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FAST FLOTATION OF FINE COAL IN THE AIR-SPARGED HYDROCYCLONE

The design and performance of the air-sparged hydrocyclone (ASH) developed at the University of Utah is described in the paper. Flotation results for coal in 2-inch and 6-inch ASH are also compared.

Separation and concentration of fine particles by froth flotation is an important unit operation in many industries. Froth flotation separation is generally accomplished in a gravitational field and is not particularly effective for the recovery of fine particles. This poor flotation response results from small inertia of fine particles. Particle penetration of the bubble film is inhibited, and hence the rate of attachment is low. Further, in conventional flotation, nominal retention times of the order of several minutes are required. The bubble/particle attachment time is frequently on the order of milliseconds, which indicates that the rate of flotation is mostly limited by bubble/particle collision and/or transport. Consideration of these two aspects of conventional flotation technology - limited fine particle recovery and relatively slow flotation rates - led to the concept of air-sparged hydrocyclone (ASH) flotation. The design was envisioned to establish a controlled high force field by swirl flow in order to increase the inertia of fine particles and to produce a high density of fine air bubbles with a directed motion to improve collision efficiency. The net result is effective fine particle flotation with a flotation rate having retention times which approach intrinsic bubble attachment times. This corresponds to a capacity on the order of 100-600 tpd/ft of cyclone volume, at least 100-300 times the capacity of a conventional mechanical or column flotation cell.

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In air-sparged hydrocyclone flotation, the slurry is fed tangentially through a conventional cyclone header into a porous tube to develop a swirl flow of a certain thickness in the radial direction (called the swirl-layer thickness). The flow is then discharged through the annular opening created between the tube wall and a froth pedestal which is located on the cylindrical axis at the bottom of the ASH, see Figure 1. Air is sparged through the jacketed porous tube wall and is

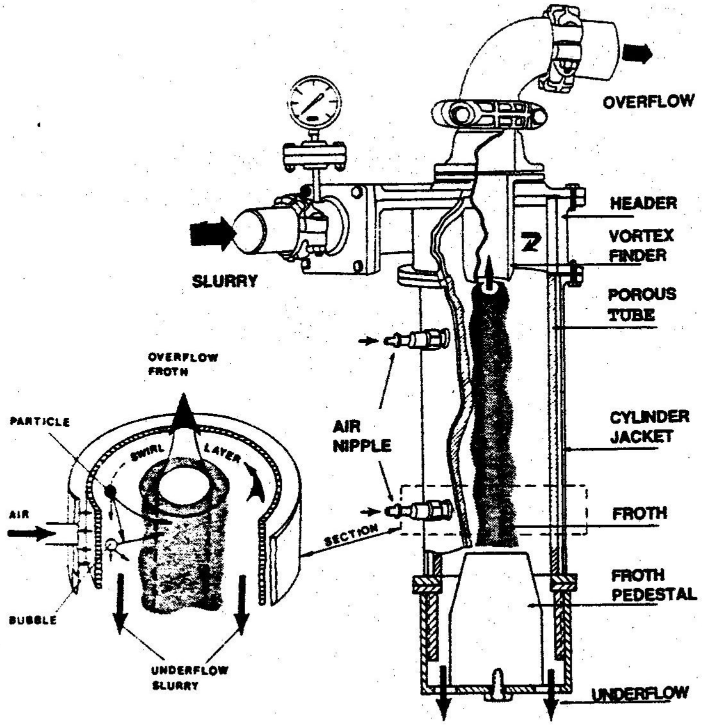

Fig.1. Air-sparged hydrocyclone

sheared into numerous small bubbles by the high-velocity swirl flow of the slurry. Hydrophobic particles in the slurry collide with these bubbles, and, after attachment, are significantly reduced in their tangential velocity and transported radially into a froth phase which forms on the cylindrical axis. The froth phase is supported and constrained by the froth pedestal and thus moves towards the vortex finder of the cyclone header, being discharged as an overflow product. Hydrophilic particles generally remain in the slurry phase and are discharged as an underflow product through the annulus between the porous tube wall and the froth pedestal. This preferred design is a result of more than a decade of both fundamental and applied research at the University of Utah.

With the development of the ASH technology, it has been shown that the air-sparged hydrocyclone can provide a high specific capacity not only for the flotation of fine particles but also for intermediate-size particles (60 to 300 μm). Research at the University of Utah has proved its efficiency for copper porphyry ore flotation, low-grade placer gold and sulfide mineral flotation, fine coal cleaning, industrial mineral flotation, etc. In these test campaigns, the air-sparged hydrocyclone provided separation efficiencies equivalent to or better than those achieved in conventional flotation. Similar results of the ASH flotation tests have also been reported from other countries.

The high processing capacity of the ASH is due to the extremely short retention time, less then one second in a 2-inch system. In this way, optimal control of all the design and operating variables is essential for the effective flotation. When compared to conventional flotation, ASH flotation requires a greater degree of control and the flotation performance of the ASH system drops significantly if the levels of the process variables are displaced from optimum conditions. It is advised that only minus 100 mesh fine coal material should be used for the 2-inch ASH flotation testing due to the strong centrifugal force developed in the 2-inch ASH system. This top size limit can be increased to about 28 mesh when a 6-inch ASH system is utilized. With a 15-inch ASH system, it is anticipated that even coarser feed material can be

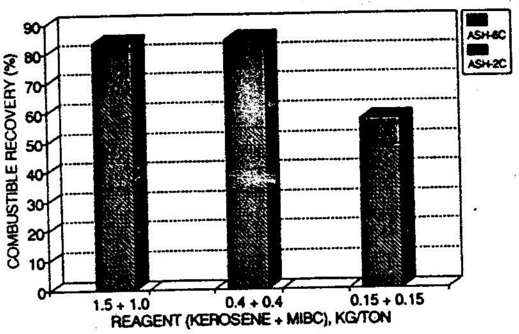

Fig. 2.
Effect of reagent schedule.

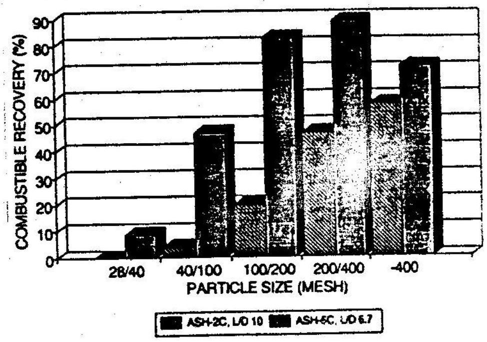

Fig. 3.
Size-by-size flotation performance

processed. In Figures 2-4 a comparison of the 6-inch ASH flotation performance with the 2-inch ASH flotation performance is presented. The comparative testing was carried out for the medium volatile bituminous coal under identical conditions. When the larger diameter ASH system is used, better flotation recovery, lower reagent consumption and the flotation of coarser particles sizes can be achieved. More details regarding this matter will be included when Polish coal processing data becomes available.

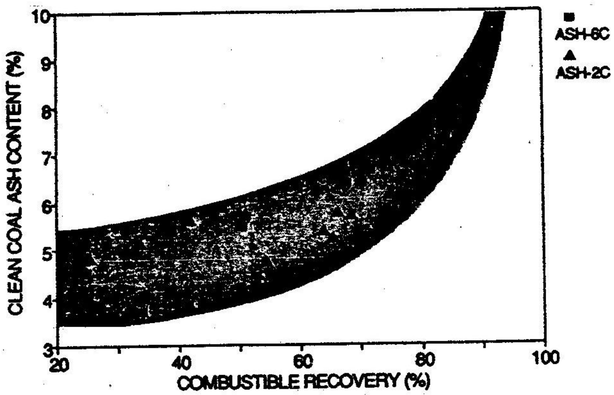

Fig. 4. Clean coal ash vs combustible recovery

STRESZCZENE

Miller J.D., Gopalakrishnan S., Ye Y., Hupka J., Kościukiewicz J., 1991. Szybka flotacja drobnych ziarn węgla w napowietrzanych hybrocyklonach. Fizykochemiczne Problemy Mineralurgii. 24; 221-224.

W pracy opisano działanie i wykorzystanie napowietrzanych hydrocyklonów (air-sparged hydrocyclone, ASH) do flotacji węgla dla dwu i sześciocalowych ASH.