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Furnace dust utilization with use of pneumatic injection method

Jan Jezierski*, Krzysztof Janerka

Silesian University of Technology, Department of Foundry Engineering, Gliwice, 44-100, Poland

Abstract

The problem of dust generation is widely present in steel and foundry plants around the world. All of the melting furnaces generate thousands of tons of dust every year. The dust itself still contains a lot of chemical elements (mostly iron and zinc) which can be returned back into the furnace increasing their content in metal bath or in final dust which then can be used as a raw material for zinc metallurgy industry. One of the method to do that is pneumatic powder injection with use of pneumatic feeder and injection lance. The paper presents the theoretical approach as well as some industrial experiences of the authors on this field of pneumatic conveying applications. The benefits of the dust reuse have been presented as well as some limits. It has been stated that the pneumatic injection can be used to blow-in cupola dust again into the cupola, the electric arc furnace into it together with some carburizer and ferroalloy and slag foaming process with use of dust blown-in through injection lances. The results showed the importance of pneumatic and geometrical parameters of the process to achieve the proper jet penetration inside the liquid metal. The literature and own authors' formulas have been validated by some model and real injection experiments. This complex approach has proven the potential of pneumatic powder injection method to utilize dust wastes in melting furnaces.

Keywords: Furnace dust; pneumatic powder injection; waste management; foundry industry; dust utilization.

1. Introduction

Monthly world's steel production is around 130 millions of tons and almost 20 kg of dust is generated per one ton of steel. So the problem of dust utilization is being one of the most important environmental issues in steel industry (Jezierski et al., 2011a, 2011b).

*Corresponding Author: jan.jezierski@polsl.pl
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Similar situation is observed in foundry industry where only in Germany the cupola's base foundries generate over 30,000 tons of dust per year (Jezierski et al., 2008, 2011c). The dust sucked out of the furnace still contains a lot of chemical elements which are beneficial for the melting process so their utilization is ecologically and economically reasonable. The another significant dust source is in foundry the moulding sand preparation process and after the castings are knocked out – the spent moulding sand reclamation (Dańko et al., 2014). There is several ways of furnace wastes utilization as it was described among the others in (Fiore et al., 2007, 2008). They can be used in cement industry, as an additions in ceramic industry, in glass production, road construction or in metallurgical and foundry plants in place (Huaiwei et al., 2011; Eisa et al., 2013; Holtzer, 2007). One of the method of furnace dust utilization is its direct pneumatic injection back into melting furnace. The paper presents authors' experimental results as well as industrial application of the method and describes the advantages and limits of the pneumatic dust injection in steel and foundry plants.

2. Dust pneumatic injection into EAF

The biggest steel plants steel utilize electric arc furnaces (EAF) although smaller units are often replaced with the induction furnaces of new generations. The EAF produces huge amount of dust as it was mentioned in (Jezierski et al., 2008) where the typical chemical analysis of dust sucked out of steel melting EAF was presented, too. Using pneumatic powder injection method, which the authors have been developing since many years, the dust can be re-introduced into the furnace together with some carburizers, alloy additions or other reagents. The example of such installation was presented in Fig. 1 and this is a case of slag foaming process implemented in steel plant employing 65 t EAF.

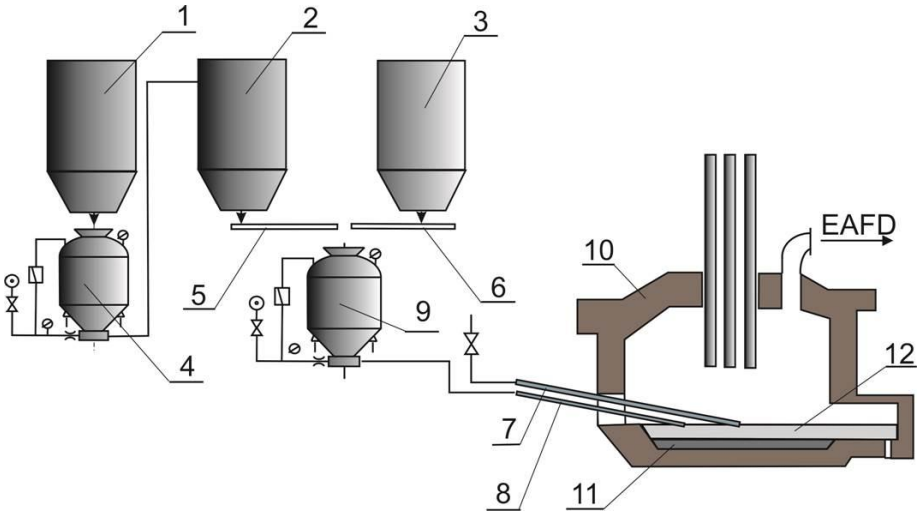

Fig. 1. Dust-carburizer pneumatic injection into 65t EAF; 1- furnace dust container, 2- intermediate dust container, 3- dust pneumatic feeder, 4- powdered coal container, 5- dust feeding screw, 6- coal feeding screw, 7- oxygen lance, 8- mixture injection lance, 9- mixture pneumatic feeder.

The results of the process are almost exactly as estimated in laboratory conditions:
- average 903 kg of EAFD possible to introduce during one melt,

- final dust production is 51% lower than previously,
- the final dust was enriched to above 30% of zinc and above 5% of lead content make it rich enough to be a secondary raw material,
- less consumption of coal and oxygen for slag foaming process.

3. Cupola dust re-injection back into furnace

Cupolas are still widely used in some countries to melt down ordinary grades of grey cast iron. Modern cupola installation are much more environmental friendly than older ones so to cope with strict rules the more pollutant units must be modernized. One of the method of modernization is pneumatic powder injection installation applied for cupola own dust re-injection back to the furnace. The experiments and industrial application were carried out in Department of Foundry and one of the typical example of the foundry plant setup is presented in Fig. 2. Similarly to the EAF pneumatic injection case it is rather difficult to pneumatically blow in the dust alone because sometimes huge transportation problems of such fine particles. So in laboratory conditions the experiments were made to optimize the composition of dust mixture with other grainy materials as ferroalloys and carburizers. After the composition were finally estimated the industrial stage was launched.

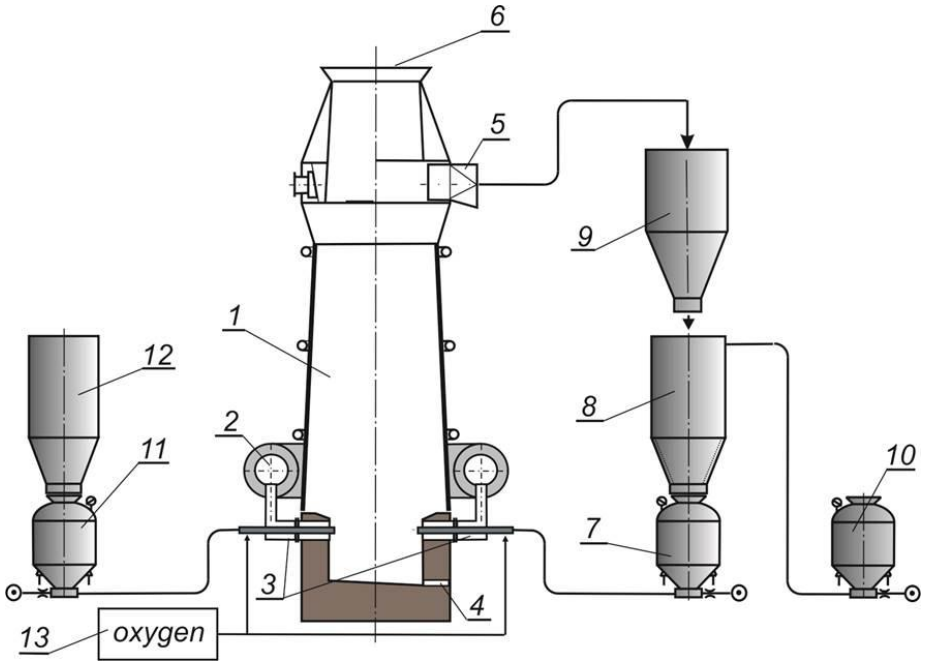

Fig. 2. Industrial cupola dust injection stand; 1- cupola, 2- wind box, 3- cupola nozzles, 4- tapping hole, 5- dust removal system, 6- charging door, 7- dust-coal mixture pneumatic feeder, 8- dust-coal mixture container, 9- dust storage container, 10- coal pneumatic feeder, 11- ferroalloys pneumatic feeder, 12- ferroalloys storage container, 13- oxygen blow.

The results based on real cupolas dust injection were as follows:
- considerable reduction of production costs about 10% because the calorific value of the dust which can be in some way additional fuel;

- increase of the cupola effectiveness up to 50% if compared to normal melting process because the injection results in additional air introduction improving the melting conditions;
- coke consumption decrease up to 10% because its combustion is much more effective due to air blowing;
- final dust contains up to 20% what means it can be used as a charge material for the metallurgical process in zinc metallurgical plants.

4. Fine fractions of ferroalloys and carburizers pneumatic injection

The goal of such approach is to utilize fine (dusty) fractions of materials, which are often considered as wastes to carburize molten cast iron or to introduce alloy additions. The authors carried out the research to provide effective methods of fine powders or dusty materials pneumatic injection with or even without the lance submersion into liquid metal surface. The example of the cast iron carburization setup for the ground electrodes scrap use is presented in Fig. 3.

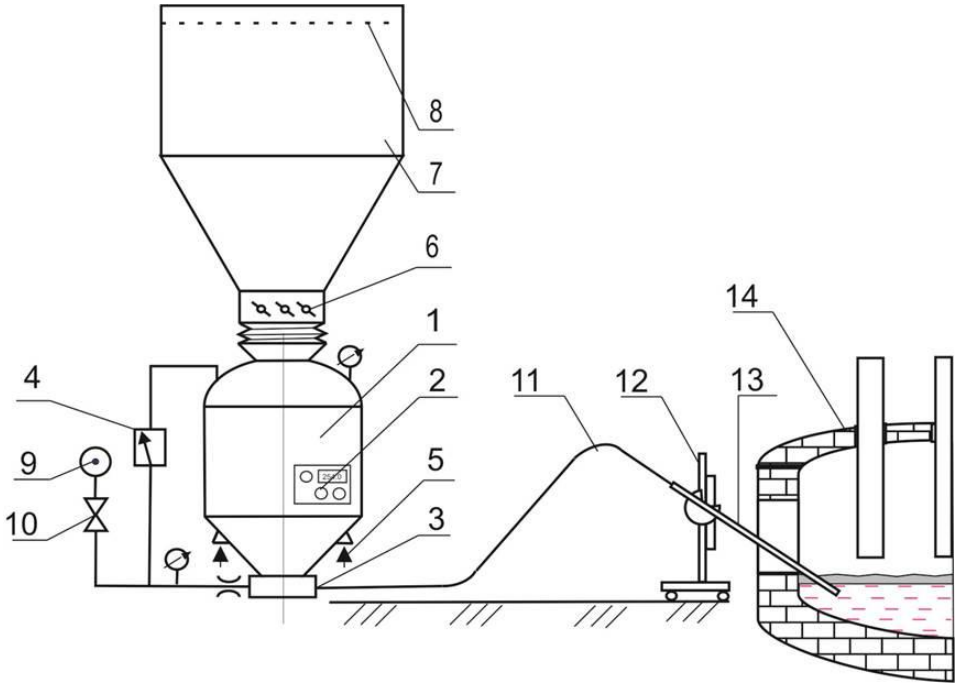

Fig. 3. Pneumatic injection of carburizer into EAF; 1- pneumatic feeder, 2- control switchboard, 3- mixing chamber, 4- gas pressure reducer, 5- scales, 6- swivel damper, 7- carburizer container, 8- screening sieve, 9- compressed air supply, 10- main valve, 11- pipeline, 12- lance manipulator, 13- injection lance, 14- EAF.

5. Minimization of dust generation during metallurgical processes

The utilization of metallurgical and foundry furnace dust is the important issue but the step forward is the minimization of the dust creation during the melting processes. The authors have launched the project together with one of the world famous copper producers which goal is to lower the dust and process gases generation volume. During the copper recovery melting process in 10 t gas-fired furnace some portion of sulphur granulates is

added to improve the physicochemical properties of the liquid copper. At the moment the sulphur is added manually on the molten metal surface what causes a huge dust and gases emission out of the furnace. So together with one of the Polish companies working inside pneumatic conveying field the authors carried out the experiments to implement the pneumatic powder injection method to introduce sulphur granulates under the molten copper surface. The preliminary results are very promising because the final dust amount lowered approx. twice and the sulphur yield almost doubled. The quality of the liquid metal before the further processing is much better, too thanks to uniform sulphur distribution in the whole metal volume after it is pneumatically introduced. Now the project is still under development to adjust all parameters to make it stable and to ensure high durability of installation (especially injection lance consumption due to heavy working conditions).

6. Conclusions

The paper presents and issue of furnace dust utilization in place by use of the pneumatic injection method. Based on the big theoretical and laboratory experiences the authors have implemented several industrial installations what was shortly described in the paper. The experiments in laboratory and real industrial conditions have drawn to the following conclusions:

- the pneumatic injection method can be easily used to utilize various furnaces dust by means of its re-introduction;
- efficiency of the process is always much better than when alternative introduction method is used;
- besides technological and economic advantages very important is improving the working conditions in shop floor;
- the best way to fight the dust inside the plant is its reduction before it is generated during the melting processes. For this purpose the pneumatic method can be used successfully, too.

7. Acknowledgements

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References

Jezierski J., Janerka K. (2011a). Selected aspects of metallurgical and foundry furnace dust utilization. Polish Journal of Environmental Studies 20 (1), 101-105.

Jezierski J., Janerka K. (2011b). Wastes utilization in foundries and metallurgical plants – selected aspects. 20th Anniversary International Conference on Metallurgy and Materials METAL 2011, Brno, Czech Republic.

Jezierski J., Janerka K. (2011c). Wastes utilization in foundries and metallurgical plants with pneumatic conveying techniques – selected aspects. Interdisciplinary Environmental Review 12 (2), 154-165.

Jezierski J., Janerka K. (2008). Pneumatic powder injection technique as a tool for waste utilization. International Journal of Environment and Waste Management 2 (6), 636-646.

Fiore S., Zanetti M.C,, Ruffino B. (2008). Waste characterization in steel casting and recycling opportunities in Europe. American Journal of Applied Science 5 (5), 512-518.

Fiore S., Zanetti M.C. (2007). Foundry wastes reuse and recycling in concrete production. American Journal of Environmental Science 3 (3), 135-142.

Huaiwei Z., Xin H.. (2011). An overview for the utilization of wastes from stainless steel industries. Resources, Conservation and Recycling 55, 745–754.

Hekal E.E., Abo-El-Enein S.A., El-Korashy S.A., Megahed G.M., El-Sayed T.M.. (2013). Utilization of electric arc furnace dust as an admixture to Portland cement pastes. Journal of Thermal Analysis and Calorimetry 114(2), 613 – 619.

Holtzer M. (2007). Influence of the cast iron melting processes on environment using BAT. Archives of Foundry Engineering 7 (4), 83-88.

Dańko R., Holtzer M., Dańko J. (2014). Investigations of physicochemical properties of dusts generated in the mechanical reclamation process of spent moulding sands with alkaline resins, China Foundry, 11(3), 132-138.