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Evaluating a High Production Eco-friendly Core Binder System for Aluminum

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A sustainable polysaccharide sand binder system was developed for a modified injection molding process. The injection molded cores are designed for aluminum casting technology. The injection molding process affords complex core shapes and allows extremely thin sections at fast cycle times. Cores from conventional processes by means of cold-box and hot-box technologies were compared to those produced by the injection molding process. This paper relates the mechanical, physical, and thermo-mechanical properties of disc-shaped core specimens. Testing of disc-shaped core specimens included density, abrasion, impact strength, permeability index, thermal distortion. The test data is valuable to identify core quality and useful for process control in core production. Aluminum casting trials were conducted and the results show tremendous as-cast finish at the core/metal interface as-well-as shakeout benefits for the injection molded.

Keywords: *Chemically Bonded Sand, Cold-Box System, Core Binder System, Disc-shaped Specimen, Hot-Box Shell, Thermal Distortion*

1. Introduction

A popular medium for the production of cast powertrain metal parts is sand. Sand has many pluses, but it is far from perfect. Problems with chemically bonded sand systems arise from variation in materials and processes. This can come from many sources such as grain size, grain shape, chemical composition, binder level, additives, work-time, strip time, pouring temperature, metallostatic pressure, etc. [1]. Thus, chemically bonded sand has many potential sources of variation; but it is still subject to the pressures of delivering near-net shaped castings. Understanding those variations is a key issue for achieving good process control, and there have been several studies toward that end [1-3].

At the 71st World Foundry Congress a "New Core Binder System for Aluminum Casting Based on Polysaccharide" was offered [4]. This paper explains the core making process detailing the polysaccharide sand binder mixing process as well as the fast injection molding technology. The new core making process is commonly referred to as LYTE CORE (LC).

In order to produce a high quality casting, the purpose of this paper was to test the mechanical, thermal and physical properties of the new sand binder system. Additionally, aluminum casting trials were conducted for all sand binder systems tested.

2. Experimental procedure

LC specimens (two binder levels 0.35% and 0.70%) were prepared using an artificial sand made of alumina, ESPEARL #60. The LC disc-specimens (50 mm dia., 8 mm thick) were prepared by injection molding [4]. Curing temperature within tool was 220°C for a curing time of 180 sec. prior to ejection.

The 50mm diameter, 8 mm thick disc-shaped LC specimens were used in a variety of physical, mechanical, and thermal tests. The following five non-standard tests were conducted with a sample size of eight specimens for each test: 1) specimen weight, 2) impact, 3) modified permeability, 4) abrasion and 5) thermal distortion test (TDT) [5-6].

Specimens of LC, Hot-Box Shell and Cold-Box were compared using an experimental pattern to perform a casting trial where an aluminum alloy (356) was poured from 22.9 cm head height at 700 ± 3°C.

3. Results and discussion

3.1 Mechanical and physical properties of LC

The LC specimen weights are shown in Table 1 and it should be noted that the $LC_{0.70}$ specimens were more consistent. LC specimens were especially abrasion resistant. Moreover, the $LC_{0.70}$ specimens were tougher and show better venting.

Table 1 Summary of test results of LC samples

Test	$LC_{0.35}$		$LC_{0.70}$	
	Mean	σ	Mean	σ
Specimen Weight (g)	26.77	0.65	26.80	0.37
Impact Strength (J)	0.43	0.05	0.56	0.12
Permeability Index (#)	182.5	0.00	187	4.80
Abrasion (% loss)	0.00	0.00	0.00	0.00

3.2 Thermo-mechanical properties of LC

The thermal distortion curves (TDCs) for LC cores tested showed undulations that indicate thermo-mechanical and thermo-chemical changes in the binder system at elevated temperature. The longitudinal distortion (D_L) curves showed plastic deformation (downward movement of a TDC) (Fig. 1). Plastic deformation occurred for ~ 30 seconds and then leveled-off for the duration of the test. The radial distortion (D_R) indicated an expansion trend for 30 seconds followed by bending (Fig. 1).

All LC specimens had similar TDCs and there was no significant difference between $LC_{0.35}$ and $LC_{0.70}$ (Fig. 1). This finding is supported by with data form heat transfer data (Fig. 2).

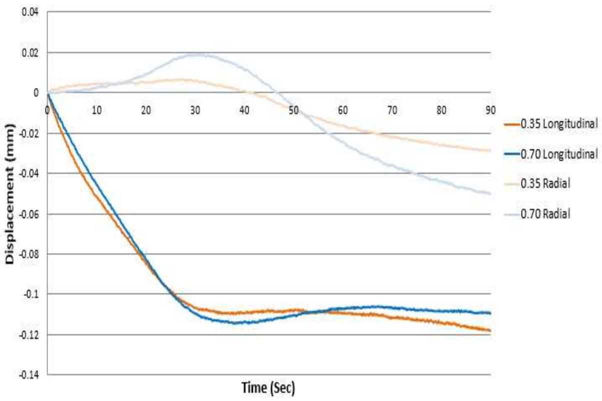

Fig. 1 Longitudinal and Radial TDC for LC 0.35% and 0.70 %

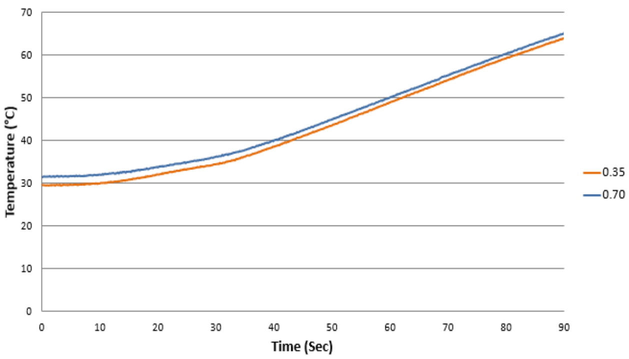

Fig. 2 Temperature versus time plots between the hot surface and the back of specimens

3.3 Observations from casting trial

All three sand binder systems were compared within the same molds using the same pouring temperature, alloy chemistry and metallostatic head pressure through solidification a shakeout comparison can be made. It is noteworthy to identify that the LC cores regardless of binder percentage collapsed from the core cavity without need for physical shakeout. Conversely, the removal of both Hot-Box Shell and Cold-Box systems required finishing equipment and aggressive shakeout.

4. Conclusions

This study has identified that thin section LC cores (8 mm thick) can handle at minimum 22.9 cm head height at 700 ± 3°C without incurring aluminum casting defects. The mechanical and physical properties of $LC_{0.70}$ are favorable to core handling in the foundry environment. Further, LC cores compares favorably with conventional Hot-Box Shell and Cold-Box systems at similar binder levels and sections thickness in aluminum casting trials. Apart from the established high production eco-friendly benefits of LC cores; this study has identified superior shakeout advantages.

Acknowledgements

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