Proceedings of the 72nd World Foundry Congress
21-25th May 2016, Nagoya, Japan

Benchmarking the High Production Sand Core and Mold Binder Systems and Most Recent Advances

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Starting with the shell molding process introduced in the '50's, some of heat cured sand core and molding binder systems which can be applicable to high production foundries were developed. In late '60's, after the first cold box system, the amine cured phenolic urethane binder was developed, number of cold box systems were developed and introduced to the foundry industry. Each system was developed based on different chemistries. Motivations of the development were sand core and mold productivity, reduction of casting defects and environmental pressure. For their different chemistries and concepts of invention, it is important to benchmark the binder systems. In this paper, benchmarking the high production sand core and mold binder systems are conducted in terms of core and sand making property, productivity, casting quality, the cost-in-use and emissions.
Furthermore, future visions of high production sand binder systems including both organic and inorganic systems are discussed.

Keywords: *Cold box processes; sand binders; equipment; environmental compliance; productivity and cost*

1. Introduction

Today over 70% of high production sand casting operations use a CB process for producing cores and molds. The expansion of CB use has been driven by numerous factors including the need for more through-put and reduced work in process in the core room, improved dimensional accuracy, improved casting quality and reduction of emissions during core making and pouring, cooling and shakeout (PCS). The primary attribute of CB – productivity - is predicated on the fact that blowing sand into vented tooling and rapidly curing it enhances yield per tool, thus drives the return on investment and takes cost out of the process chain of producing complex castings like cylinder-heads. For the purpose of this paper we will discuss the four primary CB chemistries:

- Phenolic urethane CB (PUCB)
- Epoxy acrylic SO_2 cured ($EASO_2$)
- Ester- and CO_2-cured alkaline phenolic (ECAP)
- Acrylic urethane - Amine cured (AU-Amine)

2. Discussion

2.1 Core making properties of cold box binders

Among the cold box binders the epoxy acrylic system demonstrates by far the longest mixed sand bench life. The binder itself does not react under ambient conditions of temperature and humidity unless exposed to SO2 (fig.1)[1-3].

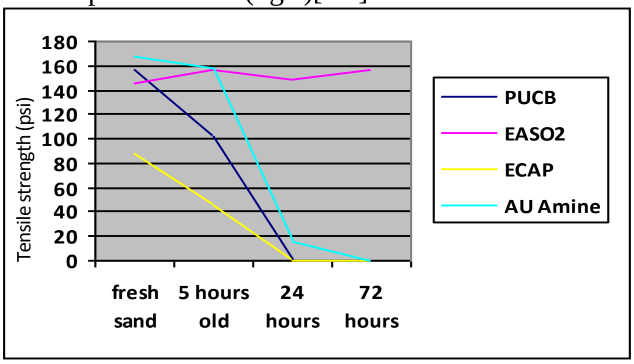

Figure 1. This chart compares mixed sand bench life vs. tensile strength for different CB binders.

It is important to note that over the years the other CB binder systems, especially the PUCB system, have also been significantly improved in mixed sand bench life performance, but more importantly the equipment including on-demand sand supply and easy cleanup has been engineered to reduce the impact of this property[4].

2.2 Advancement of PUCB in the environmental aspects

Primarily, the PUCB process historically used hydrocarbon solvents. New binders and base resins with improved solubility have resulted in a reduction up to total elimination of hydrocarbon solvents in some formulations. Ester-based and/or low evaporative solvent packages to reduce VOC's are now commonly employed (Tables 1)[5].

Table 1. PCS Emissions

CERP Data

PCS[1] emissions data generated at CERP / Technikon in 2000
with Phenolic-Urethane Cold Box Binders[2]
relative to Baseline

	Baseline	PUCB Reduced HC	PUCB All Ester
HC:E Ratio[3]	63:37	52:48	0:100
VOC		-31%	-32%
HAP		-17%	-30%
Total HC[4]		-57%	-52%

1) PCS = Pouring, Cooling, Shake-out
2) CERP Reports RV100032CM; RV100061BP
3) Ratio of hydrocarbon-ester-solvent in the binder
4) Measured as undscans

2.3 Organic vs inorganic

Inorganic binder technology, which is synonymous with ultra-low emissions performance, is viable in high productivity semi-permanent mold applications for light metal automotive castings.

Compared to cores made with "traditional, organic binders" the sharply reduced VOC emissions from cores made with inorganic binder result in exceptionally clean-running SPM tooling with no tar buildup, which in turn drives productivity and casting quality[6].

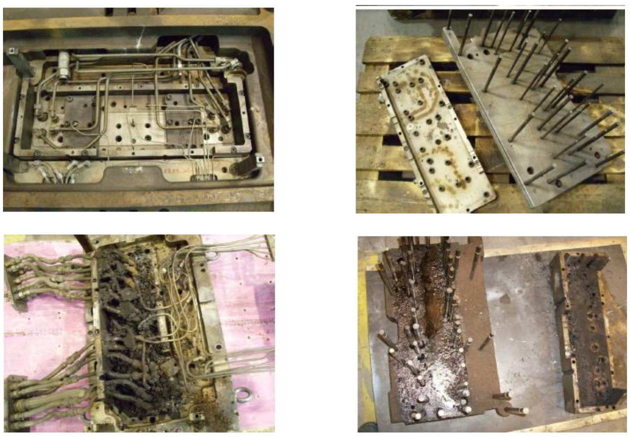

Figure 2. These pictures show SPM tooling used with inorganic core packages, prior to cleaning. There is no indication of tar formation on the tooling (Courtesy of BMW AG, Germany).

3. Conclusion

Technical, business and operational goals, as well as environmental and regulatory mandates will continue to guide and shape the development and improvements needed to advance metal casting manufacturing processes further. The information provided in this brief paper demonstrates that by combining experience, virtual simulation tools, the best available "consumables", processes and equipment, ingenuity and knowledge about the cost at each point in the metal casting manufacturing chain make up the recipe for success when designing and developing a casting. There are opportunities to remove cost from the process while improving the process itself, the return on investment, the work environment and last but not least, the performance of the final casting in service.

Acknowledgements

I would like to thank the many people and organizations who helped me write this technical publication. The Laempe Reich Company and Loramendi for updated automation and equipment illustrations. Numerous foundries and engineers we have worked with over the years including Amsted Industries, BMW Landshut, John Deere, Caterpillar, GM Powertrain, Ford Motor Company, Nemak, Hyundai Motor Company and numerous others. Friends, industry colleagues and co-workers at ASK Chemicals worldwide for their support and contributions.

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