NEW LOGIC INTERNATIONAL, INC.

Case Study

River Water Treatment for Ultrapure Water Production

A cost-effective and environmentally-sound solution

Abstract

New Logic International installed its Vibratory Shear Enhanced Processing (VSEP) Phase I system in July, 1997, and the Phase II system in August 1998 at a major international electronic disk manufacturing facility at Hokkaido Island located in Northern Japan. The VSEP is used for treatment of river water for ultrapure water production at this facility. The VSEP system uses an ultrafiltration membrane module and is able to treat river water in order to remove or reduce color, turbidity, permanganate consumption, and total iron below the required limits. The economics of installing this system are very attractive. The application of VSEP membrane technology to treat river water for ultrapure water production at electronic disk fabrication facilities is found to be an attractive economic alternative to conventional water treatment technology.

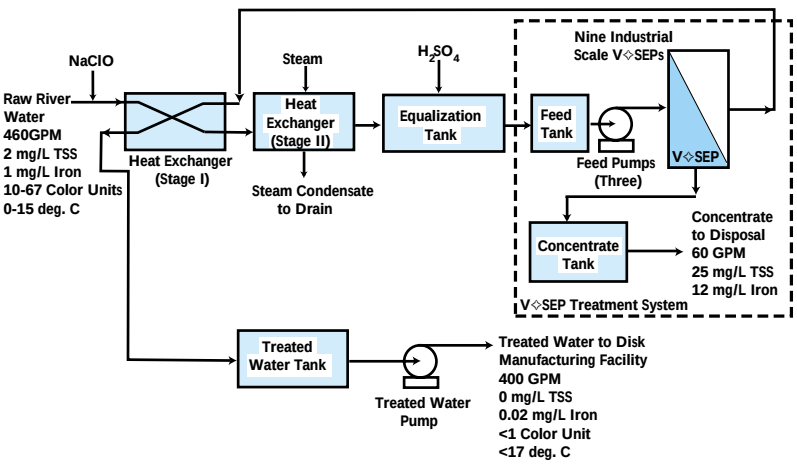
Background

Shinko Pantec Company, Ltd., a major Original Equipment Manufacturer (OEM) specialized in water and wastewater treatment in Kobe, Japan, was responsible for implementation of this project. A number of river waters in Northern Japan contain colored, natural, organic matters such as humic substances. For treatment of river water as part of ultrapure water production, this electronic disk manufacturing plant considered two treatment schemes, as follows:

Use traditional technologies, namely sand filtration and cross flow membrane filtration together with a coagulation process using poly aluminum chloride (PAC) to coagulate turbidity and natural organic matters. Use a VSEP Treatment System, consisting of preheating, equalization/pH adjustment, VSEP units, and heat recovery.

Traditional technologies such as sand filtration can not sufficiently remove color components in the water. Cross-flow membrane systems face substantial membrane fouling when dealing with water containing humic substances.

Figure 1
Integration of V◇SEP with Ultrapure Water Production at Electronic Disk Manufacturing Facility



This project was designed to find an efficient ultrafiltration system to treat river water for use in the electronic disk/ precision product manufacturing process as rinse water. The plant requires reliable treated water quality and quantity despite seasonal fluctuation in the quality of the river water. The river water has relatively low turbidity but contains considerable humic substances.

The use of VSEP system results in substantial savings primarily because of increased resistance to membrane fouling. Upon installation of the VSEP, the clean water permeate has met all design requirements for rinse water applications at this disk manufacturing facility. The concentrated wastewater stream is discharged to the plant holding ponds and then discharged to the sewer.

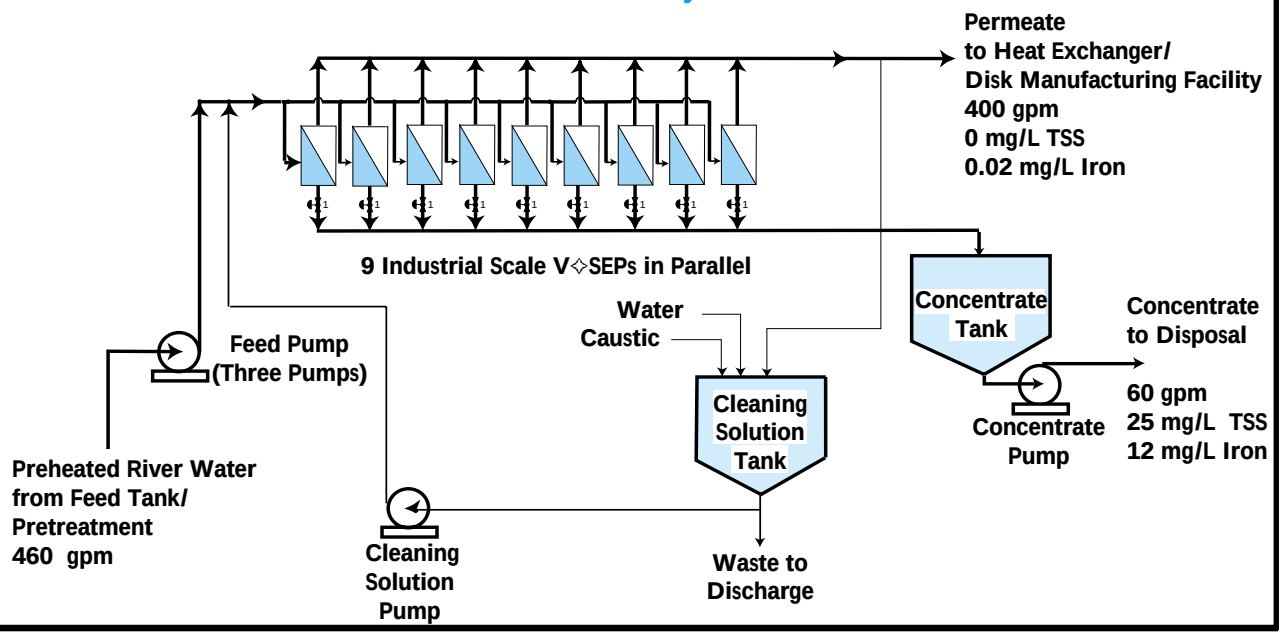
The disk manufacturing facility where the VSEP is installed operates 24 hours a day, 350 days per year. The maximum river water flow rate to be treated in the process is approximately 460 gallons per minute (gpm) or 105 m^3/hr.

Using ultrafiltration membranes in the VSEP filter modules has been shown to be a commercially viable option for treatment of river water at this facility. Nearly 85% of the feed river water is recovered as clean water suitable as rinse water at the facility, while 15% is discharged as a concentrated stream. The permeate characteristics of TSS, color, turbidity, permanganate consumption, and iron are reduced well below the process design requirements. This project summary report describes this application for the VSEP process, discusses the expected process performance, and presents the economics of the process.

System Description

Figure 1 is a process block flow diagram showing the integration of VSEP with

Figure 2
Process Schematic for River Water Treatment by V✧SEP



ultrapure water production at this disk fabrication facility. This diagram also includes the overall material balance for the river water treatment system and illustrates the performance of the VSEP units.

The temperature of the river water varies from near 0° C in winter to 15° C in the summer. As presented in Figure 1, river water is preheated in the Stage I heat exchanger with clean permeate water from VSEP and at the same time permeate water is cooled to 17° C. The river water is then further heated with a steam-heated exchanger to a temperature of 30° C. The higher feed temperature improves permeate flux through the VSEP treatment units and provides the energy drive for the first exchanger. The preheated water is introduced into the equalization tank where sulfuric acid is added for pH adjustment and other chemicals such as poly aluminum chloride (PAC) are injected to help coagulation. The equalization tank effluent is then transferred to the feed storage tank where it is fed to the VSEP units at a rate of 460 gpm (105 m3/hr).

Nine industrial scale VSEP units process the pretreated river water.

VSEP generates a permeate stream of about 400 gpm which is sent to the heat recovery exchanger and then stored in the treated water tank for further treatment and use at the disk manufacturing facility. The VSEP produces a concentrated waste stream at a flow rate of 60 gpm which is routed to the holding ponds and then the sewer.

Table 1 shows a comparison of raw and treated river water as well as the designed water quality when using the VSEP treatment system. Concentration of the raw river water ranges from 1 to 2 mg/L of TSS, 10 to 67 of color units, 0.8 to 2 NTU of turbidity, and 1 mg/L of iron. The permeate concentration is reduced to <1 mg/L of TSS, <1 color unit, <0.1 NTU of turbidity, and <0.05 mg/L of total iron, all well below the designed water quality limits.

Figure 2 presents a simplified process schematic for the river water treatment by VSEP. Nine industrial VSEP treatment units, each with a 100,000 Molecular Weight Cut Off (MWCO) ultrafiltration membrane module, are provided to operate in parallel. The Phase I system consisted of six units which were installed in July 1997, and the Phase II system consisted of three additional units installed in August 1998. A cleaning solution tank is provided for periodical cleaning of the membrane modules. Chemical cleaning with acid and alkali is conducted when the permeate flux drops below the design flux. First, sulfuric acid (pH of 1-1.5) is used to remove the inorganic foulants, and then sodium hydroxide (pH of 11.5-12) is used to dissolve and remove the organic foulants.

The VSEP field tests for treatment of river water were successfully conducted in early 1997. At a temperature of 30° C, permeate flux ranged from 80 to 90 gallons per square foot per day (GFD) (about 3.2 m^3/m^2/day, or 130 LMH). The laboratory effluent test results for TSS, color and turbidity met the design requirements. These test results are based on data from a VSEP pilot unit at

Table 1

A comparison of Raw and Treated River Water Using VSEP

Parameter	Raw River Water	Treated Water	Designed Water Quality
Temperatur[e, °C]	0 - 15	< 17	< 17
pH	7.1	6.0 - 6.7	5.8 - 6.9
TSS, mg/L	2	< 1	< 1
TS, mg/L	94 - 117	98 - 116	-
Color, units	10 - 67	<1	<1
Turbidity, NTU	4 - 16	<0.1	<0.1
Permanganate ($KMnO_4$) Consumption, mg/L	2 - 7	<1	<1
Total Iron, mg/L	1	0.01 - 0.02	<0.05
Total Manganese, mg/L	0.012	0.009	-
Aluminum, mg/L	0.02	0.01	<0.05
Total Organic Carbon (TOC), mg/L	0.7	<0.5	-
Humic Group, mg/L	<0.4	<0.4	-
Electrical Conductivity, µS	-	82 - 88	-

Figure 3

a feed pressure of 140 psig. The more recent data from actual installation indicate that flux varies from 200 GFD at the beginning of the cycle to 80 GFD at the end of that cycle and filter cleaning is only required once a month for each of the membrane modules. Figure 3 presents an actual installation photograph for this project demonstrating the fully automated VSEP system processing 460 gpm of river water and producing about 400 gpm of treated water.

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 permeate from the VSEP is held at the desired level. Three multi-stage feed pumps supply the preheated river water to the VSEP units at a total flow of 460 gpm at a pressure of 70 to 140 psig. A variable frequency electronic drive is used to set feed pressure through 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 when compared with the alternative conventional treatment technology have been calculated.

For the VSEP treatment system, the operating costs are calculated based on the power costs to operate the VSEP filter units (90 HP), filter feed pumps (30 HP), filter cleaning cost, and membrane replacement. The operation and maintenance (O&M) costs are also presented in Table 2.

VSEP Technology and Its Applications

VSEP (Vibratory Shear Enhanced Processing) technology is being incorporated into the treatment schemes for river water treatment for electronic plant applications, product concentration/dewatering, recycled effluent and/or water/wastewater treatment in various process industries. Developed by New Logic International, Inc. of Emeryville, California, a VSEP system can filter streams containing a variety of materials or contaminants without the fouling problems exhibited 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.

VSEP reduces fouling by adding shear to the membrane surface through vibration. This vibration produces shear waves that propagate sinusoidally from the membrane's surface. As a result, the stagnant boundary layer present in conventional membrane systems is eliminated thus increasing the filtration rates.

As shown in Figure 4, the industrial VSEP machines contain many sheets of membrane which are arrayed as parallel disks separated by gaskets. The disk

Figure 4
Filter Pack Cross Section

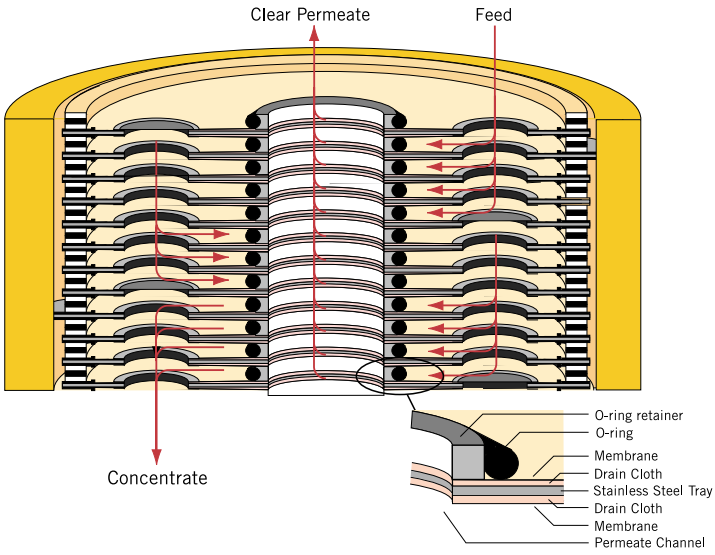


Table 2
Estimated Construction, Operation, and Maintenance Costs

Item	Costs	Unit Costs
Equipment/ Installation Cost VSEP System, freight, filter cleaning system, feed pump, holding tanks, heat exchangers, piping and control (a)		
Operation and Maintenance Cost (b) Power Cost 104 KW @ $.04/KWh System Maintenance and Cleaning		
Total O&M Costs		

(a) The VSEP system is able to process 460 gpm of river water and produce treated water suitable for disk manufacturing facility. The plant operates 24 hours per day, 350 days per year and thus processes 232 million gallons of river water per year.
(b) Operation and maintenance costs are based on a Northwestern U.S. setting. Costs for power and shipping need to be adjusted for other locations.
(c) These costs were incurred at time of installation.
(d) Current installed costs have dropped significantly since VSEP technology has been scaled up.

Figure 5

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 traditional crossflow systems. High shear has been shown to significantly reduce the fouling of many materials. The resistance to fouling can be enhanced with membrane selection where materials such as polypropylene, polysulphone, polyamide and Teflon can be used.

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 can be accomplished with a system which occupies only 20 square feet of floor space and consumes between 5 and 20 hp.

The VSEP system offers a very economical solution to control water and waste water streams within the electronic disk manufacturing as well as other electronic precision device production facilities. Traditional membrane separation capabilities coupled with the unique characteristics of the VSEP, make it possible to successfully treat raw river water streams and also handle a variety of contaminants at high flux rates. Operational savings generally can be attributed to the following areas:

- chemical treatment (reduction or elimination)
- retained BTU value
- reduction of fresh water usage and effluent flows
- improvement in filtrate quality
- pumping energy reduction
- reject concentration improvements
- eliminate fouling of heat exchangers & evaporators
- reduce BOD, COD, TSS, TDS and color

The major applications of New Logic's filtration technology include:

- **Electronic Products Manufacturing** (e.g. raw river water treatment, heavy metals recovery, wastewater treatment and recycling)
- **Pulp and Paper** (e.g. thermomechanical pulping effluent from medium density fiber board manufacture, whitewater, bleach plant effluent, box plant effluent)
- **PVC latex/ Chemical Manufacturing** (e.g. product concentration, raw water treatment)
- **Industrial and Institutional Laundries** (e.g. wastewater treatment and water recycling)
- **Chemicals Manufacturing** (e.g. calcium carbonate washing and concentration)
- **Oil production and petroleum processing** (e.g. produced water filtration)
- **Paints and Pigments** (e.g. paint and pigment concentration and washing)
- **Inks and Dyes** (e.g. flexographic inks and starch concentration)

References

Yamamoto, K., Fujii, T., and K. Takata, "*Removal of Humic Substances with Vibratory Shear Enhanced Processing Membrane Filtration,*" Shinko Pantec Co., Ltd.

Takata, K., Yamamoto, K., Bian, R., and Y. Watanabe, "*Removal of Humic Substances with Vibratory Shear Enhanced Processing Membrane Filtration,*" Presented at the Conference on Membranes in Drinking and Industrial Water Production, Amsterdam, September 21-24, 1998.

Contact a New Logic representative to develop an economic analysis and justification for the VSEP in your system. For additional information and potential application of this technology to your process, visit New Logic's Website @ www.vsep.com or contact:

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