Feasibility of using the mill tailings for preparation of self-hardening mixtures

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Abstract
The article is devoted to the substantiation of the possibility and disposal conditions of the ore beneficiation tailings of the metal-containing mineral raw materials, the storage of which is globally dangerous. Mining technology optimality criterion is justified as its humanity guarantor being the condition for the preservation of the Earth's surface during deposits development. Brand new process of the substance activation by large mechanical energy was characterized.
Key words: DEPOSIT DEVELOPMENT, ORE BENEFICIATION, TAILINGS, GEOMECHANICS, ECOLOGY, UNDERGROUND ORE MINING

Mineral extraction is characterized by the increase of amount and area of the mining development, caused by the dynamic progress of the human community's demands. Tails of ores enrichment can be raw materials for preparation of the hardening mixes. Utilization of tails without extraction of metals is impossible from the economic and ecological point of view. In world practice the increase in volumes of recycling is provided with use as a part of the hardening mix as inert fillers and without extraction of dangerous components.

Practice of moving of tails of enrichment to the developed space can be recognized correct only at decrease in the contents in waste of metals to norms of maximum concentration limit or background value. Valuable and scarce metals which cost can be comparable to the cost of the extracted metals are a part of metal-containing minerals. Combining the methods of magnetic, gravitation, and electrochemical concentration allows the extracting of iron, manganese, titanium, sulphur, and other components from high-grade tailings of the complex ores beneficiation into the selective produced commodities. The next stage of the ore beneficiation technologies is using the second type of energy – chemical one – for metal extraction. In the course of chemical leaching metals are extracted from ore beneficiation tailings into solutions, and from them – into the produced commodities sediment. This way gold is leached out of the ore concentration rejects containing 0,6-0,3 g/t, unobtainable for traditional technologies, as well as copper and uranium. In the process of sorption leaching metals extracted from the ore beneficiation tailings are precipitated on the ion-exchanging mineral pitch, and are extracted from it in the process of desorption. Crushed-ore extraction from the liquid stage increases in the counterflow of crushed ore-mineral pitch by superimposition of electric field. Brand new technology exploits previously unknown phenomenon of activating the substance with the help of big mechanical energy at processing speed of more than 250 m/s [1, 5-9].

Mechanical activation is increasing the catalyst properties of substances at ore reduction, accelerating the speed of chemical reactions and hardening.

The material is put into the central part of the labour body and is subjected to numerous strokes of impact bars on the disks, circulating at the speed of 1000 rpm in the opposite directions. The stroke speed in disintegrator is by order of magnitude greater than in vibrating or bead mills, and the acceleration comes up to the millions of accelerations of gravity. Activation creates in the material electric unequally charged centers, and by the accumulation borders of admixtures the material is being destroyed, so the phase separation processes are stirred up and preparation plant output increases. Disintegrator usage in mining was put into practice for the first time in the world in “Shokpak” deposit in North Kazakhstan as a part of the filling complex. Plant DU-65, completed with universal naves, 4- and 3-rowed rotors and engines of 200 - 250 kilowatt ensured the active class output up to 55%, and combined with the vibrating mill – up to 70%, that allowed the activated slag to compete with finished cement.

The plant was situated in the separate building with the basement square of 5-7 m in three levels. The material was delivered to the upper level and let into the plant through the sieve with mesh width of 20 mm. From the disintegrator ore reduction products went to the quieting bin and were directed to the technological series. Under the wet scheme of ore reduction the water is sent into the disintegrator, and the activation products are directed in the form of the crushed ore. The presence of non-extracted metals is the problem in using ore beneficiation tailings. As a rule, the title metals are extracted, and the accompanying ones remain, complicating the following use of tailings. Mechanic-chemical technology allows extracting metals and increasing mixture components activity simultaneously. Experimental substantiation of this phenomenon is made on the basis of ore beneficiation tailings of nonferrous and ferrous metals and coals. The uniform leaching methods are applied in the following modes: raw tailings agitation leaching; agitation leaching of pre-activated tailings; tailings leaching in disintegrator; agitation leaching of tailings activated in disintegrator; multiple tailings leaching in disintegrator. The experiments are performed using the mathematical planning of Venken-Boxa plan. The independent factors were: sulphuric acid contents in leaching solution (X_1) 2-10 g/l; sodium chlorides contents in leaching solution (X_2) 20-160 g/l; weight relation between the mass of leaching solution and the leached mass (X_3) in the unit experiment (50g) 4-10; the time of leaching (X_4) is within the range of 0,15-1,0 hour.

Complex ores of Sadon deposit (Russia, the North Caucasus) are leached in hard suspensions with the extraction of lead and zinc – 80-85 %, silver –60%, cadmium – 56%, bismuth – 30 %, and the rejects output of 25-50% from the processed ores volume. Rejects chemical composition, %: SiO_2 – 31,4; Fe – 4,4; CaO – 1,96; S – 1,88; Ag – 0,015; Cu – 0,18; Mn – 0,015; K_2O – 3,5; Al_2O_3 – 0,8; TiO_2 - 0,03; Zn – 0,95; Pb – 0,84.

The results of the research allow concluding that: activation in disintegrator and leaching outside it multiplies the extraction from ore beneficiation tailings: lead – up 1,4 times, zinc – up 1,1 times; leaching in disintegrator compared with the variant of separate activation and leaching ensures approximately the same extraction, but reduces in-process time from 15 – 60 minutes to seconds, i.e. by 2 digits. The results of the experiment allow asserting that: leaching the crushed ore tailings using the activation in disintegrator is substantially more efficient than agitation leaching; the top-down prioritization of influencing the process includes: the contents of reagent in the leaching solution, disintegrator rotor speed; the number of disintegrator processing cycles and the ratio L:S (Liquid:Solid) [1].

Jaspilites of KMA. Ore beneficiation tailings of the wet magnet separation of jaspilites present the fine dispersed powder with aggregate fractions size less than 0,071 mm 40 - 70%. Tailings analyses: SiO_2 – 64%, Fe – 8%, Al_2O_3 – 5,2%, Mn – 3,2%, K_2O – 0,7%, P – 0,1%, Ca – 0,8%, MgO – 0,2%, Cu – $5\cdot10^{-3}$%, Ni - $4\cdot10^{-3}$%, Zn - $5\cdot10^{-4}$%, As, Ba, Be, Bi, Co, Cr, Li, Mo, Nb, Pb, Sb, Sn, Sr, Ti, V, Y – within the range of $(30-50)\cdot10^{-5}$%.

Having the initial iron content of 8% in the analyzed sample the one-time leaching extracts about 1% of iron, and after the triple passing of the tailings through disintegrator 3% of iron is leached into the solution. The sanitary safe level of iron content can be reached by further increasing the processing cycles number. The chemistry of the tailings initial sample is characterized by the content of As, Ba, Be, Bi, Co, Cr, Li, Mo, Nb, Pb, Sb, Sn, Sr, Ti, V, Y within the range of $(30-50)\cdot10^{-6}$%. After the mechanic-chemical processing the content in the recycled tailings does not exceed the building materials rating.

The mechanic-chemical activation at one-time processing multiplies metal extraction into the solution up to 25% compared with the basic rate, and has the growth reserve while increasing the processing cycles number. Maximal extraction is achieved under mechanic-chemical activation of tailings and depends on the processes duration. After metal extraction to the level of sanitary demands the ore beneficiation tailings can be used for manufacturing the filling mixtures and concrete commercial output, ensuring the necessary brand using the minimum cementing materials consumption [2]. Activation in disintegrator without leaching increases the mixture durability adding the cement from 1,30 to 1,52 MPa or at the ratio 1.17. Mixtures activated in disintegrator without adding the cement can be used for filling the overwhelming majority of breakage headings.

The extraction into steamed and tempered product made, in percent: cobalt – 104,5%, nickel – 102,1%, lead – 43,5%, zinc– 36,6%, chrome – 18,0%, manganese - 1,4%. Metal extraction of more than 100% is explained by possible exceeding of their content in leaching materials over the content in analyzed samples of the initial materials. Metal extraction having very low content in solutions, mg/l: manganese – 1, nickel – 7, cobalt – 2, chrome – 4, lead – 3, zinc – 5 mg/l is rather high. The tailings of mechanic-chemical activation of coal preparation rejects are the dispersed mass, made of the particles of about 0,1 mm in size, notable for more regular structure that improves the quality substantially. The effect of it is illustrated by increasing the strength of the concrete manufactured ceteris paribus on the basis of slag, produced by different methods: grinded in a mill and activated in disintegrator [3].

Conclusion

Mechanic and chemical tailings activation in disintegrator allows ensuring the mixture correspondence to the ecological and technological demands within the minimum of time. [4].

The results of the experiment allow concluding that: the traditional beneficiation technologies are bound by the extraction limit, the result of which is the tailings that cannot be further used for metal extraction by the known methods; metal extraction from the non-ferrous and ferrous metals tailings and coals is ensured by leaching in mechanic-chemical activation of raw materials; the results convergence of the processed tailings from different off-grade raw materials verifies the perfection of the method.

Implementation of the present concept related to the waste-free utilization of the off-grade raw minerals ensures the possibility of using the processing tailings. The success of the concept implementation depends on the volumes of combining the processes of chemical leaching and mechanical activation in disintegrator within the sequence-linked operation.

References

1. Golik V.I.., Komaschenko V.I., Rasorenov Y.I. Activation of Technogenic Resources in Disintegrators. DC 10.1007/978-3-319-02678-7_ 107, *Springer International Publishing Switzerland* 2013.
2. Kozlov, D.G., Komashchenko V.I, Ismailov T.T., Drebenstedt K. (2008). Minimization of dust pollution. *M. GIAB,* No. 7, p. 26-29.
3. Golik V.I, Komashchenko V.I., Drebenstedt K. Effect of geological exploration and mining on the environment. Monograph. Moscow, KDU, 2010.
4. Komashchenko V.I, Erokhin I.V. Technogenic influence processes of extraction and processing of ores at natural-technical geo system environment. Works-V international scientific conference. "The problems of nature management and environmental situation in European Russia and adjacent countries, Belgorod 7-11 October 2013. C.73-78.

5. Morkun V., Tron V. (2014). Ore preparation multi-criteria energy-efficient automated control with considering the ecological and economic factors, *Metallurgical and Mining Industry*, No5, p.p. 4-7.
6. Morkun V., Morkun N., Pikilnyak A. (2015). Adaptive control system of ore beneficiation process based on Kaczmarz projection algorithm, *Metallurgical and Mining Industry*, No2, p.p. 35-38
7. Morkun V., Morkun N., Tron V. (2015). Identification of control systems for ore-processing industry aggregates based on nonparametric kernel estimators, *Metallurgical and Mining Industry*, No 1, p.p. 14-17.
8. Morkun V., Tron V. (2014). Automation of iron ore raw materials beneficiation with the operational recognition of its varieties in process streams, *Metallurgical and Mining Industry*, No 6, p.p. 4-7.
9. Morkun V., Tron V. (2014). Ore preparation energy-efficient automated control multi-criteria formation with considering of ecological and economic factors, *Metallurgical and Mining Industry*, No5, p.p. 8-11.