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Experimental Determination of Compacting Characteristics of Copper–Redmud Composites

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ABSTRACT
Composite materials are capable of providing higher temperature operating limits than their base metal counter parts and they can be tailored to give improved strength, stiffness, hardness, thermal conductivity, abrasion resistance, creep resistance and dimensional stability .Powder metallurgy is an appropriate process for the preparation of composite materials. Copper appears to have a potential as a base metal for composites for obtaining various improved properties. Red Mud is an industrial waste obtained in both solid state and powder form produced during the production of Alumina by Bayer's Process. The objective of the present work is to prepare copper red mud composite specimens using conventional powder metallurgy and to determine green characteristics of these compacts.

Index Terms: Powder metallurgy, Mixing and blending,, Compacting Properties.

I. INTRODUCTION

Powder metallurgy is a powerful and versatile field of technology where potential value can be portrayed by its applications. Powder metallurgy is growing continuously throughout the world and the process has become more competitive in comparisons with the metal forming techniques. Initially powder metallurgical process was used tore place casting for these metals, which were difficult to melt industrially because of their high melting points In faction manufacture depends up on the use of pressure to weld together the particles of solid iron product by reduction in a primitive hearth. Powder metallurgy is a manufacturing process in which components are directly product from powders of required material into the desired final shape by compressing The powder indies .Strength and the other properties are imparted to the components by subsequent sintering operations .Powder metallurgy principles were use dasfarasbackas300B.C ,by the Egyptian stomached iron implements . If a Metallic powder is subjected to a sufficiently high pressure, a degree of bonding takes place between the particles ever at room temperature and a coherentmasis produced.

Earring the compacted mass improves the coherence between the particle by promoting inter granular grain growth and diffusion. The temperature use dies usually somewhere above their crystallization temperature of the metals but below their melting points. The use of gold, silver, copper, brass, tin powder form perm mental purposes was common place during the middle ages. Powder metallurgy is the only process from which we can get a wide variety of properties as whole in a single component. This is made possible by blending powders of different materials which otherwise would not be make possible. So, my project is mainly intended to prepare the specimens by powder metallurgy technique using copper and different volume fractions of Red mud with three different particle sizes and to determine various properties of the green compacts.

PROCEDURE:

In this chapter an endeavor will be made to furnish the details of various step sand techniques adopted mixing of powders compacting process and determination of various compacting and sintering properties like Green Density, True Porosity, Ejection Pressure, Green Hardness and Green Strength.

Materials Used:

Materials used for the experiment constitute Copper powder and Red Mud. Copper Powder is supplied by SD Fine Chemicals Pvt Ltd .Mumbai. The specification of powder is:

Purity 99.5%

Atomic Wt	63.55
Mesh size	325

Type of powder Electrolytic he maximum limits of impurities present are:

Antimony (Sb)	0.005%
Arsenic (As)	0.0002%
Lead (Pb)	0.05%
Iron (Fe)	0.005%
Manganese (Mn)	0.005%
Silver (Ag)	0.005%
Tin (Sn)	0.005%

The Red Mud is obtained from National Aluminum Corporation (NALCO), Odessa.

Process of Sieving:

The Sieves Of 75µm, 53µm and 38µm are used to sieve there red mud powder for getting there red mud particles of respective above mentioned specifications. The three sieves with differ apertures

Fig. 1 Sieves with specifications of 75, 53 and 38microns

the Red Mud Powder with three particle sizes in range of 0-75µm. 0-53µm and 0-38µm are stirred with pure copper by taking the weight fraction. The composition of Red Mud in The amorphous form and pure copper are take midterms of weights by using Digital weight balance (0.0001gm).

Density Bottle method:

Since red mud is an industrial waste, the chemical compositions of various particle sin graded within it changes room time to time and one industry to another one. Density bottle method is one of the approaches to determine the apparent density of the red powder. For conducting this experiment, kerosene issue dasanonre active agent. The apparent density is calculated using the formulae. The experimental setup is shown in the Fig.2

Specific Gravity=$(W_2-W_1)/[(W_2-W_1)-(W_3-W_4)]$ W_1= Weight of the empty density bottle W_2 =Weight of the density bottle +Weight of 2/3 of red mud

W_3=Weight of the density bottle +Weight of 2/3 of red mud +Kerosene Up to lid

W_4=Weight of the density bottle +kerosene **Density of Red Mud=Specific Gravity*Density of Kerosene (0.8gm/cc).**

The Density of red mud powder is obtained, using density bottle method.

Fig.2Weight of the bottle using DWB (0.0001gm)

Mixing of Powders*:*

The following weight percentage compositions of the powder mix are prepared for the study of compacting and sintering characteristics for each particle size and the pure copper individually. The addition of red mud in terms of weight is of the particle sizes in 3ranges such as 0-75µm, 0-53µm and 0-38 µm respectively.

1. Pure copper
2. .Copper 2%Red Mud
3. .Copper 4%RedMud
4. .Copper 6%Red Mud
5. .Copper 8%Red Mud
6. Copper10%Red Mud
7. Copper12% Red Mud
8. Copper-14%Red Mud

The powders as per the above weight percentages have been weighed with a batch weight of around 60gms using digital weighing machine of 0.0001 gm's least count.

Fig .3 powder mixing process

They are taken in a plastic chamber, which in turn placed in the metal mixing chamber after closing with plastic lid.

The mixing chamber is are rectangular box fabricated with mild steel sheet and a mild steel rod attached to it some corner eccentrically .The end of the rod is placed in the chuck of lathe and is rotated at 60rpm for one hour with change in clock wise and anticlockwise directions for every 5minute to ensure pro premixing This process is shown in Fig.3 .After mixing the powder mixture is pouredina conical flask and closed with arubbertubecork having glass tube and flexible rubber tube. The rubber tube is folded and tied with rubber and to protect the powder mix from oxidation.

Compacting of powder mix:

Experimental Setup:

The experimental setup consists of a die, punch, Lower punch support ejection block, lubricant, cotton, test tube and funned land required powders. This powders used in this experiment are shown in Fig.4 along with die lubricant.

Fig.4 Copper, Red mud Powders and Die Lubricant

Engine valve guide and puppet valve issued as Die and punch respectively for compressing copper-red mud composites .Lower punch support Issued to place it at bottom side of the die to support the mixture of powder .Silicon spray issued as a die wall lubricant to reduce the sticking of powders to the surface of the die bore and also eject the finished component from the die easily. It Is sprayed over both die and Punch. The Following requirements are furnished below in the fig.5. A Universal Testing Machine (100KN capacity is shown in fig.6.

Preparation of Compacts:

Single action die comp acting is adopted during the course of study .A compression testing machine issued for preparing green compacts .The die and punch are cleaned with cotton. Silicon spray is applied on all the walls of die and punch. The Powder mix of constant volume is taken into a marked test tube up to the mark in order to ensure constant volume of powder mix used for each compact. The die is filled with a fixed volume of powder mix after placing the lower punch support at the bottom of the die.

Fig.5Requirements for Compaction Process

Fig.6 Universal Testing Machine (100KN)

.The upper punch is the inserted in the die before placing the die assembly on the lower plat form of the compression testing machine is shown infig.8. This comp action is carried out by the compression testing machine for the 300MPa at ambient temperature .After the completion of compacting, the switch is made off and there after pressure is released and lower platform is brought down for ejecting the compact from die .An ejection block especially fabricated for the purpose is placed between the die assembly and the lower platform of the loading machine as shown in fig.9. The loading again applied by the Compression testing machine for ejecting the green compact out of the die cavity. The maximum load take eject the comp act is taken down.

After removing the compact from the die, It is placed in the polythene packet overt oxidation of the specimen. Three different loads are applied for each composition. At each composition, six compact s are prepared by applying the same load. This is repeated or each different composition .The fabricated green compacts are shown in the fig 7.

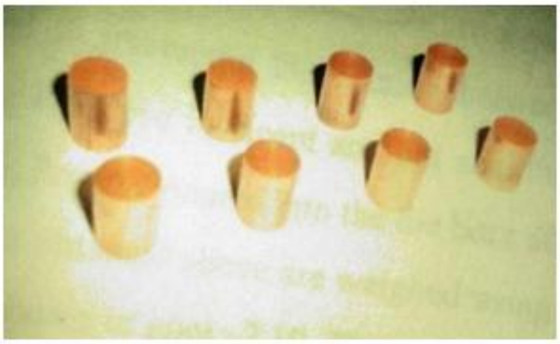

Fig.7 Green Compacts of Copper-Red mud composites

Lubricants are used to overcome the friction between the die wall and compacts. Silicon spray issued as an effective lubricant and anti sticking agent. It is sprayed over the entire length of the die wall. Powder poured in to the die bore after lubricant is sprayed.

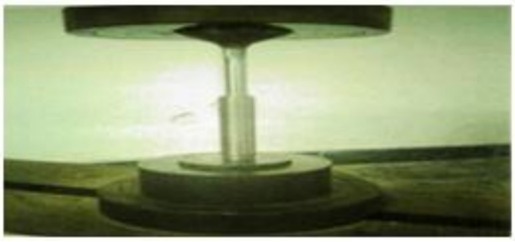

Fig.8CompactionProcess

The green compacts obtained above are Weighed using Electronic weighing machine 0.0001 gm's least count as shown in fig.10. Their lengths and diameters are measured with digital micrometer having least count of 0.001 mm. Now various compact characteristics like Ejection pressure, Green Density, %True Porosity,
%Spring back, Green hardness and Green strength are obtained from calculations.

Fig .10 Digital Weight Balance (0.0001gm)

Determination of Compacting and Characteristics:

The average value office compacts made at the same compacting pressure with same composition is taken as the reliable measure in determining the following compacting Characteristics.

Ejection Pressure:

Ejection pressure is calculated using the following formula:

Ejection pressure $P_e = F_e / \pi \times D_g \times L_{g\,M}\ pa$

Where Fe= Ejection load in new tons.
Dg=diameter of green compact in mm.
L g=Length of the green compact in mm.

Green Density:

Green Density is calculated from the formula Green density.

$$\rho_g = (4000 \times W_g)/(\pi \times D_{g2} \times L_g)$$

Where W g=weight of the green compact in gm's.
D_g=Diameter of the green compact in mm.
L_g=Length of the green compact in mm.

True Porosity:

The volume percentage of red mud and the copper addition in each composition are calculated using the following equation .Percentage volume of Redbud$_{red}$ $=[(W_{red}/\rho_{red})/(W_{cu}/\rho_{cu})+(W_{red}/\rho_{red})]\times 100$

Percentage Volume of copper,
$V_{cu}=[(W_{cu}/\rho_{cu})/(W_{cu}/\rho_{cu})+(W_{red}/\rho_{red})]\times 100$Where$W_{cu}$, $W_{red}$are weight percentages of copper and red mud.
The theoretical density of each composition calculated from the following formula.
Theoretical density

$$\rho_h=[(volofcu)\times \rho_{cu}+(volof\ red\ mud)\times \rho_{red}$$

The values of theoretical densities of different compositions thus calculated
Percentage Porosity is calculated from the formula
Percentage porosity= $[1-(\rho_g/\rho_{th})]$*100.

%Spring Back:

The diameter of the die bore is measure within side Micrometer, whose least count is 0.01mm.
The %spring back is calculated as follows,

% Spring Back=(D_g-D_d/D_d)*100.

Where D_g= Diameter of the Green compacting mm.
D_d=Diameter of the die bore in mm (9mm).

Green Hardness:

The green hardness of the compacts is testing by using Macro Vickers Hardness Tester, which is distinguished by high accuracy, wide measuring range and simplicity of operation. It combines the universal impact device and a processor as a single unit. It automatically computes the hardness values and the statistical mean are automatically provided.

Macro Vickers Hardness Tester Shown in fig.11.
The Hardness Tester is set for the clear vision of The surface of the green compact by rotating the handle .Locate the area on the surface, on which the hardness is to be measured Rotate the head of the microscope and set for indentation. The instrument is set to give mean of 6 readings for each compact. The compact is placed on the smooth heavy block with its axis vertical .The mounted specimens are shown in the fig.12.

Fig.11 Macro Vickers

Fig.12 Mounted Specimens Hardness Tester

Click the start button on the hardness tester. It starts working and gives the in dentations at a dwell period of 10sec by taking the load of 500gm .By Means of microscope take the diagonal lengths of the diamond in dentition and the hardness is calculated by means of thelengthsasshowninFig.13.

Fig.13 Touch Screen and Display of Vickers Hardness Tester

Green Strength:

The Compression Testing Machine which is used for finding the compressive strength of the compacts. The compact is placed in between the two aluminum bars using two black grippers without disturbing the edges for crushing as shown in fig.14. The compression test is carried out and the minimum load, F_e where the compact crushed, is noted down. The compressive strength is calculated using the Formula.

Green Strength=$4000*F_c/\pi*D^2$ M Pa.

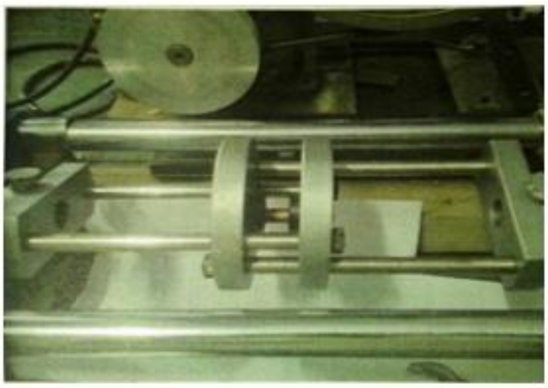

Fig.14 Tenso Meter

Fig.15 Optical Microscope

An Optical microscope is shown in fig.15. The image from an optical microscope can be captured by normal light-sensitive cameras to generate a micrograph. Originally images were captured by photo graphic film but modern developments in CMOS and charge-coupled device (CCD) cameras allow the capture of digital images. Purely digital microscopes are now available which use a CCD camera to examine as sample, showing there salting image directly on a computer screen without then effort eye pieces.

Mounting Process:

Fig.16Auto Mounting machine with Bakelite Powder (Left Side)

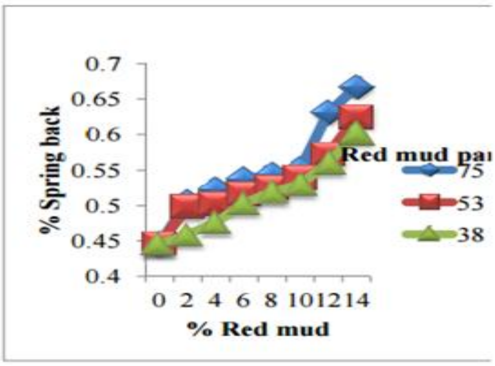

Fig.18%SpringBackVs%Red mud

The effects of red mud content and particle size on spring back of copper composites are shown in fig18. It indicates that the percentage spring back clearly increases from 0.446% to 0.667% with the addition of 0-14% red mud of different particle sizes. There elative increase in spring back with the addition of red mud can be attributed to its deformation mode under compressive forces. Most of the red mud

The effects of red mud content and particle size on green density for copper composites are shown infig.20. It indicates that the green density varies from 45.48kn/m3 to 66.68kn/m3 with Addition of red mud of different particle sizes. It is observed that there is a decrease in green density with increase in red mud content. This is because the density of red mud is less than of copper and as the red mud content increases, the compact exhibits a reduction in green density.

particles might have deformed in elastic regime. The contribution of red mud particles to spring back may due to the inelastic recovery; after the compaction pressure is removed .Thefig.23 also indicates that with increasing particle size of red mud from 38microns to 75microns, significant changes are not observed in percentage spring back.

The effects of red mud content and particle size On ejection pressure of copper compacts are shown infig.19.It indicates that ejection pressure decreases from a maximum of 29MPa to a minimum of 11.70MPa, with the addition of 0-14% red mud of different particle sizes. There is a general decrease in ejection pressure with increase in red mud content. Ejection pressure is a function of friction between the compact and the die wall during ejection. This depends up on the materials involved, the die finish and clearance. The decrease in ejection pressure with increasing red mud content can be attributed to the low frictional resistance of red mud particles and also due to the decreased volume fraction off laky and dendrite copper powder in the composite with increase in particle size, the ejection pressure gradually decreased for all compositions. With increase in particle size of red mud, the actual area of contact between the die wall and the comp act decreases, hence the decrease in Ejection pressure

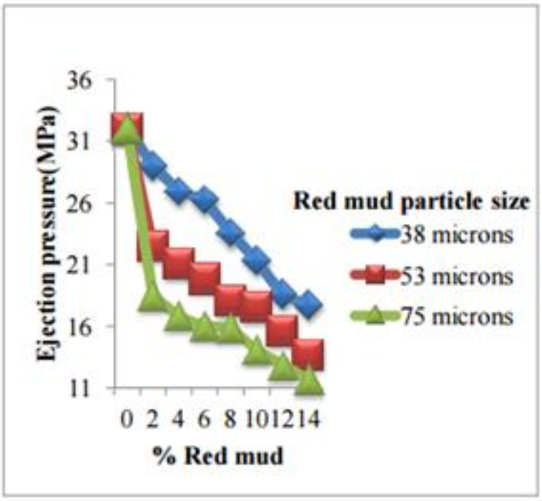

Fig.19 Ejection Pressure Vs % Red Mud

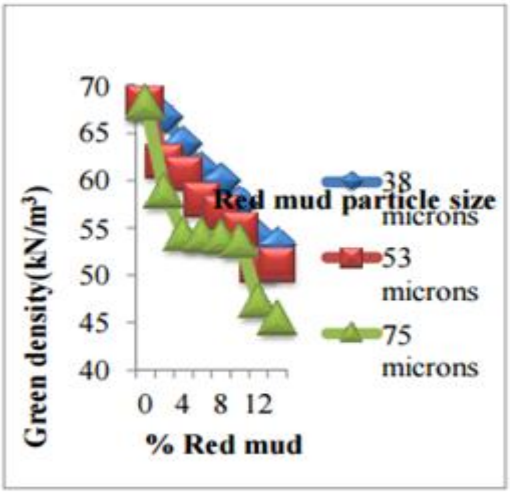

Fig.20 Green Density Vs% Red Mud

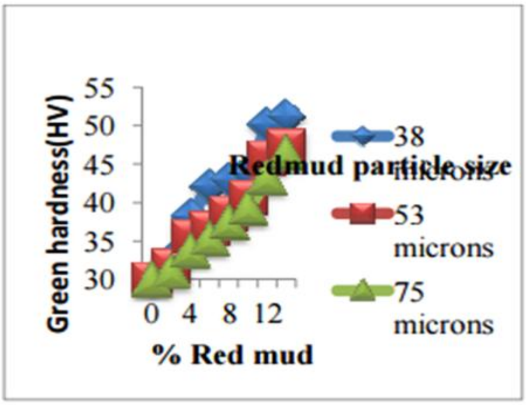

Fig.22 Green Hardness Vs% Red Mud

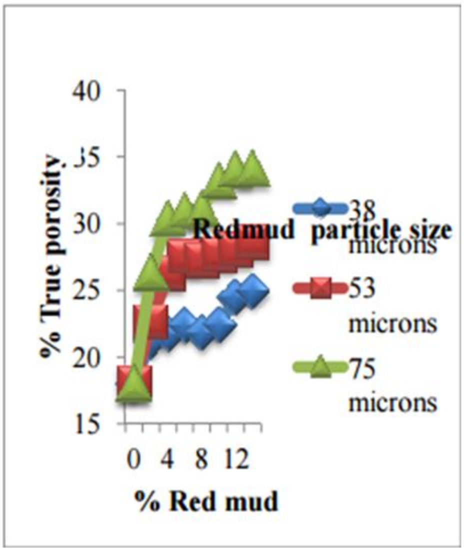

Fig.21%True Porosity Vs% Red Mud

The effects of red mud content and particle size on percentage true porosity of copper composites are shown in fig.21. It indicates that the percentage true porosity varies from a maximum of 34.08% to a minimum of 21.25% with the addition of 014% red mud of different particle sizes. The fig.21 indicates that percentage true porosity increases with increase in red mud content. The particles of red mud consists of small rounded particles of diameter ranging from 0.5-1µm and large particles having irregular profile with width/thickness ranging from2-3µm.The fig.21 also indicates that with increase in particle size of red mud the true porosity gradually increased. This is because smaller particles are packed very closely giving rise to less number of voids, where as larger particles form more voids or clearances. The effects of red mud particles and its particle size on green hardness of copper compacts are shown in fig.22. It indicates that the green hardness varies from 30.9HV-51.2HV with the addition of 0-14% red mud of different particle sizes. The green hardness increased with increasing red mud content. This is due to the presence of hard red mud particles which mainly consists of iron oxide and alumina silicates. The green hardness gradually decreased with increasing particle size of red mud. This is due to the increased porosity of the compacts with increasing particle size.

Conconclusion: Silicon spray can be used as a lubricant to reduce the friction between the die wall and the compact .it is evident from the surface finish of the green compact. The addition of red mud content to copper increased the spring back. There is no significant change in percentage spring back with increase in particle size. The addition of red mud content to copper decreased the ejection pressure. With increase in particle size, it is observed that there is a decrease in ejection pressure. The addition of red mud content to copper decreased the green density. With increase in particle size, it is observed that there is a decreasing green density. The addition of red mud content to copper increased the true porosity. With increase in particle size, it is observed that here is an increase in true porosity. The addition of red mud content to copper increased the green hardness. With increase in particle size, it is observed that there is a decreasing green hardness.

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