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High Carbon Ferro Chrome Slag – Alternative Mould Material for Foundry Industry

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Abstract

High silica sand is commonly used in foundry industry for sand moulds making. Various efforts are being made to use the industrial wastes as an alternate molding material in foundry to conserve the natural resources; and effective utilization of the industrial waste to sustain the industrialization. Ferro chrome (Fe-Cr) slag has many of the same attributes of the sand. In this paper investigations were carried out on comparative mould and casting properties of high silica sand and Fe-Cr slag for foundry applications. A series of sand tests were carried out on silica sand, Fe-Cr slag individually and various combinations of these two. The process parameters considered for this investigation were % of Sodium silicate, CO_2 gassing time, and mould setting time. Two types of moulds were made with 100%Fe-Cr Slag and 100% Silica Sand individually with 8%Sodium Silicate and 15Seconds CO_2 gassing time. AA2024 Aluminium alloy cylindrical castings were made through these two moulds; castings were investigated for its microstructure and hardness studies. Results reveal that standard samples with Fe-Cr slag can be prepared; these shows smooth surface finish and accurate dimensions on par with the sand samples. The mould permeability, compression and shear strength results showed Fe-Cr Slag will be a suitable candidate for either partial or full replacement of molding sand. Enhanced mould properties were observed for Fe-Cr slag than silica sand. Good surface finish castings with enhanced mechanical properties and fine grain microstructures were produced by Fe-Cr slag moulds.

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Keywords:Silica sand; Fe-Cr slag; CO2 process; Mould properties; AA2024 Castings;

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1. Introduction

Large quantities of natural materials like silica sand are traditionally used in the foundry applications as a moulding material. Due to the depletion of natural materials, there is a need to find suitable alternative material, which will replace the conventional materials. The large scale industrialization has resulted accumulation of huge amount of industrial wastes, endangering the environment in terms of land, air and water pollution. The sustainability of industries now depends upon the effective management and utilization of its by-products and wastes. In order to use the industrial waste in huge quantities efforts are being made to use the same as a substitute of natural resources. Various efforts have been made to use industrial wastes like fly ash, blast furnace slag, red mud, Ferro Chrome (Fe-Cr) slag etc. in civil and construction works.

Fe-Cr slag is an industrial solid waste generate from the Ferro alloys plant. Globally, Fe-Cr slag is producing around 6.5 to 9.5 million tons per annum and likely to be increased by 2.8 to 3%. Since by the large amount of availability and having similar physical and chemical properties with silica sand, investigations can be carryout to find out the suitability of this Fe-Cr slag as alternative mould materials in ferrous and non ferrous foundry industry. Till now very limited literature is available in this area. Hence, the proposed research work presented a new set of challenges when attempting to assess the suitability of Fe-Cr slag for ultimate use in ferrous and non ferrous foundries.

The development of the Sodium Silicate- CO_2 process of mould making about thirty years ago marked the advent of an epoch-making era in foundry practice. This method has not only cured the problems of foundrymen caused by the need for greater skill and care during moulding and baking, it has also removed serious bottlenecks before the management in planning a regular and streamlined production of castings at a low rejection rate. CO_2 moulds, owing to their superior mould hardness are highly suitable for casting high density alloys like steel [1, 2]. Hence, in this paper investigations were carried out on suitability of Fe-Cr slag as mould material for either full or partial replacement of existing silica sand. Owing to the superiority, Sodium Silicate- CO_2 process was adopted for evaluating the same. The process parameters considered for this investigation were %of Sodium silicate, CO_2 gassing time, and mould setting time. The current research results will be useful to the small scale and large scale/captive foundries by providing an alternative mould material for sand replacement either fully or partially.

2. Materials and Methods

The materials used in this research were high silica sand (procured from Chirala, Andhra Pradesh, India; it is commonly named as Chirala sand); high carbon Ferro Chrome (Fe-Cr) slag was procured from M/s. Jindal Steel &Ferro Alloys Ltd, Kothavalasa, Visakhapatnam, India.

2.1 Particle Size Analysis

As received Ferro chrome slag was in lumps form; hence it has been converted into fine size particles approximately equal to the silica sand grain size. A series of crushing and rolling operations were carried out to achieve the same. Figure 1 shows the sand and Fe-Cr slag particles used for this study. The grain size of the processed Fe-Cr slag and silica sand samples were done by sieve analysis method. The dried sample of 200 grams in weight was taken separately for both the materials. A series of BSS sieves range from BSS 20 to 350 was chosen for this operation. The sieving was carried out continuously for a period of 15 minutes in a Rotap sieve shaker. After this, the sieves were taken apart and the left over material on each of the sieve was carefully weighed. The grain fineness number (GFN) of the each material was quantified by using the following equation (as per AFS Standards):

$$GFN = \sum Mi\ fi / \sum fi \quad (1)$$

Where Mi= multiplying factor for the i_{th} sieve
fi= amount of sand retained on the i_{th} sieve