Approbation of Cavitation and Flotation Separation Technology of Heterogeneous Liquid Phase Environments

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***Abstract* – The concept of cavitation and flotation technology to separate heterogeneous liquid-phase environments was proposed. It implements the principle of the chemical-technological systems synthesis. The results of approbation of this technology in various industrial processes: sulfuric ore enrichment; intensification of regeneration stage of used absorbent solution from purification process of exhaust gases formed in the calcination furnaces of metatitanic acid paste from SO^2; separation of kaolin slurry; extraction of sodium oxalate from liquid wastes of leather industries; separation of the insoluble residue during dissolution of langbeinite ore. High efficiency of the developed technology was shown.**

Key words – cavitation, flotation, separation, liquid-phase heterogeneous environment, sulphuric ore, exhaust gases, suspension of kaolin, sodium oxalate, insoluble residue.

I. Introduction

Heterogeneous liquid phase environments containing solid particles of varying degrees of dispersion are formed in numerous technologies of inorganic substances. The systems separation, covering both increase the degree of processing of solid phase material, including ore, and physical separation of the phases is a complex technological task. It determines the need of use of large technological equipment, which leads to low intensity and speed of processes and significant energy consumtion for their implementation. Insufficient separation degree of dispersed systems causes not only the loss of raw components, but also environmental pollution.

Therefore, it proposed the concept of combined cavitation-flotation separation technology of liquid-phase heterogeneous environments [1], based on purposeful change of physical and chemical properties of the components under the influence of concentrated energy effects of cavitation fields and use of generated cavitation bubbles for efficient flotation separation of the dispersed phase. Developed theoretical foundations of successive stages of this technology [2-4] became the basis for approbation in various industrial processes.

The aim of the research was approbation of cavitation-flotation technology in numerous chemical and industrial processes.

II. Research results

Flotation concentration is typical process in technology of inorganic substances and related industries (metallurgy, fuel industry, processing industry). Therefore, the proposed approbation of cavitation-flotation technology for sulfuric ore enrichment provides an opportunity to estimate its effectiveness in general and predict the feasibility of its use in other technologies.

It was established that the efficiency of sulfuric ore enrichment by cavitation-flotation method is 1.65 times greater than using air flotation (sulfur content in flotation concentrate is 63.6 wt % to 38.4 wt % respectively). This is caused by increasing of the disclosure degree of ore grains due to intense erosive action of cumulative jets that are formed by cavitation bubbles splashing. The sulfur content in the ore was 19.8 wt %.

It was found on the basis of results of the research aimed on intensification of regeneration stage of used absorbent solution from purification process of exhaust gases formed in furnaces of metatitanic acid paste calcination from SO_2, that the effectiveness of oxidation of soluble calcium sulfite to sulfate in the cavitation fields is in 15 times higher than under mechanical mixing of the suspension. Calculated rate of ions SO_3^{2-} to SO_4^{2-} process oxidation in the initial period of time (0 ... 300 s) is: $1.33 \cdot 10^{-2}$ kmol/($m^3 \cdot s$) - in a reactor with a mixer; $19.94 \cdot 10^{-2}$ kmol/($m^3 \cdot s$) - in hydrodynamic jet cavitator (HJC).

Cavitation processing of kaolin slurry stabilized by 5% solution of calcium chloride during 20 minutes in HJC makes possible separation of disperse kaolin particles from the liquid phase both by flotation (25.1%), and by the coagulation of fine sludge particles (13.6%). The total level of suspension clarification was 38.7%. Increase of processing time up to 30 minutes doesn't affect of the clarification degree due to entropy, structural-mechanical and hydrodynamic stability factors caused by the development of cavitation fields and mechanical mixing. The suspensions were upheld for 3 hours (180 min) in order to eliminate these factors. The dispersed particles content in suspension was reduced to 70 mg/dm^3, which corresponds to 93.3% degree of clarification. Further growth of decantation duration to 24 hours (1440 min) led to increase of clarification degree to 98.5%, which corresponds to 15 mg/dm^3 suspended particles content, namely to requirements of present regulations.

The use of cavitation fields to activate the surface of the dispersed particles of calcium hydroxide allows to increase the degree of pollutant removal (sodium oxalate) in the liquid waste of leather production by 10% (from 85 to 95%), in comparison with traditional reagent deposition.

Flotation of insoluble calcium oxalate was carried out in the combined column type apparatus - the combined cavitation and flotation apparatus (CCFA). It was composed from two parts: bottom - jet cavitator with air filtered nozzles and top - flotation. The optimal inlet pressure in the cavitator during which formation of flotation concentrate was observed is 0.35 MPa. Film-structural foam was formed on the surface of the liquid phase under this pressure. The structure of this foam has a number of features: particle sizes of air bubbles in the upper layers of foam are larger than in the lower; the thickness of the water layers that separates air bubbles in the foam decreases with approaching to surface of the liquid phase; foam layer has a relatively small height (0.05 ... 0.20 m; in our case - 0.05 m); large bubbles are strongly deformed. Film-structural foam contains a large amount of water (foam humidity > 95% wt.), especially in the lower layers. An indication of effective flotation was the presence of free sites on the surface of foam bubbles with sizes of 0,01 ... 0.03 m, which is partially covered with a mineral particles film. The reaction system was becoming of milk intense color, caused by the accumulation of finely-dispersed air bubbles during flotation.

Flow rate growth occurred at increased pressure values that adversely affected adhesion of dispersed particles to the surface of bubbles and, consequently, the efficiency of the flotation significantly decreased. Foam with aggregate structure was formed under the cavitator entrance pressure equal to 0.57 MPa. Availability of air bubbles with dimensions smaller than in the film-structural foam, though with the same distribution of height of foam layer, is typical. The aggregate foam contained a small amount of water and was easily destroyed, which greatly reduced the effectiveness of flotation.

Thus, change of the technological parameter (cavitator entrance pressure) can purposefully influence structure of the foam in calcium oxalate flotation and therefore effectiveness of the proposed cavitation-flotation technology.

The use of HJC allows effectively combine in one device cavitation dissolution of langbeinite ore and flotation separation of insoluble residue from the saturated solution. In addition, energy costs for heating of technology environment - langbeinite ore pulp are significantly reduced because of so-called "cold" ore dissolution is implemented in HJC (for pulp processing temperature increased only from 297 to 306 K). The ore dissolving is carried out due to direct flow - counter flow scheme in three solvents accordingly to traditional technologies (halurgy, flotation, combined). The optimal temperature of the dissolution is in the first solvent - 340 ... 343 K, in the second - 343 ... 348 K and in the third - 348 ... 353 K [5]. In other words the use of traditional technologies involves so-called "hot" ore dissolution.

Conclusion

The use of CCFA original construction for treatment of liquid-phase heterogeneous environments allows to effectively separate the particles of dispersed phase from dispersion environment by flotation, and due to the coagulation of thin sludge particles. In the case energy consumption for heating of technological solutions is reduced significantly and the degree of homogenization is increases. This allows significantl decrease of volume of different production equipment.

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