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Investigation of the selected properties of dusts from the reclamation of spent sands with bentonite

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Abstract

The investigation results of the selected properties of dusts generated during the mechanical reclamation of spent sands with bentonite as well as dusts from the dedusting system of sand processing plant are presented in the hereby paper. Investigations were performed with regard to determination conditions allowing to pelletise dusts in the bowl granulator. The verified methods of testing physical and chemical dust properties such as: specific density, bulk density of loosely put materials and apparent density of compacted materials together with their corresponding porosity, ignition losses and pH values, were applied. Granular composition of dusts generated during abrasion of spent binding materials in mechanical dry reclamation processes of spent sands with bentonite and coal dusts were performed by the laser diffraction analysis, allowing to broaden the measuring range of particle diameters. The optimal wetting agent content (in this case water) at which the dust-water mixture obtains the best strength properties – after compacting by means of the standard moulder's rammer – was determined.

Keywords: Granulation process, Environmental protection, Reclamation process, Post-reclamation dust

1. Introduction

Definition of wastes in the European Parliament and Council Directive 2008/98/WE (framework directive concerning wastes) of November 19th 2008 states that: „a waste means each substance or object, which the owner is disposing of, is going to dispose of or is required to dispose of" [1].

The amount of wastes generated by the casting production in Poland equals app. 1 million Mg and is only a little bit above the casting production. The main part of these wastes, in cast iron foundries (app. 87%), constitute spent moulding and core sands from which it is possible to reclaim a sand matrix, while other wastes (Table 1) such as: slag, sludge and dusts, refractory, chips, flashes, used moulder's springs, reinforcements of moulds and cores, abrasive materials, used emulsions and oils, are not suitable for a direct reclamation and recycling [2, 3]. Similar situation concerns dusts [4] from dedusting of sand processing plants, moulding plants, internal transport or dry reclamation systems.

In spent sands dry reclamation systems even up to 10 wt.% of after-reclamation dusts are generated, in which significant amounts of residues of binder and clay (removed from sand grains) as well as products of sand abrasion are cumulated. In case of spent sands with resins those dusts exhibit often high ignition losses (above 30%), which indicate significant amounts of combustible parts [5]. In such cases the separated dusts are treated as dangerous wastes since there is a hazard of washing out

Table 1.
Percentage fraction of individual foundry wastes in Poland (acc. to data for 2006) [2, 3]

Kind of waste	Ferrous alloys foundry plants (cast iron + cast steel), %	Non-ferrous metals alloys foundry plants (Al + Cu + Zn), %
Moulding and core sands	87.43	85.26
Foundry slag	3.28	6.78
Dusts from furnace dedusting + dusts from processing plants	3.20	7.87
Sludge from dedusting devices	1.80	0.08
Debris from furnace linings	0.16	0.09
Foundry wastes - total	**100%**	

and penetration into the soil harmful substances during their storage. Several properties and a way of dusts form processing decide on the possibility of the after-reclamation dusts management. The chemical composition, grain and phase composition as well as the environmental impact are the most often taken into account.

The requirements of the European Union in the scope of the application the Best Available Techniques in Foundry Industry are forcing foundry plants to limit wastes or to utilise them rationally [6].

2. Program of own investigations

The aim of own investigations was to determine conditions prior to dusts form processing due to their pelletising (agglomeration) in the bowl granulator. As a moisturising agent water was applied, additions of which were changed in a range allowing to obtain the most favourable values of the investigated dust properties both under wet conditions and after drying.

Dusts generated in the dry mechanical reclamation processes of spent sands with bentonite and coal dusts were used in examinations.

Investigations were performed on two kinds of dusts:

1. dusts from the sand with bentonite processing plant – from the cyclone dust separator,
2. dusts from the sand with bentonite processing plant – from the fabric filter.

The following examinations of dusts were performed:

– specific density,
– bulk density of loosely put and of compacted material (apparent density) and their corresponding porosity,
– ignition losses,
– pH values.

In addition, examinations of physical and mechanical properties of dust-water mixtures by means of methods, which are usually applied in the foundry practice for testing clay-bonded sands, were performed. The purpose of these examinations was to find out whether the known and mastered testing methods can be suitable for controlling the quality of dust materials and their granulation process. The following properties were taken into account:

– compression strength in wet condition (R_c^w) and in dry condition (R_c^s),
– splitting strength in wet condition (R_p^w),
– permeability (P^w),
– compactibility under static load conditions (Z),
– fluidity by shatter test (P_z),
– friability (S).

3. Obtained results

The obtained results of physical and chemical as well as technological properties of after-reclamation dusts and dust-water mixtures are given below.

Dusts are marked as follows:

- Dust 1 – from the cyclone dust separator of the sand with bentonite processing plant,
- Dust 2 – from the fabric filter of the sand with bentonite processing plant.

Examinations were performed for four dust-water mixtures obtained by the determined additions of water into dusts. Differences in the final moisture content are caused by various initial water contents in the tested dust samples.

Table 2.
Actual moisture of dust-water mixtures

Water added to dusts [%]	Actual moisture of dust-water mixtures [%]	
	Dust 1	Dust 2
0	4.31	3.00
5	9.74	6.51
7	11.91	8.31
9	14.54	9.90
11	15.77	11.29

3.1. Examination results of physical and chemical properties of dusts

Table 3.
Physical and chemical properties of after-reclamation dusts

Tested value	Results	
	Dust 1	Dust 2
Active clay content [%]	12.19	16.01
Ignition loss, LOI, [%]	27.14	14.18
Specific density ρ [g/cm^3]	1.79	2.30
pH	8.46	8.70

The analysis of data given in Table 3 indicates a significant variability of content and character of the tested dusts, which is related to the place of sampling in the dedusting installation. Dust 1, taken from the cyclone dust separator contains much more coal dusts than Dust 2 taken from the fabric filter at the end of the dedusting installation.

3.2. Investigation results of the physical and mechanical properties of dust-water mixtures

Changes in apparent density of both dust-water mixtures in dependence of their moisture content are presented in Figure 1, with taking into account various compacting states of material, obtained by their compacting performed two or three times on the typical moulder's rammer. The more compacted mixture the higher apparent density and the lower porosity (Fig. 2).

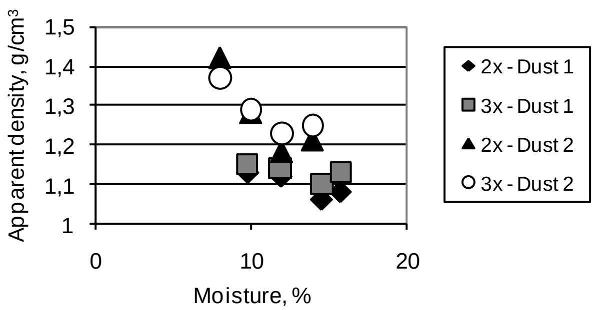

Fig. 1. Dependence of the mass samples apparent density on the dust-water mixture moisture content, 2x – two times rammer impact, 3x – three times rammer impact

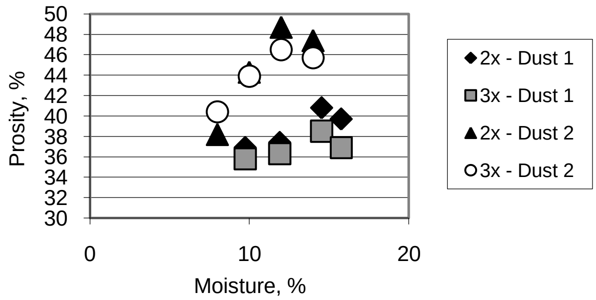

Fig. 2. Dependence of the mass samples porosity on the dust-water mixture moisture content, 2x – two times rammer impact, 3x – three times rammer impact

The results of the compression strength of samples made of dust-water mixtures under wet conditions and after drying are presented in Figures 3 and 4 - respectively. The samples were of standard dimensions: ϕ 50 x 50 mm. It can be noticed that drying of samples causes, in practice, 10 times increase of their strength and that for both mixtures there is a strength maximum at a certain moisture content. The comparison of the results for the compression and splitting strength (Fig. 5) indicates the analogical curve pathways. R_c^w values are nearly 10 times higher than R_p^w.

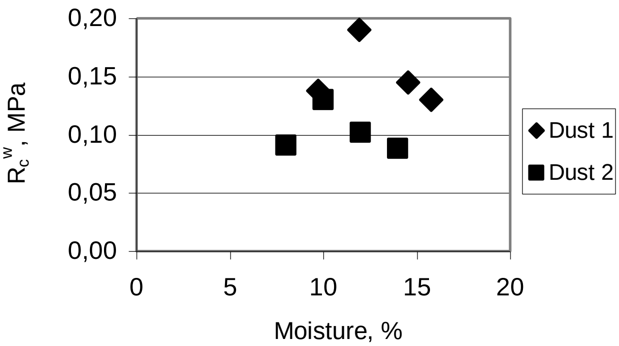

Fig. 3. Dependence of R_c^w on the dust-water mixture moisture content (in wet condition)

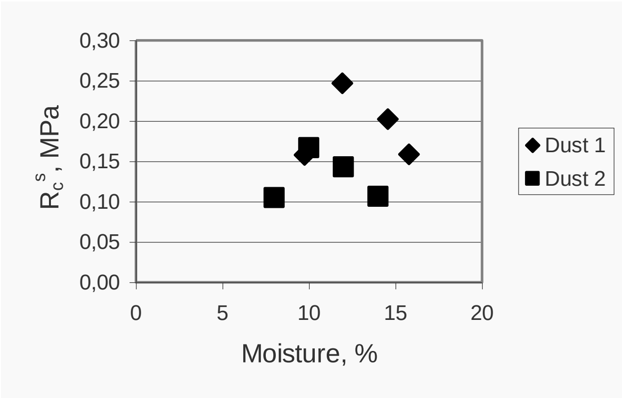

Fig. 4. Dependence of R_c^s on the dust-water mixture initial moisture content; cylindrical shapes were dried at a temperature of 150°C for 3 hours

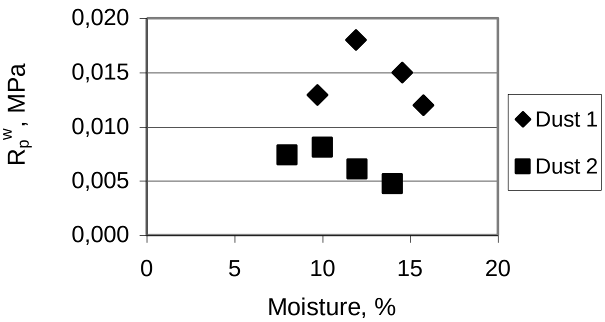

Fig. 5. Dependence of R_p^w on the dust-water mixture moisture content (in wet condition)

Changes of P^w in dependence on the moisture content are shown in Figure 6. Dust 1 obtains maximum permeability at app. 12% of moisture, whereas in case of Dust 2 continuous permeability increase was observed along with the mixture moisture content increase.

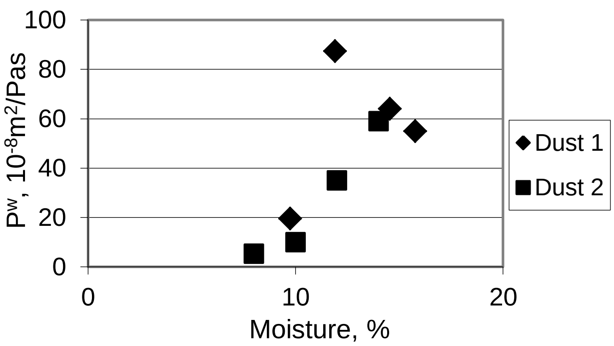

Fig. 6. Dependence of permeability on the dust-water mixture moisture content (samples after 3x – three times rammer impact)

Compactibility constitutes an indicator of the suitability of the investigated material for being formed by compaction. This property is changing when the amount of clay and its quality in the mixture is changed (including the water-clay ratio), while at the constant clay content – when the sand water content is changed [7]. Investigates were carried out at constant compaction energy.

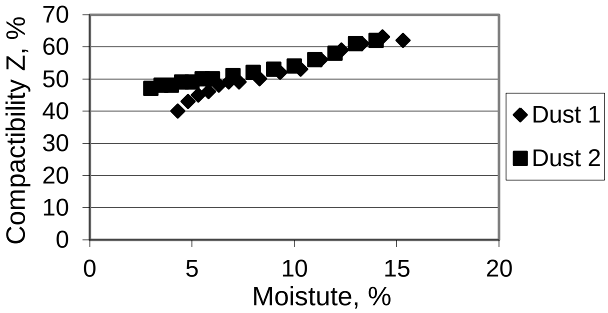

Fig. 7. Dependence of compactibility on the dust-water mixture moisture content

The moulding sand ability for a uniform compacting can be characterized by means of measuring its fluidity. The water-clay ratio mainly decides on this fluidity, while at the constant clay content the decisive factor is the sand moisture content. The performed investigations (Fig. 7) indicated that differences in dusts compactibility occur up to the moisture content of app. 8 %, and that above this value the differences are not noticeable. Fluidity measurements were done by means of a shatter test. The obtained results are presented in Figure 8. An increased moisture content causes a fluidity decrease of both Dusts (1 and 2).

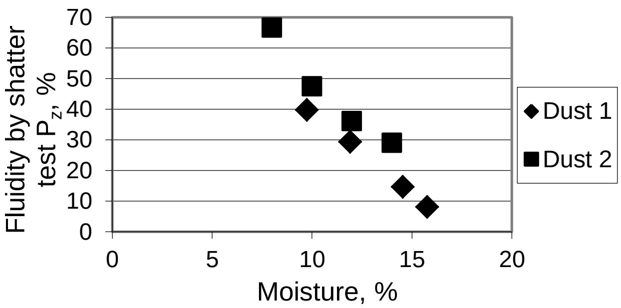

Fig. 8. Dependence of fluidity on the dust-water mixture moisture content

The property known as friability is a feature which decides on the form stability of the material undergoing granulation. Friability depends, first of all, on the clay kind and the water-clay ratio, while at the constant clay content – on the water content in materials [6]. Figure 9 presents friability changes in dependence on the moisture content. As it can be seen, Dust 2 obtains maximum friability at the moisture content of app. 10%, while Dust 1 is characterized by a decreased friability resistance at an increased moisture of the mixture.

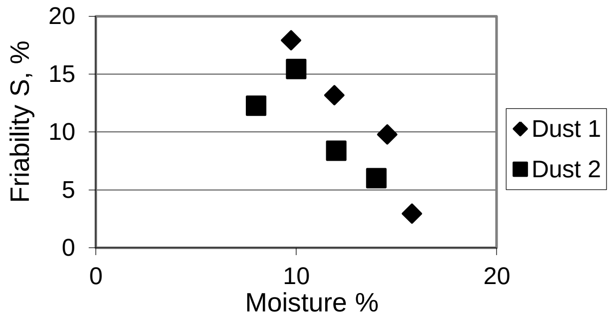

Fig. 9. Dependence of friability on the dust-water mixture moisture content

4. Conclusions

The obtained results allow to state that the assumed assessment methods of physical and mechanical properties of the tested dusts - analogous to the ones used in moulding sands investigations - can be applied for the preliminary determinations of the range of wetting changes of after-reclamation dusts containing water-wettable components.

The performed investigations of strength properties of dust-water mixtures are useful for the determination of the expected ranges of pelletised products and for the selection of parameters of dusts granulation in the granulator, which allows to obtain such pellets.

Problems related to the lack of information concerning properties characterizing the agglomeration ability of dusts, especially when the dust form processing is carried out beyond the place of their generation, often arise in the granulation processes performed in industrial devices. In such cases, an application of the testing methods described in the paper can significantly limit the number of necessary industrial tests requiring large amounts of materials.

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