The effect of RHA reinforcement on the Microstructure, Mechanical properties and Dry sliding wear behavior of Recycled waste Aluminium Can

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***Abstract*—Investigations on the mechanical and wear behavior of Al MMCs produced with the use of agro waste ashes as complementing reinforcement are quite limited in literature. In this present work, metal matrix composites have been produced from discarded aluminium cans and rice husk ash (RHA). The aim of this work is to study mechanical and wear resistance properties of the produced Aluminum can/RHA MMCs.The study presents the results of experimental investigation on mechanical and wear behavior of rice husk ash (RHA) reinforced discarded aluminium cans. The influence of reinforced ratio of 0, 3, 6 and 9 weight percentage of rice husk ash (RHA) particles on mechanical behavior and Wear properties was examined. The castings were prepared by liquid metallurgy route. This work is also aimed at providing solution to menaces associated with poor management of Aluminium cans and RHA through recycling of these waste materials. It embraces conversion of waste into wealth which on a large scale production will enhance technological development and economic growth.**

Keywords: Aluminum can, Rice Husk Ash (RHA), Stir Casting, MMCs, Hardness, Tensile, Wear

INTRODUCTION

Aluminium alloy cans is widely used in the canning industries for food storage in place of traditional glass jars, bottle and steel cans. This trend is informed by the peculiar mechanical properties of aluminum such as light weight, formability, corrosion resistant, excellent barrier, reduced thickness, and damage tolerance, ease of transportation, attractiveness and ease of printing a high-quality image on the cans [1]. The first aluminum alloy can was invented in 1972 when their weight was ten times less than that of glass jars. Modern cans in use today are even 40 % lighter than those cans used as far back as in 1972.

In India, the traditional bottle based packaging companies such as Coca-Cola, Seven –up have completely modernized their production line or in some cases shifted completely to the use of aluminium can for packaging. The transition from the traditional bottle packaging to aluminum can packaging has come with their environmental issues. Large volumes of aluminum cans drinks are being consumed daily across India and the empty cans are not properly disposed. Environmental pollution is increasing greatly, becoming uncontrollable; streets and drainages are being littered by empty drink cans, plastics, polythene bags used in our day to day lives. Those wastes were dropped in drainages, preventing water from flowing leading to water logging which aids breeding of mosquitoes and disease outbreaks. At extreme cases, canals, drainage and gutters are blocked. In rainy season, this leads to over flooding of cities which at times claiming many lives [2].

In order to reduce if not completely eliminated menaces associated with poor waste management, there is a need for recycling of waste materials. As the name implies, recycling is the new emerging technology which involves waste conversion into raw materials for production of new materials for various engineering applications and also for wealth creation. In 1992, the Commonwealth Government released the National Waste Minimization and Recycling Strategy with a target of reducing the amount of solid waste going to landfill per capita by 50 % from 1990 to 2000 [3]. The recycling of wastes reduces waste, saves energy, conserves natural resources, lessens use of municipal landfills and provides recyclers and municipalities with considerable revenue [3].

Aluminium is 100 % recyclable Recycling of aluminium uses only 5 % of the energy required for its initial extraction and processing, 10 % of the initial capital equipment costs and saves 97 % of the greenhouse gas (GHG) emissions. Aluminium is an ideal materials used for architectural, automobile and aerospace applications because of its light weight, corrosion resistance and ease of formability but its low strength and hardness has greatly limited its use in high strength, hardness and surface wear resistance applications. Currently, the design of high performance aluminium based composites at significantly reduced cost is receiving much attention from materials researchers. This is discernible from the dominant use of stir casting by most researchers from developing countries; and the sustained interest in the consideration of industrial and agro wastes as reinforcements in AMCs.

MATERIALS AND METHODS

2.1 COMPOSITE MATERIALS FABRICATION

Composites required for the present study will be prepared by Stir casting process. The composite developed by this study will contain varying percentage composition of RHA (4, 8 and 12 by weight Percentage). During fabrication of the aluminum can / RHA composite, RHA of particle sizes of ~50 µm were selected after conducting sieve analysis for the present investigation .The aim of the experiment is to study the effect of variation of the percentage composition aluminum can / RHA composite to predict the mechanical and wear properties of MMCs and Comparing the result.

Table 1: Chemical composition of aluminium can (weight percentage)

Element	Si	Fe	Cu	Mn	Mg	Ti	Al
% Composition	0.53	0.51	0.03	0.77	0.02	0.04	98.10

Table 2: Chemical composition of Rice Husk Ash (RHA)

Composition	SiO_2	Graphite	CaO	MgO	K_2O	Fe_2O_3
%weight	90.23	4.77	1.58	0.53	0.39	0.21

Table 3: Designation of Rice Husk Ash (RHA) Reinforced Alloy

S/No	**Alloy/Composite**	**Designation (Un Treated)**
1	Aluminium can (recycled waste)	Al Can
2	Aluminium can + 3% RHA	3 RHA
3	Aluminium can + 6% RHA	6 RHA
4	Aluminium can + 9% RHA	9 RHA

A primary process of composite production whereby the reinforcement ingredient material is incorporated into the molten metal by stirring. As compared to any other process available for manufacturing of MMCs, Stir casting is generally accepted as competent route and currently practiced commercially.

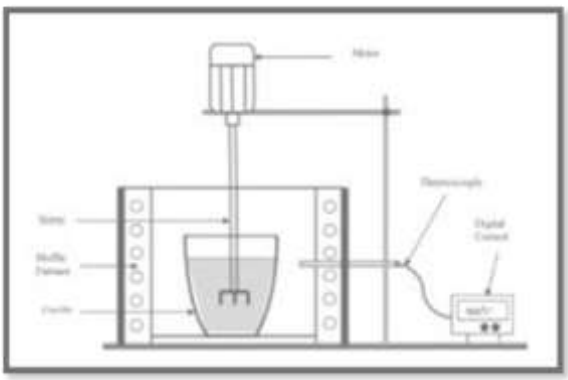


Figure 1: MMCs by casting route through Stir Casting method.

2.2 MICROSTRUCTURE

The specimens for microstructure were prepared as per standard metallurgical procedures, etched in etchant prepared using 90 ml water, 4 ml HF, 4 ml H_2S0_4 and 2g Cr_20_3 and photographed using Optical Microscope.

Figure 2: Depicting the images of emery paper, polishing machine and polished specimen for microstructure

2.3 HARDNESS TEST

The hardness tests were conducted as per ASTM E10 norms using Brinell Hardness Tester, where the tests were performed at randomly selected points on the polished surface of samples by providing sufficient space between indentations and distance from the edge of specimen.

2.4 TENSILE TEST

Tensile properties of materials were tested in Tensometer. The gauge length and diameter of samples are 30mm and 12 mm respectively. UTS and % Elongation were obtained by carrying out an average of 5 trails each and tabulated.

2.5 WEAR TEST

Dry sliding Wear tests were carried out at room temperature using Pin-on-Disc apparatus for varied loads and sliding distances. The wear rates were evaluated using weight loss method by dividing the loss of weight of specimen by the sliding distance for a known sliding time. The loss of weight was measured using an Electronic balance to the accuracy of 0.0001gm. The wear rate was based on the average value of 5 test results. During test, the load was increased gradually till seizure, indicated by high temperature rise; abnormal wear and vibration in Pin-disc assembly were observed. The worn surfaces were further analysed for type of wear.

Figure 3: Depicting the images of Hardness, Tensile and Wear Test samples

III. RESULTS AND DISCUSSIONS

3.1: OPTICAL MICROGRAPHS OF AL CANS AND ITS COMPOSITES

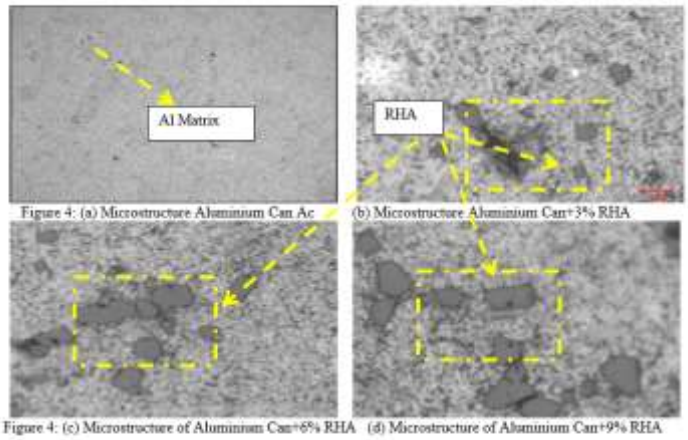
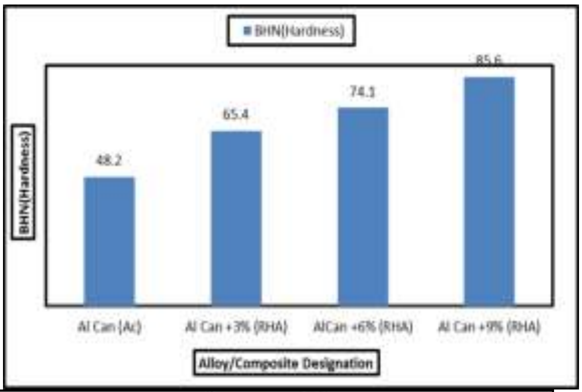


Figure 4: (a) Microstructure Aluminium Can Ac (b) Microstructure Aluminium Can+3% RHA
Figure 4: (c) Microstructure of Aluminium Can+6% RHA (d) Microstructure of Aluminium Can+9% RHA

ash husk in the matrix with minimum voids and casting defects. Casting defects such as voids and porosity leads to degradation of the mechanical and wear properties of the alloy and the composite

3.2: MECHANICAL PROPERTIES TEST RESULTS AL CANS AND ITS COMPOSITES



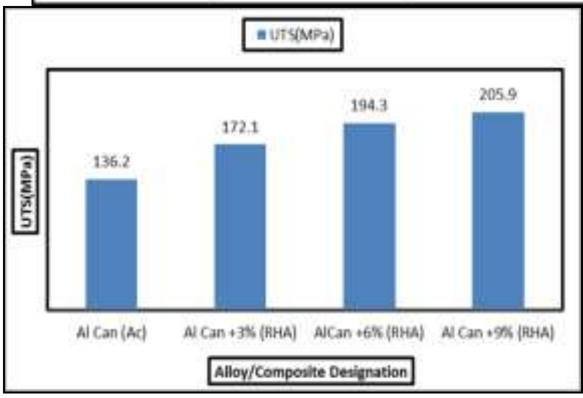
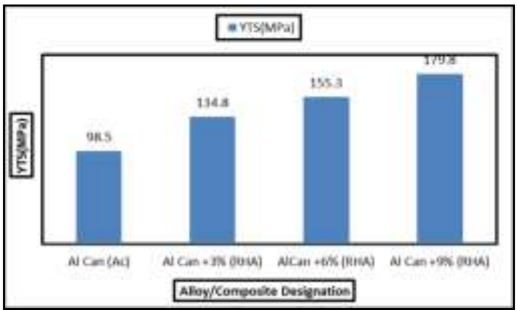


Figure 5: Hardness test result of Al can and it's Composite
Figure 6: UTS test result of Al can and it's Composite



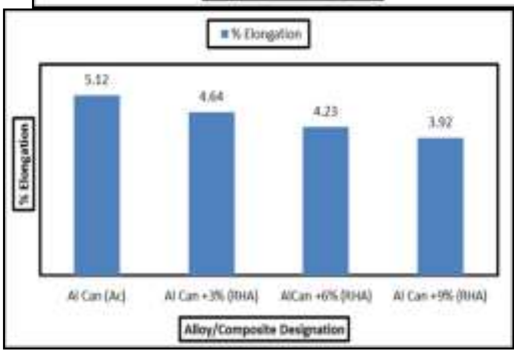


Figure 7: YTS test result of Al can and it's Composite
Figure 8: Ductility test result of Al can and it's Composite

From Figure 5 it is found that hardness of Al can is 48.2BHN, hardness of Al can+3% RHA is 65.4BHN, hardness of Al can+6% RHA is 74.1BHN, hardness of Al can+9% RHA is 85.6BHN.With increasing in RHA content in the material the hardness is increasing gradually. As compared to as-cast (Al can), Al can+3% RHA addition shows an increase of 17.2 BHN (35.68%). In contrast Al can+6% RHA and Al can+9% RHA addition shows an increase of 25.9 BHN (53.73%) and 37.4 BHN (77.59%) respectively. The enhancement in hardness in casted composites may be ascribed to even dispersal of reinforcement (RHA) in the matrix material.

From Figure 6 it is found that Ultimate Tensile Strength (UTS) of Al can is 136.2MPa, Ultimate Tensile Strength (UTS) of Al can+3% RHA is 172.1MPa, Ultimate Tensile Strength (UTS) of Al can+6% RHA is 194.3MPa, Ultimate Tensile Strength (UTS) of Al can+9% RHA is 205.6MPa.With increasing in RHA content in the material the strength is increasing gradually. As compared to as-cast (Al can), Al can+3% RHA addition shows an increase of 35.9 MPa (26.35%). In contrast Al can+6% RHA and Al can+9% RHA addition shows an increase of 58.1 MPa (42.65%) and 69.7 MPa (51.17%) respectively. The enhancement in tensile strength in casted composites may be credited to uniform scattering of reinforcement (RHA) in the matrix material. The rise husk ash particles acts as blockades to the disarticulation movement and surges tensile strength of Al can and its composites.

From Figure 7 it is found that Yield Tensile Strength (YTS) of Al can is 98.5MPa, Yield Tensile Strength (YTS) of Al can+3% RHA is 134.8MPa, Yield Tensile Strength (YTS) of Al can+6% RHA is 155.3MPa, Yield Tensile Strength (YTS) of Al can+9% RHA is 179.8MPa.With increasing in RHA content in the material the yield is increasing gradually. As compared to as-cast (Al can), Al can+3% RHA addition shows an increase of 36.3 MPa (36.85%). In contrast Al can+6% RHA and Al can+9% RHA addition shows an increase of 56.8 MPa (57.66%) and 81.3 MPa (82.53%) respectively. The enhancement in Yield strength in casted composites may be credited to uniform scattering of reinforcement (RHA) in the matrix material. The rise husk ash particles acts as blockades to the disarticulation movement and surges tensile strength of Al can and its composites.

From Figure 8 it is found that % Elongation (ductility) of Al can is around 5.2%. Elongation (ductility) of Al can+3% RHA is 4.64%, Elongation (ductility) of Al can+6% RHA is 4.23%, Elongation (ductility) of Al can+9% RHA is 3.92%.With increasing in RHA content in the material the ductility is decreasing gradually. As compared to as-cast (Al can), Al can+3% RHA addition shows a decrease of 0.48 (9.37%). In contrast Al can+6% RHA and Al can+9% RHA addition shows an decrease of 0.89 (21.04%) and 1.2 (28.36%) respectively. The decrease in ductility in casted composites compared to Al can may be due to addition of RHA in the matrix material. Al is ductile in nature, as the addition of reinforcement i.e. RHA leads to increase in brittleness of the composites so the ductility decreases.

3.3: FRACTOGRAPHY TEST RESULTS OF UN TREATED AND AL CANS / COMPOSITES

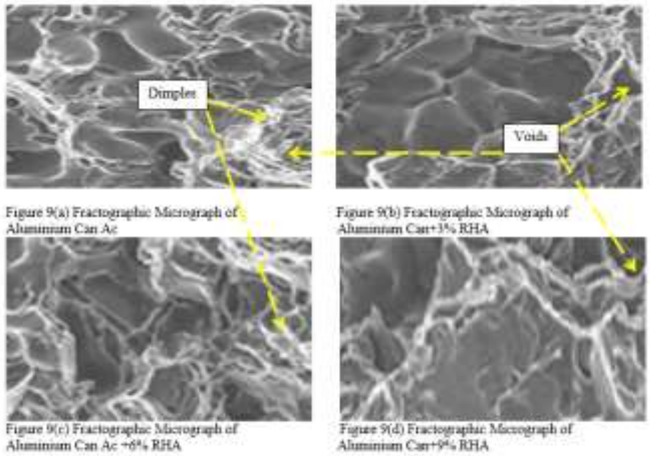


Figure 9(a) Fractographic Micrograph of Aluminium Can Ac

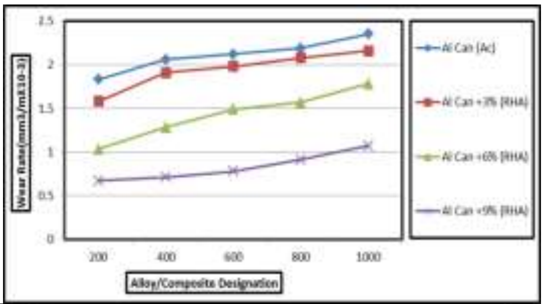
Figure 9(b) Fractographic Micrograph of Aluminium Can+3% RHA

Figure 9(c) Fractographic Micrograph of Aluminium Can Ac +6% RHA

Figure 9(d) Fractographic Micrograph of Aluminium Can+9% RHA

Figure 9 shows the SEM Fractographs of aluminium can and its rice husk ash composites. Fig 9 (a) shows the SEM Fractographs of as-cast aluminium can. Fig 9 (b) shows the SEM Fractographs of aluminium can with 3% rice husk ash. Fig 9 (c) shows the SEM Fractographs of aluminium can with 6% rice husk ash. Fig 9 (d) shows the SEM Fractography micrograph of aluminium can with 9% rice husk ash.

3.4: WEAR TEST RESULTS AL CANS AND ITS COMPOSITES



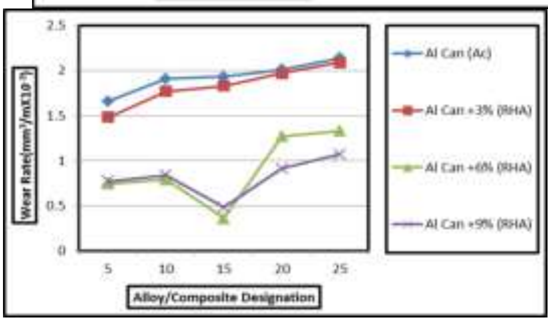


Figure 10: Effect of Sliding Distance on Wear Rate of Alcan it's Composite

Figure 11: Effect of Load on Wear Rate of Al can and it's Composite

Fig 10 shows plot of wear rate V/s sliding distance of Al can and its RHA composites. From the figure it can be seen that Al can has maximum wear rate (2.35 X 10^{-3} mm^3/m) due to the absence of reinforcement. Aluminium can with 9% rice husk ash has least wear rate (1.07 X 10-3 mm3/m) compared to aluminium can with 3% rice husk ash (2.16 X 10^{-3} mm^3/m) and aluminium can with 6% rice husk ash (1.78 X 10^{-3} mm^3/m). The decreased wear rate of aluminium can with 9% rice husk ash may be attributed to higher percentage of rice husk ash in the composite which act as solid lubricant results in reduced wear rate.

Fig 11 shows plot of wear rate V/s Load of Al can and its RHA composites. From the figure it can be seen that Al can has maximum wear rate (2.14X 10^{-3} mm^3/m) due to the absence of reinforcement. Aluminium can with 9% rice husk ash has least wear rate (1.07 X 10^{-3} mm^3/m) compared to aluminium can with 3% rice husk ash (2.09 X 10^{-3} mm^3/m) and aluminium can with 6% rice husk ash (1.33 X 10^{-3} mm^3/m). The decreased wear rate of aluminium can with 9% rice husk ash may be attributed to higher percentage of rice husk ash in the composite which act as solid lubricant results in reduced wear rate.

IV.CONCLUSIONS

In the present investigation, Al can and its RHA composites with various weight fractions (0%, 3%, 6%, and 9%) were fabricated and studied for their mechanical and tribological properties. It was found that the wear resistance, hardness and tensile properties of composites increase with an increase of particle weight fraction of RHA

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