



Adapting Organic Binder Systems to Sand Supply Variability: A Review with Industrial Case Studies

John Ozog  
United Erie, Erie, PA, USA  
Christopher H. Annear  
The Pennsylvania State University, University Park, PA 16802  
Paul C. Lynch, Ph.D.  
The Pennsylvania State University- Erie, The Behrend College, Erie, PA 16563

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Abstract

Defects can arise in any well-designed casting pattern due to quality discrepancies in the quality control of material inputs. In the world of sand casting, the sand mixing step in the molding process is one of the first places to look when such quality discrepancies arrive in patterns that have been reliable for years. Potential issues relating to variability in the flow rate, optimal ratios of binder/catalyst to the sand flow, and how the binder interacts with the sand size, shape, and chemical composition may arise. The specific grain surface area and interstitial gaps in the compacted sand play a significant role in the polymerization required to reach an intended strength. Additionally, moisture and reactive minerals in the sand mix affect the binder's chemical reactions during polymerization, resulting in weaker parts and potentially causing it to react with the metal or with heat from the metal. By providing an in-depth background, an overview of organic binders, an overview of the standards used for sand, and an analysis of 3 case studies, this paper aims to outline key areas of focus for controlling sand-source quality in foundry settings.

Keywords: organic binder, sand density, sand supply

Introduction

Sand casting has existed for thousands of years as the primary method of pattern-based casting, predating recorded history and being developed independently by numerous cultures worldwide as a crucial step in the technological development of civilization. Pre-industrial society used “green sands” for mold production, and this inorganic binder system consisted of fine bentonite clay that bonded the sand when a small amount of water was added. This method of casting was useful due to the reusability of the sand, the flexibility of the process for ferrous and nonferrous alloys, and the widely available cost-effective ingredients (sand, clay, water, and carbon can be found by any river) [1]. As the industry progressed during the Industrial Revolution, demand for molds with higher strength, better dimensional accuracy, and the ability to deliver parts with lower porosity grew, and research focused on developing new methods of bonding sand.

During the later stages of the Second Industrial Revolution, the demand for stronger, more complex castings prompted the development of new methods of bonding sands. The *International Journal of Metalcasting*

use of oils and polymers in the sand mix produced stronger molds and finer details in the castings. Naturally derived substances such as linseed oil, molasses, and plant-derived starches were better alternatives to moisture for bonding sand particles in a mold. The main developments in the sand molding process occurred in the 1950s and 1960s, driven by advances in chemistry that created synthetic resins and by engineering advances that enabled the production of uniform particles [2]. Developments occurred in chemistry with applying furan (C4H4O rings) chemistry [3] to bond to use as a glue between sand particles. Developments in phenolic chemistry (hydroxyls -OH) also occurred [3], which is attached to organic rings, can be used as a bonding agent. Additionally, as research into polymers revolutionized materials science, polyurethane chains (C3H7NO2)[3] became popular as another method for bonding sand particles. These groundbreaking developments in material science have created a versatile set of tools for delivering strength, surface finish, geometric/dimensional accuracy, and permeability needed for sand molds. As the 21<sup>st</sup> century progresses, the industry faces the challenge of properly applying these tools and maintaining processes capable of creating sand molds that meet the requirements of heavy industry.

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| Corresponding Author:                         | Paul C Lynch<br>Penn State Erie the Behrend College<br>UNITED STATES OF AMERICA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Corresponding Author Secondary Information:   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Corresponding Author's Institution:           | Penn State Erie the Behrend College                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Corresponding Author's Secondary Institution: |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| First Author:                                 | John Ozog                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| First Author Secondary Information:           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Order of Authors:                             | John Ozog<br>Christopher H Annear<br>Paul C Lynch                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Order of Authors Secondary Information:       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
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