Cavitation Air Flotation: A Breakthrough in Wastewater Treatment

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As the standards for industrial wastewater discharge become continually more strict, industry is being put under an increasing amount of pressure to slove their effluent problems. It is always theoretically possible to treat waste effluent to whatever standards are required, but individual companies may have problems with the capital costs involved, the operating costs, the space required by the treatment process and the by-products produced.

One method of minimizing these problems and others is by the installation of pre-treatment. Pre-treatment may be difined as the removal of the bulk of the polluting matter and the preparation of the effluent for further treatment. In many cases, where the effluent will pass to a municipal treatment plant. pre-treatment will be all a factory has to install to satisfy their discharge regulations. In other cases, where a factory does not have the luxury of a local municipal treatment plant, the installation of pre-treatment will significantly reduce the size, capital costs, and operating costs of further biological treatment by reducing the pollution loading and concentration with which it must deal. Pre treatment processes include amongst others, flow equalization, pH stabilization, screening and suspended solids removal.

The suspended solids in wastewater usually contribute between 30 to 70% of the Biochemical Oxygen Demand (BOD). Their efficient removal can therefore lower the BOD by these percentages. As already stated, this may meet discharge regulations alone or it will greatly reduce the size and cost of secondary biological treatment. Further to this, biological processes are more efficient at digesting dissolved solids than they are at digesting suspended solids - they are simply too big for the bacteria. Efficient oxygen transfer, in aerobic systems, also becomes a limiting factor.

Cavitaion Air Flotation (CAF®) is a new, innovative process for the efficient removal of suspended solids from water. It was invented in 1985 to overcome the problems and limitations associated with the more conventional techniques of Dissolved Air Flotation (DAF). Since then, it has gradually been taking over the market in the Americas and has been introduced to Asia, Latin America, and Europe. DAF has been around for a long time and involves the chemical treatment of the wastewater to flocculate the suspended solids, the dissolving of the air in the water to cause flotation, and then removal of the suspended solids from the surface. The technique has been shown to work very well, but the whole concept of actually having to dissolve the air in the water in the first place creates problems and sets limitations for the process. Air compressors and recirculation pumps are required, consuming large amounts of energy, the injection nozzles block up leading to operational and maintenance difficulties, and there is a limit to how much air it is physically possible to dissolve in water, giving rise to problems floating high concentrations of suspended solids CAF® overcomes all these problems with a unique and innovative, yet simple method for introducing the air to the system. The air is introduced as microbubbles, but is not dissolved, so there are no air compressors or recirculation pumps. The air is introduced by natural suction through a draught tube therefore there are no injection nozzles. The complete hydraulic flow is met by a massive quantity of air, in a confined space, so there are no problems not having enough buoyancy for flotation.

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How does it work? There are four overriding design criteria for success. The first is the selection of the best (and most cost effective) chemical treatment program for flocculating the suspended solids. This will normally require two chemicals, a chemical reagent called a coagulant, usually inorganic, to destabilize the electrostatic repulsive forces which keep colloidal and suspended particles apart. Another chemical, usually organic in nature and known as a flocculant, must then be added to cause agglomeration of the destabilized particles into flocs, which can then be more easily floated. Sufficient care and planning must be entertained to ensure the coagulant has sufficient time to achieve its aim before the flocculant is added, and that the flocculant is added at the right point as it tends to cause floc formation almost instantaneously.

The second criteria is the air injection and floc flotation process. In the CAF®, the wastewater is added at a steady rate into a cavitation chamber at one end of a rectangular tank. The flocculant is added at the inlet to the chamber, which is sized for a floc retention time of 2-4 seconds. All the air is also introduced to this chamber, below the water inlet pipe, so that it is all efficiently utilized. The air is introduced by a patented cavitation aerator. This is a hollow four pronged impeller which rotates at 1,700 rpm and is powered by a simple 2 or 3 hp motor. This process causes cavitation in the chamber and the vacuum so established, produces several effects.

Firstly, ambient air is drawn down a draft tube to fill the void left by the vacuum. This air is emitted by the impeller at the rate of one cubic foot per second - or about four times the total amount of air dissolved in water by DAF. Secondly, a combination of the cavitation effect and the shear effect from the actual chamber, causes the air bubbles to collapse into tiny microbubbles of a reasonable uniform size between 500 Nm and 1 mm. Thirdly, the vacuum encourages a natural recycle of 20-25% of the total hydraulic volume from the flotation chamber back into the cavitation chamber.

The effect of all this is, the suspended solids form flocs imediately when the water enters the chamber and are promptly met by a mass microbubble blanket. The flocs are carried to the surface of the cavitation chamber where they overflow into the flotation chamber.

The third criteria for design is the flotation clarification. The design of the CAF® system allows for 17 minutes retention time in the flotation chamber, which is the optimum time for water clarification and surface sludge thickening.

The fourth criteria is an efficient and effective solids/liquid separation system. In the CAF® process, the solids are continually pulled over an angled beach by scrapers, and deposited into a channel where a screw auger continually removes the solids for de-watering, recycling, or dumping. Both the scrapers and the auger are driven by the same 1/2 hp geared motor. The clarified effluent passes under the beach, over an adjustable weir, and into a discharge chamber from where it either flows directly down the drain or to further treatment. The hydraulic head in the tank is simply adjusted by the weir setting and the surface sludge thickness can also be optimized by adjusting the scraper/auger speed with the variable drive motor.

The advantages of the CAF® system over other flotation processes are obvious and numerous. The system has a low power requirement ($2\ ^{1}/_{2}$hp to 20 m^3/hr wastewater and $3^{1}/_{2}$ hp up to 150 m^3/hr wastewater), it is small and compact, it is simple, inexpensive and flexible to operate and maintain, there are no air compressors, recirculation pumps or injection nozzles to block, and the sheer mass of air produced and the instantaneous floc formation in the cavitation chamber provide a massive vehicle for flotation to ensure "sinkers" are rarely a problem. Probably most important, due to the system's simplicity, it is inexpensive to purchase and install.

As far as results are concerned, the CAF® is an extremely efficient suspended and colloidal solids remover. The system is equally, if not more, efficient at removing fats, oils, and grease, (FOG). Provided the correct chemical program is used, suspended solids (SS) removal efficiencies of over 90% are expected and well over 95% is common. How much BOD is removed depends on the relationship of the SS to the total BOD in each particular case, but 40-50% is the usual removal range. COD removal percentages are usually slightly higher. It is possible to get over 70% BOD removal with the CAF® if the SS concentration is particularly high. For example, in a Tannery application, 97% SS removal and 96% FOG removal yielded a 49% BOD reduction and a 64% COD reduction. In a Dairy application 80% SS removal gave rise to a 60% BOD and a 57% COD reduction It is possible to remove more SS in this application, but this was not necessary, therefore a reduced amount of flocculant was used. in a Textile plant, a 97% SS removal efficiency caused a 55% BOD and a 50% COD reduction. In a Food Processing application, 97% FOG removal rate gave rise to a 44% reduction in BOD.

It must be remembered, that while results such as these are extremely encouraging in an environmentally conscious world, it need not be all "money down the drain" for the actual effluent producer. Before treatment, the wastewater is completely useless, but after SS removal, recycling possibilities abound. The solids can often be returned to the process or used as fertilizer or even animal feed. The effluent can be used for make up water, wash down, sprays or any other process where perfectly clean water is not required. If this recycled water is above ambient temperature, vast savings can be made in heat energy costs which otherwise have to be incurred. This philosophy is particularly evident in the pulp and paper industry where CAF® is now installed in some 30 mills in the USA, Mexico, and most recently, Hong Kong. In these applications, CAF® installations typically pay for themselves in 3-6 months by recycling the solids back to the pulper to save fiber and recycling the hot effluent to the seals, showers, and pulper to save energy and water charges.

I would like to end this presentation with the thought that CAF® need not only demonstrate an inexpensive and effective way forward in the effluent treatment world, but it can and does open doors to the recycling of resources and pave new avenues for actually making a profit from treating your wastewater.