FLOTATION PROCESSES*

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(Continued from p. 123, March 1.)

Essential Elements.

Cold solutions were seen to be used with some processes. Therefore heat is not an essential element to flotation. Vacuum is used in the one type to produce the gas so it is not essential to flotation. Oil is not always used in froth flotation so it is not an essential element to any except bulk oil flotation. This fact is also shown by the new process of Louis A. Wood. An alkali is used in one case to neutralize the excess acid and in others in place of an acid. Either an acid or an alkaline solution will do and, from the amounts used in mill solutions, it is seen that extremely dilute solutions are effective. That is, complete ionization exists and the effect is that of an electrolyte. By this process of elimination there are left the essential elements as follows: air for surface tension flotation; oil for bulk oil flotation; and gas and an electrolyte for froth flotation.

It is seen that the gas, to form bubbles in froth flotation, can be generated chemically or electrolytically within the pulp mass or it can be (1) beaten in with stirrers, (2) forced in by pressure (that of the atmosphere or greater), or (3) carried in by jets.

Attachment of Mineral Particles to Bubbles.

Something more than mere bubbles of gas within the pulp mass is necessary to make froth flotation effective. The mineral particles must either be attached to the bubbles or the bubbles must be attached to the mineral particles.

Since a bubble carries with it a surface film of liquid the mineral particle must be caught by this surface film in froth flotation or caught by the free surface of the liquid in surface tension flotation. The necessary conclusion then is that some inherent property of the mineral particle itself is the cause of its resting on the surface of the liquid in the one case or on the surface of the bubble in the other. If it were possible to attach a mineral particle to a bubble already formed by some physical, chemical or electrical force, then it might be possible that surface tension flotation and froth flotation are in no way related, and that bubble attachment is in no way dependent upon some property of the particle itself. It is a well known fact, however, that no such attachment can take place to bubbles that are already formed.

A stream of compressed air turned into a pulp mass in a perfect float condition can not effect flotation, as is well known by every one who has tried it. The bubbles not only rebound from one another but the mineral particles show no tendency to adhere and the bubbles come to the surface without the mineral particles. This is due to the surface film, which phenomena will be taken up later, when it will be shown that there can be no adhesion between this liquid film and the mineral particle, be it either wetted with oil or water. There is no reason for any chemical affinity.

In an electrical field, it is possible for bubbles to be electro-negatively or electro-positively charged. There is no reason why these charges might not be reversed at will by varying the field. Also it is a well known fact that mineral particles can be electrically charged and this is taken advantage of in electrostatic concentration, Cottrell dust precipitation, clay separation, etc. It is also shown in colloidal work that, under the same condition, some minerals are negatively charged, while others have an opposite charge. It is upon these facts that electrical theories of flotation are based. Assume that the particles of metals, sulphides, tellurides, arsenides and the like "have charges of one polarity (positive), and that non-floatable particles have charges of the opposite polarity (negative)," and also that the bubbles are negatively charged. Witness then the metallic particles jumping for and clinging to the bubbles. A beautiful theory if it were true and would explain all connected with flotation.

In the first place, flotation is not dependent upon an electrical field as is electrostatic concentration, dust precipitation, Boethe Schwerin's Electro-Osmotic Process, and others. It would also be possible to attach mineral particles to bubbles already formed by the assumption of an electrical theory. So far, these electrical theories have considered oil as an essential element to flotation, which, as shown above, is not the fact. If a slight change in the strength of the electrolyte will change the polarity of quartz, calcite and the like so as to cause them to sink, when before they were floating, why will it not also change the polarity of some metallic particles so as to create a preferential flotation? No. It is far better to make a theory conformable to the facts than to try to ignore and twist facts to conform to some of the present electrical theories. Since there is no known way to attach mineral particles to bubbles already formed, bubble attachment depends directly upon some property of the particle itself. This property must then be the same for particles floating in either a surface tension or a frothing machine. As shown by Mickle's experiments, this must be due to gas occlusion.

Why is it then that no solid can be floated unless it contains occluded gas? A particle once wetted with the flotation liquid tends to sink as there is no surface tension effect tending to float it. Water is always used as the flotation liquid as it is the cheapest and has the greatest surface tension of all liquids except mercury. If all gases be driven from a solid, water will enter the pores and adhere to its surface. No surface tension effect can be then exhibited towards it for the reason that it is then as part of the water. Thus a force of adhesion predominating, flotation can not take place. This truth is not so readily seen when the particle is below the surface of the water and an attempt is made to float it by means of a bubble. The surface tension of the liquid film surrounding a gas bubble is much greater than the adhesive force of the gas for a solid. The gas is, in this way, firmly held within the enclosing liquid film and attachment between it and a solid cannot take place. As has been shown above, **it is only the gas that is formed within the pulp mass that is of any value in flotation.** In other words, this nascent gas is attracted by the gas at the surface of the solid. A cohesive force exists between the molecules of the gas at the surface of the solid and those in the immediately surrounding liquid so that the solid becomes a nucleus for the formation of a bubble from the nascent gas of the liquid.

As shown above, there are three mechanical ways of forcing air or a gas into solution. There are three methods of expelling it: (1) supersaturation so that the

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