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SOME CONSIDERATIONS ON ENVIRONMENTAL SAND CORES WITH INORGANIC BINDER

Tibor BEDŐ, Viorel ENE, Ioan CIOBANU
Faculty of Materials Science and Engineering,
Transilvania University of Brasov
email: bedo.tibor@unitbv.ro

ABSTRACT

Traditionally, complex sand cores are produced using organic binders such as phenolic and furan resins. These binders can create bad smelling fumes requiring complex and expensive ventilation equipment to fulfill environmental requirements. The increasingly more stringent environmental legislation forces the foundry industry to employ innovative and environmentally-compatible binder systems. The established organic binder systems have indeed been, and are still being, further developed with regard to their contents but it is questionable whether these will be able to fulfill the continuously increasing requirements of foundry neighborhoods and legislation. The Landshut magnesium and aluminum casting facility, which produces engine components, structural components and chassis parts for BMW, is expected to reduce its emissions of combustion residues by 98% with the implementation of the inorganic core binding system. The paper presents some considerations on environmental sand cores with inorganic binder.

KEYWORDS: sand cores, inorganic binder, foundry industry

1. Introduction

The use of modern moulds with high quality characteristics is required especially in the aircraft industry, military and engineering, under special circumstances.

In those cases are imposed strict quality characteristics on mould behavior at high temperatures, lack of responsiveness of mould components to metal alloy, dimensional stability and mechanical resistance of the mould.

"Most of what has to change is the core and mold making method," said Keith McLean, president of HA International LLC, Westmont, Ill. "Metalcasters are still mixing sand with a binder and still putting sand into a cavity.

What changes are sand preparation practices?

Sand reuse, cure speed, moldability and venting may all be significantly different and typically are not enhanced with inorganic. Larger operations might have to buy more equipment to maintain the production rate they are used to because of cure speeds."

Based on these considerations, researchers from worldwide, seek to obtain core sand recipes to meet all these requirements adequately.

2. Considerations on environmental sand cores with inorganic binder

Use of organic binders began to be restricted due to the high level of pollutants emitted during the moulding-casting-knock-out process.

A change to an inorganic system makes the foundry environmentally independent, especially for foundries which are located near a city or housing areas. A change to inorganic binder system can guarantee a foundry's existence.

Inorganic binders have been generating more and more interest in recent years because of the advantages compared to commonly use organic binder systems. These include no emissions during the whole production process as well as better castings and less rejects.

Now all known binder producers have developed good inorganic binders, where slowly but surely, all disadvantages from the beginning are eliminated, so foundries can nowadays choose between several good inorganic binders on the market.

Every binder producer has their own patented formulation, each with its own characteristics. The binder systems can even be mixed by the foundries themselves with simple mixer equipments.

Since the early 90s, the combined effect of environmental regulations and fierce competition speed forced the manufacturers of castings to invest substantial amounts in research leading to acquisition of new technologies, combined with new types of sand cores, which fall whithin new environmental regulations and have the effect of cost reduction castings. The continuous growth of industry restrictions by environmental legislation requires casting industry to seek new green and core sand systems which have ecological properties. The binders used in the sand cores can be organic or inorganic, natural or synthetic, as shown in Table 1.

Table 1. *The binders used in the sand cores*

Binder type	*Natural binders*	*Synthetic binders*
Inorganic binders	Casting loam Bentonite	Sodium silicate Ethyl silicate Potassium silicate Colloidal silica Concrete Plaster Phosphates Sulfates
Organic binders	Alizarine oils Molasses Natural resins	Amine Phenolic resins Furan resins Polyester resins Polyurethane resins Cellulose resins

In this context, it is necessary to develop new inorganic binder systems to meet both the requirements of environmental legislation and of the economy and quality demanded by the explosive growth of competitiveness.

These requirements were the motivation for the aggregating, in 2002, three renowned German companies in the industry casting [1]:

- Johann Grihmann GmbH & Co. KG, Bisingen aluminium Foundry,
- Fritz Eichenauer GmbH & Co. KG, Hatzenbuhl, heating element manufacturer,
- Maucher GmbH Formenbau u. Kunststofftechnik & Co. KG, Markdorf began an extensive research project aiming to discover new inorganic binder systems for sand cores, which have high ecological properties.

Hydrobond project aimed at the development of an inorganic binders system which does not contain any organic substances, binders which are soluble in water and allowing the recirculation almost complete of the used sand.

Measurements showed that the use of water soluble inorganic binder systems results in an almost complete reduction of gas emissions in the production of castings.

Despite the advantages offered by the synthetic resins (high strength, good knock-out of moulds and sand cores regeneration) the use of the inorganic binders provides several advantages related to economic, labor hygiene and protection environment.

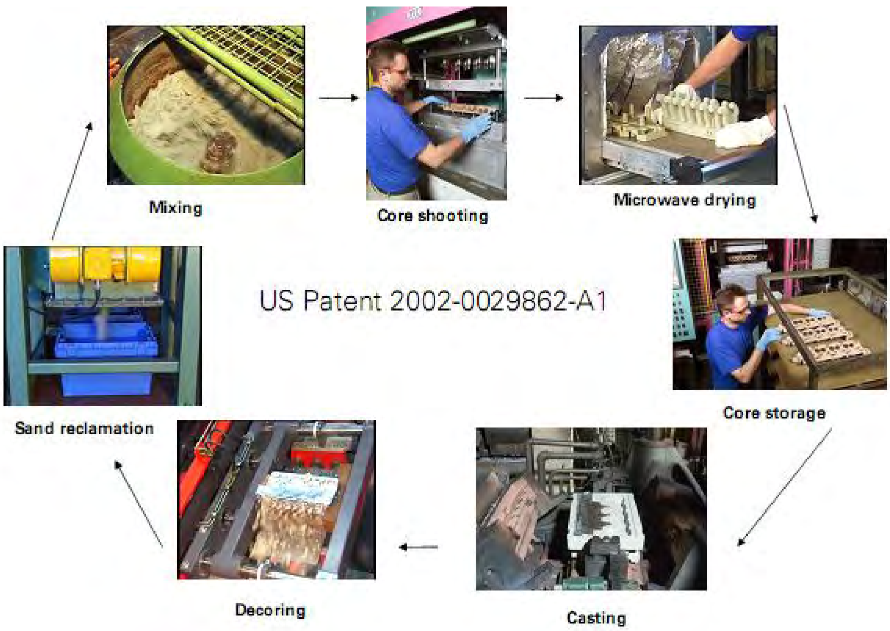

Fig. 1. *Castings production using the AWB process.*

A quality sand cores binder must law the sand particles together with sufficient force to produce a mold to keep the size and surface appearance when pouring molten alloy. The binder must also provide sufficient permeability of the mould, such as flue gases resulting from the casting to be removed without causing casting defects. During the casting process the mould must maintain integrity at high temperature avoiding the sand cores inclusions penetration in the metal weight, making the castings become scraps. Global experiments with inorganic binders have shown that these ensure the requirements of quality foundry binders.

In 2002 the United States AWB system was patented (U.S. Patent 2002-0029862-A1) to produce cores using an inorganic binder system and which has advantages for sand preparation that requires much lower power consumption compared to the organic binders systems, produces no toxic emissions during the technological process and storage or toxic combustion products are not necessary (Figure 1).

Inorganic binders, unlike the organic ones, are characterized in that, during thermal decomposition process, the gaseous emission is very low. The Beach Box process with LaempeKuhsBinder is based on the natural principle of certain minerals to bind and release water of crystallizations [2].

During core production the water of crystallization is driven off and the core or mould shows stability similar to concrete. However, the core breaks down in just a few seconds when making contact with water. De-coring problems and related damages of the casting are things of the past. The dry de-cored sand can be re-cycled repeatedly after adding water only.

When new sand is mixed with LaempeKuhsBinder, an envelope is formed around the sand grain, which is dissolved or consolidated by adding or withdrawing only water. In practice this means a substantial decrease in binder use.

The new core and mould production process developed by Laempe is, as the company claims, the most efficient method available as BAT (Best Available Technique) in foundries today. It can replace all known core production processes, particularly cold box, hot box, or warm box.

Laempe introduced a completely new <Beach Boxing> core production system to provide new solutions to solve environmental problems. Essentially it is using a binder based on magnesium sulfate mixed with sand and is subjected to heating to achieve strengthening (Patent WO/2003/013761, Method and device for the production of molds or cores for foundry purposes). The invention (Figure 2) relates to the production of molds or cores (2) for foundry purposes, wherein a mixture (3) of foundry sand and binder is produced and introduced into a mold or core tool (8), e.g. shot in a core shooter. A known binder or magnesium sulfate with and/or without at least one or additionally several crystallization waters are dispersed or dissolved in water and used as binder, which is then mixed with the foundry sand and introduced or shot into the mold tool or the core box (8).

For hardening purposes, the water and a fraction of the crystallization water are vaporized by heating and driven out by a gaseous medium, all of which can be carried out very rapidly.

To achieve a short curing time (10-40 sec.), only heated core boxes can be used at the moment. The type of heating system makes no big difference. An equal temperature distribution of 150-200°C should be achieved. Lower core box temperatures delay curing time and reduce the storage stability of the cores.

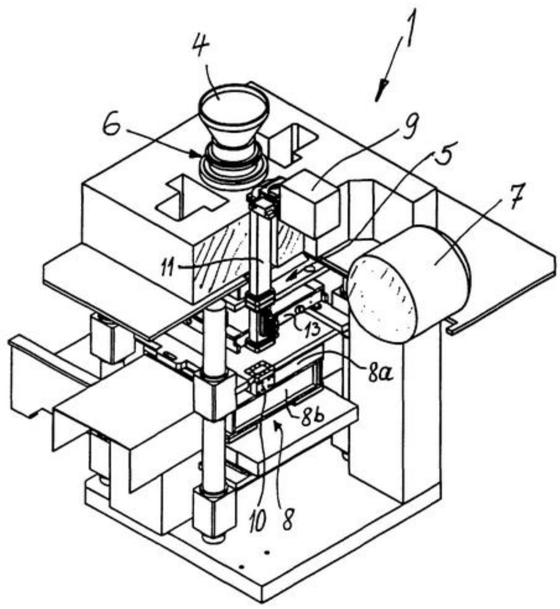

Fig. 2. *Method and device for the production of molds or cores for foundry purposes (Patent WO/2003/013761).*

Higher temperatures in the core box can give rough surfaces of the core due to binder additive reactions [3]. This is not a problem as most hot box machines supply a controlled temperature distribution.

The core production can be conducted on commonly used core shooting machines, as long they have a heated core box (Fig. 3). Commonly used hot box or shellcore machines work well without requiring any significant changes. However, a shooting pressure of 3-5 bars is needed. The shooting time should be held as short as possible, between 1-2 seconds, to avoid drying the sand in the shooting nozzle. Furthermore it is necessary to avoid heat transfer from the core box to the shooting nozzles and shooting head. This can cause drying of sand in the shooting head and blocked nozzles, especially when the machine is on standby.

The application of various inorganic binders was tested in the foundry of a German automobile manufacturer.

Instead of the expected bending strength of approx. 400 N/cm² the mixing process with an inorganic binder consisting of three liquid components by means of the STATORMIX resulted in approx. 540 N/cm² Consequently the binder consumption can be reduced considerably. Core sand containing less humidity can be better shot and the drying expenditure is reduced. The diagram illustrates the achieved bending strength depending on the added amount of binder (Figure 4).

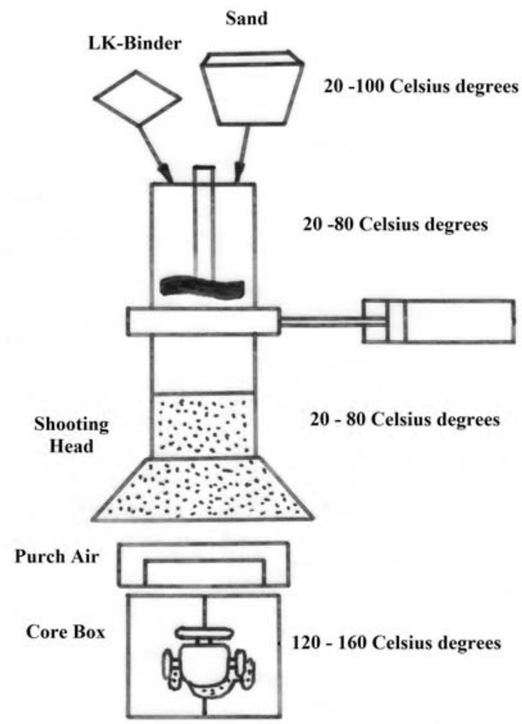

Fig. 3. *Making the moulds into the Beach Box [4]*

The Cordis process has meanwhile been available to the foundry binder market for more than 10 years. The process is based on an inorganic binder (silicate, phosphate and borate) one of the most environmentally compatible, low odor and smoke binders in existence.

Curing of the core in the core box takes place by means of water removal.

Cordis is an inorganic binder (silicat, phosphat and borat). Curing of the core in the corebox takes place by means of water removal.

The molding sand produced using this one-component system may also is cured with the aid of conventional ester-based hardeners.

The molding sand mix, made with AFS 55 silica sand, can be prepared in any commercial mixer. Depending on the geometry of the cores to be fabricated, the addition level of Cordis to sand is 2.0 - 2.5 parts by weight.

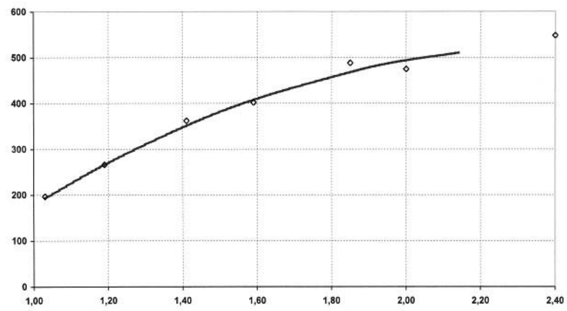

Fig. 4. *The achieved bending strength depending on the added amount of binder*

The sand mix is ready for use as soon as it leaves the mixer. The molding sand mix is very easy to process.

The coreboxes used for this process must be modified in such a manner that a large flow of warm air can be quickly and directly passed through the corebox. The corebox should be constructed of a material that can be heated to approx. 200 °C. Since - as previously mentioned - curing is critically influenced by the throughput of warm air, it is important to keep the temperature of the required air at 150 °C over the entire gassing period. The achieved gassing time for an intake manifold core would be of 30 seconds [5].

3. Conclusions

Using new types of inorganic binders is required as a necessity because it presents numerous advantages.

Advantages include:

- no emissions;
- no ash or products of combustion associated with decomposition of organic binder components;
- immediate stability comparable with cold box binder;
- dimensionally stable and accurate during storage, pouring, cooling;
- complete core breakdown in just a few seconds, allowing for gentle casting shake out;
- smallest orifices can be de-cored as the core sand is washed out with water;
- reduced cooling times by wet de-coring in water;
- no necessary coating, therefore no core wash drying required; extremely thin walled castings can be produced because of accurate and stable moulds and cores;
- sand with higher fines content can be used, producing a casting surface comparable to die-casting;

- core package process eliminates moisture problems attributed to green molding sand;
- minimal core production costs.

The large number of advantages justifies without any doubt the use of inorganic foundry binders, even if they show some minor drawbacks:

- binder shelf life of three months (for the Cordis inorganic binders);
- humidity/moisture reduce the storage life of the cores;
- sand crusting on the submerged nozzles.

These self-made inorganic binders reduce costs.

The core sand requires approximately 2.5% binder, which is much cheaper than any other organic system.

This makes the use of inorganic binder viable for small and medium sized foundries. Additional money can be saved, because no air cleaners are needed anymore, no thermal treatment, easy decoring, no condensation on the dies and easy reclaiming of the sand. Also, if the sand is not reclaimed, it is easily disposable as non-toxic land fill.

"It is absolutely not true that inorganic binders are too expensive," Furness said. "If that is the case, then why do so many major European [metal casting facilities] use low emission binders? When switching to low emission binders in green sand, a metal casting facility can save up to 20% of energy costs.

References

[1]. Helge Hansel – *An innovative inorganic binder system*, Casting Plant + Technology International, 2/2002

[2]. http://www.allbusiness.com/primary-metal-manufacturing/foundries/648620-1.html

[3]. http://kuhs-invent.com/3.html

[4]. http://www.epa.gov/ttn/atw/ifoundry/binders/laempe_reich10-26-05.pdf

[5]. http://www.huettenes-albertus.com.au/Cordis.1010.0.html