

# Method of the Moulding Sands Binding Power Assessment in Two-Layer Moulds Systems

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## Abstract

More and more foundry plants applying moulding sands with water-glass or its substitutes for obtaining the high-quality casting surface at the smallest costs, consider the possibility of implementing two-layer moulds, in which e.g. the facing sand is a sand with an organic binder (no-bake type) and the backing sand is a sand with inorganic binder. Both kinds of sands must have the same chemical reaction. The most often applied system is the moulding sand on the water-glass or geopolymer bases – as the backing sand and the moulding sand from the group of self-hardening sands with a resol resin – as the facing sand. Investigations were performed for the system: moulding sand with inorganic GEOPOL binder or moulding sand with water glass (as a backing sand) and moulding sand, no-bake type, with a resol resin originated from various producers: Rezolit AM, Estrofen, Avenol NB 700 (as a facing sand). The LUZ apparatus, produced by Multiserw Morek, was adapted for investigations. A special partition with cuts was mounted in the attachment for making test specimens for measuring the tensile strength. This partition allowed a simultaneous compaction of two kinds of moulding sands. After 24 hours of hardening the highest values were obtained for the system: Geopol binder - Avenol resin.

**Keywords:** Innovative materials and foundry technologies, Mechanical properties, Two-layer moulds, Moulding sands, Alkaline organic binder

## 1. Introduction

More and more foundry plants applying moulding sands with water-glass or its substitutes (e.g. Rudal binder), for obtaining the high-quality casting surface at the smallest costs, consider the possibility of implementing two-layer moulds, in which e.g. the facing sand is a sand with an organic binder (no-bake type) and the backing sand is a sand with inorganic binder. The sand with an organic binder is more expensive but allows to obtain a very good casting surface [1, 2]. Due to the technological process and the foundry sand reclamation process

both kinds of sands must have the same chemical reaction [3]. The most often applied system is the moulding sand on the water-glass or geopolymer bases – as the backing sand and the moulding sand from the group of self-hardening sands with a resol resin – as the facing sand [4-7]. The mechanical reclamation of such sands mixture is without problems and the obtained reclaimed materials can be reused in preparations of backing sands [8]. However, in case of two-layer moulds, apart from the same chemical character of both sands, a binding power of these two sand layers is very important. This power decides on the binding strength at both sands boundary, which influences the casting quality and occupational safety. Up to the

present, there is a lack of a methodology allowing to determine, even preliminarily, the binding power of two kinds of moulding sands in two-layer moulds. Therefore, within the NOT project realised together with the CEMA MYSTAL Company, the special investigation method was developed in the Faculty of Foundry Engineering, AGH, University of Science and Technology. This method allows to estimate the binding power by determination of the tensile strength of tensile test specimens made up of two kinds of sands.

## 2. Methodology of investigations and the applied materials

Investigations were performed for the system: moulding sand with inorganic GEOPOL binder or moulding sand with water glass (as a backing sand) and moulding sand, no-bake type, with a resol resin originated from various producers: Rezolit AM, Estrofen, Avenol NB 700 (as a facing sand).

Moulding sands of the following compositions were used:

- 1) quartz sand (100 p. wt.), Geopol (2.5 p. wt.), hardener SA 73 (0.38 p. wt.);
- 2) quartz sand (100 p. wt.), Rezolit AM (2.3 p. wt.), hardener R-1/5 (0.115 p. wt.);
- 3) quartz sand (100 p. wt.), Estrofen (1.8 p. wt.), hardener PR6 (0.09 p. wt.);
- 4) quartz sand (100 p. wt.), Avenol 700 NB (1.9 p. wt.), Katalysator 4040 (0.185 p. wt.);
- 5) quartz sand (100 p. wt.), water glass (3.7 p. wt.), hardener Mach IV (0.40 p. wt.).

The LUZ apparatus, produced by Multiserw Morek, was adapted for investigations. A special partition with cuts was mounted in the attachment for making test specimens for measuring the tensile strength. This partition allowed a simultaneous compaction of two kinds of moulding sands (Fig. 1 - 3). Its shape was the result of several tests concerning the proper compaction and binding of both sands.

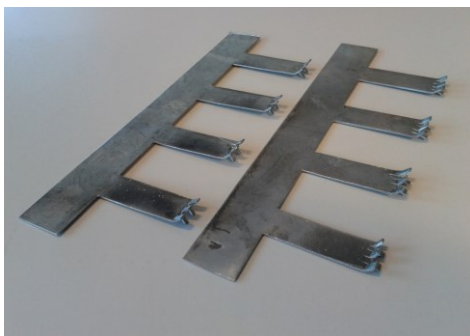


Fig. 1. Partition with cuts separating two kinds of sands when making tensile test specimens

The method applied for making test specimens was as follows: the partition was placed in the LUZ apparatus mould, and two moulding sands were simultaneously poured at both sides of this partition. Test specimens were subjected to vibrations for 15 seconds, then the partition was pulled out and vibrations continued for next 15 seconds. Such preparation

method warranted formation of a properly strong bond between two kinds of the tested moulding sands. The tensile test specimens were ripped by means of LRU-2e.



Fig. 2. The way of mounting the partition separating two sands in the LUZ apparatus

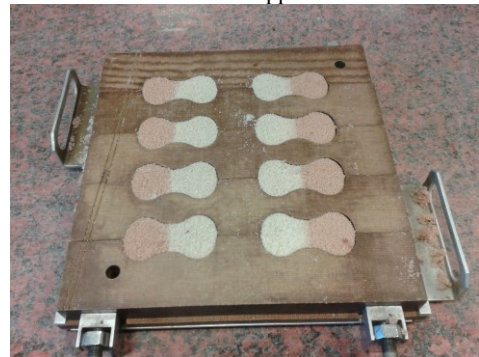


Fig. 3. Two-layer tensile test specimen for measuring the tensile strength after compaction

## 3. Investigation results and their discussion

The tensile strength results of test specimens made of two kinds of moulding sands, at application of various resol resins, are presented in Fig. 4.

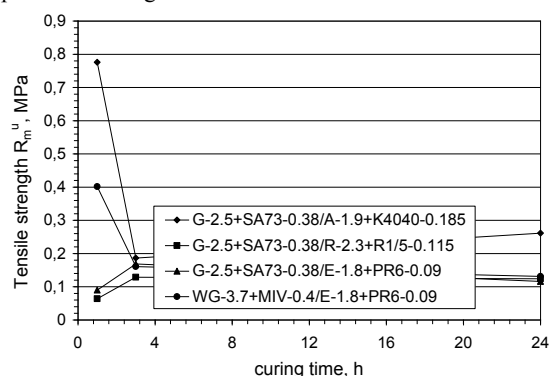


Fig. 4. Tensile strength of two-layer test specimens. Notations: G – Geopol, E – Estrofen, A – Avenol, R – Rezolit, WG – water-glass

Cross-sections of binding of two sands in the place, in which they were fractured are shown in Fig. 5 (a-f).



Fig. 5a. Fracture of tensile test specimens - after 24 h - of the system: Geopol + Avenol  
(Tensile failure occurred at the boundary of two sands)



Fig. 5d. Fracture of tensile test specimens – after 24h – for the system: Geopol + Estrofen  
(The fracture of the tensile test specimen of the system: Geopol+Estrofen after 24h - occurs in the sand with the Estrofen resin)



Fig. 5b. Fracture of tensile test specimens of the system: Geopol + Rezolit (after 3h)



Fig. 5e. Fracture of tensile test specimens of the system: water-glass + Estrofen, after 3h



Fig. 5c. Fracture of tensile test specimens - after 24h – of the system: Geopol + Rezolit  
(The fracture of the tensile test specimen of the system: Geopol+Rezolit after 3h - occurs in the sand with the Rezolit resin, while after 24h - at the boundary of two sands)



Fig. 5f. Fracture of tensile test specimens of the system: water-glass + Estrofen, after 24h  
(Contrary to the system Geopol+Rezolit after 3h the fracture occurs at the boundary of two sands, while after 24h in the sand with the Estrofen resin, since the binding of two sands strengthened).

## Conclusions

1. The developed method of measuring binding powers between two kinds of moulding sands, with applying the standard equipment, allows for the preliminary assessment of these sands behaviour towards each other in the mould.
2. It is possible to determine time after which binding in between two sands achieves the proper value to allow a safe manoeuvring of the mould during forming.
3. As long as after 1 hour of hardening no significant differences in the tensile strength of the tested systems were observed (all values were below 0,1 MPa), after 3 hours these differences already occurred.
4. After 24 hours of hardening the highest values were obtained for the system: Geopol binder - Avenol resin and they were higher than the values after 3 hours of hardening. Whereas for the remaining systems after 24 hours of hardening the tensile strength decrease occurred – in relation to this value after 3 hours of hardening - and they were lower by more than 0,1 MPa than for the system: Geopol – Avenol resin.

## Acknowledgements

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## Metoda oceny wielkości siły wiązania mas w układzie form dwuwarstwowych

### Streszczenie

Coraz więcej odlewni stosujących masy ze szkłem wodnym lub jego zamiennikami (np. spoiwo Rudal, dla uzyskania wysokiej jakości powierzchni odlewów przy możliwie najniższych kosztach, rozważa możliwość wdrożenia tzw. form dwuwarstwowych, w których np. masa przymodelowa jest masą ze spoiwem organicznym typu SMS, a masa wypełniająca masą ze spoiwem nieorganicznym. Oba rodzaje piasków muszą mieć taki sam charakter chemiczny. Najczęściej stosowanym układem jest masa na bazie szkła wodnego lub geopolimeru, jako masa wypełniająca oraz masa z grupy mas samoutwardzalnych z żywica rezolową jako masa przymodelowa. Badania prowadzono dla układu masa ze spoiwem nieorganicznym GEOPOL lub masa ze szkłem wodnym (jako masa wypełniająca) i masa typu SMS z żywica rezolową pochodzącą od różnych producentów: Rezolit AM, Estrofen, Avenol 700 NB (jako masa przymodelowa). Do badań przystosowano aparat LUZ produkcji Multiserw Morek, w którym w przystawce do sporządzania kształtek z masy do pomiaru wytrzymałości na rozciąganie zamontowano specjalną nacinaną przegrodę, która umożliwiała równoczesne zagęszczenie dwóch rodzajów masy. Po 24 godzinach utwardzania wyraźnie najwyższe wartości uzyskano dla układu spoiwo Geopol - żywica Avenol.

**Słowa kluczowe:** innowacyjne materiały i technologie odlewnicze, właściwości mechaniczne, formy dwuwarstwowe, masy formierskie, alkaliczne spoiwa organiczne.