HEAVY METAL REMOVAL FROM FOUNDRY SAND USING
BACTERIOLOGICAL TREATMENT

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ABSTRACT

In India the metal casting industry has been catering to a large market including agriculture and forestry, automotive and so on in the casting of engines, accessories and also to the export market. Consequently, there are enormous amounts of sand being removed from the casting cycle. To prevent further damage to the environment caused by disposal of this sand, more efficient and environment friendly methods are to be adopted. This sand has found its use in a wide range of applications ranging from agriculture to construction. Use of foundry sand in these fields has proved to be beneficial in waste disposal, in energy saving and so on.

Foundry sand is a byproduct from the ferrous and non-ferrous metal casting industry. Foundry sand obtained from the latter has been found to contain heavy metals in them. Most heavy metals are well known carcinogenic agents and pose a hazardous impact to life and hence must be treated to permissible limits. Bacterial methods involving the use of bacteria such as Bacillus has proved to be effective in the treatment of heavy metals such as Aluminium and Nickel present in the sands by reducing their concentration as much as 50% to 90%.

Key words: Foundry sand, Ferrous and Non-ferrous, Heavy metals, Carcinogenic agents, Bacillus.

1. INTRODUCTION

Foundry sand is widely used as a molding material due to the easiest of the material involved and due to its unique engineering properties[9,11]. The primary composition of foundry sand is clean, uniformly sized, high-quality silica sand or lake sand that is bonded to form molds. These sands are used for ferrous metal castings such as iron and steel and also nonferrous metal castings such as copper, and aluminum[13].

The physical and chemical characteristics of foundry sand will depend on the type of casting process and the industry from which it originates. Foundry sands can be classified into two basic types, green sand (referred to as molding sand) and chemically bonded sand.

Green sand consists of 85-95% silica, about 10% bentonite clay (as the binder), 2%-5% water and 2-10% carbonaceous additives, such as seacoal (a carbonaceous mold additive to improve casting finish). The silica sand resists high temperatures and the coating of clay binds the sand together[10]. The water adds plasticity. The carbonaceous additives prevent the “burn-on” or fusing of sand onto the casting surface.

In addition to green sand molds, chemically bonded sand systems are also used. Chemically bonded sand consists of 93-99% silica and 1-3% chemical binder. A catalyst initiates the reaction that cures and hardens the mass. There are various chemical binder systems used in the foundry industry. The most common chemical binder systems used are phenolic-urethanes, epoxy-resins, furfyl alcohol, and sodium silicates. Chemically bonded systems are most often used for cores and for molds for nonferrous castings.

In this sand casting process, sand is typically recycled and reused through many production cycles. After a number of cycles, this sand becomes unfit for casting purposes and a portion of this sand is replaced with virgin sand. Typically, about 1 ton of foundry sand is required for each ton of iron or steel casting produced. Environmentally, it is becoming more and more difficult to dispose of great quantities of material into the ground. In addition to the environmental plus of reclamation, the process is of value from the conservation
point. The deposits of high quality sand will last longer if they are used more efficiently[5]. The use of foundry sand is being tested in various manufacturing processes as a replacement to improve durability factors in concrete, its use in asphalt concrete and so on[2,3].

2. MATERIALS AND METHODS

Sand casting is the most common technique used around the world. The casting process is efficient in reusing the casting sand over a number of cycles. At a certain point, the sand becomes unfit for the casting process and is disposed. This is known as foundry sand. It exhibits lower unit weight, higher water absorption, and higher percent void compared to regular sand. These properties affect the workability of concrete when used as a replacement[6,7]. Foundry sands have been used for various landfill and geotechnical applications and also as a replacement for fine aggregate in cement concrete[1,4]. Discarded foundry sand will be contaminated and depending on the industry, they may also contain heavy metals such as aluminium and nickel. Heavy metals are well known toxic and carcinogenic agents and present a serious threat to human population and flora and fauna. Biological methods were found to be very effective with the percentage removal above 90%[8].

The microbes Pseudomonas Aeruginosa, Bacillus and Nutrient Broth are used in the treatment of heavy metals present in casting sand. They are mixed in varying ratios over varying time periods to identify the microbe having maximum heavy metal biosorption capacity[12]. The basic procedure for the manufacture by sand casting involves melting of the raw metal into which additives are added to obtain the required properties. This molten metal is then poured into the mould which is made of sand. It is left to cool after which the shakeout process is done. After this, sand is reclaimed and for further use in consecutive molding cycles. From the reclaimed sand, part of it is removed and treated before being disposed.

3. RESULTS AND DISCUSSIONS

The treatment of casting sand containing heavy metals is carried out with microbes namely Pseudomonas Aeruginosa and Bacillus with different rations and time period of treatment.

Casted sand is treated with Pseudomonas Aeruginosa and Bacillus in the ratio 1:0.5 with interval periods of 3 days and 5 days and the results are represented in Figure 1.

![Figure 1. Composition of heavy metals (Ratio 1:0.5 – 3 days)](image)

As evident from the above graph, in the 3 day time period, both the bacteria’s have the same values except nickel where Bacillus has higher removal compared to Pseudomonas Aeruginosa and comparatively in the 5 day interval, there are negligible differences in the composition and hence it is further tested by varying the ratio and interval periods.

The sample was then tested with Pseudomonas Aeruginosa, Bacillus, Co-Culture of Pseudomonas Aeruginosa and Bacillus in the ratio 1:1 and Nutrient Broth without the use of microbes, all in the ratio 1:1 and an interval period of 5 days. The results are depicted in Figure 2.
It can be inferred from the above graph that in comparison to Pseudomonas Aeruginosa, Co-Culture of Pseudomonas Aeruginosa and Bacillus in the ratio 1:1 and Nutrient Broth, Bacillus has the most effective results and also the nutrient broth has not degraded any heavy metals. Thus the casting sand is then treated with Bacillus in the ratio 1:2 for an interval period of 5 days and the result is depicted in Figure 3.

As evident from the above graphs if the bacillus ratio is increased, there is a subsequent decrease in the heavy metal concentrations. The heavy metal concentration before treatment and after treatment is depicted in Figure 4.
4. CONCLUSION

The casting sand contaminated with heavy metals is brought under permissible limits by treating it with the Bacillus microbe. On treatment with Bacillus, the heavy metals present in casting sand such as aluminium and nickel have been removed by 60% to 90% respectively. Based on the reduction efficiency, it can be concluded that Bacillus can be used as an efficient adsorbent in the treatment of contaminated sand having high aluminium and nickel concentrations. After treatment, this sand can be reused for casting operations. Study is in progress to use treated casting sand as a replacement for fine aggregate in concrete and thus it can be used for construction, consequently reducing the load on landfills and associated disposal costs. It is a possible source of revenue by converting waste to a valuable by-product or raw material for another process, consequently reducing the demand on sand and quarry resources.

REFERENCES

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