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The Current State and Development of the Integrated Use of Technogenic Waste

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Abstract: *From the very nature of mineral raw materials arises the need for its complex processing. Therefore, the fullest possible use of raw materials is possible only when several processing enterprises are merged into a single structure. Consequently, for the rational use of raw materials it is necessary to create territorial inter-sectoral production associations consisting of enterprises of different industries. When this occurs, a connection into a single complex of productions of various industries, representing either successive stages of processing raw materials (for example, smelting iron from ore and conversion of iron into steel, and then, perhaps, the production of certain finished products from steel), or having a supporting role in relation to each other (for example, processing of by-products, production of packaging items, etc.). The integrated use of available resources by combining various industries allows the use of waste from one production as feedstock for another. The regional approach to the processing of material and energy resources helps to reduce the loss of raw materials, materials, energy, reduces transportation costs and labor costs, expands the range of products made from the raw materials used. The creation in the region of combined production and ¬ economic systems, including a group of enterprises of various industries, necessitates the formation of a common technological chain. In this case, it is possible to develop regional technology, which is a combination of technologies of individual industries located in a given territory and interconnected with the task of maximizing the use of raw materials with the lowest costs.*

Keywords— ***metallurgy, slag, complex use, recycling, ecology, environmental protection, technogenic waste, production.***

1. Introduction

Processing of raw materials consists of a number of interconnected unit technological processes. The theory of unit processes (systems) is studied by physical chemistry and the theory of metallurgical processes. However, in the transition from single processes to their complex combinations, which form the basis of technological schemes of modern enterprises, one has to face a large amount of dishonest information of an empirical nature [1].

There are a number of developments in the scientific foundations of chemical technology that can be used to describe metallurgical processes. Mathematical models of chemical technological systems (CTS) have been created as the main element of the design of chemical production. Methods for calculating material and energy balances and determining the degrees of free CES, methods for creating mathematical models and the principle of optimization are given. A thermodynamic criterion for the wall efficiency of the simulated CES is introduced [2-5].

The technological methods underlying the CTS are assumed to be given: the optimization of parameters and equipment is considered, but not the essence of technological operations. The selection of the technological scheme and its individual elements is assumed to be completed before the start of these stages of work, which is quite legitimate in the technological design and management of enterprises, but not enough either to choose the direction of scientific research, not to find methods for improving the technology of operating enterprises [6-9].

A technique for identifying objects, analogs, determining to which generation, in comparison with the created object, should be attributed to the previous or new one, and in the presence of a variety of solutions, is proposed. Carrying out their comparative analysis in six stages in order to select the most progressive solution to the problem as a whole or its individual elements. This experience is very interesting and fruitful for analyzing the state of the art, especially in patent research (a necessary stage of any scientific and engineering work), but it is insufficient neither for creating new solutions to particular problems, much less new technological schemes for processing technical waste [10-15].

There are several reasons limiting the capabilities of the analog method. This is, firstly, the complexity and non-standard nature of a significant part of metallurgical raw materials, which limits the transfer of experience from one facility to another. Secondly, the requirements for the choice of technology for newly built and reconstructed enterprises may not coincide. Thirdly, the new cannot be built only on improvement by analogy: the essentially new must differ significantly from its analogues [16].

The generally accepted criterion for evaluating a technological scheme is the economy. When performing a technical and economic assessment, the indicators of several technological schemes are compared, that is, the technical and economic assessment is a very important, but relative criterion that plays a role in choosing the best option from several compared ones [17].

From the standpoint of ecology, the technology should be waste-free. This means that all the main materials introduced into the process - raw materials, reagents, fluxes, auxiliary materials, etc., should be discharged only in the form of marketable products or in the form of intermediates processed in other industries [18].

It is not possible to completely eliminate the formation of waste products, but reducing emissions is one of the main directions of improving metallurgical production [19].

The creation of low-waste industries is inextricably linked with the problem of the rational use of reagents and related components of raw materials. According to the method of using reagents and basic materials, technological schemes can be divided into five groups [20-23]:

1) reagents are consumed in the process and are introduced in waste products;
2) reagents are consumed in the processes and introduced in the form of intermediates used in other industries;
3) reagents are consumed in the processes and introduced in the form of commercial by-products.
4) the technological schemes provide for additional operations for the regeneration of reagents.
5) reagents are regenerated within the technological cycle without special operations; in this case, a closed loop technology is usually used.

It is quite obvious that the use of reagents and minerals is not only an environmental problem, but also an economic one. Of those from other positions, the most attractive technology is the second, third and fifth groups [24].

In low-waste technologies, all of the listed groups of techniques are used, except for the first. When creating technological schemes for processing man-made waste, which are tasks of the highest ranges, in the form of uncertainty of technological tasks for setting, goals and ways (triple uncertainty), the solution requires a "feedback" methodology. Indeed, these uncertainties can only be disclosed by repeatedly correcting decisions as the work progresses, since they are all interconnected by direct and feedback [25].

The complex use of raw materials and metals in the conditions of territorial-industrial complexes (TIC) is determined by the very nature of mineral raw materials, which necessitates its complex processing. Briefly, the formation of TIC can be characterized as follows [26-27]:

1) the geographical grouping of the enterprise into related technological combinations within the territories of the industrial zone.
2) location of industrial enterprises, taking into account the direction of movement of raw materials, waste and by-products of production.
3) technological combination of production, processes (energy, raw materials, etc.).
4) economic combination through the mutual exchange of products of production.

creation of a common infrastructure.

2. FOREIGN EXPERIENCE IN THE RATIONAL USE OF SECONDARY MATERIAL RESOURCES

Considering the threat to people and the environment from the accumulation of waste and the irrational use of raw materials, many countries are paying considerable attention to this problem, using all possible means: economic, legal, educational. This allowed many countries to achieve significant success in the processing of basic types of waste by the mid-1980s of the last century [28-30].

In the United States, government regulation at both the federal and state levels is playing an increasingly prominent role in stimulating the production of secondary raw materials from waste. The annual expenditures of the government of the US enterprises on environmental protection from pollution exceeded 100 billion. dollars, and 60% of this amount is spent by the entrepreneurs themselves. This is due not so much to their high sense of duty to society and the coming generation, as to the real necessity arising from the legislation in force in the country. For comparison: in 1998 enterprises and organizations of all forms of ownership in Russia spent about 9.1 billion rubles on environmental protection and rational use of natural resources [31].

Adopted in the USA in 1976. the law on the control of solid waste focuses on the production of secondary materials from them. The country has standards for the mandatory minimum content of secondary raw materials in marketable products, and a law has been passed prohibiting the disposal of waste produced outside the territory of this state [32].

Some state governments are even more active, with high landfill fees, resulting in increased consumption of recycled materials. New Jersey has passed a 50% tax credit bill for manufacturing equipment that manufactures products containing at least 50% recycled materials [33].

The most important economic incentive for recycling is that recycling is becoming the cheapest way to deal with waste. Much attention is paid to the problem of waste in the EEC countries, whose strategy is as follows [34-37]:

1) prevention of waste generation;
2) recycling of waste and secondary use of materials;
3) optimization of the final waste treatment;
4) regulation of waste transportation;
5) carrying out measures to rehabilitate the environment.
6) Particular attention in the EEC countries is paid to measures for:

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7) revision of the range of raw materials and materials used in the manufacture of a particular product, with a preference for environmentally friendly substitutes;
8) revision of technological processes in order to develop safer for the environment;
9) development of new technological processes that allow the reuse of materials in the production cycle after their initial use;
10) inclusion of environmental parameters in product quality standards.

In western Europe, waste processing is carried out mainly by small and medium-sized enterprises, which employ 3.5 million. human. They recycle over 37% of solid waste [38].

In the coming years, further development of the waste processing industry and a corresponding increase in employment is expected in the EEC countries, which will have a beneficial effect on the economy as a whole. In these countries, the cost of waste treatment is estimated at 9% of GDP, but the growth rate is 20% per year [39].

Japan has made great strides in terms of environmental management. Already by 1985 in Japanese industry, up to 60% of the waste was utilized [40].

Industrial waste, according to Japanese law, is understood as waste arising from production activities, including ash, slags, waste oils, acidic, alkaline waste, plastics, etc., and its assignment to specialized enterprises is only of an auxiliary nature.

Japan has standards for the processing and disposal of hazardous industrial waste. For example, in order to prevent pollution of seas and oceans, standards prohibit the dumping of such waste. If they are buried, they are required to be isolated from water resources entering public consumption and from groundwater [41].

In general, in the manufacturing industry in Japan, more than half of all generated waste is treated (52.3%). What kind of savings in raw materials is provided by waste disposal in Japan can be judged by the following data. The use of each ton of secondary aluminum replaces more than 5 tons of main raw materials and auxiliary materials. The production of 1 ton of paper and cardboard from waste paper releases 5m3 of wood and 165-200m3 of water. The production of aluminum, steel and paper from recycled materials saves respectively 97; 74 and 70% energy; compared to production from primary raw materials, will reduce imports of bauxite, timber, metallurgical ores, oil and gas [42].

In Japan, it is believed that the main areas of waste recycling are reduced to:

1) creation of systems of a closed production cycle;
2) reuse of waste for its original purpose without additional processing;
3) disposal of waste as a raw material for the manufacture of the initial product (waste paper for the production of paper, scrap metal for the production of steel);
4) the use of waste to obtain any marketable product (incineration to obtain energy, composting to obtain fertilizers);
5) the use of waste to obtain fill-up areas, dams, roads, etc.

In the course of organizational work on the rationing of waste as a branch of the economy, the government bodies of Japan solved the following problems:

A. Hiring a shift for waste collection and transportation enterprises.
B. Ensuring the stability of demand was achieved by rationing the mandatory additions of secondary raw materials to primary ones.

The maintenance of quality indicators was achieved by the introduction of state standards, both for the waste itself and for the products of their processing, which facilitated the collection, processing of waste and the sale of products of their recycling:

A. Reducing the cost of transporting waste.
B. Ensuring the stability of prices and profits of small enterprises was achieved by establishing and maintaining stable prices for waste.

3. REASONS FOR WASTE GENERATION AND CURRENT TRENDS IN THEIR PROCESSING

An analysis of the work of mining and metallurgical enterprises made it possible to identify the following reasons for the current situation at the present stage of development of technology and technology for processing ores, which inevitably lead to the formation of waste [43]:

a) If earlier the progress was based on an increase in labor productivity, now there is an increase in the productivity of resources and a decrease in the cost of the resulting marketable products;
b) A stable, but extremely erroneous, but in essence, opinion about the unlimited resource and energy potential has been formed;
c) Striving to develop the richest deposits for reasons of immediate economic benefits, avoiding their combination with poor raw materials, which, with this approach, is off-balance;
d) Absolutely insufficient allocation of funds for nature restoration, which is the main thing;
e) Deterioration of the technical and economic indicators of ore mining due to the inevitable involvement of hard-to-reach and recoverable ores in processing;
f) The growing negative impact of mining on the environment associated with the growth of significant volumes of waste accumulated on the earth's surface in the form of tailings, overburden and substandard minerals;

g) Any pollutant, after being released into any part of the biosphere, dissolves to the limit in it, and also simultaneously penetrates into other parts of the biosphere and interacts with them;
h) Incomplete disposal of waste due to imperfection of the process itself or the presence of significant impurities in the original product during a continuous technological process leads to environmental pollution.

In general, the following main trends in the development of technologies for processing waste from hydrometallurgical industries are noted [44]:

a) Organization of fundamentally new processes for obtaining products, allowing to exclude or reduce processing stages (or technological stages), which generate the bulk of waste;
b) Development and implementation of modernized systems for processing production and consumption waste, which should be considered as secondary material resources. During the operation of modern water and gas purification systems, solid waste is formed, which is a concentrated mixture of pollutants;
c) Recycling waste by maintaining closed-loop production systems and reusing them for their original purpose without additional processing of waste raw materials or by mixing waste with raw materials;
d) Creation of drainless technological systems on the basis of existing, introduced and promising treatment methods, use in wastewater circulation, in which a sharp reduction in water consumption is achieved, but as a rule, secondary pollution is formed in the form of solid residues or saturated solutions;
e) The release of products of a fundamentally new quality and the creation of technologies that ensure the complex extraction of metals from liquid and solid waste using highly effective methods of biotechnology;

The main tasks in the development of low-waste and non-waste technologies in metallurgy and complex waste processing, in order to reduce the cost of the resulting products, are to develop fundamentally new directions, unconventional methods and improve existing technologies of metallurgical production in order to reduce harmful emissions at all stages and full use of the resulting waste [45].

Waste from metallurgical production is classified as follows:

1. Stored off-balance ores;
2. Overburden (mineralized masses);
3. Intermediate waste from the ore preparation process of hydrometallurgy;
4. Waste tailings of the flotation and sorption process;
5. Slags from the pyrometallurgy process.

Waste reserves, concentrated in the form of dumps of balance and off-balance ores, tailings and slag dumps, constitute one of the types of mineral resources and are classified as technogenic deposits [46].

Providing mineral resources is a fundamental condition for the development of the world community. At the same time, it is known that in a fairly distant future, the material needs of mankind will be covered by 75-80% through the processing of minerals with an increase in the amount of waste in the form of overburden and substandard minerals.

Thus, using the example of developed countries, one can see that resource conservation and waste disposal, and in the ideal case, the organization of the economy on the principles of recycling is a real chance of society in preserving the natural environment and its resources.

4. Conclusion

Analysis of the state of work on the disposal of liquid and solid waste indicates the absence of systematized, coordinated, scientifically substantiated methods for their processing. The development of scientifically grounded technologies for processing specific waste and in the industry as a whole, providing additional extraction of valuable components of non-ferrous and noble metals, is an important direction for increasing the economic efficiency of mining and metallurgical production.

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