International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 6 Volume No.6 October - November – 2022
DOI:10.46647/ijetms.2022.v06i06.016 ISSN: 2581-4621

Analysis of wear behaviour on the recycled aluminium mixed scrap modified with Zn using the Taguchi Approach

Gottmyers Melwyn j [1], Bhagyanathan c[2], Sathiya Seelan g[3], Srinath p[4]
[1,3,4,]*Research scholars, Sri Ramakrishna Engineering College, Vattamalaipalayam, Coimbatore-641022*
[2,]*Associate Professor, Department of Mechanical Engineering, Sri Ramakrishna Engineering College, Vattamalaipalayam, Coimbatore-641022*

ABSTRACT
Aluminum scraps are a common kind of recyclable material that are used in the manufacturing of a broad variety of lightweight and high-strength goods all over the globe. In order to further strengthen the toughness of these alloys, reinforcement is also used. This investigation makes use of a variety of aluminium scrap as the primary material, reinforcing it with zinc (Zn) at several concentrations, including 0 percent, 0.25 percent, 0.50 percent, 0.75 percent, 1 percent, and 1.25 percent, respectively. The design of experiments used to improve process parameters is put to use in order to investigate the wear of these composites (Taguchi technique). The investigation on wear was carried out using sliding velocities of 2 and 4 metres per second, a sliding distance that was held constant at 90 millimetres, and a weight that varied from to (10N, 20N). In this particular instance, the sliding distance served as an important part of the total three. According to the findings of the microstructure study, the samples included zinc particles, which showed decreased wear. According to the results of the corrosion test, zinc also serves a role that protects against the effects of corrosion. Aluminum alloy is the material that gets recycled the most all around the world.
Keywords: assorted aluminium scrap alloys, zinc, microstructure study, tribology study, taguchi method.

1 INTRODUCTION

Aluminum recycling refers to the process of reusing scrap aluminium in products after they have been manufactured. The electrolysis of aluminium oxide is a far more costly and energy-intensive process than the technique described here, which involves re-melting the metal (Al2O3). In the case of primary production, the ore must first be extracted from bauxite, then processed via the Bayer process to produce aluminium oxide, and then processed through the Hall–Héroult process to produce another kind of aluminium metal. Only five percent of the energy required to create new aluminium from raw ore is used during the recycling process for old aluminium. The composition of metal matrices is a technique that may be used to alter the properties of a base material that is used in industry. There is a possibility that the tribological and mechanical properties of the metal may be improved using these composite materials. The strength of the base metal may be greatly increased by using metal matrix composites, which include reinforcing the base metal with another material. When producing lightweight metal, any component that is a carbide or oxide is used to enhance the amount of aluminium or titanium in the matrix. When it comes to the production of lightweight commercial items, the matrix metal that is used most often is aluminium or an aluminium alloy, which is also referred to as Aluminium Matrix Composition. However, in order to boost its strength, the vast majority of aluminium produced today is alloyed with other elements. The most frequent alloying elements are manganese (Mn), magnesium (Mg), copper (Cu), zinc (Zn), and silicon (Si). In addition, several of the most modern aviation alloys have been found to include lithium (abbreviated as Li). The grain refinement, resilience to temperature extremes, and corrosion

DOI:10.46647/ijetms.2022.v06i06.016 ISSN: 2581-4621

resistance of different aluminium scraps may all be improved by the addition of zinc alloying components. After adding zinc alloying components to a variety of aluminium scraps, what kind of effect does zinc have on the material's resistance to wear and corrosion?

1.1LITERATURE SURVEY

[1] The AA6063 material with silicon carbide reinforcement was investigated using the stir casting process.

The stir casting process lasted approximately fifteen minutes and included two hundred and fifty rotations per minute. Based on the results of the impact test, it was established that the tensile strength and hardness of reinforced aluminium alloys were superior to those of unreinforced alloys. Venkatesan et al.

[2] The graphene-reinforced aluminium alloy 7050 was tested using Taguchi's L27 orthogonal array, and the sliding velocity of the load and the sliding distance were the independent variables.

The sliding wear behaviour of nanocomposites with an aluminium matrix was investigated in [3], which may be found here. The applied average load, the sliding velocity, and the sliding distance are the factors that are being taken into account for their study. The Taguchi method was used to the problem of calculating sliding wear in this research, and the author came to the conclusion that SiC reinforcement is more resistant to wear than Al2O3 reinforcement. The individuals associated with Skip Koksal.

The remaining portions of the text are organised as shown below: In Section 2, the Taguchi method of assessing the planned task is broken down and explained. In Section 3, we talk about the work that was done in the lab. The next part contains a presentation of the results as well as a discussion of them. The last portion of the paper contains a presentation of the article's conclusion.

1.2 TAGUCHI APPROACH

An OA-based process may have its design manipulated in a variety of ways, one of which is the Taguchi technique. The use of ANOVA helps to reduce the total number of studies required while simultaneously enhancing the quality of the processes. In the course of this inquiry, take into consideration the wear rate response value as well as the element's percent reinforcement, sliding velocity, and sliding distance. Within the scope of this work is an investigation of the L9 orthogonal array experiment design.

The Taguchi method's step-by-step process is detailed below.

Point 1: There is a parameter. Control factor identification and selection

Point 2: Identification of each factor level

Point 3: Choosing an Orthogonal Array (OA) experiment

Point 4: Carrying out the matrix experiment by allocating a controlling factor to the columns of the OA

Point 5: Analyse the data to forecast the optimum value and assess performance.

Point 6: Check and double-check the data that has been analysed.

2. EXPERIMENTAL WORK

For the purpose of this experiment, the base material consisted of various scraps of aluminium, and the reinforcement was zinc (Zn). The scraps of aluminium were recycled in an electrical stir casting furnace, which resulted in the samples having the chemical composition given in table 1. The main melt was obtained without adding any zinc to the melt, and the subsequent experiments were carried out with the addition of zinc to the melt at concentrations of 0.25%, 0.50%, 0.750%, 1%, and 1.25% respectively. After that, the Spectromax OES machine was used to do an analysis on the samples' chemical make-up. As can be seen in Figure 1, the samples were cut into pieces with dimensions of

DOI:10.46647/ijetms.2022.v06i06.016 ISSN: 2581-4621

10 millimetres in diameter and 50 millimetres in length. Before carrying out the wear test using the Ducom Pin0-on-disc equipment, each of the samples was given a thorough cleaning in the acetone. Table 1 displays the chemical make-up of a variety of scraps

Figure 1: (a) Recycled aluminium samples; (b) Pin-On-Disc Apparatus

Table 1: Chemical composition of assorted scraps

%	Si	Fe	Cu	Mg	Mn	Zn	Ti	Ni	Sr	Al
Scrap	7.43	0.241	0.673	0.068	0.298	0.070	0.0158	0.003	0.002	91.7

The process parameters and their levels are outlined in Table 2.

Parameter	Range
Melting point	420 °C (788 °F)
Molar weight	65.4
density	7.13 (g/cm3)
Boiling point	420 °C (788 °F)
electron configuration	[Ar]3*d*104*s*2

Table 2: Process parameters and their levels.

S. No	Factors	node 1	node 2	node3	node4	node5	node6
1	% Of addition	0	0.25	0.50	0.75	1.0	1.25
2	sliding velocity (m/s)	2 4	2 4	2 4	2 4	2 4	2 4
3	Sliding distance (mm)	90	90	90	90	90	90
4	Load (N)	10	10	10	10	10	10

The compositions of the components that might be found in different aluminium scraps are outlined in Table 1. Table 2 contains an inventory of zinc's qualities and characteristics. The L9 Orthogonal array design of experiments developed by Taguchi is used in this study to investigate the wear of chosen aluminium scrap as well as the reinforcement of zinc metal matrix composites. The process factors that need to be taken into consideration for this wear research experiment are the percentage of reinforcement, the sliding velocity (m/s), and the sliding distance (mm). In Table 3, they are each given one of three distinct levels to occupy. The type of the wear test equipment is called DUCOM TR 20-LE, and it has variable sliding velocity parameters of 2 and 4 m/s, a constant sliding distance

Website: ijetms.in Issue: 6 Volume No.6 October - November – 2022
DOI:10.46647/ijetms.2022.v06i06.016 ISSN: 2581-4621

of 90m, and a weight of 10 and 20 N. The specimens were given a thorough cleaning with an emery sheet of a finer grit prior to being soaked in acetone. The weights of the specimens were recorded both before and after they were worn, and then the wear loss, also known as weight loss, was calculated.

3. RESULT AND DISCUSSION

The chemical composition of the samples was determined, and the results were tabulated in accordance with the table's instructions.

Table 3: Chemical composition of Zn modified samples

%	Si	Fe	Cu	Mg	Mn	Zn	Ti	Ni	Sr	Al
Scrap	7.43	0.241	0.673	0.068	0.298	0.070	0.0158	0.003	0.002	91.7
Zn1	7.44	0.24	0.679	0.060	0.28	0.28	0.016	0.002	0.002	91.5
Zn2	7.40	0.25	0.67	0.061	0.25	0.52	0.015	0.0025	0.002	91.1
Zn3	7.41	0.26	0.65	0.069	0.30	0.78	0.016	0.002	0.003	90.8
Zn4	7.44	0.23	0.66	0.065	0.28	1.08	0.0165	0.003	0.001	90.6
Zn5	7.40	0.24	0.67	0.062	0.24	1.22	0.014	0.004	0.002	90.45

This experiment consisted of six separate trials, with the wear rate and S/N ratio statistics being calculated and shown in Table 4. Tables 4 and 5 illustrate the disparity in value that exists between the most significant mean and the lowest permissible value for the S/N ratio. It is a well-known fact that the parameter that has the biggest delta value has a greater influence on the wear rate response (Fig. 2). Figures 3 and 4 show, respectively, the principal effect plots for the mean and S/N ratio of the wear. These plots were generated using the data from the wear. Figures 3 and 4 demonstrate that there was a significant amount of variation in the wear rate even when the value of the sliding distance was held constant. This was due to the fact that the sliding distance was a primary factor that influenced other factors. According to the findings of the tribological tests, there is an inverse relationship between the quantity of SiC contained in the hybrid composite and the level of wear. As the sliding speed and normal load continue to grow, the rate of wear on composites is also increasing at a faster pace.

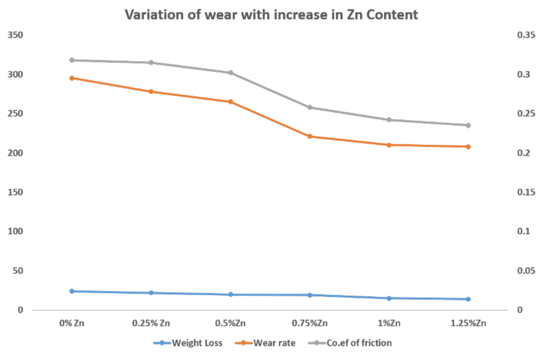

Figure 2: Variation of wear with Zn content

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 6 Volume No.6 October - November – 2022
DOI:10.46647/ijetms.2022.v06i06.016 ISSN: 2581-4621

The amount of load that is applied is the factor that has the most significant influence on how wear occurs, and it is the one that has a large impact on the rate of wear that alloys and composites experience. The amount of normal load that is applied results in a volume loss that is proportionate to the total amount of load that is applied.

As shown in Figure, the wear rates of the recycled aluminium alloy decreased as the quantity of Zn additives that were added continued to expand. This phenomenon may be attributed to the recycling process (6). When the load that was being applied was increased, it caused the rate of wear to increase, as well as a transition from mild wear to severe wear, both of which are conditions that occur when the load is in a dry lubrication state. When the load was in a dry lubrication state, the transition from mild wear to severe wear also occurred. The transformation of the unalloyed recycled aluminium was much more pronounced as compared to the Zn modified recycled alloys [13]. There is a possibility that the enhanced reinforcing has resulted in an increase in the material's hardness, which has resulted in the creation of a barrier on the surface to hinder the entrance of hard particles. It was found that the amount of wear loss was reduced to a minimum when the reinforcing level was set at 1.0% Zn. Because reinforcing materials were present, the wear rate decreased as the number of Zn particles increased [14]. This was due to the fact that Zn particles helped to reinforce the material. This finding is based on the supposition that the Zn in the recycled aluminium alloy refined the grains, which resulted in the induction of a wear-resistant mechanism.

3.1. MICROSTRUCTURE ANALYSIS

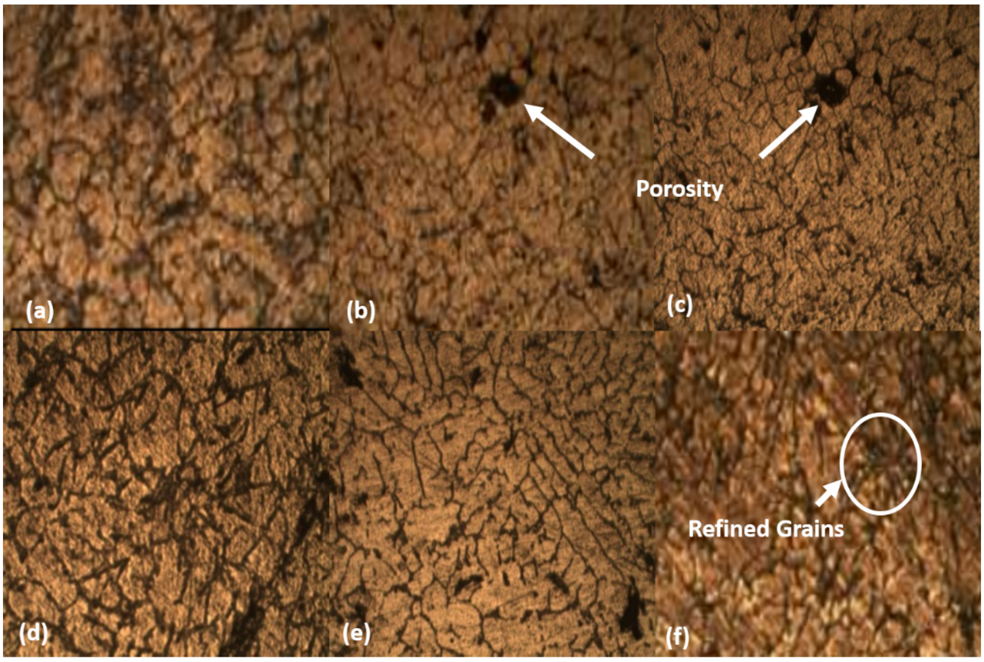

Figure 3: Microstructures of Al scraps with (a)No Zn addition; (b)0.25% Zn addition; (c)0.5% Zn; (d)0.75% Zn; (e) 1.0% Zn; (f) 1.25% Zn

It may be deduced from the existence of a white layer structure within the photographs that the friction surfaces are being subjected to high temperatures [17]. The majority of worn surfaces include cracks here and there in addition to smooth strips and grooves that were generated by abrasion. These surface features are typical of worn surfaces. Figure 8 shows that a smooth layer that slopes in the direction of sliding has a number of fractures all over the surface of the layer. These fractures are spread evenly throughout the surface of the layer. The edge cracks, which started at the edge of the smooth strip and spread away from the edge intercept, were the cause of the development of metal debris. These edge cracks started at the edge of the smooth strip. For the aim of conducting an assessment of the subsurface, the worn surface was sectioned off into individual pieces. These components were cut in a way that was perpendicular to the worn surface and parallel to the wear tracks. This was done in order to ensure that the pieces would fit together properly.

DOI:10.46647/ijetms.2022.v06i06.016 ISSN: 2581-4621

4. CONCLUSION

At low loads, the particles are able to withstand the load that is being applied, and under these conditions, the wear resistance of Zn reinforced alloys is much higher than that of Al-alloy by at least an order of magnitude. When exposed to high loads, the wear rates of MMCs and Al-alloy were equivalent to one another.

The dry sliding wear and friction of recycled aluminium scraps are impacted by the microstructural properties of the recycled aluminium scraps, as well as the applied load, sliding speed, and sliding distance.

The results highlighted that the recycled alloy with 1.0% Zn had nearly 33% better resistance to wear compared to the unalloyed aluminium, highlighting the fact that the grain refinement was obtained through the Zn addition

ACKNOWLEDGEMENT

The authors acknowledge the financial support of SINTEF for this work. Also thanks are due to Hydro Aluminium Rolled Products AS, Holmestrand and Leif Ivar Koksvik for providing materials, and to Alcoa for supplying the cast material. Thorvald Abel Engh is acknowledged for assistance.
The authors acknowledge the financial support of SINTEF for this work. Also thanks are due to Hydro Aluminium Rolled Products AS, Holmestrand and Leif Ivar Koksvik for providing materials, and to Alcoa for supplying the cast material. Thorvald Abel Engh is acknowledged for assistance.
The authors acknowledge the financial support of SINTEF for this work. Also thanks are due to Hydro Aluminium Rolled Products AS, Holmestrand and Leif Ivar Koksvik for providing materials, and to Alcoa for supplying the cast material. Thorvald Abel Engh is acknowledged for assistance.
The authors acknowledge the financial support of SINTEF for this work. Also thanks are due to Hydro Aluminium Rolled Products AS, Holmestrand and Leif Ivar Koksvik for providing materials, and to Alcoa for supplying the cast material. Thorvald Abel Engh is acknowledged for assistance.
We would like to thank the DST-WMT program, for their financial support to carry out the experimental works

REFERENCES

1. Yawer, A.K., Abdulkader, N.J. and Zainalaadbeen, A.A., 2021, February. Study of Wear Properties of Recycled Composite Zn-Al Alloy Reinforced with Hybrid Nanoparticles. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1094, No. 1, p. 012145). IOP Publishing.

2. Kumar, S., Gupta, A. and Gupta, P., Some Investigations to Improve the Wear Resistance & Hardness of an Aluminium Alloyed Piston by Addition of Zinc.

3. Rahman, M.S.U. and Jayahari, L., 2018. Study of mechanical properties and wear behaviour of aluminium 6061 matrix composites reinforced with steel machining chips. *Materials today: proceedings*, *5*(9), pp.20117-20123.

4. Dharmalingam, S., Subramanian, R., Somasundara Vinoth, K. and Anandavel, B., 2011. Optimization of tribological properties in aluminum hybrid metal matrix composites using gray-taguchi method. *Journal of Materials Engineering and Performance*, *20*(8), pp.1457-1466.

5. Kazeem, A., Badarulzaman, N.A. and Ali, W.F.F.W., 2020. Optimization of wear and hardness of Al–Zn–Mg–Cu alloy fabricated from recycled beverage can using response surface methodology. *SN Applied Sciences*, *2*(7), pp.1-11.

6. Lakshmanan, A.M. and Charles, E., 2019. Wear Study Of Stir Cast Aa7075 Metal Matrix Composites And Optimization Of Wear Using Grey Relational Analysis. *Think India Journal*, *22*(14), pp.10147-10151.

Website: ijetms.in Issue: 6 Volume No.6 October - November – 2022
DOI:10.46647/ijetms.2022.v06i06.016 ISSN: 2581-4621

7. Sydow, Z., Sydow, M., Wojciechowski, Ł. and Bieńczak, K., 2021. Tribological performance of composites reinforced with the agricultural, industrial and post-consumer wastes: A review. *Materials*, *14*(8), p.1863.
8. Teo, G.S., Liew, K.W. and Kok, C.K., 2022. A Study on Friction Stir Processing Parameters of Recycled AA 6063/TiO2 Surface Composites for Better Tribological Performance. *Metals*, *12*(6), p.973.
9. Manikandan, R.A. and Arjunan, T.V., 2020. Studies on micro structural characteristics, mechanical and tribological behaviours of boron carbide and cow dung ash reinforced aluminium (Al 7075) hybrid metal matrix composite. *Composites Part B: Engineering*, *183*, p.107668.
10. Selvam, B., Marimuthu, P., Narayanasamy, R., Anandakrishnan, V., Tun, K.S., Gupta, M. and Kamaraj, M., 2014. Dry sliding wear behaviour of zinc oxide reinforced magnesium matrix nano-composites. *Materials & Design*, *58*, pp.475-481.
11. Teo, G.S., Liew, K.W. and Kok, C.K., 2022. Optimization of Friction Stir Processing Parameters of Recycled AA 6063 for Enhanced Surface Microhardness and Tribological Properties. *Metals*, *12*(2), p.310.
12. Moona, G., Walia, R.S., Rastogi, V. and Sharma, R., 2020. Tribological characterization of eco-designed aluminium hybrid metal matrix composites.
13. AGBELEYE, A., DUROWAYE, S., OLADOYE, A. and BOLASODUN, B., Effect of Zinc Addition on the Mechanical and Corrosion Characteristics of Aluminium Matrix Composites. *Acta Materialia Turcica*, *5*(1), pp.30-37.
14. Reboul, M.C. and Baroux, B., 2011. Metallurgical aspects of corrosion resistance of aluminium alloys. *Materials and Corrosion*, *62*(3), pp.215-233.
15. Sathiyaseelan, G. and Bhagyanathan, C., 2019. SECTIONAL ANALYSIS ON THE IMPACT OF STRONTIUM ON RECYCLED ALUMINIUM ALLOY.