Membrane Filtration of Colloidal Silica
A cost-effective and efficient solution

Background

New Logic Research’s patented V✧SEP membrane filtration system has been installed at Silica Gel processing plants. Vibrational membrane filtration is an innovative new way to dewater or diafilter Silica product. V✧SEP can be used as a pre-treatment for a spray dryer or evaporator. It can replace other less reliable pre-treatment systems such as Centrifuges. Today’s Industrial Silica market is very competitive and efficiency in operating costs can make the difference. The V✧SEP system consumes about 12 kW of electricity and can reduce the gas consumption of a spray dryer by an average of 700,000 Thersms/year. Also, the power consumption of a V✧SEP system is 10-20 times lower than Centrifuges.

New Logic’s vibrating Membrane System is currently being used for dewatering of PVC Latex, Paper Coatings, Titanium Dioxide, Latex Paint Wastewater, and many other thick slurries where volume reduction is desired. There are Silica customers who are using V✧SEP to diafilter the slurry to wash it and remove impurities and salts and for product recovery from wastewater during wash down.

Characteristics

Colloidal Silica comes in many forms and has many unique properties. It has a strange and widespread number of uses. It is used as a viscosity additive for the latex in tennis shoe soles and is also used for de-inking during paper recycling. Colloidal Silica has many unique characteristics that make it useful. The man-made amorphous type has no defined shape and the surface of the particles has great molecular charge. Just as the coastline of Norway is saturated with fjords giving a very small country one of the largest coastlines in the world, the surface area of amorphous Silica is incredibly large in relation to its size. Silica Gel has a surface area equal to 700m2/g. Only activated carbon has a higher surface area. Another way to illustrate this is that the surface area of one teaspoon of colloidal Silica gel is equal to more than one football field in size.

Fumed Silica is more densely gathered due to its chemical synthesis process. Silica Gel is a suspension solution of random colloidal silica without definite form or size. The particles in the solution form a loose network due to the “Brownian Motion Theory” which describes the random collision of fluid molecules against the suspended matter. Because the particles repel each other, they are evenly dispersed and will not settle out. In addition, colloidal silica will have a very high viscosity and a low gel point. Colloidal Silicas and other Silicates can have Gel points as low as 15-35%. The gel point is the concentration at which the fluid will not flow and cannot be pumped.

Raw Materials

The main ingredient for amorphous silica is regular quartz sand which can be found in abundance anywhere. This sand is processed with Sodium Carbonate, Na2CO3 which is made using the Solvay process combining salt, ammonia, carbon dioxide, and limestone all naturally occurring substances.

Silica Gel:

Step One, sand is fused with Sodium Carbonate in a high temperature furnace. The result is Sodium Silicate and Carbon Dioxide gas:

\[ SiO₂ + Na₂CO₃ \rightarrow Na₂O.SiO₂ + CO₂ \]

Step 2, the Silica Gel is made using Sulfuric Acid:

\[ Na₂O.SiO₂ + H₂SO₄ \rightarrow SiO₂ + H₂O + Na₂SO₄ \]

The result is an aqueous salty solution containing Silica colloids. The Sodium Sulfate salts must be washed using diafiltration and then the Silica must be partially dewatered. The exact methods used will vary, however, most all silica ends up in a salty solution that must be rinsed and then dewatered.

During the refining process, the colloidal Silica is suspended in a salty aqueous slurry. This slurry must be desalted and dewatered. V✧SEP is uniquely able to be used as a diafiltration process and then to dewater in a single pass. During diafiltration, a UF membrane is used which will reject the particles and allow the salty water to pass through the membrane. By successive rinses, the silica can be completely separated from the salt solution. The resulting gel is nearly pure colloidal silica with some water.

Colloidal Silica sells for about $25 per Pound. While in production, 2.3 tons of product is recovered each hour per 84” V✧SEP.
New Logic's Solution

Technological advances in membrane filtration systems and membranes have created an opportunity for the efficient and economical treatment of Silica Diafiltration and Concentration. The “Vibratory Shear Enhanced Process” or VSEP® developed by New Logic makes it possible to filter chemical processing streams without the fouling problems exhibited by conventional membrane systems.

In this case study, the VSEP membrane system utilizes an Ultrafiltration membrane which will reject the suspended solids and colloids. New Logic uses over 200 membranes and tighter RO and NF membranes are available.

VSEP is capable of handling thick slurries and concentrating the feed stream to a sludge which can be dried. The filtrate from this can be reused for washdown operations, used as plant water, or sewered. The VSEP can be used by itself or in conjunction with other equipment for a comprehensive treatment system.

VSEP ... A New Standard in Rapid Separation
Process Description

V✧SEP is capable of handling influent streams in a single pass with very little pre-treatment. Usually just a 100 mesh prescreen is all that is required. In this case study, the V✧SEP was used to replace a centrifuge. The Block diagram below shows the treatment system. The raw process feed enters the feed tank at the left of the drawing. From here it goes to a bag filter and then to the V✧SEP machine itself. The concentrate is returned to the feed tank for successive washes until the conductivity reached the design target at which time it is diverted to the concentrate holding tank for further treatment. The Filtrate is partially reused in washdown operations and partially sewered.

Process Conditions

The membrane treatment system can process at a rate of about 80 GPM (18 m³/hr). The process feed containing salts is first concentrated to remove the bulk of the water. Then, with a process of wash volumes, water is added and the removed thus diluting and removing the unwanted salts and other dissolved contaminants. The operating conditions are 30°C at about 80 psi using an Ultrafiltration membrane. The footprint of the V✧SEP is about 16 SF (1.5 M²).

Process Results

This rate of production would be equal to about 105,000 gallons per day. The concentrate produced is about 15% total solids which is very near the Gel Point with extremely high viscosity. This stream is sent for further processing using other equipment.

Colloidal:
A group of small particles suspended in a solution from about 10 nm to 10 µm. These particles have non-defined random shape and size and differ from other particles which have uniform shape or size.
The V_SEP is periodically cleaned using a caustic cleaner to reset the flux and produce consistent long term results.

**System Throughput**

The V_SEP system performance is a function of temperature, % recovery, & % Total Solids in the feed slurry. The more concentrated and colder the feed, the lower the throughput of the V_SEP system. Temperature affects the viscosity of the liquid and viscosity affects the liquid fraction’s ability to move through the membrane surface. In general, one 84” V_SEP is capable of producing 60-80 gpm of clean water filtrate from Colloidal Silica at a recovery of 75% of the total volume as permeate.

**System Components**

The process feed is pulled out of an existing 5000 gal feed tank. The tank is located near to the V_SEP and the feed pump of the V_SEP system is able to prime with only head pressure from the tank. The liquid transfers through a pre-screening unit to remove large particles, (100 mesh). There are many types of mechanical screens that could be used. The picture below shows the type used.

The feed water then flows into a vertical multistage centrifugal feed pump which provides the pressure to the Filtration unit. The bag filters and pumps are provided with the V_SEP system and are skid mounted for easy installation.

The V_SEP system comes with a cleaning tank and many of the valves and other interface equipment. The system is “Plug and Play”. The feed tank, transfer pumps, heat exchangers, and boiler are not normally included, but, can be provided as part of a complete process package. The V_SEP system is automated and controlled by a PLC (Programmable Logic Controller). Operator interface is limited to monitoring the system and making periodic adjustment to parameter settings. The system comes standard with “Foxboro” brand instrumentation including pressure sensors, tank level sensors, flow transmitters, pH analyzers, temperature meters, and conductivity sensors to monitor the process conditions and will send a 4-20 mA digital signal to the PLC for seamless operation.

**UF Flux vs. Time on Colloidal SiO2**

Using V_SEP (Vibratory Shear Enhanced Process)

Test Conditions: 80 psi, 30°C

Process Feed Water saturated with dissolved and suspended Silicon (Si) and Silica (SiO2)
Company

New Logic is a privately held company located in Emeryville, California. Incorporated in 1986, New Logic manufactures a proprietary membrane filtration system called VSEP® (for Vibratory Shear Enhanced Processing). Originally developed for blood plasma separation, the technology has been scaled up to meet the growing separation needs for many industries. VSEP can be employed in water treatment, product separation, solids dewatering or wastewater treatment. The industries and applications for VSEP are quite diversified and include: Pulp & Paper (black liquor, whitewater, box plant effluent, end of pipe), Industrial Water Pretreatment (ultrapure, boiler feed, surface water), Pigments & Paint (latex emulsions, product recovery), Mining (mine tailings), Solids Dewatering (calcium carbonate, kaolin clay, TiO₂), and Metal Working (oily wastewater, metal hydroxides).

Technical Services

New Logic has years of experience and expertise in membrane filtration. Their 40,000 sq. ft. facility provides comprehensive manufacturing and facilities. Highly trained engineers and technical staff are available to support your application questions. Feasibility testing can be accomplished in-house, or a fleet of pilot units are available to support on-site testing. Operational surveys are available to help assess your needs and the potential cost savings. An experienced team of technicians are available to support both on-site pilot work and VSEP system installations.

People

From scientists to customer service associates, New Logic recruits some of the best people available. Academic credentials include doctorates and advanced degrees from such notable universities as Northwestern, Cal Berkeley, UCLA, Johns Hopkins and others.