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STUDIES OF THE INFLUENCE OF THE NUMBER AND DISTRIBUTION OF VENTS ON THE PRODUCTION PROCESS OF CORES BY THE BLOWING METHOD

The results of studies of the cores production by blowing methods with utilising the modified experimental shooting machine SR-3D, are provided in the hereby paper. The core sands from the Cordis technology were applied in the presented investigations. The influence of the number and distribution of vents on the shaped core box filling, filmed by a digital camera, was determined. Investigations were performed for the shooting pressures of 0.4, 0.5 and 0.6 MPa and for three surfaces of the shooting hole, at various numbers and distribution ways of vents in the experimental core box. The selected results of the model investigations were compared with the results of simulations performed previously in the PROCAST programme.

The intensity of the core sand outflow from the shooting chamber into the core box of the experimental shooting machine was measured. Technological effects were assessed on the basis of the core sand apparent density in individual parts of the core, in dependence on the character of the pressure increase in the shooting chamber and the pressure value obtained in the core box.

Keywords: core shooter, core sands, blowing method

1. Introduction

An optimisation of the production process of cores by blowing methods contains the selection of work parameters of the core box filling and moulding sand compaction processes as well as methods of moulding sand hardening by gaseous or thermal agents. Out of the parameters deciding on the processes of the mould cavity filling and moulding sand compaction the influence of such factors as: kind of the core sand and its reclaim [1-9], complication of the core shape, shooting pressure value, recommended surfaces and dimensions of shooting and venting holes, should be taken into account. The mentioned subjects, concerning traditional core binders (oil or linseed varnish, water glass, some resins for the hot-box process), were previously investigated [10-18], while analogous investigations for core sands with the inorganic Cordis binder – introduction of which into the foundry practice holds promise of decreasing pollution of the natural environment – were not performed.

The necessity of a certain diversification of the blowing process parameters (in relation to the previously applied) occurs in modern core sands. It concerns both the blast hole (either individual or a few ones) and vent holes, which in modern forms of the cold-box technology obtain an additional function, since regardless of the traditional task – being the proper core-box filling and sand compaction – the new task is added. This new task concerns providing favourable conditions for the core sand hardening (by its blowing through in the core box) and the removal of harmful substances formed during this process.

The presentation of the performed studies of the influence of several process and technological factors on the blowing process course and on the compaction degree of sands, having physical-mechanical properties and compaction abilities [4] diverging from the typical core sands – applied so-far in the blowing processes – is the aim of this paper.

2. Experimental stand

The experimental stand (Fig. 1) consisted of:

1. experimental shooting machine of a shooting chamber volume (Fig. 1b) of 2300 cm^3;
2. experimental flat core box (horizontal – Fig. 1c) of a volume of 795 cm^3;
3. blowing sleeves set: d1 = 25, 15, 12 and 10 mm.

Data concerning the construction elements of the experimental stand and its process parameters, are given in Table 1.

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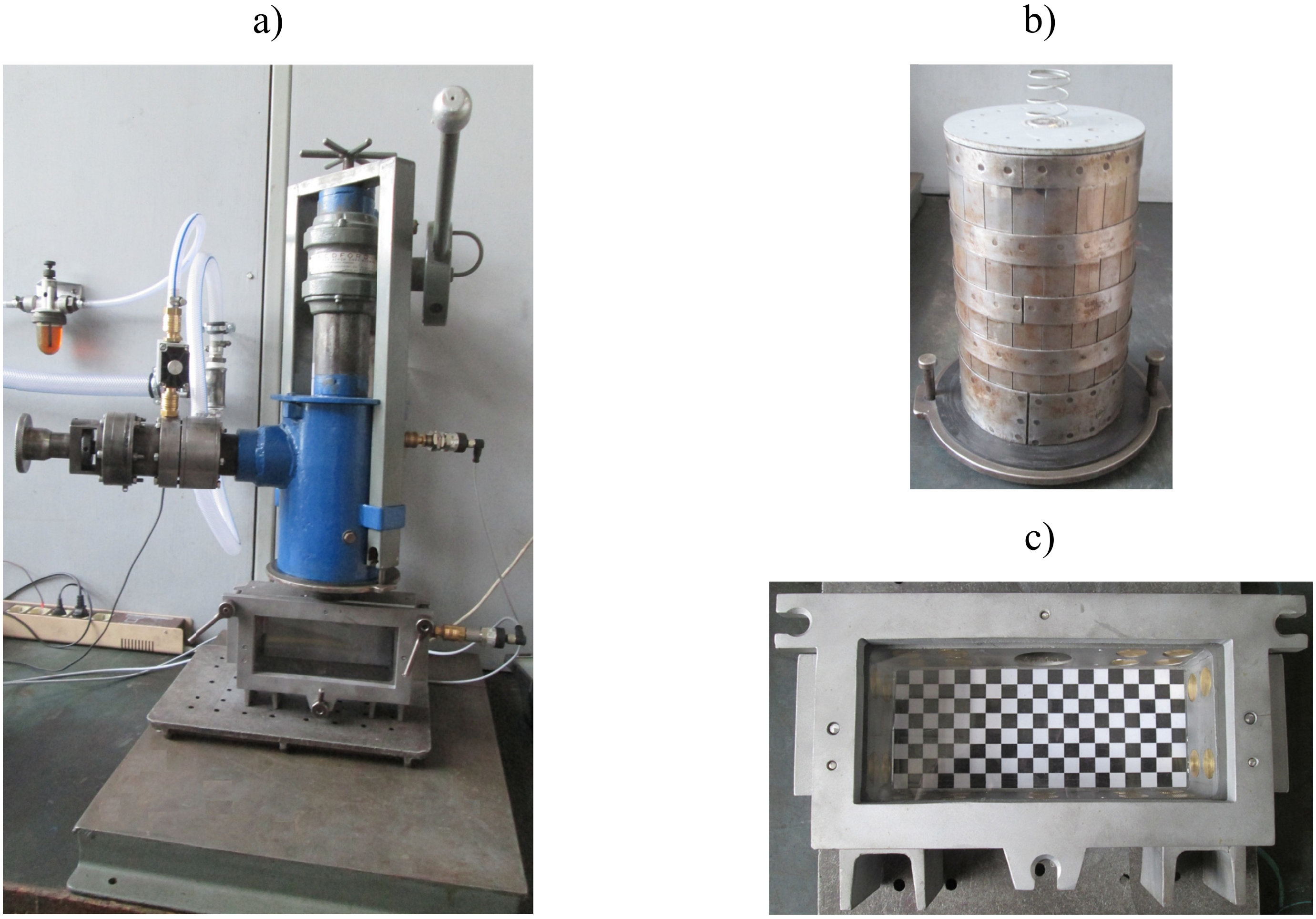


Fig. 1. Experimental stand of the shooting machine SR-3D; a – General view, b – Shooting chamber, c – Experimental core box

TABLE 1

Construction parameters of the stand of the shooting machine SR-3D

No.	Element of the stand	Process parameters	
1.	**Shooting chamber**		
	a) Volume of the perforated insert	– constructional: $V_{bk} = 3340$ cm^3 – usable: $V_{bu} = 2300$ cm^3	
	b) Surface of side perforations	– total surface: $\Sigma F_{pc} = 10.2$ cm^2 – horizontal slits: $F_{ph} = 4.8$ cm^2 – vertical slits: $F_{pv} = 5.4$ cm^2	
	c) Shooting hole surface $F_1(d)$	– $F_1(d_1{=}25$ mm$) = 4.908$ cm^2 – $F_1(d_1{=}20$ mm$) = 3.140$ cm^2 – $F_1(d_1{=}15$ mm$) = 1.767$ cm^2 – $F_1(d_1{=}12$ mm$) = 1.130$ cm^2	
2.	**Experimental horizontal core box**		
	a) Chamber volume	– constructional: $V_c = 795$ cm^3	
	b) Number and usable surface of vents F_2	– total number –12 – $\Sigma F_{2\ total} = 4.2$ cm^2 – upper vents – 8 – $\Sigma F_{2\ upper} = 2.8$ cm^2 – side vents – 4 – $\Sigma F_{2\ side} = 1.4$ cm^2	
	c) Venting degree: $S_{resp} = F_2(d) / F_1(d)$ for various shooting sleeves	$S_{total}(25) = 0.856$ $S_{upper}(25) = 0.570$ $S_{side}(25) = 0.285$	$S_{total}(20) = 1.338$ $S_{upper}(20) = 0.892$ $S_{side}(20) = 0.446$
		$S_{total}(15) = 2.377$ $S_{upper}(15) = 1.587$ $S_{side}(15) = 0.792$	$S_{total}(12) = 3.717$ $S_{upper}(12) = 2.479$ $S_{side}(12) = 1.239$

3. Programme and investigation conditions

Investigations of the core shooting processes were preceded by the preparation of the core sand with the inorganic Cordis binder. The composition of the core sand was as follows:

- High-silica sand 100 parts by weight,
- Cordis 8323 binder 2.2 parts by weight,
- Anorgit 8322 addition 1.0 part by weight.

The studies were divided into two series.

Series I – investigations of the airflow without the sand participation (at the so-called idle running) – aimed at checking the vents functioning by determining pressure changes in the shooting chamber and core box of the shooting machine as well as the pressure boundary values in these spaces under the following conditions:

- applied shooting sleeves diameters d1 are: d1 = 25, 20, 15, 12 mm,
- number of actively operating vents being in the core box, obtained by plugging part of them, creates for each shooting sleeve the following categories of the core box venting:
  - total venting – 12 holes, $\Sigma F_{2total} = 4.2\ cm^2$
  - upper venting – 8 holes, $\Sigma F_{2upper} = 2.8\ cm^2$
  - side venting – 4 holes, $\Sigma F_{2side} = 1.4\ cm^2$.

Series II – process investigations (at the so-called work gear) – in order to determine the apparent density, degree of the core box filling, intensity of the core sand outflow as well as the visualisation of filling the experimental core box. The constant shooting pressure, being respectively pa = 0.4 MPa (3 atn.) and pa = 0.6 MPa (5 atn.), was applied. Conditions concerning the number and diameters of shooting sleeves and the number and distributions of vents were the same as in Series I.

4. Investigation results

Examples of the pressure courses in the shooting chamber and in the shooting machine core box, prepared at the shooting pressure of 0.4 MPa, for the shooting hole of 12 mm and various distributions of vents, are presented in Figure 2. The courses obtained at the total venting of the core box are shown in Figure 2a, while those obtained at the side venting in Figure 2b.

Dependencies of the boundary pressure in the shooting chamber (Fig. 3a) and in the core box (Fig. 3b) – obtained for the applied shooting pressure values and vents distributions – are presented as a function of the shooting hole diameter in Figure 3.

It can be observed – on the basis of data shown in Figure 3 – that increasing the work pressure causes the boundary pressure increase in the shooting chamber and in the core box. Decreasing the active surface of vents causes that boundary pressures in the shooting chamber and in the core box are increasing. The highest boundary pressure values are found at the side venting, reduced to 4 active vents, while the lowest values at the total venting, which uses 12 active vents. In addition, at the shooting hole diameter – being 12 mm – the highest boundary pressure was obtained in the shooting chamber, while the lowest in the core box. Along with increasing diameters of shooting sleeves, the boundary pressure in the shooting chamber decreases, while in the core box increases. These observations are exactly in agreement with the calculation model of airflow fluxes in blowing machines, given in publications [1,4].

During further investigations the influence of the shooting hole diameter and the number and distribution of venting holes on the core apparent density was determined. These tests were performed for the shooting pressures being 0.4 and 0.6 MPa, and the obtained results are shown graphically in Figure 4.

The analysis of data presented in Figure 4 indicates, that along with the increase of the shooting hole the apparent density of the obtained core also increases. This effect was observed for both tested shooting pressure values and for all applied venting variants. The venting value is essential for the core compaction degree. The highest compaction is obtained at the total venting, which is characterised by the highest total venting surface. A lower compaction was obtained for the upper venting, while the lowest for the side venting, where the venting surface – being

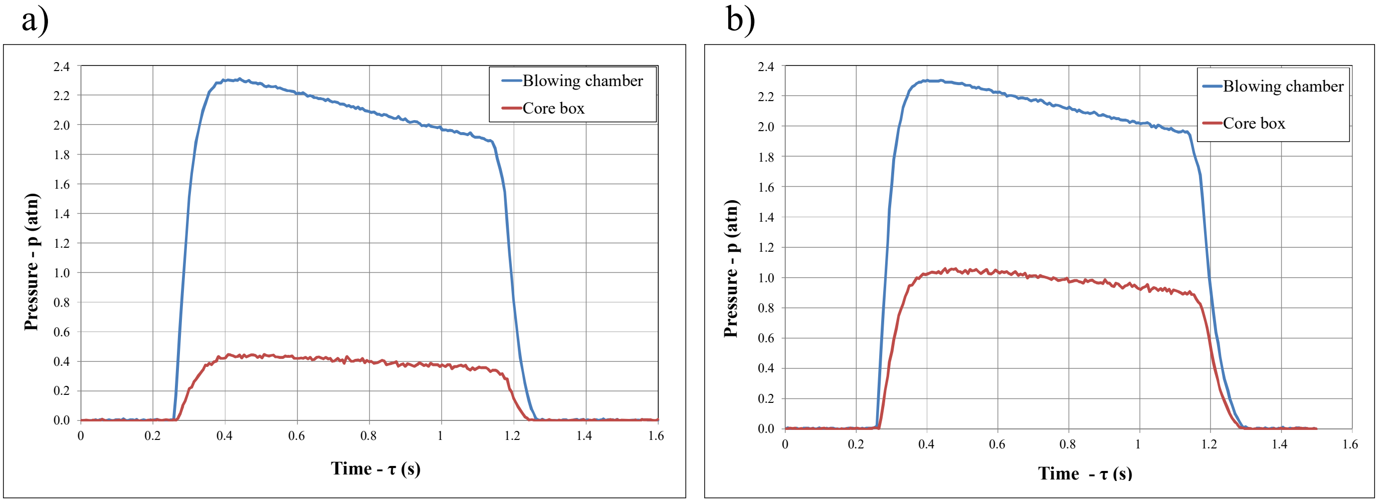
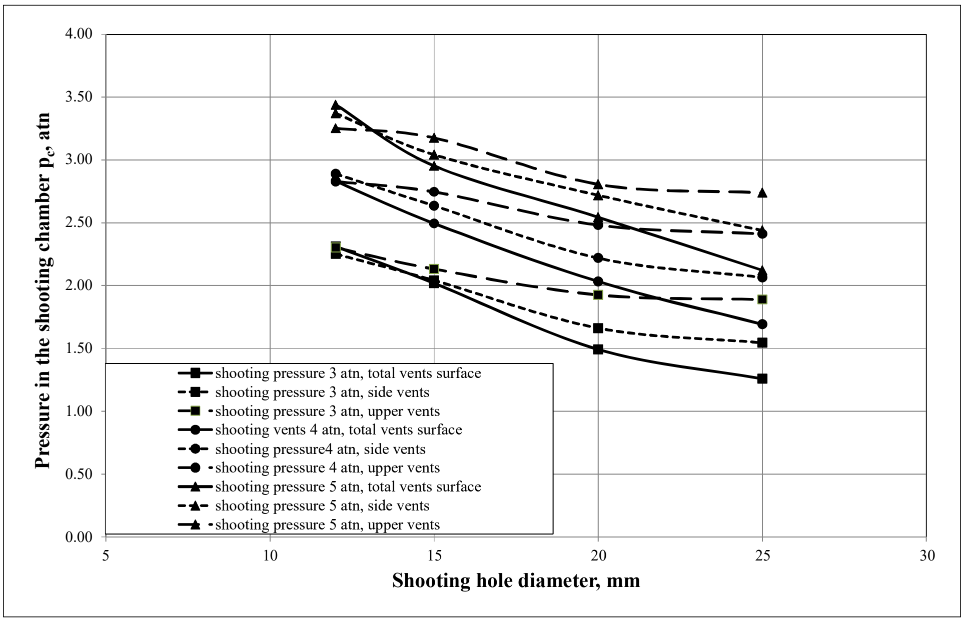


Fig. 2. Pressure changes in the shooting chamber and in the core box of the shooting machine. Shooting pressure 0.4 MPa, d_1 =12 mm; a – Total venting, b – Side venting

a)



b)

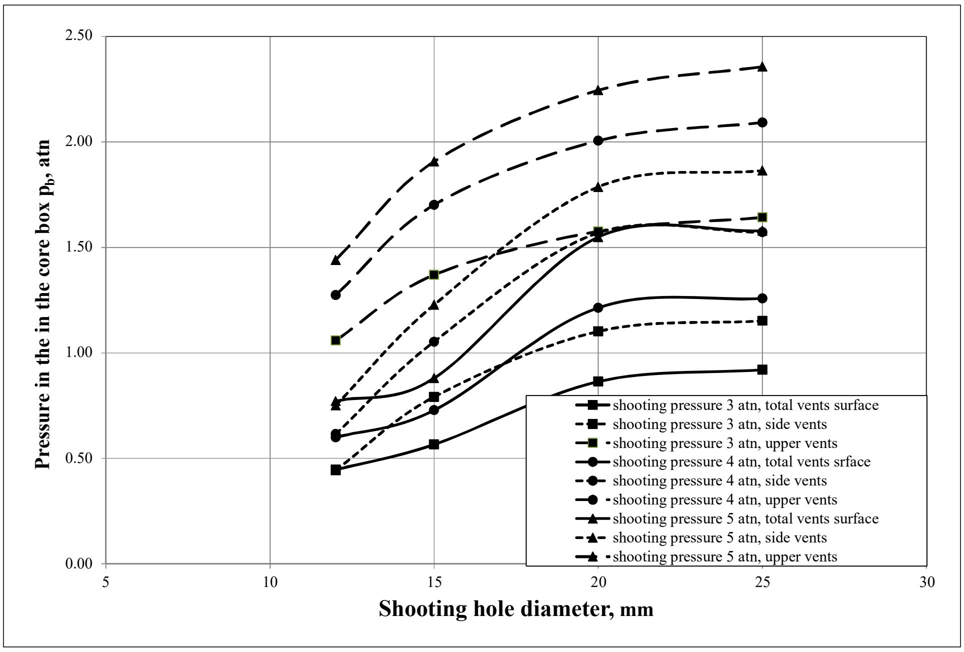


Fig. 3. Changes of the boundary pressure in the shooting chamber (a) and in the core box (b) of the shooting machine as a function of the shooting hole diameter

1.4 cm^2 – is three times smaller than the value corresponding to the total core box venting (see Table 1).

The results of measuring the outflow intensity of the core sand from the shooting chamber of the experimental shooting machine into the core box are presented in the next Figure (Fig. 5). These results are taking into account the shooting pressure, shooting sleeves diameters as well as the applied venting. It can be noticed that all mentioned values are influencing the intensity value. However, as long as the influence of the shooting sleeve diameter and the shooting pressure is obvious, investigations allow also to estimate the influence of numbers and distribution of vents on the sand outflow intensity. The higher total surface of vents the smaller resistances inhibiting the outflow of the sand-air mixture and its intensity. The curve courses character is analogous to the one obtained in previous studies [2].

The successive stage of the performed studies constituted model tests carried out on the experimental stand and attempts of their verifying by the simulation investigations performed by means of the PROCAST calculation package.

The possibility of utilising the calculation model offered by this package requires introducing of several data characterising the calculated process with regard to the core sand properties (viscosity, density, coefficient of friction between core box walls and core sand) and the shooting machine parameters (applied

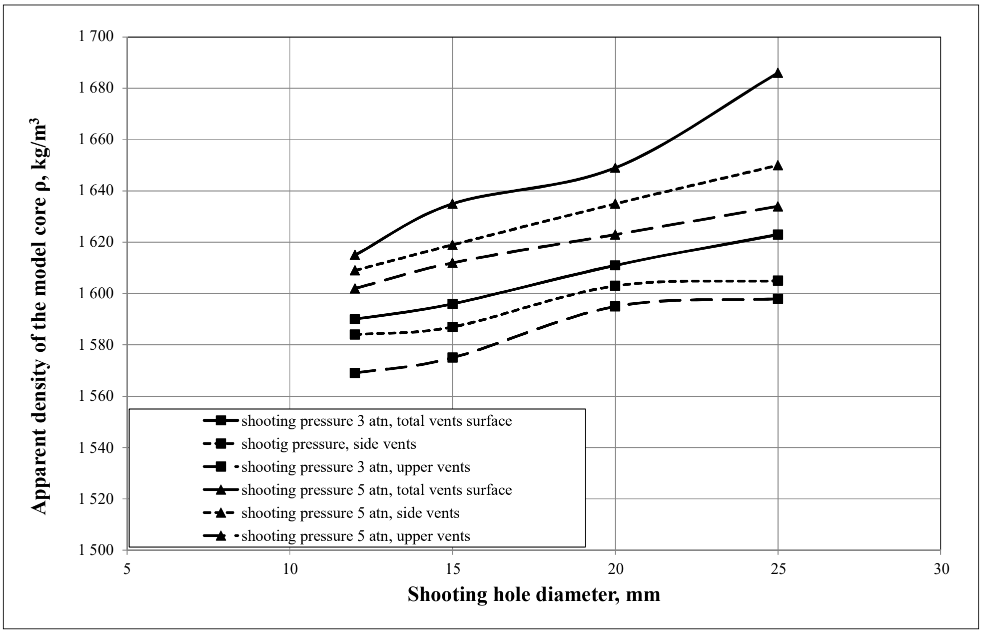


Fig. 4. Influence of the shooting hole diameter and venting on the apparent density of the model core

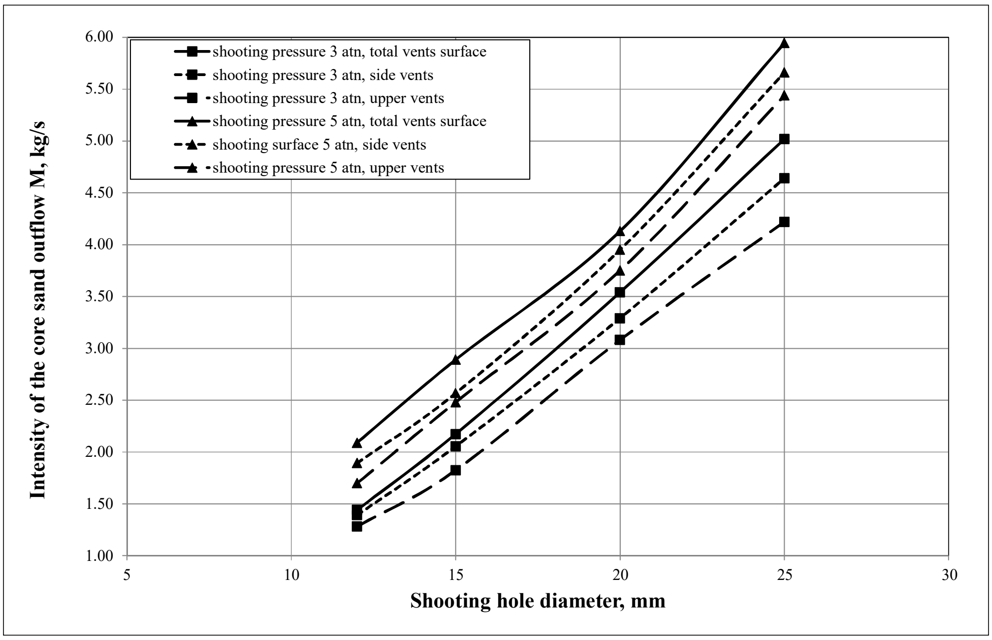


Fig. 5. Results of the intensity of the core sand outflow from the shooting chamber into the core box

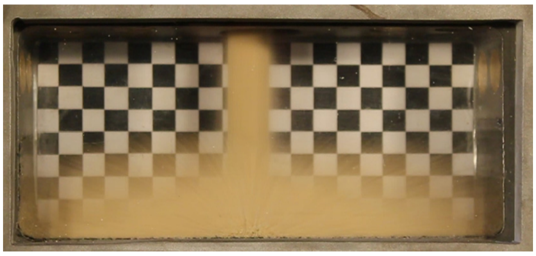
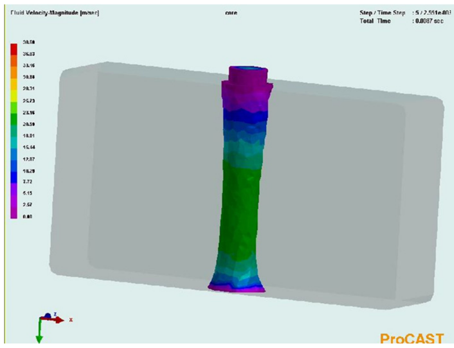
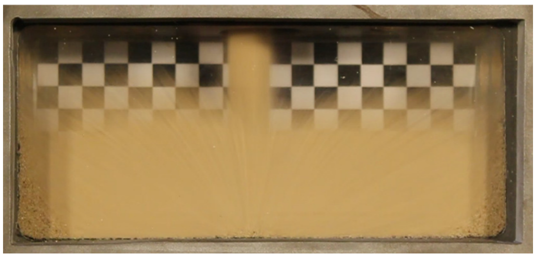
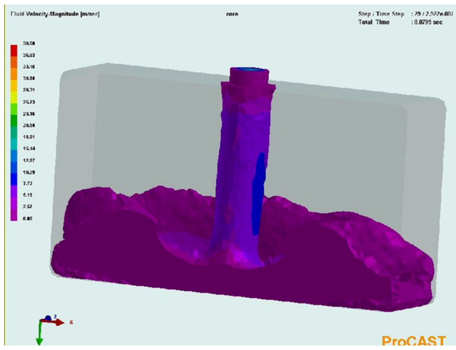
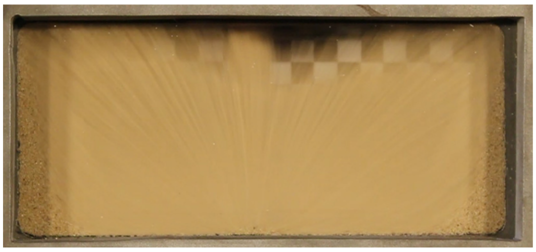
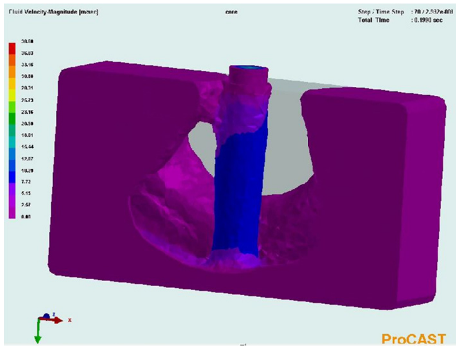
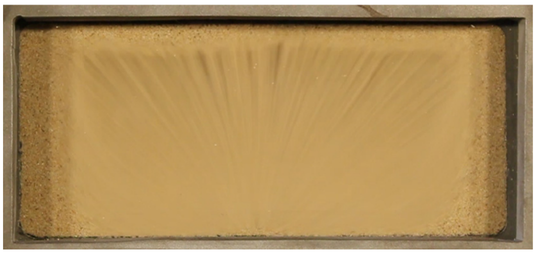
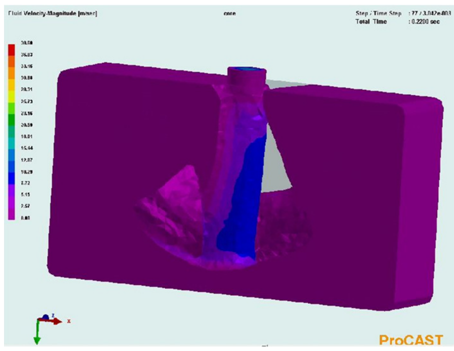
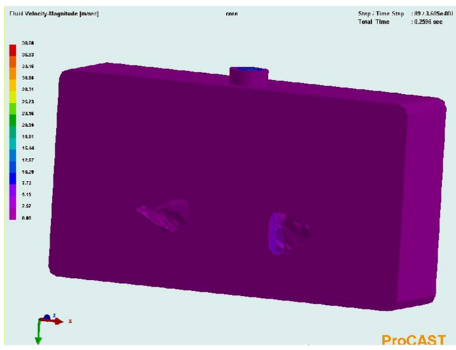
pressures, shooting sleeves diameters (surfaces), vent numbers and distribution).

Simulations of the core box filling was performed for the rectangular core box, corresponding dimensionally to the one applied in model tests (Fig. 1). The shooting pressure of 0.6 MPA (5 atn) and total venting of the core box were assumed. The moulding sand for the cold-box technology was applied as the core sand, since its density, permeability and physical-mechanical properties are similar to the sand from the CORDIS technology, used when recording the filling process of the model core box. The comparison and visualisation of model investigations and simulations of the experimental core box filling are presented in Table 2.

When analysing the obtained results of simulation studies, certain differences – in relation to model investigations – can be noticed. The most essential difference constitutes the different character of the sand outflow and final filling of the core box near the shooting hole. It seems that ‘simulated’ courses are characterised by too high fluidity, resembling liquid, and in the result the filling character is more turbulent than in the reality. When the part of the core being near the shooting hole is filled as the first one it does not indicate differences in relation to the remaining core parts. Under real conditions the highest compaction of cores is obtained near the shooting hole.

TABLE 2

Visualisation of model investigations and simulations of the experimental core box filling

Time	Model investigations	Simulations
0,008 sec.		
0,120 sec.		
0,200 sec.		
0,225 sec.		
0,330 sec.		

5. Conclusions

Within the performed studies the essential influence of the venting on the pressure courses in the shooting chamber and core box of the shooting machine was revealed. This influence transfers directly to the character of the core sand outflow from the shooting chamber into the core box as well as to the core compaction degree.

The obtained results indicate that the proper formulation of the problem in simulation calculations is very important. Regardless of such properties as shooting process parameters and instrumentation (shooting pressure, its growing rate in the core box, shooting hole diameter, surface of vents) the factors characterising physical-mechanical properties of core sands, related to the applied binder properties and core geometry, should be precisely taken into account. For the assumed parameters of the shooting process, being of a forcing character, the core box filling and sand movement within this core box depends – to a high degree – on rheological properties of the sand binder.

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