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Mladen Radovanović
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INFLUENCE OF HEAT TREATMENT ON THE MICROSTRUCTURE AND HARDNESS OF THE EN AW-7075 ALUMINIUM ALLOY

Student: Avram Kovačević

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Abstract

An experimental investigation was carried out on the commercial aluminium alloy EN AW-7075. The study included changes in the microstructures as well as the changes in mechanical properties (hardness) during heat treatments. Heat treatment conducted in this paper included annealing, solution heat treatment at 480°C for one hour, quenching in ice water in order to obtain the super saturated solid solution and after that artificial aging at different temperature (110°C-250°C) for 30 minutes. After each heat treatment measurements were taken and analyzed. Hardness and microstructural changes were investigated as a function of aging temperature (isochronal aging). Obtained results show an increase in hardness values with the increment of aging temperature due to the precipitation hardening that this alloy possesses. This increment in hardness is also confirmed by the optical microscopic analysis and obtained microstructures that show precipitation of metastable η` phase.

***Keywords**: EN AW-7075 alloy, heat treatment, hardness, microstructural investigation*

ACKNOWLEDGEMENT

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ANALYSIS OF WASTE TRANSPORT FROM THE VELIKI KRIVELJ OPEN PIT INTO THE EXCAVATED SPACE OF THE BOR OPEN PIT

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Abstract

Transport of excavations with dump trucks is most widespread in surface mines. Although they are the most expensive type of transport, due to the large investment and operating costs, trucks enable the transport of all types of materials in almost all conditions. Belt conveyors, on the other hand, enable the transport of excavations under a higher slope with a lower transport cost, and also provide the possibility of overcoming large transport lengths. The main disadvantage of belt conveyors is in regularity in their mutual connection, so a stoppage on one conveyor causes a stoppage of the entire system, which can result in delays in the overall production process. The aim of this paper is to analyze the option of waste transportation with dump trucks from open pit Veliki Krivelj in the free space of the closed open pit Bor, as well as to compare the obtained data with the already existing system of transport and disposal of waste. Based on the achieved results in the previous 20 years, the analysis of the existing combined transport system (truck - crusher - belt conveyor - depositor) was performed. The alternative for transport of waste, for the same or similar capacity, is performed only by dump trucks, was developed in this paper, and then compared with the previous one. This was done for the past period, since when the combined transport system has been working, but also for the future period until 2035, which is foreseen by the last study from 2017.

***Keywords**: dump truck, transport of waste, open pit, disposal*

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CONVERTER SLAG FROM FERRO-NICKEL METALLURGICAL PLANT AS REINFORCEMENT FOR PVC-BASED ECO-FRIENDLY COMPOSITES

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Abstract

The last stage of ferro-nickel production process in EURONICKEL, Kavadarci, generates converter slag (CS) consisted mostly of hematite (Fe_2O_3) and magnetite (Fe_3O_4), wuestite (FeO), MgO, CaO and less SiO_2, as well as oxides of other heavy metals (Cr, Ni, Co, Zn etc). Traditional disposal of this type of metallurgical waste is marked as potential environmental risk, mainly for soils and groundwaters [1,2]. Following the principles of circular economy and solid waste management, CS can be used as a low-cost and functional reinforcement of PVC-based eco-friendly composite materials [2,3].

This study is concerned with use of converter slag (CS) as reinforcement in PVC-based composites. CS was treated in acid (HCl) and alkaline (NaOH) solutions. The modified CS was implemented in PVC polymer matrix by film-casting method.

Characterization of CS and PVC/CS composites was performed by x-ray diffraction (XRD) method, thermogravimetric analysis (TGA), scanning electron microscope (SEM) and Fourier-transform infrared spectroscopy (FTIR).

A swelling test and corresponding kinetic analysis were done in order to determine adsorption behavior of the studied composites. The model of pseudo-second order was shown as the most appropriate for description of the adsorption mechanism.

***Keywords**: converter slag (CS), ferro-nickel production, PVC/FA composites, geomembrane.*

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This research was supported and performed within the bilateral Project with PR China, "Transformation of industrial waste powders into new functional materials" founded by Ministry of education and science of R. N. Macedonia (No20-6334/1; 29.06.2020).

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ANALYSIS OF THE PARAMETERS OF PRIMARY DRILLING AT THE VELIKI KRIVELJ OPEN PIT

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Abstract

The topic of this paper is the analysis of the parameters of primary drilling at the Veliki Krivelj open pit, which operates within the company SERBIA ZIJIN COPPER DOO BOR. Two types of drills are used at the Veliki Krivelj open pit mine – first type with drilling diameter of 251 mm; the second type with drilling diameters of 180 and 150 mm. The aim of this paper was the analysis of the parameters of primary drilling at the open-pit mine Veliki Krivelj, in order to determine whether the achieved parameters in the field correspond to those given in the project. The calculation of the necessary parameters was performed with an appropriate presentation of the data measured in the field during the direct monitoring of the technological phase of primary drilling. Direct monitoring of the primary drilling process showed that its parameters largely depend on the characteristics of the rock environment in which it is drilled, as well as that the values of drilling speed, measured in the field, are higher than the projected values. This enables the realization of the projected capacity for drilling, despite unforeseen delays that may occur during the technological phase of drilling. In relation to the projected drilling speed, the measured ones have the following ratio:

- the speed of direct drilling is higher by 68%,
- the speed of the total process of individual drilling is higher by 32%.

***Keywords**: drilling, parameters, analysis, open-pit*

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EXAMINATION OF COPPER VALORIZATION FROM LOW GRADE SULFIDE-OXIDE ORES BY LEACHING

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Abstract

About 80% of the world's copper comes from sulfide ores. Copper sulfide ores, with impurities of iron, are not easy to dissolve in aqueous solutions, so in most cases, copper is extracted from these minerals by the flotation process, followed by pyrometallurgical processing. However, complex sulfide ores are in many cases difficult to treat with conventional methods of processing mineral raw materials, and the obtained concentrates are often not pure enough, which makes their commercialization difficult. Pyrometallurgical treatment is difficult and expensive for low-grade ores that are increasingly being mined, which has led to increased research in the development of hydrometallurgical processes and in the investigation of copper valorization from low-grade sulfide oxide ores using leaching. The treatment of raw materials containing sulfide - oxide ores with a low content of useful components in order to obtain copper, as well as the treatment of oxide and low-grade sulfide ores can be done by leaching the minerals present and subsequent extraction of copper from alkaline solutions. The agents used can be acidic, base or salt solutions, and sulfuric acid has the greatest industrial application. In this paper, the basic parameters that are important for acid leaching of mixed sulfide - oxide ore from the deposit "Kraku Bugaresku - Cementacija" (sulfuric acid concentration, leaching time, solid - liquid ratio and others) was examined. Also the quality of the alkaline solution and the degree of copper leaching was determined.

***Keywords**: leaching, sulfide-oxide ore, copper*

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INVESTIGATION OF SULFATE ROASTING PROCESS OF AN ARC STEELMAKING FURNACE DUST FOR THE EXTRACTION OF ZINC

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Abstract

Studies have been conducted to optimize the process of sulfate roasting of dust of an arc steelmaking furnaces, which is more energy-efficient than the Welz process, to increase the extraction of zinc into the solution during subsequent leaching.

Currently, zinc-containing the dust of an arc steelmaking furnaces is practically not recycled. Their return into the main process is impossible due to the presence of zinc.

Due to the presence of chemically resistant zinc ferrite in the dust, the most common approach to the processing of zinc – containing secondary raw materials is the pyrometallurgical method - the Welz process, the final product of which is zinc oxide.

The object of research is the dust of an arc steelmaking furnace. In sulfate roasting tests, 10 g dust of the arc steelmaking furnace was mixed with H_2SO_4 in different solid rates and this process were undertaken in heat up to 200°C and durations 2-4 hours in the muffle furnace.

The roasted product was leaching for an hour (t=25 °C) in chemical glasses with a speed stirrer of 400 rpm with an IKA-basic magnetic stirrer. The mixture after the leach was filtered under a vacuum. The analyses of the elements in the solution were done using AAS.
The results of the study showed that the consumption of sulfuric acid has the greatest influence on the extraction of zinc into the solution. Thus, the extraction of zinc into solution of more than 95 % is achieved with a consumption of sulfuric acid of at least 1.35 kg /kg dust of the arc steelmaking furnace and a process duration of 2-4 hours.

Keywords: *steel production, dust, zinc, sulfate roasting, extraction*

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ANALYSIS OF THE SUCCESSFULNESS OF LAND RECLAMATION AROUND THE ACCESS ROAD FOR THE JAMA MINE

Student: Katarina Puškić

Mentors: Miodrag Žikić, Jovica Sokolović

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Abstract

In this paper, an analysis of the success of the land reclamation around the access road to the Jama Mine Factory in 2019 was performed, and suggestions were given that would contribute to it being more efficient in a similar case.

Before the reclamation of the land around the access road, the road itself had been arranged, so that the works on that would not negatively affect the reclamation. The arrangement also included the removal of bulk material, on and around the road, the restoration of the road surface, the installation of curbs and in the end paving. After the road got its final form, reclamation was started.

The scope of executed works and their value are stated in the priced bill of quantities, so that the analysis can be performed from the technical economical point of view.

Two years after planting, a comparison was made between the number of planted seedlings and the number of seedlings successfully grown, and it was concluded that the planting success rate was 65%, which is less than expected. Therefore, further analysis focused on the reasons for lower seedling successful planting rate and concluded that the main causes are poor seedling selection and lack of adequate seedling care.

In order to achieve better results within the repeated reclamation of the same land or reclamation in a similar case, the recommendations are as follows:

-choice of plant types in accordance with the specific climate: it is proposed to plant black pine and birch planted in a triangular pattern in combination with grass-legumes.

-intensive care and maintenance of seedlings for a period of 3 years (watering, hoeing, fertilising, chemical protection and transplanting dried seedlings).

***Keywords**: land, remediation, reclamation, planting success, landscaping.*

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ANALYSIS OF THE POSSIBILITY OF INCREASING THE PRODUCTION CAPACITIES OF THE PONORAC QUARRY

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Abstract

The quarry "Ponorac", where it is exploited high quality limestone, is an integral part of the company "ABM International". As a consequence of the growing demand for calcium carbonate, there is a need to increase the production capacity of the quarry. In order to ensure safe and economically justified exploitation, it is necessary to increase the annual capacity of the quarry from the projected 60,000 tons to 120,000 tons. In this paper, the possibility of increasing the annual capacity of the quarry "Ponorac" was examined, by applying the existing mechanization. Based on the data on the adopted number of working days, shifts and effective hours in shifts, the planned daily capacity of 780 t was defined. The calculation determined that the technical capacity of the existing excavator meets the planned daily operating capacity, and can still be used as basic loading machinery, while it was concluded on the basis of the calculated technical capacity of the loader that it can be used as an auxiliary loading machinery. In this way, it was confirmed that existing equipment in quarry "Ponorac" can be used for the planned annual exploitation capacity. Based on the data on the planned daily capacity, the required number of dump trucks are defined. In order to achieve the planned capacity, it is necessary to engage five dump trucks with a capacity of 30 tons, whereby it is necessary for each to perform six transport cycles per day.

***Keywords**: quarry, annual capacity, limestone*

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ELECTRIC-ARC FURNACE SLAG FROM FERRO-NICKEL METALLURGICAL PLANT AS REINFORCEMENT FOR PVC-BASED SUSTAINABLE COMPOSITES

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Abstract

Production line in EURONICKEL, Kavadarci generates large amount of electric-arc furnace slag (EAFS) more than 1 Mt slag, which could be potential risk for environment (soil and groundwater) disposed on dump [1,2]. According to the principles of sustainable development and circular economy (reuse instead of disposal), EAFS can be used as low-cost and effective reinforcing agent for PVC based eco-friendly composite materials.

The aim of this work is use of electric-arc furnace slag (EAFS) from ferro-nickel production plant EURONICKEL, Kavadarci, as reinforcement of PVC-based composites.

EAFS and composites prepared with PVC and EAFS were characterized by means of X-ray fluorescence (XRF) method, x-ray diffraction (XRD) method, scanning electron microscope (SEM) and thermogravimetric analysis (TGA) and Fourier-transform infrared spectroscopy (FTIR). Moisture stability was determined by swelling test for 24 h. Adsorption capacity and mechanism of the adsorption process were determined using the model of pseudo-second order.

Characterization results point out on well dispersion of the FA particles where the particles were tightly embedded and mechanically interlocked in the PVC matrix indicating interfacial interaction with the polymer matrix. Moisture stability test showed higher adsorption of the composites than PVC, but satisfactory for their use as geomembranes.

***Keywords**: electric-arc furnace slag (EAFS), ferro-nickel production, PVC/EAFC composites.*

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ELECTROCHEMICAL BEHAVIOUR OF COPPER IN 0.9% NaCl IN THE PRESENCE OF SYRUP CONTAINING IVY LEAVES DRY EXTRACT

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Abstract

Excluding their widespread industrial application, copper and its alloys are also frequently used as biomaterials. The main concern when using metals as biomaterials is their susceptibility to various types of corrosion processes, and therefore these metals should be protected from the corrosive environment in the body, most often by using corrosion inhibitors. Toxicity and higher price of some compounds that are used as corrosion inhibitors, has led to more intensive research of non-toxic compounds as potential environmentally friendly (green) corrosion inhibitors. The application of expired drugs can lead to a reduction in the cost of disposing of pharmaceutical waste and a reduction in environmental pollution. Due to broncholytic and secretolytic efficacy preparations from ivy leaves (*Hedera helix L.*) are used in the treatment of productive cough. In this research the electrochemical behavior of copper in synthetic physiological solution (0.9% NaCl) in the presence of expired syrup containing ivy leaves dry extract (Prospan syrup®) as potential green inhibitor is investigated. Electrochemical methods used in this research are open circuit potential measurements, potentiodynamic polarization and cyclic voltammetry. The results obtained by potentiodynamic polarization indicated that Prospan syrup® acts as mixed type inhibitor. The inhibition efficiency of inhibitor rises with increase in its concentration and can reach a value of 74.0%. Obtained Gibbs free energy value indicates that spontaneous adsorption of inhibitor molecules takes place on the copper surface. Adsorption of Prospan syrup® in 0.9% NaCl solution obeys the Langmuir adsorption isotherm model. Further research may focus on the use of pure ivy leaf extract as a potentially more effective corrosion inhibitor.

***Keywords**: green inhibitor, copper, corrosion, expired drug, ivy leaves dry extract*

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FUEL CONSUMPTION DURING TRUCK TRANSPORT OF EXCAVATIONS AT THE VELIKI KRIVELJ OPEN PIT

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Abstract

Truck transport is used in the surface exploitation of all types of deposits of mineral raw materials. Truck transport has a wide application on surface mines, thanks to a number of advantages over other types of transport. It is used as a basic type of transport or in combination with other types of transport. One of the main disadvantages of truck transport is the high fuel consumption. Optimizing this parameter can significantly improve transport efficiency. The task of the paper was to analyze the dependence of average fuel consumption in relation to the average distance of truck transport, at the Veliki Krivelj open pit, in order to use the obtained data and information as a basis for future planning of fuel consumption. The analysis was performed using the data obtained from the technical documentation for trucks with a carrying capacity of 136 tons, 154 tons and 220 tons for the period from 1983. to the end of 2016. From the previous, it can be concluded that the fuel consumption is crucially influenced by the length of transport, type of truck, coefficient of loading, road slope, road condition, truck age, driver training, work organization, weather conditions, fuel quality and failure of projected values. From the cumulative graphs obtained by the functional dependence of the analyzed data, the growth of fuel consumption (per ton of transported excavation) can be seen with the increase of the transport length, for all types of trucks.

***Keywords**: trucks, transport, fuel consumption*

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INVESTIGATION OF TEMPERATURE EFFECT ON NEODYMIUM CARBONATE PRECIPITATE CHARACTERISTICS

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Abstract

Effect of neodymium carbonate deposition temperature from nitric acid solutions (60 g/l Nd_2O_3, pH=1) by 20 % ammonium carbonate solution on pulp filtration rate, morphology and granulometric composition of precipitates was investigated.

The possibility to increase filtration rate of neodymium carbonate pulp by 5-10 times at increase of deposition temperature from 25 to 40-53 ° C is established.

***Keywords**: rare earth metals; neodymium carbonate; deposition*

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PREPOSITION OF NEW DEWATERING SYSTEM FOR EXCAVATION FIELD OP-2 IN STRMOSTEN PIT

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Abstract

Dewatering in mining means complex measures related to the fight against surface and ground water in all phases of construction and exploitation of mineral deposits. There is a constant interaction between mining operations for the extraction of mineral raw materials and ground and surface water. In excavation field OP-2 of the pit "Strmosten" in Vodna coal mine, the exploitation is currently carried out near the old works and there is a danger of larger inflows of groundwater. Based on the stated facts, there is a need to build a water reservoir in the lowest part of the pit, at the end of the main transport decline GTN-2 below the intersection with main transport incline GTU-2, and whose purpose will be to accept water from the OP-2 excavation and development sites. As the excavation works go deeper, the existing dewatering system cannot be able to provide sufficient capacity. Therefore, this paper proposes to improve the dewatering system in the "Strmosten" pit by designing a new dewatering system that will solve the problem for the future exploitation. The preposition and calculation of a new pump station and new water reservoirs, as well as a new dewatering system with all accompanying facilities were also given.

***Keywords**: dewatering, water reservoir, pump station*

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EXAMINATION O THE INFLUENCE OF DENSITY AND GRAIN SIZE ON SAMPLING ACCURACY USING AN AUTOMATIC SAMPLER

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Abstract

Sampling is the first and key step in testing a raw material and checking the operation of the plant. The taken sample must be representative. Modern plants for the preparation and concentration of mineral and secondary raw materials are mainly equipped with automatic sampling systems. In this paper, the influence of density and size during the sampling a multicomponent raw material using an automatic sampler was investigated. When sampling with an automatic rotary sampler, the flow of raw material moving vertically downwards is interrupted, so it can be assumed that the density and size of the various components in the sample will affect the accuracy of sampling. The tests were performed on synthetic two-component samples made of aluminum, PVC and copper, which have different densities, on three size classes -3.35 + 2.36; -2.36 + 1.7 and -1.7 + 1.18 mm. In the first phase of the research, the influence of the density of different components in the mixture on the precision of the sampler was examined, and their size was the same. In the second phase, the influence of the size of individual samples on the accuracy of the automatic sampler is examined, while in the third phase, the subject of the test is a mixture made of components of different densities with different sizes. The obtained results were processed statistically, and on the basis of statistical analysis, the work of the automatic sampler and the influence of density and coarseness on its accuracy during the work were evaluated.

***Keywords**: sampling, density, grain size*

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APPLICATION OF CHERRY STONES FOR THE REMOVAL OF BRILLIANT GREEN

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Abstract

Dyes, which are widely used in many industries, are often discharged into the water, without further treatment, causing serious problems for human health and the natural ecosystems. Brilliant green (BG) is a cationic dye, with genotoxic and carcinogenic properties and therefore needs to be separated from wastewater. In this study, environmental and low-cost food industry waste, cherry stones, was mechanically treated in order to obtain sorbent (CS) and analysed for the sorption of BG. Sorbent CS was characterized by SEM-EDX and ATR-FTIR technique, while the pH_{sus} and pH_{pzc} were also evaluated. Characterization results revealed that CS pose multilayer porous surface, rich in functional groups (dominantly carboxyl and hydroxyl) with pH_{pzc} close to 5, indicating plausible interaction with BG at pH values greater than this one. Sorption experiments were conducted in a stirring batch system under isothermal conditions. The influence of operating parameters such as pH, sorbent contact time and initial dye concentration on the sorption of BG was investigated. The nonlinear forms of two adsorption isotherms (Langmuir and Freundlich) were used to analyze the sorbent uptake capacity. The maximum sorption capacity obtained by Langmuir model was found to be 189.05 mg/g (with adsorbent dosage 2 g/L, in BG concentration range 10 – 200 mg/L, pH = 7, agitation speed 200 rpm and T=25 ^{o}C). Results from this study suggest that CS sorbent, as a renewable resource which is, at the same time, waste from the food industry, have a potential to be applied for removing BG dye from contaminated wastewater.

***Keywords**: Brilliant green, cherry stone, sorption, food waste*

ACKNOWLEDGEMENT

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PRESCRIBED MEASURES FOR TRANSPORTING EMPLOYEES BY BELT CONVEYORS IN UNDERGROUND COAL MINES

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Abstract

Within the process of continuous transport in underground exploitation, belt conveyors have found a very wide application. These are high-capacity transporters that can be applied in all working conditions and all mines, regardless of whether they are mines with underground or surface exploitation. They are most widely used in coal mines. They can transport useful mineral raw materials, tailings, overburden, backfill material, but also transport people. Mining, like many other industries, faces the challenge of doing as much as possible in the field of accident prevention and of reducing their impact through organizing and planning, awareness raising and communication. Transporting employees with belt conveyors during underground coal exploitation greatly contributes to them coming and leaving the work site with less effort and in a shorter time, but it carries risks that can sometimes endanger their safety. Therefore, it is necessary to take all necessary measures to avoid these risks. Because that, it is necessary to apply and esteem the prescribed measures for the transport of employees by conveyors with a belt in the underground exploitation of coal, which are defined by the Rulebook. In addition, it is necessary to apply and esteem other regulations related to this area, and above all the appropriate Serbian and international standards. In this paper, an overview and analysis of regulations related to the possibility of transporting employees by conveyor belt is performed.

***Keywords**: Belt conveyor, underground coal mine, measures*

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AGITATION LEACHING OF COPPER CONCENTRATE WITH H_2SO_4 AND HNO_3

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Abstract

In this paper the results of agitation leaching of copper concentrate with 2M H_2SO_4 and 2M HNO_3 solutions are presented. Agitation leaching is a preliminary step in the hydrometallurgical treatment of copper ores. High increase in the use of this metal over the past few decades has resulted in an increased flux of metallic substances in the environment. The recovery and extraction of copper is necessary and important from various standpoints, including environmental protection. Agitation leaching is the leaching of crushed material with stirring that can be performed in various ways. This way of leaching is more intensive than percolation leaching, but it's also more expensive because of the need for crushing and grinding the ore.

The experimental investigation was done by measuring the concentrate sample and bringing it into contact with the leaching solution. The suspension was stirred for 20 minutes. After 5, 10 and 20 minutes 2 cm^3 samples were collected and their copper concentration determined. The leaching degree was calculated based on the determined copper concentrations in the leachate samples. After 5 minutes of leaching, the leaching degree was determined to be 23.28 %. After 10 minutes, the leaching degree was 23.5 %. Stirring the suspension for 20 minutes resulted in a leaching degree of 25.41 %.The obtained results indicate that the analyzed copper concentrate can be successfully leached with H_2SO_4 and HNO_3 solutions. Also, stirring time doesn't have a significant influence on the leaching degree, as the results didn't change considerably after 5 minutes.

***Keywords**: leaching, concentrate, copper, agitation*

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OBTAINING AND PROPERTIES OF GADOLINIUM CERIATE BY MECHANOCHEMICAL SYNTHESIS

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Abstract

With the development of new generation reactors and increased requirements for the safety of personnel and environmental protection, it is important to study materials for PEL. Nowadays, the material for PEL is boron carbide. The compound has a number of disadvantages: swelling under irradiation, helium formation during burnout and gas evolution under the shell of absorbing elements, low thermal conductivity. In this regard, it is promising to study new materials for PEL with more appropriate properties. Titanates and hafnates of lanthanides have a high radiation resistance, and also do not form products when burned out. The aim of this work is to obtain and study the properties and structure of gadolinium cerate by mechano-chemical synthesis. For mechanical activation, we used powders of cerium oxide and gadolinium oxide of the chemically pure class. Mechano-chemical activation was carried out in a planetary centrifugal mill according to the modes of obtaining titanates and lanthanide hafnates. The structure of the powder material was studied using TEM and XRD. As a result, the optimal mode of obtaining gadolinium ceriate was revealed. XRD showed that the complete transformation of the initial mixture taken in a stoichiometric ratio into a nanocrystalline powder material occurs during mechano-chemical processing for 30-40 minutes. TEM images of gadolinium cerate powder showed a typical banded structure of atomic planes characteristic of the X-ray crystal phase, and an X-ray amorphous ring structure was also present. Thus, gadolinium cerate is a promising compound for studying its properties; later it can be used in regulatory bodies of nuclear reactors as a material for PEL or an additive to materials for PEL.

Keywords: *mechanical activation, lanthanide hafnates, nuclear power*

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ANALYSIS OF THE MAIN INDICATORS OF APPLIED MINIG METHOD IN BORSKA REKA ORE BODY

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Abstract

For the excavation in the ore body Borska Reka in the underground mine Jama Bor, the chamber-pillar method with block excavation and backfilling was adopted. The introduced mining method is characterized by the specific construction of the excavation, the possibility of mechanized ore exploitation, safe working conditions, as well as the preservation of the terrain surface above the ore body. The need for analysis of mining method indicators stemmed from the fact that excavation in this ore body with a low content of useful component, which lies at great depth, is carried out using the method of excavation with filling the excavated space, which significantly affects the cost of ore production, and thus the overall economy of underground exploitation. Such a forced solution, conditioned by the impossibility of applying mass mining methods due to the existence of important infrastructural facilities on the surface of the terrain, requires a detailed analysis of the indicators of the applied mining method, in order to assess its efficiency as accurately as possible. The main indicators of the applied mining method, based on actual data during exploitation, were calculated. In that occasion, the deviation of the obtained results in relation to the values defined by the project is noticed. This difference primarily stems from the fact that the annual production capacity is significantly less than projected, which is a consequence of the absence of certain technological operations characterized by the adopted method.

***Keywords**: mining method, indicators of mining method, underground mining*

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ANALYSIS OF STABILITY OF EXCAVATION CHAMBER IN BORSKA REKA ORE BODY

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Abstract

The perspective of exploitation in the underground mine Jama Bor is ore body "Borska Reka", in which the exploitation takes place by applying the Chamber-pillar method with block excavation and backfilling. Excavation in the ore body "Borska reka" is characterized by leaving the excavation chambers open, due to the lack of a backfill plant. In that way, the stability of the chambers and the pillars were disturbed, safe working conditions were not provided, and the predicted parameters of the applied mining method can't be achieved. Despite these problems, the exploitation continues without the use of backfill, and as a result there is a need to analyze the stability of the chambers and pillars that are excavated in the first phase. Although this is not foreseen by the project, currently excavation is done in every other chamber, and in chambers that are located opposite each other. In this way, the stability of the chambers and the pillar between the opposite chambers is endangered. Also pillar is exposed to additional pressures and thus there is a risk of failure and endangering the stability of the main haulage drift as well as the safety of workers and equipment. The Rock Science software was used for analysis of stability and stress - strain state of excavation chambers and pillars, RMR classification of rock mass for analysis of time interval under which chambers can be unfilled, as well as methodology of LD Sevjakov for determining the width of pillars between opposite excavation chambers of different lengths.

***Keywords**: underground mining, mining method, stability*

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FLY ASH FROM FERRO-NICKEL METALLURGICAL PLANT AS REINFORCEMENT FOR PVC-BASED ECO-FRIENDLY COMPOSITES

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Abstract

Disposal of metallurgical waste produced either in non-ferrous or in ferrous metallurgy is recognized as potential environmental hazard (hot spot) [1,2]. On the other hand, metallurgical waste could be useful as a raw material for some metal extraction, production of glass-ceramic or as reinforcement for polymer composite (geomembranes) [2,3]. According to the principles of the circular economy, metallurgical waste should be reused incorporation in new eco-friendly materials as not expensive, satisfying the technical requirements.

The main goal of this research is to use flay ash (FA) produced in ferro-nickel production plant EURONICKEL, Kavadarci, as reinforcing agent for PVC-based composites as geomembranes. Film-casting method was used for composites preparation. Polyvinyl chloride (PVC) was used as matrix, reinforced by the FA.

As-produced fly ash was studied by means of x-ray fluorescence (XRF) method, x-ray diffraction (XRD) method, scanning electron microscope (SEM) and thermogravimetric analysis (TGA). The composite samples were studied by means of scanning electron microscope (SEM), thermogravimetric analysis (TGA) and Fourier-transform infrared spectroscopy (FTIR). Water resistivity was observed by swelling test for 24 h. Corresponding kinetic analysis was done in order to determine adsorption capacity and mechanism of the adsorption process.

Characterization results showed well dispersion of the FA particles where the particles were tightly embedded and mechanically interlocked in the PVC matrix indicating strong interfacial interaction with the polymer matrix. Water resistivity test showed higher adsorption degree of the composites than PVC, but satisfactory for their use as geomembranes.

***Keywords**: fly ash (FA), ferro-nickel production, PVC/FA composites, geomembrane.*

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BARIUM-TITANATE IN CERAMICS

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Abstract

Nanotechnologies have attracted a lot of attention from scientists and engineers and have thus become one of the most researched areas. When choosing a material for a component, it is very important to take into account the electrical properties of the material. Recently, there has been a growing interest in ceramic thin films, functional ceramic devices and sensors that are used in electric curcuits. Thin ceramic films are very important in the development of modern technology because they provide miniaturization of electronic components and have a wide range of applications (capacitors, sensors, memory units, tunable microwave devices, etc.). Ferroelectric materials are used for making these specific electronic components. These materials exhibit properties that are closely related to their crystal structure and response to changes in conditions such as stress or mechanical pressure. A large number of ferroelectric materials are compounds that have a perovskite structure, ABX_3 structure. Barium-titanate, $BaTiO_3$ is the most important and researched compound from this group because of its good dielectric, piezoelectric and ferroelectric properties and because it easily forms solid solutions with other titanates and oxides which can improve some of its properties. Unlike lead-titanate ceramics, barium-titanate ceramics are not toxic and harmful to the environment.

***Keywords**: ceramics, barium-titanate, nanotechnologies*

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POSSIBILITIES AND PERSPECTIVES OF EXPLOITATION IN THE LUBNICA COAL MINE

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Abstract

Coal reserves in the deposits of the Lubnica coal mine are located in parts of the Osojno, Stara jama, Centralno polje and Istočno polje deposits. In the part of the "Osojno" deposit, the reserves are concentrated in three geological blocks, ie fields: "Osojno-south", "Osojno-center" and "Osojno-north". Currently, the exploitation in the part of the deposit "Osojno" is carried out in the excavation field "Osojno-south". Coal reserves in the Osojno excavation field represent the basis of the mine development perspective. The planned production in exploitation field OP-1 in the Osojno-South pit was 1.000.000 tons of commercial coal per year. However, this production was never achieved due to extremely poor geological and tectonic conditions in the deposit (a large number of faults). The OP-2 excavation field is in the excavation phase, while during that time investment works should be carried out for the opening and development of the Osojno-center excavation field. After the preparation of the excavation field Osojno-center, and due to the realization of the set capacity of 150.000 tons of commercial coal per year double-sided excavation will be applied in the excavation field OP-2 and in the part of the pit Osojno-centar, ie in the Central excavation field, and later in the Northern excavation field. Analyzing the techno-economic indicators, it can be concluded that investments in coal exploitation in the Lubnica coal mine are justified.

***Keywords**: coal mine, underground mining, techno-economic indicators*

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APPLICATION OF MEDICINAL PLANTS IN PHYTOREMEDIATION TECHNLOGIES

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Abstract

Society intensively attempts to face worldwide environmental health issues menacing soil, water, and other environmental media, especially in the last decades. One of the major threads and the most substantial concerns are heavy metals, known for their high toxicity and difficult degradability. The need for an efficient, low-cost, and sustainable approach to this problem led to the development of phytoremediation. This promising remediation strategy implies plant species utilization to isolate contaminants and minimize environmental risks. Plants able to inhabit contaminated sites and accumulate extraordinarily high concentrations of heavy metals, with no toxic effects, are called hyperaccumulators. Some of them belong to the group of aromatic and medicinal plants, containing natural substances widely used in food, cosmetics, and farmaceutical industries. Owing to the secondary metabolites biosynthesis and distinctive morphological features, medicinal plants with phytoremediation capabilities seem to be one of the possible choices for utilization in the remediation of contaminated lands. According to the published data, the most suitable aromatic plants for heavy metal contaminated soils remediation belong to the families: *Asteraceae, Geraniaceae, Poaceae, and Lamiaceae*. As researches revealed, the percentage yield of the essential oil (EO) distilled from the medicinal plants enhances with the increased heavy metal stress. Besides, it has turned out that heavy metals do not significantly contaminate essential oils, contrary to the expected. Thus, medicinal and aromatic plants hold great phytoremediation potential while simultaneously enabling the production of essential oils. Their usage has been proposed as feasible and profitable, providing multiple benefits from both environmental and economic aspects.

***Keywords**: heavy metals, soil, phytoremediation, medicinal plants*

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ANALYSIS OF DRILLING AND BLASTING PARAMETRES ON OPEN PIT ČOKOĆE – NOVI POPOVAC

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Abstract

For the needs of cement production limestone is exploited at the Čokoće open pit, which operate within the company Moravacem. In this paper, the parameters of drilling and blasting were analyzed, for two drilling rigs, AtlasCopco ROC F6 and Epiroc SmartRoc D50, which are currently working on the Čokoće open pit. In order to optimize the drilling and blasting process, a comparative analysis of the operation of both drilling rigs was performed, where the drilling speed, capacities of drilling rigs, drilling time, as well as drill hole parameters were analyzed. The analysis leads to the conclusion that the new generation Epiroc SmartRoc D50 drilling rig achieves better operating results, which lead to savings in the process of production and processing of limestone. Epiroc SmartRoc D50 has a system for automatic drilling and rod handling. HNS (hole navigation system) is a system for automatic feed alignment, where the drill monitors parameters such as coordinates, depth, inclination and azimuth through the entered data and thus reduces the influence of the human factor on drilling parameters. All of this result in a better blasting effect, ie blasted rock mass has better fragmentation, and the effects of blasting, specifically ground shaking, are much better controlled. Norms, such as specific fuel consumption, are much better because the drilling speed is much higher. Drilling rig also has an intelligent fuel consumption system, more precisely automatic regulation of air pressure, shock and rotation in relation to the working environment through which it drills, which further contributes to fuel savings, ie further reduces specific fuel consumption.

***Keywords**: drilling, blasting, limestone*

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EXTRACTION OF METAL IONS USING ION EXCHANGE RESINS

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Abstract

Ion exchange resins have numerous uses such as separation, purification and decontamination, etc. They can be also used for the removal of Ca, Mg, Fe and Mn salts from water, for purification of sugar and for concentration of valuable elements.

The results of Cu^{2+} ions adsorption using Amberlite IR-120 (granulation from 0.2 mm to 1 mm) as ion exchange resin, followed by the desorption process, using 2M H_2SO_4, are presented in this paper. The initial concentration of Cu^{2+} ions in the solution was 0.02M. As a result, it was calculated that the concentration of copper ions in the solution was eight times higher compared to the initial concetration.

***Keywords**: ion exchange resins, adsorption, desorption, copper ions*

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OPTIMIZATION OF THE CERIUM CARBONATE DEPOSITION PROCESS

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Abstract

Optimization of the process of deposition of cerium carbonate from nitric acid solutions with obtaining well-filterable pulps has been carried out. The method of steep ascent was used in planning and processing the results of the experiments. As an optimization parameter, the specific filtration rate of the cerium carbonate pulp (l/(m^2·min)) was selected, and the factors: X1 - the concentration of cerium in the initial solution (50-120) g/l; X_2 - excess of precipitant ($(NH_4)_2CO_3$), (30-150)% of from the stoichiometrically required amount (SRA); X_3 - temperature, (25-40) °C; X_4 - is the reduced rate of introduction of the reagent, (1,5-3) l/h; X_5 - concentration of NH_4NO_3, (0-100) g/l. It was found that a filtration rate acceptable for production of 27-30 l/(m^2·min) is achieved in the absence of ammonium nitrate in the initial solution, an excess of precipitant of at least 100%, and the rate of introduction of the reagent is not more than 1,4 l/h.

***Keywords**: rare earth metals; cerium carbonate; deposition*

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RECLAMATION OF DEGRADED LAND AT BCM REMBAS WASTE DUMPS

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Abstract

In Serbia, there are a large number of coal mines, quarries and similar areas that are left to natural reclamation after exploitation. During the long-term exploitation in BCM "Rembas", the surface of the terrain was degraded, mainly in the parts where the exploitation was carried out at a shallower depth. All these degradations of surface are mainly related to subsidence of land in areas where there are no settlements and buildings. Spontaneous reclamation took place in waste dumps that are no longer active, ie the area is completely self-renewed. Active l waste dumps "Duboki potok" and "Ražanjski potok" need to be gradually, first technically and then biologically, recultivated and restored to their original condition in the future. During the technical reclamation, the available mechanization of BCM "Rembas" can be used which will significantly reduce the costs of reclamation. Biological reclamation will be done by sowing grass and afforestation with acacia seedlings. After the performed technical and biological reclamation, the spatial arrangement of the obtained flat surface of the waste dump will be approached with the aim of bringing the area damaged by underground exploitation or tailings into use. In addition to the construction of sports fields, it is proposed to build a restaurant with log cabins, to arrange a space for a picnic, as well as to arrange a space for fishing. The construction of such a complex would significantly increase the cost of reclamation, but in a shorter period of time, the invested funds would be returned through tourist visits.

***Keywords**: coal mine, reclamation, waste dump*

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COMPARATIVE OVERVIEW OF STANDARDS IN THE FIELD OF BLASTING SEISMICS

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Abstract

Blasting is a process of controlled use of explosives with the aim of destroying rock mass, controlled demolition of buildings or to make joints between metals or their alloys. Modern mining, as one of the most important branches of the economy, cannot be imagined without the application of explosives. The primary goal of blasting in mining is the destruction of rock mass, ie the separation of rock material from the massif, achieving the desired degree of crushing and the appropriate shape of the pile of destroyed material. However, a large part of the total energy of the explosion delivered to the massif is spent on causing side effects such as seismic shock, strong air shocks, rejection of rock mass in the undesired direction and other. The main task of miners in mines is to enable the desired degree of crushing and the position of the blasted mass with reducing the side effects to the limit, since these effects cannot be eliminated. The side effects of blasting on surrounding objects are the subject of the study of seismic blasting. Since the Republic of Serbia does not have its own standard in the field of blasting seismic, this paper presents a comparative analysis of European standards (German, French, British, Swiss, Russian and Swedish) in the field of blasting seismic. Based on these standards, after the previously defined law of oscillation, it is possible to determine the maximum amount of explosives by delay interval, in order to protect facilities near open pits and quarries.

***Keywords**: blasting, standards, open pit, side effect*

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