A Novel Reclamation Method of Chemical-Mechanical Grinding for Inorganic Binder Waste Sand in Aluminum Alloy Casting Process

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Abstract: The current approach to reclaiming inorganic binder waste sand discharged in aluminum alloy casting process typically involves mechanical grinding combined with calcination treatment (650-700 °C). However, this method encounters challenges such as the accumulation of residual binder on the surface of the reclaimed sand and a subsequent decline in its refractoriness. This study proposes a novel method to reclaim inorganic binder waste sand, integrating chemical infiltration with mechanical grinding. The effects of different types and concentrations of chemical reagents on the electrical conductivity and Na_2O content of the reclaimed sand were investigated. The microstructure and chemical composition of both waste and reclaimed sand were analyzed, and revealing the chemical-mechanical grinding reclamation mechanism. When the dosage of $CaCl_2$ solution is 5wt.% of the waste sand weight, and the concentration is 10 wt.%, the electrical conductivity and Na2O content of the obtained reclaimed sand are 776.7 μS/cm and 0.039%, respectively, meeting the utilization requirements for reclaimed sand. Microscopic analysis reveals that the $CaCl_2$ solution reacts with the residual binder on the surface of the waste sand, disrupting the structure and morphology of the residual binder. After drying, the reaction product crystallizes in the form of blocky inorganic salts, facilitating their removal during mechanical grinding.

Keywords: inorganic binder waste sand; chemical infiltration; mechanical grinding; electrical conductivity; Na_2O content

1 Introduction

The inorganic silicate binder sand process is one of the most widely used molding sands in the casting process, known for its low cost, high dimensional accuracy of molds and cores, as well as non-toxic and odorless properties [1-3]. Generally, approximately one ton of waste sand is generated for every ton of castings produced. Currently, China is the world's largest producer of castings, generating over 6 million tons of inorganic binder waste sand annually [4,5]. This waste sand contains a large amount of alkaline residual binder on its surface, making it unsuitable for direct recycling in casting materials. Discharging it without treatment not only causes serious environmental pollution but also wastes the limited silica sand resources [6-8]. Therefore, addressing the reclamation and recycling of inorganic binder waste sand holds significant environmental and economic benefits.

This study addresses the issues with traditional dry and wet reclamation methods and the characteristics of aluminum alloy casting production. A novel reclamation method of chemical-mechanical grinding for inorganic silicate binder waste sand in aluminum alloy casting process is proposed and designed. In this method, the waste sand undergoes initial crushing, preliminary grinding, and dust removal. Subsequently, chemical reagents are introduced to infiltrate the sand particles, followed by low-temperature drying, additional grinding, and dust removal to obtain reclaimed sand. Based on this method, the particle characteristics of inorganic silicate binder waste sand are analyzed. The influences of the types and concentrations of chemical reagents on the reclaimed sand quality were studied. Furthermore, the chemical-mechanical grinding reclamation mechanism was elucidated to develop an optimal reclamation process for inorganic silicate binder waste sand discharged in aluminum alloy casting.

2 Experimental procedure

The chemical-mechanical grinding reclamation process and conventional reclamation process for inorganic silicate binder waste sand discharged in the aluminum alloy casting are illustrated in Figures 1 and 2.

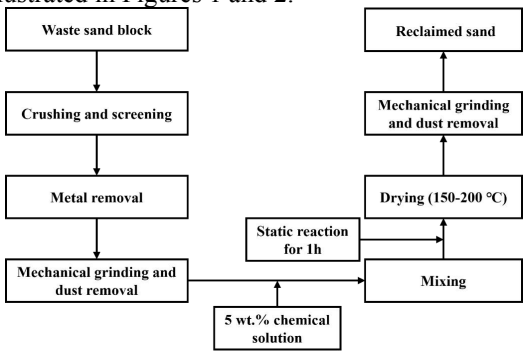

Figure 1 Process flow chart of chemical-mechanical grinding reclamation for waste sand.

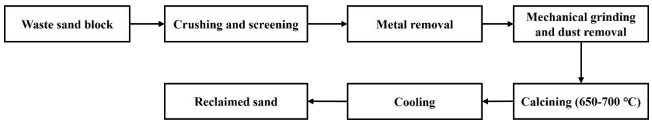

Figure 2 Process flow chart of conventional reclamation for waste sand.

3 Result and discussion

Effect of different chemical reagents

Figure 3 illustrates the effect of different chemical reagents on the electrical conductivity and Na_2O content of reclaimed sand. It can be observed that the reclaimed sand pretreated with $CaCl_2$ solution has the lowest electrical conductivity, and the reclaimed sand treated with $H_2C_2O_4$ solution has the lowest Na_2O content, but the highest electrical conductivity.

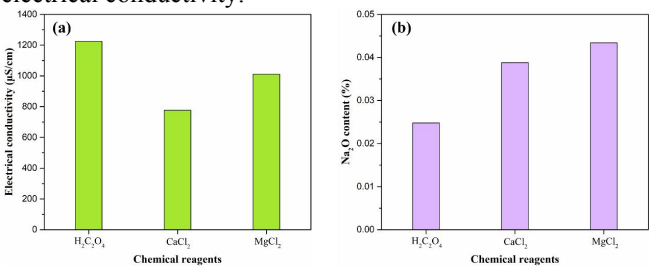

Figure 3 Effect of different chemical reagents on the quality of reclaimed sand: (a) electrical conductivity, (b) Na_2O content.

Effect of $CaCl_2$ concentration

The microscopic morphology of waste sand after infiltrating pretreatment with different concentrations of $CaCl_2$ solution is depicted in Figure 4. It can be observed that when the amount of $CaCl_2$ solution added is fixed at 5wt.% of the weight of the waste sand, the number of reaction products on the surface of the sand particles increases with increasing concentration of $CaCl_2$ solution. Furthermore, the morphology of the reaction products changes from granular to block-like. However, minimal changes are observed when the concentration exceeds 10wt.%. Additionally, from Figure 4(b and c), it can be seen that the block-like reaction products have weak adhesion to the silica sand particles, indicating that they are easily removed under the action of mechanical grinding, thereby obtaining high-quality reclaimed sand.

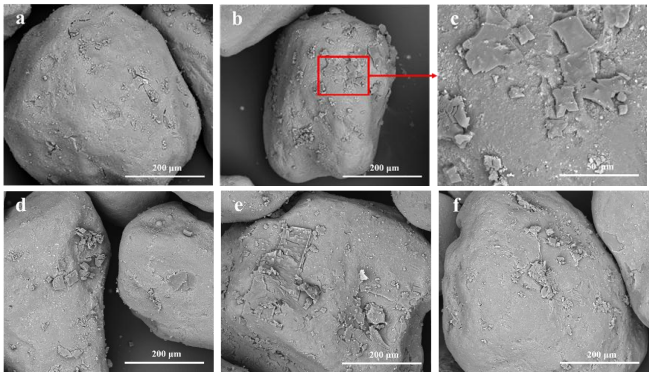

Figure 4 Microtopography of waste sand pretreated with different concentrations of CaCl2 solution: (a) 5wt.%; (b, c) 10wt.%; (d) 15wt.%; (e) 20wt.%; (f) 25wt.%

4 Conclusion

This paper addresses the reclamation issues of inorganic binder waste sand and proposes a novel chemical-mechanical grinding reclamation method. Three chemical reagents can enhance the quality of the reclaimed sand, but the $CaCl_2$ solution exhibits the most effective treatment. Optimal results are achieved with a $CaCl_2$ concentration of 10 wt.%, where the electrical conductivity of reclaimed sand measures 776.7μS/cm, and the Na_2O content is 0.039%. The $CaCl_2$ solution reacts with the alkaline residual binder on the surface of waste sand. After drying, these chemicals crystallize into inorganic salts, which can be entirely removed by following mechanical grinding, resulting in high-quality reclaimed sand.

5 Acknowledgments

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