Practical filtration – metallurgy:

New membrane filter tackles metallurgical water demands

A new type of high velocity, cross-flow filter has been developed by Finnish company Sofi Filtration. The membrane filter is already providing solutions to demanding applications in minerals processing and metallurgy.

Sofi Filtration Ltd., together with Aalto University, Department of Materials Science and Engineering in Finland, has developed a new type of high velocity, cross-flow filter under a commercial brand name Sofi Filter. Membrane filtration in general is operated either in a dead-end or cross-flow mode. In dead-end systems the biggest problem is low filtration (flux) flow, solids' concentration and fouling. Consequently, the membrane has to be either cleaned or replaced often. In cross-flow membrane filtration, the shearing effect takes place, i.e. the feed flows tangentially along the membrane. This reduces the build-up of potential fouling layers on the membrane, and reduces concentration, polarisation, adsorption, and cake layer formation.

The Sofi Filter development project involved combining the challenges of microfiltration with the experience of filtration specialists. The design criteria for the new filter had been to accomplish a compact and fully automated unit that has high microfiltration capacity and novel clean-in-place abilities to prevent plugging. The commercial breakthrough lay in the idea of a unit that requires no moving parts inside to create the high cross-flow velocity, thus making the unit robust and economic to use. Computational fluid dynamics modeling was undertaken at Aalto University, and calculations showed a cross-flow velocity of about 20 m/s is achieved in Sofi Filter. Patent applications for the innovation have been made.

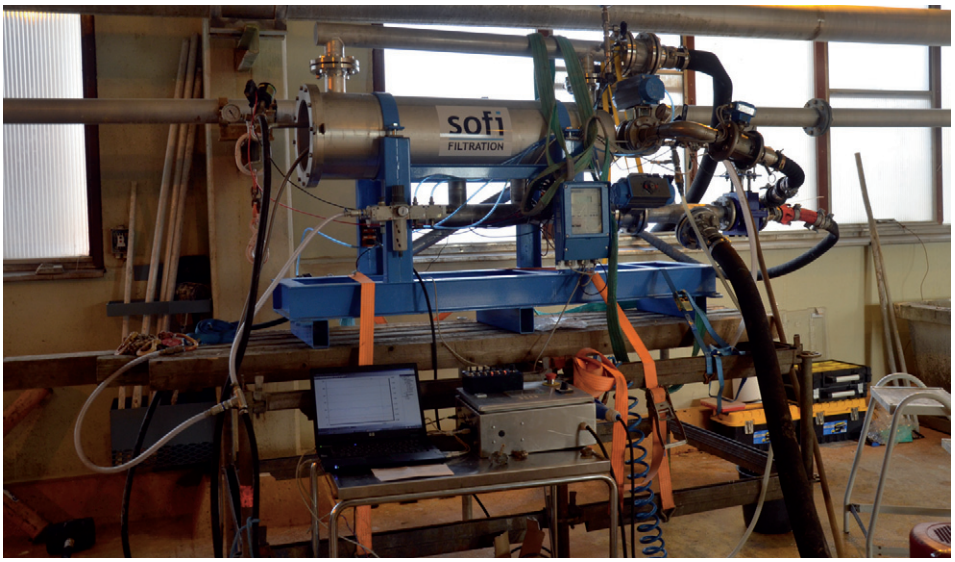

Figure 1: Sofi Filter in process plant.

Mining, minerals processing and metallurgical industries have challenging process water conditions and the streams tend to be large containing fine particles. These kinds of waters are difficult to treat with traditional methods such as settling, because the fine particles do not settle by gravity efficiently. Therefore a method for high-rate filtration and a small footprint is crucial for increasing the water recirculation rate at a plant, as well as the benefits of having clear water for process. The Sofi Filter technology has been put to the test in three application studies in hydrometallurgical plants. All cases are from 2012 in Finland.

High-rate microfiltration in metallurgical processes

Sofi Filter is solid-liquid separation technology that provides filtration in the

Figure 2: Clear process water produced by the Sofi Filter.

range 0.1–40 µm and the method is most suitable to low viscosity liquids with a solids concentration lower than 50 g/l. Ceramic, sintered metal or silicon carbide can be used as filter elements. Flux rates of 3-30 m^3/m^2h have been measured depending on the element pore size and the liquid and solid particle characteristics. Applications in mining and metallurgical industries include settling and clarification overflow microfiltering, belt and pressure filter permeate treatment and pre-treatment of fresh water intake.

A high and stable capacity is an important quality that determines the profitability of the investment and the level of operating expenses. When small colloidal particles are filtered by conventional means through a micro-porous filter material, different plugging phenomena occur in a short time and weaken the filter's capacity. At the beginning of the filtration process, a clean filter element has a high capacity level, but after a relatively short period the capacity of the equipment decreases to a fraction of the full capacity, and the filter element must be regenerated. The surface area of the micro-porous material is large, allowing it to absorb small particles, ions or molecules from the liquid flowing through. The open pore volume of the filter material decreases at the same rate. The surface of the filter media is especially susceptible to plugging, either mechanically or through a chemical reaction. In the Sofi Filter, effective self-cleaning abilities are implemented to prevent the plugging.

Sofi Filter operation

The Sofi Filter is designed for industrial processes in which closed water circulation is used or waste contamination needs to be minimised. The filtration is done with over-pressure, in other words the bubble-point of the membrane is exceeded. The required feed pressure is low, varying between 0.05 and 0.2 MPa (0.5-2 bar). The Sofi Filter is a compact unit consisting of an acid-proof steel vessel, a sintered metal filtrate element, ultrasonic cleaning unit and PLC control unit. The modular structure enables high capacity installations by economic combination of units for virtually all capacity needs. The Sofi Filter operates automatically and the filtration data is collected on-line. Feed water is pumped into a steel cylinder at a sufficient speed (for example, 3m/s). The feed design accelerates and distributes the flow evenly on the filter element surface to achieve a high permeate flow.

Solid particles consolidate on the surface of the filter membrane and clear filtrate passes through a filtrate outlet. The majority of the solids are removed by cross-flow stream as reject, so there is no solid cake formation to plug the filtrate flow. The solid particles that remain on the surface of membrane are removed by counter-current washing with a short compressed air shock. The filter element requires automated, periodic cleaning so that the element pores remain clear. The design enables several cleaning options: ultrasonic cleaning, vapour and chemical washing and backwash. Ultrasonic cleaning causes cavitation on the surface of the metallic membrane which has proven to be very efficient for maintaining good long-term performance.

Case study 2 - Treating belt filter permeate at nickel processing plant

A Sofi Filter was installed to treat a belt filter's permeate in a nickel reduction facility.

Liquid: Belt filter permeate
Temperature: 25°C
Total process flow: 7 m^3/h
Element #: 10 µm
Solids: Metal hydroxide
Solids concentration: About 1000 mg/l
pH: 10.5

See Figure 5

Case study 1 - Treating copper electrolysis solution

The Sofi Filter was installed to treat copper electrolysis pool circulation solution. The solution included contaminants such as bismuth and antimony that need to be removed.

Liquid: Copper electrolysis solution
Temperature: 65°C
Total process flow: 17 m^3/h per cell
Element #: 1 µm
Solids concentration: About 1 mg/l
pH: About 1

See Figure 4

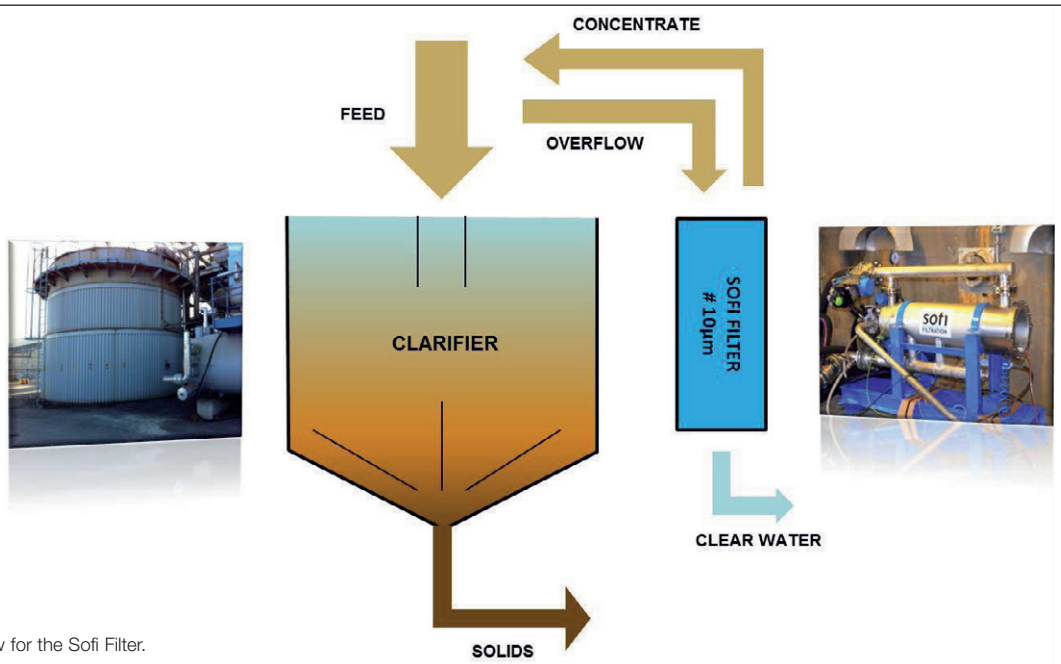

Figure 3: Process flow for the Sofi Filter.

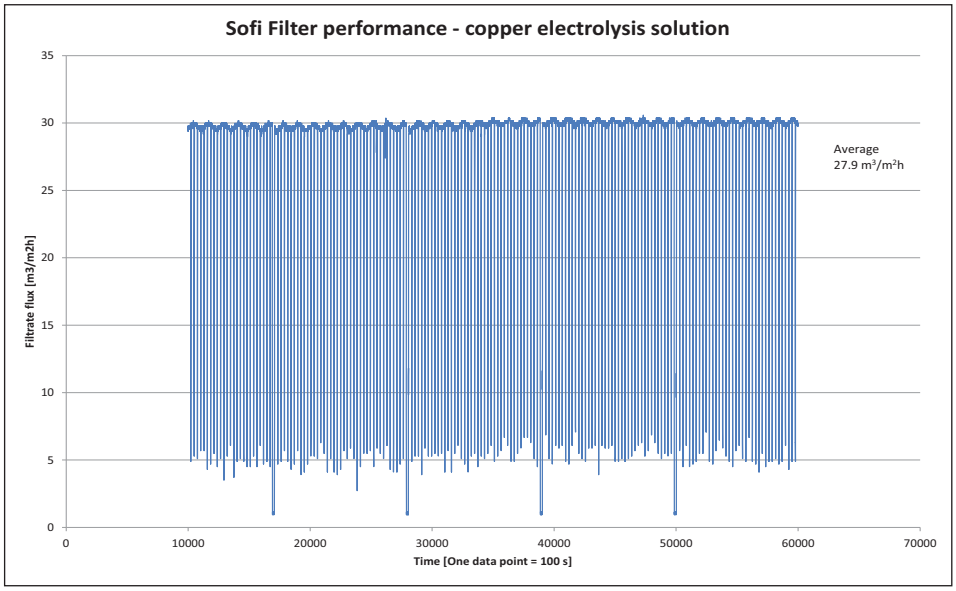

Figure 4: Filtrate flux data in copper electrolysis process.

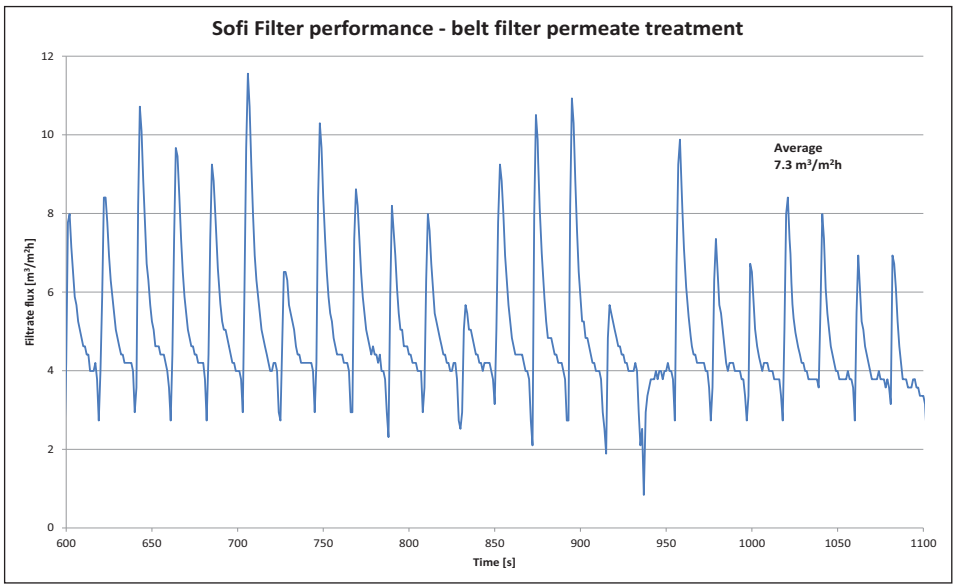

Figure 5: Filtrate flux data in nickel plant application.

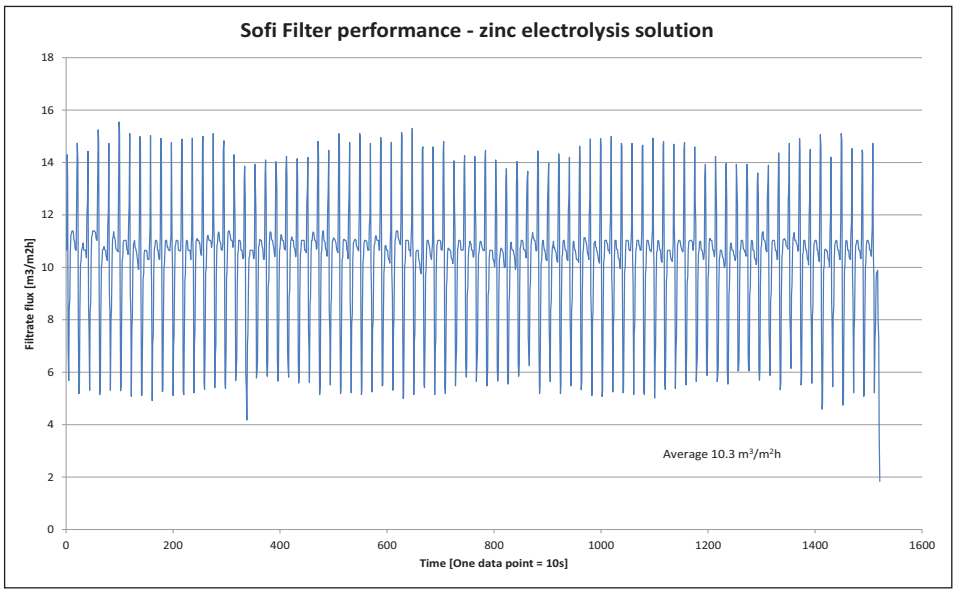

Figure 6: Filtrate flux data in zinc electrolysis application.

Case study 3 - Treating zinc electrolysis feed solution

Sofi Filter was installed to separate gypsum solid particles from zinc electrolysis process water.

Liquid: Zinc electrolysis feed
Temperature: 30°C
Total process flow: 360 m3/h
Element #: 10 µm
Solids: Gypsum, CaSO4
Solids concentration: 600 mg/l
pH: 2

See Figure 6

Case studies

A laboratory and pilot plant Sofi Filter units are available for customer tests. The laboratory unit is an important tool in finding out the starting values for the pilot unit that is applied into a real process. In these series of studies both laboratory and pilot units were used. According to the laboratory test results, the filter element pore size is chosen for pilot unit tests. The usually used filter element sizes are 1, 5, 10 and 20 µm. The pilot tests at customer site will give the long-term Sofi Filter capacity measured in m³/m²h as design criteria for the eventual installation. The Sofi Filter performance in three metallurgical plant studies is presented in the case studies.
"In metallurgy the process waters are difficult to filter as the streams tend to be large, the solid particles are extremely fine and the conditions such as pH and temperature are challenging. After testing Sofi Filter I am convinced of its capability to separate the suspended solids from the electrolysis process. In particular, the performance with the 1 micron element was a positive surprise," says Jukka Tähkä, manager at Boliden Harjavalta's copper refinery.

Conclusions

The uses for the Sofi Filter in mining and metallurgical industry are many. Sofi Filter enables high water recycling rate and provides clear water for process. Future opportunities include less environmental impact by wastewater clarification at discharge, better performing desalination process by pre-filtering solid particles from water before water treatment process, capturing precious elements from waste streams and better plant performance by removing contaminants from process waters in a flotation circuit, for example. ●

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