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Investigation into the flotation response of refractory molybdenum ore to depressant mixtures: A case study

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ABSTRACT

In this paper, bulk flotation followed by separation was investigated to concentrate purified molybdenite product from Jinduicheng molybdenum ores (Shanxi province, China). The bench scale tests mainly focussed on separation of molybdenite from other sulfide minerals using the new type of depressants. The effect of each single depressant, including organic depressant-modified dextrin (MD), P-Nokes reagent (PN) and sodium trithiocarbonate (ST), and their mixtures on galena, chalcopyrite and other sulfide ores, was examined in turn by changing the concentrations used in cleaner flotation tests. Closed circuit experiments were carried out under the optimal condition and satisfying recovery and grade of molybdenite concentrate could be achieved (86.294% and 53.157%, respectively). A potential reagent regime was developed, with more environmental friendly and more economical advantages due to the introduction of modified dextrin.

1. Introduction

The Jinduicheng molybdenum mine is located in Shanxi province and currently processes ores at over 30,000 t/d. Molybdenite concentrate is recovered as the main product in two stages; first, the bulk flotation concentrate of copper, lead and molybdenite is produced, and second, the molybdenum minerals are separated from other sulfide ores.

The JDC brand of molybdenum concentrate was famous around the world in past decades, for its high quality with low impurity. After more than 30 years of practical exploration, the JDC mine is facing new challenges for producing high quality molybdenum concentrate because of lower quality feed which contains a higher content of galena and other unwanted sulfide minerals. P-Nokes reagent and sodium thioglycollate have been proved to be effective depressants for galena and chalcopyrite in JDC mine in the past 20 years, but this classical reagent regime meets many difficulties when ore feed contains more and more lead sulfides.

The most common plant practice involves depression of chalcopyrite, galena and other sulfide minerals from molybdenite using sodium thioglycollate, pseudo glycolythiourea acid, sodium cyanide, sodium sulfide or Nokes reagent to generate the molybdenite concentrate [1–4]. However, given the toxic nature of most of these depressants, there have been significant efforts made to determine the effect of non-toxic organic polymers on molybdenite flotation recovery [5–8]. It has been reported that dextrin was a very effective depressant for the air flotation of molybdenite in the absence of a collector, whereas it did not depress molybdenite effectively in an oil flotation process using iso-octane [5]. Moreover, reports on the use of dextrin as a selective depressant for the differential separation of chalcopyrite/sphalerite and galena are abundant [9–13]. Inspired by the literature previously mentioned, modified dextrin was adopted to inhibit the flotation of galena and other unwanted sulfide minerals for the first time.

In the present investigation, the effect of each single depressant, including MD, PN, ST and their mixtures on galena, chalcopyrite and other sulfide ores were examined under varied experimental conditions. Closed circuit experiments were carried out at the optimized parameters and satisfying recovery and grade of molybdenite concentrate can be achieved. Compared to the running regime at the mine site, a potential reagent regime was developed with better environmental compatibility and economic adaptability due to the introduction of modified dextrin.

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2. Experimental

2.1. Material and reagent

The test minerals are from Jinduicheng mine site of Shanxi province in China, and the copper-bearing minerals mainly are chalcopyrite with some copper oxide ore. The main lead-bearing mineral is galena and a trace amount of oxide ore is also discovered. The main iron-bearing mineral is pyrite. Molybdenite is the main molybdenum-bearing mineral and a small portion of oxide ores (<5%) is present.

In the bulk flotation test, kerosene and pine oil were used as collector and foaming agent respectively. P-Nokes reagent (PN), sodium trithiocarbonate (ST) and modified dextrin (MD) were used as the depressants of copper/lead-molybdenum separation.

2.2. Flotation experiments

The first stage of the flotation tests was conducted in a 3.0 L Denver laboratory flotation cell with a rotation rate of 1544 r/min and a series of flotation cells were also used in the cleaner flotation stage (XFD-0.5L, XFGC II Model Hanging Cell Flotation Machine). In the second stage, three different reagents were adopted as depressants, i.e., (a) PN with the dosage of 10, 20, 30, 40 g/t; (b) ST at 10, 20, 30, 40 g/t; and (c) MD at 0, 5, 10, 15 g/t. The present investigation aims at examining the effect of each single depressant PN, ST, MD and their mixtures on chalcopyrite, galena, pyrite and other sulfide ores. The effect of grinding and regrinding fineness on grade and recovery of molybdenum concentrate was also investigated.

2.3. Beneficiation flowsheet

The principle flowsheet for processing the ore is presented in Fig. 1.

3. Mineralogy

3.1. Mineral composition

The polymetallic ore contains minerals such as molybdenite, pyrite, rutile, ilmenite and magnetite, sphalerite, chalcopyrite, galena, limonite, hematite, spot copper, nickel pyrite, arsenopyrite, scheelite. The gangue minerals mainly include quartz, biotite, muscovite, potassium feldspar, a small amount of sodium feldspar, grossular, calcite, fluorite, apatite, sphene, chlorite, sericite, kaolinite, and so on.

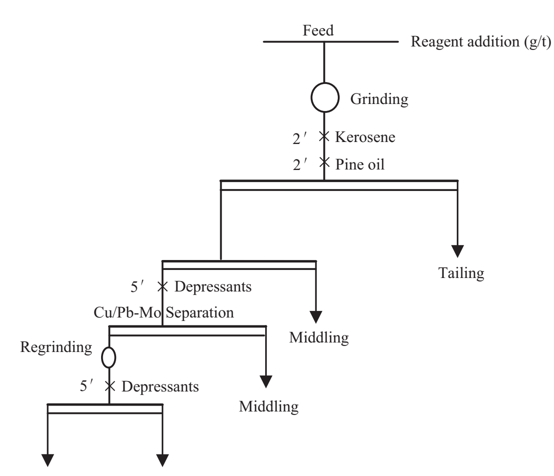

Fig. 1. Principle flowsheet for recovery of molybdenum.

3.2. Dissemination character of the major metal minerals

Under the reflecting microscope, molybdenite is gray with strong heterogeneity and occurs mainly in the form of flake, grain size and scale aggregation of intergrowth with gangue minerals. The molybdenite minerals are mainly distributed in the size range of 0.02–0.2 mm, with a small portion less than 0.01 mm. Galena occurs as granular aggregates with the size of 0.02–0.074 mm, and is distributed in the gangue minerals as sparse disseminated type or intergrowth with sphalerite. Chalcopyrite occurs as granular aggregates or fine grains with the size of 0.01–0.2 mm, and portion intergrowth with sphalerite. The sphalerite minerals are mainly distributed in the range of 0.02–0.2 mm and intergrows with galena or chalcopyrite. Figs. 2–5 are reflecting microscope scanning maps of the main sulfide minerals.

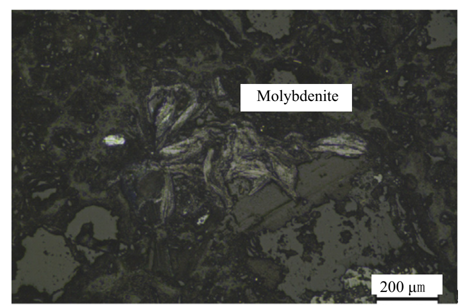

Fig. 2. Reflecting microscope to enlarge 100 times (molybdenite as scale aggregation included in gangue mineral).

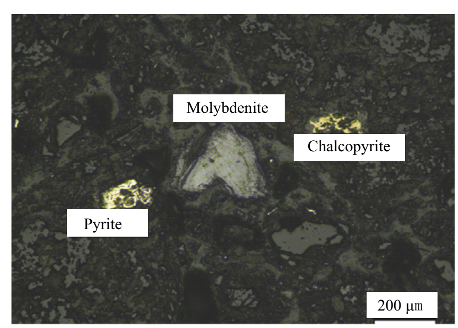

Fig. 3. Reflecting microscope to enlarge 100 times (molybdenite, chalcopyrite and pyrite as grain size distributed).

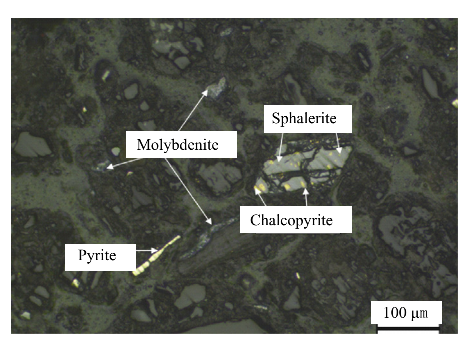

Fig. 4. Reflecting microscope to enlarge 200 times (molybdenite as grain size or aggregation distributed, chalcopyrite included in sphalerite distributed as grain size).

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