UTILIZATION OF WASTE MILD STEEL CHIPS FOR ENGINEERING APPLICATIONS

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ABSTRACT

Metal chips have the ability to remain in the environment for a long period of time before biodegrading. It causes irreversible harm to wildlife and renders arable soil unfit for farming activities. This study is aimed at assessing waste metal chips for potential engineering applications in some selected machining workshops in Maiduguri. Interview and observation approaches were adopted as an instrument for the data collection using a prepared interview guide. The majority of the metal chips available are mild steel chips, cast iron chips and aluminum chips whereas brass chips, copper chips and chips from other metals are rarely produced. The aluminum chips, brass chips and copper chips are used in casting operations or are rather converted to billet for other uses base on demand. The cast iron chips and mild steel chips are not recycled despite their quantity (60%) being considerably high. They are mainly disposed at refuse site or sold to scrap buyers. From the findings of this investigation, an average of 4,800 kg of waste metal chips is generated in Maiduguri annually. The findings reveal that metal chip composites good hardness index of 66.9 HRD and tensile strength of 17.266 MPa improvement from standard based. If properly harnessed, these chips have potentials for use in areas such as: production of abrasives (sandpaper), grinding wheels, and automobile brake pads. It is recommended that use of advance metal -metal adhesive be utilized to develop more robust applications of chip as desulfurizer in biogas desulfurizer and as replacement for raw sand in concrete development among others.

Keywords: mild steel, chips, metal, utilization

1 INTRODUCTION

Metal chips are waste materials removed by grinding, drilling, turning, milling, etc. during machining of metals. The form of the chips produced depends completely on the type of metals being machined [1]. Hard and brittle metals with low strength are often discarded as small and uneven bits, while softer metals or those of higher strength may peel off as coils or ribbons often very sharp and able to cause minor to serious injuries to all those who handle them, it is absolutely essential to remove them immediately before they become airborne [2]. These materials can cause serious health and safety risks for humans, properties and even damage to the surrounding environment [3]. Metals such as Fe, Al, etc. are widely used in manufacturing to produce almost all kinds of industrial and domestic products. Each year, a huge amount of metal chip solid waste is generated from the manufacturing industry. Current manufacturing companies either landfill these wastes or pay a third party to haul them away, causing both environmental and economic problems [4, 5]. Machining operations usually generate considerable amounts of waste in the form of chips (usually 3–5% of the casting weight). Traditionally, swarf is sold to scrapers, but this option is quite expensive because the selling price is roughly 30% of the acquisition price of the commercial 2nd melt raw material [6]. There are limited ways to recycle steel chips, either by disposal in

landfill or by melting. According to a study by [7, 8]. the melting of steel chips in Arc furnaces could be expensive, non-ecological and not effective. The metal chips used for recycling can involve industrial residues or as machined fresh type, resulting from operations such as turning, roughing and finishing obtained by low-speed machining or a high-speed process. Materials studied so far involve aluminum alloys, stainless steel, tool steel, titanium alloy, tin alloy and nickel alloy [3]. Chips are formed during the machining processes like boring, turning, drilling, milling, shaping etc. these machining processes are done with the help lathe machines. Slotting machines, drilling machines, milling machines, grinding machines etc. [9, 10]. Composite materials based on light metal alloy bases are characterized by very good mechanical properties and applications in the production technology of aircraft and cars, in defense technology and in astronautics [11, 12]. Composite materials based on light metal alloys are reinforced with dispersion particles, platelets, short and continuous. The investigations seek ways of utilizing the waste metal chips for engineering varied applications to preserved our environment with ease.

2 MATERIALS AND METHODS

The following are the materials that were used for the research; mild steel chips; gasoline[petrol]; Synthetic adhesive (epoxy 160g). The following equipment were used; sieves, magnet, spatula, containers, scale, measuring tube, hammer and anvil, mold, Container (washing basin), digital measuring Scale, Vernier caliper, Measuring tube (5ml, 1.5g), Hammer and anvil, Casting mold, Manual compression machine (tamper), Rockwell hardness testing machine, and Tensile testing machine [7].

2.1 Method of Collection of Materials

The mild steel chips were collected from mechanical workshops in Maiduguri, Borno State, from grinding and turning operations on the lathe and grinding machine. This was followed by sorting and cleaning of the chips and sample preparation. The type of chips obtained are continuous chips and powdered metal chips. The continuous chips were crushed by the use of hammer and anvil, to obtain a smaller sized chip. Plates 1 and 2 shows metal chips scattered on operation sites in machine workshop.

Plate 1. Metal Chips from Turning Operation

Plate 2. metal Chips on The Floor

2.2 Samples Preparations

The chips obtained were mixed with grease, coolant, dirt and dust. The following procedure was used to remove the dirt and wash away the grease and dust (Plates 3 and 4). Sieve analysis was first used to remove large dirt particles (e.g. stones), and unwanted metal chip size. Three different types of sieves with different diameter were used to perform the analysis. The crushed mild steel chips were sieved using a 0.3μm and 0.8μm diameter sieve size. Magnet was used to extract the powdered mild steel from the dust and dirt. The powdered mild steel chips were first extracted from dirt and other metal particles using magnet [because of the magnetic nature of mild steel].

Plate 3. metal during sieve analysis

Plate 4. metal chips with dirt

Then, the chips were placed in a washing basin containing gasoline to wash away the dust, coolant and grease. A stirring rod was used to stir the chips and the gasoline to help wash away the dust, grease and coolant. The clean metal chips were sun dried and aired to allow the gasoline(petrol) to evaporate (Plates 5 and 6). Plates 7 and 8 shows the intermediate chips after cleaning and finer grain sized chips respectively.

Plate 5. chips separation using magnet

Plate 6. larger metal chips after cleaning

Plate 7. intermediate chips after cleaning

Plate 8. finer grain sized chips

2.3 Composites Formulation

The following procedures ASTM E18-07 were used to obtain total of five samples of composite. Each of the samples contain different content of chips and epoxy. This was done in order to be able to run a comprehensive test on the samples to archieve the desired hardness. The Table 1 contain the ratio and weight of materials used in making the composites.

Table 1. Composites making with % of composition

S/No.	Type of Chips	Samples	Weight of Particles (g)	Weight of Adhesive (g)
1	Finer grain-sized particle	A	65	40
2	Intermediate and large grain-sized particle	B	70	30
3		C	75	25
4				
5	Finer grain-sized particle	D	70	30
6		E	75	25

Table 2 shows the different sizes of metal chips obtained after the sieve analysis was conducted, and will be used subsequently in this research.

Table 2. Types of Chips Obtained and Their Sizes

S/No	Types of chips	Size of sieve
1	Powdered metal chips (finer grain particle)	425µm
2	Inter mediate grain sized particle	600µm
3	Large grain sized particle	850µm

The metal chips were measured and weigh and placed in a container, the epoxy was measured and weigh then it was poured on the chips. The composite was mixed and compacted thoroughly using the manual compaction machine. Then, the mixture was poured in a mold. The mixture was compacted and allowed to solidify and cool. The sample was taken out of the mold after 24hr. The sample was taken to the machine workshop for finishing. The grinding machine was used to surface finish the samples as depicted in Plates 9 and 10. Table 3 shows the values of obtained samples.

Plate 9. fine grain sized composite.

Plate10. large grain sized composite

Table 3. samples obtained

Samples	Weight of samples (g)	Size of Samples		
		Thickness (mm)	Length (mm)	Width (mm)
A	38.7	5.5	29.6	29.4
B	50.2	5.7	30.1	29.7
C	53.2	6.0	30.1	29.7
D	57.4	5.9	29.9	29.8
E	59.6	6.0	30.0	29.7

2.4 Rockwell Hardness Test

The procedure for Rockwell hardness test using the ASTM standard for the test. were carried out. For this experiment, the B scale and steel ball indenter of 1/16 in (1.588mm) was used). Initial load was 10kgf and final load 100kgf. The loading and unloading lever were kept at position "A" which was unloading position. suitable indenter & weights according to the scale was selected. the specimen was Place on testing table anvil. the hand wheel was turned to raise a job until it makes contact with indenter & continue turning till the longer pointer at the dial gauge makes 2 ½ rotations. Then it stops at zero continue turning slowly till the small pointer reaches the red spot at 3‟, this is automatic zero setting dial gauge. the lever was turned to position "A" to "B" i.e., from unloading to the loading position. So that the total load will act. When the longer pointer of the dial gauge reaches steady position, the lever was taken back to the unloading position "A". [Avoid sudden release at the lever]. the reading was noted down in the last dial indicator by notifying the large pointer. the hand wheel was turned back and the specimen was removed [13]. Plate 11 shows the Rockwell hardness tester.

Plate 11. Rockwell hardness tester

2.5 Experimental for Tensile Test

The universal material testing machine (UTM) was used accordance with ASTM E8 standard. A standard test specimen of mild steel chips composites was axially loaded on the universal material testing machine. the extensions were recorded at load increment for every 5kN in the elastic region. Extra reading was taken at yield point for metal exhibiting an upper and lower yield point. the load was continued place and recorded the extension at 0.5kN increment up to safe value below the forecast fracture load. the extensometer removed before fracture. the digital load meter was set to peak hold. the load was Increase uniformly and fracture the specimen. Thus, the fracture load recorded. the specimen was removed for study of fractured area, the two pieces were fitted together and measured. the final length between the extensometer marks and diameter in the neck using Vernier caliper.

3 RESULTS AND DISCUSSION

The test was run on five sample A, B, C, D, E using the ASTM standard for Rockwell hardness test on metallic materials i.e., ASTM E18-07 and ASTM E8/E8M for tensile strength test. The following results were obtained after the test on the samples [14]. Table 4 present hardness test results. Figure 1 depict the hardness test graph and Figure 2 pictured Tensile strength test. Table 4 shows hardness test result. Furthermore, Tables 5 to 9 indicated the tensile strength test result for specimen A-E. meanwhile, Table 10 depicted the computation of tensile test.

Table 4. Hardness Test Result

Samples	Hardness Test (H)			Average ($\bar{H}$) HRB
	Test 1	Test 2	Test 3	
A	50.3	50.8	50.7	50.6
B	55.5	55.1	55.9	55.5
C	56.8	56.7	56.9	56.8
D	60.5	60.7	60.8	60.8
E	66.6	66.8	66.6	66.9

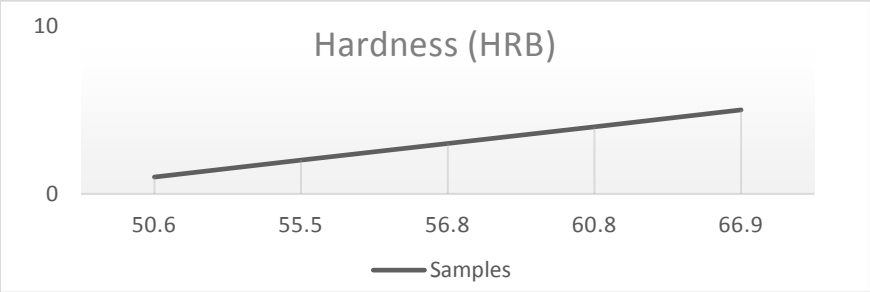

Figure 1. Hardness Test

Table 5. Tensile Strength Test Result for Specimen A

S/No	Load (kN)	Extension (mm)
1	0	0
2	5	0.032
3	10	0.091
4	15	0.235
5	17.5	0.521

Table 6. Tensile Strength Test results for Specimen B

S/No	Load (kN)	Extension (mm)
1	0	0
2	5	0.026
3	10	0.084
4	20	0.135
5	23.5	0.182

Table 7. Tensile Strength Test Result for Specimen C

S/No	Load (kN)	Extension (mm)
1	0	0
2	5	0.0233
3	10	0.0546
4	15	0.0667
5	16.4	0.0723

Table 8. Tensile Strength Test Result for Specimen D

S/No	Load (kN)	Extension (mm)
1	0	0
2	5	0.046
3	10	0.077
4	15	0.136
5	15.5	0.189

Table 9. Tensile Strength Test Result for specimen E

S/No	Load (kN)	Extension (mm)
1	0	0
2	5	0.0136
3	10	0.0332
4	15	0.0422
5	14.5	0.0582

Table 10. Computation for tensile tests

Samples	Stress	Strain	Ultimate tensile stress	Breaking stress
A	8.379	29.091	0.545	0.636
B	17.016	10.526	0.701	0.702
C	22.179	8.333	0.500	0.516
D	22.997	8.475	0.508	0.556
E	17.266	5-000	0.300	0.483

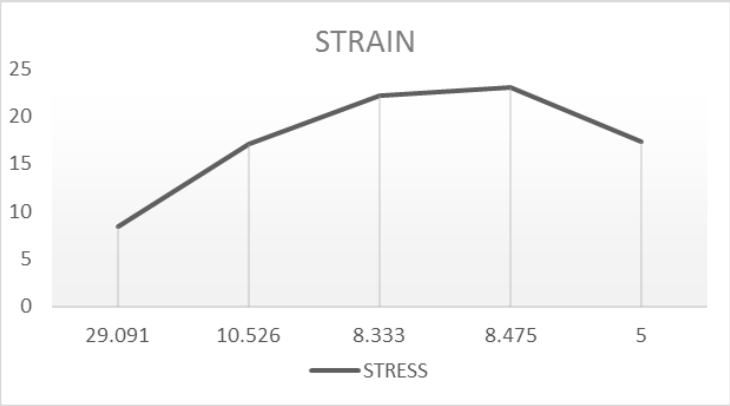

Figure 2. Tensile strength test

3.2.1 Hardness Test

From the Table 1 above (hardness test result), the variations in the hardness values can be seen among the samples. Sample E, has the highest hardness value with the composition of 75% fine grain sized chips and 25% epoxy. Sample D has the composition of 50% fine grain sized chips and 50% epoxy. Sample C has the composition of 75% mixture of intermediate and large grain sized chips and 25% epoxy. Sample B has the composition of 50% mixture of intermediate and large grain sized chips and 50% epoxy. Sample A which has the lowest hardness test, has the composition of 65% epoxy and 35% fine grain sized chips, similar report was presented by [6]. It can be seen that, the sample with the highest hardness value has a composition containing 75% fine grain sized chips. The bonding of the chips with the epoxy is much stronger here. The sample with lowest hardness value, even though containing fine grain sized chips, is soft because of the high amount of epoxy in the mixture. The graph shows the increase in the hardness of the composites.

3.2.2 Tensile Strength Test

From Tables 2, 3, 4, 5 and 6 above (tensile strength test), the variations in the values of the samples vary a little. From the results, the samples cannot withstand the load of more than 25kN. The means that the samples is more brittle than ductile especially sample D and E which contain fine grain sized chips and has the lowest tensile strength. Sample B and C can withstand more deformation than D and E. sample A can withstand more deformation than the rest due to the fact that it is softer than the rest. The epoxy content in sample A makes the composite to exhibit a plastic like nature rather than that of metals similar findings were reported by [7]. The tensile strength graph shows the difference in the tensile strength of the composites.

4 CONCLUSIONS

The metal chips reinforced composites were produced in controlled environment using a less costly adhesive (Araldite epoxy). The data shows that, the composite produce has a hardness value of up to HRB 66.8, and tensile strength of 67MPa by average. a material of such hardness can be classified as a material with good hardness. Although the material is brittle in nature rather than been ductile which is one of the characteristics of mild steel. it can resist plastic deformation to certain limit as all other materials. This shows that mild steel chips obtain from different machine operation can be utilize to produce a material that can be used in the immediate environment rather than been dispose in open fields. The conclusion can be summarized as thus, the composites were produced from the available waste mild steel chips around Maiduguri. The composites produced can be used in a different engineering field, where a hardness of not more than HRB67 and a load of not more than 25kN will applied.

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