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INVESTIGATIONS REGARDING THE IMPROVEMENT OF THE SELECTIVITY AND THE PROFITABLENESS IN THE TIN FLOTATION PROCESSING OF FINE CLASSES

Savvidis S.	**Karathanos A.**	**Sariannidis N.**	**Chatziaugustis T.**	**Vatalis K.**	**Kargiotis E.**
TEI of W Macedonis Greece	TEI of W Macedonia Greece	TEI of W Macedoni Greece	TEI of W Macedonia Greece	TEI of W Macedonia Greece	TEI of Kavala Greece

ABSTRACT
The principle of multistage de-sliming to be separated the fine class is used up to now in all flotation plants in the process of the fine tin ore dressing. In this case the losses of tin amounts of up to 40% from the used initial ore material. A decrease of these losses of tin by using of slim flotation is the main aim in the present investigations. Flotation tests in washer and rod flotation plants were performed to optimize the flotation conditions. The recovery values in the flotation process performed in the second type of the plants mentioned above vary in the range about 60%. They are between 65-80% in the case of washer impeller. Good results in the recovery process could be expected when washer impellers with a high speed (5,65 m/s) are used during the preliminary flotation stage and after that low revolutions are used during the following stages of purification activities. Similar results could be expected also in usage of rod impellers when during the preliminary flotation stages is used a low speed and during the purification stages – a high speed. It should be mentioned that a heavy minerals dissolving and tendency of the slurry to a coagulation is observed especially in the case of water flotation. In this case an intensive agitation of the slurry is necessary by using of a high rotor speed. The high revolutions in the case of finger impeller usage lead to low recovery losses. The introduction of modified impellers of that type is very promising in respect to the low grinding size ores. It could be concluded from the performed calculations for the profitableness that a flotation plant will be effective only in the case when the concentrate contents are higher than 7,5% Sn and the recovery is more than 70%.

INTRODUCTION

Wetting gravimetric methods of grading are used very often in the process of dressing which ones depending on the density and the density differences of the minerals to be separated give the best results in processing of the classes grading of 20 – 100 μm and are economically profitable respectively. Other methods are used in principle in the processing of a material of a lower size than the mentioned above but usually they used the flotation. A premise for establishing of the flotation method is the variable character of the ore materials.

The most of the present deposits are characterized by a fine accretion of the ore and rock minerals and which requires by itself a fine grinding to be guaranteed a good outcropping of the minerals. As the necessary grade of outcropping of the minerals is often less than the grinding achieved by using of density grinding the flotation methods find a great application as of a grinding method for the classes of size less than 100 μm.

There are problems arising very often in the process of the primary tin ores flotation and which are a subject to the present paper. In spite of the fact that there are appropriate flotation plants existing in Bolivia as well as in England, Australia, South Africa and the former DDR (Moncrief et al. 1977; Arbiter, N., 1977) the problem of the tin flotation is not fully solved yet. The last one is proved by the fact that independently of the intensive investigations performed and the made new proposals about usage of new methods and reagents (Savvidis 1996), up to the moment there is not a tin ore flotation conception developed yet which uses a specific and selectively acting collector. It is like that because of the specific properties and the different forms of the tin.

It is well-known that the friableness of the tin facilitates the fine classes formation during the grinding, but for example in Bolivia could be to meet very needle-shaped and crossed forms of the crystal structures, noted as needle-shaped or wood tin. The needle-shaped tin could be easily transversally in respect to its length axis during the processing and therefore it forms a big amount of fine classes. The "wood" tin being formed by weathering of sulphostanates forms in the most of the cases fine complex aggregates which are difficult to be separated. The colloidal tin as well as the needle-shaped one have a tendency to over-grinding.

It is established that the most part of the Bolivian tin ores tends to possibility for tin enrichment for the fine classes (Savvidis 1996, Savvidis et al., 2001). For the moment the rich of tin fine slimes in Bolivia were predominantly thrown out, because there were not an existing method of grading.

The accents of the present investigation are aimed on the investigations of a fine classes extraction by the flotation aiming an extraction improvement as whole as well as the tin extraction profitableness.

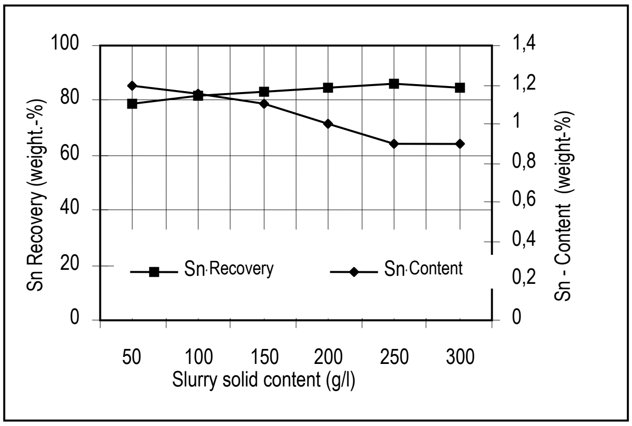
EXPERIMENT CONDITION

Influence of the slurry density

The experiments were performed by using of a sample of the cyclone weir form Huanuny aiming an optimization of the flotation conditions in the flotation cells. There are different opinions about the optimal slurry solid content. Imhof (1975) realizes that in the process of the sulphide ore slimes flotation the solid content should not exceed 25 g/l. Töpfer (1964) to the opposite of that proposes the fine fragments to float in conditions of high slurry density. The very high solid fragment contents in the slurry should be avoided as the slurry viscosity becomes very high. The following conditions were established for the investigations in respect of the slurry density influence:
Flotation cell: 1,4l – laboratorial, with a washer impeller
Air consumption: 30 $cm^3/cm^2 min$
Solid content in the slurry: 30 – 500 g/l
Collector: Phosphonic acid P-184 (750 g/t)
Foam generator: Flotigol CS/MK, 50 mg/ l
pH: 5,8
Conditioning time: 20 min
Flotation time: 15 min (5 concentrates)

The collector feed was made on the base of each stage. The variant of a continuous reagent feeding was rejected to be estimated how the slurry density is influenced by the other factors

The flotation results are shown in the figure 1.



1Figuire 1. Sn content and Sn-recovery in dependence on the slurry density, collector: P-184, 750 g/t, pH 5.8.

As it could be seen in the figure, the slurry density influence on the Sn recovery and content is small. The tin recovery is about 80% and in case of an average slurry solid content– 250 g/l a slight maximum is observed. The tin contents in the concentrate are low and at low slurry solid content - 50 ÷ 150 g/l they have a highest value of 1,2%. Probably, the slime is recovered unselectively. It is supposed that in that case in flotation tests the following effects are competitive to each other: the foaming consistence is slightly stabile at at its low concentration; the floated out valued minerals leave partly in the foaming product; the high solid contents increase the slurry viscosity; the turbulence needed for the mineralization could be not achieved. The tin concentrates contents at different slurry density are presented in respect to the flotation times are presented in the Figure 2.

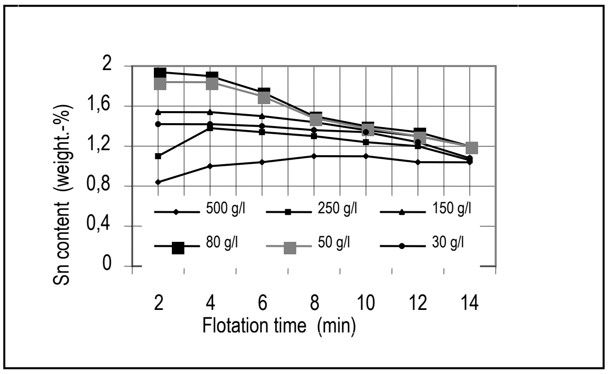


Figure 2. Sn content in respect to the flotation times,*collector: P-184, 750 g/t, pH 5.8*

As it is obviously seen the tin flotation is optimal only at low solid fraction content (up to 50 g/l) as in conditions of a normal processing of the test the selectivity is low. Initially, the most of the fine fragments are floated out at high slurry solid content ant that is why the selectivity of the process is delayed. Wollmann (1981) has established that at high slurry density the finest fragments emerge with the air upward and a only a small number of them go back to the slurry. Therefore, the unselective slime recovery is stimulated.

The rotor speed influence

The slurry solid content was not changed in those tests (50 g/l); Most probably, the selectivity is influenced in the same way.
Initially, the tests were performed in conditions of different speed of mixing by washer impeller. The tin content and recovery in dependence on the rotor revolutions are presented in Figure 3

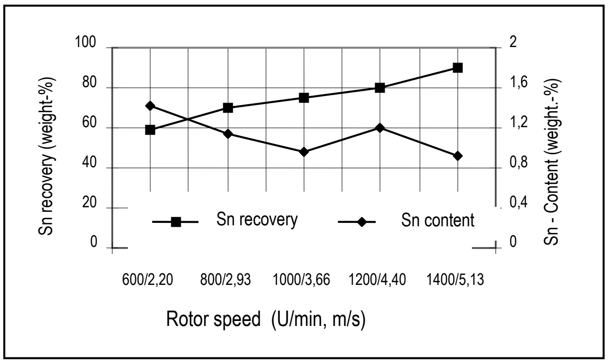


Figure 3. Sn content and u Sn-recovery depending on the rotor speed of washer impeller, collector: P-184, 750 g/t, pH 5.

Initially, the recovery values were scientifically increased by increasing of the speed. It was 60% at 2,4 m/s and at 5,5 m/s – 90%. Simultaneously, the concentrate content decreased from1,4 to 0,8%.

As it could be seen in the figure 3 the best conditions are obtained at 1200 min. In that case the achieved Sn content is 1,2% at 80% of recovery. It appears that a significant improvement of the selectivity is not possible to achieve as by solid content change as by rotor revolutions adjustment.

In contrast of that , the better results were obtained by specific air consumption decrease – 20 cm^3/cm^2min and the parallel collector concentration increases up to 1250 g/t, accompanied by a tangible selectivity increase.

Tests were performed in the same conditions for establishing of the rotor speed influence by using of a pin mixing system. The results are shown in the Figure

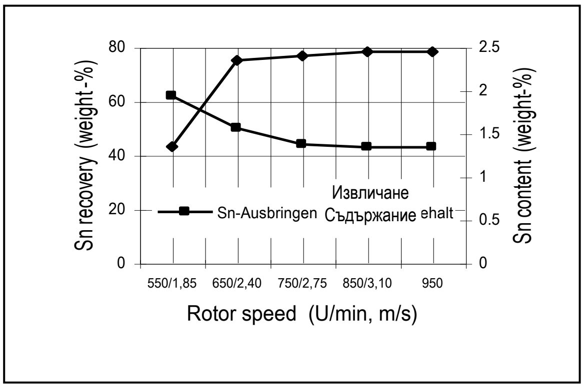


Figure 4. Sn content and Sn recovery depending on the rotor speed of pin impeller, collector: P-184, 750 g/t, pH 5.8

Here, for a difference of the results obtained for a washer impeller, now the Sn recovery from the concentrate decreases when the rotor speed increases. In the same time, a Sn content increase is observed up to 2,5% at revolutions of 850 min^{-1} but the recovery here is only 45%.

The result differences obtained for the different impellers could be explained by the different turbulence degree. According to Shubert (1977, 1979, 1979, 1982) exactly the turbulence is an important factor in the processing of the flotation with mechanical flotation devices. The investigations by different impellers show Shubert (1982) that in the process of the flotation of fine fragments of silvine parallel to the increasing the thickness in the cell at high rotor speed the valuable component content in the concentrate increases. From the other hand, it is established for the fine tin ore classes the increased recovery values accompanied by lowering of the content are observed with the increasing of the rotor speed Shubert (1977).

The authors find the conclusion that a specific low power is necessary for the coarse fragments flotation, and a high speed is necessary for the fine fragments flotation for achieving of high recovery values.
The investigation results and the conclusions do not fit the separate results as whole.

It could be observed during the washer impeller tests that there is not a strong agitation of the slurry surface at rotor speed up to 5,5 m/s. There is strong slurry agitation is running at the very near of the rotor which helps the fed air and solid material dispersion as well as an intensive collision in the solid – bubble system.

In spite of the high power it is possible a calm foam layer to be formed at the slurry surface because directly on the stator runs a negligible influence of mineralized air bubbles. The speed increase of a washer impeller leads to an increased possibility of collision between the bubbles and solids caused by the increased power. The influence on the mineralized bubbles strongly decreases in the upper part of the cell because of a significant turbulence decrease observed in the area over the stator. It could favour the rock solids extraction in the foam and which are very slightly attached to the air bubbles.

In a contrast of that the slurry is is mixed by means of strong turbulence not only in the stator area but also on the surface in the case of using of the finger impeller. A strong interaction of the mineralized bubbles runs in the whole cell volume and as a consequence it increases with the mixing speed.

Te last leads to an increased coalescence of the fine solids on the mineralized air bubbles and to an extraction increase. There are also slightly attached rock fragments and therefore a selectivity increase is observed.

Profitableness consideration

The flotation profitableness of fine tin solids is investigated in a plant with capacity of 100 t/d.

Investment costs:	**млн.DM**	
1. Machines and apparatuses		0,875
2. Electrical equipment Including measurement devices		0,26
3. Pipes and water pipes		0,085
4. Buildings and steel constructions		0,485
5. Erection and internal industrial supervision		0,221
6. Engineering		0,26
7. Contingencies		0,085
Installation costs	**2,271**	
8. Packing, transport and Insurance (5% of 1÷4)		0,085
Total costs		**2,356**

The production costs calculations are made on the base of 300 work days per annum in the following capital conditions (15% of the investment costs), i.e. 11,78 DM/t.

Energy consumption

The necessary electrical energy power for the flotation plant, including agitators, pumps and dehydratation is about 170 KW
The specific costs for the energy consumption are calculated on the base of an initial current price of 0,15 DM/KWh and they amount of 14 KWh/t, i.e. 2,1 DM/t.

Reagent costs

Type of regent	Reagent consumption, g/t	Price, DM/kg	Costs, DM/t
P-184	750	13,5	10,13
H_2SO_4	15.000	0,12	1,80

Specific costs for reagents: 11,93 DM/t

Total industrial costs:

Capital costs:	11,78 DM/t	
Energy costs:	2,10 DM/t	
Reagent costs:	11,93 DM/t	
Total:		25,81 DM/t

DISCUSSION OF THE RESULTS

The multistage de-sliming for a fine solid separation in the process of the tin flotation is up to now applied in the all still working flotation plants in the process of fine tin ores dressing.

It is accompanied by losses which amount of about 40% of the initial ore material. In the present investigation an attempt was made to be decreased flotation losses of the slimes
For the purpose were performed tests with flotation machines having finger and pin impellers for the optimization of the flotation conditions. The values of the recovery in the pin impeller flotation were about 60%. The same values amount of 65 – 80% if a washer impeller is used. The high recovery values could be achieved if the washer impeller flotation is performed at high rotor speed – 5,65 m/s, and the impurities removal operations run at low revolutions.

Similar results could be expected also by using of pin impeller when for the basic flotation are used low revolutions and the impurities removal operations are performed at high revolutions.

A fact more should be taken into account that the heavy metal ions content increases if the water flotation is used and they stimulate the coagulation of the slurry.
An intensive agitation of the slurry by rotor speed increasing is required in this case. The finger impeller high revolutions lead to (as it is seen from the results) decreased recovery values. A modified pin impeller could be applied more successfully in the process of fine-grained ore flotation.

As it could be seen from the performed economic estimation of the profitableness that the flotation plant existing is economically reasonable only in the case if the tin concentrate content is more than 7,5% and recovery is more tham 70%.

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