ARCHIVES
of
FOUNDRY ENGINEERING
Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

ISSN (1897-3310)
Volume 10
Special Issue 2/2010
51 – 55

9/2

Influence of dust addition from cast iron production on bentonite sand mixture properties

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Received 20.05.2010; accepted in revised form 05.06.2010

Abstract

In cast iron foundry operations like melting, casting, feetling, casts cleaning and grinding of a high amount of dusts are produced. Three kinds of dusts from different parts of cast iron foundry were analysed; chemical analyses, granulometric analyses and microscopic analyses were carried out. The bentonite sand mixtures with different portion of dusts were prepared. Technological properties of prepared sand mixtures (compression strength, shearing strength and permeability) were measured.

Keywords: Environment Protection, Mechanical Properties, Sand Mixture, Dust, Foundry

1. Introduction

During the casts production the huge quantity of dusts is generated, which have different physical and chemical properties. These dusts come from melting, metal treatment, cast cleaning and grinding [1, 2, 3].

A metal casting foundry is a commercial establishment for producing metal casting. A metal casting is a shape obtained by pouring liquid metal into a mould or cavity and allowing it to freeze and thus to take the form of the mould.

Each step in foundry process is followed by wastes generation, especially dusts.

The main steps of foundry industry processes are [4]:

- handling; preparation of raw materials,
- melting; treating of molten metal,
- preparation of sand mixture; core mixture,
- casting of molten metal,
- casts cooling; shaking out from moulds,
- finishing operations of the raw cast.

One of the most pressing problems facing metal casting industry today is the disposal of foundry by-products. The annual generation of foundry by-products is reported to range from 9 to 13.6 million tons in 1999. These by-products are generated by metal casting foundries during the production of cast metal components. Disposal of foundry by-products is a large cost for foundry industry, whether disposal occurs in company-owned facilities or in municipal or privately owned landfills [5].

Cast iron foundries generate next types of wastes [6]:

- dusts from casts cleaning – 1.32 %,
- dusts from furnaces – 1.42 %,
- dusts comes from sand mixtures – 0.66 %,
- slags – 3.5 %,
- used refractory material – 0.17 %,
- used sand mixtures – 92.93 %.

Emission factors for fugitive particulates from grey iron foundries are [7]:

- scrap and charge handling, heating – 0.3 kg/tone,
- sand handling and preparation – 20 kg/tone,
- core making, baking – 0.6 kg/tone,
- pouring – 2.5 kg/tone,
- cooling – 5 kg/tone,
- shakeout – 16 kg/tone,
- cleaning, finishing – 8.5 kg/tone,
- cupola furnace – 8.5 kg/tone.

Quantity if different kinds of dusts is about 3,4% of all wastes. Producing of 1 tonne of cast iron creates about 61,4 kg dust with different chemical composition, granulometry and physical properties.

2. Realised experiments

The main goal of these experiments has been to determine foundry dust addition possibilities into the bentonite sand mixture and its influence on the sand mixture quality and properties.

Three kinds of the foundry dusts were analyzed from various foundry parts. Every dust was subjected to chemical and granulometric analyse and stereomicroscopy. On the base of analyses, three kinds of foundry dusts were chosen, namely:

1) non-magnetic part of dust from casts blasting (A) (Fig. 1),
2) flue-dust from cupola furnace (B) (Fig. 2),
3) dust from sand mixture preparation (bentonite sand mixture) and from sand moulding (C) (Fig. 3).

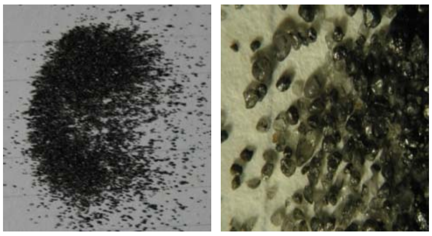

Fig. 1: Non-magnetic part of dust from casts blasting (a) appearance, b) stereomicroscopy)

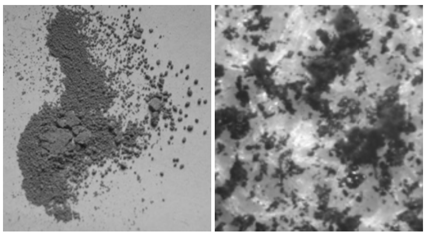

Fig. 2: Flue dust from cupola furnace (a) appearance, b) stereomicroscopy)

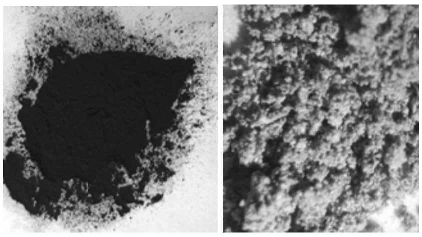

Fig. 3: Dust from moulding (a) appearance, b) stereomicroscopy)

2.1. Sand mixture (with dust addition) technological properties testing

In the first part of experiment new sand mixtures were prepared from 89.4 % of new SiO_2 sand (opening material) and 8.4 % of bentonite with 2.2 % (69 ml) destilled water addition (amount of water was estimated by calculation). The mixture was mixed for the duration of seven minutes in the sand mill (fig. 4 A), next sand mixtures were prepared from opening material (new sand, dust), bentonite and destilled water.

Quantity of dust in opening material was 2, 5, 7 and 15 % (dust moisture was not taken in to the consideration). From these mixtures testing cylinders (145 g) (fig.4 D, E) were prepared, on which a compression strength, shearing strength and permeability (fig. 4 H, I, F) were measured.

In the second part of experiment the bentonite sand mixture was used. The moisture of bentonite sand mixture was 3.54 %. Quantity of dust in bentonite sand mixture was 0, 5, 10, 15 and 20 %. Addition of destilled water was 69 ml in the first case and 49 ml in the second case. Preparation of the tested samples and testing was the same as in the first part.

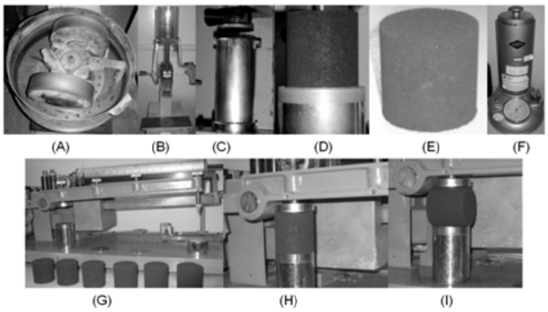

Fig. 4: Sand mixture technological properties determination; A – sand mill, B – device for testing element preparation, C – core box, D, E – testing cylinder, F – permeability measure apparatus, G - sand strength apparatus, H – compression strength measuring, I – shearing strength measuring

3. Description of achieved results

On the base of above mentioned experiments the next results were achieved. The chemical analyses of tested dusts are given in Tab. 1.

Tab. 2 shows the granulometric analyses of tested dusts.

Table 1.
Chemical analyses of tested dusts

Foundry dust	Fe [%]	FeO [%]	Fe_{metal} [%]	SiO_2 [%]	CaO [%]	MgO [%]	MnO [%]	ZnO [%]	PbO [%]	C [%]
A	0.16	0.718	-	86.50	-	3.60	0.00	-	-	0.84
B	16.20	7.19	1.90	49.91	3.25	0.52	2.80	0.909	0.115	8.98
C	5.03	3.02	0.00	39.29	2.38	2.17	0.07	0.00	0.00	17.50

Table 2.
Granulometric analyses of tested dusts

Grains size [mm]	New sand [g]	Dust A [g]	Dust B [g]	Dust C [g]
< 0.063	0.28	2.54	0.31	17.54
0.063 – 0.09	0.39	3.56	6.41	40.05
0.09 – 0.125	2.86	8.07	21.94	31.23
0.125 – 0.18	20.12	17.16	25.35	8.50
0.18 – 0.250	37.47	26.79	23.50	0.35
0.250 – 0.355	31.66	40.19	11.89	0.00
0.355 – 0.5	4.66	0.00	5.62	0.00
0.5 – 0.71	1.56	0.00	0.00	0.00
0.71 - 1	0.24	0.00	0.00	0.00
> 1	0.00	0.00	0.00	0.00

Dust from casts blasting

Non-magnetic part of dust was used for sand mixture preparation.

Following Tab. 3 shows technological properties of sand mixture with gradually dust addition from experiment 1. Results from experiment 2 are given in Tab 4.

Table 3.
Sand mixture properties with addition of non-magnetic part of dust from casts blasting (new sand mixture)

Dust addition [%]	Compression strength [kPa]	Shearing strength [kPa]	Permeability [SI-unit]
0	95.00	25.00	415.83
2	77.75	16.75	114.81
5	102.50	25.75	261.77
7	103.75	23.25	245.49
10	93.25	22.75	361.97
15	91.25	20.75	322.31

Table 4.
Sand mixture properties with addition of non-magnetic part of dust from casts blasting (used sand mixture)

	69 ml of destilled water			49 ml of destilled water		
Dust addition [%]	**Compression strength [kPa]**	**Shearing strength [kPa]**	**Permeability [SI-unit]**	**Compression strength [kPa]**	**Shearing strength [kPa]**	**Permeability [SI-unit]**
0	150.00	23.33	193.17	-	-	-
5	78.33	24.00	244.94	73.33	22.67	283.35
10	64.33	25.00	268.32	89.00	23.33	255.51
15	61.33	20.00	256.63	81.00	17.67	260.52
20	67.67	24.67	255.51	70.00	17.67	267.20

Flue dust from cupola furnace

Tab. 5 shows achieve values of technological properties with addition of flue dust from cupola furnace. Measurements at 15 % dust addition were not carried by the reason of very low mixture cohesion. This dust gives one of the worst results and as an addition into the sand mixture is inappropriate. Also the second part of experiment was not carried out from the reason mentioned above.

Dust from moulding

The dust was captured at the moulding, so it is highly suitable as an addition into the sand mixture. Tab. 6 shows technological properties results of individual tested sand mixtures in experiment 1. Tab. 7 shows results from experiment 2.

Table 5.
Sand mixture properties with addition of flue dust from cupola furnace (new sand mixture)

Dust addition [%]	Compression strength [kPa]	Shearing strength [kPa]	Permeability [SI-unit]
0	95.00	25.00	415.83
2	88.50	20.50	239.23
5	93.50	20.00	201.65
7	99.00	19.50	149.88
10	39.25	8.75	65.97
15	-	-	-

Table 6.
Sand mixture properties with addition of dust from moulding (new sand mixture)

Dust addition [%]	Compression strength [kPa]	Shearing strength [kPa]	Permeability [SI-unit]
0	95.00	25.00	415.83
2	107.33	27.00	411.66
5	124.33	28.00	298.10
7	109.50	24.25	265.53
10	105.75	20.67	128.04
15	90.00	20.00	55.95

Table 7.
Sand mixture properties with addition of dust from moulding (used sand mixture with - 69 ml of water)

	69 ml of destilled water			49 ml of destilled water		
Dust addition [%]	**Compression strength [kPa]**	**Shearing strength [kPa]**	**Permeability [SI-unit]**	**Compression strength [kPa]**	**Shearing strength [kPa]**	**Permeability [SI-unit]**
0	150.00	23.33	193.17	-	-	-
5	150.00	30.67	140.28	105.00	17.67	64.01
10	141.67	23.33	74.60	111.67	17.67	47.88
15	138.33	15.00	46.76	116.00	14.00	35.62
20	128.33	16.33	25.05	148.33	26.67	51.22

4. Conclusions

Foundry dusts in individual steps of foundry plants differ by their chemical composition, appearance and granulometry. These properties mostly indicated on their next utilization possibilities.

Achieved results (compression strength, shearing strength and permeability) show that the best mechanical properties were reached by the dust from moulding (C), but on the other hand its permeability was lower.

Non-magnetic part of dust comes from casts blasting (A) had worse mechanical properties than dust from moulding, but the permeability was higher.

Dust from cupola furnace (B) is not suitable as an addition into the sand mixtures.

It is possible that fine grained particles from dust C improving mechanical properties of sand mixtures, and coarse particles from dust A increasing permeability.

By mixture these two dusts advantageous properties of sand mixture could be reached, it means high mechanical properties, simultaneously with high permeability.

Further experimental work is required to establish the use of this material.

Acknowledgements

This work was supported by the Scientific Grant Agency of The Ministry of Education of the Slovak republic No. VEGA 1/0568/10.

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Wpływ dodatku pyłów z procesów odlewniczych na właściwości mas z bentonitem

Streszczenie

W poszczególnych operacjach procesu wykonywania odlewów powstają znaczne ilości pyłów. W większości pyły te są składowane, mimo że zawierają szereg cennych składników. Celem pracy było określenie możliwości dodatku pyłów do mas z bentonitem i wpływ na właściwości tych mas. Zbadano 3 rodzaje pyłów: niemagnetyczną część pyłów z oczyszczania odlewów, pyły z suchego odpylania żeliwiaków, pyły z odpylania stanowiska sporządzania mas z bentonitem i wykonywania form. Wykonano analizę chemiczną tych pyłów, analizę granulometryczną i badania mikroskopowe. Masy z bentonitem i dodatkiem tych pyłów badano w zakresie: wytrzymałości na ściskanie, wytrzymałości na ścinanie oraz przepuszczalności. Najlepsze wyniki uzyskano przy dodatku pyłów z odpylania stanowisk sporządzani masy oraz wykonywania form, aczkolwiek w tym przypadku mialo miejsce zmniejszenie przepuszczalności masy.