POSSIBILITIES FOR THE UTILIZATION OF TECHNOGENIC WASTE FROM THE ACTIVITY OF MINING AND PROCESSING PLANTS IN THE RHODOPE REGION

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ABSTRACT. Sustainable and long-term development is a major goal in the use of non-renewable natural resources nowadays. The concept of sustainable development of the mining industry includes the rational and efficient utilization of mineral resources. From an environmental point of view, it is necessary to combine many different approaches for the protection of the environment. One of the most important and complex environmental tasks is the solution to the problems related to the treatment and utilization of the technogenic waste. The aim is to utilize waste as a secondary resource. The issue of "Waste management" is regarded more and more seriously, especially after Bulgaria joined the European Union. This paper presents the possibilities of using the technogenic waste from the mining and processing industries in the Rhodope region as a secondary resource.

Keywords: mining and processing industries, Rhodope region (Bulgaria), technogenic waste, utilization of waste

ВЪЗМОЖНОСТИ ЗА ОПОЛЗОТВОРЯВАНЕ НА ТЕХНОГЕННИ ОТПАДЪЦИ ОТ ДЕЙНОСТТА НА МИННО-ДОБИВНИ И ПРЕРАБОТВАТЕЛНИ ПРЕДПРИЯТИЯ В РОДОПСКИЯ РЕГИОН

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РЕЗЮМЕ. Устойчивото и дългосрочно развитие е основна цел при използването на невъзобновимите природни ресурси в днешно време. Концепцията за устойчиво развитие на минната промишленост включва рационално и ефективно усвояване на минералните ресурси. В екологичен план се налага комбиниране на множество различни подходи за опазване на околната среда. Една от най-важните и сложни екологични задачи е решаването на проблемите, свързани с третирането и утилизацията на техногенните отпадъци. Целта е оползотворяване на отпадъците като вторичен ресурс. Темата „Управление на отпадъците" се развива все по-сериозно, особено след присъединяване на страната ни към Европейския съюз. В настоящата статия се разглеждат възможностите за използване на техногенни отпадъци от минно-добивната и преработвателна промишленост в Родопския регион като вторичен ресурс.

Ключови думи: минно-добивна и преработвателна промишленост, Родопски регион (България), техногенни отпадъци, оползотворяване на отпадъци

Introduction

The development of the mining and processing industries makes the mining sector one of the main engines for the economic development of our country. A serious problem in the extraction and processing of natural resources is the generation of large quantities of waste. A National Strategy for the development of the mining industry was adopted in 2015 to meet the existing legal and regulatory framework for underground natural resources in the European Union. The strategy includes the sustainable and balanced management of mining waste and the minimization of waste through its utilization in relevant industrial sub-sectors. The recovery of mining waste will help reduce its amount by using it as a secondary resource for various industries. It will also reduce environmental pollution associated with the extraction and processing of primary raw materials, and will protect human health.

This paper aims at exploring the possibilities for the utilization of technogenic waste by analyzing the mining and processing industry in the Rhodope region. The mining industry is one of the most important economic sectors in this region.

The extraction and processing of minerals, non-metallic minerals, and coal in the Rhodope region is the main subject of the present study. The above are classified as non-renewable natural resources and their processing and efficient recovery is essential because of their depletion. Minerals (lead-zinc and gold-containing ores) and non-ore minerals (bentonite, perlite, zeolite and lignite coal) are extracted and processed in the region. Depending on the minerals that are extracted and processed according to the accepted technological scheme of the individual enterprises, different waste types are obtained. The utilization of these wastes is important both in economic and environmental terms.

The present work examines the types of waste generated by the production and technological processing and the alternatives for their use as raw material. The essence of the problem is to follow the concept of sustainable development of the mineral raw materials sector by limiting the depletion of non-renewable resources and reducing their harmful impact on the environment.

Characterization of mining waste

The characterization of mining waste aims to identify and assess its properties and behaviour, as well as to select management methods that provide: prevention, reduction or minimization the harmful impact of waste on the environment, safety, and human health (Grigorova, 2011). For the characterization of mining waste, information is needed about the region, including: relief, soils and vegetation, surface and underground water, climate, threats of natural disasters (earthquakes, landslides, floods, etc.) and socio-economic data. Technological characteristics of the deposit, closed or being mined, are of great importance (depth, shape, and size of the deposit); applied extraction technologies in the region and their characteristics; applied processing technologies (used reagents, concentration and quantities, requirements for the circulating water, purification technologies in the mineral processing plant; sources of pollution in mine dumps); transport connections (auto transport, conveyor belts, pipelines); opportunities for backfilling of processed mining sites. Consideration should be given to:

- The geological characteristics of the deposit - characterization of the underground resources, the country rocks and waste rock (their type, mass and volume); mineralogical characteristic; granulometric characteristic; chemical properties; hydrothermal changes, as well as changes that occurred as a result of the weathering and supergene processes of the underground resources and the country rocks; physical, engineering and technical characteristics (volumetric weight, density, porosity, strength, elasticity, plasticity, fissuration, hardness, abrasiveness, permeability, filtration properties, moisture, sludge separation, dusting, etc.); risk of acidic water generation; surface water properties, etc .;
- Characterization of mining waste - annual (hourly) output and total quantity; granulometric composition of the solid fraction; solid waste or suspended sludge, pulp density, solid phase density; chemical composition of the liquid phase, metal content.

The geochemical characterization of mining waste includes assessment of the mineral and chemical composition of the waste, the presence of residual chemical compounds (reagents) from its processing, as well as predicting the leakage potential of chemicals polluting the components of the environment and affecting the health and safety of people, also, the leaching of metals leading to soil contamination (Panayotova et al., 2013).

External factors, such as transport, storage, type of storage facility, may also have effect on the characteristics of mining waste.

Each mining company must have a waste management plan compliant with European directives.

Information for the characterization of mining waste is used for the preparation of management plans, working projects for the construction, for the operation and closing down of mining waste facilities, and for the categorization of the mine waste storage facilities (Nishkov, 2010). The treatment and utilization of waste generated by ore beneficiation is less developed than the utilization of metallurgical waste. It is necessary to search alternatives for relatively closed production cycles where it is possible to use waste as a secondary resource.

Generated waste from mining and processing plants and opportunities for its utilization

Waste from the beneficiation of lead-zinc ores in the Rhodope region

In the Rhodope region, the polymetallic lead-zinc ores in the ore fields near the towns of Madan, Rudozem, Laki and Zlatograd, are with the greatest industrial importance. The production of lead-zinc ores is carried out in an underground way with systems of mining adapted to these conditions. The lead-zinc ores in the Rhodope region are processed by a flotation method of beneficiation. During the flotation process, the waste rock and small amounts of non-extracted useful minerals are separated as solid waste; a liquid phase is also formed, consisting of water, suspended solids and residual flotation reagents. The slurry is discharged in the tailing pond, where the suspended particles are precipitated. Some natural physicochemical processes occur, leading to the neutralization of some compounds or to the formation of soluble compounds. The precipitated waste contains valuable components for which extraction is possible when new technologies are introduced. This is particularly important for waste from past productions, since rich ores were processed with less developed technologies then and the accumulated waste contains metals of high concentration. At present, pyrite (FeS_2) is not extracted as a concentrate and it precipitates into the waste because of the content that is currently unprofitable for extraction. With the development of mining waste processing technologies, it is possible to extract metals from sources with low metal content, such as mineral processing waste. The introduction of a new technological scheme will enable the extraction of pyrite which will be used for the production of sulfuric acid.

Secondary pyrite tailings were treated by using an oxidizing-reducing roasting technological flow sheet. The two-stage oxidizing roasting technology is suitable for eliminating S and As. The material was enriched in Fe to more than 64% after treatment at a temperature of over 600 - 700°C and can be used as a fine iron-making raw material (Gu et al., 2008).

It is proposed to process the material from the mine dump of the Bor Mine, in which the main sulfide mineral is pyrite. Before the flotation process, the pre-treatment of the material is essential. For the release of sulfide minerals from the rock formations, better results have been obtained by abrasion of the surface through friction compared to the conventional grinding (Panayotova, 2011).

A mineral admixture with photocatalytic activity is obtained through acid leaching-hydrolyzation and the single calcination method, using industrial waste pyrite tailings and high titanium slag as raw materials in which pyrite tailings were the substrate and high titanium slag was the source of titanium (Zhang, 2017).

It will be possible to extract Mn, Fe, Zn, Pb, Cu, Au, Ag, Ni, Co, and others with the use of modern technologies and technical means.

Waste from the beneficiation of gold-containing ores in the Rhodope mining basin

Since 2006, gold-containing polymetal ores have been extracted from the Chala deposit by means of underground method in the Eastern Rhodopes. Their processing and beneficiation are realized in the Kardzhali Enrichment Factory through gravity technology. In 2012, cyanide technology, the so-called CIL-process (Carbon in leach), was introduced for the processing of the gravitational waste. This technology provides a high level of extraction of gold, over 95% (http://gorubso.bg). Costs of reagents are low and the introduced technology for cyanide destruction in the waste pulp guarantees concentrations of pollutants, including cyanides, that comply with the Bulgarian and European legislation.

The waste, generated by the processes of gravitational beneficiation for the period 2006 – 2012, is shipped from the tailing pond and processed for finishing off the gold extraction.

The mining of polymetallic gold and silver ores from the Sedefche deposit in the municipality of Momchilgrad is being developed. The ore will be extracted by means of open-pit mining and processed in the enrichment plant in the town of Kardzhali.

Mining and processing of gold-containing ores from the Ada Tepe site of the Khan Krum deposit, in the town of Krumovgrad is also envisaged. The main beneficiation process for the extraction of gold and silver from the ore will be realized by means of flotation.

The limited resources of gold in the world, as well as the reduction of its content in the ore, leads to the regulation of the mining of this precious metal and the steady rise in its value due to the increasing demand. The recovery of gold is of importance because of high market prices and huge industrial applications.

Waste from the beneficiation processes, the so-called mineral waste, often contains significant amounts of precious metals, especially when the efficiency of the flotation technologies used in the past to concentrate the target minerals was not so good.

Pyrometallurgical and hydrometallurgical processes are the main methods which are applied for the extraction of gold from ores and technogenic wastes. Recent years have witnessed an increasing interest in the wastes from the metallurgical industries for the extraction of precious metals available in them. These wastes can be utilized and are secondary resource of metals.

Through diverse biosorbents, such as bacteria, yeasts, fungi, actinomycetes, algae, bio-polymers and some bio spent materials, biosorption is considered a promising and efficient technology for the recovery of gold from secondary sources (Syed, 2012).

In long terms, the application of new geotechnological methods for gold extraction is envisaged:
- Heap leaching;
- Heap - biological leaching;
- Combined leaching.

Waste from mining industry can be processed to extract a wide range of minerals by applying technology schemes using chemical and biochemical leaching in heaps, baths, etc., (National Strategy for the Development of the Mining Industry, 2015).

Before the processing of gold-containing ore, the enrichment factory in Kardzhali processed lead-zinc ore through a flotation method. Waste from the factory, accumulated in the tailing pond, is a secondary resource of metals that can be utilized by applying new methods or modified technologies.

Wastes from the extraction and processing of industrial minerals

Of the industrial minerals in the Rhodopes, bentonite, perlite and zeolites are the most important. The deposits of bentonite clays are "Propast-Dobrovolets" and "Enchets". Perlite is extracted from a deposit known as "Schupenata planina", and zeolite from the "Beli Plast" deposit. The extraction is carried out by an open-pit mining and the material is processed to obtain a final product. Their growing consumption is due to their specific qualities (http://bentonite-bg.com). In January 2017, a concession for the extraction of bentonite clays and zeolite from the "Ralitsa" deposit was obtained (Decision No 92/ 26.01.2017 of the Ministry of Energy).

In mining of industrial minerals, significant quantities of rubble are extracted.

The humus layer of the rubble can be separated and subsequently utilized.

As the amount of the earth's mass from the overburden is large, it is possible to return the overburden to fill the space from which the extraction of bentonite, zeolite and perlite is made.

Solid wastes are obtained by the mining and processing industries of industrial minerals. In practice, these are inert materials - rock fragments, limestone, sand, clay and others. These materials can be separated and used as they have a wide-ranging application. Rock materials can be used in road construction; sands can be used in casting, as well as in the production of bricks and tiles; limestone can be used to produce cement, lime, enhancers, colouring agents; clays can be used to create anti-filtration screens of tailing ponds.

Wastes from the extraction and processing of lignite coal

In Bulgaria, the main source of energy is still coal. The largest deposit in the country is the East Maritsa Coal Basin. Lignite coal from this deposit is extracted through open-pit mining and is mainly used for electricity generation and for the production of briquettes. Three thermal power plants in Maritsa - Iztok generate electricity by using this coal.

The overburden that is removed in coal mining is used to re-cultivate the landscape, align the terrain, and build roads. The humus layer is collected and transported to temporary landfills. After aligning the terrains intended for agricultural use, the humus collected is spread over them. It can be used on lands for agricultural use and in areas for forestry use.

Slags, ashes and cinder are the main wastes from the thermal power plants. Although waste management requirements are adopted and have to be implemented, large quantities of wastes are disposed. The utilization of these wastes can be performed in different areas.

Waste from thermoelectric power plants can be used in the following ways: in the construction of roads, bridges, dams and buildings (as an ash additive in building mortars, in the form of gypsum, gypsum board and other panels for interior lining); for the production of cement, concrete, and other construction mixtures; in the production of bricks and roof tiles; for piling and filling activities, roofing, asphalt roads; as a soil cultivator in agriculture; for the production of paints, adhesives, varnishes (Zarichinova et al., 2016).

The utilization of the ash from thermal power stations can produce glass and glass products using the high temperature method. The ash from thermal power stations is a suitable recourse for the production of zeolites, which can be used for cleaning industrial and household waters (Panayotova et al., 2013).

In order to minimize the waste generated by the thermal power stations, it is necessary to promote its utilization.

Conclusions

- Effective utilization of primary natural resources requires complex and efficient processing;
- Using waste from a single production as a secondary resource (feedstock) for another production would contribute to the efficient and complex use of the raw materials;
- The main factor for waste reduction is the introduction of new high-tech processing using waste-free and low-waste technologies.

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