



CANADIAN PROCESS
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CAVITATION SPARGING SYSTEM





Pico-bubble Enhanced Flotation

Effect of pico-bubbles on particle collision/attachment

Extremely small bubbles, referred to as Pico-bubbles, naturally exist in liquids such as seawater and distilled water. Picobubbles attach more readily to particles than large bubbles due to their lower ascending velocity and rebound velocity from the surface and higher surface free energy to be satisfied. More efficient attachment of particles and improved flotation rate has been observed when tiny bubbles co-exist with air bubbles commonly used in flotation cells. Klassen and Mokrousov showed that the combined flotation by gas nuclei from air supersaturation and by mechanically generated bubbles produced higher flotation recovery than by either of them alone. Gas nuclei or picobubbles on a particle surface activate flotation by promoting the attachment of larger bubbles (as shown in Fig. 1) since attachment between gas nuclei or picobubbles and large bubbles is more favored than bubble–solid attachment.

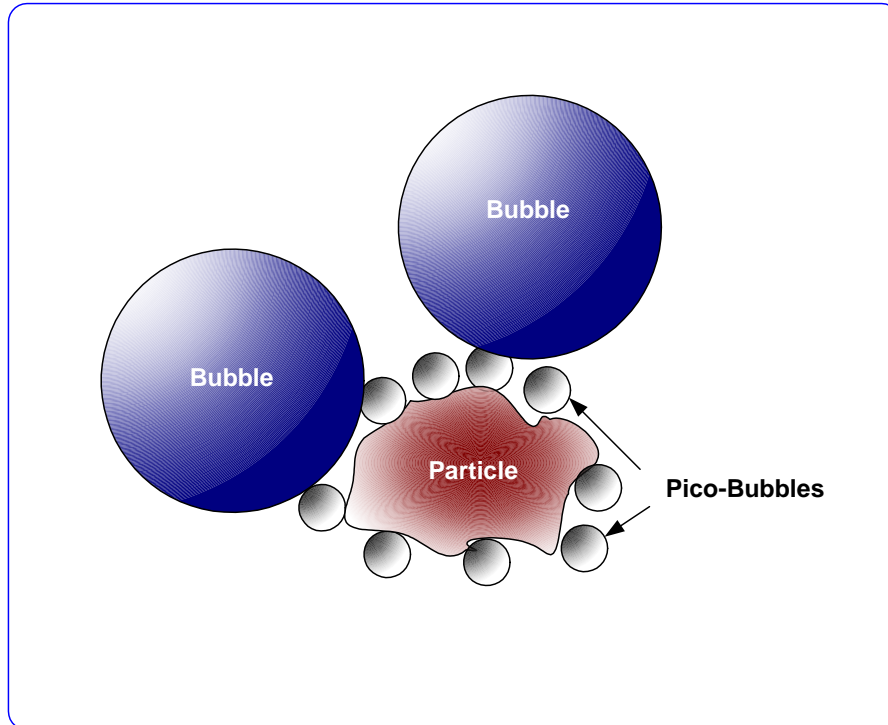


Figure 1

In other words, pico-bubbles act as a secondary collector for particles, reducing flotation collector dosage, enhancing particle attachment probability, and reducing the detachment probability. This leads to substantially improved flotation recovery of poorly floating fine and coarse particles and reduced reagent cost, which is often the largest single operating cost in commercial mineral flotation plants. Application of this process to coal flotation resulted in an increase in flotation yield up to 15 wt%, a frother dose reduction of 10%, and a collector dose reduction of 90%. Zhou et al. showed that hydrodynamic cavitation significantly increased flotation kinetics of silica and zinc sulfide precipitates.



Hydrodynamic Cavitation

Hydrodynamic cavitation is the process of creation and growth of gas bubbles in a liquid due to the rupture of a liquid–liquid or a liquid–solid interface under the influence of external forces. The bubbles generated on a particle surface by cavitation naturally attach to the particle, eliminating the collision and attachment process, which is often the rate-determining step for flotation. Cavitation also improves the flotation efficiency of coarse particles by reducing the detachment probability during the rise of particle–bubble aggregate in liquid. This is best illustrated in Fig. 2 where the large bubble represents the one produced by breaking the external air and smaller ones (pico-bubbles) are created by cavitation. While the large bubble may run away from the particle, the cavitation bubbles, particularly those underneath the particle, will push the particle upward, facilitating particle recovery. Without cavitation-generated bubbles, particles will detach from the bubble surface when the capillary force and other attachment forces are exceeded by detachment forces, such as the viscous or drag force (F_d), the gravitational force, and the hydrostatic pressure. As the drag force is directly proportional to the particle diameter; coarse particles are more likely to detach from the bubble surface than fine particles. This is the main reason for low flotation recovery of coarse particles, which is recognized by many researchers.

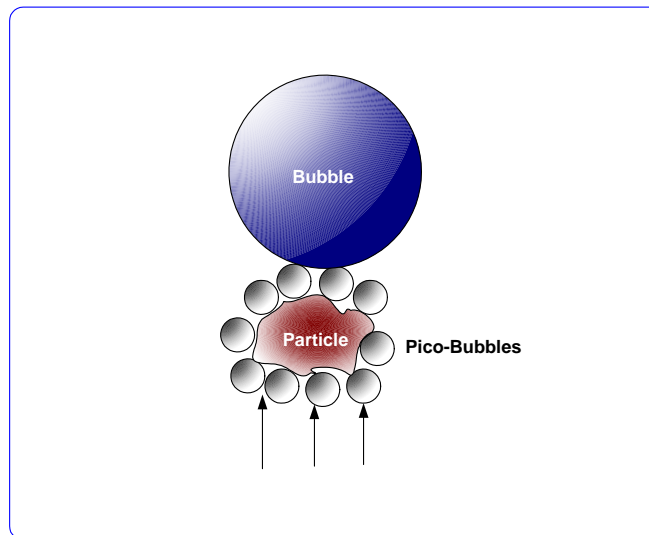


Figure 2

Cavitation takes place in the form of gas supersaturation or hydrodynamic cavitation. Tiny bubbles may form by gas supersaturation in liquid from preexisting gas nuclei trapped in crevices of solid particles. Hydrodynamic cavitation occurs when the pressure at a point in a liquid is momentarily reduced below its vapor pressure due to high flow velocity. Minute air or vapor-filled bubbles are carried on by the flow to regions of higher pressure.

The CPT Cavitation Tube is shown in Fig. 3. The liquid in the cylindrical throat is higher in flow velocity and lower in pressure than liquid in the entrance cylinder, resulting in cavitation. The differential pressure between the entrance cylinder and the cylindrical throat measured by the manometers is indicative of cavitation behavior. The presence of tiny pockets of un-dissolved gas in crevices on mineral particles assists the cavitation as a result of the expansion of these gas pockets under the negative pressure. Holl found that the cavitation was directly proportional to the dissolved air content in liquid. Addition of organic chemicals such as frothers produces smaller and more copious cavities by stabilizing the cavity and preventing cavity collapse and coalescence.



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CavTube Spargers...Smaller Bubbles...Higher Recoveries

Cavitation Tube sparging generates 'pico bubbles' substantially increasing the surface area available to the desired target particles

Improved flotation using cavitation tube sparging systems results in:

Higher Attachment Probability...more target particles floated

Higher Flotation Recoveries...greater concentrate production

Reduced Flotation Reagents...lower collection dosage costs

Long Operating Life... no internal wear elements



CavTube Spargers...‘No-Wear Pico bubble’ generation

CavTube spargers, unlike static mixers, don't use 'wear-prone' internal elements

The combined slurry/gas mixture exiting the 'throat' of the CavTube is lower in pressure and higher in velocity than the combined slurry/gas mixture entering the CavTube.

The resulting hydrodynamic cavitation produces pico sparging bubbles so fine that they resemble 'smoke'.

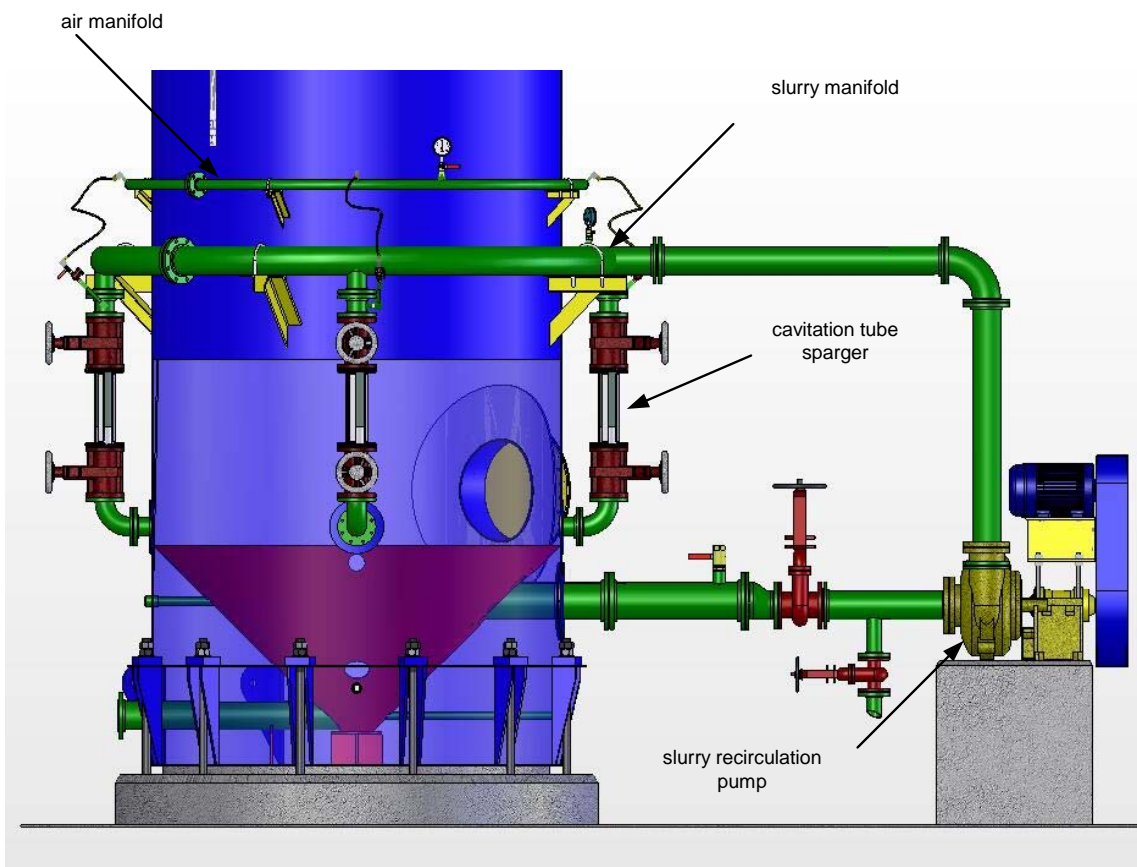
Phosphate industry user

“...we replaced inline static mixers with cavTubes, the recoveries are better and wear is negligible...”



Typically an external sparging system by definition requires a slurry re-circulation pump. Its function is to pump slurry from the bottom of the CPT flotation column into the slurry manifold back into the flotation column via the cavitation tube sparger. Sparger air is introduced into the re-circulated slurry just above the cavitation tube sparger.

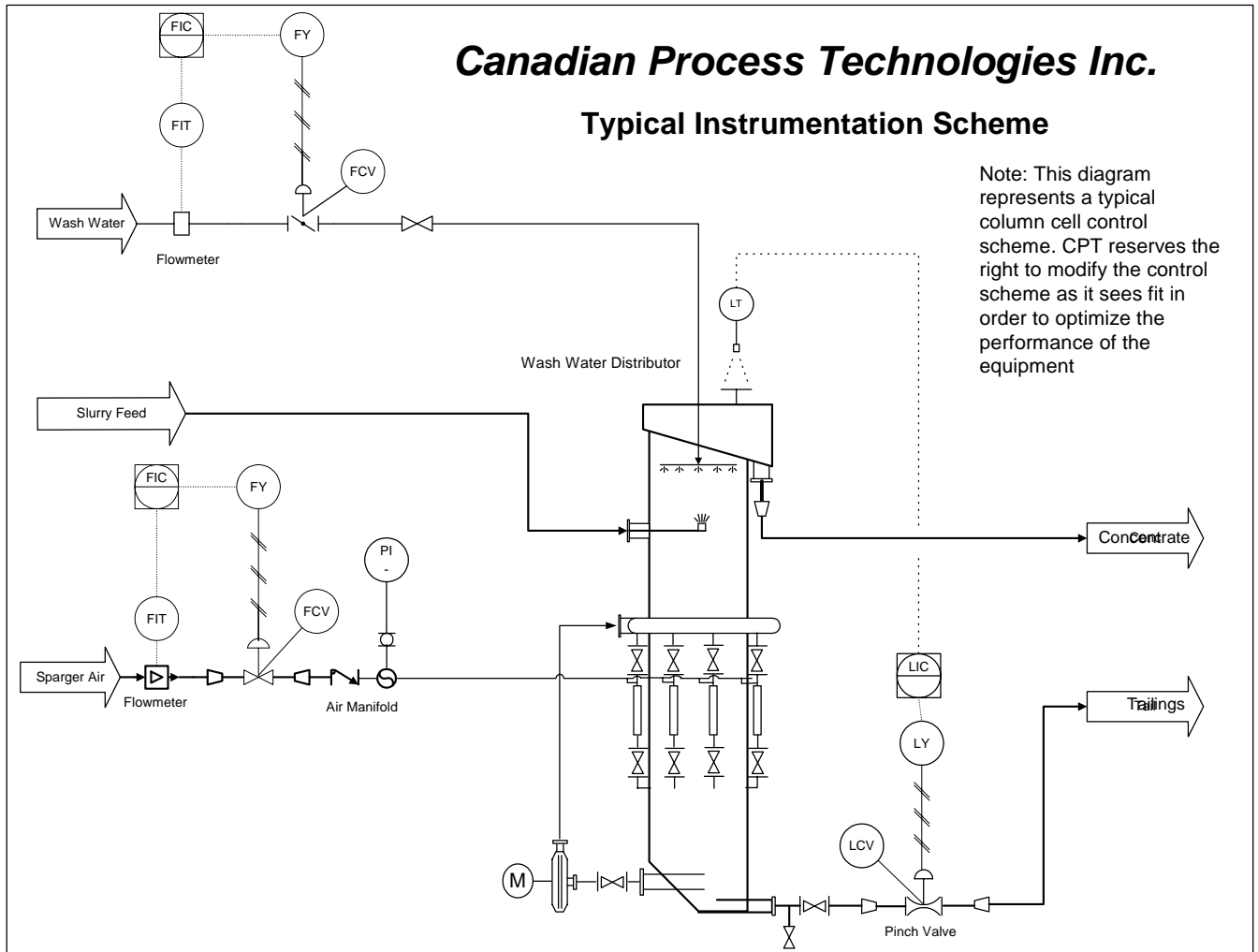
As the mixture of slurry and sparger air is pumped through the cavitation tube sparger, the resulting effect of hydrodynamic cavitation on the slurry-air mixture causes the formation of pico-bubbles acting to improve flotation kinetics.



Typical Cavitation Tube sparger installation



Canadian Process Technologies Inc. Typical Instrumentation Scheme





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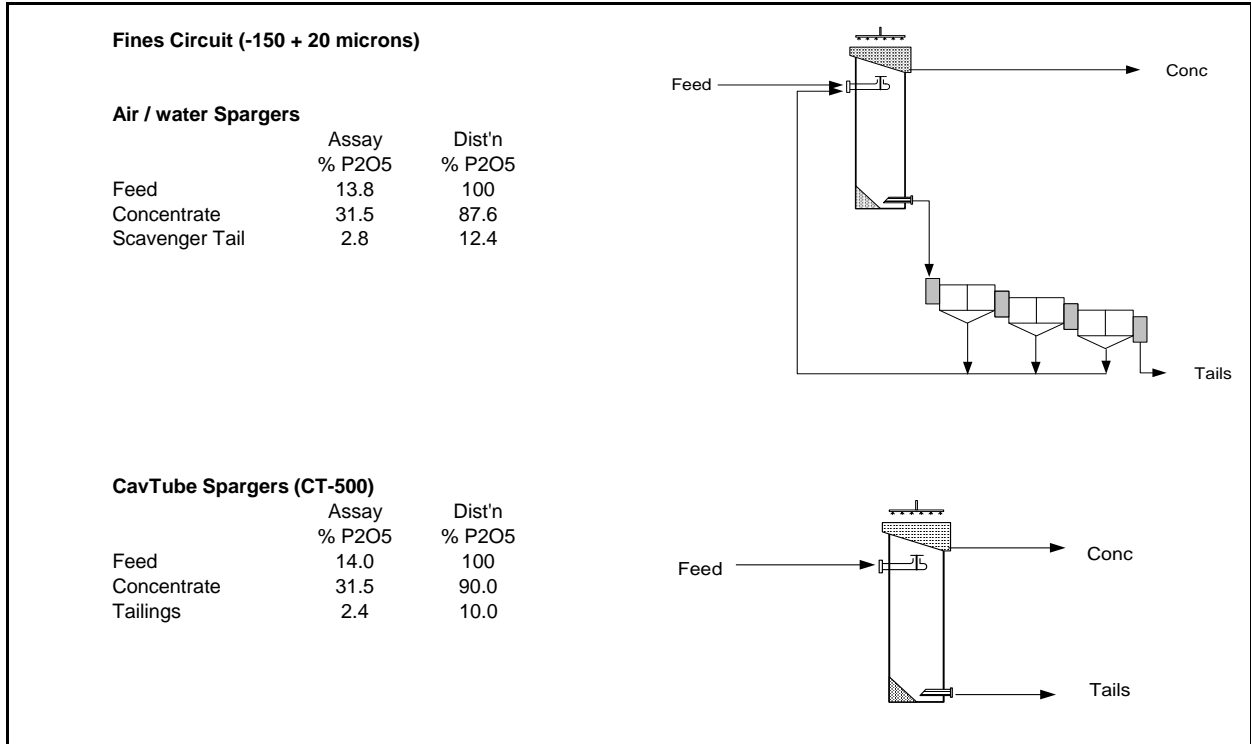
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Installation Photos





Various circuit installations where CPT cavitation tube sparger have demonstrated an improvement in both grade and recovery



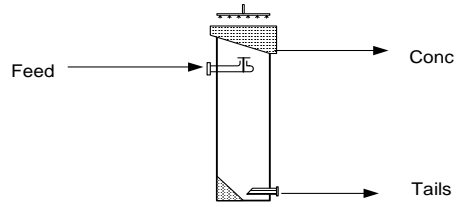


Ultrafines Rougher (-20 + 7 Microns)

Column 3m x 5m x 12m H

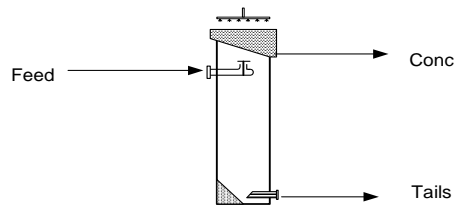
Air / water Spargers

	Assay % P2O5	Dist'n % P2O5
Feed	11.06	100
Concentrate	32.97	62.3
Tailings	5.27	37.7



CavTube Spargers (CT-350)

	Assay % P2O5	Dist'n % P2O5
Feed	11.5	100
Concentrate	33.7	84.2
Tailings	2.5	15.8



Zinc Calamine Flotation Cyclone Overflow (-20 microns)

CavTube Sparg (CT-350)

	Assay % Zn	Dist'n % Zn
Feed	19.37	100
Concentrate	39.12	92.6
Tailings	2.64	7.4

