Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Synthesis and testing of aluminium composite using industrial waste as reinforcement

R. Akash [a], R. Muraliraja [b,*], R. Suthan [a], V.S. Shaisundaram [c]

[a] Department of Mechanical Engineering, Panimalar Engineering College, Chennai, India
[b] Department of Mechanical Engineering, Vels Institute of Science Technology and Advanced Studies, Chennai, India
[c] Department of Automobile Engineering, Vels Institute of Science Technology and Advanced Studies, Chennai, India

ARTICLE INFO

Article history:
Received 19 May 2020
Accepted 24 May 2020
Available online xxxx

Keywords:
Composites
Waste reinforcement
Characterisation
Hardness
Compression
Wear
Friction

ABSTRACT

Composite is made of two or more elements with different physical or chemical properties are combined together to form a new material. The property of the produced material shows elevated properties when compared to individual elements. Composites has two major elements called matrixes and reinforcements. Aluminium matrix composites are commonly used in many industrial and automobile applications because of its availability, high strength to weight ratio, good wear and corrosion resistance. Reinforcement is added into the composite to improve the tribological and mechanical properties, also it reduces the cost of the composites. The Al_2O_3 and SiC are the favourable elements for aluminium to make to make internal bonding between the matrix and reinforcement. In this research work, the new material is formulated using powder metallurgy process, aluminium is selected as matrix material and waste Al_2O_3material from oil refinery industry is used as reinforcement material. The composition of new materials is 0%, 5% and 10% were added as reinforcement based on weight. The produced substrate is tested for mechanical properties such as hardness, compression. The tribological properties such as wear and friction were tested using pin on disc tribometer. The characterisation is done on the produced substrate using scanning electron microscope, energy dispersive X-Ray analysis and X-Ray diffraction.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Newer Trends and Innovation in Mechanical Engineering: Materials Science.

1. Introduction

The potential application of the aluminium matrix composites is aerospace, defence, food, automobile, structural and various engineering divisions since it has high stiffness, high resistance to wear and seizure as compared to the aluminium alloy. The composites are majorly classified into polymer matrix composites (nylon, polyester, epoxy, pp, abs, pc), metal matrix composites (aluminium, copper, magnesium, nickel) and ceramic matrix composites (glass, silicon, cement) based on, matrix material. Based on reinforcement it is classified into whisker, particle (large particle, dispersion), fibre (continuous, short, hybrid) and structural (laminate, sandwich) reinforcement. For the last two decades, particle reinforced metal matrix composite are more popular among researches to optimise mechanical and tribological properties for the modern trend applications. The main focus of current researches on aluminium and magnesium because of significant and elevated properties in corrosion, density, wear and exceptional tribomechanica lproperties.

Currently, researchers are developing new aluminium composite material by adding waste material as reinforcement to reduce the cost. Some of the recent works found in the literatures are discussed. Joseph et. al. studied the mechanical properties of aluminium metal matrix composite reinforced with agricultural waste. The obtained results are significantly high when compared to pure aluminium [1]. Dinaharan et. al. [2] used industrial fly ash as reinforcement to produce aluminium metal matrix composites and identified the wear mechanism involved in the composites which is processed by friction stir processing. The new material properties are significantly improved compared to the composites available commercially. The hardness of the material was improved from 62 to 125 HV. The wear rate is 411×10^{-5} mm^3 /m at 0 vol% and 203×10^{-5} mm^3 /m at 18 vol%. Kenneth and Kazeem investigated the effect of hybrid composite with alumina, rice husk and graphene as reinforcement, the wear rate increased

* Corresponding author.
E-mail address: muralimechraja@gmail.com (R. Muraliraja).

https://doi.org/10.1016/j.matpr.2020.05.627
2214-7853/© 2020 Elsevier Ltd. All rights reserved.
Selection and peer-review under responsibility of the scientific committee of the International Conference on Newer Trends and Innovation in Mechanical Engineering: Materials Science.

Please cite this article as: R. Akash, R. Muraliraja, R. Suthan et al., Synthesis and testing of aluminium composite using industrial waste as reinforcement, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2020.05.627

with increase in the graphite content from 0.5 to 1.5 wt% [3]. Singla et. al. [4] studied the wear behaviour of aluminium 6061 alloy with reinforcement as sic, al2o3 and ead mud. The addition of red mud reduces the cost of the material. The composite which has 7.5% of red mud produces high hardness and wear resistance. Alaneme ET. Al. used rice husk ash as reinforcement to improve the corrosion and wear behaviour, it was observed that addition of rice husk and silicon carbide improves both corrosion and wear properties at 7.5% of reinforcement. the different waste reinforcement have been incorporated in the aluminium composites are quarry dust [5], basalt [6], agro waste [7], egg shell [8],corn cob ash [9], carbonised maize stock [10,14–18], palm oil clinkers [11] and so on are used effectively to reduce the cost of the composite. The mechanical property of aluminium composite is improved with addition of alumina and rice husk ash. The hardness is improved to 11% and tensile strength is improved to 8% [9,18–23]. Ajith Kumar senapati ET. Al. reviewed the use of scarp material in metal matrix composites. Fly ash, rice husk and coconut shell are reviewed critically, it revealed that the cost of the material is reduced and also the properties such as mechanical, physical, tribogical property of the metal matrix composites can be improved. These composites can be used in industrial and automotive applications [12]. Pradeep Kumar et al. used waste car alloy wheel is used as matrix material to produce the novel material. The prepared composite showed enhanced tensile strength of 125 MPa and compressive strength of 312 MPa [13,4,25].

In this research work, waste al2o3 is collected from oil refinery industry in Oman, the serened material is used as reinforcement to reduce the cost of aluminium composite. To minimize casting defects such as porosity, blow holes and shrinkage powder metallurgy process is adopted. Mixing of matrix and reinforcement is done using ball milling process. The compaction and sintering process is done with the help UTM and muffle furnace respectively. The mechanical properties such as hardness and compression. The prepared substrates are analysed using X-ray diffraction, scanning electron microscope and energy dispersive x-ray analysis.

2. Experimental details and proceduers

The aluminium metal powder of 50 μm size is purchased from local vendor. The sample of waste aluminium oxide is collected from oil refinery industry from Oman. The die size selected for powder metallurgy process is 25 mm diameter and 150 mm height. The mixing of matrix and reinforcement is done with the help of hand stirring process 10 mins. The prepared powder is filled into the die and compaction is done with the help of top punch using UTM machine with a applied load of 49KN. Finally, the green compact is sintered for 5 hrs at the temperature of 530○C then it is cooled under ambient temperature. The prepared samples are tested for hardness value using Wilson wolpert machine (model number: MVD 410) in Vickers hardness scale. The load applied on sample is 0.3Kgf dwell time is 10 sec at 3 different locations finally considered average of hardness values as hardness number. The compression test is done using UTM machine with a capacity of 10KN. The obtained samples is then given to wire EDM for getting desired shape and size of 10 mm diameter and 10 mm height. X-ray diffraction test was analysed using shimago machine. SEM and EDAX was analysed using thermos scientific machine.

3. Results and discussion

3.1. Hardness analysis

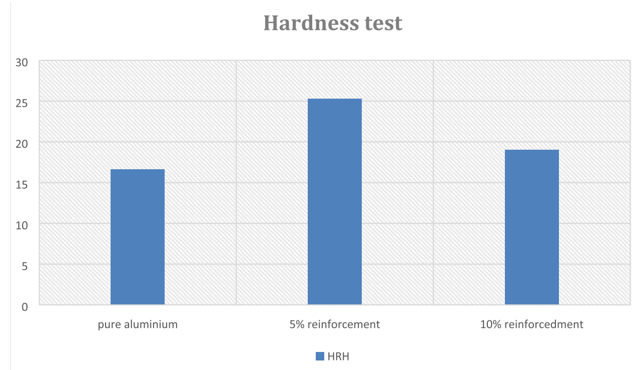

Fig. 1. Hardness value for the produced substrate.

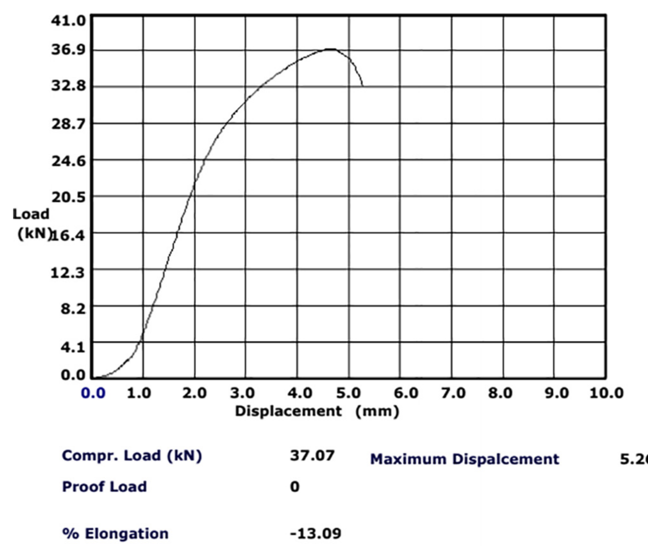

Fig. 2. Compression test result for 0% reinforcement.

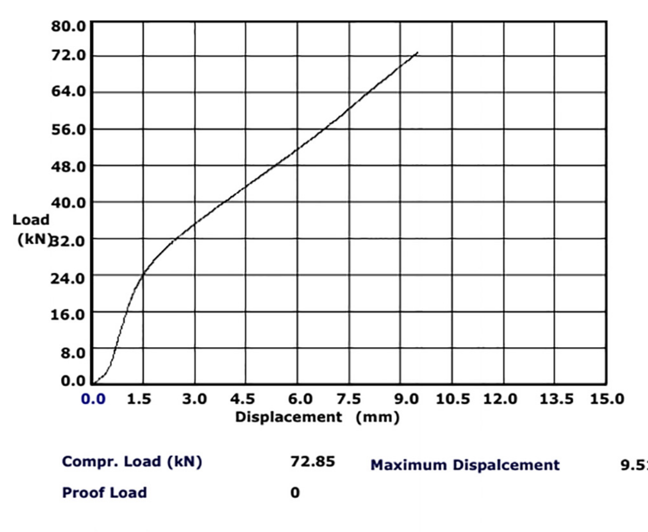

Fig. 3. Compression test result for 5% reinforcement.

Fig. 1 shows the hardness value of produced substrates. It depicts that when compared to pure aluminium and 10% reinforcement, the sample which has 5% of reinforcement gives highest hardness value. The reason behind the improved hardness is the

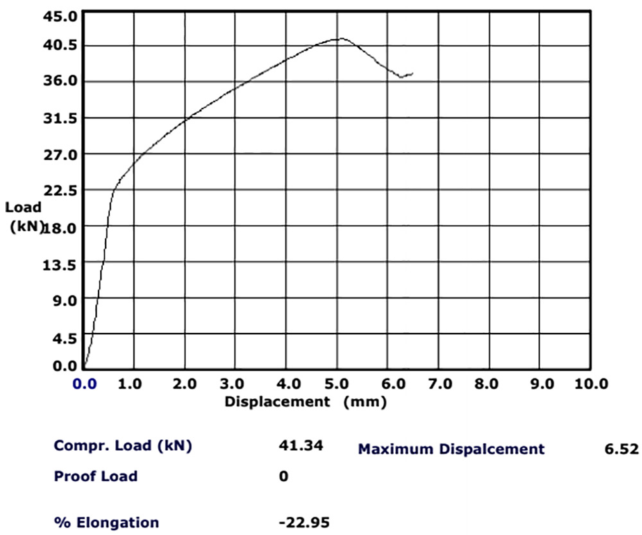

Fig. 4. Compression test result for 10% reinforcement.

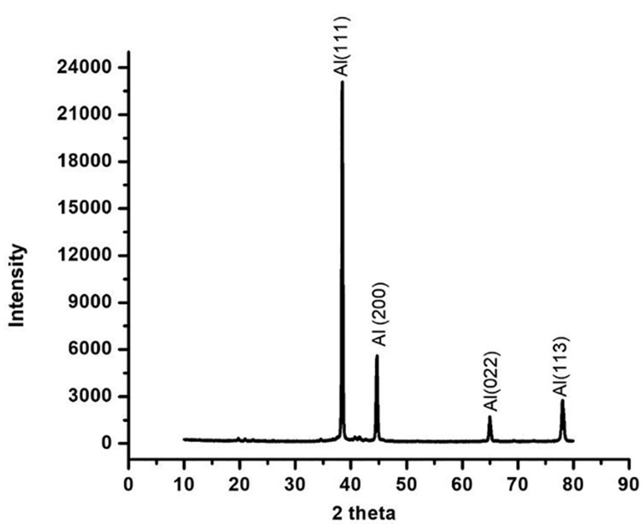

Fig. 5. X-ray diffraction of 0% reinforcement.

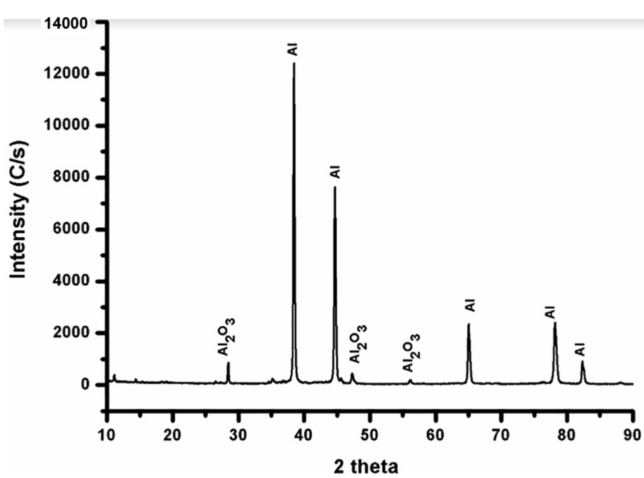

Fig. 6. X-ray diffraction of 5% reinforcement.

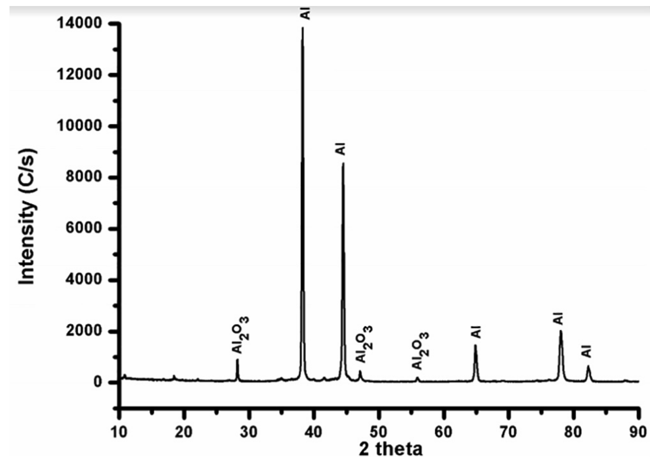

Fig. 7. X-ray diffraction of 10% reinforcement.

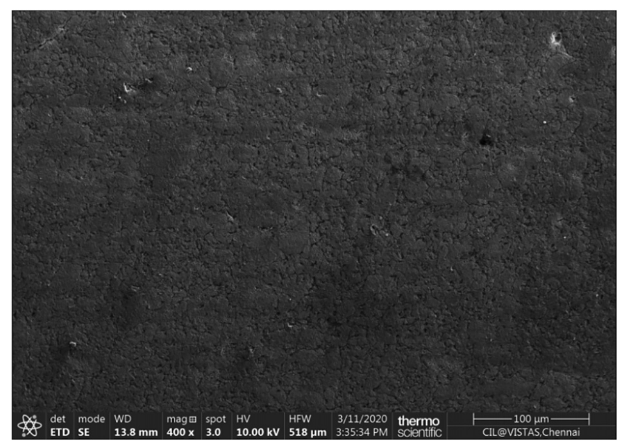

Fig. 8. SEM micrograph of 0% reinforcement.

point load applied on the surface of the substrate is shared with the reinforcement added. The pure aluminium has the hardness value of 17 HRH, the sample has 5% and 10% of reinforcement shows the hardness value of 25 and 19 HRH respectively.

3.2. Compression analysis

Figs. 2–4 shows the graph of compression test results for the substrates produced using powder metallurgy process. It is observed from the graph that the substrate produced without reinforcement which is shown in Fig. 2 has the compression strength of 10 MPa whereas the substrates produced using 5% and 10% of reinforcement has the compression strength of 22 and 12 MPa. It is predicted that the applied load on the substrate withstand more load than pure aluminium alloy.

3.3. XRD analysis

It is observed from the Fig. 5, there is no identification of Al2O3 on the sample because it has no reinforcement. It is also considered as one of the evident of the addition of reinforcement of different percentage. In Figs. 6 and 7, the intensity value of the sample is varied and also the traces of Al2O3 are observed for the sample 5% and 10%.

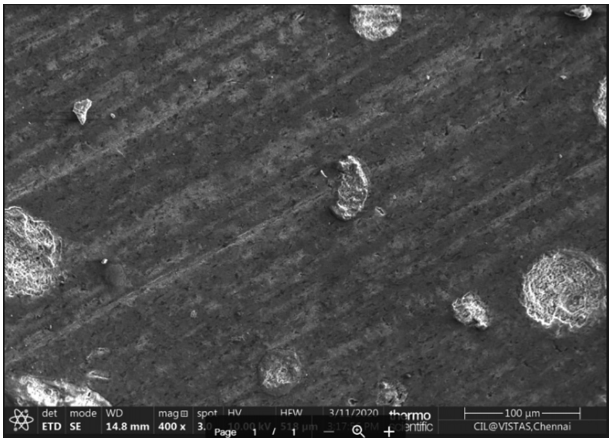

Fig. 9. SEM micrograph of 5% reinforcement.

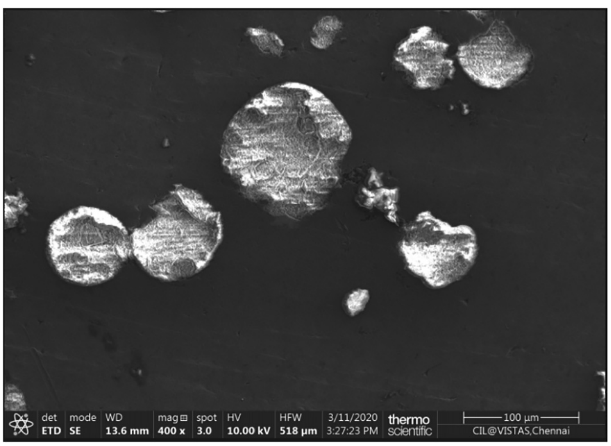

Fig. 10. SEM micrograph of 10% reinforcement.

3.4. SEM analysis

The Figs. 8–10 shows the SEM micrograph of prepared substrates it clearly depicts that the reinforcement are successfully incorporated in 5 and 10% in the substrate. The added reinforcement mixed well with the matrix it is clearly visible in the micrograph. The percentage of porosity is very less in all the substrate because of its manufacturing method selected.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] O.O. Joseph, K.O. Babaremu, Agricultural waste as a reinforcement particulate for aluminum metal matrix composite (AMMCs): A review, Fibers 7 (4) (2019) 33.

[2] I. Dinaharan, R. Nelson, S.J. Vijay, E.T. Akinlabi, Microstructure and wear characterization of aluminum matrix composites reinforced with industrial waste fly ash particulates synthesized by friction stir processing, Mater. Charact. 118 (2016) 149–158.

[3] K.K. Alaneme, K.O. Sanusi, Microstructural characteristics, mechanical and wear behaviour of aluminium matrix hybrid composites reinforced with alumina, rice husk ash and graphite, Eng. Sci. Technol. Int. J. 18 (3) (2015) 416–422.

[4] Y.K. Singla, R. Chhibber, H. Bansal, A. Kalra, Wear behavior of aluminum alloy 6061-based composites reinforced with SiC, Al 2 O 3, and red mud: a comparative study, JOM 67 (9) (2015) 2160–2169.

[5] M. Ramesh, T. Karthikeyan, A. Kumaravel, Effect of reinforcement of natural residue (quarry dust) to enhance the properties of aluminium metal matrix composites, J. Ind. Pollut. Control 30 (1) (2014).

[6] G. Venkatachalam, A. Kumaravel, Mechanical behaviour of aluminium alloy reinforced with SiC/Fly Ash/Basalt composite for brake rotor, Polym. Polym. Compos. 25 (3) (2017) 203–208.

[7] L. Lancaster, M.H. Lung, D. Sujan. (2013). Utilization of agro-industrial waste in metal matrix composites: towards sustainability, in: Proceedings of World Academy of Science, Engineering and Technology. World Academy of Science, Engineering and Technology (WASET), No. 73, p. 1136.

[8] S.P. Dwivedi, S. Sharma, R.K. Mishra, Characterization of waste eggshells and CaCO 3 reinforced AA2014 green metal matrix composites: a green approach in the synthesis of composites, Int. J. Precis. Eng. Manuf. 17 (10) (2016) 1383–1393.

[9] O.B. Fatile, J.I. Akinruli, A.A. Amori, Microstructure and mechanical behaviour of stir-cast Al-Mg-Sl alloy matrix hybrid composite reinforced with corn cob ash and silicon carbide, Int. J. Eng. Technol. Innov. 4 (4) (2014) 251.

[10] J.E. Oghenevweta, V.S. Aigbodion, G.B. Nyior, F. Asuke, Mechanical properties and microstructural analysis of Al–Si–Mg/carbonized maize stalk waste particulate composites, J. King Saud Univ. Eng. Sci. 28 (2) (2016) 222–229.

[11] Y.B. Zamri, J.B. Shamsul, M.M. Amin, Potential of palm oil clinker as reinforcement in aluminium matrix composites for tribological applications, Int. J. Mech. Mater. Eng. 6 (1) (2011) 10–17.

[12] A.K. Senapati, P.K. Sahoo, A. Singh, S. Dash, V.S. Manas, A review on utilization of waste material as reinforcement in MMCs, Int. J. Res. Advent Technol. 3 (5) (2015) 15–20.

[13] P.K. Krishnan, J.V. Christy, R. Arunachalam, A.H.I. Mourad, R. Muraliraja, M. Al-Maharbi, M.M. Chandra, Production of aluminum alloy-based metal matrix composites using scrap aluminum alloy and waste materials: influence on microstructure and mechanical properties, J. Alloys Compounds 784 (2019) 1047–1061.

[14] V.S. Shaisundaram, M. Chandrasekaran, S. Mohan Raj, R. Muraliraja, Investigation on the effect of thermal barrier coating at different dosing levels of cerium oxide nanoparticle fuel on diesel in a CI engine, Int. J. Ambient Energy 41 (1) (2020) 98–104.

[15] V.S. Shaisundaram, M. Chandrasekaran, M. Shanmugam, S. Padmanabhan, R. Muraliraja, L. Karikalan, Investigation of Momordicacharantia seed biodiesel with cerium oxide nanoparticle on CI engine, Int. J. Ambient Energy (2019) 1–5.

[16] V.S. Shaisundaram, M. Chandrasekaran, S. Mohan Raj, R. Muraliraja, T. Vinodkumar, Control of carbon dioxide emission in automobile vehicles using CO2 scrubber, Int. J. Ambient Energy 40 (7) (2019) 699–703.

[17] V.S. Shaisundaram, L. Karikalan, M. Chandrasekaran, Experimental investigation on the effect of cerium oxide nanoparticle fuel additives on pumpkin seed oil in CI engine, Int. J. Vehicle Struct. Syst. (IJVSS) 11 (3) (2019).

[18] R. Muraliraja, J. Sudagar, R. Elansezhian, A.V. Raviprakash, R. Dhinakaran, V.S. Shaisundaram, M. Chandrasekaran, Estimation of Zwitterionic surfactant response in electroless composite coating and properties of Ni–P–CuO (Nano) coating, Arabian J. Sci. Eng. 44 (2) (2019) 821–828.

[19] R. Muraliraja, R. Elansezhian, Influence of nickel recovery efficiency on crystallinity and microhardness of electroless Ni–P coatings and optimisation using Taguchi technique, Trans. IMF 93 (3) (2015) 126–132.

[20] R. Muraliraja, D. Sendilkumar, D.R. Elansezhian, Prediction and supplementation of reducing agent to improve the coating efficiency and wear behavior of electroless Ni-P plating, Int. J. ElectrochemSci. 10 (2015) 5536–5547.

[21] A. Godwin Antony, V. Vijayan, S. Saravanan, S. Baskar, M. Loganathan, Analysis of wear behaviour of aluminium composite with silicon carbide and titanium reinforcement, Int. J. Mech. Eng. Technol. 9 (2018) 681–691.

[22] S. Dinesh, A. Godwin Antony, K. Rajaguru, V. Vijayan, Experimental investigation and optimization of material removal rate and surface roughness in centerless grinding of magnesium alloy using grey relational analysis, Mech. Mech. Eng. 21 (2017) 17–28.

[23] S. Baskar, V. Vijayan, S. Saravanan, A.V. Balan, A. Godwin Antony, Effect of Al2O3, aluminium alloy and fly ash for making engine component, Int. J. Mech. Eng. Technol. (IJMET) 9 (12) (2018) 91–96.

[24] Baskar Sanjeevi, Karikalan Loganathan, Synthesis of MWCNT Nanofluid by using Two Step Method, Thermal Science, International Scientific Journal, Published Online: November 2019.

[25] S. Baskar, L. Karikalan, V.S. Shai sundaram, S. Jacob, S. Venugopal, Theoretical study and performance of vapour refrigeration system along with additive of zro2, International Journal of Management, Technology and Engineering, ISSN NO: 2249-7455, Volume 8, Issue XII, December/2018, pp. 4811-4817.

Please cite this article as: R. Akash, R. Muraliraja, R. Suthan et al., Synthesis and testing of aluminium composite using industrial waste as reinforcement, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2020.05.627