SELF-CLEANING SCREEN FILTRATION FOR RO SYSTEMS

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Recent advancements in the manufacturing technology of woven stainless steel screens have created new applications for mechanical filtration systems. One such application is the pretreatment of water supplied to Reverse Osmosis and other demineralization systems. Standard practice for pretreatment is a multimedia depth filtration system followed by disposable cartridge filters ahead of the RO system. The introduction of self-cleaning mechanical filters, which effectively remove a significant portion of the particles as fine as 1 micron in size, allow plant designers an alternative to multimedia systems. The advantages of mechanical filters are simplicity of operation, small footprints, less complexity in piping and valving, and higher efficiency resulting in reduction of the backwash water by 80-90%. This paper describes two sites where a mechanical filter is used as the pretreatment to a demineralizer in an electric utility. Filtration data is presented for a well water and reservoir water supply. The effectiveness of the mechanical filter on each water source is compared.

FILTER DESCRIPTION

Mechanical filtration has been in use for over 30 years with screens having filtration capabilities of 40 micron and above. Developments in manufacturing technology of woven stainless steel screen over the past 10 years have enabled mechanical filters to remove particles in the 1-5 micron range. The filter that was used in the case studies is shown in Figure 1.

There are a variety of mechanical filtration systems available on the market, each with its own unique screen construction and self-cleaning design. The systems and filtration performance described in this paper are based upon the patented designs of Amiad Filtration Systems. Mechanical filters incorporate an in-line filter body, which houses a screen to capture the suspended solids in the water stream. The system measures a differential pressure across the screen surface to determine when to initiate the cleaning cycle. As particulate builds, the DP will rise to 7 psi, which will start the cleaning cycle.

FILTER CONSTRUCTION -The filter is available in three body styles, supplied with flange connections from 2 inch to 24 inch diameters, depending upon the design flow. Filters are rated at flows from 30-3200 gpm per unit when using the 10 micron screen.

Body -The standard filter body is rated at 150 psi and constructed of carbon steel material. The body received 5 coats of epoxy on the interior and exterior surfaces.

Screen -The screen construction is the significant development, which allows mechanical filters to be used as RO pre-filters. Utilizing European technology, the screen is manufactured entirely of 316L stainless steel. In a joint R&D effort, the filter OEM and the screen manufacturer brought the screen rated at 10 micron to market in mid 1996. This "working" screen is woven in a 600 mesh square weave pattern. The square weave is a critical factor in maintaining the integrity of filtration. The tight, square weave keeps the screen ridged and wire spacing intact so the screen continues to provide the same particle removal efficiency over its service life. Screens woven in 1:2.5 or 1:5 rectangular patterns can distort or separate over time and allow smaller particles to pass.

Protection of the "working" screen while maintaining the ability to provide automatic self-cleaning, is critical in evaluating the filter design. The filter in this study resolved this by sandwiching the working screen between two heavier mesh screens and installing retaining rings on either end to keep the components together. This patented assembly is then welded together to become a single, integral unit. Screen thickness of the assembly is 3/16", allowing the suction device close proximity to the filtered material, enabling it to remove debris form the screen effectively.

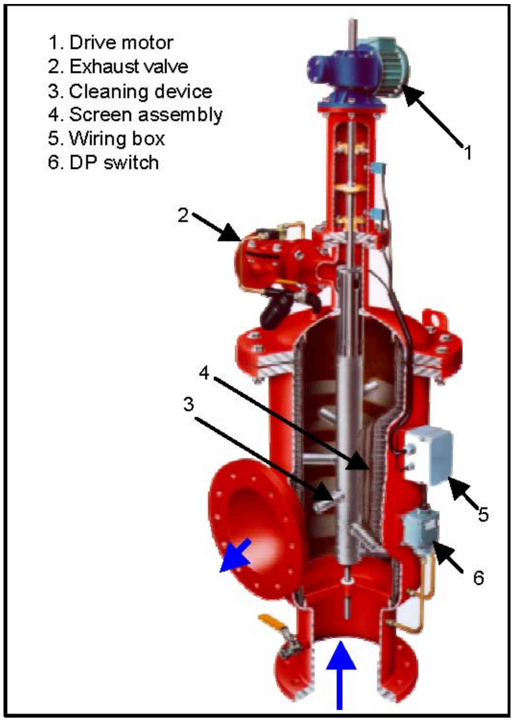

FIGURE 1. Cut View of a Mechanical Filter

FILTER OPERATION - The filter has flanged connections and is arranged so that the water flows from the inside of the screen out; collecting suspended material on the inside screen surface. A typical installation will have a clean condition pressure drop of 1-2 psi. As the silt builds on the screen and the DP rises to 7 psi, the cleaning cycle is initiated by a differential pressure switch.

The self-cleaning mechanism consists of a hollow shaft down the centerline of the filter body. This shaft has scanner nozzles that extend to approximately 1/8" from the screen surface. In 2006, the OEM brought a new design using “Spring Loaded Nozzles” (SLN) to market. The SLN enhances cleaning ability and reduces the amount of water used for backwash. The shaft is sealed on one end and opens to an exhaust chamber at the top of the filter. When the exhaust valve is open, the differential pressure between the supply pressure and the atmospheric pressure at the outlet of the exhaust chamber create a powerful vacuum effect at the end of each nozzle. This sucks the material from the screen surface through the shaft and out the exhaust valve.

The start of the cleaning cycle causes the exhaust valve to open to atmosphere and the electric motor to start. The motor simultaneously rotates the shaft at 17 rpm and moves the shaft axially so the nozzles cover the entire inner screen surface during each cleaning cycle. The duration of the cleaning cycle is 17-45 seconds, depending upon the style of the filter.

EVALUATION OF FILTER EFFICIENCY

Evaluation of the filter efficiency in this study uses a scattered light laser particle counter manufactured by Spectrex to establish the quantities and distribution of particles. The water sample to be checked is dropped into a beaker of particle-free distilled water and ultrasonically cleaned for up to 30 seconds. The beaker is then placed in the "in-situ" particle counter where a laser beam is passed through it to scan the volume for particles. Two different lenses determine the size and number of particles in the 1-16 micron range and the 16-100 micron range. The size is measured and displayed on the computer screen and printout. Precision of this optical method appears to be very good. Testing of replicate samples show that the variation of particle counts is less than 5 percent.

SYSTEM DESIGN CRITERIA

In order to design the system, the data required includes:

- Water source
- Detailed PSD analysis/TSS loading
- Minimum/Maximum Flow rates
- System Pressure
- Nature of solids

The capacity of a filter is directly related to the screen surface area. The TSS loading into a 10 micron screen is typically limited to 15 ppm. With water having a higher TSS loading, two filters may be run in series with the first filter using a roughing screen and the second with the 10 micron screen. For larger flow rates, filters may be joined by a manifold to achieve virtually any flow rate.

CASE STUDIES CASE #1 -WELL WATER SOURCE. This case study is from a coal fired utility plant near Las Vegas, NV. The plant purchases water from a local water district which draws from a deep well. Water is supplied to a Reverse Osmosis system. Original pretreatment for the system was a sand media filter. The plant experienced problems with the media filter in several areas; first was media carry-over; second was the backwash water rates. Downstream of the sand filter where 1 micron cartridge filters which is part of the RO skid. The system is designed for 250 gpm system flow. The plant elected to eliminate the sand filter upstream of the cartridge filters to reduce the carryover problems, essentially using the raw well water for the RO feed. This resulted in changing the 1 micron cartridge filters every two weeks as a costly maintenance expense.

The plant engineers reviewed available filtration options and determined that screen filtration was the most effective, low cost option for pre-treating the RO system. After the installation of a 6" SAF-6000 filter, water samples were analyzed using the laser particle counter. A graphical representation is shown in Figure 2. Results showed the screen, rated by the filter manufacturer at 10 micron, removed 99% of the particles over 5 micron and 86% of the 1 micron particles. The Total Suspended Solids (TSS) of the raw well water was 10.46 ppm. The filter effluent TSS was determined to be 0.001 ppm. This system has been in operation for 10 years with no reported operating or maintenance issues, other than normal wear and tear of the equipment.

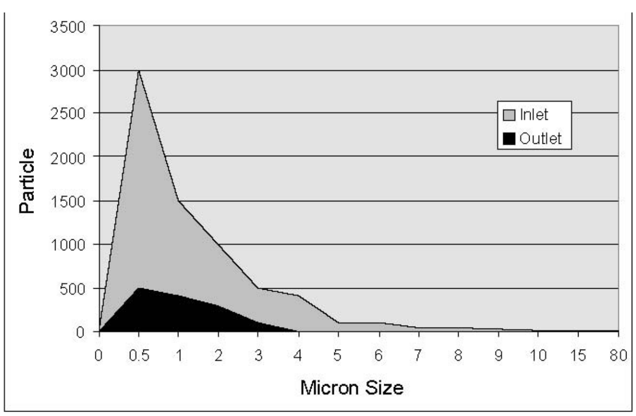

FIGURE 2. Well Water. Particle Removal

CASE #2 -RESERVOIR WATER SOURCE. This case study is from an installation at a coal fired utility plant in eastern Wyoming. This plant draws water from a river fed reservoir, into a holding pond on the plant site. The original plant pretreatment system included a bank of carbon media filters followed by 10 micron bag filters and 5 micron cartridge filters. The water is then fed into three RO machines. The plant was experiencing problems with plugging of the cartridge filters. Plugging was caused due to TSS material channeling through the media filter bed. In addition, there were intermittent problems with the carbon media carrying over into the process stream. A mechanical screen filter was installed in June, 1998. The system uses a single filter with 8 inch flanges to treat 800 gpm. Particle size distribution analysis of the filter inlet and effluent stream show the mechanical filter is removing over 90% of the suspended material, reducing the TSS from 0.49 ppm to 0.04 ppm.

Comparison of the well water results to the reservoir water particle removal in Figure 3 shows the filter removes a higher percentage of 1-4 micron particles from the well than the reservoir water. The well water effluent had no particles over 5 micron compared to the reservoir water effluent where particles were detected in all bins 10 micron and below. The particle counts in the 5-10 micron bin were low; all less than 40 particle counts, and accounted for 0.03 ppm mass.

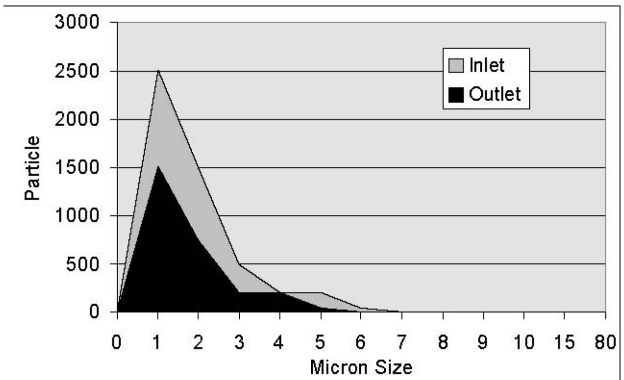

Figure 3

A primary factor in justification for the mechanical filter was the insurance that if a major upset occurred in the carbon filters resulting in carbon carryover, the mechanical filter's stainless steel screen offered 100% protection against any media reaching the RO membrane. With bags and cartridges, it is possible for media to pass through torn bags, or cartridges that may not be seated properly.

SUSPENDED SOLIDS - The effectiveness of mechanical filtration is directly affected by the nature of the particulate being filtered. The graphs shown in Figures 2 and 3, showing particulate removal of well water and surface water, illustrate the difference in particle removal of hard vs. soft particulate.
The mechanical filter is least effective when the suspended particulate is very soft in nature. A characteristic of the softer particles is that they can "extrude" through the screen surface. Rather than being trapped on the screen and increasing the filtration efficiency by bridging the pore opening to the screen, the soft particles are pliable and pass through the screen. Table 1 provides data showing the amount of mass removed from each water source in the study.

EVALUATION OF PARTICULATE
When designing a pre-filtration system it is imperative that a detailed Particle Size Distribution (PSD) analysis be performed. Well water is a fairly consistent water quality with hard suspended particles and one PSD is generally adequate. Surface water supplies, depending upon the type of water, regional location, and level of suspended solids often require a pilot test be performed on-site

ADVANTAGES OFFERED BY MECHANICAL FILTERS

Mechanical filters offer many advantages over traditional multimedia systems:

- Capital cost of the equipment is 30-50% lower.
- Water required for backwash is <1% on mechanical filters compared to 5-7% for a media filter
- Energy costs are lower, with a 2-7 psi operating range across a screen filter.
- Flocculation chemicals are not required.
- Mechanical systems require a smaller footprint and less complicated valving arrangements, especially important in many retrofit applications.
- Mechanical screens have a service life of 5-10 years.
- Screens protect R-O membranes, ensuring suspended solids do not pass down stream.

CONCLUSION

The use of mechanical filters for RO pre-filtration is a viable alternative which merits consideration in the design or retrofit of a water treatment plant. An inexpensive water analysis can be performed to determine the suitability of mechanical filtration on any water supply. The advantages outlined for mechanical filtration systems over traditional pretreatment systems are justified when evaluated on a capital investment or an operating and maintenance basis.