NEW LOGIC INTERNATIONAL, INC.

Case Study

VSEP Separates PVC Latex

Overview

New Logic International installed its Vibratory Shear Enhanced Processing (VSEP®) system on August 21, 1996 at a major international latex/chemicals manufacturing facility in Europe. VSEP is used for preconcentration of Poly Vinyl Chloride (PVC) latex to a spray dryer at this facility. The VSEP system uses an ultrafiltration membrane module and is able to concentrate (dewater) latex emulsions from a concentration level of 38 percent to a level of 55 to 68 percent. The system is also able to substantially reduce the process dryer energy requirements, thus debottlenecking the process and increasing manufacturing capacity by a factor of 2 to 3. The Economics of installing this system are extremely attractive and result in a pay back period of 4 to 9 months. Application of the VSEP membrane technology to PVC and similar latex concentration (e.g. Styrene Butadiene Rubber (SBR) and Acrylonitrile Butadiene Styrene (ABS)) at latex/chemical manufacturing facilities has proven to be an attractive economic alternative.

Background

The concentration of latex emulsions was one of the early applications suggested for membrane separations using ultrafiltration. Unfortunately, not all latexes were amenable to processing with ultrafiltration. Many latexes were found to be unstable under the high shear induced by pumps used for traditional crossflow ultrafiltration modules.

Ultrafiltration has also been proposed to clean up polymerization kettle wash waters before disposal. The dilute latex can be concentrated from 0.5 to 25%, thus reducing the volume to be hauled away to 1/50th of the original volume. In some cases, the waste latex is recycled for reformulation or sold directly for low grade applications. Where there is a significant sewer charge, ultrafiltration is an economic alternative even without recovery of the latex. However, it has not been widely used because there is a history of problems with traditional crossflow membrane systems. These systems have short membrane life, exhibit membrane fouling, and are unable to achieve the final concentration requirements. Unlike other technologies, VSEP overcomes these shortcomings by the use of diaphragm pumps and the careful control of hydrodynamic shear within VSEP, thereby avoiding fouling problems and extending membrane life to an acceptable level. VSEP also achieves the much higher final product concentrations that are desired.

The PVC latex manufacturing facility where VSEP is installed operates 24 hours a day, 300 days per year. The maximum latex emulsion flow rate in the process is approximately 44 gallons per minute (gpm). The latex emulsion is normally fed directly to the dryer via the dryer feed pump. Installation of VSEP before the dryer allows substantial energy savings and allows debottlenecking of the process by reducing the load on the dryer. The introduction of VSEP has provided a highly concentrated latex stream to the plant dryer with substantially reduced water content. Permeate generated from the VSEP is discharged to the sewer. The VSEP system has increased both the efficiency of latex recovery and the processing capacity of the plant, thus allowing the plant dryer to handle a larger latex emulsion load.

In addition to the commercial installation summarized in this paper, New Logic also has extensive pilot testing experience with latex washwater and latex product concentration for other types of latex, including Styrene Butadiene Rubber (SBR) and Acrylonitrile Butadiene Styrene (ABS). These results suggest very economically attractive applications for all types of latex. Utilizing VSEP with ultrafiltration membranes has been shown to be a commercially-viable option to be used in front of spray dryers and evaporators to concentrate in-process latex streams from 30 percent to as high as 68 percent, thus substantially reducing energy consumption. This project summary report describes the application of VSEP to process Polyvinyl chloride (PVC), the most prominent latex for this type of application. The expected process performance and its economic advantages for this application are also discussed.

System Description

A process schematic for this application of VSEP is presented in Figure 1. This diagram also includes the overall material balance for the PVC latex concentration process. Latex/ flush water emulsion from a dryer feed water head tank is pumped to the feed/ circulation tank and VSEP unit at a rate of 35 to 44 gpm. An industrial scale VSEP unit, using an ultrafiltration membrane module, processes the feed latex emulsion. The VSEP produces a concentrated latex stream at a flow rate of 27 to 32 gpm with a concentration of 48 to 55% latex which is stored in the latex stock tank and then introduced to the spray dryer feed pump. VSEP also generates a permeate stream of about 8 to 12 gpm which is routed to the sewer and meets discharge limits.

An overall flow chart for the PVC latex manufacturing process, including the VSEP latex concentration system, is presented in Figure 2. Vinyl chloride monomer liquid is introduced to the polymerization kettles, along with solvents and catalysts. The polymerization/copolymerization kettles generate a latex emulsion with a concentration of about 38 to 44%, which usually is fed to the dryer feed water head tank and then to the spray dryers. By introduction of VSEP,

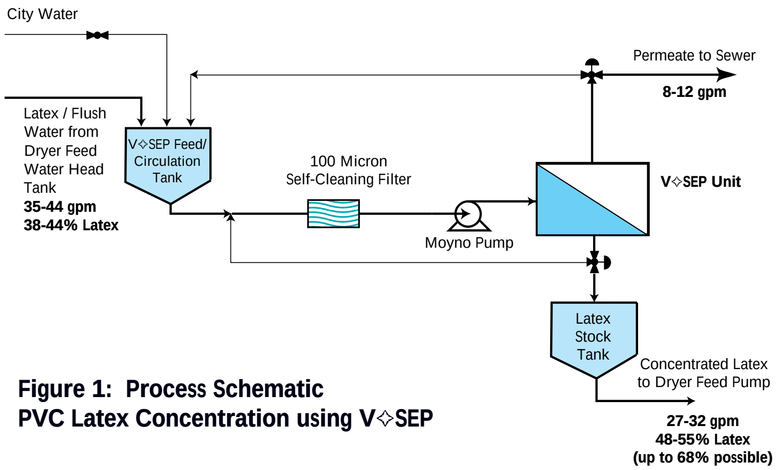


Figure 1: Process Schematic
PVC Latex Concentration using V✧SEP

debottlenecking of the process is possible because the hydraulic water load on the dryer is substantially reduced. The PVC latex product is concentrated to a level of 55%. For some streams a concentration level of up to 68% is possible for the concentrated latex stream. The spray dryer then processes the concentrated latex stream to a bone dry PVC latex product. With the much higher solids concentration in the feed to the dryer, the plant can operate at a much higher dryer processing capacity, resulting in an overall capacity increase ranging from 200% to 300% of the original capacity.

Figure 3 presents the VSEP laboratory testing results for PVC latex concentration. At a temperature of 86°F (30°C), permeate flux ranges from 70 to 110 gallons per square foot per day (GFD) at the 36% latex concentration level to 25 to 65 GFD at the 55% latex concentration. These test results are based on data from the VSEP pilot unit at a feed pressure of 60 psig.

The concentrate level out of the VSEP unit is controlled by an automatic, timed control valve. This valve is set such that the concentration of the latex fraction from the VSEP is held at the desired level. A multi-stage moyno pump supplies the latex emulsion to the VSEP unit at flows ranging from 35 to 44 gpm at a pressure of about 50 psig. A variable frequency electronic drive is used to set feed pressure through a P.I.D. (Proportional-Integral-Derivative) control loop. This kind of drive acts to control the rotational speed of the pump, thus controlling the flow rate.

Project Economics

The cost of installing and operating the VSEP system and related savings that would be realized at different dewatering rates by reducing water evaporation and drying costs have been calculated.

Operating costs are calculated based on the power costs to operate the filter unit (10 HP) and the filter feed pump (3 HP), filter cleaning cost, filter replacement cost and additional water heating/evaporation costs that would be saved due to the reduction of the amount of water that would no longer require heating/evaporation in the spray dryer. Results from the operation also point to substantial additional savings that result from not having to invest in additional spray dryer capacity. The concentration/dewatering function of VSEP results in reducing the load on the spray dryer and thus debottlenecking the plant production of PVC latex.

Operation and maintenance (O&M) costs are presented in Table 2. Cost savings associated with the reduced dryer energy requirements at different latex dewatering rates are calculated and presented. The energy costs are based on rate information from a Northwest U.S. setting, typically about $0.32/therm, as well as a European setting, ranging from $0.4 to $0.6 per therm. At higher dewatering rates, maximum benefit from the VSEP will be realized both from the point of view of reducing the load on the dryer and allowing higher capacity for production of PVC latex.

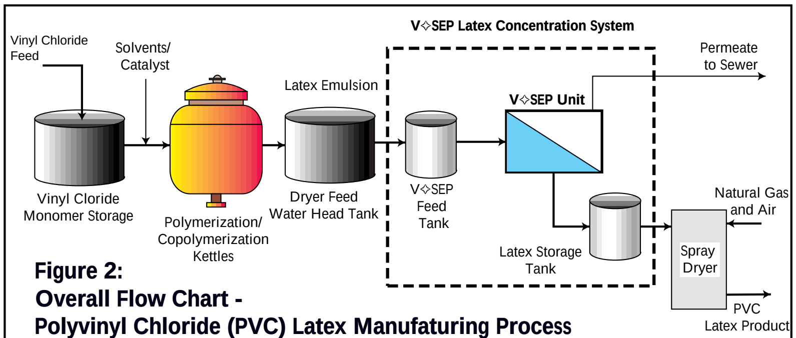
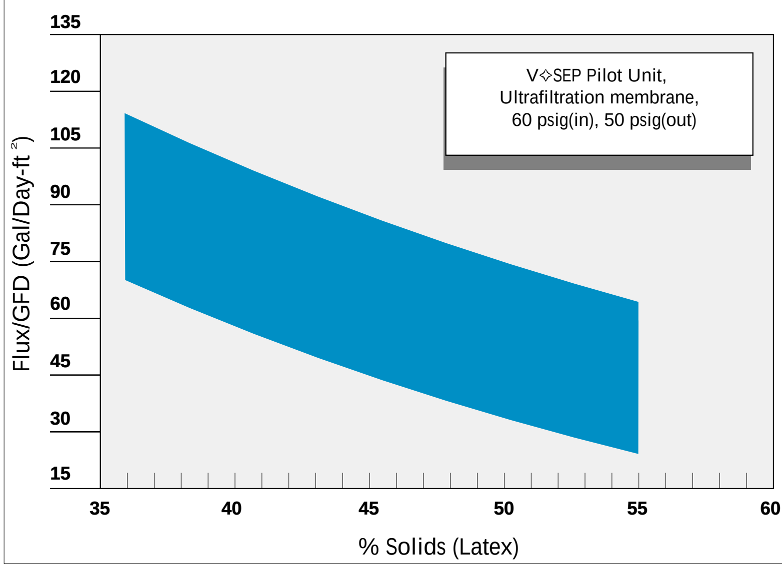


Figure 2:
Overall Flow Chart -
Polyvinyl Chloride (PVC) Latex Manufaturing Process
Including V✧SEP Latex Concentration System

Figure 3
V✧SEP Laboratory Testing Results for PVC Latex Concentration



Additional Benefits

As an example, a PVC Latex manufacturing plant has a capital investment on the order of $200 million. The bottleneck for production capacity is the spray dryer, which has a capital investment of $4 to 8 million. As more production capacity is demanded from the plant, the plant management has a choice of adding an additional spray dryer unit at $4 to 8 million or add a VSEP system at $200,000 to debottleneck the plant. By adding a single VSEP unit, the plant capacity can be increased by a factor of 2 to 3 and the existing dryer can act as a final step for drying the product beyond what is achievable with VSEP. The additional savings from the reduced capital investment for a VSEP concentration/dewatering system versus the new spray dryer system that does not need to be installed have not been incorporated into this economic analysis. Nevertheless, this ability to debottleneck the process incrementally using VSEP is an important advantage over spray drying.

VSEP Technology

VSEP technology is being incorporated into the treatment schemes for product concentration/dewatering, recycled effluent and/or water/wastewater treatment in various process industries. A VSEP system can filter streams containing a variety of materials or contaminants without the fouling problems experienced by conventional membrane systems. The process not only filters suspended solids, but it also reduces or eliminates BOD, COD and color bodies. The result is a crystal clear, reusable water stream and a concentrated product stream or sludge.

Rather than simply preventing fouling with high velocity feed, VSEP reduces fouling by adding shear to the membrane surface with vibration. This vibration produces shear waves that

Table 1
Estimated Construction, Operation, and Maintenance Costs and Savings

Item	Costs	Savings
Equipment/ Installation Cost VSEP System, freight, filter-cleaning system, feed pump, holding tank, piping and control (a)		
Operation and Maintenance Cost Power Cost: 10 KW@ $.04/KWh System Maintenance and Cleaning Dryer Heating Costs Savings: 10 gpm (120,100 lb/day) @ 2,000 Btu/lb = 2,400 therms/day = 721,000 therms/year @ $0.32/therm (b)		
Total O&M Cost Savings		

(a) The VSEP system is able to process 35-44 gpm of latex emulsion and concentrate latex emulsion from a feed concentration of 38-44% to a concentration of 48-55%.
(b) Assumes a Northwest U.S. setting. For a European setting, a rate of $0.4 to $0.6 per therm should be used.

Table 2
Cost Savings Realized Upon Installation of VSEP

Latex Emulsion Feed Rate (gpm)	Rate of Dewatering (Permeate Flow Rate) (gpm)	Concentrate Latex to Dryer (gpm)	Total Cost Savings per Year @ $0.32 /Therm (a) ($/year)	Total Cost Savings per Year @ $0.40 /Therm (a) ($/year)	Total Cost Savings per Year @ $0.60 /Therm (a) ($/year)	Payback Period (b) (Mos.)
35	8	27	173,100	219,200	449,900	
40	10	30	219,200	276,900	565,200	
44	12	32	265,400	334,600	680,500	

(a) Assumes operation 24 hours per day for 300 days per year.

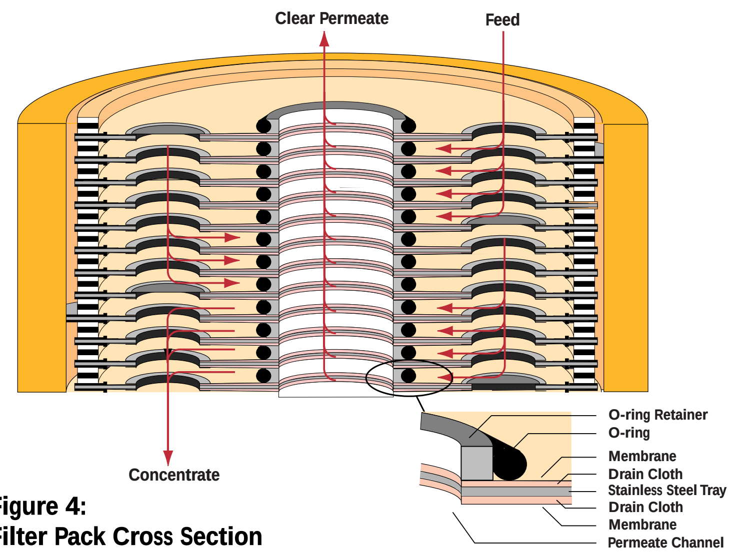


Figure 4:
Filter Pack Cross Section

propagate sinusoidally from the membrane's surface. As a result, the stagnant boundary layer is eliminated which increases filtration rates.

As shown in Figure 4, industrial VSEP machines contain many sheets of membrane which are arrayed as parallel disks separated by gaskets. The disk stack is contained within a Fiberglass Reinforced Plastic (FRP) cylinder. This entire assembly is vibrated in torsional oscillation similar to the agitation of a washing machine. The resulting shear is 150,000 inverse seconds which is ten times greater than the shear in crossflow systems. This high shearing has been shown to significantly reduce the fouling of many materials. The resistance to fouling can be enhanced by selecting one of over 200 membranes made from materials such as polypropylene and Teflon.

Figure 5 presents a photograph of an industrial scale Series i system. Each Series i system contains up to 1600 square feet of membrane filtration area. A single VSEP unit is capable of processing from 5 to 200 U.S. gallons per minute while producing a crystal clear filtrate and a concentrated sludge in a single pass. This large throughput capability is accomplished by a system which occupies only 20 square feet of floor space and consumes between 5 and 20 hp.

The VSEP system can offer a very economical solution to control water and wastewater streams within the chemical manufacturing processes. Traditional membrane separation capabilities coupled with the unique characteristics of VSEP make it possible to successfully concentrate product streams and handle a variety of contaminants at high flux rates. This provides opportunities for the use of VSEP in the treatment and/ or recycling of raw water, boiler feed water, chemical plant effluent, filtrate treatment and condensates.

Figure 5: An Industrial Scale Series i System

The industries and applications for VSEP are quite diversified and include: **Industrial Laundries** (wastewater treatment & water recycling), **Pulp & Paper** (black liquor, whitewater, box plant effluent, end-of-pipe), **Industrial Water Pretreatment** (ultrapure, boiler feed, surface water R.O.), **Pigments & Paint** (latex emulsions, product recovery), **Mining** (mine tailings), **Solids Dewatering** (calcium carbonate, kaolin clay, TiO_2) and **Metal Working** (oily wastewater, metal hydroxides).

References

Austin, G. T., 1984, Shreve's Chemical Process Industries, Fifth Edition, McGraw-Hill Book Company, pp. 633-665.

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