REUSING OF DUST COLLECTOR MATERIAL AS A GREEN SAND ADDITIVE

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SUMMARY

Possibilities of reusing materials from dry and wet dust collector systems to the green moulding sand. Results of dusts testing active bentonite, pH, lustrous carbon, sieve analysis, fines, hazardous components i.e. Reusing of dust as a green moulding sand additive – laboratory testing and pilot plant experiences – technological properties of such moulding sand and the quality of produced castings.

Key words: waste, dust, green sand.

1. INTRODUCTION

More and more waste materials are produced – nowadays it is about three times more than in 1950! Within the years 1995 up to 1998 only the amount of waste materials generated by us has grown by 15%. If we will continue in such a way then in 2020 we will produce probably by 45% of waste material more than in 1995. Only in Europe more than 1.3 milliard tons of waste materials is produced every year. It amounts 3.5 t of solid waste materials per a European. If we will continue tipping our wastes on dumps they will overflow us. It is a reason why the European Union and national governments involve in a policy of waste amount reduction. It is a European aim to decrease the final waste amounts by 20% within 2000 up to 2010 and by 50% within 2010 up to 2050 [1].

According to statistical data of the international organization WFO in British Birmingham in manufacture of 1 ton of sound castings about 1 ton of waste materials is produced that need to be recycled or deposited on controlled dumps. In Czech Republic it represents about 600,000 tons of foundry waste.

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This amount includes a part of depreciated moulding sands, slag forming during melting of metal alloys, depreciated lining of furnaces and ladles. An important part is formed by dust particles captured by exhausting equipment during metal melting, moulding sand preparation, knocking out of castings from moulds, and during fettling of castings.

Material captured in dust collectors is of different composition and a danger degree according to the locality of dust source. Many oxides or metal particles are carcinogenic and deleterious, SiO$_2$ particles are generators of silicosis, phenolic and furan resin remainders are toxic. When depositing such wastes on dumps the clays contained in them after rainfall wetting form a solid layer that is impermeable. Underneath this layer the toxic liquids are forming that can penetrate in bottom water and contaminate it.

2. **FOUNDRY DUSTS**

Dust separation systems are of two types:

1. *Wet dust separators* that use for dust separation the water spray and the result are two different products – „black water“ and sludge. Black water contains colloidal clay, most frequently of the montmorillonitic type and carbonaceous particles that sediment very slowly. The sludge product contains greater and heavier particles of coal, sand, and metal that settle very fast.

2. *Dry dust separators* use textile inserts that separate dust similarly as different kinds of vacuum cleaners. The material is periodically shaken in tanks; captured particles are of similar composition as from wet dust separators.

In some workshops the separators are placed at the dust source, in another ones this waste is collected centrally and periodically deposited on controlled dumps.

In evaluation of a possibility of reuse of dust from separators as an additive in bentonite moulding sands it is necessary to keep a condition that the dust is collected from a moulding system only (a moulding sand preparation shop, a moulding shop, knocking out of castings). Dust from wet and dry filters in such a case contains detached components of moulding sand – bentonite, carbonaceous additives. Those components, up to now maltreat as a dangerous waste material, can be reused in preparation of new moulding mixture.

If the separator will collect dust from several sources (as e.g. furnaces, fettling shop, reclamation of self-setting sands) then the use of dust in bentonite mixture is unreal. High content of metal particles decreases the mixture refractoriness; it initiates the formation of fayalite, and increases the tendency of melting metal penetration in a mould. Dust off particles from technologies using organic binders hardened in acid environment (e.g. furane mixtures) are unusable too. The content of them decreases pH of a mixture and it deactivates bentonite with considerable deterioration of its technological properties.
2.1. Evaluation of the dust

It is evident that knowledge of qualitative and quantitative composition of dust is a condition for its right dosing in moulding mixture. Dust addition must be balanced and in correlation with other raw materials used for mixture revitalization. The aim is to achieve optimum composition from the point of view of required mixture properties and casting quality connected with it.

Our working out a methodology of evaluation of dust off materials was based on a precondition that the dust exhausted form the moulding system is of the same composition as used moulding mixture.

After initial phase the variability of dust off properties was studied within about six months in several foundries working both with dry types of dust separators, and wet ones.

Testing procedures included the determination of granulometric composition of fine dust particles, determination of pH, conductivity, amount of active bentonite, content of active carbonaceous matters, float out parts, content of heavy metals, granulometric composition of base sand contained in dust, DTA.

Chosen test results

- **Determination of pH and conductivity**
  Keeping line with expectations the dust off pH ranges in a gently alkaline region (pH 7.5 – 8.6) what enables to use the material as an additive in unit bentonite sand without occurrence of bentonite deactivation and deterioration of properties due to it.

- **Determination of active bentonite and carbonaceous matters**
  Test results have sustained relatively high content of active bentonite. In taken operational samples the value of adsorption of MM bentonite ranged from 77 up to 86 ml/g. The content of LC carrier was very low in all cases compared with expectations and it ranged from 0.45 up to 0.85 %. The method and intensity of dedusting give the size of dust off particles. In studied cases the content of 0.02-0.06 parts ranged about 20 % and the 0.06 – 0.1 interval beneath 5 %.

- **Determination of heavy metals content**
  This determination was done with the aid to prove if in separated dust materials some harmful substances are not cumulated. The determination was done in the University Institute of Material Chemistry of the Ostrava University of Technology and the method of the X-ray fluorescence spectroscopy with use of the SPECTRO X-LAB apparatus was applied.

  Test results have not proved any important difference in concentration of harmful substances in dust and in moulding mixture. Generally the heavy metals concentrations (40 of them were studied) are very low in both cases.

- **Cast tests**
  They were aimed at evaluation of influence of dust addition in bentonite mixture on smoothness of casting surface and on the tendency to burning-in.
Table. 1. Concentrations of chosen harmful substances in dust materials from several different sources and in moulding mixture

Tabela 1. Stężenie wybranych substancji szkodliwych w pyłach pochodzących z różnych źródeł w masach formierskich

<table>
<thead>
<tr>
<th>Substance</th>
<th>concentration [μg/g]</th>
<th>concentration [μg/g] used green sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni</td>
<td>9.0 - 60.3</td>
<td>9.2 - 14.0</td>
</tr>
<tr>
<td>Cd</td>
<td>&lt;0.3</td>
<td>&lt;0.3</td>
</tr>
<tr>
<td>Hg</td>
<td>&lt;2.2</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>Pb</td>
<td>7.0 - 22.4</td>
<td>9.5 – 10.6</td>
</tr>
<tr>
<td>Se</td>
<td>0.5 – 0.7</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Sb</td>
<td>0.7 – 2.8</td>
<td>1.1 – 1.2</td>
</tr>
<tr>
<td>As</td>
<td>1.8 – 14.3</td>
<td>6.7 – 8.5</td>
</tr>
</tbody>
</table>

Tests aimed at comparison of surface quality were done on a test casting given in Fig.1.

Fig. 1. Test casting pattern.
Rys.1. Model odlewu testowego.

For keeping the same conditions (chemical composition of metal, casting temperature) two sets of plates of dimensions 100 x 100 mm with wall thickness of 10, 20, and 30 mm were simultaneously cast through one gate. One set of plates serves as a comparative standard. Roughness was evaluated on the bottom surface of castings, i.e. on the core side that was surface treated in no way. For keeping the same degree of compacting these evaluated surfaces were formed by inset cores and the compaction degree was checked on the one hand by weighing, and on the other by measuring the core surface hardness. Mass density of cores ranged from 1590 up to 1644 kg.m⁻³ and abrasive hardness was 89 – 93 units according to +GF+. Green sand from foundry works was used for moulding. It was revitalized with 1% of Sabenil bentonite (a comparative A mixture). In second case (B mixture) the mixture was enriched with dust off materials in such a way that the same amount of active bentonite was kept. (6% of dust)

Castings were made from grey iron according to the CSN 42 2420 standard with casting temperature of 1390 °C. Surface roughness was evaluated according to the
reference sample designed by the National Research Institute for Materials. The roughness of both used mixtures ranged from 4.5 up to 5 degree of the reference sample mentioned above what represents the mean roughness value of $R_a=25\mu m$.

<table>
<thead>
<tr>
<th>Table 2. Properties of moulding mixtures</th>
<th>Tabela 2. Właściwości mas formierskich</th>
</tr>
</thead>
<tbody>
<tr>
<td>mixture A</td>
<td>Mixture B</td>
</tr>
<tr>
<td>moisture content</td>
<td>3.2%</td>
</tr>
<tr>
<td>green bond</td>
<td>140 – 180 kPa</td>
</tr>
<tr>
<td>clay wash</td>
<td>13.5%</td>
</tr>
<tr>
<td>lustrous carbon</td>
<td>0.22%</td>
</tr>
<tr>
<td>methylene blue</td>
<td>82 ml.g$^{-1}$</td>
</tr>
</tbody>
</table>

Measurement results have proved that the addition of dust parts in unit bentonite sand did not deteriorate the casting quality. This fact was proved for all wall thicknesses, i.e. 10, 20, and 30 mm.

The tendency of bentonite mixture to burning-in was modelled on a test casting used in Foundry Department of the Ostrava Technical University. The question is the casting with wedge-shaped inset cores inserted in a cylinder. The gating system allowed the bottom filling of the mould, metallostatic pressure was constant for all series of tests, the height of the central stock was 300 mm + 100 mm the riser that was equipped with exothermic sleeve for prolongation of solidification time. Castings were cast from grey iron according to the CSN 42 24 20 standard with casting temperature of 1390 °C, casting time of 15 sec., and gross weight of the casting was 33 kg. The extension of metal penetration in a core cut in a half height of the casting cylinder and the depth of metal penetration in the mould were used as a degree of burn-on size and surface quality.

The test result is evident from Fig. 2 showing the casting surface of the inset cores – the standard, the A mixture, and of the B mixture.

In both cases the question is the bentonite mixture without surface treatment. The measured point is only manually scoured. The measured core (the B mixture with dust) shows negligibly rougher surface but no deep burning-in occurs.

3. CONCLUSION

Results of qualitative and quantitative evaluation have proved that the dust material collected by dry and wet filters contains active usable components of moulding mixtures and there exists a real possibility of their use as an additive in unit bentonite sands without deterioration of mixture quality.

Casting tests done up to now have proved that with use of dust material no deterioration of surface quality of castings was noted, and namely both from the point of view of surface smoothness, and from the point of view of possible occurrence of surface or deep metal penetration.
Modern separators have higher efficiency and they are able to capture more of active bentonite particles, sea coal, additives, and quartz of the size 0.02 mm depleted the moulding mixture. Therefore it shows to be uneconomical to buy those materials dearly paid, then to lose a part of them in the exhausting system and later on to pay considerable costs for their depositing on dumps.

REFERENCES


STRESZCZENIE

W artykule opisano badania dotyczące możliwości wykorzystania pyłów pochodzących z odpylania stanowisk sporządzania mas, wykonywania form i wybijania odleów. Pyły te w składzie mają bentonit i dodatki substancji zawierających węgiel. Pyły zostały wykorzystane do sporządzania mas z bentonitem. Wykonane, w formach sporządzonych z tych mas, odlewy posiadały dobrą powierzchnię. Próby przeprowadzono dla odleów żeliwnych o grubości ścianek 10, 20 i 30 mm.

Recenzent: prof. dr hab. Mariusz Holtzer.