Preliminary assessment of new approach to scale-up the laboratory results of flotation reagents tests based on mineralogical analysis.

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Abstract. The question of introducing new collectors into copper concentrator plants referring to KGHM experience has been presented in this paper. Description of present methodology of flotation reagents testing has been indicated followed by explanation of crucial problems and limitations with proper qualification of reagents. Some attempts to apply scale-up methodology have been reported in technical literature. In this article assumptions of new methodology based on advanced mineralogy tests have been suggested. This methodology should allow the more accurate forecast of flotation performance of industrial plant after the laboratory tests.

1. Introduction

The right selection of flotation collectors is an essential issue for each flotation process optimisation. As reagents have main influence on process performance, scientist' efforts are focused on continuous development of their efficiency. In KGHM the research investigations on flotation reagents has been still continuing since commissioning ore processing plants in KGHM structures (1968-1974).

Testing of reagents were aimed to introduce various mixtures of collectors to optimise technology efficiency and reagents consumption rates. Works have been performed by KGHM own forces as well as with cooperation with outside research and development centres. Consequently, some tens of reagents with different properties have been examined. They were delivered by well-known global scale manufacturers as well as by domestic local producers. Reagents have been tested as separate collectors or as additives to regularly used collectors. Their efficiency has been tested together with optimal consumption rate and synergy with other reagent(s) but also the influence of different points of dosing in flotation and grinding circuits on process efficiency has been examined [1].

As a result of long-term research the proper mixtures of collectors have been chosen and approved for each KGHM concentrator plant. Nowadays mixtures with fixed quantities of sodium xanthates and mixtures of sodium xanthates with sodium diethylditiophosphate are used as a regular collectors chosen for different qualities of flotation feed. Selected reagent species are the most popular collector applied worldwide not only for copper sulphide ore but also for Cu-Mo and Cu-Au ores. They are recognized as presently most efficient reagents for polymetallic sulphide ores [1].

2. Some aspects of development the appropriate method of flotation reagents testing

In spite of satisfactory results of collector tests there is a continuous effort to develop new reagents or their mixtures which might provide better process efficiency performed on copper ores of Legnica-

Glogow Copper District (LGOM) deposit. The investigation attempts are often finalized with no positive recommendation. Conclusions made on laboratory scale results are not sufficient to recommend the plant trial. Among the large amount of tested tens of reagents only few of them were approved to be tested in industrial scale. Hence the researchers activity should be still focused on continuously development of methods of new reagents testing which are applied in concentrator plants.

The problem of scale-up results is a complex issue. It is known that in laboratory scale investigation should range many variable parameters, so they should be conducted on small amounts of tested samples [2]. The laboratory scale experiments should be proper planned and developed to reflect the real industrial conditions. Testing parameters should be representative what means they should mirror specific physicochemical phenomena and hydrodynamic conditions present in industrial flotation cells [3]. Laboratory experiments should be replicate at least twice or three times and their results should be statistical evaluated. The method suggested by Dell is based on set of multiple fractional flotation experiments followed by scale-up prognosis. Another method targeted to forecast industrial results is comparison of flotation selectivity observed in laboratory flotation with selectivity so called re-flotation of industrial final concentrates and tailings [4].

Comprehensive study on scale-up methodology proves that complete forecasting industrial results based on laboratory testing has not been developed yet. Even though the aspect of scaling-up reagent tests in KGHM conditions was thoroughly analysed, the reliable, universal and ready-to-use method of laboratory tests still needs to be established. According to current practise, tested reagent is approved to industrial scale trial only on slight differences between lab results for reference and tested reagents. Generally laboratory results do not repeat in industrial scale for majority of conducted tests [5-7]. Subsequently the aspect of scale-up and results reproducing must be better investigated as a crucial factor of testing the new reagents. The aim of this approach is to minimize or eliminate negative results of industrial scale trials and in results to avoid undesirable costs.

3. The error sources of method of laboratory tests and industrial trials

Applied in KGHM new reagents testing procedure includes preliminary laboratory testing stage followed by industrial trial for approved reagents with promising prognosis of their efficiency in plant conditions. The range of laboratory testing is practically limited to fractional flotation in pneumomechanic cell of one litre volume. On the other hand, comparing to industrial conditions, laboratory scale allows to dose precisely reagents and to control air flowrate, to ensure scheduled retention time, froth level and other important process parameters.

It needs to be emphasized that in real, industrial circuits the process efficiency depends not only on controlled flotation cell operating parameters but also on set of various process factors and their influence on process is difficult to predict. Among others, one of the important aspects of industrial conditions is recirculation of slurries resulting with gathering material with low floatability and some amounts of reagents. Moreover, in plant conditions many variable parameters affects process stability as fluctuation of ore throughput, feed flowrate, accuracy of airflow and reagents dosing and important role of industrial circuits inertia after changing operating regime.

Difficulties with prognosis of industrial reagents efficiency are also related with complexity of geological morphology of LGOM deposit. KGHM owned resources, formed as stratoidal type of deposit, constitute sulphides minerals accumulation in layer of sandstone, rotliegend, zechstein shales and carbonates (mainly dolomites) rocks. Based on this stratigraphy the three species of ore lithology have been described: sandstones, shale and dolomites. In large part of deposits they occur common but in different ratio and with various mineralization. Copper orebody has several forms of sulphide minerals occurrence with different grain size. Hence geological conditions strongly influence on lithological and mineralogical constitution of run-of-mine ore.

To summarize all the limitations listed above, it is difficult to conclude about forecast reagents efficiency in real environment avoiding important uncertainty of calculated result. It is necessary to develop more accurate scale-up model which is dedicated strongly to KGHM conditions.

4. Guidelines for developing the new procedure of reagents testing

Unsuccessful effects of present reagents testing are the background to resume effective model of scaling-up laboratory results to industrial reality. The more specialized and specific approach is needed, which can deliver more reliable laboratory results on which decision of industrial trial is considered.

This task should be based on experience and knowledge of researchers who investigated procedures of application flotation reagents to KGHM concentrator plants. As a new concept it is suggested to support industrial trails with parallel (simultaneous) laboratory tasting. Results of laboratory tests achieved during industrial trial will be compared with previous laboratory data delivered by tests conducted to decide on industrial trial. These data together with industrial results will be base to develop algorithm which allows to forecast industrial performance of reagents only on laboratory tests data. It is a new approach but with reasonable background both theoretical and practical. The details of such methodology is based on reports presented in scientific literature but also derives from realized testing of reagents conducted during years of KGHM activity. This is why it is promising direction of future research with a great potential. This approach will allow include a range of characteristic parameters of laboratory flotation in scaling-up its results. These parameters are difficult to consider separately and can be exemplified by slurry hydrodynamic phenomena occurring in different conditions in laboratory, pilot or industrial flotation cells.

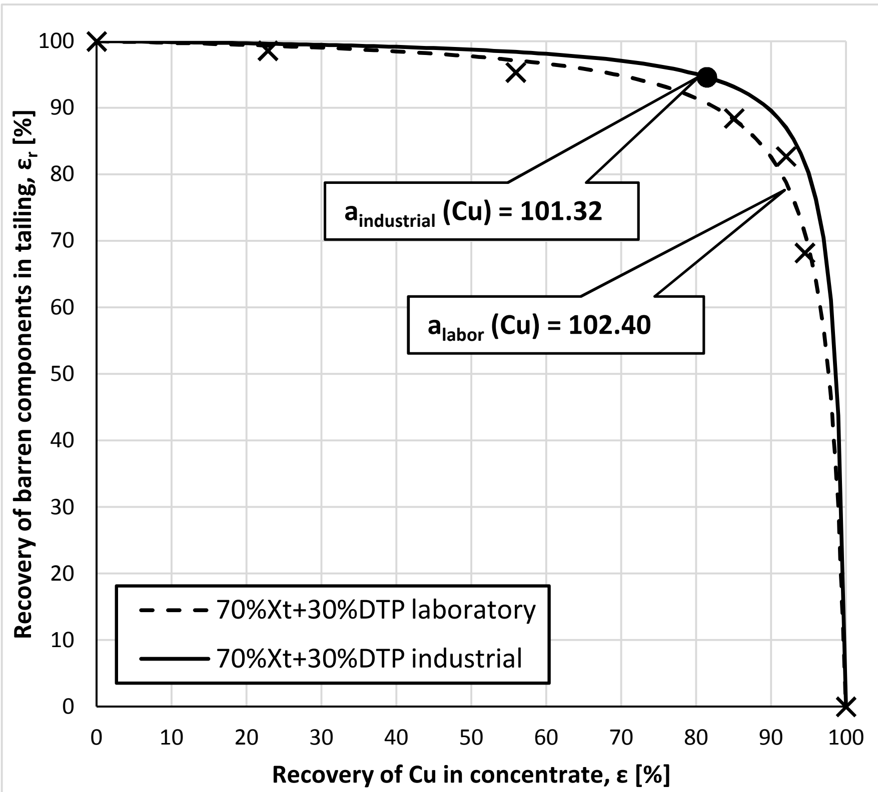

Figure 1. Comparison of Fuerstenau upgrading curves for copper obtained during reagent test in laboratory and industrial scale for one of the technology line of KGHM concentrator plant.

Present attempts to develop the reliable method of reagents testing are based mainly on chemical assay to determine and balance Cu content, sometimes complemented by Ag and other elements, in analysed samples. Nowadays the more detailed and specific information may be obtained by mineralogy investigation of analysed samples. Referring to geological complexity of LGOM deposit described in previous paragraph, it seems to be reasonable to determine and compare upgrading susceptibility of specific copper sulphide minerals in laboratory and industrial scale.

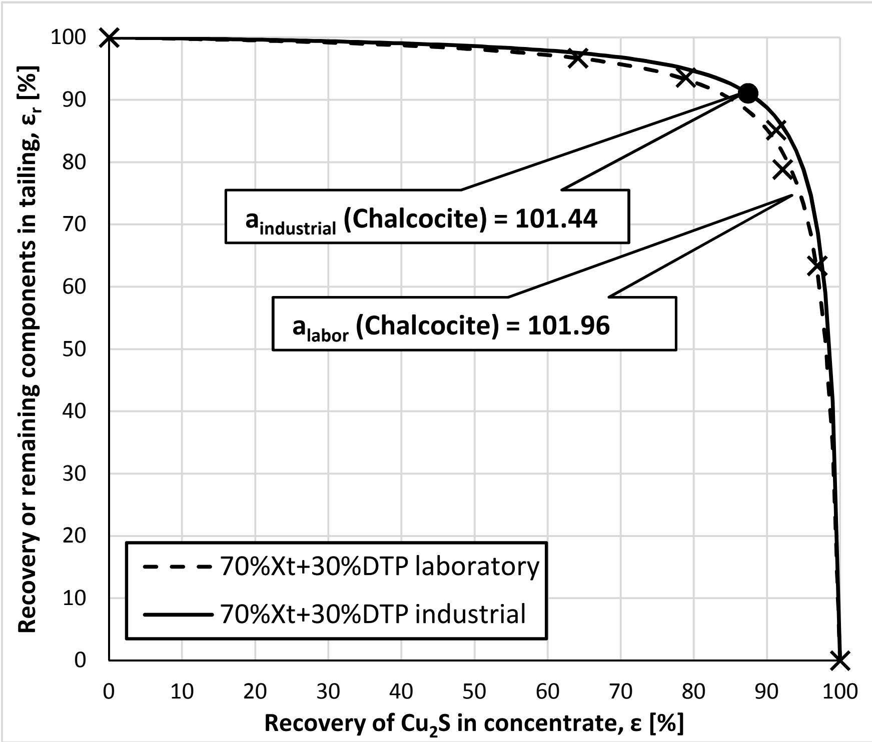

Figure 2. Comparison of Fuerstenau upgrading curves of chalcocite obtained during reagent test in laboratory and industrial scale for one of the technology line of KGHM concentrator plant.

During some research on application of new mixtures of collectors a set of laboratory flotation experiments was executed [1]. The feed samples were collected from one of the technology line of KGHM concentrator plant to examine performance of selected collector mixture. Concentrates and tailing were examined with MLA technic to quantify mineralogical species. The results of comparison laboratory and industrial upgrading of copper and major copper bearing copper sulphide minerals are shown in figures 1 – figures. 4. The comparison of laboratory and industrial data was possible due to laboratory research with collector mixtures conducted simultaneously with regular metallurgy assay of production process. Both experiments were conducted with the same collectors mixture (70% mixture of ethyl/isobutyl sodium xanthate and 30% sodium diethylditiophosphate). To present results of reagents efficiency Fuerstenau upgrading curve with corresponding selectivity factors “a” was chosen as a curve not sensitive to α variation. This is necessary to avoid influence of differences between feed grade in laboratory and industrial observation.

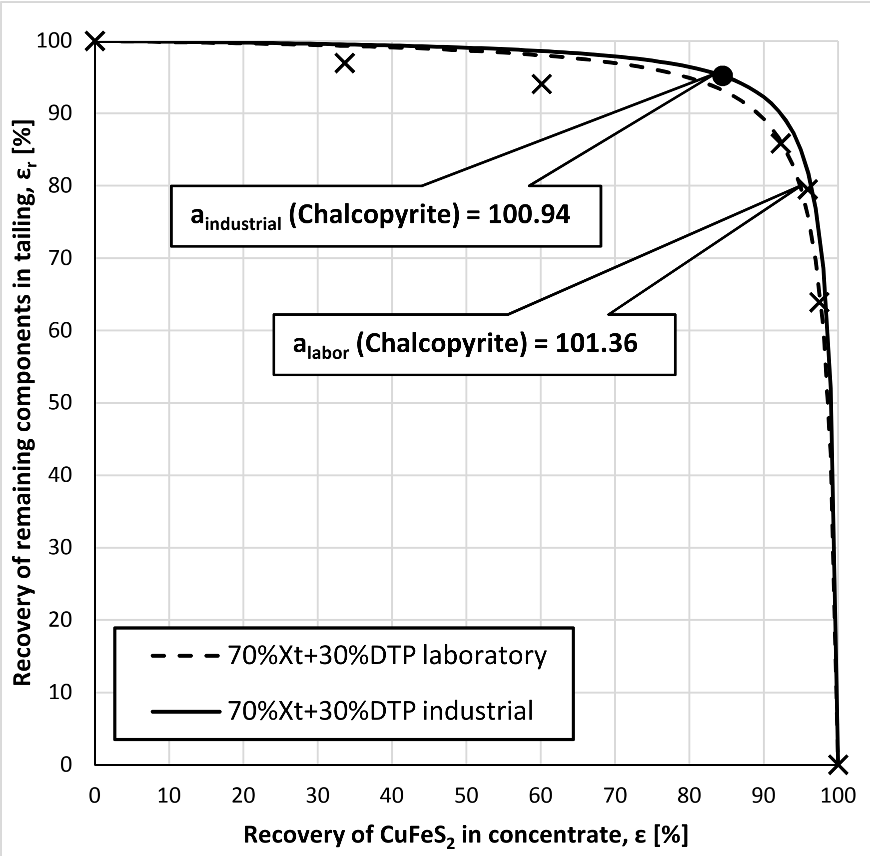

Figure 3. Comparison of Fuerstenau upgrading curves of chalcopyrite obtained during reagent test in laboratory and industrial scale for one of the technology line of KGHM concentrator plant.

Obtained results (figure 1 – figure. 4) show the differences between laboratory and industrial upgrading behaviour of specific mineral components present in feed. Comparison of upgrading curves for Cu and analysed copper sulphide minerals demonstrates that difference between selectivity factors for elemental copper is evident higher than relevant differences for chalcocite, chalcopyrite and bornite. It appears the possibly influence of other copper bearing minerals and barren minerals on total copper upgrade performance. Therefore, minor sulphide minerals may negative affect flotation efficiency. Observed phenomenon should be investigated and verified by broaden analysis of relationships between laboratory and industrial upgrade rates of remaining copper bearing minerals as well as accompanying sulphide minerals present in flotation feed. Extended mineralogical tests may bring crucial information on mutual interactions between specific minerals during scaling-up process conducted in order to implement new flotation reagents.

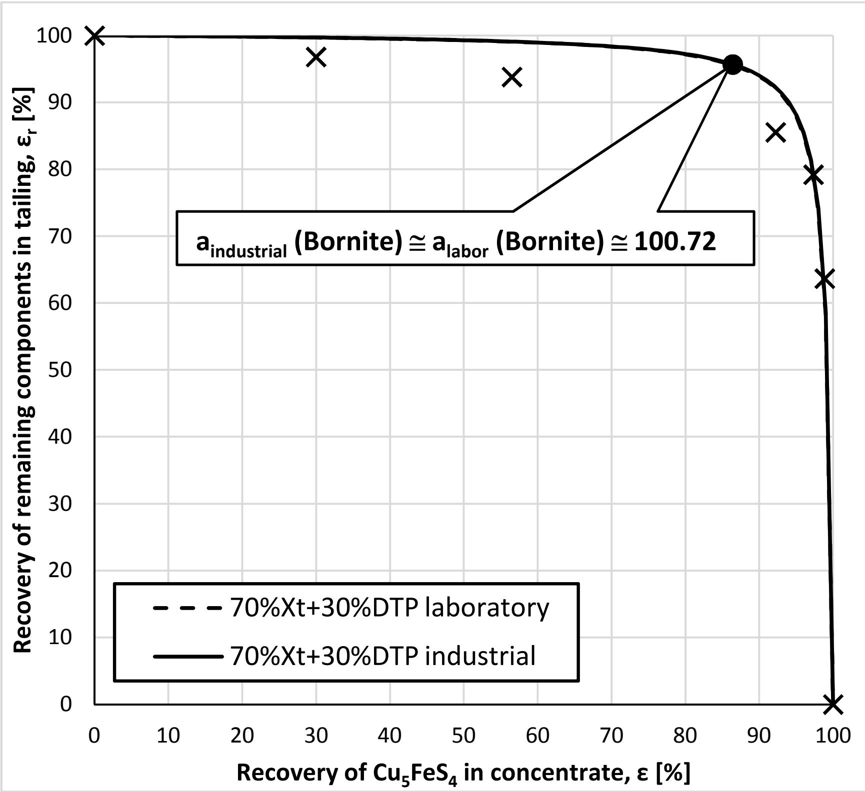

Figure 4. Comparison of Fuerstenau upgrading curves of bornite obtained during reagent test in laboratory and industrial scale for one of the technology line of KGHM concentrator plant.

5. Summary

Latest research on selection flotation reagents was generally based on assessment of upgrading properties of coppers and other valuable metals in laboratory and industrial conditions. Collected experience proves that positive results of laboratory tests do not guarantee satisfactory effects in concentrators plant when new reagents is applied. Many attempts have been taken to form scale-up model for test results from laboratory to industrial environment. However, no reliable, universal and easy-to-use laboratory reagent testing method to predict their industrial performance has been developed yet. The accuracy of scale-up models is affected by many factors influencing on process stability besides geological complexity of LGOM deposit. In industrial conditions research and testing policy and operational procedures of new collectors implementation have the key impact on process economy. Since the present knowledge on practical aspects of scaling-up is unsatisfactory, discussed subject desires complex approach which should be develop in further studies. As preliminary tests, upgrading behaviour of main copper sulphide minerals has been investigated, simultaneously in laboratory and industrial scale. Results reveals complexity of scaling-up models for specific minerals. Therefore the scope of future investigation should include possibilities delivering by contemporary mineralogical analysis methods.

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