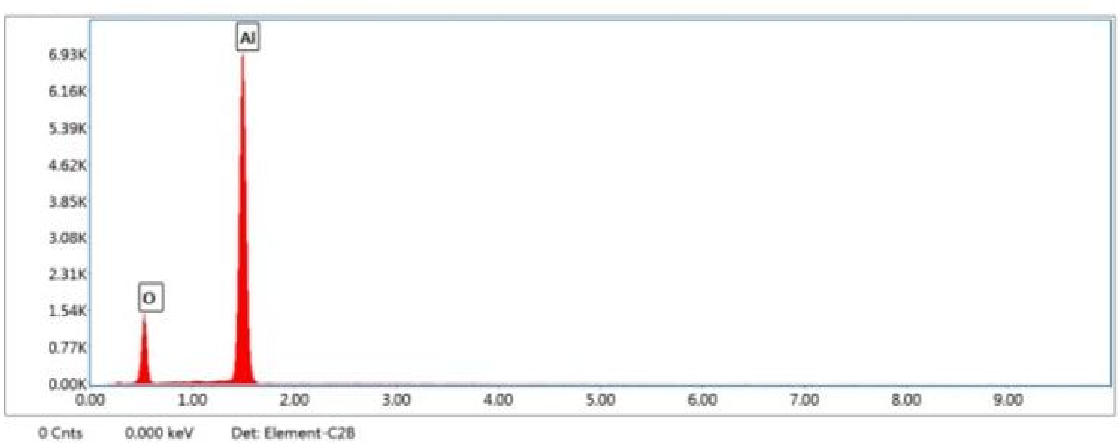

Fig-1: Sample 1 major portion is pure aluminium.

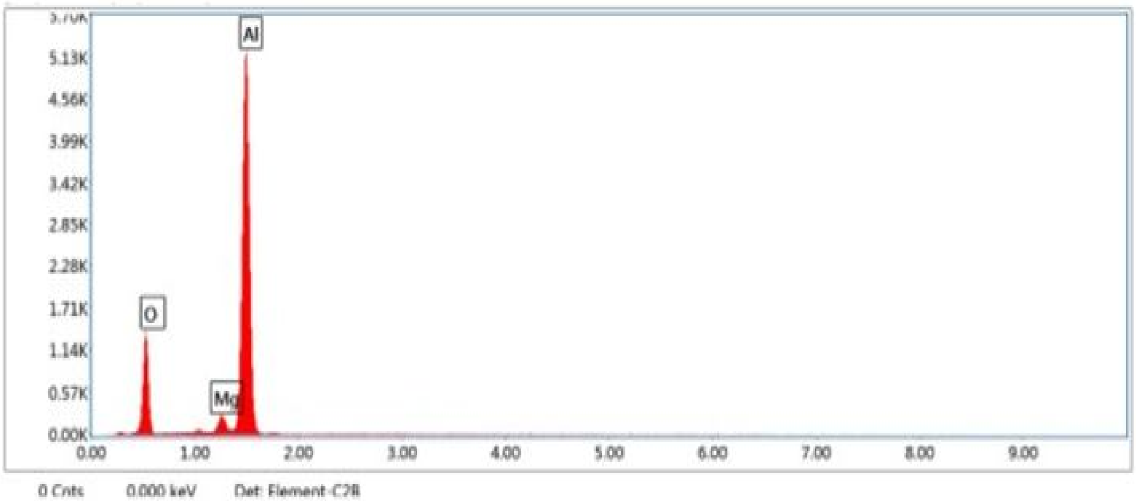

Fig-2: Sample 2 aluminium and magnesium.

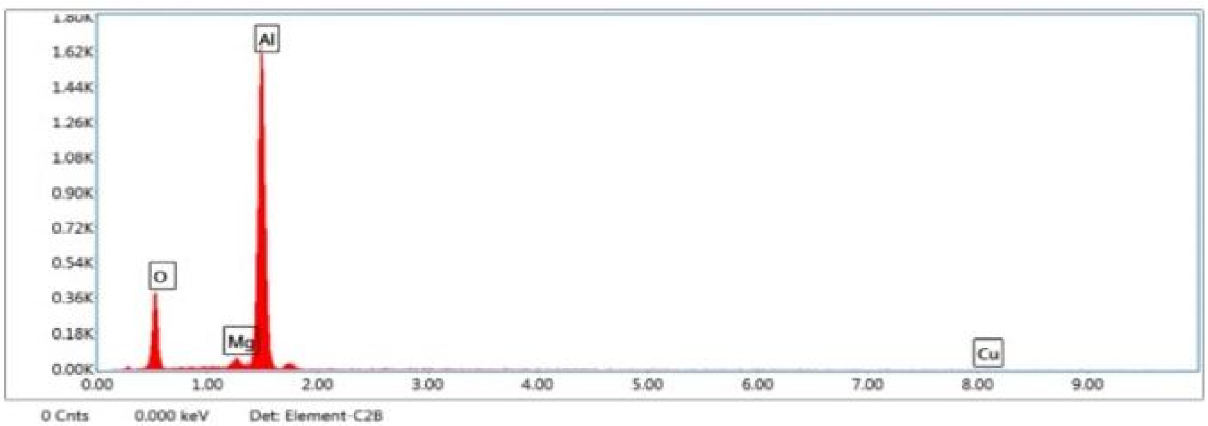

Fig-3: Sample 3 aluminium, copper and magnesium.

V. XRD ANALYSIS

X-Ray Diffraction (XRD) was performed to analyze the crystal structure of Aluminium alloy. The images are as shown below.

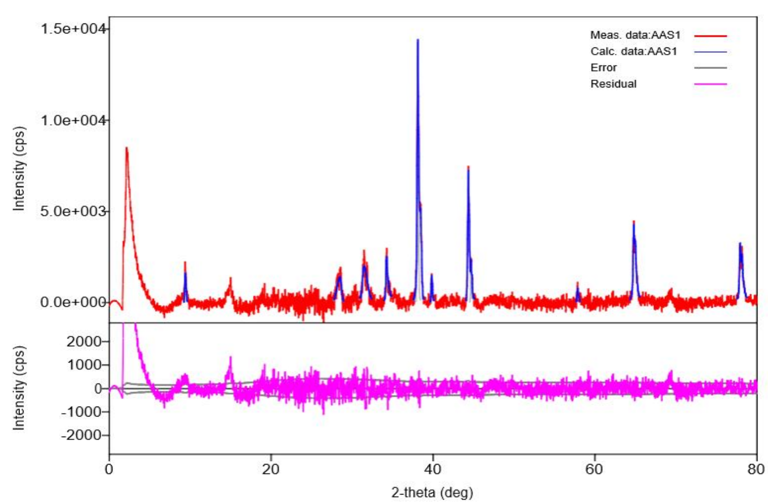

Fig-4: Sample 1 XRD Graph

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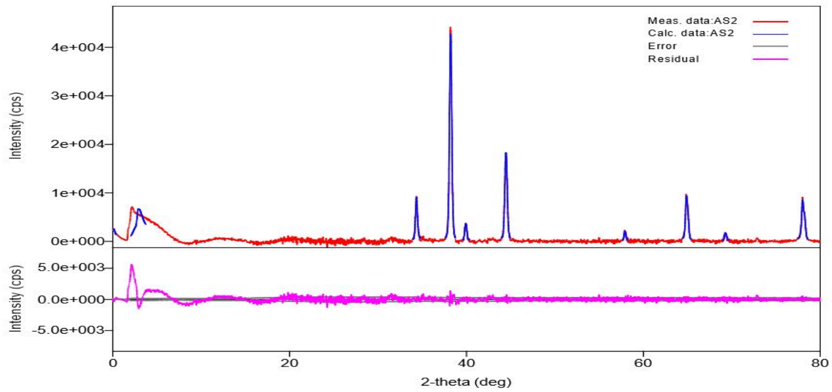


Fig-5: Sample 2 XRD Graph

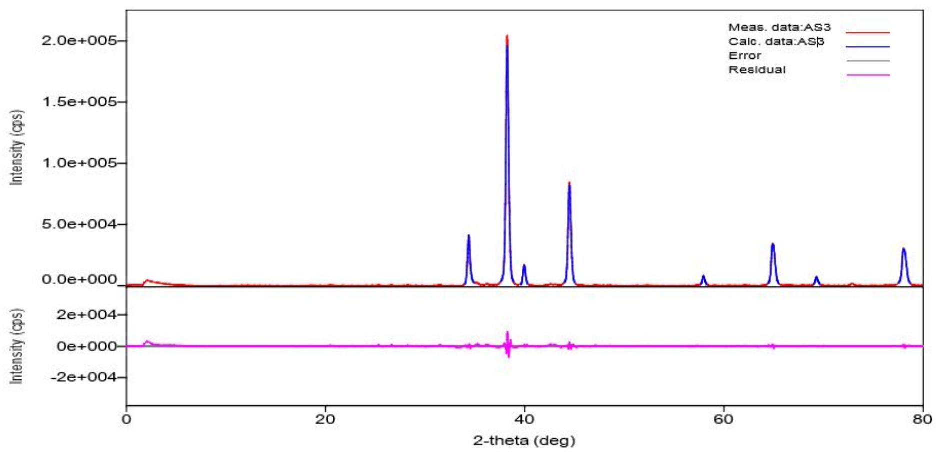


Fig-6: Sample 3 XRD Graph

A. Material Removal Rate

The material removal rate is obtained by using a milling machine for variations in the Depth of Cut and feed rate. It causes the hardness of the materials to be found. The rate of removal of the material depends on the hardness of the material. While changing thefeed rate of the components and the values obtained, the material removal rate is calculatedon the basis of these values.

MRR Formulae: **MRR=D*W*F**

Where D= Depth of cut (mm)
W=Width of cut (mm)
F=Feed rate (mm/min)

Table 3 : Material Removal Rate Values

SAMPLE	Depth of cut(mm)			
	0.5	1	1.5	2.0
Pure Al	62.5	125	187.5	250
Al-1.5%Mg	50	100	150	200
Al- 1.5%Mg - 2%Cu	50	100	150	200
Al- 1.5%Mg -3%Cu	37.5	75	112.5	150
Al- 1.5%Mg -4%Cu	37.5	75	112.5	150
Al- 1.5%Mg -5%Cu	25	50	75	100
Al- 1.5%Mg -6%Cu	25	50	75	100

B. Surface Roughness

The surface roughness is determined by using a surface roughness tester. Surface roughness is carried out by each depth of cutting of the samples.

Table 4 : Surface Roughness Values

SAMPLE	SURFACE ROUGHNESS VALUE (µm)	DEPTH OF CUT(mm)			
		0.5	1	1.5	2.0
Pure Al	R1	3.36	6.73	5.47	5.88
Al-1.5%Mg	R2	1.83	3.72	5.55	4.16
Al- 1.5%Mg - 2%Cu	R3	1.38	2.69	3.53	2.73
Al- 1.5%Mg -3%Cu	R4	2.28	2.36	2.42	4.13
Al- 1.5%Mg -4%Cu	R5	1.30	4.01	2.08	3.56
Al- 1.5%Mg -5%Cu	R6	1.38	2.79	2.29	2.34
Al- 1.5%Mg -6%Cu	R7	1.57	3.63	3.63	2.68

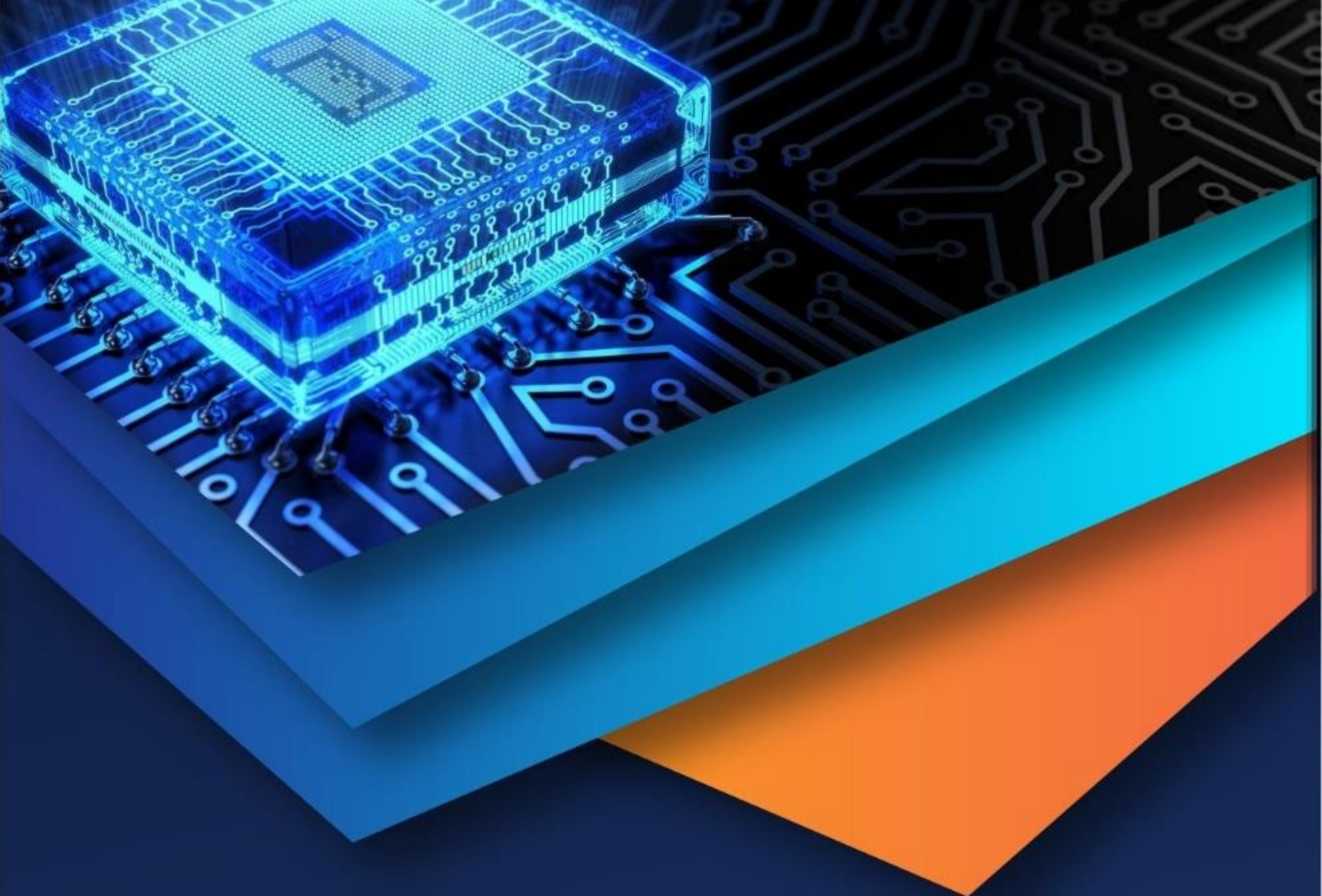
VI. CONCLUSION

This experimental investigation study has reached the following conclusions. The Al2024 alloy was manufactured successfully through conventional powder metallurgical technique with less oxidation on sintered samples. The microstructure of the alloy was given a clear picture about internal structure and it was observed through SEM analysis. The fine grain structure were observed in SEM analysis which means the strength of alloy was increased. The XRD analysis shows that the oxidation levels and various levels of chemical elements that are present in the alloy. It also confirmed that Face Centered Cubic structure is existing in the Al2024 alloy. The material removal rate is increased with increase in depth of cut. Also the surface roughness of the alloy was reduced with increase in weight present of the Copper element in the alloy. But by increase in weight percent of the Copper the density of the alloy were increased so that the weight of the manufacturing component will increase. The machinability of the alloy were increased with increase in weight percent ofthe Copper in Aluminium alloy.

REFERENCES

[1] Gregory A.W sweet, “microstructural Evolution of a forged 2XXX Al powder metallurgy alloy”. Material cauterization 151, pp. -342-350, 2019.
[2] F.Erdemir and A.Ccanakcai “microstructural characterization and mechanical properties of functional graded Al2024/Sic composites prepared by Powder Metallurgy techniques”. Transaction of non- ferrous metals society of china 25pp-3569-3577, 2015.
[3] Young Do Kim “sintering characteristics of Al2o3 –reinforced 2XXX series Al composite powders”. Journal of alloys and compounds400, pp-50-153, 2005.
[4] M.Abdel-Rahman “workability in forging compacts of powder metallurgy compacts”. Journal of processing technology54, pp-97-102, 1995.
[5] D.P.Bishop “press and sinter processing of PM counterpart to wrought Al 2618”. Journal of material processing technology230, pp-72-79, 2016.
[6] G.A.Sweet and D.P.Bishop “powder metallurgy processing of 2XXX series APM metal alloy reinforced with Al particulate additions”. Material science and engineering A755, pp-10-17, 2019.
[7] D.L.Zhang “Effects of holding time during sintering of post forging annealing on the microstructural and mechanical properties of Ti parts fabricated by powder compact forging”. Material Science and Engineering A655, pp-113-121, 2016.
[8] D.P.Bishop “Hot deformation of Al-Cu-Mg powder metallurgy alloy”. Material science and engineering A528, pp-5476-5483, 2011.
[9] R.Seetharaman and S.Kanmani subbu “Hot workability and densification behaviour of sintered powder metallurgy Al –B4C performs during upsetting”. Journal of manufacturing process28, pp-309-318, 2017.
[10] R. Chandramoulli “Deformation, Densification and corrosion studies of sintered powder metallurgy plain carbon steel preforms”. Material and Design 25, pp-2260- 2264, 2017.
[11] L.P.Lefebure “Effects of lubricants and compacting pressure on the process ability and properties of aluminium powder metallurgy parts”. Journal of light metals 2, pp-239-246, 2002.
[12] M.A.Jabbari Talegani “Microstructural and mechanical characteristics of 7075 Al alloy consolidated from a premixed powder by cold compaction and hot extrusion”.Materials and Design55, pp-674-682, 2014.
[13] D.P.Bishop “Powder metallurgy processing of 2XXX and 7XXX series aluminiumalloys”. Canadian metallurgical quarterly 50, pp-246-252, 2011.
[14] M Mili et al 2018 IOP Conference Series: Materials Science and Engineering.
[15] Li, P., Chen, T., & Qin, H. (2017). The microstructure and mechanical properties of Al2024-SiCp composite fabricated by powder thixoforming. Journal of Materials Research, 32(11), 2079-2091.
[16] L, Bharath Reddy, et al., Formation and Evaluation of Tensile Strength and Hardness Properties of AL2024 Alloy Reinforced With Boron Carbide Particulates. (January 7, 2020). Volume.7, Issue 1, Page No pp.494-501, January 2020.

[17] B. T. Ramesh, R. P. Swamy and Koppad Vinayak, AIP Conference Proceedings 1943, 020101 (2018)
[18] H.S. Kumaraswamy, V. Bharat, T. Krishna Rao, Influence of Mechanical & Tribological Behaviour of Al 2024 MMC Fabricated By Stir Casting Technique- A Review, Materials Today: Proceedings, Volume 5, Issue 5, Part 2, 2018, Pages 11962-11970
[19] Bhargavi Rebba, N. Ramanaiah, Evaluation of Mechanical Properties of Aluminium Alloy (Al-2024) Reinforced with Molybdenum Disulphide (MOS2) Metal Matrix Composites, Procedia Materials Science, Volume 6, 2014, Pages 1161-1169,
[20] Effect of Solutionizing on Dry Sliding Wear of Al2024-Beryl Metal Matrix Composite December 2012 JOURNAL OF MECHANICAL ENGINEERING AND SCIENCES 281-290
[21] K. Punith Gowda, J. N. Prakash, Shivashankare Gowda, Effect of Particulate Reinforcement on the Mechanical Properties of Al2024-WC MMCs, Journal of Minerals and Materials Characterization and Engineering, January 2015, 469-476.
[22] Jaswinder Singh, Amit Chauhan "Characterization of hybrid aluminum matrix composites for advanced applications – A review" Journal of Materials Reasearch and Technology, Volume 3, pp 101-194 (2015)
[23] Reddy G. Chandrakanth, K. Rajkumar, Sivanandam Aravindan, "Fabrication of copper–TiC–graphite hybrid metal matrix composites through microwave processing" The International Journal of Advanced Manufacturing Technology, Volume 48, pp 645-653, (2010)



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