EFFECT OF POLYETHYLENE OXIDE ON BASIC PROPERTIES OF BENTONITE FOUNDRY SAND MIXTURES

Harold Mäsiar[1*], Jozef Kasala[1], Peter Lipták[1], Zuzana Lacková[1]

[1]*Alexander Dubcek University of Trencin, Faculty of Special Technology, Pri parku 19, 911 06 Trenčín, Slovak Republic*
*Corresponding author E-mail address: harold.masiar@tnuni.sk

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Abstract
Very small quantities of polyethylene oxide with molecular weight of 600 000 (PEO) exhibit a non-additive effect of increased permeability that is higher in higher compaction energies (19.62 J). Increased permeability has been proven at such small PEO quantities as 0.0365 %-wt., 0.073 %-wt., and 0.1 %-wt.. That effect is limited for PEO higher than 0.1 %-wt. it is that PEO effect will find application in metal casting at lower melting temperatures.

Keywords: Bentonite, Polyethylene Oxide, Foundry mixtures, Permeability, Bondability, Surface Hardness

1 Introduction

Bentonite foundry moulding mixtures exhibit a substantial effect on the cast quality. During detection of faults it was found that as much as 50 % defective casts are due to the owing to of moulding mixtures or inadequate use thereof.

On previous occasions, we were able to detect a non-additive high effect of small PEO quantities on polypropylene, as well as of a combination of polyacryl amide with PEO at the treatment of some waste - sludges. These results propelled us to study the PEO effect on changes of technological properties of bentonite foundry mixtures.

PEO is a relatively new polymer. Clarifying the PEO effect under consideration here is of both practical and theoretical significance.

The need of modifying foundry moulding mixtures by using very small PEO quantities is propelled by this polymer's non-additive effect on increased permeability. Additional changes include properties such as bondability, splitting strength and hardness, that all contribute to improved casting quality.

Slovakia offers favorable conditions for producing this polymer in terms of raw materials, technology and qualified professionals.

2 Methodology

PEO effect was examined on the properties of the following bentonite moulding mixture:

- 92 art of weight (p.w.) foundry sand,
- 5 p.w. foundry bentonite,
- 3 p.w. petrous coal powder.

The foundry sand is supplied by Kerkosand of Šajdíkové Humence, Slovak Republic. The sand has a qualification mark KI – 27 – D, and meets the Slovak technical standard 72 1205. The sand's chemical properties include 96% SiO_2, 0,2% Fe_2O_3 and 2% Al_2O_3; it has high homogeneity and uniquely rounded shape typical for Aeolian sands. The medium grog grain (d_{50}) is 0.29 mm for the 50% sieve residue. The foundry Bentonite is supplied by Keramost of Most, Czech Republic, and meets the Slovak technical standard 72 1350. It is a calcareous non-activated Bentonite type Standard 650 with the following properties according to manufacturer:

- load moisture 7 – 14 %
- sieve residue 0.315 mm, no more than 1 %
- sieve residue 0.063 mm, no more than 30%
- bondability at moisture 3 % ± 0.1 % 64 kPa
- bondability at moisture 6 % ± 0.2 % 29 kPa.

The petrous coal powder is supplied by ZUD – LETEK of Zbůch, Czech Republic. The said ingredients (sand, Bentonite and petrous coal powder) created 100 p.w. of dry mixture and with additional water of PEO water solution were obtained 100 % - wt. moistened mixture.

Preparation of specimens for testing foundry technology properties:

The said materials (with or without PEO) were weighed and mixed using the LM-R1 laboratory mexer, manufactured by Instytut odlewnictwa Kraków, Poland, Foreign §Trade Enterprise: Centrozap, Katowice, Poland. The specimen mixtures were cautiously poured into the rammer type SP-PO and rammed as follows: at 3 hits (with 9.81 J compaction energy); 6 hits (19.62 J compaction energy) additional number of specimens. Rammer manufactured by SVÚM Prague, Úsek slévárenství, Brno, Czech Republic. The height of test cylinders (50 ± 0.3 mm) was checked as designated on rammer.

In thes manner, specimens with 0.0365, 0.073 and 0.100 % - wt. and reference specimens without PEO designated “0” were prepared.

Determination of foundry technology properties:

The said samples with and without the relevant PEO concentrations were subjected to the following testing:

Determination of the mixture's moisture (W),[%]. Sample was taken from mixer's feed (type LM-R1).

Determination of permeability (D). [p.u.] of test cylinder (instrument LP R1 manufactured by Instytut odlewnictwa, Kraków, Poland; Foreign Trade Enterprise: Centrozap, Katowice, Poland).

Determination of bondability (R_D) [kPa] of test cylinder (instrument PFA + GF+; manufactured by Georg Fisher, Switzerland).

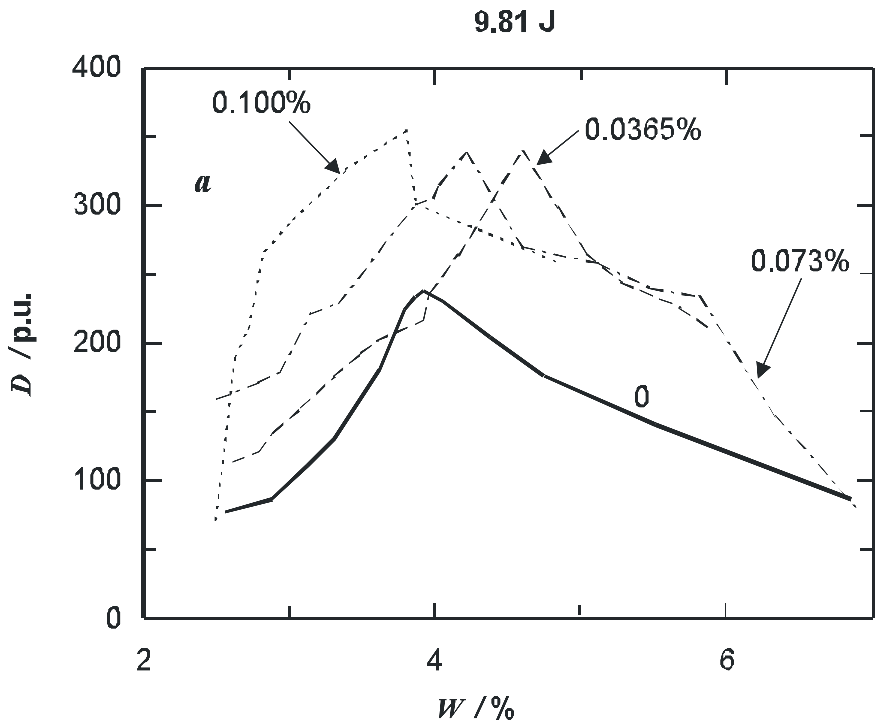
Determination of surgace hardness (H), [kPa] of test cylinder (with durometer type HVF-1, manufactured by SVÚM Prague, Úsek slévárenství, Brno, Czech Republic).

The abbreviations of the relevant properties are given in parentheses and property units are given in square brackets.

The values of examined properties of moulding mixtures at optimum moisture (optimum moisture at maximum permeability) and 3 hits and 6 hits respective compaction energies are illustrated at Fig. 1 - 4; these are average values as obtained from three measurements.

3 Results

Very small quantities of polyethylene oxide have a non-additive high effect of increased permeability (Fig. 1*a*, *b*) that is higher in proportion to higher compaction energies (19.62 J) (Fig. 1*b*). Increased permeability has been proven at such small PEO quantities as 0.0365 %-wt., 0.073 %-wt., and 0.1 %-wt. (Fig. 1*a*, *b* – the corresponding curves). Value of maximum permeability at optimum dampness increases in proportion to the increasing PEO quantity. That increase is higher at 19.62 J compaction energies of test cylinders. That effect is limited for PEO higher than 0.1 %-wt., resulting in a seemingly drier mixture with negative effect on its moulding. The mixture is usable only in a narrower interval of relative humidity. Additionally, higher than 0.1 %-wt. PEO and higher relative humidity start to develop thickened effect.



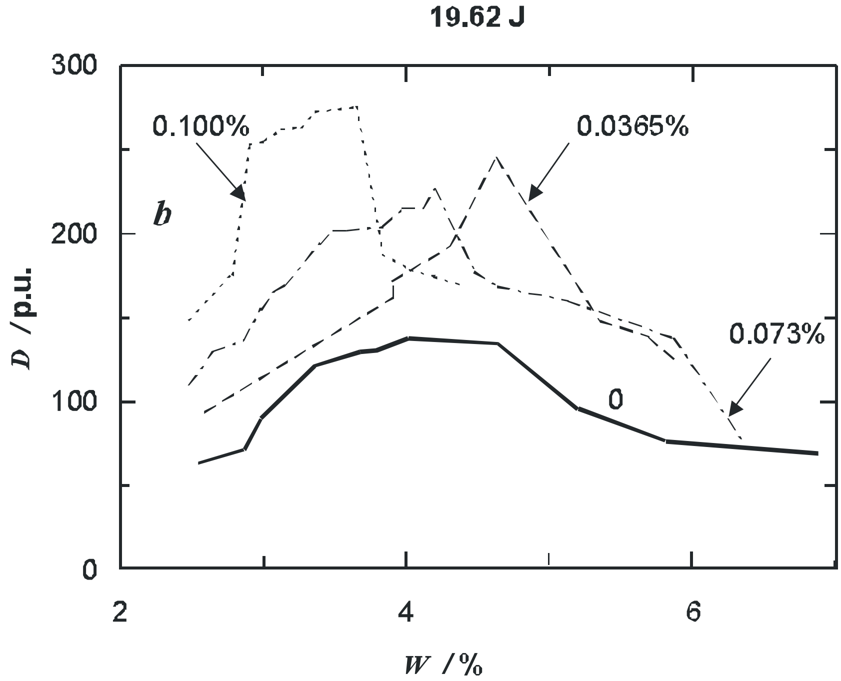


Fig. 1 *Non-additive high permeability (D) values at different humidities (W) of foundry mixtures on effect of very small polyethylene oxide quantities (0.0365, 0.073 and 0.100 %- wt., respectively). Reference specimens without polyethylene oxide are referred to as "0". a) The energy of test cylinders is 9.81 J, b) 19.62 J.*

Bondability is less increased with the above mentioned very small PEO quantities (Fig. 2). This increase being limited to the region of mixture begin overdamp. Better results were achieved at lower compaction energies (9.81 J).

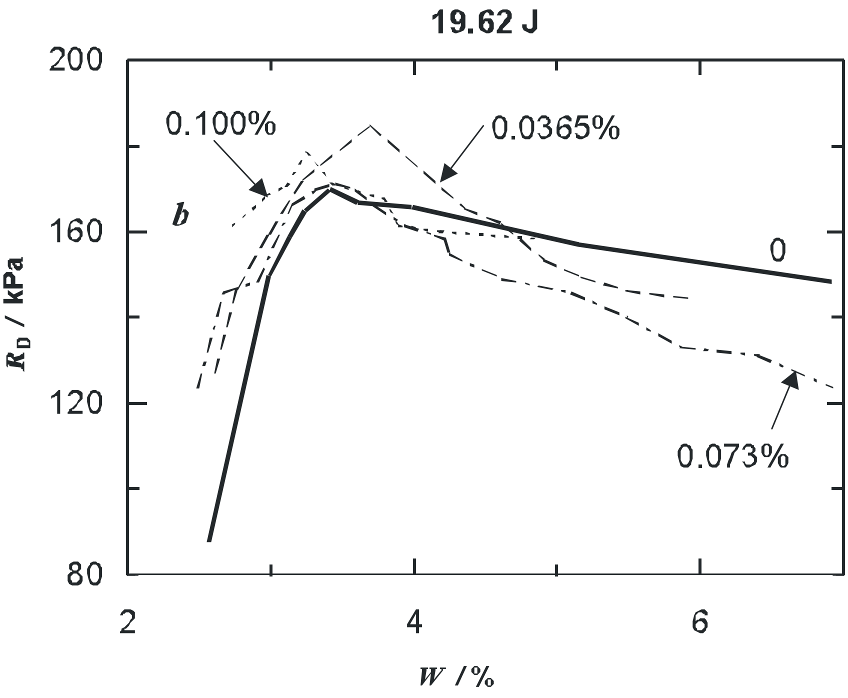
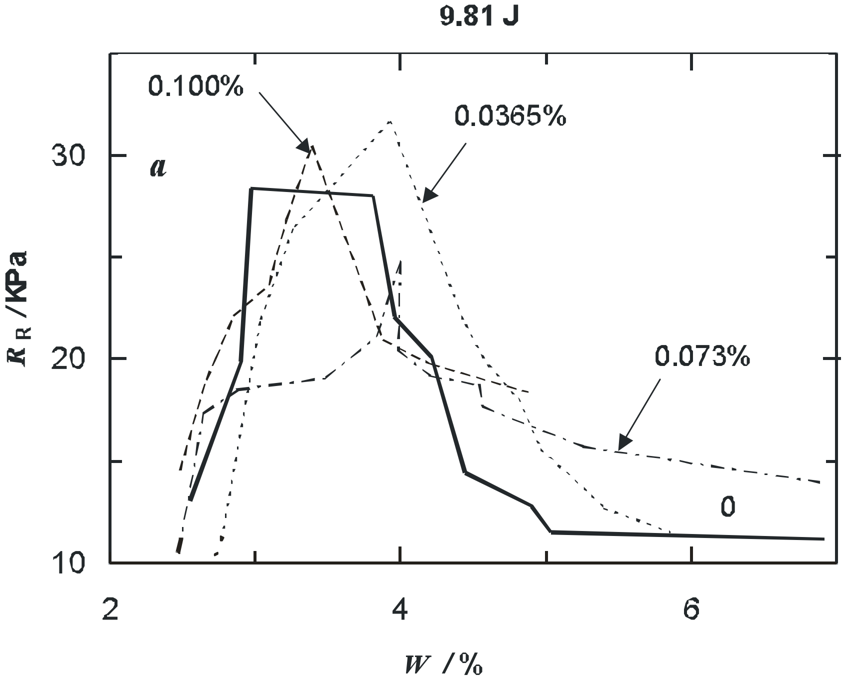
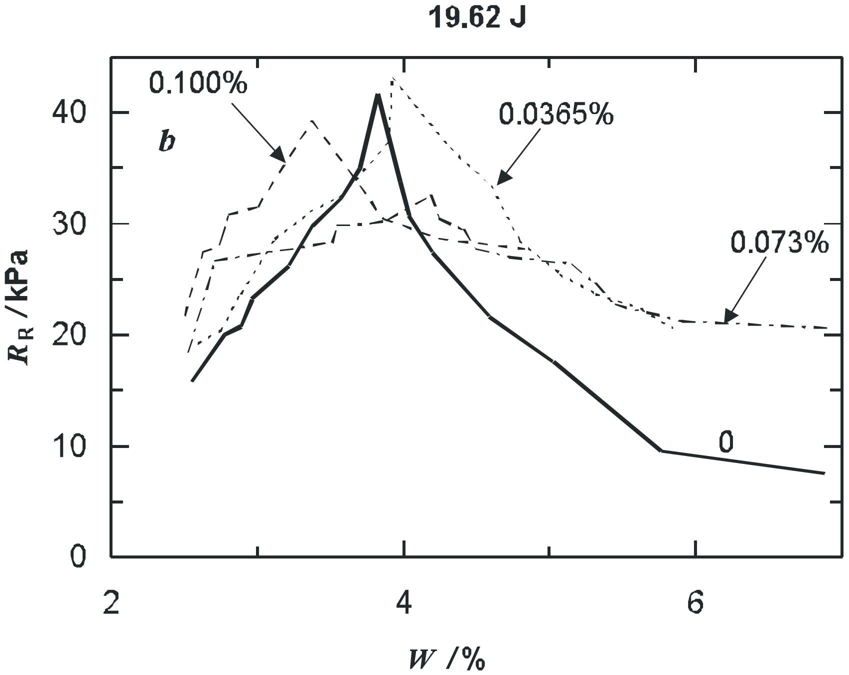


Fig. 2 *The increased bondability (R_D) values at different humidities (W) of foundry mixtures on effect of very small polyethylene oxide quantities (0.0365 and 0.100 %- wt., respectively). Reference specimens and test cylinders energy as in Fig. 1.*

Splitting strength is less increased with the above mentioned very small PEO quantities (Fig. 3 a,b).



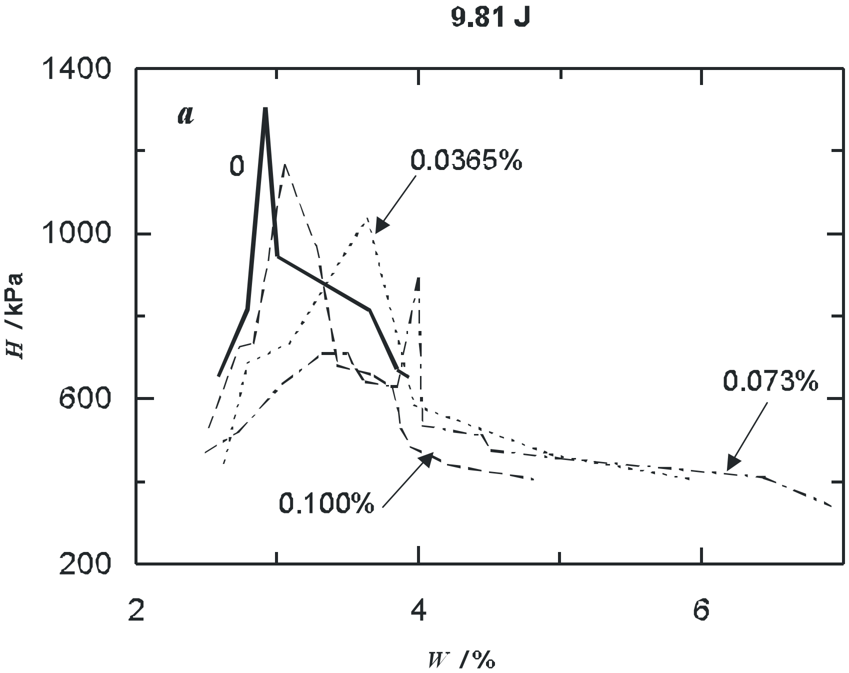
a)



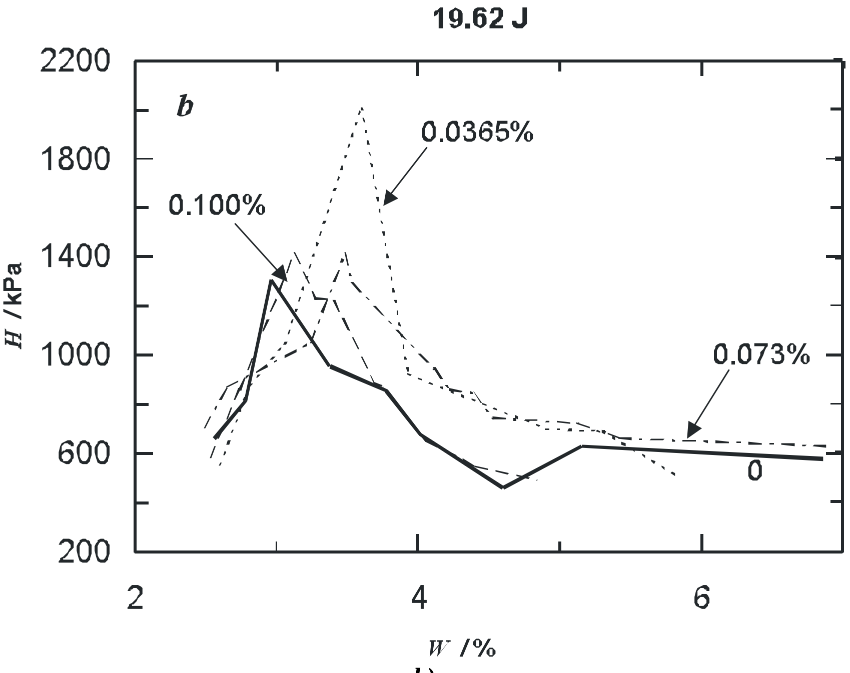
b)

Fig. 3 *The increased splitting strength (RR) at different humidity (W) of foundry mixtures on effect of very small polyethylene oxide quantities (0.0365, 0.073 and 0.100 %- wt., respectively). Reference specimens and test cylinders energy as in Fig. 1*

Hardness values (Fig. 4 a,b) are increased on impact by very small PEO quantities at higher compaction energies (Fig. 4b).



a)



b)

Fig. 4 *The increased hardness values (H) at different humidity (W) of foundry mixtures on effect of very small polyethylene oxide quantities (0.0365, 0.073 and 0.100 %- wt., respectively; in particular, Fig. b) Reference specimens and test cylinders energy as in Fig. 1*

4 Discussion

For explanation the non-additive high effect of very small PEO quantities on increased permeability and additional change of technological properties of foundry moulding mixtures, from all causes we wish to take apart the possibility of complex formation. Paired electrons of etheric bonded oxygen atoms of the PEO chain (CH2-CH2-O-)n are capable of forming a strong hydrogen bond with a number of compounds (including foundry binders) that are capable of accepting electrons, resulting in formation of complex compounds. Electron acceptors include, e.g. fenolic resins, polyurethanes, urea that are all foundry binders , polyacryl amid etc. The properties of complex compounds differ from properties of constitutive single substance and often appear synergistic effects. Additionally, PEO absorbs at the surface of sand particles.

During draining of several types of sludge it has been proven that a mixture of small quantities of polyacryl amid and polyethylene oxide has a stronger effect than individual polymers. This synergistic effect results from complex formation among polymers and sludge components, affects as a binder on particles of the sludge.

The non-additive high changes (synergistic effect) in structure and properties of polypropylene were obtained on addition small (0.02 – 0.2%-wt.) PEO quantities. This fact was explained by formation of “structural” or “superstructural” complexes among the two polymers on the surface of polymere or pigment particles. For a moulding mixture, similar changes of properties of the electron-accepting binder (bentonites, water, polymers, other organic substances – all in the range of 4 – 10%-wt.) are expected on effect of very small PEO quantities (0.02 – 0.15%-wt.). If is Peo effect in very small quantities (in the presence of additional binder) fail to afford the possibility of stoichiometric complex compounds. In that case the resulting complex compounds should be referred to as “structural” or “superstructural”.

The ideas outlined above we wish to spread in further articles published recently on non-additive high effects of very small PEO quantities on technological properties of bentonite foundry moulding mixtures.

5 Conclusion

Very small (0.03 – 0.1 % - wt.) PEO quantities have effect on modification the properties of bentonite moulding mixtures. The above mentioned PEO quantities are non-additive in their effect on changing permeability; the effect is increased at higher compaction energies (19.62J). Bondability is less increased on effect of the above mentioned very small PEO quantities; better results were achieved at lower compaction energies (9.81 J). Splitting strength is less increased on effect of the very small PEO quantities. Hardness is increased on effect of the very small PEO quantities at higher compaction energies.

It is estimated on the strength experimental results that PEO effect on the above mentioned moulding mixtures will find application in metal casting at lower melting temperatures with high permeability requirements, or nuclear resin mixtures.

References

[1] KALOFOROV, N., *Czechoslov*. 219652 (1986).
[2] KALOFOROV, N., In: 13th International Discussion Conference "Mechanisms of Polymer Strength and Toughness", p. 14. Prague, 1990.
[3] KALOFOROV, N., *Russ. Colloid. J. 69*, 460 (1987).
[4] KALOFOROV, N., *Russ. Appl. Chem. 63*, 1471 (1990).
[5] KALOFOROV, N., *Vysokomol. Soedin. A 29*, 774 (1987).
[6] KALOFOROV, N. AND KRIŠ, J., *Chem. Listy 87* (9a), 174 (1993).
[7] BOENISCH, D. AND RUHLAND, N., *Giesserei 74*, 109 (1987).
[8] Kirk-Othmer *Encyclopedia of Chemical Technology*, Vol. *18*, 3rd Edition, p. 623. Wiley, New York, 1982.
[9] *Handbook of Water-Soluble Gums and Resins.* (Robert, L., Davidson, Editor.) Chapter 19, p. 4. McGraw-Hill Publishing Company, New York, 1980.
[10] *Encyclopedia of Polymer Science and Technology*, Vol. *6*, p. 112. Wiley, New York,1967.
[11] *Nonionic Surfactants Physical Chemistry*. (Schick, M. J., Editor.) P. 959. Dekker, New York, 1987.
[12] VILČKO, J. AND SLOVÁK, S., *Zlievárenská technológia*. (Foundry Technology.) P. 142. Alfa, Bratislava, 1987.
[13] KALOFOROV, N. AND MÄSIAR, H., In: *51. Zjazd chemických spoločností*. (Congress of the Chemical Societies.) G-P 7. Nitra, (Slovakia), 1999.
[14] MÄSIAR, H. AND KALOFOROV, N., in *Zborník z konferencie so zahraničnou účasťou ekonomika a ekológia zlievarenskej výroby*. (Collection of the Conference with Foreign Participation Economy and Ecology of the Foundry Production.) Nitra, (Slovakia), 1994.
[15] MÄSIAR, H., BARÉNYI, I., AND SMOLKOVÁ, M., in *Zborník zo 7. medzinárodnej konferencie Akademická Dubnica*. (Collection of the 7. International Conference Academical Dubnica.) Dubnica nad Váhom, (Slovakia), 2001.

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Igor Barényi