Tubular Membrane Filter System in Operation

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Installed tubular membrane filtration system in operation with POREX® filter modules.

Following is a review of a back-grinding wastewater recycling system that has been in continuous operation for three years. The details demonstrate excellent filtrate quality, flux rate, and membrane life. The process continues to make a very positive impact on plant operations and financial savings from recycled water

WAFER PROCESSING

The thickness of a wafer is much larger during the process of forming the microelectronic device than in the final integrated circuit (IC) package. The initial thickness is required to maintain strength, rigidity and flatness during the manufacturing processes. Prior to IC packaging, the wafer is ground from approximately 750µ thickness to less than 20µ in 'back grinding' process. Large amounts of ultrapure water are used for rinsing of the fine silicon particles, and this backgrinding waste water is discharged from the wafer packaging work shop. This discharged water contains primarily ultrapure water, fine silicon and silica particles, and in some cases, a small amount of grinding fluid. If the fine particles can be removed, the reclaimed, filtered water is exceptionally pure due to the resulting low TDS (low conductivity).

FILTRATION TECHNOLOGY UTILIZED

Using the POREX® Filtration 0.05 µm Tubular Membrane Filter (TMF™) modules, Veolia built a simple system for the solid/liquid separation process without the need for any chemical dosing. Filtered water is then sent to a RO system for silica removal only, not for desalination, since the original influent water conductivity is less than 10µs/cm. The RO product water is then sent back to the workshop for reuse as ultra-pure DI water. The slurry from the POREX TMF system, which contains all the suspended solids, is sent to a dehydration system. The resulting sludge cake is transferred out of the workshop for disposal, and the squeezed water is sent back to the waste water treatment system.

WASTE WATER INFORMATION

Back grinding waste water: the influent suspended solids concentration is 500 to 1,000 mg/l DLS (Dynamic Light Scattering). Analysis demonstrated that most particles are larger than 50nm (0.05µm).

System capacity is designed as 3,000m3/day. The mixed raw waste water has a brown appearance with numerous fine sharp particles in the liquid (see water in left bottle in below picture, water in right bottle is filtrate water from the TMF system).

Water comparison

TUBULAR MEMBRANE FILTRATION

When used to treat back grinding waste water:

1. Combined with filter press or other solids separation process, this system will divide the waste water into two parts: filtrate water and dewatered sludge cake. There is no concentrated or reject water sent to drain. This results in a nearly 100% recovery rate (if the squeezed water returns to main reclaim system).

2. No chemicals are dosed into the waste water. Therefore, sludge can be reused with appropriate processing.

3. No pretreatment stage: the entire system operates based on simple physical solid/liquid separation.

4. Excellent filtrate water quality: particles larger than the membrane pore size will be rejected. The treated water quality is equal to UF product water.

5. The uniquely designed membrane tube has very high abrasion resistance. The membrane is not damaged by the sharp silicon particles. Normally that is the most significant problem when attempting to use hollow fiber UF membranes for this type of wastewater. Hollow fiber breakage or plugging will occur due to the hard and sharp particulate, high solids concentration and the lack of a membrane substrate layer.

6. The POREX Tubular Membrane Filter has high resistance to fouling compared with hollow fiber membranes; membrane flux can be restored easily since very strong chemical solutions can be used during clean-in-place (CIP) procedures.

7. Ease of maintenance: The system can be designed for automatic operation and can be returned to service mode from standby mode at any time.

8. The system footprint is small, requiring less space.

9. Scalability: water capacity can be enlarged by simply adding more modules/skids.

TMF SYSTEM INFORMATION

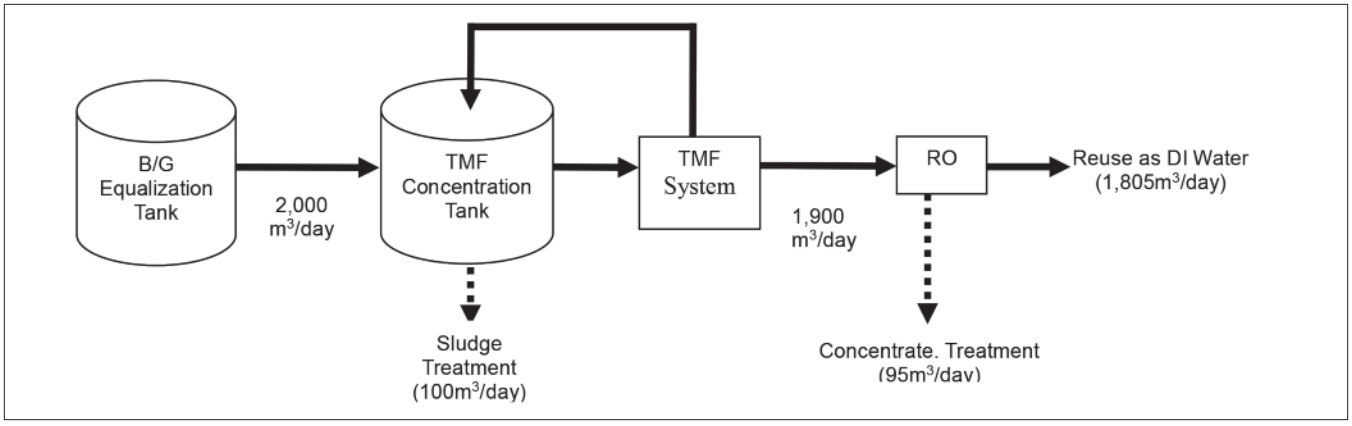
Module Specification: The Porex TMF 61-tube module configuration was utilized in this system. Specification of this module includes:

- 61 half-inch membrane tubes in each module
- Membrane pore size of 0.05 µm
- 4.25m2 effective membrane filtration area per module
- PE substrate tube with anchored PVDF membrane
- 8” diameter PVC module housing

Module Quantity and System Array:

- 4 skids (3 in service and 1 standby)
- 36 modules per skid, 4 trains, 9 modules in series in each train (Total of 144 modules in the system)
- Each skid is designed to treat 1,000 m3/day waste water

Process Description: The back-grinding waste water is collected in the equalization tank and is then pumped to the TMF concentration tank. The



Schemttic of the tubular membrane filtration system process

waste water is then fed into the POREX TMF unit for solid/liquid separation. Water is circulated between the TMF modules and concentration tank in a cross-flow filtration process. The feed flow is down the center of the tube (lumen feed) with the permeate pass-ing through the tubular wall and collected in the area outside of the tubes and inside the housing. Filtered water is then sent to a separate product water tank and fed into a RO system for ionic type silica removal. It is then reused as DI water. Silicon and silica particles that are rejected by the TMF mem-branes accumulate in the concentration tank during operation. Typically, the partially concentrated liquid is sent to a filter press for dewatering with a cer-tain flow rate. The sludge cake result-ing from the filter press will be disposed or it can be available for reuse since it is a pure silicon cake with no coagulant. In this installation, the "squeezed" water from the filter press is discharged; however, it could be sent processing. Currently this stream and approximately 95m3/day of RO reject water are sent to the existing waste water station for further treatment. No chemicals are fed into the system during normal service.

OPERATIONAL STATUS

Construction was completed and the system was commissioned in July 2013. The system performance has been excellent with many operating parameters exceeding the original design requirements such as:

- Flux: 210 to 270 lmh (designed at 210 lmh when stand-by unit in operation, 270 lmh when stand-by unit is idle)
- Recovery: 95% (designed at 95%)
- Operating pressure: 1.5 to 3.0 bars (designed at 5.0 bars)
- Operating linear velocity: 1.5 to 2.5 meters/square foot/second (m/s) (designed at 4 m/s)
- CIP frequency: once per 2 to 4 months (designed at once per month)
- Permeate water quality: Between 0.1 NTU to 0.02NTU (designed at < 0.5 NTU)
- Suspended solids concentration in circulation tank is maintained at approximately 2% to optimize performance
- Outstanding design (both process and mechanical) and construction work ensured excellent performance of this system

A TF Membrane

OPERATION AFTER 3 YEARS

The site was visited and system performance reviewed in April 2016. Operating parameters were documented and are presented in the Table 1.

Review of the operating data above reveals several interesting details:

- Operating pressure is very low compared to "typical" operating parameters for a TMF system. The lower operating pressure was selected from experience operating the system to save power. The system flow rate was determined to be satisfactory for the current required flows
- Cross flowrate (or cross flow velocity) is much less than typical operating parameters of a TMF system. Again, the flow rate was reduced based upon operating experience to save on required power; flow rate was determined to be more than adequate for this installation.

Table 1

	Skid Designation			
	A	B	C	D
Filtrate Flow Rate (m^3/hr)	35-40	OFF	30	34-38
Pressure In (MPA)	0.1	OFF	0.12	0.1
Pressure Out (MPA)	0.08	OFF	0.06	0.06
Filtrate Back Pressure (MPA)	0.04	OFF	0.04	0.04
Cross flowrate (m^3/hr)	120-130	OFF	180	150
Filtrate Turbidity (NTU)	0.020	OFF	0.024	0.034

- Filtrate quality of the 3-year-old membrane modules was determined to be outstanding
- System operation includes shutting down one train at a time on a rotating basis
- Chemical cleaning is performed once every two months using caustic soda

Overall, the system continues to operate at high production rates; operating costs are less than originally designed. One train is shut down on a weekly rotating basis as it is not currently required to meet process flow rate.

SUMMARY

The backgrinding process generates fine, abrasive silicon and colloidal silica particles that must be removed prior to the water being further processed for reuse in the plant. While many other types of UF technologies (e.g., hollow fiber) have not been effective in reclaiming back grinding waste water, the POREX TMF has been tested and verified as superior in this application even after extended operation.

The POREX TMF technology demon-strates exceptional membrane perform-ance making it possible to filter back grinding waste water and produce out-standing filtrate quality with stable and excellent flux. The simplified process utilized in this design not only reduces waste water discharge volume, but also recovers a large amount of high-quality DI water. By reducing discharge vol-ume and producing reusable ultrapure water, the end user estimates that this plant has saved approximately $3,000,000 in water usage and sewer discharge fees.

The original TMF modules put into service over 3 years ago continue to op-erate as expected with no replacement modules required, and the system has continuously provided reliable, ultrapure recycled water since the original system start-up.

The POREX TMF membranes were supplied by SI Membranes, Seoul, South Korea, and the system was con-structed by JM Tech Co., Ltd., also based in South Korea.

For more information contact: