Production of Steel Casts in Two-Layer Moulds with Alkaline Binders
Part 1. Backing sand with the alkaline inorganic binder RUDAL

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Abstract
Steel casts in Z.N. POMET were produced in moulds made of the moulding sand Floster. This sand did not have good knocking out properties, required a significant binder addition (4.5-5.0 parts by weight), and the casting surface quality gave rise to clients objections. Therefore a decision of implementing two-layer moulds, in which the facing sand would consist of the moulding sand with an alkaline organic binder while the backing sand would be made of the moulding sand with an inorganic binder also of an alkaline character was undertaken. The fraction of this last binder in the moulding sand mass would be smaller than that of the binder used up to now (water glass). The application of two moulding sands of the same chemical character (highly alkaline) should facilitate the reclamation process and improve the obtained reclaimed material quality, due to which it would be possible to increase the reclaim fraction in the moulding sand (up to now it was 50%). The results of the laboratory investigations of sands with the RUDAL binder are presented in the paper.

Key words: steel casts, two-layer moulds, moulding sands, inorganic alkaline binder

1. Introduction
Up to the present, casting moulds for steel casts in the Foundry Plant Z.M. POMET S.A. were made from the moulding sands Floster S containing water glass 145 and an organic ester hardener flodur. These sands were characterized by rather not good knocking out properties, were difficult for reclamation, and required the relatively high binder addition (4.5-5.0 parts by weight). Apart from that, the casting surface quality was not satisfying all requirements of clients. To this end the decision of implementing two-layer moulds, in which the facing sand would be constituted of the sand with an alkaline organic binder, while the backing sand would be made of the moulding sand with an inorganic binder of the alkaline character too, was undertaken. The fraction of this inorganic binder would be smaller than the fraction of the binder used till now (water glass). The application of two moulding sands of the same chemical character (highly alkaline) should significantly facilitate the reclamation process and improve the obtained reclaimed material quality, due to which it would be possible to increase the reclaim fraction in the moulding sand (up to now it was 50%) [1].

The moulding sand with the inorganic composition (highly alkaline) RUDAL, produced by the Chemical Plant RUDNIKI,
binding on the basis of geopolymers for self-hardening sands was selected [2, 3]. This binding agent is applied for the production of moulds and cores from self-hardening sands for cast steel, cast iron and non-ferrous metals castings [4]. In Part 2 of the paper the investigations concerning the optimisation of the facing sand composition with the organic binder called REZOLIT will be discussed.

2. Applied materials and their characteristics

Matrix

High-silica sand Grudzeń Las; sand moisture 0.03%, sand pH = 6.70. Main fraction (0.400/0.320/0.200) constitutes 91.31%. Powdery fraction (≤ 0.10 mm) content in sand equals 0.36%. Sand specific surface is 6.02 m²/kg.

Reclaimed material: moisture 0.27%, pH = 10.20, reclaim ignition loss = 0.73%. Main fraction (0.40/0.32/0.20) constitutes 88.96%. Powdery fraction content (≤ 0.10 mm) in reclaim equals 0.53%. Reclaim specific surface is 5.80 m²/kg [5, 6].

Binding agent

The binding agent RUDAL is an inorganic composition binding on the basis of geopolymers for self-hardening sands (sodium modified water glass). Its main component is sodium silicate (40–46% Na₂O + SiO₂). It is characterised by a high alkalinity (pH = 12.5–13.5). The binder addition is 1.4–2.0% of the sand. It has a high binding ability. The sand working time is from 2 to 90 minutes. The moulding sand with this binding agent has good knocking out properties. It easily undergoes the mechanical reclamation and the obtained reclaimer can be used in amounts from 70 to 100% in the moulding sand [4].

Hardeners

SA type hardeners – this is a series of hardeners types of a high binding ability, intended for hardening polymers of the RUDAL A series. By applying various types of hardeners the sand working time can be regulated. The hardener is applied in the amount ranging from 6% to 16% in relation to the binder amount [4].

Two hardeners SA63 (of a medium hardening rate) and SA62 (of a low hardening rate) were applied.

Moulding sands were prepared in the laboratory roller mixer, LM-1 type. Samples for examinations were made in the device for vibratory compacting of shaped elements LUZ-1 type, while strength investigations were performed by means of the universal apparatus for strength determination LRu-2e type [7]. The moulding sand permeability was determined in the apparatus LPiR-1 [8].

3. The obtained results of moulding sands properties and their discussion

Composition of the investigated moulding sands

The initial composition of moulding sands used in investigations was as follows: fresh sand – 40% parts by weight, reclaimer – 60 parts by weight, binder RUDAL 1.78–2.34 parts by weight, hardener – 0.28–0.34 parts by weight (approximately 0.15% in relation to the binder amount).

Required properties:

– compressive strength (Rc) after:
  1 h ≥ 0.2 MPa
  3 h ≥ 0.5 MPa
  24 h ≥ 1.2 MPa
– permeability after hardening (Pp) after 24 h: ≥ 500*10⁻⁸ m²/Pa·s
– moisture W = 0.8–1.1%.

The obtained results and their discussion

The obtained results are graphically presented in Figures 1–18.

Moulding sands with the SA63 hardener

The influence of the binder amount on the compressive strength is presented in Fig. 1, while the influence of the hardener amount in Fig. 2 and 3. The influence of the binder amount on the moulding sand grindability S is shown in Fig. 4, while its influence on the moulding sand permeability Pp in Fig. 5.

![Fig. 1. Influence of the hardening time on the compressive strength for various binder amounts in the moulding sand of the following composition: high-silica sand – 40%, reclaim – 60%, RUDAL, SA63 hardener – 15%](image)

![Fig. 2. Influence of the hardening time on the compressive strength for various hardener amounts in the moulding sand](image)
of the following composition: high-silica sand – 40%, reclaim – 60%, RUDAL – 2.0 parts by weight, SA63 hardener

Fig. 3. Influence of the hardener amount on the moulding sand compressive strength $R_c$ of the following composition: high-silica sand – 40%, reclaim – 60%, RUDAL – 2.0 parts by weight, SA63 hardener

Fig. 4. Influence of the binder amount on the moulding sand grindability $S$ of the following composition: high-silica sand – 40%, reclaim – 60%, RUDAL, SA63 hardener – 15%

Fig. 5. Influence of the binder amount on the moulding sand permeability $P$ of the following composition: high-silica sand – 40%, reclaim – 60%, RUDAL, SA63 hardener - 15%

The working time of the moulding sand of the following composition: 40 parts by weight of the high-silica sand, 60 parts by weight of the reclaim, 2 parts by weight of RUDAL, 15% (in relation to the binder amount) of the SA63 hardener - was 9 minutes (Fig. 6).

The influence of the reclaim fraction on the moulding sand properties was investigated at the reclaim additions being: 60, 80 and 100%. The moulding sand compressive strength $R_c$ (Fig. 7), grindability $S$ (Fig. 8) and permeability $P$ (Fig. 9) were determined.
The influence of the reclaim fraction on the moulding sand properties was investigated at its additions being: 60, 80 and 100%. The moulding sand compressive strength $R_c$ (Fig. 16), grindability $S$ (Fig. 17) and permeability $P_{pu}$ (Fig. 18) were determined.

**Moulding sands with the SA62 hardener**

The influence of the applied binder amount on the compressive strength $R_c$ is presented in Fig. 10, while the influence of the hardener amount in Fig. 11 and 12. The influence of the binder amount on the moulding sand grindability $S$ is shown in Fig. 13, while its influence on the moulding sand permeability $P_{pu}$ in Fig. 14.

The working time of the moulding sand of the following composition: 40 parts by weight of the high-silica sand, 60 parts by weight of the reclaim, 2 parts by weight of RUDAL, 15% (in relation to the binder amount) of the SA62 hardener - was 10 minutes (Fig. 15).
Fig. 12. Influence of the hardener amount on the moulding sand compressive strength $R_c^u$ of the following composition: high-silica sand – 40%, reclaim – 60%, RUDAL – 2.0 parts by weight, SA62 hardener

Fig. 13. Influence of the binder amount on the moulding sand grindability $S$ of the following composition: high-silica sand – 40%, reclaim – 60%, RUDAL, SA62 hardener – 15%

Fig. 14. Influence of the binder amount on the moulding sand permeability $P$ of the following composition: high-silica sand – 40%, reclaim – 60%, RUDAL, SA62 hardener - 15%

Fig. 15. Influence of the sand maturing time of not compacted moulding sand (working time) on the tensile strength of the moulding sand of the following composition: high-silica sand – 40%, reclaim – 60%, RUDAL – 2.0 parts by weight, SA62 hardener – 15%

Fig. 16. Influence of the hardening time on the moulding sand compressive strength $R_c^u$ for various reclaim fractions. The moulding sand composition: high-silica sand (s), reclaim (r), RUDAL – 2.0 parts by weight, SA62 hardener – 15%

Fig. 17. Influence of the reclaim addition on the moulding sand grindability $S$ of the following composition: high-silica sand (s), reclaim (r), RUDAL – 2.0 parts by weight, SA62 hardener – 15%
4. Conclusions

On the basis of the performed investigations the following conclusions can be drawn:

1. The backing sand with the RUDAL A binder and SA63 hardener obtains - under laboratory conditions - the required properties when there are 2.0 parts by weight of the binding agent and 0.35 parts by weight of the hardener. Such moulding sand is also characterized by a very small grindability and high permeability. In order to obtain the required properties a smaller addition of the binder (2.0 parts by weight) and a higher fraction of the hardener (up to 0.5 parts by weight) can be applied. The decisive factor will constitute the cost of such changes and the reclaiming ability of the spent sand.

2. The moulding sand containing 2.0 parts by weight of the binder and 0.3 parts by weight of the SA63 hardener, obtains - in a practical way – all required properties, apart from the compressive strength after 24 h, which is lower. The working time of such sand is 9 minutes.

3. It seems possible to increase the reclaimed material fraction to 80% (at 2 parts by weight of the binder and 0.3 parts by weight of the SA63 hardener). Such sand achieves, after 24 h, the compressive strength of approximately 140 N/cm², which means higher than the moulding sand containing 60% of the reclaim. The remaining properties are similar to the ones of the sand containing 60% of the reclaim.

4. When the SA62 hardener is applied the moulding sand achieves the required properties at the addition of 1.8 parts by weight of the binder and 0.27 parts by weight of the hardener. In this case it seems also possible to apply 80% addition of the reclaimed material. The working time of the moulding sand with the SA62 hardener is 10 minutes.

5. The obtained results concern the laboratory conditions of the moulding sand preparation and examination. In the industry practice these conditions can be different, especially sand mixing and hardening. Therefore before eventual changes in the moulding sand composition it is necessary to perform examinations under industrial conditions. It mainly concerns increasing the reclaimed material fraction in the moulding sand. The diversity of the casting mass should be also taken into consideration. Heavier castings will, for sure, require the application of the moulding sand of the higher strength.

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References:


Wykonywanie odlewni staliwych w formach dwuwarstwowych ze spoiwami nieorganicznymi. Cz. 1. Masa wypełniająca z alkalicznym spoiwem nieorganicznym RUDAL

Streszczenie

Odlewy staliwne w Z.M. POMET wykonywane były w formach z masy Floster. Masy te posiadały niezbyt dobrą wybijalność, konieczny był znaczny dodatek spoiwa (4,5-5,0 cz. wag.), a jakość powierzchni odlewni budziła zastrzeżenia klientów. Dlatego też podjęto decyzję o wdrożeniu form dwuwarstwowych, w których masę przymodelową stanowiłby masa ze spoiwem organicznym o charakterze alkalicznym, a masę wypełniającą masa ze spoiwem nieorganicznym. W dwóch masach przewidziano stosunkowo małą ilość charakteru alkalicznego, którego udział w masie byłby mniejszy niż dotychczasowego spoiwa (szkła wodnego). Zastosowanie dwóch mas z tym samym charakterem chemicznym (wysoce alkaliczne) pomimo znacznie ułatwia proces regeneracji i poprawia jakość otrzymywanego regeneratu, dzięki czemu możliwe będzie większe udział regeneratu w masie (dotychczasowo do 50%). W artykule przedstawiono wyniki badań laboratoryjnych masy ze spoiwem RUDAL.