

**ULT-02-001-IP****High Power Ultrasound to Recover Fine Particles in Flotation Process**Y. Vargas-Hernández<sup>a</sup> L. Gaete-Garretón<sup>a</sup> L. Magne-Ortega<sup>b</sup><sup>a</sup> Laboratorio de Ultrasonidos, Dpto. de Física, Universidad de Santiago de Chile, Casilla 307 Santiago-2, Chile<sup>b</sup> Dpto. de Metalurgia, Universidad de Santiago de Chile

Keywords High: power ultrasound, flotation of minerals, high intensity conditioning copper particles.

**Introduction**

The flotation process to recover useful substances from minerals have been used during dozen of years. For the flotation, air bubbles in a water solution of finely ground mineral particles must be introduced. The particles were prepared with chemical substances (surfactants) to be caught for the bubbles.

It is recognized that flotation is a very efficiency and economical process, however, still to day is very difficult the recovering of fine and ultra fine particles. There are several problems that make difficult to recover of fine and ultra-fine particles, some of them will be listed in the following lines.

The conventional systems to produce very small bubbles present operational problems like obstruction, and a lack of a number enough of bubbles to be applied to an industrial process. The kinetic energy of tiny particles are not enough to stick it to the bubble. The collision probability between the particle and the bubble is scarce. The high specific surface of tiny bubbles produce a diminution in the specific concentration of surfactants decreasing the whole reactivity.

If the relative number of bubbles are small, goes down the collision probability between the particles and bubbles diminishing the process efficiency.

Some attempt were made to improve the whole process, the best results reported were obtained for a technique called the "high energy" flotation experiments, [1] [2][3]. It seems that the recovering of the useful substances can be improved if some energy can be injected to the reactor with the

metallurgic pulp , this suggest that an ultrasonic field can also improve the recovering in flotation.

In this paper an application of acoustic cavitation to the flotation process it is explored.

Because the problem is very complex it was necessary to make a design that avoid complications raising from different geometries that can be involved in. To deal with this problem, a specially designed normalized Denver flotation Cell with ultrasonic capabilities were designed and constructed. The Denver Cell was constructed in such a way that normalized flotation experiments can be done with the same geometry with and without ultrasonic activation. The ultrasonic source was mounted in such a way that it not disturb the whole process. The applied power and the working frequency was controlled for an specially designed electronic circuit [1].

With the Ultrasonic Denver Cell a number of flotation experiments with copper mineral from Chuquicamata CODELCO-CHILE with and without ultrasonic activation were carry out. To compare the results the recovered substances were chemically analyzed and the total recovering was assezed. In addition, the process kinetics were studied.

The results were promising but to obtain concluding results new experiments with chemical reagents specialized to the situation must be tested, also the best conditions for ultrasonic frequency would be very useful.

## **Material and Method**

The Denver Cell was built in acrylic material. The experimental arrangement it is shown in the figure 1. The transducers are mounted in a sealed chamber filled with distilled water, in this way a good coupling between transducers and the metallurgic pulp is obtained. The chamber have a flat-mounted membrane in the Denver Cell wall to avoid perturbations in the process kinetics but allowing the acoustic field to go into it .The transducer frequency is approximately 18 kHz and the power capabilities goes up to 300 Watts.

Previous to the experimental work an evaluation of acoustic field in three planes inside the Denver Cell filled with distilled water was done. First the low plane, near the bottom, referred as the plane of three phases because the

three elements exist simultaneously in the region: particles (solid) water (liquid) and Bubbles (gases) was scanned. Second the medium plane, called the separation plane, because the particles with useful substances were classified and separated in this region And at last, the upper region, referred as the region of foam, formed with particles adhered to bubbles, rich in the product that we are interested in.

The measurement of acoustic field was done with a specially designed probe to work in a cavitating environment [4]. Using a non-linear technique the probe calibration was done for a wide range of frequencies [5]. To avoid excessive perturbation of the acoustic field the probe diameter must be as little as possible, in our case 2mm. The frequency range of the probe goes from 0.001 to 1 MHz.

A three dimensional picture of scanned acoustic field in the central plane of medium region is presented in the figure 2. It can be appreciated, a region without acoustic field in the middle of the scanned plane, it corresponds to the position of the "estator", a device to shake the pulp maintaining the suspension and with a air inlet to produce bubbles.

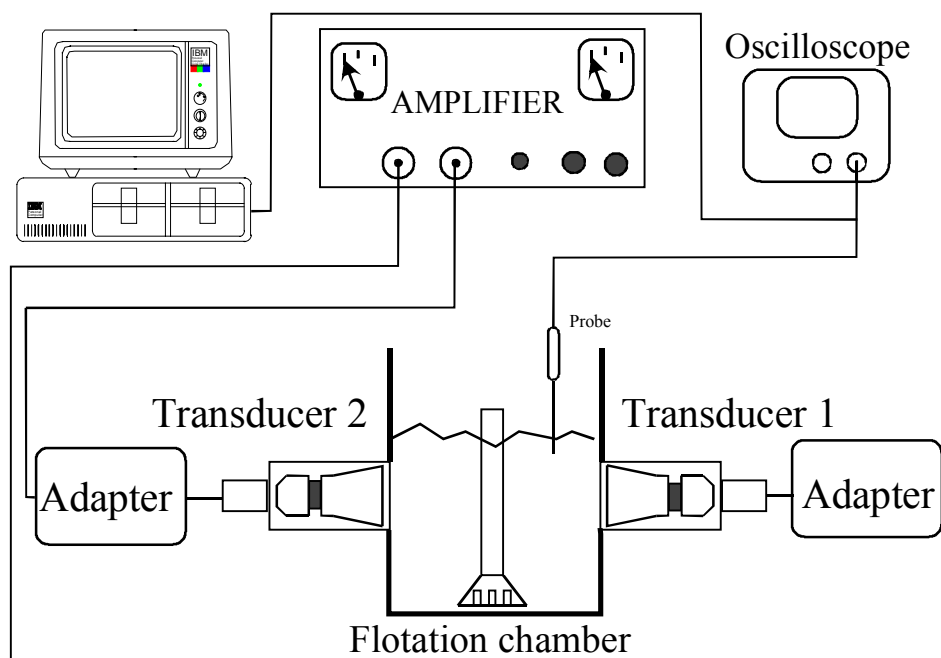


Fig. 1 Block diagram of experimental set up for flotation experiments.

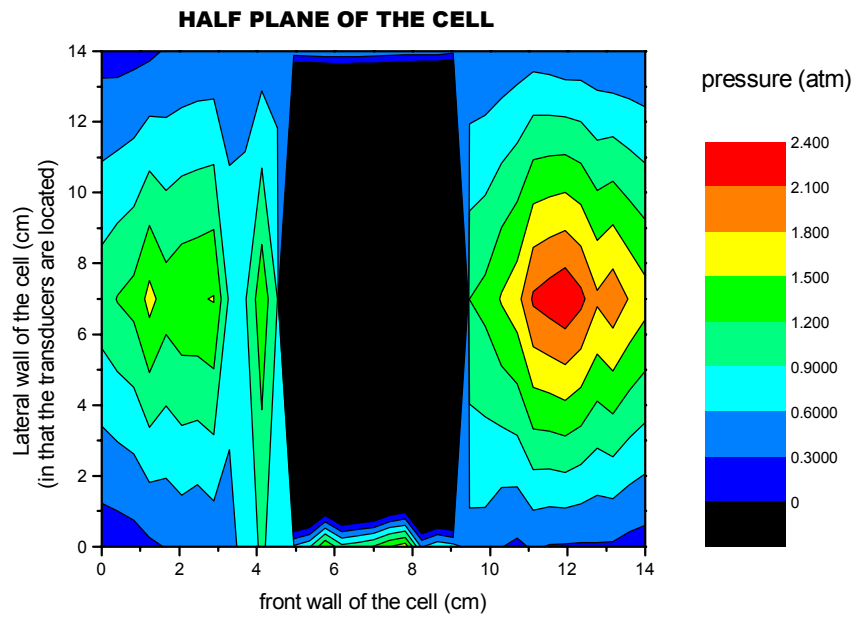


Fig.2 The acoustic field in the half plane of the chamber

As can be appreciated in the figure, the acoustic field is not very homogeneous, and also it is slightly asymmetric. In the central part of the scanned plane the acoustic field is as high as 2.4 atm. Because the high agitation degree, the pulp circulates by all the chamber in a low time scale and the asymmetry in acoustic field do not appear as a very disadvantageous fact.

In the figure 3 a three dimensional picture of the treatment chamber it is shown. In this figure can be appreciated clearly that the acoustic field is increasing from the bottom, to the center of the chamber, in the halfway plane. In this plane the acoustic pressure values is maximum and going up it take decreasing values until the top of the reactor. This is a consequence of the design because an acoustic field too much strong in the upper part of the chamber would dissolve the foam and could spoil process efficiency.

The results, of the first test for different applied powers are shown in the figure 4

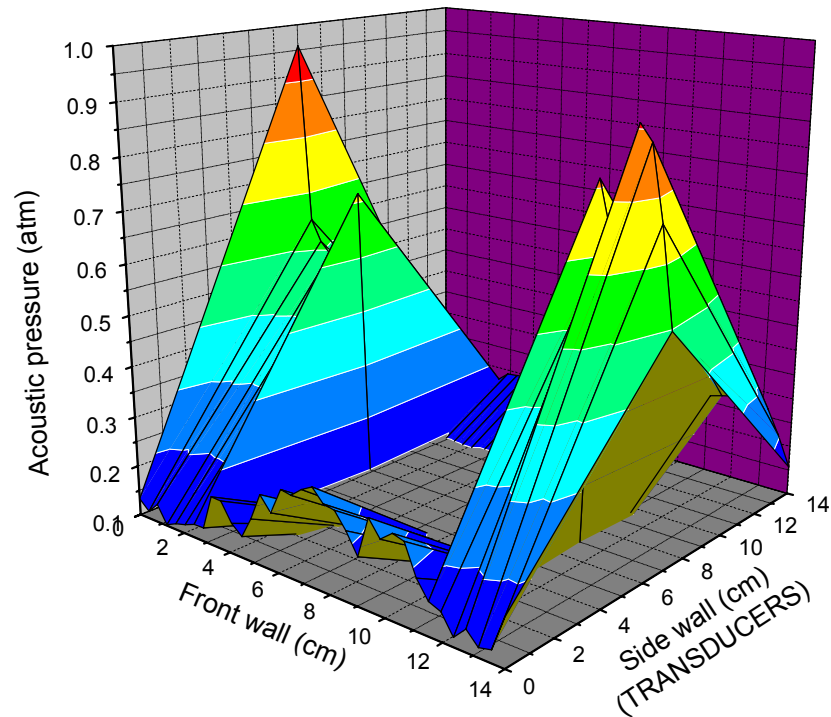


Fig 3. Three dimensional acoustic field in flotation chamber

As can be appreciated in the figure, the acoustic field it is rather homogeneous, and also it is slightly asymmetric. In the central part of the scanned plane the acoustic field is as high as 2.4 atm. Because the high agitation degree, the pulp circulates by all the chamber in a low time scale and the asymmetry in acoustic field do not appear as very disadvantageous fact.

Because the chamber in the experiments was filled with metallurgic pulp, too much attenuating than distilled water, the acoustic field measurements must be considered only as an indication of the relative acoustic pressures.

With this experimental dispositive a number of flotation experiments were done. The results, looking for the fine particles recovering, are shown in the figure 4, the best performance was obtained for an acoustic power of 10 Watts, it is interesting to note that the acoustic pressure greater than this value,

the results are less interesting than at low pressure. It must be noted that the

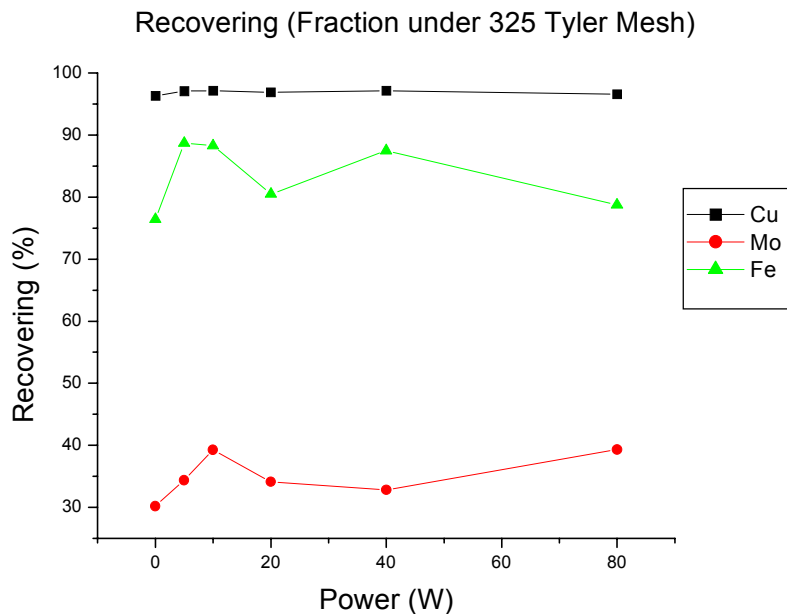


Fig. 4 results for flotation made at different applied powers

iron recovering, a non-desired product also goes up with the ultrasonic action

By other hand, if the global recovering of useful substances that we are looking for it is considered (figure 5), it can be noted that interesting, the iron recovering goes down for the best values of the recovering in the substances that we are search it: the molybdenum and the copper. This is a very interesting experimental fact that suggest that the chemistry of the process under ultrasonic field must be considered.

To have a complete picture of the new ultrasonic technique kinetics studies were done. In this experiments the recovering process are stopped a different times after the reactions begin, in this way it is apparent the chemical behavior of the substances that in the process are involved in. The results are shown in the figure 6.

In the figure 6 it is clear that the kinetics of the process are improved for the first 3 minutes of the reaction, after this time the reactions occur in the same way with or without ultrasonic action. This effect can be produced because the ultrasonic action accelerates the recovering of the disposable substances and

after this process is finished, it is not relevant the application or not of ultrasound to the process.

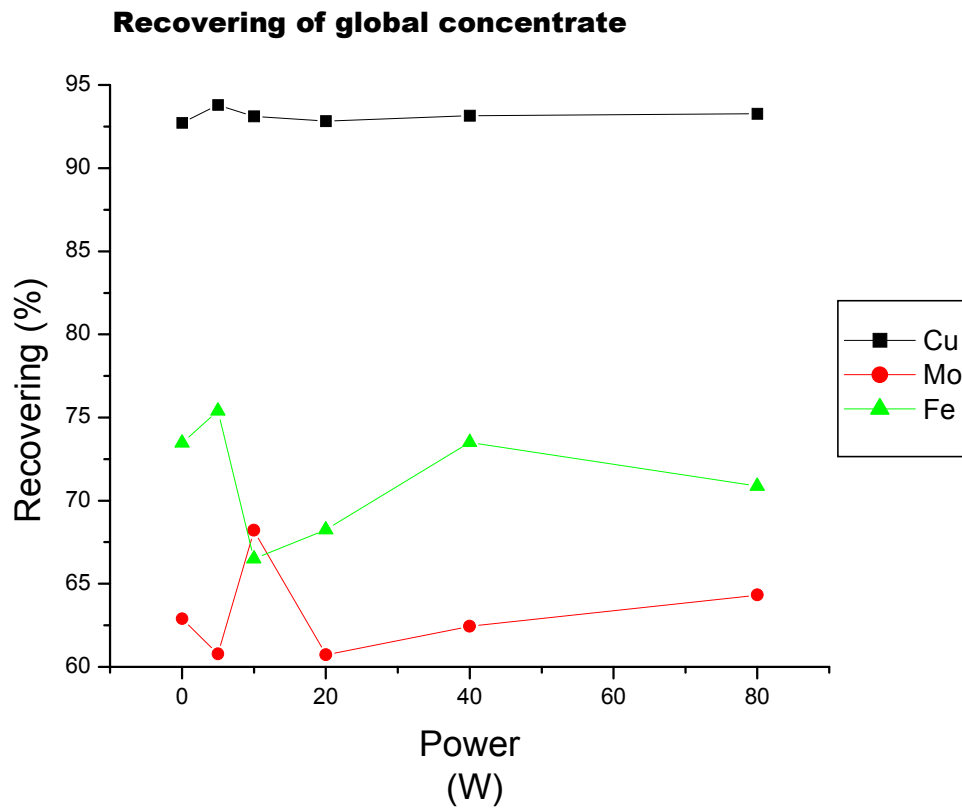


Fig. 5 The global recovering in ultrasonic experiments

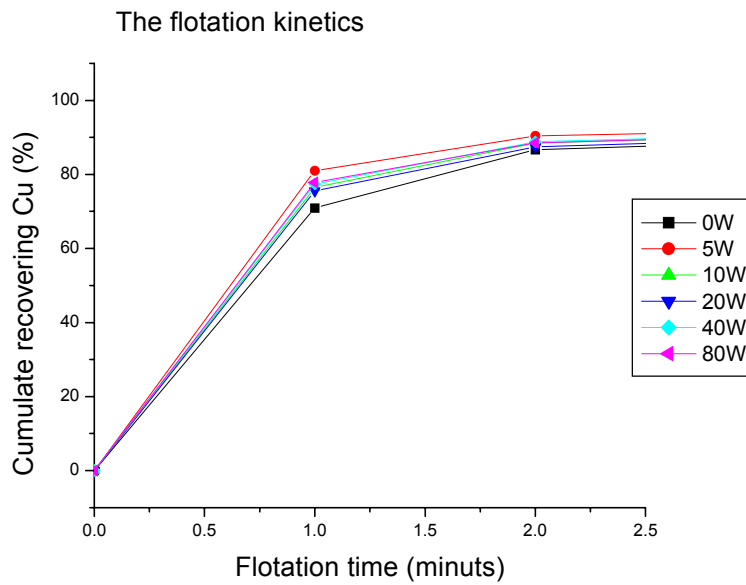


Fig 6.- The kinetics of the ultrasonic flotation experiments

## **Discussion and Conclusions**

In this paper an application of ultrasound to flotation process it is explored. The obtained results show an improvement in the recovering quality of the process. The study shows that the kinetics of the process are also improved.

The growing in the law of the concentrates suggest some possible effect of superficial cleaning (superficial removal of oxides), tendency of the ultrasound to inhibit the trapping or hydrodynamic haulage of fine particles and ultrafine belonging to the bargain.

The analysis of the laws achieved in the fraction + and do -325 meshes of the concentrate show a similar behavior to that of the global concentrate and could give support to the previous considerations and would suggest the pursuit of this behavior in later studies.

The experimental conditions do not allowing the consideration of cavitation bubbles in the process but it is a aspect that really must be considered in the future, we are interested in the number and quality of the cavaiaon bubbles in the flotation process.

It is possible that a factor that could be important in the improvement of the process is the improvement in the capture properties of the bubbles: the increase in the kinetics energy allowing the particle to adhere the bubble, the growing of collision probability between bubbles and particles and the effect, that can no be positive, of the free surface in the reactor, for this task a physique-chemical study must be conducted that allow to know the fundamentals of the process looking for its optimization.

## **Acknowledgment**

The authors would like to thank the financial support of project FONDECYT 1010243.

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