An Abrimix Technology Introduction

Presented in partnership by Jalema Technologies, Ltd. & Abrimix (Pty), Ltd.

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An introduction to a new high shear reaction enhancement and flotation technology designed to deliver process efficiencies to metallurgical and industrial wastewater treatment applications

Document Description: A summary review of the patented High Shear Reactor (HSR) technology developed by Abrimix (Pty) Ltd. and successfully commercialized across numerous industries in Africa and Europe. This document provides an overview of the Abrimix Technology with regard to high shear mixing enhancement and rapid rate solid-liquid separation & flotation water treatment.

Please refer any questions to:

Eric Atwood or Jay Lombardi

eric@jalematech.com / jay@jalematech.com

303-884-0867 / 720-315-6924

Abrimix Technology Introduction

Abrimix represents an innovative technology that applies "shear" to increase the kinetics and completeness of reactions within aqueous solutions. The Abrimix Technology can be applied to various influents where certain reactions are desired to achieve the dissolution, oxidation, and/or precipitation of certain elements, the phase separation of ultra-fine suspended solids and the breaking of emulsions within a liquid.

When air is applied into the Abrimix treatment process, precipitated and entrained solids are effectively separated and removed in accordance with conventional flotation principles. This proprietary technology is particularly beneficial within hydrometallurgical and wastewater treatment processes. Within hydrometallurgical applications, the Abrimix Technology improves precious metal recovery by enhancing conventional leach and flotation recovery systems. Within wastewater treatment, Abrimix has achieved outstanding results in treating some of the most challenging wastewaters contaminated by high concentrations of oils and/or fine suspended solids. The unique bubble regime generated by the Abrimix shearing of injected air (Sheared Air Flotation) has proven to be highly effective in separating and removing ultrafine organic and inorganic suspended particulates within aqueous solutions. Due to the efficiencies provided by the Abrimix Technology, retention times, operating footprint and chemical consumption rates are consistently reduced relative to traditional flotation treatment systems. This has made this technology disruptive in terms of cost-effectiveness.

The term "Abrimix" is a conjugate for "abrasive mixing" and was originally developed by a South African metallurgist for the initial purpose of improving gold recovery within traditional leach treatment extraction processes. The Abrimix shear mixing intensity removed oxide and/or reagent coatings from mineral surfaces that inhibited mineral dissolution and recovery. The Abrimix shearing power also scoured the mineral's exposed liquid-solid boundary layer, thereby enhancing reagent access to dissolve and remove gold from the crushed ore body. In addition, the "polished" mineral surface becomes more responsive to other reagent applications such as frothers, collectors, depressants and various agglomeration polymers. The innovative combination of shear mixing and highly effective bubble generation increased gold leaching recovery rates four-fold (while reducing chemical usage) relative to conventional vat leaching. Essentially, more gold was recovered in less time using less chemicals.

The Abrimix High Shear Reactor (HSR)

The key component to the Abrimix Technology is the powerful static in-line mixer or "Reaction Enhancing Unit". This patented unit improves the speed and thoroughness of liquid and gaseous chemical interactions within aqueous solutions. The unit, most commonly referred to as a High Shear Reactor (HSR), utilizes a specifically designed and researched hydrodynamic flow path that is derived from proven and sound fluid engineering mechanics. The proprietary design creates increased differential velocity gradients and unique impact zones that generate recurrent molecular collisions, extremely high shear and mixing intensity. This shearing effect is achieved when liquids or slurries are pumped through the HSR at pressure

Unit	Capacity	Length	Weight	Diameter
RE LW 10	50 gpm	17.7 in	23 lbs	3.0 in
RE PW 25	100 gpm	22.0 in	48 lbs	3.5 in
RE 400W	450 gpm	39.0 in	297 lbs	8.5 in
LE 500S	1600 gpm	54.0 in	760 lbs	14.0 in

velocities of approximately 3 Bar (~45 psi) or greater. The turbulent mixing generated by the Abrimix HSR has been calculated to be in the order of 25,000 Reynolds Number (Re). In comparison, a jet mixer generally achieves a mixing turbulence measurement of about 8,000 Re.

The typical Abrimix Shear Reactor unit is constructed with a stainless steel cylinder outer-housing with either threaded or flange connections at each end of the device. In addition, the unit normally includes an air/gas injection port to accommodate gas reagent mixing or micro and nanobubble production for flotation applications. The "materials of construction" of the patented inner core reactor varies and is dependent upon the characteristics of the influent and application parameters. The unit has been designed to accommodate flow rates from 15 gallons per minute (gpm) to over 1600 gpm.

Water Treatment Applications

Though the Abrimix Technology was originally designed to enhance precious metal recovery in the mining industry, most of the Abrimix applications operating today involve industrial wastewater treatment. The Abrimix Technology has proven to be very successful at cost effectively reducing total suspended solids (TSS), chemical oxygen demand (COD) and fats, oils and grease (FOG) from numerous types of "hard to treat" wastewaters. The technology has helped clients minimize their water footprint while reliably meeting their environmental requirements.

Each Abrimix treatment system is custom designed to accommodate a wide variety of effluent flow rates and suspended solid pollutant characteristics. On-site pilot testing and demonstrations are normally conducted prior to a commercial installation to collect pertinent engineering design data and to validate and optimize operating configuration and performance.

Abrimix has achieved excellent results in treating the wastewaters from abattoirs, wineries, tannery operations, pharmaceutical production facilities, breweries, paint shops, juice producers, rendering plants and numerous types of creamery, cheese and dairy operations. Post treatment TSS and COD performance targets are consistently achieved or exceeded.

Within the oil and gas industry, the Abrimix Flotation Treatment System (FTS) successfully produced clear "clean brine" from oily, high TSS "produced water" that originated from drilling operations. In addition, the Abrimix FTS was successfully tested at various coal burning power plants to remove coal ultra-fines, fly ash and other forms of coal combustion residue from washout containment ponds and from boiler power cleaning operations. The Abrimix treatment process consistently removed 95% or more of the TSS from these discharge waters.

Abrimix Sheared Air Flotation

When air is injected into the Abrimix HSR, it is shear-torn into micro bubbles estimated to be in the size range of 10 – 80 microns. Some of these bubbles are, in turn, Venturi-shattered by hydrodynamic pressure forces to produce much smaller "cavitation generated" nano-bubbles. The creation of these

smaller "frosting" bubbles greatly enhances flotation performance by improving the hydrophobicity of the particulates and the adhesiveness between the bubbles and the floccules. The very small bubbles created by the Abrimix HSR are advantageous because the collection of smaller bubbles provide a larger surface area which more effectively promotes the aggregation of the suspended solids. The smaller bubbles optimize bubble-particle collision probability and more effectively aggregate and stabilize the floccules by adhering to and entraining inside the floccules, forming aerated flocs. Conversely, larger bubbles tend to rise rapidly, thereby lowering particle-bubble "collision and carry" efficiency.

When the unique Abrimix "sheared air" bubble regime and associated mixing power are combined with the proprietary design of the Abrimix Suspended Solids Flotation (SSF) column technology, the result is a significantly enhanced physicochemical treatment solution that has proven to be extremely effective in delivering overall efficiency and performance to flotation water treatment.

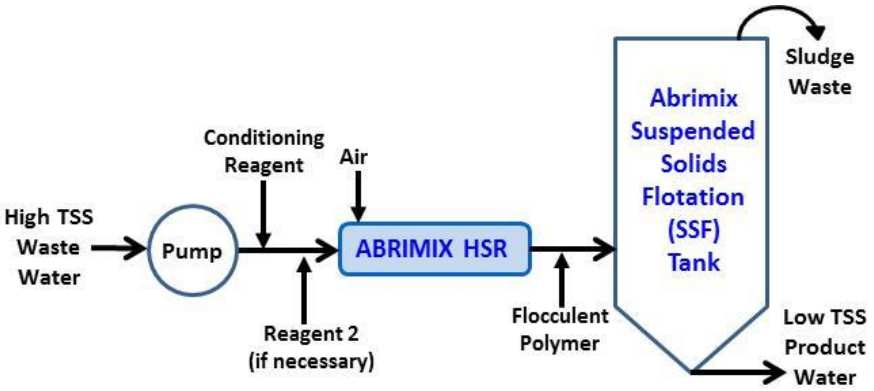
Abrimix Flotation Treatment System Overview (The Abrimix *"HSR-SSF"* Process)

The Abrimix Water Treatment System generally operates as a fixed flow treatment plant. This allows for the most efficient control of chemical treatment and operations management. In water treatment applications, the wastewater is fed into the Abrimix treatment system with a centrifugal pump capable of delivering the required flow rate and feed pressure. One or more conditioning reagents may be injected into the Abrimix process to facilitate particulate ionic charge modification, agglomeration and flotation enhancement. The conditioned effluent is pumped through the Abrimix HSR along with a low and continuous injection of regulated air flow. The air is sheared into micro and sub-micron bubbles and thoroughly mixed within the conditioned effluent stream.

Once the chemically treated, bubble-infused aqueous stream passes through the Abrimix HSR, it is usually dosed with an agglomeration polymer that helps link the neutralized and settling solids into a collection of aerated floc clusters. The combined homogeneous mixture is then discharged into the specially designed Abrimix Suspended Solids Flotation (SSF) column where the conditioned solids further agglomerate and separate from the water. The SSF tank produces two products—a concentrated solids sludge overflow and a low TSS product water underflow. Given the enhanced electrostatic attraction and bubble-solid contact efficiency, the floccule solids

effectively float to the top of the SSF column. Once on the surface, the solids concentrate, dewater and overflow into the sludge collection launder and corresponding solids collection bin. The treated, low TSS product water discharges from piping fixtures located at the bottom of the flotation column. The retention requirement within the flotation tank is generally less than 5 minutes, thereby producing a very rapid separation and solids removal process. The following graphic represents a simple illustration of the standard Abrimix Flotation Treatment Process.

Standard Abrimix Flotation Treatment Process



Abrimix Mixing/Reaction Enhancement

As previously mentioned, the powerful mixing and shearing capability of the Abrimix High Shear Reactor significantly enhances the rate and thoroughness of chemical reactions within liquid mediums. Through the Abrimix shearing process, diverse combinations of liquid, solid and gas reagents and influent may be brought into contact in an extreme mixing environment on a continuous feed basis. Benefits of this process generally include reduced mixing retention times, reduced chemical consumption and, in turn, smaller operating footprint.

Coincident with the mixing, the Abrimix HSR can also abrade and de-armor encapsulated chemicals and remove passivating films that inhibit reactionary processes. The Abrimix mixing power also enhances chemical crystallization kinetics by accelerating crystal formation and, in turn, precipitation. This benefit can help prevent damaging scale formation attributable to high concentrations of various crystalized inorganic compounds (calcium sulfate, calcium silicate) residing in certain wastewaters. The Abrimix technology has proven to be very effective at de-super-saturating the calcium sulfate (gypsum) content in reverse osmosis (RO) discharge brines.

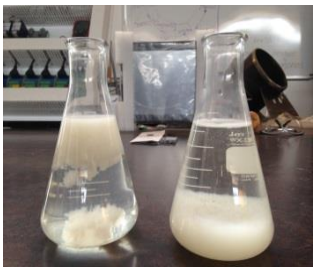
Summary

Abrimix offers significant process efficiencies by achieving more with less. Through a combination of high shear mixing enhancement and rapid solid-liquid separation and flotation effectiveness, the Abrimix Technology can deliver a high performance, cost effective solution within numerous hydrometallurgical and water treatment applications.

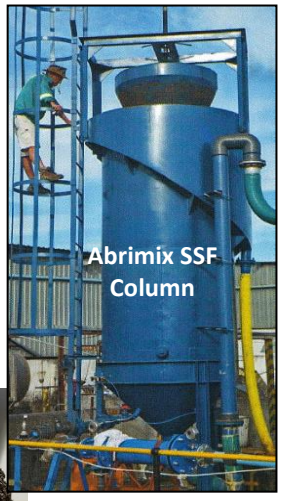
The Abrimix Technology's primary benefits include accelerating the rate and thoroughness of chemical reactions, reducing retention time requirements, reducing chemical consumption, providing greater process control and minimizing operating foot-print. The extreme mixing and hydrodynamic cavitation affect generated by the Abrimix Shear Reactor can simultaneously create efficient homogeneous mixing, phase diffusion, emulsion breaking and air/gas shearing.

In addition, the Abrimix Technology delivers state-of-the-art flotation performance. This is achieved by the Abrimix Reactor's ability to generate a unique and varied mixture of sub-micron and microbubbles that optimize bubble-particle collision probability, attachment and floatability. Through optimal bubble generation and the effective mixing of agglomeration polymers and conditioning reagents (as necessary), Abrimix has achieved outstanding results in "float" removing some of the most challenging and very fine insoluble organic and inorganic particulates from a wide variety of industrial process and wastewaters.

In essence, the Abrimix Technology represents a unique combination of kinetic efficiency and flotation separation effectiveness. Primary markets served include the food & beverage, power and mining industries. Abrimix's advanced proprietary technology is robust yet simple in its application and easy to operate. The technology is currently in the process of being introduced to the North American market. Successful operations have already been established in Africa and Europe.



Solid-Liquid Separation



Abrimix HSRs

Flotation Sludge

Jalema Technologies

Jalema Technologies (Jalema), a specialty water treatment consultancy established in 2010 and based near Denver Colorado, exclusively promotes and distributes the Abrimix Technology within North America. The company's primary focus is to provide innovative, sustainable and high efficiency water treatment solutions to the food and beverage, energy and mining sectors. As water treatment specialists, Jalema recognized the unique and extraordinary advantages the Abrimix Technology represents. Therefore, in partnership with Abrimix (Pty) Ltd of South Africa, Jalema is currently evaluating numerous industrial and environmental water treatment and compliance applications where the Abrimix Technology will offer the greatest value to prospective clients and strategic partners. Correspondingly, Jalema is actively exploring opportunities to establish strategic partnerships and sub-licensing relationships that will help increase awareness and more effectively promote and distribute this new Technology within the North American market.