ARCHIVES
Of
FOUNDRY ENGINEERING

ISSN (1897-3310)
Volume 11
Special Issue
2/2011
81–86

16/2

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

Production of Steel Casts in Two-Layer Moulds with Alkaline Binders

Part 2. Facing sand with the alkaline organic binder REZOLIT

M. Holtzer, A. Bobrowski, D. Drożyński, [a,*] M. Tomczak, E. Rozmiarek, B. Isendorf [b]

[a] Faculty of Foundry Engineering, AGH University of Science and Technology , Reymonta 23 Str., 30-059 Cracow, Poland

[b] Z. M. POMET S.A., Krańcowa 20 Str., 61-037 Poznań, Poland

* Corresponding author. E-mail address: holtzer@agh.edu.pl

Received 11.04.2011; Approved for print on: 26.04.2011

Abstract

This paper constitutes the second part of the article concerning the implementation of the two-layer mould technology for steel casts in Z.M. POMET. The results of the laboratory examinations of the backing sand with the inorganic binder RUDAL were presented in the first part of the paper. Whereas in the second part the results of the laboratory testing of the facing sand with the alkaline resin REZOLIT are given. The technology of two-layer moulds was already implemented in Z.M. POMET within the target project. Examples of castings made in this technology are shown in the final part of this paper.

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

1. Introduction

The binder used in the technology of loose self-hardening sands called REZOLIT AM (produced by PT-P MACHMAT MINERALS) was singled out as a binding agent for facing sands. This is a highly concentrated alkaline resol. Sand hardening occurs at an ambient temperature. REZOLIT AM is especially suitable for making moulds and cores for castings of high quality cast steels.

Moulding sands with phenolic resin hardened by ester compared to sands with furan resin has the following advantages [1, 2, 3]:

- on account of nitrogen, sulphur and phosphor absence there is no hazard of sulphurising or phosphorising of casting surfaces, and the possibility of pinholes occurrence also significantly decreases;
- sands with furan resin – during pouring into moulds – emit significant amount of CO, CO_2 and SO_2 , which worsens working conditions in foundry plants;
- due to a high alkaline character of phenolic resin it can be applied together with high-silica, olivine, zircon or chromite sands.

Investigations concerning the optimisation of the composition of the facing sand with alkaline phenolic resin hardened by ester are discussed in this part of the paper.

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 (≤ 0.100 mm) content in sand equals 0.36%. Sand specific surface is 6.02 m^2/kg [4, 5].

Binding agent

REZOLIT AM: alkaline phenol-formaldehyde resin (pH = 12 – 14) applied in the technology of self-hardening sands, which hardens at an ambient temperature [6].

Main hazardous components: potassium hydroxide (KOH) < 20% and methanol (CH_3OH) $3.0 \leq c \leq 20\%$. Free phenol content < 0.8%, free formaldehyde content < 0.1% (in resin).

Moulding sand composition (acc. to the producer's data):

- High-silica sand - 100 parts by weight
- REZOLIT AM resin – 1.5 parts by weight
- PRESTAL R1 hardener – 0.3 parts by weight

Moulding sand preparation:

Mixing sand with the hardener for 1.5 minutes followed by the resin addition and mixing for the next 1.5 minutes.

Obtained moulding sand parameters:

- Moulding sand working time: 5-15 minutes,
- R_g after 24 hours: minimum 2 MPa (3 rammer strokes).

Hardener

PRESTAL: hardener for loose self-hardening sands bonded with the resol resin REZOLIT AM. This hardener is being prepared on the basis of esters and improvers. Usually, it is added as 15 to 25 % of the resin mass ratio. Versions of various reactivity, slower or faster than the basic hardener R1, are available. The basic hardener PRESTAL R1 and the slower one R 3/1 were used in investigations.

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 the strength determination LRu-2e type [7]. The moulding sand permeability was determined according to standard PN-80/H-11072 [8].

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

3.1. Composition of moulding sands

The initial composition of moulding sands, used in investigations, was as follows: fresh sand – 100% parts by weight, phenol-formaldehyde resin – 1.60 parts by weight, hardener PRESTAL R1 – 0.352 parts by weight (22% in relation to the resin amount). Required properties:

Compressive strength (R_c^u) after:

- 1 h ≥ 0,5 MPa
- 3 h ≥ 1,0 MPa
- 24 h ≥ 1,5 MPa

Permeability after hardening (P^u) after po 24 h:

- ≥ $500*10^{-8}$ m^2/Pa*s

The following parameters of the moulding sand were obtained [5-9]:

- Compressive strength R_c^u (after 1, 3 and 24 h.)
- Grindability after 24 h,
- Permeability after 1, 3 and 24 h.:
- Working time.

1.3 and 1.6 parts by weight of the resin and 10, 20 and 30% - in relation to the resin – of the R1 hardener were added and the resin addition of 1.6 parts by weight with the R3/1 hardener in amount of 20, 30 and 40% - in relation to the resin.

3.2. The obtained results and their discussion

The obtained results are graphically presented in Figures 1–9.

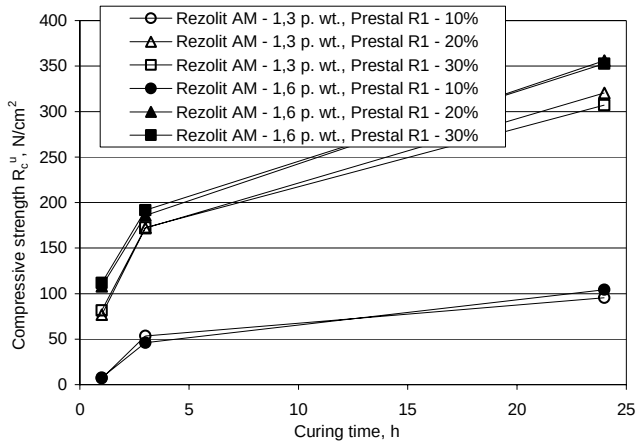

Fig. 1. Influence of the hardener amount on the compressive strength of the moulding sands with the REZOLIT binder

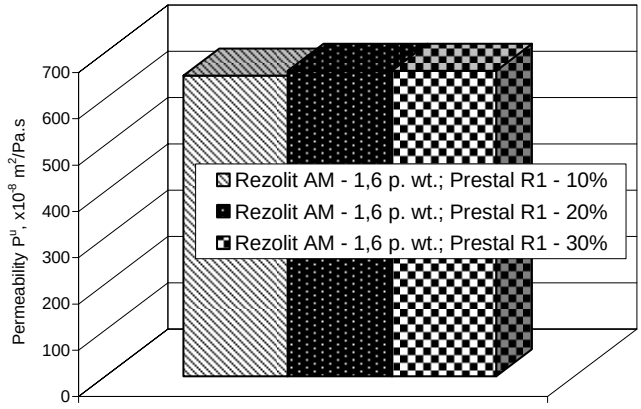

Fig. 2. Influence of the hardener amount (winter type/faster) on the permeability of the moulding sands with the REZOLIT binder

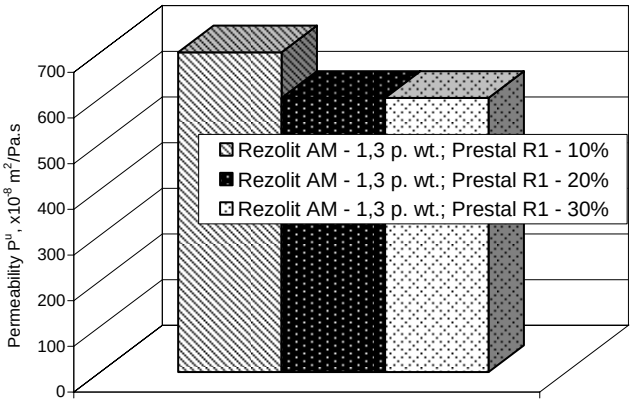

Fig. 3. Influence of the hardener amount (winter type/faster) on the permeability of the moulding sands with the REZOLIT binder

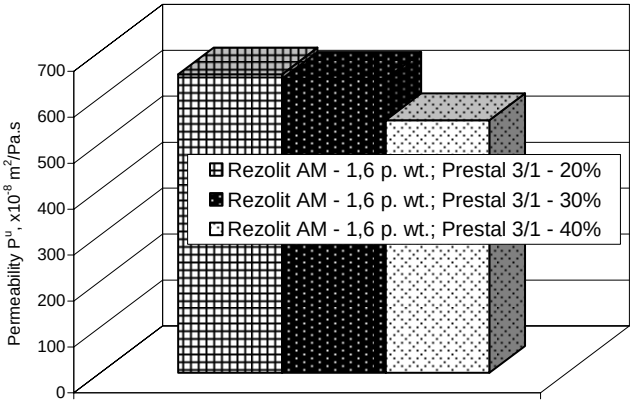

Fig. 4. Influence of the hardener amount (summer type/slower) on the permeability of the moulding sands with the REZOLIT binder

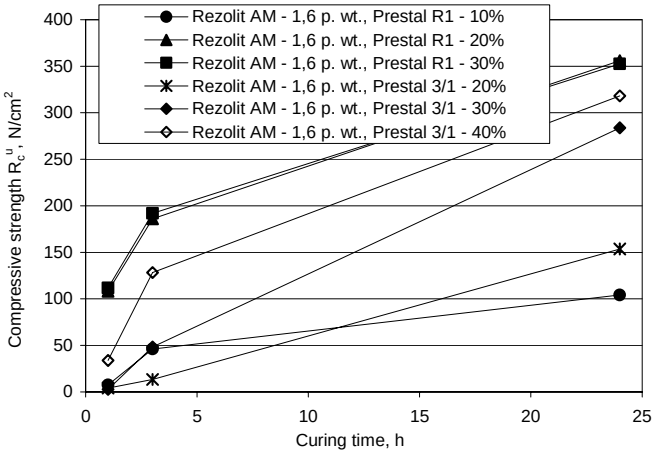

Fig. 5. Influence of the hardener type on the compressive strength of the moulding sands with the REZOLIT binder

- Permeability after hardening (P^u)
  - after 24 h $600*10^{-8}$ m^2/Pa*s (Fig. 3)
- Grindability (after 24 h) (Fig. 6)
  S = 0,89%.

Increasing the resin addition to the level of 1.6 parts by weight at the same 20% fraction of the R1 hardener results in only app. 10% increase of the compressive strength (Fig. 1) and permeability (Fig. 2). The increase of the hardener amount in relation to the resin amount in both cases (1.3 parts by weight and 1.6 parts by weight of resin) also does not cause the strength properties increase (Fig. 1). The decrease of the resin amount does not influence the permeability of the moulding sand with the resin REZOLIT (Fig. 3).

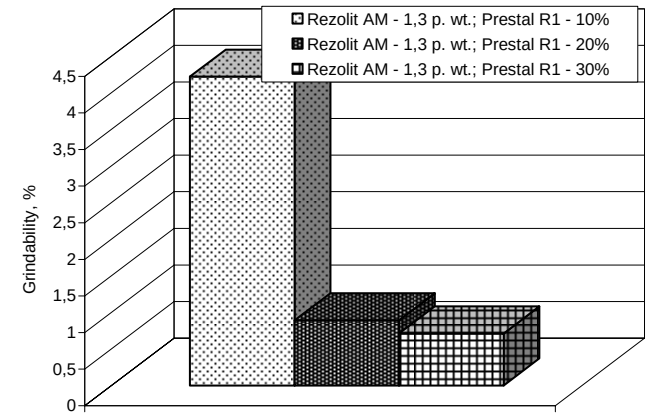

Fig. 6. Influence of the hardener amount (winter type/faster) on grindability of the moulding sands with the REZOLIT binder

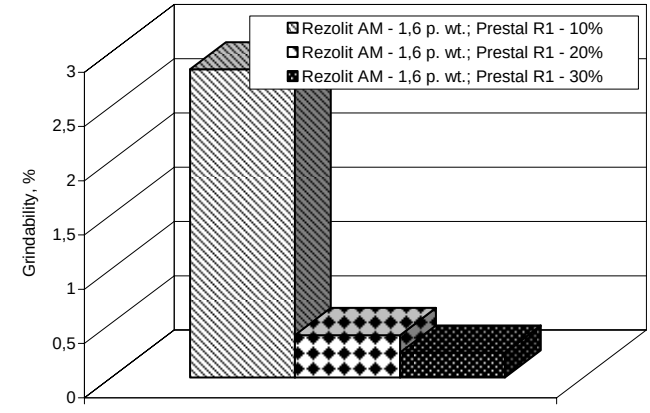

Fig. 7. Influence of the hardener amount (summer type/slower) on grindability of the moulding sands with the REZOLIT binder

The application of 20% of the slower R3/1 hardener causes a significant decrease of the compressive strength (Fig. 5) and an increase of grindability (Fig. 7 and 8). Addition of 20-30% of the Prestal 3/1 hardener does not influence significantly the moulding sand permeability (Fig. 4). Therefore in this case it is necessary to apply moulding sand containing 1.6 parts by weight of the resin and 30% of the hardener (in relation to resin,

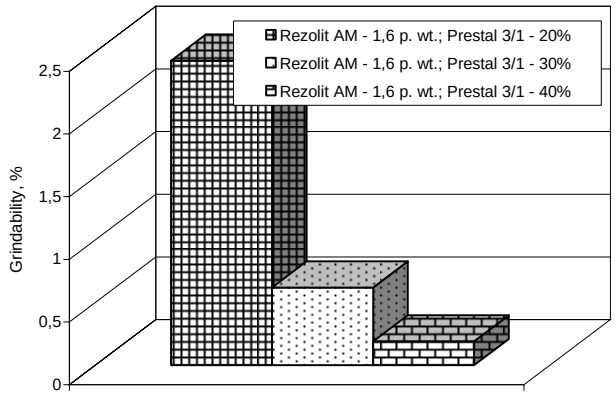

Fig. 8. Influence of the hardener amount (winter type/faster) on grindability of the moulding sands with the REZOLIT binder

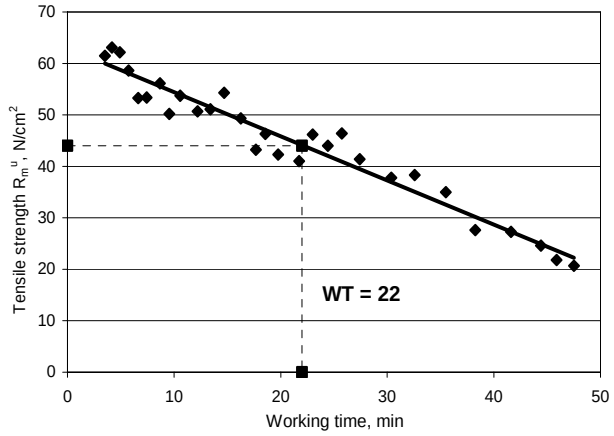

Fig. 9. Working time of the moulding sand with the summer type hardener (slower)

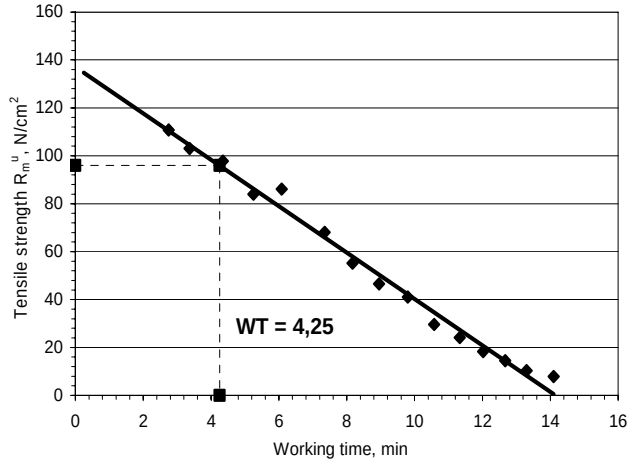

Fig. 10. Working time of the moulding sand with the winter type hardener (faster)

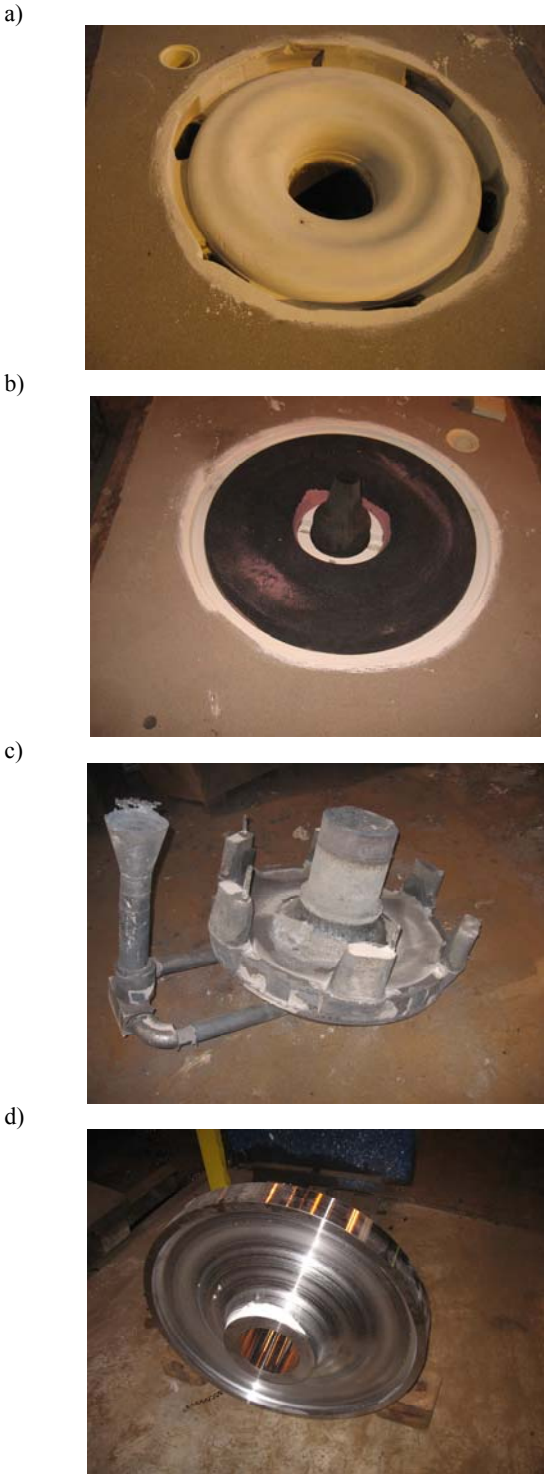

Fig. 11. Process of the casting preparation in two-layer moulds: a) Upper half of the wheel form, b) Lower half of the wheel form, c) Wheel casting after knocking out from the two-layer mould, d) Wheel casting after mechanical working

which means 0.48 parts by weight). On the other hand the moulding sand containing 1.6 parts by weight of the resin and 20% of the R3/1 hardener has a much longer working time (22 minutes) (Fig. 9), as compared to the moulding sand of the same composition but with the R1 hardener (Fig. 10) (working time 4.25 minutes).

The process of making castings in the developed two-layer moulds is presented in Fig. 11 a-d: the facing sand with the alkaline phenol resin hardened by the REZOLIT ester, the backing sand with the inorganic RUDAL binder.

This is the casting of the wheel centre made of cast steel (cast steel grade 340-550W acc. to PN-ISO 3755:1994). Rough casting mass: 290kg, mass of the casting after working 230kg, pouring temperature: 1560-1580C. The reclaimed material, obtained as the result of the reclamation of the moulding sands mixture from two-layer moulds used in the amount of 60% addition to the moulding sand, meets the requirements. The strength of the moulding sands prepared on the basis of the two-component reclaimed material satisfies the technological requirements. The surface of the obtained castings does not raise any objections.

Conclusions

On the bases of the performed measurements the following conclusions can be drawn:

1. The laboratory investigations indicated that, in the case of the facing sand with the REZOLIT binder, the parameters required by the foundry plant are obtained by the moulding sand containing 1.3 parts by weight of the resin and 0.26 parts by weight of the R1 hardener. An increase of the resin and hardener fractions to 1.6 and 0.32 parts by weight of the resin and hardener, respectively, causes only 10% improvement of properties. Also an increase of the hardener in relation to the resin amount does not improve strength properties.
2. The working time of the moulding sand containing 1.6 parts by weight of the resin and 0.32 parts by weight of the R1 hardener equals only 4.25 minutes, while when the R3/1 hardener is used the working time is 22 minutes. At performing further tests - under industrial conditions – the estimation of the time, necessary for the proper bonding of two kinds of moulding sands: facing and backing, will be needed.
3. In practice, it will be possible to control (by the composition) the moulding sand properties in dependence on the casting mass and its complexity.
4. The obtained results concern the laboratory conditions of the moulding sand preparation and testing. In the industrial practice these conditions can be different, especially at the moulding sand mixing and hardening. Therefore before undertaking eventual changes in the composition carrying investigations under industrial conditions is necessary. Various weights of castings should be also taken into account. Castings of a larger mass will require moulding sands of a higher strength.
5. The high quality of steel casts produced in two-layer moulds confirmed the usefulness of the applied technology.

The work was realised within the target project: NOT No. 6 ZR7 2009 C/07207 (2010-2011).

References

[1] J.L. Lewandowski: Tworzywa na formy odlewnicze. Wyd. Akapit, Kraków 1997.
[2] Li Hankus, Li Shichenh i in.: Study on the Ester-Cured Alkaline Phenolic Binder Systems for Large Steel Casting. Proceedings of 60th World Foundry Congress, October 16-20, 2010, Hangzhou, China, 0674-0678.
[3] Wang Jin liang, Huang Ren he: Synthesizing Technique of Ester-Cured Alkaline Phenolic Resine for Reclaimed Sand. FOUNDRY, 2009, 02.
[4] PN-83/H-11077 Analiza sitowa piasku formierskiego i bentonitu.
[5] PN-83/H11078 Odlewnicze materiały formierskie. Określanie powierzchni właściwej i wskaźnika kształtu ziarn.
[6] Materiały informacyjne producenta żywicy i utwardzacza.
[7] PN-83/H-11073. Odlewnicze materiały formierskie. Pomiar wytrzymałości.
[8] PN-80/H-11072 Odlewnicze materiały formierskie. Pomiar przepuszczalności.

Wykonywanie odlewów staliwnych w formach dwuwarstwowych ze spoiwami alkalicznymi
Cz. 2. Masa przymodelowa z alkalicznym spoiwem organicznym REZOLIT

Streszczenie

Jest to 2 część artykułu dotyczącego wdrożenia technologii form dwuwarstwowych do wykonywania odlewów staliwnych w Z.M. POMET. W części 1 przedstawiono wyniki badań laboratoryjnych masy wypełniającej ze spoiwem nieorganicznym RUDAL. Natomiast w części 2 zamieszczono wyniki badań laboratoryjnych masy przymodelowej z żywicą alkaliczną REZOLIT. Technologia form dwuwarstwowych została już wdrożona w Z.M. POMET w ramach projektu celowego. W końcowej części artykułu zamieszczono przykłady wykonanych odlewów w tej technologii.

Słowa kluczowe: odlewy staliwne, formy dwuwarstwowe, masy formierskie, alkaliczne spoiwo organiczne