1913

Flotation applied to Joplin sludge

Thaddeus C. Wilson

Gustaf Axel Hellstrand

FLOTATION APPLIED TO JOPLIN SLUDGE.

by

Thaddeus C. Wilson
and
Gustaf Axel Hellstrand

A

THESIS

Submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

DEGREE OF

BACHELOR OF SCIENCE IN MINE ENGINEERING
and
BACHELOR OF SCIENCE IN GENERAL SCIENCE

Rolla, Mo.

1913.

Approved by L. C. Copeland.
Professor of Metallurgy.

TABLE OF CONTENTS

General Mill Practice in Joplin District Pages 1 _2

PPrinciples of Floatation 2 4

Chemical and Screen Analysis of Sludge 5

Preliminary Tests 6

Floatation Machine 6

Proceedure in Making Tests 6 - 7

Limitation of Floatation Machine 7

Tests 8-11

Reconcentration 12

Summary 12-13

Conclusion 14

FLOTATION APPLIED TO JOPLIN SLUDGE.

Under conditions existing today the cost of mining and milling the ores of the Joplin district is generally satisfactory from an economic viewpoint. Methods of ore concentration have been developed which, owing to the nature of the ore, are peculiarly well adapted for obtaining high recoveries with relatively low costs. A visitor to this district often receives a first impression of crudity in methods when compared with those in vogue in other districts, but he is soon impressed with the results and the prevailing mining and milling practice. However, any process tending toward a further recovery which may be applied along with the present schemes employed, deserves consideration.

The wide diversity of ores in the Joplin district is not generally appreciated. This diversity is not great in physical appearance, and less in chemical analysis, but becomes evident in the finer details of concentration. The ordinary Southwest Missouri practice is embodied in a simple system of roughing and cleaning jigs. Fine grinding is generally condemned, and it is probable that in the majority of the mills this procedure would not be profitable. The use of tables has been instituted only recently and vanners have not been tried. Of the users of tables not more than ten per cent are getting the full value of their tables. Probably not more than twenty five per cent of the mills containing tables are dewatering the tailings from their roughing jigs and settling this water to feed their tables. The other seventy five per cent are using at least a portion of this water, which undoubtedly is rich in fine ore, to wash their tailings to the tailings elevator. The sludge (fine material) which daily is being sent to the tailing dump by the Joplin mills contains values in lead and zinc often in excess, as to percentage, of that of the crude ore. At present no attempt is being made to treat this material. It is at this point that it is proposed to introduce some flotation process to supplement the ordinary scheme of wet concentration. With this end in view we have conducted a series of experiments in the flotation of a Joplin sludge. The investigation has been prosecuted by means of standard tests, involving the use of variable factors which are known to affect the flotation of minerals. Among these may be mentioned the physical and chemical nature of the ore, the amount and physical properties of the oil, the temperature of the water, the time and speed of agitation.

Before entering into a detailed discussion of our tests it may be well to consider some of the generally known phenomena attending the flotation of minerals.

Any flotation process is based on the knowledge that substances heavier than water will, under certain conditions, float on the surface of water. The fact that certain minerals will float more readily than others is the basis for the various schemes for the concentration of ores by this method. In order to understand the act of the flotation of particles heavier than water we must consider certain molecular forces, of which that of adhesion is of primary importance.

* "The films of gases that are attracted to the surface of solid particles adhere strongly in some instances, and are displaced therefrom by liquids with considerable difficulty. This quality of adhesion varies remarkedly with different substances. With some substances the gas adhesion is strong and the liquid adhesion is weak; in other words, they are wetted with difficulty. In this class are the metallic sulphides, which, although they have a natural tendency not to adhere strongly to water, do fortunately have a strong natural tendency to adhere to oil. And further, oil has an even stronger tendency to adhere to its gas film, so that a sulphide particle, covered with an oil film has an already strong tendency not to adhere to water considerably increased. Quartz and gangue minerals generally, on the other hand, have preference in directly the opposite direction. They have a comparatively feeble adhesiveness to gas films and oil, and a strong adhesiveness to water, and this already strong adhesive-

ness for water is generally increased by a slight acidulation of the water. There has been no satisfactory theory yet propounded as to why acid does promote the preferencial adhesion of water to gangue particles, and probably also at the time the preferencial adhesion of oil to sulphides.***********It has been established that there are: (1) Forces acting at the surfaces of liquid, the resultant of which tend to prevent the rupture of the surface; (2) Forces acting at the surfaces of all substances, especially at the surface of sulphide particles, that cause*films of gases, resisting displacement to adhere to their surfaces; (3) Forces acting at the surfaces of sulphides to cause these surfaces to show a preferencial adhesion to oil; (4) Forces acting at the surfaces of gangue minerals that cause these surfaces to show a preferencial adhesion to water, and especially acidified water."

With these principles in mind we have been able to pursue the investigations which are embodied in this thesis.

For our investigation a Joplin sludge was obtained. It represents the material which is ordinarily lost through the inability of wet concentration to handle it economically. The chemical and screen analysis is given following:

*T. J. Hoover, "Concentrating Ores by Flotation".

JOPLIN SLUDGE.

Assay:

Zinc as blende ---------------2.9 %
Lead as galena ---------------2.4 %
Gangue-chert with little limestone.

Screen Analysis:

Sample 400 gm.

On	100 M	------0.25	gm.	-------0.06 %
"	120 "	------3.75	"	-------0.94 %
"	150 "	------3.00	"	-------0.75 %
"	200 "	------7.75	"	-------1.94 %
Thru	200 "	-----385.25	"	------96.31 %

Thru	100 M	-----99.94 %
"	120 "	-----99.00 %
"	150 "	-----98.25 %
"	200 "	-----96.31 %

It will be apparent from the screen analysis that because of its finely divided state the sludge presents problems in concentration impossible of economical solution by the ordinary methods of wet concentration.

While the physical conditions of the above sludge may be considered very typical, its metallic content is lower by a number of per cent than many of the sludges produced. It will be seen that under such conditions the sludge contains very much higher values than the crude ore.

A number of preliminary tests were made. In these tests, which were of qualitative nature, a few grams of ore in about 30 c. c. of water, together with a drop each of crude petroleum and H_2SO_4 was shaken in an ordinary 6-8 inch test tube and allowed to stand for a few seconds. Although there were no marked differenciation of the sulphides from the gangue the results were sufficient to prompt us to attempt the application of the principle of flotation quantitatively to a large amount of ore.

In carrying on the tests it was realized that some means must be employed to introduce gas or air into the mass of the ore or pulp to aid in the "flotation" or separation of sulphides from the gangue. To produce this aeration of the pulp, a mechanical agitator was devised consisting essentially of a small brass propellor 2 inches diameter affixed to a rod, the whole driven by an electric motor. A round glass jar of 2000 c. c. capacity was employed to contain the ore under agitation. The method of procedure in making a test was briefly as follows:

To a pulp consisting usually of twenty parts by weight of water, 60-70° temperature, to one part of dry sludge, was added varying amounts of oil, acid or soap, and the whole agitated for from three to five minutes. After this period of agitation the pulp was allowed to stand for sufficiently long time to permit the sulphides in form of froth or film to collect at the surface and the gangue to settle to the bottom. The floating sulphides were then skimmed and agitation again renewed without, however, further addition of material. As many skimmings as were necessary to remove all sulphides that would float were made. Generally three to four skimmings were necessary.

Both the skimmings, which represent the concentrate and the residue, which represent the tailing were dried, weighed, and assayed for metallic content.

Owing to the small scale upon which our tests were conducted and the limited mechanical means for approximating the conditions that are most favorable for the application of flotation principle it was necessary to run a large number of tests in order to obtain a few results which demonstrate the applicability of flotation principles to this kind of material. We were handicapped, for example, by the inability of the machine to handle a pulp heavier than 100 gm. in 1000 c. c. of water with any adequate agitation. Moreover, the limited surface area to which the sulphides could rise, and the intermittent character of the agitation, both contributed to prevent a successful flotation. Because of these limitations many tests were necessarily performed which merely served as a basis for more successful experiments.

The following are some of the more favorable results secured in our experimentation:

TEST 16.

Ore-----50 gm.

'

1000 c. c. H_2O at 70° c.

'

5 drops crude petroleum

'

Agitation 3 minutes, no film

'

5 drops H_2SO_4

'

Agitation 3 minutes, very slight film-skimmed; apparently high grade but not sufficient in amount to assay.

'

The second agitation resulted in similar film as the first, but the third agitation did not produce any further float.

TEST 28.

Ore-----50 gm.

Water 1000 c. c. at 70° c.

Soap shaving----3m. gm.

½ inch float light color

10 drops H_2SO_4

Agitation 3 minutes-acid neutralized the soap, and a thin film of sulphide floated on the surface.

Crude petroleum

Agitation 3 minutes-heavy film sulphides, two skimmings.

	Head	Concentrate	Tailing
Zn	----------2.9	29.8 %	1.1
Pb	----------2.4	10.5 %	1.0

TEST 17.

Ore ------50 gm.

1000 c. c. H_2O, 70° c.

Soap 1 m. gm.

Oil 15 drops

Agitate 3 minutes-heavy float (first skim)

Agitate 3 minutes-heavy float (second skim)

Agitate 3 minutes- slight film, no froth

Soap 2 m. gm.

Agitate 3 minutes-barren froth

5 drops crude petroleum

Agitate 3 minutes-no change, barren froth.

	Head	1st Concentrate %	Wt.	2nd Concentrate %	Wt.	Tail
Zn	---------2.9	24.9	2.9 gm.	18.8	1.0 gm	1.3
Pb	---------2.4	12.0		6.6		.9

TEST 26.

50 gm. Ore

1000 c. c. water 70° c.

Soap shaving 3 m. gm.

Agitate 3 minutes-½ inch froth, light color

6 drops H_2SO_4

Agitate-no froth, thin film of sulphides

5 drops crude petroleum

Agitate 3 minutes-thicker film of sulphides

10 drops crude petroleum

Agitate 3 minutes-heavy film of sulphides

Four successive agitations and skimmings necessary.

	Head	Concentrate		Tailing
		%	Wt.	
Zn	2.9	21.9	2.9 gm	1.54
Pb	2.4	9.0		1.0

The maximum results that could be attained by direct concentration, using a head as low as that of the sludge, were found to be between 25-30 % for the zinc and 10-15 % for the lead. Further experiments were therefore made in the attempt to raise the grade of the concentrate by retreatment, following the general scheme of Test 28. Using the concentrate obtained from the foregoing tests, it was possible to secure a "float" which was of much higher grade, the zinc content from 40-46 %.

SUMMARY.

In reviewing the tests we find that although the oil is an essential element in flotation its use alone will not result in a separation of the sulphides from the gangue. In practically all cases it was necessary to supplement the oil with other frothing agents in order to obtain favorable results. The nature of the oil itself influences not to a small degree the success of the separation of the sulphides. Between two oils there may be a difference of as much as 25 % in the amount of froth produced. The Illinois crude petroleum was used in our tests because of the fact that from a commercial standpoint it would be easily and economically procurable in the Joplin district. The addition of acid seemed to be beneficial although its effect was not so clearly shown as when it was used together with soap. An attempt to use soap as an acid in the production of froth resulted in two things:

First, if applied in small quantity, 1-2 m. gm. to 50 gm. sludge in 1000 c. c. water it seemed to have a beneficial action producing a heavier froth than if soap were not used.

Second, if used in larger amount than already mentioned it was most detrimental, in fact it totally destroyed all selective action of the oil.

TEST 32.

50 gm.-----Ore

1000 c. c. H_2O at 70°

Soap 5 m. gm.

Agitation 3 minutes-heavy froth, light color, skimmed.

8-10 successive agitation and skimming-flotation of all the solids. Evidently no selective action by the soap.

CONCLUSION.

It must be borne in mind that our work was carried out on small laboratory scale, and the results secured are therefore not necessarily conclusive. We believe, however, that the results obtained even under condition with which our work was surrounded, justify further investigation upon a larger scale; and that flotation may be considered as one of the solutions of the problem presented in the concentration of the Joplin sludge.