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INFLUENCE OF FOUNDRY DUST ON MOULDING MIXTURES QUALITY

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The objective of this paper was to observe the effect of the addition of the dust from the moulding plant on the quality parameters of the moulding mixtures and determine tolerable content in the moulding mixture. Three types of moulding mixtures were used in experiments: mixture prepared from new quartz sand and bentonite, mixture which is recycled in the experimental foundry and mixture came from the small foundry. To tthese moulding mixture was added the dust from moulding plant in the range 0 – 10%. Influence of dust addition on the compression strength, splitting strength and permeability was observed in all three kinds of mixtures.

Key words: moulding mixture, foundry dust, compression strength, splitting strength.

INTRODUCTION

Processing of wastes of any kind and their reuse becomes still more urgent global problem because of the ecological conditions improvement [1-2]. However, the assuming of the most complex recycling calls for the laborious preparation and construction of the costly facilities.

Foundry waste represents the economical burden for the foundries on one hand and on the other hand the ecological burden for environment. The costs related to the foundry waste disposal are becoming still higher and at the same time increased are also the fees for the waste transport and a landfill operation. The most ideal solution is to find the way of their recycling within the reproduction process free of costly processing and in such a way to save on inputs as well as on energy.

DUSTS FORMED IN MOULDS PRODUCTION, PREPARATION AND PROCESSING OF THE SAND MIXTURES

In process of the moulds production, including the preparation of the moulding mixtures and the forming process alone produced are large quantities of dusts trapped in the separating devices as filters or dust separators. Dusts are formed in all stages of the moulding mixtures preparation, when handling the raw materials, in course of mixing and forming mixture preparation in mixers, in the forming process alone, so in manual as machines forming and in reclamation process of used sand [3]. The reason of the rather significant amount of dust formation in course of all operations related to the moulds production is the moulding mixture alone, the base of which is an opening material – sand, either quartz and or of other chemical composition.

When evaluating the opportunities of the utilization of the wastes from the dust separators (from the preparation of the moulding mixtures and moulds manufacture) as the additive to the bentonite sand mixtures, it is necessary to consider the condition that the dust shall come from the moulding system only (preparation of the moulding mixture, moulding plant) [4-7]. Dust from the wet and dry filters then contains the components of the moulding mixture – bentonite, carboneous additives, dust from the quartz sand and further additives. These components, which have so far handled as the waste, are able of the reuse in the sand mixtures preparation.

The quartz sand, bentonite, quartz – coal like raw materials as well as the further additives purchased from the manufacturers possess the guaranteed quality. Material from dust separators is the refuse product from the foundry and it is necessary to design the system for its occurrence and quality assessment. Considered should be also the variability of the properties in case of the alternation of the manufacturing program of the foundry.

Experiments with the application of the dust in the moulding mixtures are described in the literature [8]. Authors state that the exploitation of the bentonite from dust provided not only technological but also economical benefit. The authors consider the optimum composition of the moulding mixture as follows: SiO_2 sand – 87 %, bentonite – 6 %, dust – 4 %, carbon – 3 % and water – 4,5 %. They also claim that replacement of the bentonite by dust did not cause the change of the properties of the castings, mainly as the quality of the castings surface is considered.

Similarly, the authors [4,5,7,9] state that the dust from the preparation of the bentonite moulding mix-

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tures contains large amount of the valuable components. Besides the active bentonite there is also the bright carbon, which loses its value when deposited on landfill. According to the authors, the addition of dust from the moulding plant should not exceed 1 % in the mixture for the given cycle of the sand mixture revitalisation. The implementation of the sand mixture revitalisation by the addition of the dust from the dry dedusting process from the moulding mixture preparation section has made it possible to use the dust that had been piled until that time, as well as reduction of the amount of bentonite and bright carbon carrier by 20 %.

The objective of this paper was to observe the effect of the addition of the dust from the moulding plant (from the manufacture of the cast iron castings) on the quality parameters of the sand mixture and determine tolerable content in the moulding mixture.

USED EXPERIMENTAL MATERIALS

The dust exhausted and trapped in the sleeve filters from the moulding mixture preparation plant and mould preparation was used in experiments. Chemical composition of this dust is provided in Table 1. Dust from the moulding plant contained almost 40 % SiO_2 and relatively high proportion of carbon. This was very fine grain material, the biggest proportion represented the granulometry fraction 0,125 mm (34 %), grain size classes 0,09 mm, 0,125 mm and 0,18 mm represented 70 % of the overall dust weight.

Table 1 **Chemical composition of dust / weight %**

Fe	FeO	Al_2O_3	SiO_2	CaO	MgO	MnO	C
5,03	3,02	4,82	39,29	2,38	2,17	0,07	17,50

Three types of the moulding mixtures were used in experiments: mixture **N** – new sand mixture prepared from new quartz sand and bentonite. The content of quartz sand in the mixtures was 89,6 % and bentonite 7,8 %. The quartz sand was gradually replaced by the dust from the moulding plant and in the amount of 2, 4, 6, 8 and 10 % out of the weight of the quartz sand weight. The moisture content in the quartz sand was 0,14 %, the moisture content in the bentonite was 10,72 % and moisture content in the dust from the moulding plant was 13,11 %. The amount of the added water was adjusted to the required moisture content in the moulding mixture of 3,5 %. The second applied was the moulding mixture – **R**, which is recycled in the experimental foundry at the Department of Iron Metallurgy and Foundry. Number of the cycles of this sand mixture is not known, its moisture content was 4,01 %, and so neither water nor other additives were added. The dust from the moulding plant was added to this moulding mixture and its content in the final moulding mixture was in the range from 0 to 10 %. The third sand mixture - **F** came from the foundry where small and medium size castings are cast. It was common moulding mixture with the moisture content of 7,58 %. This moulding mixture is revitalised in each cycle by the addition of bentonite and dextrin. The amount of added bentonite is 1 200 g and dextrin 260 g per 150 kg of the moulding mixture. The pre-dried dust from the moulding plant was added to this moulding mixture, with the moisture content of 6 %. Similarly, also to this moulding mixture added was the dust from the moulding plant in the range of 0 – 10 % out from the moulding mixture weight.

THE EXPERIMENT DESCRIPTION

The individual moulding mixture was prepared in the wheel mixer, where they were mixed for 7 minutes. The quality of the moulding mixtures was determined based on three tests: test of compression strength, splitting test and test of moulding mixture permeability. The compression strength and splitting strength is determined on the cylindrical specimen with diameter of 50 ± 0,2 mm and a height of 50 ± 0,8 mm.

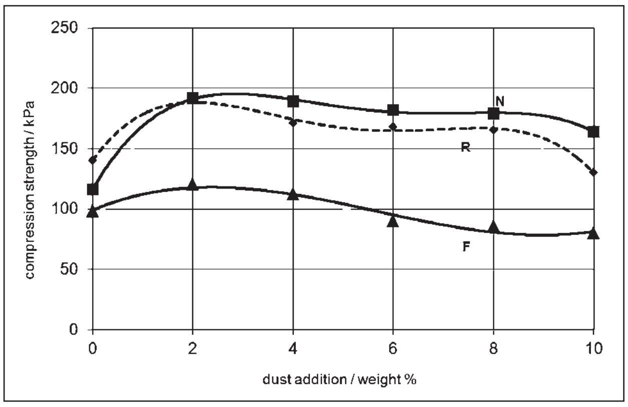
Measurement of compression and splitting strength was carried out on the instrument determined for the estimation of the strength properties of moulding mixtures LRu-2e. The splitting strength expresses the mixture plasticity and is used for the bentonite green sand mixtures exclusively. The permeability of the moulding mixture means its ability to pass the gasses and the vapours and is expressed by the amount of air (15 – 20 °C), which passes the area of 1 m^2 and the length of 1 m of the tested mixture under the overpressure of 1Pa per 1 second. In the foundry practice as the unit of permeability used is SI unit = n.j.p x 1,67.

ACHIEVED RESULTS AND THEIR DISCUSSION

The effect of the content of dust from the moulding plant on the compression strength of the newly prepared moulding mixture (N), recycled moulding mixture from the Department of Iron Metallurgy and Foundry (R) and the moulding mixture from the foundry plant (F) is given in Figure 1.

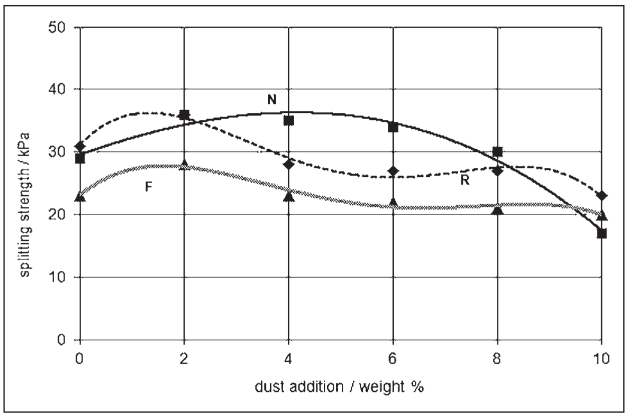
Figure 2 illustrates the effect of this dust on the splitting strength in case of three above-mentioned moulding mixtures. The effect of the dust content in these moulding mixtures on the permeability is given in Figure 3. The highest compression strength prior the addition of the dust from the moulding plant had the newly prepared moulding mixture, what is obvious as this mixture was prepared from the pure raw materials (new quartz sand and new bentonite).

The lowest compression strength had the moulding mixture coming from the foundry. In all three cases the dust addition (in the first case to the opening material, in the second and third to the moulding mixture) caused the significant rise in the compression strength. In case of the newly prepared moulding mixture 2 and 4 % of dust in the opening material caused the rise in strength, which is higher comparing to the moulding mixture



N sand mixture (R_N^2 = 0.9982)
$y_N = -0{,}1185x^4 + 2{,}7353x^3 - 22{,}821x^2 + 72{,}937x + 116{,}17$
R sand mixture (R_R^2 = 0,9881)
$y_N = -0{,}1523x^4 + 3{,}2054x^3 - 22{,}707x^2 + 57{,}798x + 140{,}34$
F sand mixture (R_N^2 = 0,9466)
$y_N = 0{,}2731x^3 - 4{,}6508x^2 + 17{,}447x + 99{,}016$

Figure 1 Influence of dust addition on compression strength



N sand mixture (R_N^2 = 0,9706)
$y_N = - 0{,}0162x^3 - 0{,}2569x^2 + 2{,}9835x + 29{,}532$
R sand mixture (R_R^2 = 0,9703)
$y_N = -0{,}0326x^4 + 0{,}6823x^3 - 4{,}526x^2 + 8{,}7619x + 31{,}107$
F sand mixture (R_N^2 = 0,9505)
$y_N = 0{,}0182x^4 + 0{,}4086x^3 + 2{,}9618x^2 + 6{,}6773x + 23{,}087$

Figure 2 Influence of dust addition on splitting strength

without dust. However 6 % of the dust in the moulding mixture caused the more significant drop in the compression strength, this holds also in the case of the moulding mixture from foundry. In case of the recycled moulding mixture from the Department, the addition of the dust (2, 4, 6, 8 and 10 %) caused higher compression strength comparing to the moulding mixture without dust. The similar situation occurred also in case of the splitting strength. This was highest in case of newly prepared mixture and lowest in case of the mixture from the foundry. Though the dust addition to the moulding mixture affected the splitting strength in all three moulding mixtures only slightly, however after addition of 2 % of dust, in all three cases occurred slight increase in the splitting strength.

Further increase in the dust content lead to the drop in the splitting strength, though this drop was relatively not significant. The dust addition has most significantly affected the permeability of the moulding mixture. The

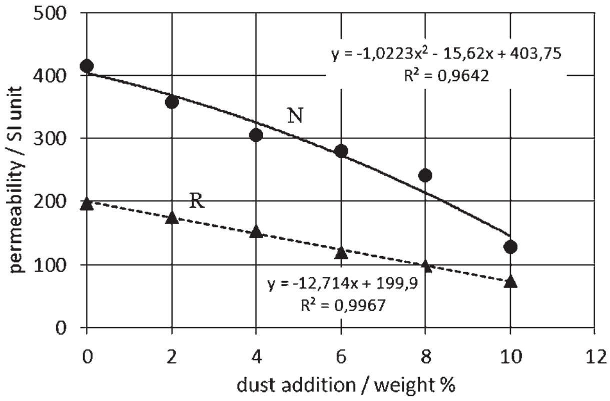


Figure 3 Influence of dust addition on permeability

permeability was measured only on the samples of the newly prepared moulding mixture (N) and the recycled moulding mixture from the Department (R). This drop in the permeability is rather significant in both cases and has the significantly linear character, which may be described by the equations:

$$Y_N = -25{,}843x + 417{,}38 \quad (1)$$
$$Y_R = -12{,}714\,x + 199{,}9 \quad (2)$$

The improvement of the compression strength after the dust addition may be explained by the content of much finer fractions comparing to the new quartz sand or recycled moulding mixture. These finer fractions fill up the space among the grain the quartz sand, regardless this would the case of new one (i.e. pure SiO_2) or containing the layer of bentonite after multiplied use and in such way increased would be the compression strength of such moulding mixture. Another explanation may be the increased content of Al_2O_3 in the dust, which is the integral part of the bentonite. It means that the dust from the moulding plant fulfils the role of the binder. On the other hand, the filling up such spaces leads to the drop in the permeability of the moulding mixture. Therefore when adding the dust fraction to the moulding mixture, it is necessary to take into the consideration both these facts and its amount should be so selected that that no significant drop in permeability occurs and at the same time expressed was its positive effect on the strength.

With the objective to disclose whether the addition of the dust to the moulding mixture causes the deterioration of the surface quality of the castings, the experiments were carried out in which for the moulds production used were the moulding mixtures made up from the new quartz sand and bentonite and the dust was added in the amount of 2, 5 and 8 % from the weight of the opening material as the opening material replacement. Evaluated were 4 moulds. To melt the charge used was the electrical medium level frequencies induction furnace ISTOL 40. The charge was the cast iron. The quality of the surface of the cast samples was evaluated visually only; and no change of surface quality was noticed on the individual samples. Similar experiment was realised also in the foundry plant, where after the moulding mixture revitalisation added to it was the dust from the moulding plant in the amount of 2, 4 and 6 % from the weight of the moulding mixture. From in such way prepared moulding mixtures formed were the casts of the sheet, which were afterwards casting. The surface quality of the castings was evaluated visually only and it was obvious that no negative effect on the castings surface occurred. Castings have been sold and no claims had been placed until the present day.

RESULTS

The dust exhausted from the preparation of the moulding mixtures and mould manufacture is still piled on landfills in Slovakia. The objective of this paper was to determine how its application in the moulding mixture affects the properties of the moulding mixture. Examined were 3 types of the moulding mixtures, the moulding mixture prepared from the new quartz sand and bentonite, moulding mixture recycling from the experimental foundry and the moulding mixture from the Slovak foundry. The dust from the moulding plant was added to these moulding mixtures in the different proportions. The following conclusion followed out from the obtained results:

The addition of the dust to each type of the moulding mixture resulted in the increased compression strength; however the higher contents of dust in the moulding mixture caused the slight drop in the strength.

The dust in the moulding mixture did not affect significantly the splitting strength, the higher content of dust resulted in the slighter drop of this property.

The highest effect of the dust addition was on the mixture permeability. This effect could be observed in the case of newly prepared moulding mixture as well as in the mixture recycling in the experimental foundry. Right this property will play the decisive role for the estimation of the permissible amount of dust in the moulding mixture.

Based on the above conclusions it can be recommended that the content of dust in the moulding mixture should not exceed 2 %. This content of dust should neither cause the worsening of the properties of the moulding mixtures nor the worsening of the surface quality of the casts.

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Note: The responsible for English Language is Assoc. Prof. I. Repasova, PhD. – official translator.