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INNOVATION IN METALLURGICAL WASTE MANAGEMENT

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In the paper was presented innovative solutions of sludge and dust management generated by metallurgical enterprises. These solutions are as follows: usage of steelmaking dust in production of decorative glassware and deoiling of metallurgical sludge useful in producing of iron-bearing briquette for electric arc furnaces (EAF). The influence of the aforementioned technologies on the environment was also discussed.

Key words: metallurgical industry, steelmaking dust, waste management, innovation, products

INTRODUCTION

Innovative activity undertaken by enterprises is an important element of a pursuit of dynamic and competitive knowledge-based economy. This type of activity comprises a number of operations being scientific (research related), technical, organisational, financial and commercial in nature.

The innovative activity of industry is associated with development and implementation of new or significantly enhanced products (product innovation) and processes (process innovation). To market a new or enhanced product as well as to apply a new or enhanced process in production, where both the said product and the process are new at least from the perspective of the enterprise introducing them, is referred to as technological innovation. This paper addresses specific technological innovations proposed, intended to be used to create a new product (glass decorations with steelmaking dust additives) and to develop a new technology (removal of oils from metallurgical sludge enabling their recycling to the iron-bearing briquette manufacture).

METALLURGICAL WASTE

Substances referred to as *waste* are subject to rigorous legal regulations the purpose of which is to protect human life and health as well as natural environment. Directive 2008/98/EC of the European Parliament and of the Council (Waste Framework Directive) of 19th November 2008 defines waste as “any substance or object which the holder discards or intends or is required to discard” [1]. The requirements laid down in the Waste Framework Directive have been implemented in the Polish legal system under the act on waste [2]. The act regulates obligations of parties producing waste, holding waste, managing waste and selling waste as well as waste trade agents and public administration bodies competent in the area of waste management.

Metallurgical industry is one of the largest sources of wastes. The Polish metallurgy restructuring process have caused both quantity and quality of waste to change. In accordance with the applicable legal regulations, every manufacturer, including metallurgical manufacturers, should prevent generation of waste in the first instance, or limit both generation of waste and its negative impact on human life and health as well as on natural environment. Holders of waste whose generation could not have been prevented is obliged to recycle it first and foremost. The following types of waste are generated in the metallurgical industry:

- sintering dust and sludge from the sintering process,
- blast furnace dust and sludge from the blast furnace process,
- steelmaking dust and sludge from steel production in converters,
- steelmaking dust from steel production in electric arc furnaces,
- blast furnace and steelmaking slag,
- ceramic debris.

INNOVATIVE PRODUCT – DECORATIVE GLASS WITH ADDITION OF STEELMAKING DUST FROM ELECTRIC AR6C FURNACES

Electric arc furnace dusts are among the most troublesome products of steelmaking processes being particularly difficult to store and transport as well as posing a serious environmental threat due to their physical and chemical properties [3-5]. Steelmaking dusts are production waste which can be utilised in various ways primarily depending on the dust’s content of zinc. The utilisation options are as follows:

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- furnace recycling by introducing dusts with the zinc content of up to 4 % (feeding of blast furnaces, converters, electric arc furnaces) together with other charge materials,
- zinc recovery from dust with the zinc content exceeding 20 %, e.g. in a rolldown furnace [6], by application of the INDUTEC technology or by hydrometallurgical methods, including EZINEX [7],
- recycling of dust with the zinc content from 4 to 20 % in other non-metallurgical processes.

In their studies, the authors of this article attempted to develop and propose utilisation options for dusts with the zinc content higher than 4 % and lower than 20 %, being waste produced by numerous electric steel-melting shops and causing them to face a serious environmental problem. The components found in the course of analysis of the dust chemical composition included 33,91 % or iron, 9,07 % of zinc, 0,158 % of lead, 1,99 % of manganese, 0,767 %; of sulphur, whereas the remaining components of the dust examined were as follows: arsenic (0,01 %), calcium (4,19 %), cadmium (0,02 %), chromium (0,25 %), copper (0,14 %), potassium (1,11 %), sodium (0,99 %), nickel (0,05 %) and phosphorus (0,16 %) [8].

For the sake of assessment of the potential negative environmental hazard caused by the steelmaking dust studied, leachability tests were conducted for the contaminants it contained. Results of the analysis of water extract prepared from steelmaking dust were compared with maximum values of permissible contaminant contents for treated industrial waste discharged into water or soil [9], and what was found was the excessive leaching of sulphides, fluorides and zinc as well as pH of the dust examined implying its basic nature. The dust water extracts tested were characterised by high electrolytic conductivity which evidenced a considerable content of water soluble inorganic compounds. Based on the results obtained, one could claim that if the waste in question was to be dumped in the environment, specific means of protection would be required, namely complete isolation of the dust from surface and underground waters or dumping of transformed dust (having previously applied appropriate physical or chemical processes) in order to reduce its harmfulness. Neutralisation of steelmaking dusts through storage is only permissible at hazardous waste landfill sites. The manner in which such landfills are arranged are laid down in the applicable legal regulations which mainly define such parameters as: filtration coefficient and thickness of the mineral separation layer developed at the bottom and on lateral slopes of the landfill, parameters of a plastic separation layer (geomembrane) as well as other parameters, such as those defining the drainage of run-offs caused by the waste washing with storm water or the scope of reclamation works required. Appropriate arrangement of a hazardous waste landfill site requires considerable financial outlays, and consequently all the actions bearing a potential to reduce the amount of dust in need of storage should be considered as reasonable.

Figure 1 Decorated glassware – black glass (left), powdering glass (right)

The steelmaking dust components such as iron, heavy metals, alkalis and sulphides are involved in the production of glass as additives, e.g. fluxing agents, dyes or agents modifying the use properties of glass. Contents of lead and cadmium in steelmaking dust are close to the contents that may be introduced to glass raw material mixtures as lead oxide (II) and cadmium oxide.

Domestic glassware products are made of molten glass of optimum optical properties, chemical and thermal resistance as well as appropriate hardness. The raw materials used in the coloured glassware production are characterised by colouring properties (for instance, they contain iron). An analysis of the domestic glassware production technologies applied shows that the chemical composition of steelmaking dusts suits the manufacturing of green or black glass best. An industrial test of the steelmaking dust application was conducted in the course of manufacture of typical commercial products, namely 20 and 30 cm high vases. Green glassware was obtained while adding 5 % of steelmaking dust, whereas the black colour of glassware was an effect of adding 15 % of steelmaking dust to the molten glass [5] (Figure 1). Decorated domestic glassware was made with steelmaking dusts as complete substitutes of the set of technological dyes previously used by applying dry dyes on the surface of semi-finished products (powdering method – Figure 1).

The industrial tests undertaken in order to examine the options of using steelmaking dust in domestic glassware production proved its usefulness as a molten glass dye in manufacturing of coloured domestic glassware as well as semi-finished glass products for artistic purposes. While preparing the molten glass, the steelmaking dust is subject to full vitrification and the heavy metals it contains are incorporated with the glass structure, and hence it generates no polluting emissions released into the environment.

INNOVATIVE TECHNOLOGY – OIL REMOVAL FROM IRON-BEARING SLUDGE (DEPOSITS)

Oily sludges (deposits) are currently utilised in small quantities, most commonly in production of Portland cement clinker or as a colouring additive in concrete production [10]. It is indeed for their oiling that wider application of those waste materials is rather difficult. What the oil content precludes is, among others, their utilisation in sintering plants equipped with electrostatic precipitators due to the hazard of self-ignition and heat fires.

Hence the development of the oil removal technology for iron-bearing sludge extends the capacity to utilise this iron-bearing metallurgical waste type. Oil may be removed from oily sludge by spraying it with organic acid at the temperature of 60 – 80 ^{o}C [11]. The deoiling products are: deoiled scale and effluents in need of treatment.

The innovation in the proposal made is to manage the oil removal process in a manner precluding generation of further waste. Oil removal from metallurgical waste consists in thermal degradation of the petroleum derivatives the sludge contains in a leak-tight, hermetic system [12]. The oily sludge is pre-dried (to attain the moisture content of ca. 10 %), and then delivered to a heating chamber where it is processed at the temperature of ca. 400 ^{o}C. In the chamber, the moisture remaining in the sludge is evaporated and the petroleum derivative is degraded. The processing products are: deoiled sludge with the iron content of 50 - 60 % as well as vapours of hydrocarbons and waters, first condensed and then separated. The hydrocarbons separated may be used as a semi-finished product in the oil refining process at refining plants or as fuel for oil burners, whereas the energy accumulated in hot water utilised for pre-drying of sludge. The deoiled sludge (scale) is then briquetted to become iron-bearing charge for blast furnaces. The iron content in deoiled sludge is only insignificantly lower than that of imported iron ores. Being hermetic and delivering the aforementioned processing products (scale, hydrocarbons, water), such a system exerts no negative environmental impact.

CONCLUSIONS

Introducing innovative products and/or innovative technologies into the market reinforces economic growth. And when the innovative operations are related to waste management, the benefits are multiplied. Metallurgical waste management is a difficult activity, primarily due to the deleterious impact of most such waste types on natural environment as well as human life and health. The solutions proposed in this paper are environmentally safe, constituting a proposal for innovative utilisation of a part of dust from electric steelmaking plants as well as oily metallurgical sludge. The outcome envisaged when developing and implementing such innovative solutions is the reduction of consumption of primary raw materials and improvement of natural environment.

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Note: P. Nowak is responsible for English language