International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 07 | July - 2022 Impact Factor: 7.185 ISSN: 2582-3930

Development and Characterization of Aluminium Reinforced with MWCNT and Fly-Ash Using Powder Metallurgy Technique

LAKSHMIKANTHA M R[1], AKSHAY S[2],

AMBARISHA V A[3], ROHITH KUMAR T G[4]

Mr. Manjunath Naik H R[5]

[1234]UG students,Department of Mechanical Engineering, SJB Institute of Technology, Bangalore-560060,Karnataka, India.

[5]Assistant Professor, Departmentof Mechanical Engineering, SJB Institute of Technology, Bangalore-560060, Karnataka, India.

ABSTRACT

The main AIM of this study is to develop MWCNT and Fly ash reinforced aluminium composites by using Powder metallurgy process. Aluminium reinforced with MWCNT And Fly- ash via powder metallurgy (PM) technique can provide a very distinct advantage. The prepared composites are characterized by the mechanical properties, structural properties on MWCNT and Fly ash.

In recent years, the utilization of Composites has increased in various areas of science and technology, due to their special physical, mechanical, and wear properties. Of all the Composites, aluminium-based composites particularly are finding a lot of scope, due to their excellent high strength to weight ratio, high stiffness, higher thermal conductivity as well as corrosion, and wear resistance properties. Therefore, aluminium based, composites have the potential to replace the conventional materials in the field of automobile, aerospace, construction, house-hold appliances, and food packaging industries. In the past decades, various materials have been used as reinforcements to fabricate aluminium composites.

Composites have gained importance and considered as future engineering materials. These composite materials are used in various fields such as automotive, aerospace, civil and other structural fields. Composite materials possess higher specific strength, lower density, better physical and mechanical properties compared to the base materials. Aluminium Composites have gained increasing commercial applications over the years. The property of composite materials mainly depends on the percentage weight of reinforced material in the base material and the process of developing such composite materials.

The objective of the study is to develop the appropriate materials having low density with high strength and modulus. Composites has been emerged as a promising material for structural and engineering applications for aerospace, automobile, engines and biomaterial devices. The (MWCNT) are gaining more importance due to their enhanced thermal and electrical conductivity. MWCNT as a reinforcing particulate for the purpose to enhance the characteristics including low density, high strength, and hardness together with excellent thermal and electrical conductivity of the aluminium Composites.

Fly ash is also known as alumina-silicate particles, has been incorporated in to metal matrix composites for the last few decades mainly to reduced their weight, manufacturing cost and enhancing selected properties. Fly ash for reinforcement was found one of the most important criteria for fabricating aluminium matrix composites. Fly ash is one of the most promising inexpensive and low density reinforcement available in large quantities among other reinforcement. Even though, it is a solid waste by-product obtained from thermal power plants the advantages of fly ash such as low density, strong filling ability, excellent fluidity and good processibility of the filled materials.

INTRODUCTION

Aluminium is one of the lightest engineering metals and does the third most common element comprise 8% of the earth's crust. Low strength and hardness of aluminium, which limits its use in many engineering applications, could be increased through the addition of microparticles. Multi walled Carbon nanotubes are nano materials, which are gaining popularity as good reinforcements due to their distinctive properties. MWCNTs are attractive reinforcement materials for composites not only due to their high strength and elastic modulus, but also due to their exceptionally small diameters. Multi walled carbon nanotubes reinforcement would possess better tensile and compressive properties compared to pure Aluminium.

Powder metallurgy (PM) technique is the preferred route for most researchers due to most common and cheaper production route for composite fabrication and characterized by good dimensional and geometrical precision as well as good mechanical properties. Using PM process several properties of composite can be improved such as hardness, wear resistance, mechanical durability, thermal durability, and thermal conductivity with decreased density of the material

Multi walled Carbon nanotubes are nano materials, which are gaining popularity as good reinforcements due to their distinctive properties. MWCNTs are attractive reinforcement materials for composites not only due to their high strength and elastic modulus, but also due to their exceptionally small diameters. This is because, when the same weight of MWCNTs is contained in composites, the number of MWCNTs in composite increases as the diameter of MWCNTs becomes smaller. And, when the MWCNTs are uniformly dispersed in the composites, the respective matrix domains enclosed by the MWCNTs become extremely small. It is expected that the Aluminium composites with Multi walled carbon nanotubes reinforcement would possess better tensile and compressive properties compared to pure Aluminium.

The hardness of the obtained composites is also expected to be greater than that of pure aluminium. The Al-MWCNT composite is found to be affluent in improving the mechanical properties such that even for a small amount of MWCNT addition the response ineffective. The improvement in strength primarily depends on the dispersive phenomenon of MWCNTs and the bonding between the reinforcement (MWCNT) and matrix. The improvement in mechanical properties of Al-MWCNTs also depends upon nature of processing techniques, microstructure, grain size, amount and type of reinforcement.

Powder metallurgy (PM) technique is the preferred route for most researchers due to most common and cheaper production route for composite fabrication and characterized by good dimensional and geometrical precision as well as good mechanical properties. Using PM process several properties of composite can be improved such as hardness, wear resistance, mechanical durability, thermal durability, and thermal conductivity with decreased density of the material. With this improvement in nanocomposite properties, the material exhibited better quality and can be used in many applications whereby demand of quality and less material are high especially in automotive and aerospace applications.

Powder metallurgy and ingot melting route can be subdivided into four different methods. A composite produced by powder metallurgy route has significant influence on strength enhancement owing to fine grain size obtained by powder metallurgy route when compared with liquid phase processing.

Composite materials are playing vital and major role in research and development of various engineering and aeronautical sectors. In the past three decades composite materials are replaced most of the traditional materials because of obtaining superior properties such as higher specific strength, high hardness, high wear resistance, high thermal resistance and low density. For obtaining best result of mechanical properties specifically aluminium metal matrix composites have preferred in aeronautics, marine and automotive industries.

Powder Metallurgy

Powder metallurgy is science of producing metal powders and making finished / semifinished objects from mixed or alloyed powders with or without the addition of nonmetallic constituents. This is one of the most common routes to synthesize a metal matrix composite. The reinforcements used in this process are generally particulates or whiskers reinforced MMCs. The powder metallurgy is one of the popular solid-state methods used in production of metal matrix composites. The matrix and the reinforcement powders are blended to produce a homogeneous distribution. In this process, prepared powders of both matrix and reinforcement phases are mixed and blended together. This mixture is put in a mould of required shape and appropriate pressure is applied to compact the powder. Then the compacted form of the powder is heated at a sufficiently high temperature in an inert atmosphere to develop proper bonding between the matrix and reinforcement through solid state diffusion. This is the sintering process. Hot pressing can also be used to directly press the blended mixture of powders.

APPLICATIONS

The applications of P/M are quite extensive. Metal powders are being used in thefabrication of tungsten lamp filament, dental restoration, oil-less bearing, automotivetransmission gears, armour piercing projectiles, electrical contacts, nuclear power fuelelements, orthopedic implants, business,machines, high temperature filters, aircraftbrake pads, rechargeable batteries, and jet engine components.

RESULTS & DISCUSSIONS

Table 1.1 Hardness value of composites

Sl no	Composition by weight percentage	Rockwell Hardness Number	% Improvement in Hardness
01	AL 100%	45.73	Nil
02	AL80%-MWCNT20%	49.83	8.58
03	AL70%-MWCNT20%-FLYASH10%	52.86	14.93
04	AL60%-MWCNT20%-FLYASH20%	55.73	20.95

05	AL50%-MWCNT20%-FLYASH30%	58.76	27.29
06	AL30%-MWCNT20%-FLYASH50%	58.13	23.88

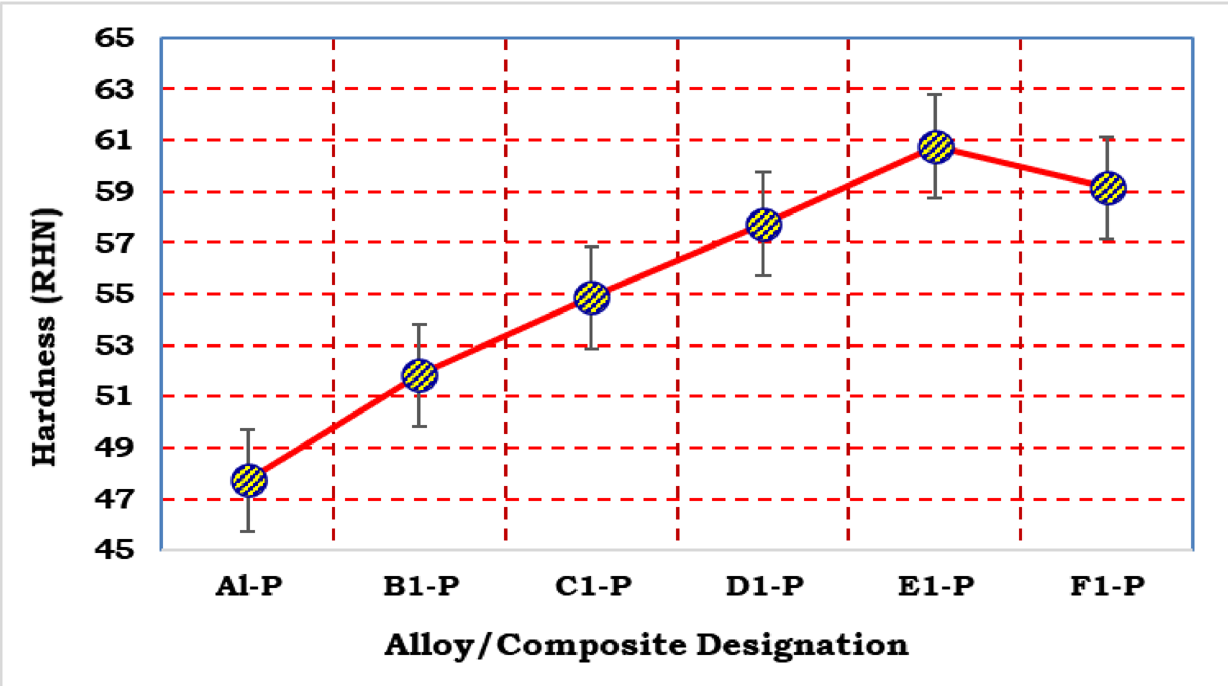

Fig1.1 Graphical representations of hardness values

It was observed that the hardness values were increased with increase in composition of Fly ash in Aluminium-Fly ash and MWCNT composite. Initially the hardness is 47.73 and it was increased to 60.76 on increasing the fly ash percentage.

Compression Test

The compression test is carried out on the specimen to find out the compression strength of the composite synthesized. Compression test were carried out in a Computerized Universal Testing Machine with a capacity of 1000 KN. Specimens are of standard cylindrical shape having l/d ratio less than 2 (short specimen) were prepared as per ASTM standard EN09. it can be observed that compressive strength increases with increase in the percentage of MWCNT up to 2 wt%. Higher value is observed in the sample having 2 wt% of MWCNT as reinforcement. This clearly indicates that the increase in the strength is attributed to the presence of MWCNT in the matrix which acts as an obstacle for crack propagation in turn increasing the strength of the composites. It is also clear that there is adequate bond between the MWCNT reinforcement and the Al-6061 matrix material. It is also observed that the specimen S4 with 2 wt% MWCNT as reinforcement shows 12% increase in the strength when compared to unreinforced Al-6061 alloy.

Table 2.0: Results of compression test carried on sintered Al-Fly-ash + MWCNT composites

S/No	Al-Fly-ash+MWCNT Composition	Designation	UCS (MPa)	%decreasein compression
1	As-castAl	Al-P	112.8	Nil
2	Al+ 2Wt. % MWCNT	B1-P	121.3	7.34
3	Al+(2 %MWCNTs:1 %Fly-ash)	C1-P	132.2	16.75
4	Al+ (2% MWCNTs:2 %Fly-ash)	D1-P	141.6	24.87
5	Al+ (2% MWCNTs:3 %Fly-ash)	E1-P	149.4	30.74
6	Al+ (2%MWMWCNTs:5 %Fly-ash)	F1-P	143.5	27.37

Compression test results of sintered Al+Fly-ash+MWCNT composites

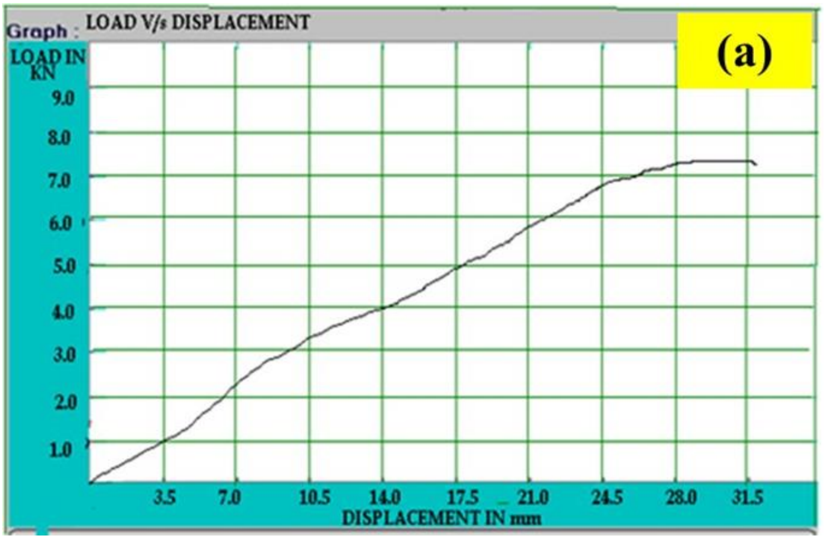

Fig 2.1 Graphical representations of Load (kN) V/s Displacement (mm) curve of Pure Aluminium.

Fig 2.2 Graphical representations of Load (kN) V/s Displacement (mm) curve of Al + 2 Wt. % MWCNT.

Fig 2.3 Graphical representations of Load (kN) V/s Displacement (mm) curve of Al + 2 Wt. % MWCNT+ 1 Wt. % fly ash.

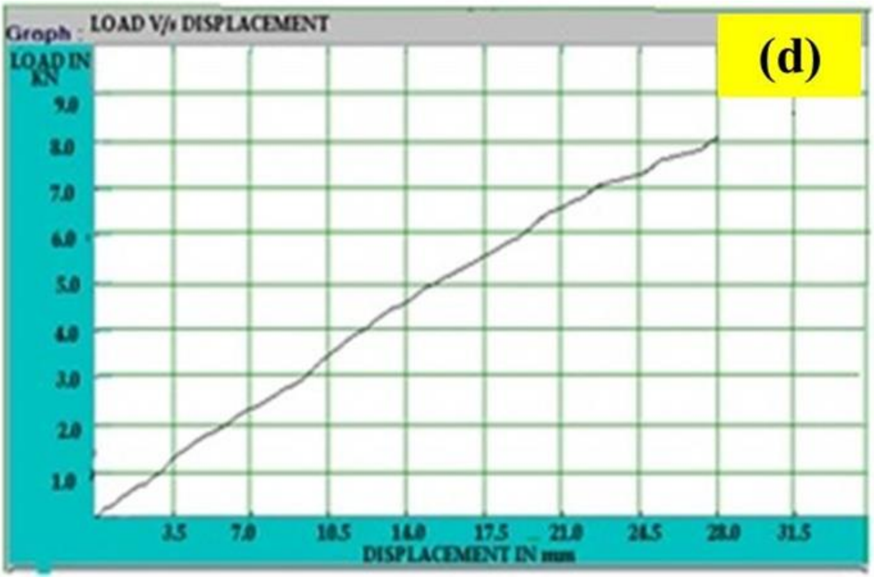

Fig 2.4 Graphical representations of Load (kN) V/s Displacement (mm) curve of Al + 2 Wt. % MWCNT+ 2 Wt. % fly ash.

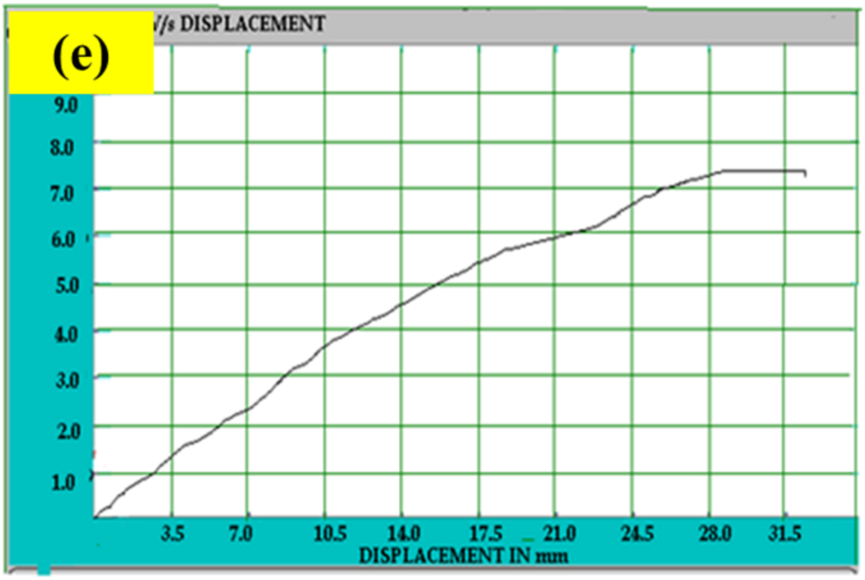

Fig 2.5 Graphical representations of Load (kN) V/s Displacement (mm) curve of Al + 2 Wt. % MWCNT+ 3 Wt. % fly ash.

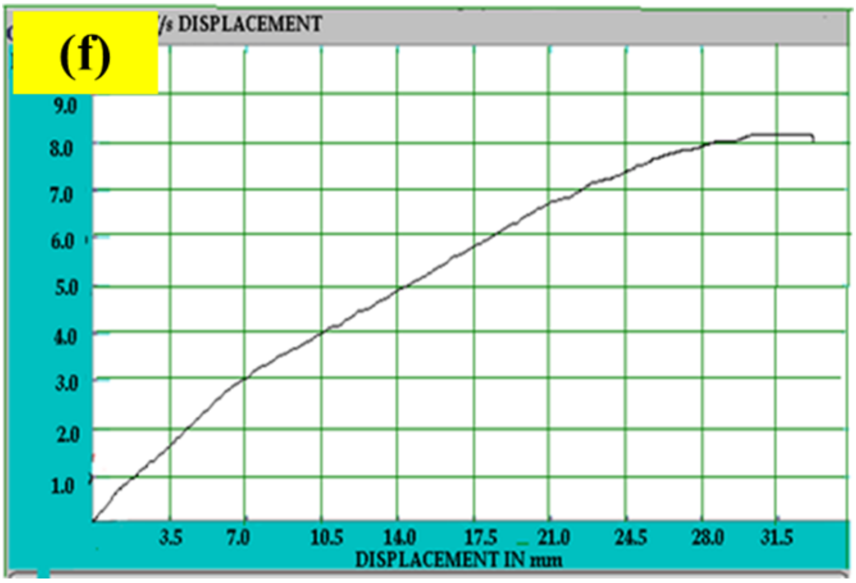

Fig 2.6 Graphical representations of Load (kN) V/s Displacement (mm) curve of Al + 2 Wt. % MWCNT+ 5 Wt. % fly ash.

Microstructural characterization of sintered Al/Fly-ash/MWCNT using Optical microscope (OM)

The samples for microstructure study are equipped in the shape of tubular slices of (Ø13 mm * 5 mm), to attain glass surface. The specimens are properly grinded, polished, and etched. Sandpapers are available in different grit sizes in the market. The initial phase, of material is ongoing, begins through a hard coarse (possibly 60 or 80 grate) & all successive phase utilizes a sharper coarse, such as 220, 400, 600 and elevated grind abrasives, till the chosen surface is attained. Also, at each grit of sandpapers, the polishing are done by rotating the specimen by 900 in a particular fashion. Hence at each grit the specimen are moved on the paper in a particular fashion, 'To' motion and 'Fro' motion and the same motion should be repeated after the 900 rotation. In this project study, Sandpapers of grit size 220 µm, 400µm, 800µm and then Grade 1.0, 2.0, 3.0, 4.0 and 5.0 are respectively used for polishing purposes.

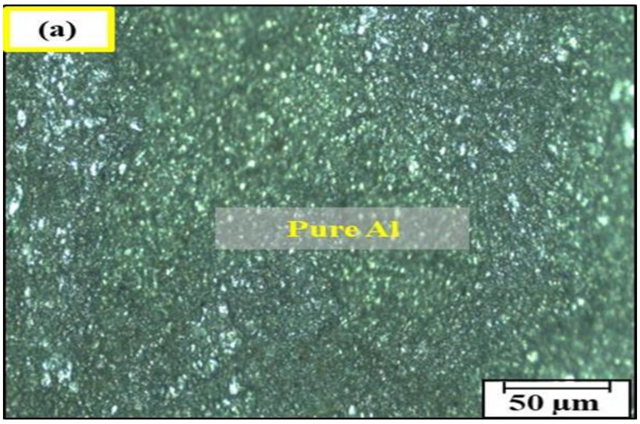

Figure 3.1 (a): Micrograph (Optical) of Pure Aluminium

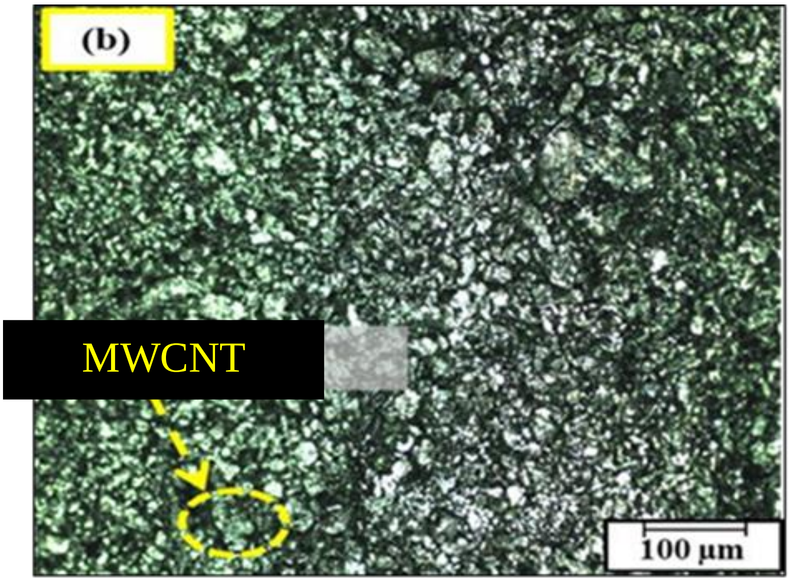

Figure 3.1 (b): Micrograph (Optical) of Al + 2 Wt. % MWCNT

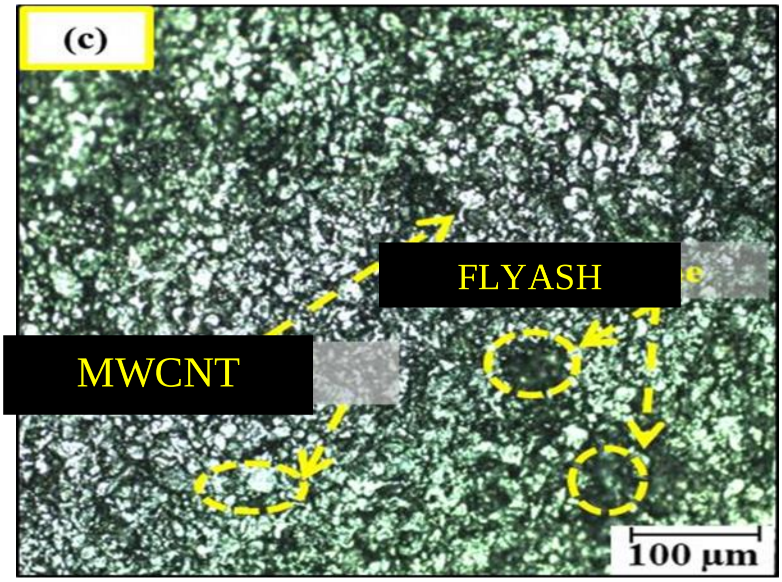

Figure 3.1 (c): Micrograph (Optical) of Al + 2 Wt. % MWCNT + 1 Wt. % Fly-ash

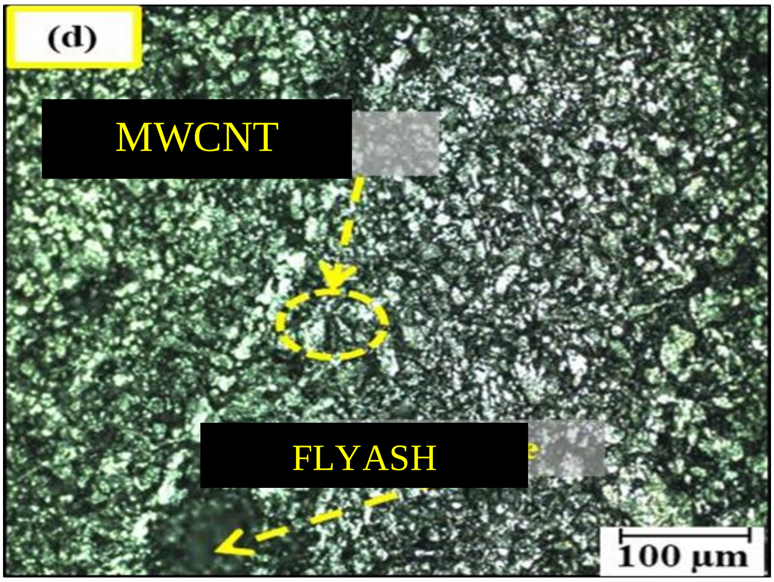

Figure 3.1 (d): Micrograph (Optical) of Al + 2 Wt. % MWCNT + 2 Wt. % Fly-ash

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 07 | July - 2022 Impact Factor: 7.185 ISSN: 2582-3930

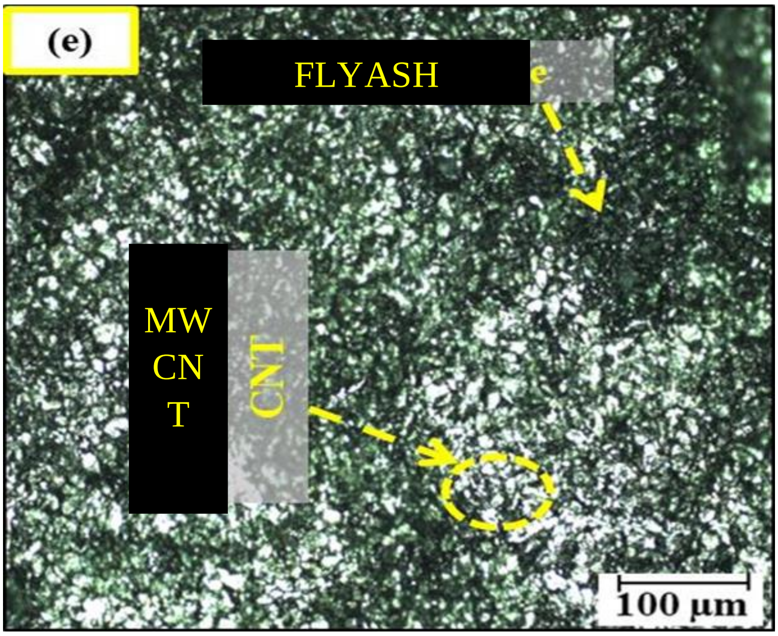

Figure 3.1 (e): Micrograph (Optical) of Al + 2 Wt. % MWCNT + 3 Wt. % Fly-ash

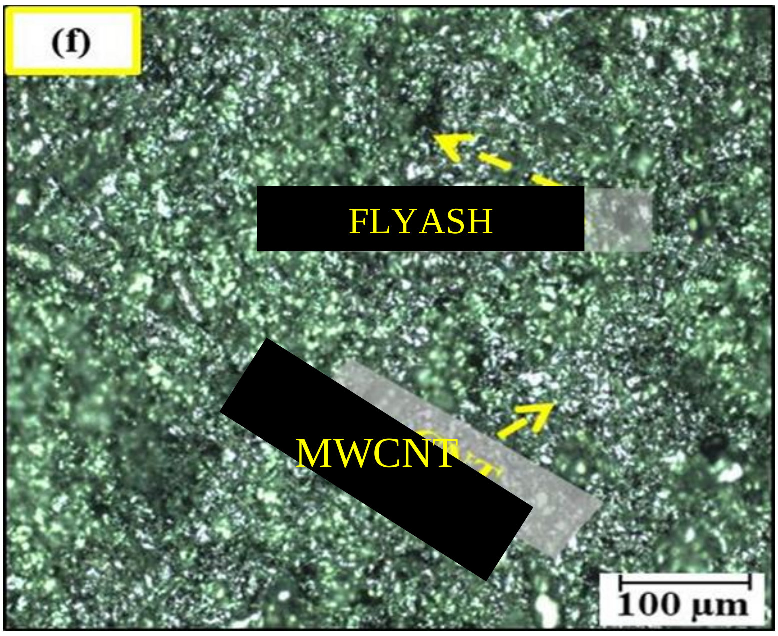

Figure 3.1 (f): Micrograph (Optical) of Al + 2 Wt. % MWCNT + 5 Wt. % Fly-ash

CONCLUSIONS

Present study has highlighted the need for developing aluminium reinforcement multiwalled carbon nanotubes and fly ash composites have been prepared by using powder metallurgy. The industrial waste fly ash and multiwalled carbon nanotubes are turn into industrial wealth by light weight composites with high strength. Determining the mechanical properties of the prepared composites. Microstructure of the aluminium reinforcement composite has been studied. The experimentation of compression strength is conducted on the specimens and found the ultimate compression strength. The specimen has been fabricated for experimentation and observed under scanning electron beam microscope for microstructure study. Understand the variation in mechanical properties before and after reinforcement to the aluminium.

The specimens of aluminum reinforcement multi-walled carbon nanotubes and Fly-ash reinforced composites has been prepared by using Powder Metallurgy method. Microstructure of the aluminum reinforcement composite has been studied. The experimentation for compression strength is conducted on the specimens and found the ultimate compression strength. The specimens has been fabricated for experimentation and observed under scanning electron beam microscope for microstructure study.

REFERENCES

1. Manjunath Naik HR, Manjunath LH, Vinayak Malik, Manjunath Patel GC, Kuldeep K Saxena, Avinash Lakshmikanthan Advances in Materials and Processing Technologies, 1-14, 2021 Effect of microstructure, mechanical and wear on Al-CNTs/graphene hybrid MMC'S

2. A K Shrivastava, C L Xu, B Q Wei, R Kishore and K N Sood, 2008, 'Microstructural features and mechanical properties of carbon nanotubes reinforced aluminium based metal matrix composites', vol 15, june 2008 pp, 247-255.

3 Balamurugan Adhithan, Hari Prasada Rao Pydi, 'Microstructure Analysis of the Carbon NanoTubes Aluminum Composite with different Manufacturing Conditions', International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064.

4. Gehad Goudah, Faiz Ahmad, O. Mamat ,'Micro structural studies of sintered carbon nanotubes reinforced copper matrix composite', Journal of Engineering Science and Technology, Vol. 5, No. 3 (2010) 272 – 283.

5. K M.S. Senthil Saravanan, S.P. Kumaresh Babu, K. Sivaprasad, 2010 'Mechanically Alloyed Carbon Nanotubes (MWCNT) Reinforced Nano crystalline AA 4032: Synthesis and Characterization', Journal of Minerals & Materials Characterization & Engineering, Vol. 9, No.11, pp.1027- 1035.

6. K.E. Thomson, D. Jiang, W. Yao, R.O. Ritchie, A.K. Mukherjee,2011, 'Characterization and mechanical testing of alumina-based nano composites reinforced with niobium and/or carbon nanotubes fabricated by spark plasma sintering', Acta Materialia 60 (2012) 622–632.

7. ManjunathaL.H. P.Dinesh, 'Fabrication and Properties of dispersed carbon nanotube–Al6061', composites International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, ISSN: 2319-8753.

8. Mohamed Mahmoud Emara, 'Effect of Consolidation Conditions on the Tensile Behavior of Pure Aluminium Carbon Nanotubes Reinforced Metal Matrix Composites', Journal of Materials Science and Engineering A 3 (4) (2013) 232-236.

9. RupeshKhare, Suryasarathi Bose, 'Carbon Nanotube Based Composites- A Review', Journal of Minerals & Materials Characterization & Engineering, Vol. 4, No.1, pp: 31-46, 2005.

10. Umma A, Maleque M.A, Iskandar I.Y and Mohammed Y.A, 2012, 'Carbon Nano tube Reinforced Aluminium Matrix Nano-Composite: a Critical Review', Australian Journal of Basic and Applied Sciences, 6(12): 69-75, 2012 ISSN 1991- 8178.

11. Sudarshan, and M. K. Surappa, "Synthesis of fly ash particle reinforced A356 Al composites and their characterization," Material Science and Engineering- A, vol. 480 (1-2), pp. 117-124, 2008.

12 M. B. Mahagundappa, H. K. Shivanand, and M. Muralidhara, "Influence of Reinforcements and Thermal Ageing on the Mechanical Properties of Al (6061) Based Hybrid Composites," India Foundry Journal, vol. 52, pp. 20-43, 2006.

13.H. Ahlatci, E. Candan, and H. Cimenoglu, "Abrasive wear and mechanical properties of Al-Si/SiC composites," Wear, vol. 257, pp. 625-632, 2004.

14. P. K. Rohatgi, “Low-Cost, fly-ash-containing aluminum–matrix composites,” JOM, vol. 46, pp. 55–69, 1994.

15. P. K. Rohatgi, R. Q. Guo, P. Huang, and S. Ray, “Friction and abrasion resistance of cast aluminum alloy–fly ash composites,” Metal Mater Trans, vol. 28, pp. 245–50, 1997.

16. B. N. Keshavaram, K. G. Satyanarayana, B. Majumdar, P. K. Rohatgi, B. Duttagur, In Proc. ICF-6, 1984. p. 2979.

17. P. K. Rohatgi, “Synthesis of metal matrix composites containing Fly-ash, Fly-ashaphite, glass, ceramics or other metals,” U.S. Patent 5228494, 1993.

18. P. K. Rohatgi, R. Q. Guo, H. Iksan, and R. Asthana, “Pressure infiltration technique for synthesis of aluminum–fly ash particulate composite,” Mater Sci. Eng. A, vol. 244, pp. 22–30, 1998.

19. P. K. Rohatgi, “Method of producing metal matrix composites containing fly ash,” U. S. Patent 5711362, 1998.