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Behaviour of Al-7075 Reinforced With Red Mud Using Chill Casting Process

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ABSTRACT: Previous researches on Aluminium matrix with the different reinforcement materials like silicon carbide, tin, red mud, zinc, fly ash etc, are made using stir casting process. In this present work is made using Al 7075 is used as the metal matrix and the Red Mud as the reinforcement material, along with this liquid nitrogen is used for the chilling effect at -195°C to develop the Metal Matrix Composition. Matrix Material Al 7075 is heated in the electric furnace up to 660°C and the reinforcement Red mud is added to it in the ratios of 2% and 3%. Accordingly, this mixture of MMC and reinforcement are stirred continuously for 4-5 minutes using zircon coated iron rod at 640°C and the liquid nitrogen gas is allowed to pass through the mould with proper arrangements simultaneously at the time of pouring molten metal. The specimens are made of both with and without chill casting. The studies show importance in mechanical behaviour like tensile, hardness and impact strength. In addition were compared between with and without chill cast component of same grade.

KEYWORDS: Liquid nitrogen, chill casting, red mud, stir casting.

I. INTRODUCTION

The outstanding mechanical properties of Aluminium and Aluminium alloys made it to play a major role in the industrial area. The properties like weight, strength, linear expansion, conductivity, reflectivity, corrosive resistance, machinability are higher in aluminum and its alloys. Due, to this it is used more in aerospace industries and automobile industries along with magnesium, titanium and copper. Red mud is the waste produced in the production of Alumina (Al_2O_3) from bauxite ore from Bayer's process, which contains high alkalinity and heavy toxic. Stir casting is the process where the reinforcement material (Red mud) is mixed up with the molten metal (Al 7075) and stirred for 4-5 min, at 640°C using stirrer. The reinforcement is added in the ratio of 2%, 3% and 6%. In this process the uniform distribution of reinforcement material is important. The viscosity on the layer of molten metal should be uniform if, it is not uniform in nature the used reinforcement will stay on surface or it will shuttle down in the crucible. The addition of ceramics is important part in this, lower the wear property gives good machining and lubrication and higher the wear property gives good strength.

Chill casting is the process where the rapid solidification takes place with the help of any cooled surfaces using chills. Chills are those which will help or promote metal to attain solidification in certain portion of molten metal. There are two types of chills i) internal chill ii) external chill, chills of the same material that of molten metal causes the chilling effect around its surroundings are called internal chills, and external chills are those which are mixed with the sand, they melts and produce cooling sense around its surrounding metal when the molten is poured in to mould.

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II. LITERATURE REVIEW

Naresh Prasad: In this work he aimed to use red mud as the reinforcement material as a low cost option. The experiments are made in pure sliding mode on pin-on-disc machine. It helps to access wear character of the aluminium with red mud on different working conditions. Samples were subjected to heat treatment process to improve the wear behavior. Surfaces of samples were studied under optical microscope to get the detailed knowledge of individual composites. Finally, it says wear behavior can be improved by using heat treatment process at proper cooling rate.

Hitesh Bansal: This study is carried out to measure the microhardness and abrasive wear behavior of the MMC by using VHM (Vickers hardness machine) and X-ray diffraction. Here, aluminium is used as metal matrix and Red mud is used as reinforcement material. Arrangement of VHM of diamond indicator with constant load of 200 grams at 10X optical zoom is applied and results observed by varying the percentage of reinforcement continuously. To check the presence of the phase of the reinforce material in MMC the X-ray diffraction (XRD) is made. Where the dispersion of particles is greater in the composition the wear behavior and hardness will be high in the metal.

S. Rajesh: This study mainly focuses on the effect of machining parameters on the specimen when subjected to turning operation in CNC machine. Here, Red mud based Aluminium composition is used. The major aspects considered during turning are like Surface roughness, feed rate, speed, depth of cut, noise radius etc are considered. The analysis is made through The Principle Component analysis (PCA) to check the weighing value compared with different parameters. Taguchi-based grey method is applied to check the optimization of design in turning operation. Lastly it says that applied Taguchi-based grey method is an important tool to improve the turning operation in the CNC machines.

P.V. Krupakara: Aluminium 6061 and Red mud composition is used as the Metal matrix in this study. Red mud metal matrix is concentrated in different neutral chlorides like sodium chloride solution. Red mud is varied as 2%, 4%, 6% in the composition, in which the loss in the corrosion, potential tests are conducted. Tests are conducted in 0.035, 0.35, and 3.5% solution of chlorides. Finally it says, the rate of corrosion decreases with increase in percentage addition of reinforcement and it decreases with increase in expose time of all specimens.

P.V. Krupakara: This paper aim is also to check the corrosive loss in MMC. Aluminium 6061 is used with Red mud as reinforcement material. Under dry condition reinforcement is added in the intervals of 2% from 2%-6%. The tests were conducted at 230⁰c using conventional method. Specimens are dipped in to sea water for every 24 hours intervals up to 4 days (96 hours). The rate of corrosion decreases with increase in the expose time of all specimens of metal matrix compositions.

Shaik Mujeeb Quader et.al: This study is done mainly to check the effect of reinforcement addition on mechanical properties, hardness, tensile strength and microstructures. Here Al 6061 is used with two reinforcements like Al₂O₃ and Red mud. Examination on samples shows that the higher the addition of reinforcement causes little porosity in the material and scanning electron microscope shows the microstructure of the material which is uniformly distributed with some porosity in it. The hardness and tensile strength are increased with higher addition of reinforcement in to base metal.

Amit Sharma: The metallurgical technique is used in this process to determine the mechanical properties of Al 2024 reinforced with Red mud. Different sizes and different weights of red mud are added in the sequence of 2%, 4%, and 6% in to base metal. Results shows that the tensile and hardness are increased with increase in addition of red mud of different size. The uniform distribution of Red mud particles in MMC being observed through SEM.

III. METHODOLOGY

Mould is prepared as shown in the above design figure. The temperature of 620⁰C is used in this process, so mild steel is used to make this mould. Mould is Symmetric in nature which should be clamped using core-pin arrangement. The front and back plates of mould are of 25mm and 10mm respectively. Considering the shrinkage of 16% in the Aluminium shrinkage allowances are provided. The design is made such that, the mould will produce three components

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at a time. One component of size 30mm diameter and 50mm length is used for Hardness and microstructure analysis. Second one is used to analyse tensile strength, of size 20mm diameter and 125mm length. Third component of 10X10 and 25mm is used for Impact test.

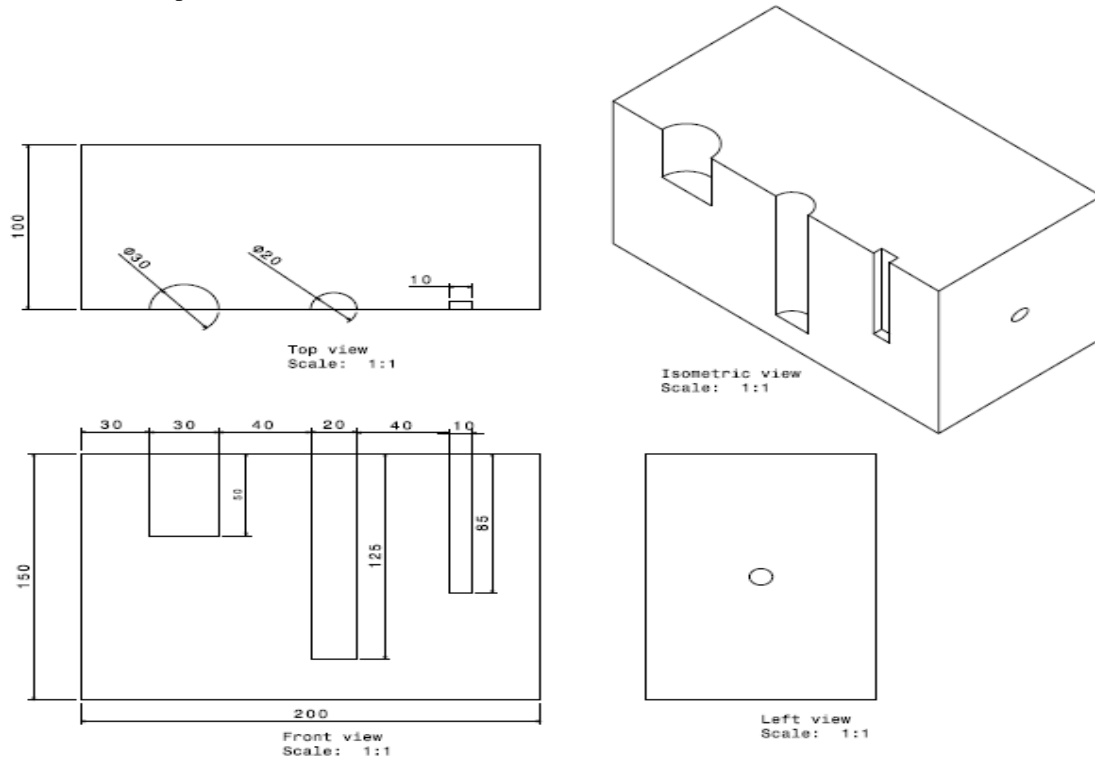


Fig 1: Stainless steel hollow mould used for casting with detailed dimensions

Gear oil is applied as the coat inside the mould; to avoid the stick of metal inside the mould. The mould is subjected to preheat treatment process at 150⁰C after applying coat. Here Castrol D120 is used as gear oil. Aluminium is weighed and kept inside the cleaned crucible. The crucible with the metal is kept inside and power is supplied through Electric furnace and metal is heated up to 740⁰C. Clamp the cope and drag part of the mold by using provided core- pin arrangement, and insert the channel arrangement made for liquid nitrogen supply. Slowly start pouring the liquid nitrogen into the channel to cool down the temperature of mold. After heating up to 3-4 hours adds the gasifier to the molten metal to remove the unwanted gases from it. Here used gasifier is C₂Cl₅ which removes the unwanted slag from the surface of the molten metal. Add Red mud reinforcement in to the molten metal at the ratios of 2% and 3% and stir it for 4-5 continuously to make such that reinforcement is uniformly distributed over the surface of molten metal, and wait for few minutes. Then the molten metal is poured in to mould and simultaneously the liquid nitrogen is supplied through the channel with made arrangements. Liquid nitrogen evaporates speedy at room temperature hence the evaporated vacuum gas is passed through the mould. Wait for few minutes to cool down the temperature of cast component to room temperature. Finally, after all tests make a comparative study on result on with and without chill casting.

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IV. RESULTS AND DISCUSSION

MICROSTRUCTURE

Comparison of microstructures for Al 7075 alloy reinforced with Red mud added at different ratios (with and without chilling effect)

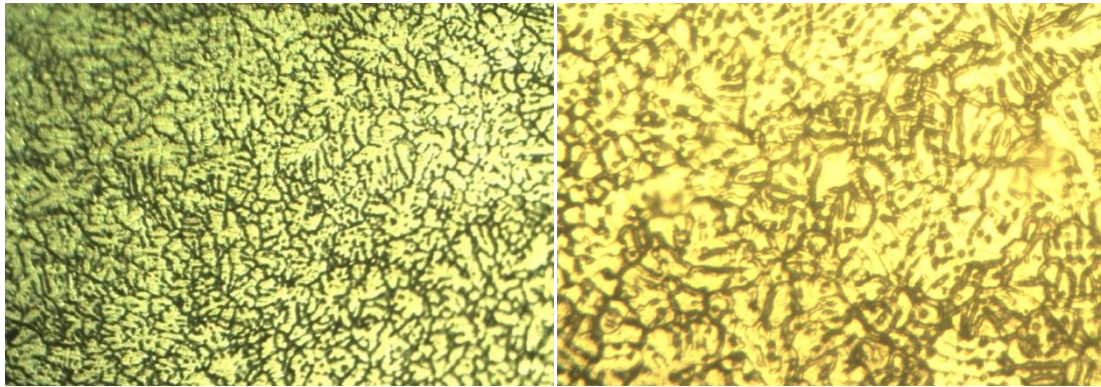


Fig 2: Micro structure images of Al 7075+2% RM without chilling effect Fig 3: Micro structure images of Al 7075+2% RM with chilling effect

The above micro structure images are captured in the optical telescope. Figure (4.3) shows microstructure of Al 7075 + 2% RM of without chilling effect. And it is observed that the grain size is smaller and finer when compared with chilling of same composition. A micro structure, with the addition of the reinforcement the grains size gets attains cellular structure. In the figure (b) with the effect of chills and rapid solidification the grain sizes are larger in size. Hence the mechanical properties decrease with the effect of chills.

HARDNESS AND IMPACT TEST

Comparison of hardness and Impact strength for Al 7075 alloy reinforced with Red mud added at different ratios (with and without chilling effect)

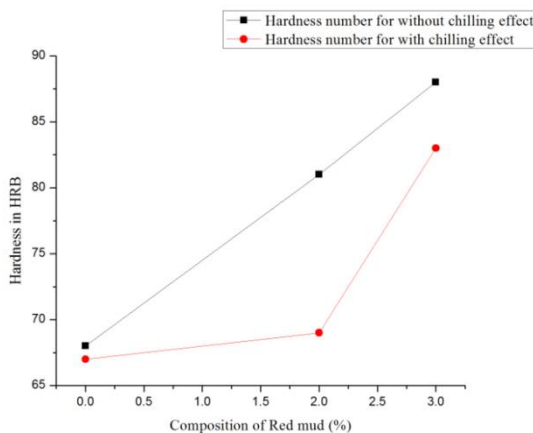


Fig 4 Comparison of hardness number of without and with chilling effect chill casting

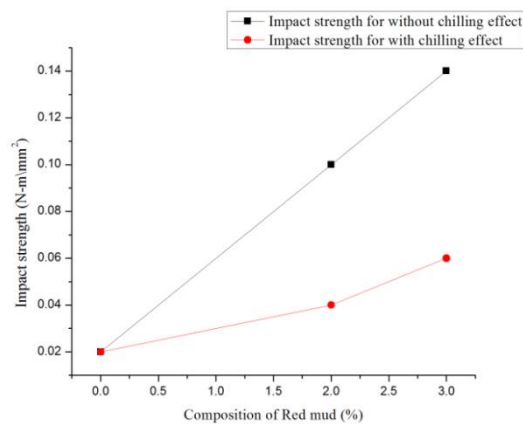


Fig 5: Comparison of impact strength of without and with components

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The hardness in the material increases with the addition of reinforcement material Red mud into matrix material during comparison of hardness for both with chill and without chill cast component. But it is important to note that, the early formed micro segregation will propagate under rapid cooling condition, hence hardness number decreases in chilled cast component in comparison with without chilled cast component

The Impact strength in the material increases with the addition of reinforcement material Red mud into matrix material during comparison of Impact strength for both with chill cast and without chill cast component,. But it is important to note that, the early formed micro segregation will propagate under rapid cooling condition, hence hardness number decreases in chilled cast component in comparison with without chilled cast component

V. CONCLUSION

- The metal matrix Al 7075 is reinforced with Red mud by using chill casting process to attain rapid solidification. Hence, liquid nitrogen is used for the rapid solidification of molten metal.
- The reinforcement Red mud is added in the ratios of 0% 2% 3% and mixed with molten metal. The composites are prepared both of with chill and without chilling effect. The primary defects in the alloys like holes, porosity, and cracks propagate during rapid solidification and the liquid solute rejected solidified part of the material cause's micro segregation.
- Micro segregation propagates rapidly under cooling conditions. By considering these conditions we conclude that the Hardness, Tensile strength, Impact strength will decrease in case of with chilled components as compared with without chilled components.
- Finally we conclude that, mechanical properties of the metal matrix composition cannot be increased by using rapid cooling phenomenon.

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