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Characteristic of Core Manufacturing Process with Use of Sand, Bonded by Ecological Friendly Nonorganic Binders

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Abstract

Mechanization of the process of core making with the use of inorganic and organic binders is based, almost solely, on core blowing machines. Presently the core blowing machines are equipped with tools and devices that allow for application of different technologies of core making. Cold-box, hot-box and warm-air technologies require that core blowing machines shall be additionally equipped with either core-box pre-heating system or gas purging and neutralization system, or hot air purging systems.

Considering the possibility of using varied, the most advantageous technologies of core making, the production of universal core blowing machines equipped with replaceable devices has been undertaken in Poland. The universal core blowing systems allow for mechanization of core making process also with the use of sand, bonded by modern, eco-friendly binder systems.

The paper presents selected results-based evaluation of core blowing process showing the scope of conducted design and implementation works.

Keywords: Mechanization and automation of foundry processes, Core blowing machine, Casting core, Inorganic binder

1. Introduction

Foundry production systems include also mechanized core making department ensuring fabrication of high-quality cores, productivity increase and reduction of the manufacturing cost.

In order to meet the user's expectations, the company undertook the works aiming for presentation of an offer of mechanized equipment for universal system of core manufacturing, also with the use of eco-friendly, inorganic binders.

A number of tests with the use of various core sands were carried out before development of technical documentation. The characteristics of core sands compacted by means of blowing methods were developed. The obtained results of tests were the

base for improvement of design approach of the equipment as well as the parameters of the process.

The scope of works of the universal core making system included selection of the parameters of core making process with the use of quick-hardened sands. Loose quick-hardened sands need elevated temperature for setting and simultaneously contain the hardening agent for increasing the time of the process [1]. The basic components of quick-setting sand are mainly synthetic resins. They are applied in the following processes: Croning process (shell moulding), hot-box, warm-box, Thermoshock, warm air process [1].

In warm air technology, quick-setting sands comprising organic and inorganic binders are used. In case of sands comprising organic binders, synthetic resins are used as binding agent. P-

toluene sulphoric acid or orthophosphoric acid solutions (alcoholic solution are the best) are used as hardening agents. Compacted sand is purged with the use of air preheated to the temperature of 150-230°C during 10-20 s.

Air consumption – depending on sand composition, the size and shapes of the core and temperature of preheated air – amounts to 400-600 dcm³ per 1 kg of the sand. The temperature of preheated air is about 40-150°C but it is recommended to use higher temperature. The time of purging is 30 s – 4 min [1].

In case of sands with inorganic binders, sodium silicate powder or water solution of trisodium phosphate are used as a binding material. Compacted sand is purged with air preheated to the temperature of 85-130°C. The strength of the sand increases if the cores are additionally preheated during drying in the temperature of 135°C.

Information about the process of core making with the use of warm air comes from 70's and 80's when the first description of warm-air process with the use of sands comprising, beside

binder and matrix – also acid hardener, were published (Modern Casting, 10/1970); to accelerate the process of setting, the compacted sand was purged with warm air.

In the Foundry Research Institute in Krakow, Poland a substitute of warm-air technology, called WZ technology was developed (Foundry Journal, 5/1982). The air consumption in this method amounted to 400-600 dcm³ per 1 kg of sand, depending on the composition of the sand, the size and shapes of the core and the temperature of preheated air. The air temperature was 40-150°C. The time of purging was 30 s to 4 min [2].

Implementation of WZ technology included setting the level of hardening by determination of the relation between the weight of the hardened sample m_{utw} and the total weight of the sample m_c . The value $m_{utw}/m_c \times 100\%$ was presented as a relation of heat flux Q provided by airflow (Fig. 1 and Fig. 2).

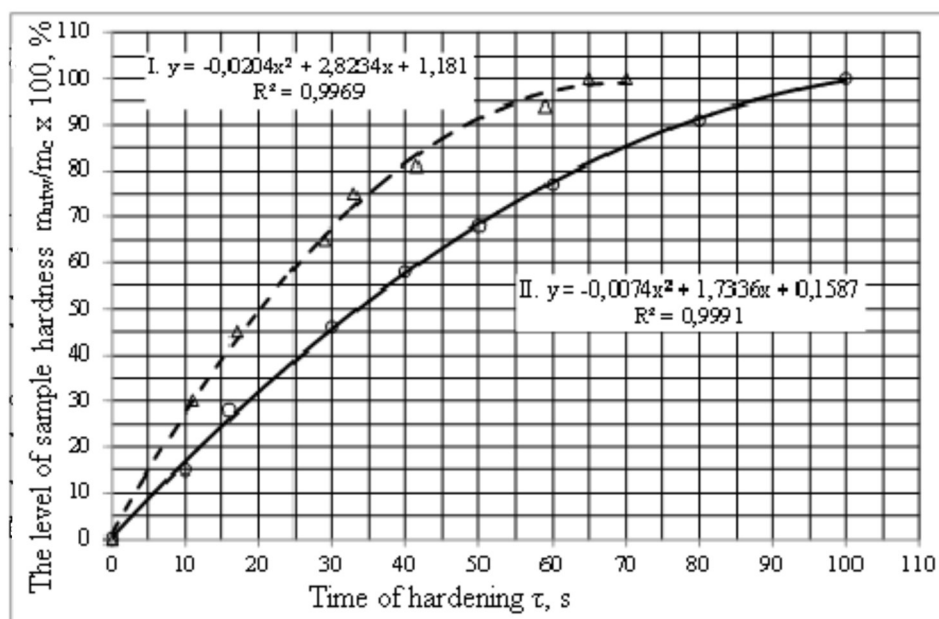


Fig. 1. Influence of the way to provide air to the sample on the results of hardening process;
 I – air supply to the front of the $\phi 50 \times 50$ mm sample, II – extended surface of air influence on the sample

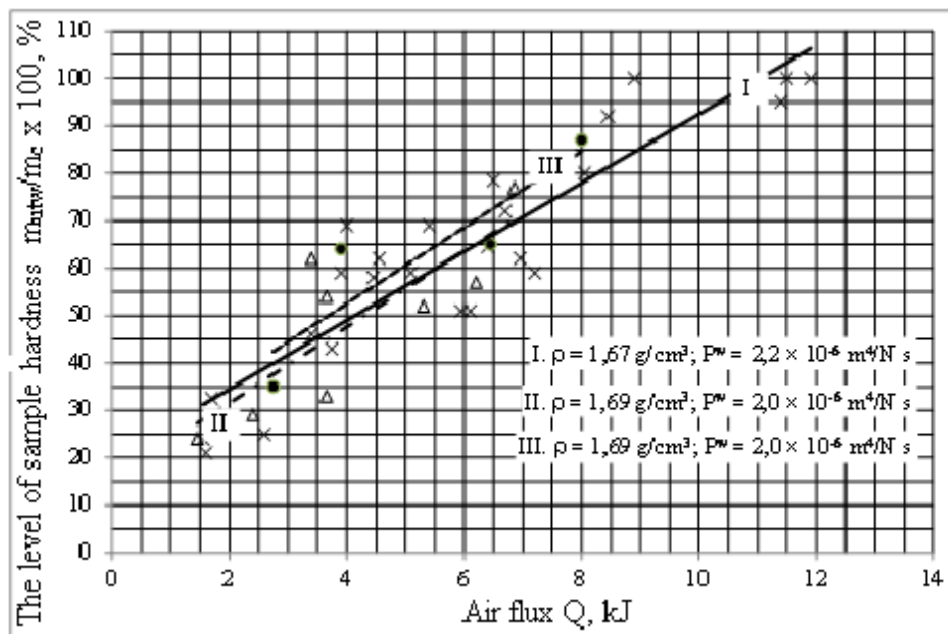


Fig. 2. Change of quantity of the hardened sample $\phi 50 \times 50$ mm depending on air-hardening process parameters

The heat flux provided by air has been evaluated by determining its weight m and enthalpy change Δi . Molier diagram (i-x chart) for humid air was used for determining of enthalpy change.

The analysis of air-hardening process indicated the essential influence of the process conditions for the level of core hardness; core sand hardening depends on:

- time and flow rate of the preheated air,
- air temperature for the given air flow rate,
- air pressure,
- the way of air supply.

The knowledge of the above parameters allows for precise determination of the air-hardening process conditions as well as range of parameters of core-making process.

2. Core manufacturing process with the use of sand, bonded by inorganic binders

Known technologies of eco-friendly inorganic binders are mainly: AWB and CORDIS from Hüttenes Albertus and INOTEC from ASK Chemicals [3-5]. The above mentioned technologies are based mainly on water solutions of silicates and the process of hardening is performed with the use of thermal method by preheating in the core-box and additionally purging with warm air.

Core sands based on such binders increases comfort of handling; no odor and emission of hazardous substances during core manufacturing and pouring into moulds occurred.

The main advantages of the technology with the use of blowing methods are as follows:

- reduction in the emission of hot hazardous gases (such as furfuryl alcohol, volatile amines, formaldehyde, organic solvents),
- reduction of odor (compared to cold-box and hot-box processes): zero emission of amine and formaldehyde,
- reduction of noise level to 82 dB.

The scope of works includes determining of the bending strength of the samples in the hardened form R_g^u . Samples were hardened by preheating in the core-box and drying room and by purging with hot air. Square cross-section samples of the sand with dimensions of $22,36 \times 22,36 \times 165$ mm, were prepared with the use of LUT/c/CO₂/An device. This device is meant for fabricating shaped elements and small cores in hot-box, cold-box, CO₂ hardening and warm air hardening technologies.

The core blower unit is shown at the Fig. 3. Core-blowing machine is equipped with shooting chamber with the volume of 3 liters, ended with shooting head with 3 nozzles $\phi 5,5$ and 12 mm. Vents are mounted on the shooting head.

The sample results of the research are presented at the Fig. 4. The following composition of moulding sand was used for tests: quartz sand – 100 parts by mass, Cordis 8323 binder – 2,2 parts by mass, Anorgit 8322 additive – 1,2 parts by mass.

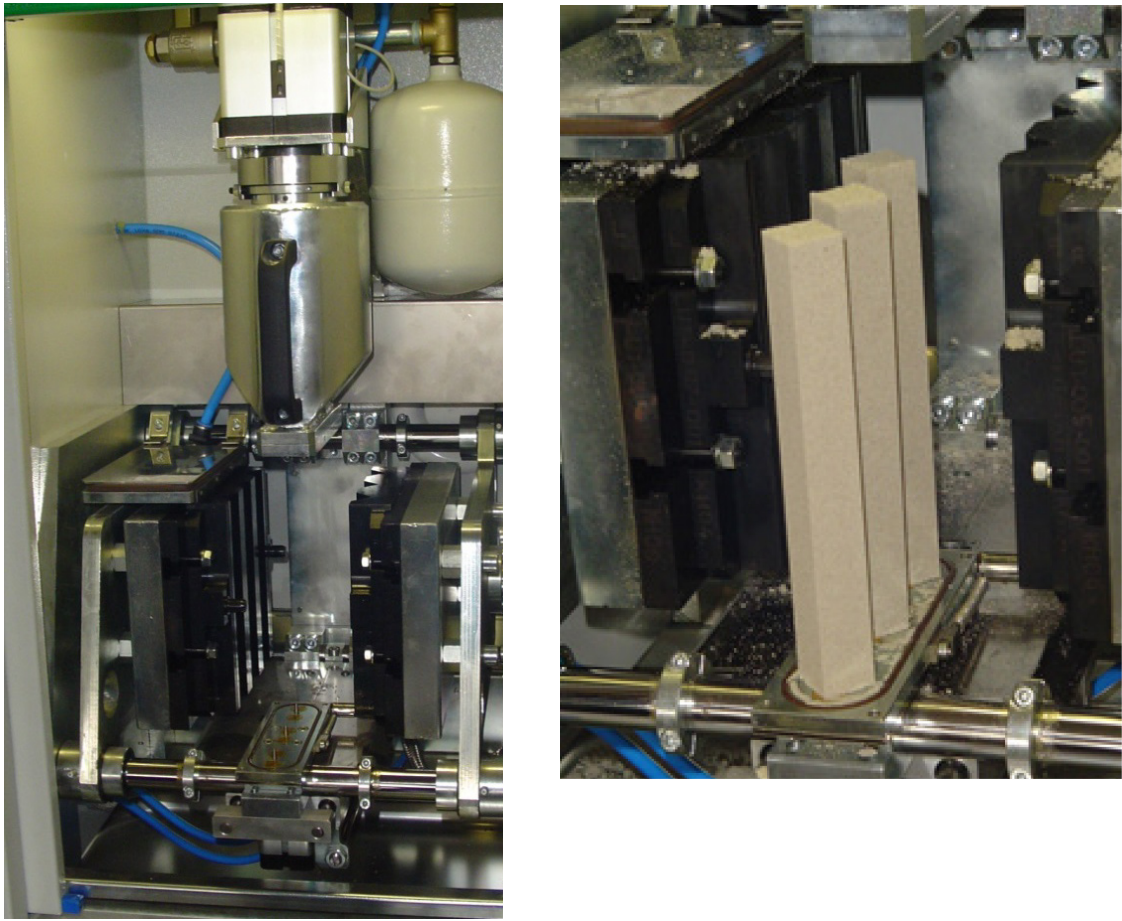


Fig. 3. LUT/c/CO₂/An device and core-making (samples) station

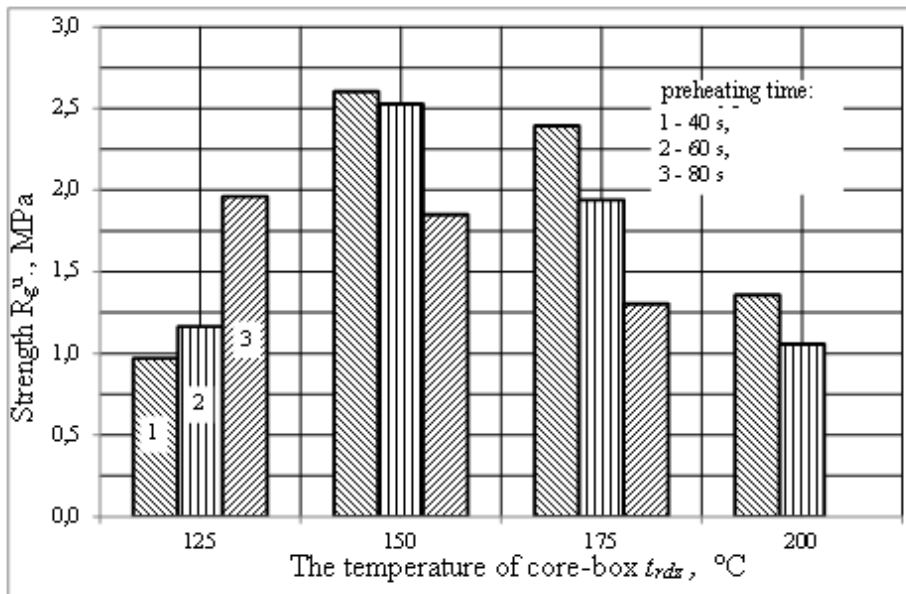


Fig. 4. Test results for samples with Cordis binder

Process parameters for preparation of samples for strength tests (for bending strength R_g^u tests) are as follows: shooting pressure – 5 bar, shooting time 0,5-1 s, core-box temperature: 125, 150, 175 and 200°C, time of preheating of the samples inside the core-box: 40, 60 and 80 s.

The strength of the samples was measured directly after manufacturing but without warm air purging.

The scope of research included determining of strength of the samples additionally preheated in a drying room and purged with hot air.

The results of tests performed by a binder manufacturer are shown on the Fig. 5 [7].

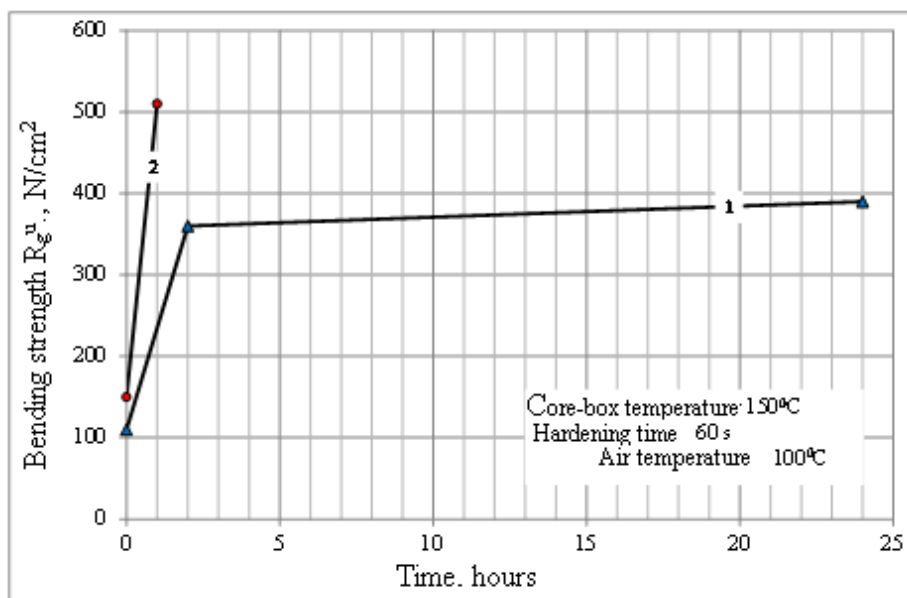


Fig. 5. Bending strength of the samples on the base of inorganic binder 1 - 100 parts by mass of quartz sand H 33, 2.5 parts by mass of Cordis 7820 (shooting pressure 6 bar); 2 – 100 parts by mass of quartz sand H33, 2.5 parts by mass of Cordis 8323, Anorgit 8322 (shooting pressure 5 bar) [7]

The results of the tests performed with the aim of determining parameters of core-making process by means of blowing methods confirmed the guidelines of binder producer.

The cores manufactured by means of blowing methods have the following properties [7]; cold-bending strength of 350-550 N/cm² with the Cordis binder content of 1,5–3%. Considering the flow behavior there is a possibility of manufacturing thin-walled cores. Alcohol- and water-based coatings can be applied at the core surface. The cores manufactured with the use of Cordis binders can be stored within 24 hours with high relative humidity of air and lose only 30% of its strength. Considering the fact that no adhering to the metal mould surface has been reported, cleaning of them is easier. Moulds reclamation is also typical with the use of standard equipment.

Positive effects of using cores manufactured with the use of Cordis and other inorganic binders have been achieved with gravity die castings and low-pressure aluminum casting. The technology with Cordis binders has been also tested, under industrial conditions, with positive effects, with cast iron castings [5-7].

3. Conclusions

Implementation of the technology of core manufacturing with the use of inorganic binders is connected with improvement of working conditions and environment protection.

Core sand on the base of inorganic binder has good parameters and is suitable for core-making with the use of blowing methods.

The results of the tests indicate that implemented technology with the use of eco-friendly inorganic binders has positive scores; the cores with excellent strength properties are obtained.

The conducted works confirmed the possibility of core manufacturing and determined required working parameters of core blowing machine and additional equipment – purging with hot-air depending on the size of the machine and manufactured cores.

It is necessary to emphasize the fact that additional equipment enables for utilization of various technologies, including warm air and all cold and hot processes, which makes it universal and meet the requirements of many small and medium-sized foundries in Poland.

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