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Thermal Utilization of the Post Reclamation Dust from Molding Sand with Furan Resin in Test Unit

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„At the current civilisation level the sustainable development, it means the development during which the needs of the present generation can be satisfied without decreasing the chances of the future generations for their needs satisfaction, is possible"

Abstract

Mechanical reclamation process of spent moulding sands generate large amounts dusts containing mainly rubbed spent binding agents and quartz dust. The amounts of post-reclamation dusts, depending of the reclamation system efficiency and reclaim dedusting system, can reach 5 -10% in relation to the total reclaimed moulding sand. This dust due to the high content of the organic substances is a threat to the environment and therefore requires the storage on landfills specially adapted for this type of waste. On the other hand, the presence of organic substances causes that these dusts have relatively high energy values that could be used. However, at present there is no coherent, environmentally friendly concept for the management of this type of dust.
The paper presents the results of tests of thermal utilization the dusts (as a source of energy) were carried out at AGH University of Science and Technology. Thermal utilization of dusts was carried out in the co-burning with carbon carriers process or in individual burning (Patent PL 227878 B1 and patent application PL - 411 902).

Keywords: Thermal utilization of dusts, Furan resin, Environmental protection in foundry

1. Introduction

The concept of the sustainable development originated at the beginning of the XIX century and concerned only woods, however - with time - was transferred into other economic sectors. This is not the substitutive development, i.e. improvement of one part of the environment in return for the destruction of its other part. This is the development of all economic sectors in a way not threatening the environment goods [1].

Operations of foundry plants is related to using a lot of energy, natural resources and metals as well as to generating significant amounts of gases and solid wastes. It is important to realise that the responsibility for the environment and the financial returns are not mutually exclusive. Taking care of the environment and introducing more environment friendly changes can cause a production increase and costs lowering, improve the brand recognition, strengthen relations with customers and increase the company profitability. Due to the implementation of environment management systems and the proper management of materials and wastes, as well as the application of recycling, foundry plants can play an essential role in the sustainable usage of natural resources. Foundry plants, which operation is based in large measure on treatments of wastes (metal scrap is treated as waste) and on recycling (reclamation of spent moulding sands and using the reclaimed material), are essential elements of the sustainable development concept [2-5].

Spent foundry sands, in accordance with the current regulations on limiting the amount of waste generated, is subjected in a large fraction to the process of mechanical regeneration. As a result, we get a product that is a regenerate with appropriate properties and waste in the form of dust (in an amount of 5-10% in relation to the amount spent foundry sand [6-8]). This dust due to the high content of the organic substances is a very dangerous for the environment. This is a problem not only of several Polish foundry plants whose implemented - in the last years - the technology of moulding sands with furan binders but also of foreign foundries [9-11].

2. Characteristics of post-reclamation dusts from moulding sands with furan resins

The subject of the research was 5 post-reclamation dusts obtained during mechanical treatment of used moulding sands with furan resins originated from different foundries. The properties of dust strongly differs if consider the technical parameters of a given installation for the regeneration process and the regenerate dedusting system (e.g. intensity, effectiveness) [12-14]. This may explained the sometimes significant differences in the properties of these dusts given below:

- mass density 1 .92 – 2.38 g/cm^3
- pH 4.30 – 5.52
- moisture 0.8 - 3.1 % by mass
- loss on ignition 10.24 - 46.00 % by mass
- emissivity of gases at 1000°C 102 - 154 cm^3/g.

As could be seen the most significant differences occurred in the values of losses of ignition (content of organic compounds in the dust) which in turn determines the high heat of combustion process of dusts utilization. The high loss on ignition value indicates effectively carried out the regenerating process, i.e. a more accurate removal of the binder film from the grain surface. Some energy properties data of dusts from the mechanical reclamation process of moulding sand with furan resin are listed below:

- ash content A^a 55.2 - 87.9 % by mass,
- volatile matter content V^a 3.96 - 12.50 % by mass,
- heat of combustion 3101 - 13746 J/g
- calorific value 8.4 - 35.3 % by mass.

3. Test unit for thermal utilization of the post-reclamation dust

On the bases of several physical-chemical properties of post-reclamation dusts, it was found that this material has a relatively high heat of combustion (Q_s^a) and is suitable for the thermal utilisation. On account of this, within realising the INNOTECH project, the prototype device for the practical realisation of this project was developed and built. It consists of the body with insulated walls, covered by fire-resisting materials. The vertical partition divides the combustion chamber and reheating chamber joined by the upper passage and equipped with gas burners [15,16]. Post-reclamation dusts are fed into the combustion chamber and in the counter-current of gases are gravitationally falling down, forming a suspension of dusts in a mixture of combustion gases and air. The reheating chamber is connected with the negative pressure installation of the heat recovery, dedusting and emission. Gas burners are on two levels in the combustion chamber and on one level in the reheating chamber. Solid materials remaining after the thermal treatment are taken out from bottom parts of both chambers. Gasification of organic substances requires heating the combustion chamber to a temperature: 700 – 800^{0}C. For the efficient utilisation and total oxidation of organic components of dusts it is possible to apply additional oxygen blowing through the material gathered on sieves. The test stand used for the thermal utilisation of post-reclamation dusts is presented in Fig.1.

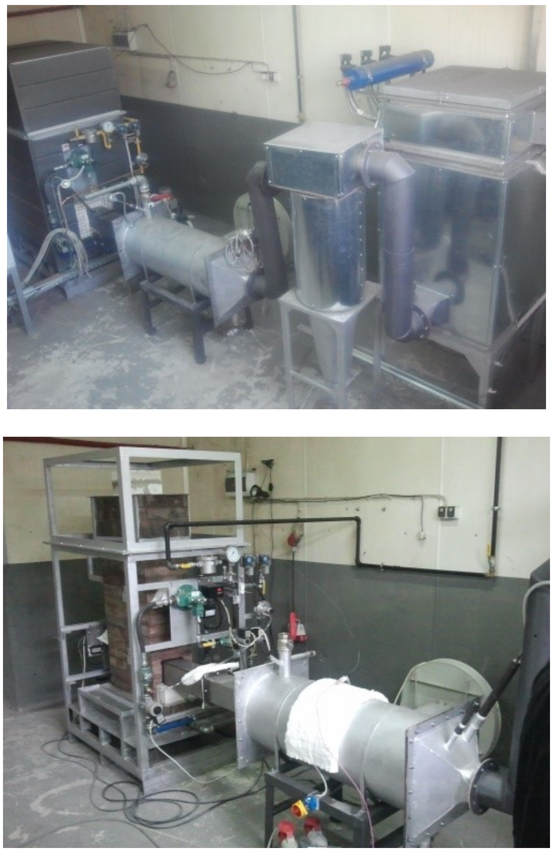

Fig. 1. View of the research stand for the thermal utilisation of post-reclamation dusts: in the stage of testing operations in the final version

The examples of the dusts utilisation with using chosen dust P1, are discussed in the hereby paper. The averaged thermal balance of the prototype installation for the proecological conversion and heat recovery from post-reclamation dusts is shown in Table 1.

Table 1.
The averaged thermal balance of the prototype installation for the proecological conversion and heat recovery from post-reclamation dusts

Results of tests	Unit	Results
Average consumption of natural gas with a calorific value of 35 MJ / m^3	[m^3/h]	4.0
Average consumption of post-reclamation dusts with a calorific value of 5 MJ / kg	[kg/h]	15.0
Thermal power from natural gas combustion	[kW]	38.9
Thermal power from post-reclamation dust combustion	[kW]	20.83
Total generated thermal power	[kW]	59.73
Expenditure of water collected from the system	[m^3/h] [kg/s]	0.70 0.194(4)
Changing the water temperature at the t_{inlet} $\Delta t = t_{outlet} - t_{inlet}$	[^{o}C]	14 38,5
Heat power absorbed by water, Specific heat C_{pH2O} = 4189.9 J/kgK	[kW]	31.29
The degree of using power (efficiency of the exchanger)	**[%]**	**52.38**

* T_{outlet} = 52.5 ^{o}C was accepted as the average value of water temperature during the utilization process

4. Conclusions

The written below conclusions can be drawn on the bases of the preliminary tests.

- The presented concept of the stand for the thermal utilisation of wastes is the proper one, however requires certain constructional corrects to prolong the exposure time of the utilised material to the influence of heating.
- Another possibility of improving the device efficiency with regard to the final state of the utilised product, is applying oxygen as a factor supporting burning in the combustion chamber.
- The power usage coefficient is at the level of 50%. Further works are needed to increase the efficiency to approximately 80-90%.

The obtained final solid product, after burning at a temperature of 950^{o}C, had ignition losses at the level of 0.6 – 0.8 %, was characterised by a high purity, and its quartz grains were already after the change: quartz α → quartz ß (573^{o}C). Due to that, they could be used in the building, ceramic or foundry industry.
It should be emphasised that the presented results are the preliminary ones. It especially concerns the energetic efficiency of the prototype device, which in case of its practical application should be significantly improved. This could be done by the optimisation of systems of: dusts feeding for utilisation, air blowing through in the combustion chamber, temperature of air used for blowing through as well as small changes in the construction of the combustion chamber leading to the prolongation of the dusts exposure to the high temperature influence.

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