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Effect of cryogenic treatment on disintegration of clay aggregates in washing drum

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Abstract. The article addresses the problems arising in alluvial clay sand washing in drum-type machines. The author proposes a method to increase disintegration efficiency by cryogenic treatment of initial sands. The results of the experimental studies on formation and destruction of dense clay aggregates in the laboratory model of a washing drum after preliminary freezing–thawing are presented. The investigations have experimentally proved that after 3 freeze–thaw cycles in the temperature range from 243 K to 293 K, a high-clayey lump breaks down at the first minute of disintegration and dissolves in the washing medium, which eliminates subsequent formation of compact clay balls.

1. Introduction

As a result of reduction in number of placers of readily dressible minerals, including diamonds and precious metals, the processing industry is increasingly often faced with materials with high content of clay, which complicates recovery of useful components.

At the present time, clayey sand is disintegrated in drum-type machines which yield satisfactory results in case of readily and moderate-washable sands and offer a drop in efficiency with highly clayey materials (content of silt and clay more than 20%). The key problem of this type washing machines is generation of secondary clayey aggregates—hereinafter, balls, which, depending in size, either go to dredge tailing dumps (40% of balls) or come to tailings after mineral dressing. Owing to excessive adhesion ability, non-decomposed clayey balls can hold some useful minerals which eventually are lost.

As a rule, aimed to improve gold recovery from rebellious materials without modification of processing technologies, it is suggested to use multi-stage washing and concentration circuits which only results in the higher cost of production. One of the methods for improving washing efficiency with highly dispersed clayey sands in the Far North conditions is cryogenic pre-treatment.

The research into the frost effect on clayey rocks, both in Russia [1–5] and abroad [6–9], addressed structural changes in clayey materials in static environment without regard to the process of disintegration. The analyses of cryogenic pre-treatment aimed to weaken sands before washing focused on dispergation in water-and-air medium [10], preparation of rock mass [11], etc. This article describes studies into the effect of freezing on disintegration of sands in dynamic environment, in particular, in drum-type machines.

The earlier research has divided the process of ball formation in a dead-end washing drum into three stages: gain in weight, compaction and disintegration [12]. The aim of the new cycle of investigations is to estimate the effect of cryogenic pre-treatment on the behavior of clay balls in washing drums and to reveal details of change in adhesion ability of highly dispersed geomaterias, as well as to identify significant factors of freezing (time and temperature, number of freeze and thaw cycles) which have influence on the dynamics of formation and disintegration of compact clayey aggregates.

2. Experiment results

The tests were carried out on a lab-scale model of a washing drum *1* (Figure 1) with a seal cap *2* placed on supporting rollers *3* mounted on a frame *4* with a pressure regulator *5* and an electric motor *6*.

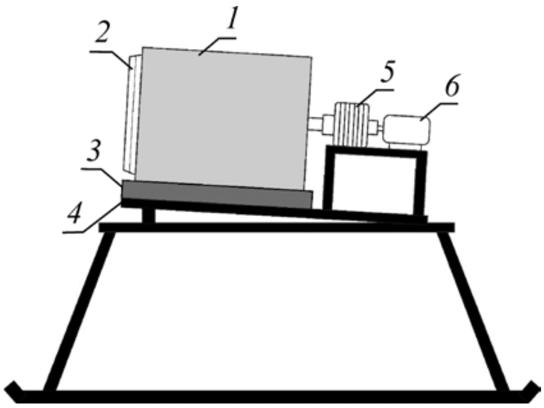

Figure 1. Lab-scale model of dead-end washing drum.

The balls for the tests were made of a dispersed material from a Kuranakh group placer, Aldan Region in the Republic of Sakha (Yakutia). The content of fines -0.05 mm in the initial sand was 45%, the size of $+2$ mm was pre-separated. The moisture of the balls was 25% and the weight was 120 g. Some balls were air-dried, the other balls were subjected to pre-freezing. In addition, balls with the preset moisture content without cryogenic pre-treatment were also examined. Frosting of specimens was implemented outdoor, in sealed containers, under the temperature of 243 K for not less than 15 h. Thawing was carried out in a lab room, under the temperature of 293 K, in sealed containers for 15 h.

To estimate dynamics of lumping, a clay ball with the certain properties (weight, moisture content, with and without cryogenic pre-treatment) was placed in a dead-end washing drum with water-and-clay mixture (660 g of mixture with the content of fines -0.05 mm of 10 and pebbles $-5+2$ mm in size of 340 g) with the preset moisture content of 50% to simulate a washing medium. The ball was taken out of the drum and weighted in 1 min.

The tests of clay lumping in the dead-end washing drum demonstrated significant effect of cryogenic pre-treatment on disintegration of compact clayey aggregates. In the tests, the air-dried balls did not swell and fail for 1 h, and showed no appreciable adhesion ability for lumping, while the balls with the moisture content of 25% placed in the drum without cryogenic pre-treatment gained on average 20% in weight in the form of pebbles and clay from the washing medium during the first minutes, swelled by the 10th minute into compressed sphere and completely lost the spherical shape and became clots by the 15th minute of the test.

The samples subjected to washing after one cycle of freezing and thawing showed low adhesion and gained weight insignificantly (round 10%) with the material from the washing medium but became more resistant to disintegration—the balls lost the gained weight by the 20th min and turned into clots by the 40th min.

After two freeze–thaw cycles, the samples showed no adhesion ability, became unstable, swelled and became plastic in 5 minutes. The surface of the balls after three freezing cycles was cracked (Figure 2a), the samples became brittle and some of them decomposed during thawing (Figure 2b). The test proved that after three freeze–thaw cycles, the balls completely dissolved in the drum in 1 minute.

Figure 2. A ball after three freeze–thaw cycles: (a) cracks on the surface of the frozen ball; (b) decomposed ball after thawing.

The testing results are depicted in Figure 3.

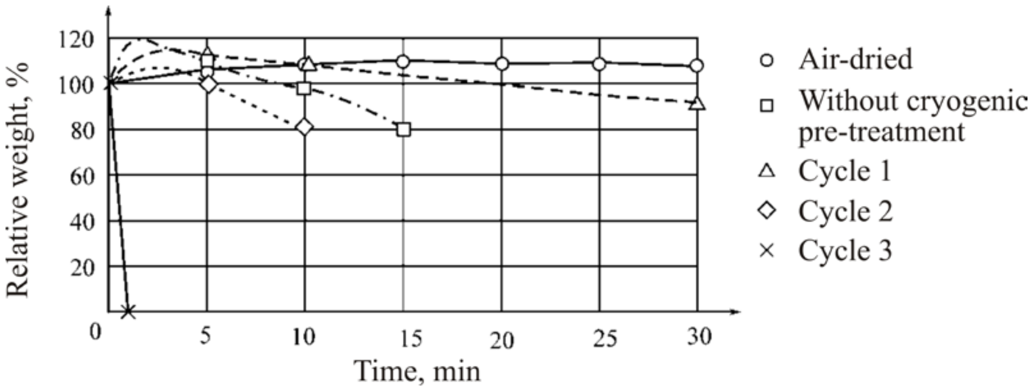

Figure 3. Dynamics of disintegration of clayey balls in washing drum after various techniques of pre-treatment.

3. Conclusions

As a result of the estimate of the cryogenic pre-treatment effect on disintegration of most highly clayey balls in the dead-end washing drum, it has been experimentally found that after three cycles of freezing–thawing in the temperature range of 243–293 K, the highly clayey balls with the moisture content of 25% fails in the first minute of disintegration and disperses in the washing medium, which eliminate subsequent formation of compact lumps.

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