Effect of Red Mud on Aluminium- Silicon Carbide Metal Matrix Composites

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Abstract— **The project is completely based on Powder Metallurgy domain where which specific powders are blended, compacted and sintered and planned to undergo performance characteristics by tests and properties verifications. The project title is "Effect of Red Mud on Aluminium-Silicon Carbide metal matrix composites" which strictly adheres powder metallurgy domain. Aluminium-Silicon Carbide Metal Matrix composites is one of the important composite material which is very extensively used for wide over applications in Aerospace, Automobile and other Industrial applications. The desired strength which it posses made every material to be fabricated and designed very successfully but some of the major problems faced during its utilization were very vast due to the loss of value of its essential properties. The main intention is to enhance the Pre-defined properties which it possessed by the utilization of a property enhancer "Red mud" during a Metal matrix composite production.**
The "Red Mud" is a slag obtained at the outlet part of an Aluminum metal extraction factory. This slag contains about 95% of Alumina content which consists of very high possessing properties of rigidity, heat withstanding capability, toughness and due to which when it is combined with an aluminum reinforced metal matrix composites using Powder Metallurgy concept, the properties of the manufactured component will be outstanding in its applicative point of view and so they can be used for various engineering applications effectively.

Keywords— Al, SiC, Red mud

I. INTRODUCTION (*Heading 1*)

1. Aluminium- The matrix (Base metal):-

Aluminum powder is a light, silvery-white to gray, odourless powder. It is a reactive flammable material. Aluminum powder is a fine granular powder made from Aluminium. In form of powders, Aluminium is used for several applications such as manufacture of slurry, explosive and detonators, thermit process used for manufacture of ferro alloys and forspecialised welding applications such as rails, pyrotechnic to manufacture crackers, sparkles and other pyrotechnic products; manufacture of aluminium paste, paints and several powder components used in automobiles.Aluminum powders are used in paints, pigments, protective coatings, printing inks, rocket fuel, explosives, abrasives and ceramics; production of inorganic and organic aluminum chemicals; and as catalysts. Pyro powder is mixed with carbon and used in the manufacture of fireworks. The coarse powder is used in aluminothermics. We selected Aluminium due to the above discussed applications which are adapted in our day to day life and mainly due to its cost effectiveness factor. So, a reinforcement is done on this base powder to increase its extensive properties in its applications which were used typically at present.

1.1 Silicon Carbide- The Reinforcement metal:-

Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good mechanical properties. It is used in abrasives, refractories, ceramics, and numerous high-performance applications. The material can also be made an electrical conductor and has applications in resistance heating, flame igniters and electronic components. Structural and wear applications are constantly developing. Some essential properties which silicon carbide possess are listed as follows,

- High strength
- Low thermal expansion
- High thermal conductivity
- High hardness
- High elastic modulus
- Excellent thermal shock resistance
- Superior chemical inertness

1.11 Red mud- The property enhancer:-

Red mud or red sludge is a toxic waste product of the Bayer process, the principal industrial means of refining bauxite in order to provide alumina as raw material for the electrolysis of aluminium by the Hall–Héroult process. A typical plant produces one to two times as much red mud as alumina. This ratio is dependent on the type of bauxite used in the refining process.

Red mud is composed of a mixture of solid and metallic oxide-bearing impurities, and presents one of the aluminium industry's most important disposal problems. The red colour is caused by the oxidised iron present, which can make up to 60% of the mass of the red mud. In addition to iron, the other dominant particles include silica, unleached residual aluminium, and titanium oxide. So, due to its highest nature of exhibiting part of alumina content in its outcome part as a slag it is planned to utilize red mud in the metal matrix composite material to improve its properties.

II. EASE OF USE

A. Aluminium

[1] The scientists who preceded Héroult and Hall had been concerned entirely with a chemical process for producing the metal. Héroult and Hall introduced a new concept. They believed that the answer to economic production lay in an electrolytic method. They had the idea that if some substance could be found which would conduct electricity and in which aluminium oxide (Al2O3), known as alumina, would dissolve, then an electriccurrent passed through the solution could deposit the aluminium as metal.

B. Silicon Carbide

[1, 2] In the past, the list of ceramics used as industrial materials consisted of alumina and other oxides. In recent years, there have been strong demands for the use of
ceramics as structural materials in place of metals and alloys and for use in harsh environments. Consequently, new ceramics such as nitrides, carbides and other covalently bonded materials have received increased attention because of their unique characteristics. The formation of SiC from the reaction between silicon
and carbon can take place at temperatures below the melting point of silicon. A eutectic point between silicon and SiC exists at 1402°C and 0.75 atom % carbon. The liquidus curve between Si and SiC is shown up to 2600°C and 27 atom
% C. A peritectic point is located at 2540°C and 27 atom % C under normal conditions. There are numerous (~200) polytypes for SiC, but only a few are common. All of the structures may be visualized as being made up of a single basic unit, a layer of tetrahedra, in which each silicon atom is tetrahedrally bonded

C. Red mud

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Red mud cannot be disposed of easily. In most countries where red mud is produced, it is pumped into holding ponds. [2] Red mud presents a problem as it takes up land area and can neither be built on nor farmed, even when dry. As a waste product of the Bayer process the mud is highly basic with a pH ranging from 10 to 13. Several methods are used to lower the alkaline pH to an acceptable level to decrease the impact on the environment. Research is being performed to find a suitable way to use the mud for other applications, but drying the mud requires much energy (latent heat for water evaporation) and can represent high costs if fossil fuels have to be used in the drying process.

III. EXPERIMENTAL PROCESS

Powder metallurgy is the process of blending fine powdered materials, pressing them into a desired shape or form (compacting), and then heating the compressed material in a controlled atmosphere to bond the material (sintering). The powder metallurgy process generally consists of four basic steps: powder manufacture, powder blending, compacting, and sintering. Compacting is generally performed at room temperature, and the elevated-temperature process of sintering is usually conducted at atmospheric pressure. Optional secondary processing often follows to obtain special properties or enhanced precision.

3.1.2 Powder Blending:-

The powders are blended according to the calculated individual mass obtained after calculation and it is blended properly. The powders are blended and then placed in the center cavity of the manufactured die. Initially the composition of the samples without red mud

is first analyzed and then the composition of samples with red mud is analyzed.

3.1.3 Composition of samples:-

It is subjected to have two different set of samples of Aluminium- Silicon Carbide combination and Aluminium- Silicon Carbide and Red mud composition. The main intention is to compare the prepared samples and to make the metal matrix composites and to compare them by undertaking different types of tests and to state the strength and extent of utilization of the metal matrix composites manufactured.

Composition calculation:-

Theoretical density is calculated as,

Theo density = 100/ ((% Al / density of Al + % of SiC / density of SiC)) (g/cc)

Mass of powder required for 95% achievement is calculated as,

Mass = [(3.14/4)* D^2* L* theo density* 95%] (g)

For calculating individual amount of composition of powders, say 95%

*Mass of Al = Mass for 95% * % of Al selected (g)*

Mass of SiC = Mass of 95% * % of SiC selected (g)

Mass of red mud = Mass of 95% * % of Red Mud selected (g)

Compaction process

Coming to compaction part of the sample, the powders are compacted under the compaction pressure of 240 Mpa on the blended powder. In sedimentology, compaction refers to the process by which a sediment progressively loses its porosity due to the effects of loading. This forms part of the process of lithification. When a layer of sediment is originally deposited, it contains an open framework of particles with the pore space being usually filled with water. As more sediment is deposited above the layer, the effect of the increased loading is to increase the particle-to-particle stresses resulting in porosity reduction primarily through a more efficient packing of the particles and to a lesser extent through elastic compression and pressure solution. High pressure loading is been provided to the powder which is been placed at the centre part of the die cavity. The compaction process can be made using Universal Testing Machine by providing sufficient loading on the powder part.

Sintering process

Sintering is the process of compacting and forming a solid mass of material by heat or pressure without melting it to the point of liquefaction. Sintering happens naturally in mineral deposits or as a manufacturing process used with metals, ceramics, plastics, and other materials. The atoms in the materials diffuse across the boundaries of the particles, fusing the particles together and creating one solid piece. The study of sintering in metallurgy powder-related processes is known as powder metallurgy. Sintering is effective when the process reduces the porosity and enhances properties such as strength, electrical conductivity, translucency and thermal conductivity; yet, in other cases, it may be useful to increase its strength but keep its gas absorbency constant as in filters or catalysts. During the firing process, atomic diffusion drives powder surface elimination in different stages, starting from the formation of necks between powders to final elimination of small pores at the end of the process.

IV TESTING DETAILS

It is planned to undertake three important tests to check whether our manufactured metal matrix composites are capable to withstand high strength, compressive strength and resistant to wear factor. Hence the three tests are

1. Hardness test
2. Compression test
3. Wear test

Metallurgical tests

Scanning Electron Microscopy (SEM) is used to image and investigate the properties and compositions of a broad range of sample types.

- High resolution surface inspection and backscatter analysis of samples
- Non-destructive, semi-quantitative elemental analysis of solids using energy dispersive X-ray microanalysis

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