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MANAGEMENT OF SOLID WASTE GENERATED BY THE INTEGRATED STEELWORKS ACTIVITY AND SOLUTIONS TO REDUCE THE ENVIRONMENTAL IMPACT

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Rezumat. *Dezvoltarea industriei siderurgice este condiționată de rezolvarea problemelor majore care decurg din relația industrie-natură, strict orientate spre controlul poluării şi protecția resurselor naturale şi energiei. În această lucrare se abordează problema managementului deşeurilor solide generate de un combinat siderurgic integrat şi a soluțiilor adoptate pentru reducerea impactului acestuia asupra mediului. Sunt prezentate pe scurt soluțiile tehnice aplicate şi se propun altele noi, în conformitate cu legislația de mediu specifică. Se propune un management integrat al deşeurilor solide care să aibă în vedere: cuantificarea (din punct de vedere cantitativ, calitativ şi al surselor de generare) emisiilor şi deşeurilor solide; depozitarea controlată; minimizarea emisiilor şi reducerea nocivității; transformarea deşeurilor în subproduse valoroase ca intrări în procesele de producție proprii sau în alte domenii.*

Abstract. *The development of steel industry is subject to solve major problems arising from industry-nature relationship, strictly targeted on pollution control and protection of natural resources and energy. In this paper we discussed about the management of solid waste generated by an integrated steelwork located near a major urban area and the adopted solutions for the reduction of environmental impact. There are summarized technical solutions that are currently applied and were proposed some solutions that can be applied in accordance with the environmental legislations. The new solutions are proposed for integrated management of solid wastes in accordance with: the exact quantification (quantitative, qualitative and the generation sources) of emissions and solid wastes; controlled storage; minimization of the wastes and its harmfulness; transformation of the wastes into valuable by-products used directly by the company in a subsequent process, or by external down-stream user.*

Keywords: controlled storage, environment, wastes, management.

1. Introduction

Nowadays, the metallurgical industry is in front of a big challenge. This is not so much in eventual shortage of raw materials and energy or competition against other materials but rather in rapidly increasing demands to solve the environmental problems. Environmental protection by safe elimination or recovery and usage of harmful by-products and wastes will be a very essential task in the development of metallurgical processes. The key in the development of

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metallurgical industry is to solve the major problems in respect to the industry-nature relation. For the steelmaking industry is imperative necessary to eliminate the wastes by their transformation into by-products [1-3].

The essential changes for steel industry can be aimed to development of the metallurgical processes in respect to ecological approach. The fields of industrial ecology systems engineering and ecological approach are used to developed a closed-loop system in which no resources are depleted, all materials are perpetually reused, and no harmful waste is produced or discharged. The steel industry provides a classic example of an evolving industrial ecosystem. The strategy of converting waste energy and materials into useful products is central to industrial ecology. The steel industry provides numerous examples of loop closing at the process plant.

There are two main directions for the steel producer's strategies in accordance with the increasing of environmental efficiency: development of the advanced technologies for that the emissions are essentially reduced and increase of the recycling ratio of the by-products near to 100%.

The production of steel and iron into ideal factories named "dream factory", involves pushing the boundaries of metallurgical processes to a point where virtually any output can be used as input in other subsequence of same flow-line.

The ecological systems engineering applied to industrial flows involve the development of those technological flow lines with closed loop in which no resource is removed, all materials are reused continuously, no hazardous waste or other product is discharged into the environment, in literature this is found as the "steel industry waste free" or "zero waste steel industry". Thus is followed the approach of the concept for the natural substances which follows a closed loop.

Finding the efficient solutions in point of economical technology flows and ecological for the steel industry must allow an affirmative answer to the question "Is steel a green material?" In order to make the steel become what is called "the environmentally preferred material" one should primarily identify and then apply the most effective methods for retaining all possible iron units in the production cycle-use-recycling [4]. By other hand should be used other by-product in own flow-line or in further application. Management will determine the successful protection of natural resources, the recovery of those who were consumed and thus costs can be reduced and also eliminate the environmental impact of wastes.

The steel industry of the European countries is motivated in the promotion of a new industrial management. The forces driving the changes required in this area are legislation, public pressure and the image of a "green product". The reorientation of iron and steel industry on resources saving technologies is the basis of steady development in many countries. The solution of the environmental

problems is not only the application of effective cleaning devices and systems, but also the introduction of new technologies; providing a decrease of energy and raw materials consumption and quantity of various emissions [5].

2. Solid waste definition and sources of waste generation

A simplified schematic of the iron and steel production process appears in Figures 1 and 2. There are basically two separate routes to making steel. The integrated steel production path uses a blast furnace to produce molten pig iron using inputs of iron ore, coke, and limestone. This pig iron is subsequently processed in a basic oxygen furnace to produce molten steel. The other path uses an electric arc furnace to melt either exclusively steel scrap or combinations of scrap and directly reduced iron (see Figure 1). From this point, the process paths converge to continuous casting of steel into slabs, blooms, or billets. These intermediate products are then transformed into an array of finished products, including sheets, strips, plates, pipes, rods, bars, structural shapes, and other miscellaneous products (see Figure 2) [6].

For the steelwork analyzed in this paper, the integrated steel production path route is available. This path directly generates more environmental residuals than scrap based production because it converts virgin materials [7].

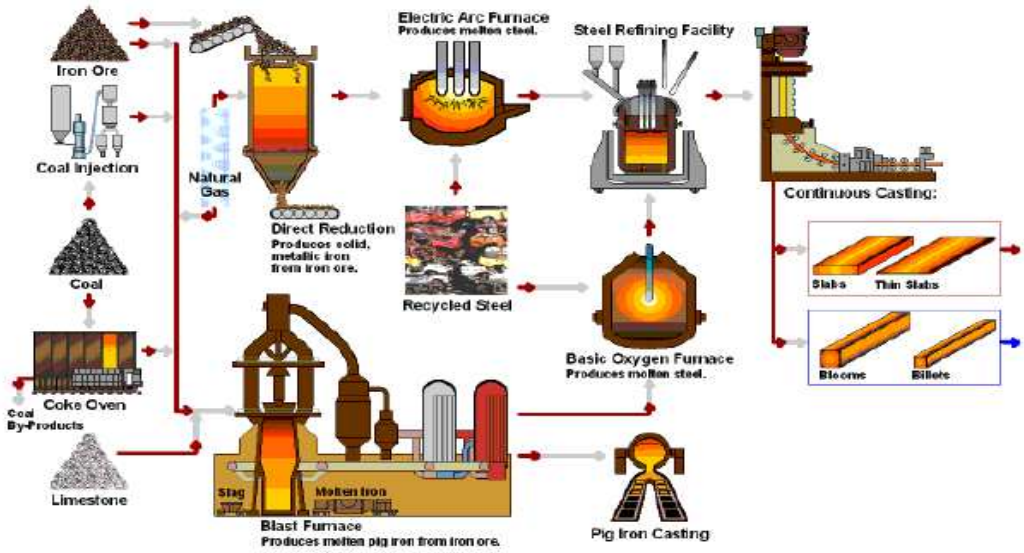

Fig.1. The steel making flow-line [6]

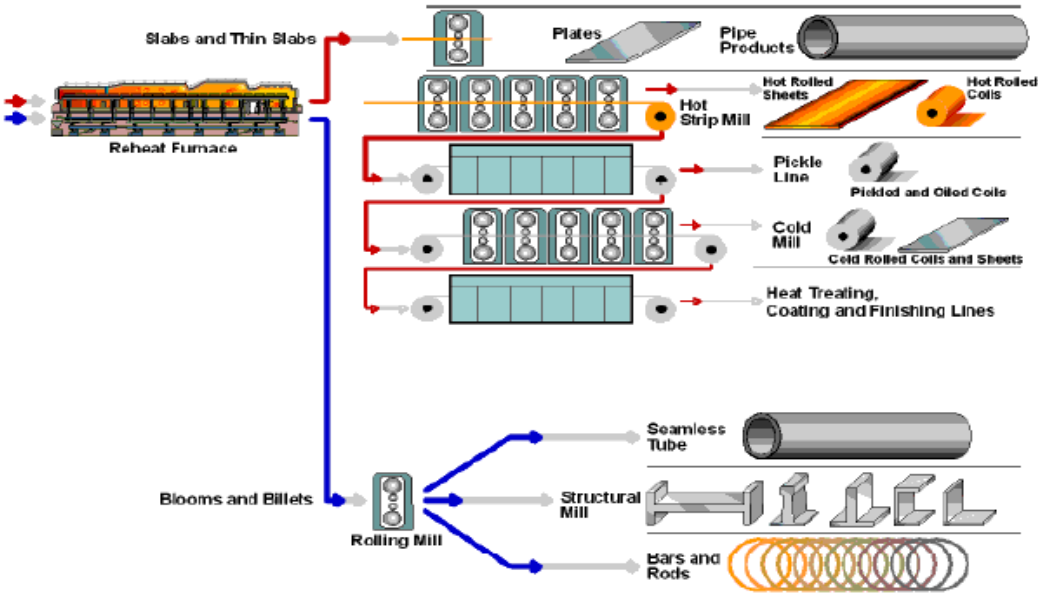

Fig.2. The steel finishing flow-line [6]

All stages of the integrated steelworks flow from the transport, storage and preparation of raw materials to the steel finishing steps generate air emissions, water emissions and solid wastes. More than half of the mass input of the iron and steel industry becomes outputs in the form of off-gases and solid wastes/by-products. These by-products are produced in the different stages of the production process including: sinter plant, coke making, iron making, steelmaking, rolling mills. All metallurgical residues can be divided by origin into internal and external materials.

An important part of the solid wastes contain valuable iron units:
- BF dust or sludge generated by the dry and wet off-gas cleaning systems;
- BOF sludge generated when off-gas is cleaned in a wet process. Separately, the coarse and fine particles (the ratio coarse/fine is ~40/60) are collected from a screw separator;
- Oily mill sludge collected from water treatment of the cooling cycle from continuous casting;
- Oily mill scale collected from rolling mill.

The most ponderous by-product of the iron and steel making process are slag. There are primary slag from blast furnace and basic oxygen furnace, and secondary slag from refinery process. They created environmental problems: they are harmful materials, and its disposal required large sites.

3. The present situation of the valuable solid wastes

The numerous solutions are available on the steel industry to solve the problem of these solid wastes, but only a few are capable to recycling a large variety of the residues in an environmentally responsible manner at low investment and operation cost.

Many operating steel works was concerned only to handle and storage these wastes. These steel makes need be more proactive towards finding solutions because today they are confronted with the following problems:

- Disposal cost for the iron-bearing wastes: non-hazardous wastes from integrated steel works can cost more to send to a landfill; a hazardous material can cost more to be stabilized;
- Recovery of valuable iron units for economic effect;
- Controlling steelmaking raw material costs: successful steel makes must continually reduce costs. Effective ways to do this is by processing waste materials and thereby eliminate the associated landfill fee;
- Environmental problems of sinter plants in respect to stricter regulations for integrated steel works emissions. Many companies would shut down sinter plants if there finding other viable alternative;
- Closure of on-site landfills: steel works wide have stockpiled wastes on site for years. Theoretically, because the land is “free”, this is a low-cost approach. However, many of these on-site landfills are filling in and coming under attention of the environmental authorities.

The Romanian integrated steelwork is confronted with the problem of the unrecycled solid wastes. Integrated steelwork of Galati is the largest Romanian steel manufacturer accounting for more than 80% of the Romanian crude steel production and has a monopoly in the flat products sector [8]. By correlation, this is a major contributor to the pollutant emissions and the solid wastes. A considerable amount of these are disposed in-side or on-side of steel work. For the iron-bearing wastes, there has the following situation:

- The total quantity of BF sludge cannot be recycled in the sinter plant due to the chemistry. The most harmful element in this case for the BF process is Zink. With 1.5 % Zn, the BF sludge cannot be recycled in the sinter plant. Therefore the sludge is pumped to an internal landfill;
- The BF dust is collected in the dust tasks. The dust tasks are emptied on a regular basis and the dust is transported directly to the sinter bedding area. The dust is then charged to the bedding together with other materials;
- The total quantity of BOF fine sludge cannot be recycled in the sinter plant due to the chemistry. The most harmful element in this case for the BF process is Zink. With 1.5 % Zn, the BOF fine sludge cannot be recycled in the sinter plant. Therefore the sludge is pumped to the same internal landfill as the BF sludge;

- The BOF coarse sludge is collected and charged after a short dewatering time directly to the sinter plant;
- The small quantity of oily mill sludge is charged after dewatering to the sinter bedding. The problem for the oily mill sludge recycling is mainly the high oil content. The presence of oil implies a big risk when recycling in the sinter plant. The higher quantity of oily mill sludge is stored in-side of integrated steel work.

The slag is the most ponderous by-product for the integrated steel work. Together with other solid wastes the slag was uncontrolled historically landfilled. In this situation a dump was grows near the steel work (see Figure 3). At present, 160 hectares are affected by this dumping. This uncontrolled storage has a major impact on environment. The soil, the water and the settlements are affected.

Fig.3. Solid wastes dumps located near the integrated steel work

For conclusion, at present, dust and sludge from the integrated steelwork is recycled only as raw material for sintering. The sinter plant plays a central role in the integrated steel work for reuse of these wastes which would have to be disposed otherwise. The utilization of the recycling of the iron-bearing wastes generated by integrated steelwork as iron raw materials substitute involves supplementary environmental problems. The flexibility of the sintering process permits the iron bearing wastes valorisation but environmental problems associated these must be resolved. Due to the limitation of the amount of dust and sludge that can be charged into a blast furnace, a higher volume of these solid wastes is disposed in landfill [9].

The metallurgical slag from different sources was uncontrolled dumped. There was mixed blast furnace slag, basic oxygen furnace slag, electric arc furnace steel slag, secondary slag from refinery process. Varied solid wastes (trough rubbish, refractory wastes and other) were dumped to the same landfill as the slag and the uncontrolled mixture is resulted. For this reason, the knowledge of the characteristics or the separation of the components for the old solid wastes mixtures is not possible today. A united theory and technology do not exist for the utilization of all wastes dumped. At present just the new slag is separately stored and partially valorised.

4. Waste management applied to the integrated steel work

In accordance with the new legislation the main goals concerning waste of industrial processes are at first the avoidance, the reuse and only in last consequence of the waste stored.

In the context of modern concepts like total quality and sustainable development promoted by the proposed environmental policy, the evolution of metallurgical industrial systems is mainly based on the understanding capacity of metallurgical process, correlated with environmental issues and balance restoring, especially by recycling: metallurgical process – environment – recycling – energy.

The environmental excellence, incorporated in all processing activities must be promoted by the following principles:

- Constant improvement of environmental performance, by systematic monitoring of environmental factors, minimizing environmental impact of waste and the use of „pollution prevention" principle;
- Avoiding waste generation, and where wastes are produced, they must be capitalized and if not technically and economically possible, wastes should be stored in controlled special zones (after neutralizing treatments, stabilization), avoiding environmental impact;
- Implementation of new „clean" technologies that produce reduced quantities of wastes simultaneously with a economy of energy and raw materials.

According to the principles of environmental management a company should systematically carry out actions that enable it to identify environmental aspects, evaluate the impact of their technologies on the environment, define the scope and use the information while setting for its environmental strategy applying. Prior the environmental aspects are necessary to be analyzed and identified. The identified aspects evaluated in terms of quantity and quality must be in accordance with the establishing objectives of the environmental policies. Out of the whole set of identified aspects, the integrated steel work selects the significant ones, which have to be controlled and monitored by itself.

The aspects that are most important for environmental protection are the key elements of environmental strategy. Sustainable development will not be brought about by environmental policies [10, 11].

The integrated steel work is motivated and forced to promote a new industrial management for the wastes. The forces driving for the changes required in this area are governmental legislation, local regulations, punitive measures and finally the public pressure.

Laws, regulations, taxes and payments, connected with preservation of the environment and rationalization of the nature management, have started to play an essential role in many countries since 1960 [5].

Romania was adapted these European instruments and makes programs for each emissions, in order for all industrial wastes. The local authorities were analyzed the actual situation of the integrated steel work. They are established a Concordance Environmental Program which the integrated steel work staff obligations in accordance with local regulations, and governmental laws [12].

First of all, wastes management from analyzed the integrated steel works, must lead to environmental impact minimization. To solve the solid wastes problem, the integrated steel works must address to waste management concerning the two main categories of wastes: waste stored history located in slag dump near the integrated steel works, new wastes from steel making processes.

The development strategies of the integrated steel works around the world have two directions: development of the advanced technologies in respect to the substantially emissions decreasing and increasing the recycling ratio of the by-products. Comparatively with the practice and trends manifested in the world, the Romanian steel industry has unsolved problems for the collection, transport and storage of all categories of wastes, as well as the solutions of their recovery.

The proposed policies is also subject to limit the negative impact to affected areas in accordance with the environmental strategy and policies, particularly by rehabilitation of the affected areas by historical storage of such solid wastes. In

order can be achieve the efficient technical and management issues from energetic, economic and environmental point of view.

Conclusions

Limited landfill capacities, rising costs, tighter laws and governmental regulations, and the public environmental discussion, make it increasingly difficult to continue the current practice. Therefore, new technologies had to be developed to recycle the residuals back into the production process and prevent dumping, for environmental and cost reasons. Solutions for best available techniques for iron making and steel making can be applied for the control and prevention all emissions.

Several industrial and pilot technologies of pyro-hydrometallurgical as well hybrid nature have been developed for treatment of iron-bearing steelmaking wastes: rotating hearth furnace process (Inmetco), fluidized bed process, circulating fluidized bed reactor, plasma process (Siromelt, Plasmelt), Daido Special Method, CONTOP, RADUST [13].

Environmental concerns and the capital and operating costs will lead to choose the optimum solutions. The maximum valorisation of the slag is possible in varied applications.

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