

Characterization of No-Bake Phenolic-Isocyanate and Furanic Binders in Different Base Metal Casting Sands

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ABSTRACT

This paper presents test results for silica and corundum base metals casting sands. Standardized tests were carried out to understand physical and mechanical properties of the metal casting sands and molding mixtures prepared with these refractory bases. Grain distribution, grain size, grain shape classification, moisture content, pH, LOI, Weibull distribution tensile test, permeability, and roughness are the properties that have been evaluated. Tensile, permeability, and roughness tests are carried out with different molding mixtures changing base sand and Phenolic-isocyanate and Furanic binders. The results of the tensile test were adjusted to a Weibull distribution. Weibull modulus of each molding mixture and the strength at a probability of failure of 63% is obtained. The permeability and roughness results were subjected to ANOVA and t-test. Regular grains contributes to increase strength of molding mixture while permeability is not affected by time and amount of binder.

KEYWORDS

ANOVA Analysis and T-Test, Corundum, Molding Mixture, Silica Sand, Weibull Distribution

I. INTRODUCTION

The molding mixture is the result of the combination between base refractory sand and chemical binder. The analysis of base sand and molding mixture is of great importance for the foundry industry because its quality influences the production process of metal castings products (Daňko et al., 2015). However, a great variety of base sands and chemical binders makes it difficult find the best mixture combination. The choice of the molding mixture is considered correct when it does not present problems during the casting process and produces parts with a good quality. Chemical binder no-bake molding is usually applied in foundry industry with two representative molding systems PUNB (phenolic urethane resin) and FA (furan resin), both are commonly used in foundry processes that varies depending on the size of the casting, chemical composition of the material to be cast, reuse of base sand, among others (Łucarz et al., 2019). Depending on the type of base sand, type of binder and quantity of binders, the properties and characteristics between one and another molding mixture may substantially vary. Variations can positively or negatively affect the casting process.

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In this research, the effect of base sand characteristics such as grain distribution, grain size and grain shape classification, moisture content, pH and LOI on tensile strength, permeability and roughness are investigated. In addition, the present study evaluates the behavior of the molding mixture by adjusting the tensile strength results to a Weibull distribution as recommended for ceramic like materials(Li et al., 2017)(Basu et al., 2009). Additionally, by means of ANOVA and T-Test analysis, the effect of time and quantity of binders on the permeability of various molding mixtures was assessed. Similarly, the effect of the base sand, type of binders, amount of binders and brand of binders on the roughness of various molding mixtures is analyzed. These analyzes are important because the quality of the base sand and molding mixtures has a great influence on the production of castings.

II. MATERIAL AND METHOD

A. Materials

For the development of this research, types of silica sands from two different suppliers (Sierra Central and Sibelco) is uses. Another, corundum base sand from a third supplier (Cast Ball from Mineração Curimbaba) is also studied. A summary of the main characteristics of these base sand is presented in Table 1. On the other hand, phenolic-urethane (PUNB) and furanic resin (FA) are the chemical binders applied in the research due to their widespread use.

The molding mixtures to be evaluated are shown in Table 2. In the table the abbreviation PUNB means Phenolic-urethane No Bake System and the abbreviation FA means Furan Resin. Characteristics such as grain size, amount of fine powder, moisture content, pH and LOI, were determined based on procedures given in the Mold & Core Test Handbook from AFS.

The classification of the grain shape is carried out based on Figures 1, 2 and 3. According to the AFS 1107-12-S procedure, the shape of the different base sands is as follows: Sibelco silica sand and Sierra Central silica sand have a subangular shape and Corundum Cast Ball has a rounded shape.

Table 1. Characteristics of the base sands used

Base sand	Grain Size AFS index	Amount of fine powder (%)	Moisture content (%)	pH	LOI (%)
Silica sand Sierra Central	39,42	0,34	0,02	7,15	0,3
Silica sand Sibelco	56,09	2,18	0,05	7,08	0,55
Corundum Cast Ball	51,46	1,94	0,01	6,84	0,03

B. Molding mixture

The molding mixtures made for the production of traction and permeability specimens were made with the different base sands shown in Table 1, different type of binders (PUNB and FA), different amounts of binder as shown in Table 2. The process for making tensile and permeability specimens is carried out in accordance with the GB / T2684-2009 standard.

The compositions of Tables 3, 4 and 5 correspond with the amount of binders used for the elaboration of each molding mixture seen in Table 2. It should be stated that the binders come in parts, so one must mix the parts in order to fully form the binder. Tables 3 and 4 show the amount of parts for PUNB systems: Total resin 1% of the total amount of base sand, Part I 55% of the total resin, Part II 45% of the total resin and Part III 1% or 5% of Part I. Part III is a very small amount which must be mixed separately with Part I (100 gr Part I and 1 to 5 gr of Part III are recommended). This interpretation also applies when the amount of resin is 1.4% with the percentages for said

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