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# Cross-flow microsand filtration for membrane pre-treatment

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#### ABSTRACT

*VORTISAND* microsand filters were introduced in the mid-1980s as a means to remove very fine particles (less than 2 microns) in cooling tower circuits. Computational fluid dynamics, lab-scale, and full-scale studies were used to determine the optimal design parameters of the *VORTISAND* filters. Filtration rates of 50–60 m<sup>3</sup>/m<sup>2</sup> h (20–25 gpm/sq. ft.) are typical. About 90% removal of particles greater than 2 microns and SDI reduction of 42–68% are demonstrated.

Keywords: Cross-flow; Microsand; Filtration; Membrane; Pretreatment

#### 1. Introduction

The primary objective of pretreatment to any membrane system is to make the feed water compatible with the membrane. Inadequate membrane pretreatment results in high-chemical cleaning costs, increased downtime, permanent loss of performance, and reduced membrane life [1].

*VORTISAND* microsand filters (Fig. 1) were introduced in the mid-1980s in the HVAC market as a means to remove very fine particles (less than 2 microns) in cooling tower circuits. More than 2,500 systems were installed worldwide.

In 2013, as *VORTISAND* was introduced in new markets and applications (wastewater reuse, RO pretreatment, process water), extensive R&D efforts began to understand the cross-flow effect (Fig. 2), to improve the performance and to increase the filtration capacity. In the *VORTISAND* filter, the filtrate flow is always equal to the feed flow (no retentate).

The results of this work are summarized herein.

#### 2. Material and methods

Computational fluid dynamics (CFD), lab-scale, and full-scale studies were used to determine the optimal design parameters of the *VORTISAND* filters.

Laser particle counts (LPC) were used to measure the efficiency of the *VORTISAND* filters (Fig. 3).

#### 3. Results

CFD modeling of the VORTISAND filter shows:

- (1) The cross-flow effect occurs across the entire media surface.
- (2) The media remains undisturbed (the surface stays flat).

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Fig. 1. (a) Filtration mode and (b) backwash mode.

- (3) There is no migration of fine media (top layer) into the coarse media (bottom layers).
- (4) Backwash flow is evenly distributed.

### LPC (Fig. 3) show:

(1) About 90% removal of particles greater than 2 microns that are far better than multimedia filters (MMF).

Lab-scale and full-scale studies show:

- (1) Filtration rates of 50–60  $m^3/m^2\,h$  (20–25 gpm/ sq. ft.) are typical.
- (2) Coagulation is not required to aggregate very fine particles.
- (3) SDI reduction of 42–68% is demonstrated.



Fig. 2. Type of filtration.

| Interim               |                  |          |        |          |          |          |                 |          |              | Spectrex |              |            |        |                      | Laser Particle |          |       | ie (   | Counter 800-822-3 |         |        |          |  |
|-----------------------|------------------|----------|--------|----------|----------|----------|-----------------|----------|--------------|----------|--------------|------------|--------|----------------------|----------------|----------|-------|--------|-------------------|---------|--------|----------|--|
| # um                  | %                | Count    | 0      | 11       | 30       |          | 6               |          | 9            | 0        | 1            | 20         | 1      | 50                   | 1              | 80       | 2     | 10     | + <sup>24</sup>   | 40      | 2      | 70       |  |
| <                     | -38.34-          |          |        |          | ÷        |          |                 |          | ÷            |          | ÷            |            |        |                      |                |          |       |        |                   |         |        |          |  |
| $=_{2}^{1}=_{2}^{1}=$ | -10.70-          |          |        | +        |          | 1        | ,               | 1        | 1            |          |              | •          | 4      | - 6                  | *              | •        |       | •      |                   |         | •      |          |  |
| 3-3-                  | -5.01-           | 38       | -      |          | -        |          | 1               | 3        | 3            |          | 8            |            | ŝ      |                      | ŝ              | - 6      | 2     | ÷      |                   | 3       |        | i.       |  |
| -4-4-5-5-5            | -3.33-<br>-1.36- |          |        | i.       |          | 2        | 2003            | 12       | 5            | 1        | 2            |            | 8      | 10                   | 2              | 10       | 2     | •      |                   |         | 12     |          |  |
| 6-6-                  | -0.72-           | 5        |        | -        |          | 30<br>22 |                 |          | - 80<br>- 20 | 3        |              |            | 2      | 1                    |                |          | 10    |        |                   |         | -      |          |  |
|                       | -0.89-<br>-0.39- | 6<br>3   |        | 10       | 8        | 2        | 1120            | 2        | 2.9          | 52       | 26           | 82.2       | $\sim$ | 25                   | 32             |          | 11    | 23     | 020               | 82      | 27     | 12       |  |
|                       | -0.21-           | ĭ        | -7     | 8)<br>•  | 21<br>14 | 2<br>x   |                 | 3<br>    | 23<br>20     | 1        | - 33<br>- 10 | 585<br>540 | 1      | 10                   | а<br>ж         | 20<br>10 | 27    | *      |                   | े.<br>अ | - 20   |          |  |
| -10-10-10-11          | -0.29-           | 21       |        |          | 5        | 2        |                 |          | 13           | 2        | 2            |            |        | 43                   | 4              | 12       | 24    | e.     |                   |         |        | 4        |  |
| -12-12                | -0.11-           | 0        | -      | 23       | 87       | а        | 1421            | 14       | 1            | 14       | 2            | 1.20       |        | 18                   | 4              | <u>_</u> | 1     |        |                   | 4       | 20     | 2        |  |
|                       | -0.07-           | 0        | -!     | 5.<br>51 | 10<br>61 | а<br>Ж   | 2973)<br>(1933) | 2        | 83<br>83     | 3        | 8            |            |        | 50                   | 3              | 1        | 12    |        |                   | 3       | 10     |          |  |
| -15-15-               | -0.14-           |          | 4      | ж<br>С   | 34<br>53 |          | •               | 98<br>10 | 10           |          | - 20         | 100        |        | - 43                 | 8              |          | - 12  | 1      | 5365<br>2020      | *       | - 40   | 34<br>22 |  |
|                       |                  |          |        |          |          |          |                 |          |              |          |              | OUTIET     |        |                      |                |          | Total |        |                   |         |        |          |  |
| INLET                 | INLET TOTAL      |          |        |          |          | Counto   |                 |          |              |          | OUTLET       |            |        |                      |                |          |       |        |                   |         | Counto |          |  |
| 0.                    |                  |          | Counts |          |          |          | 0.              |          |              |          |              | counts     |        |                      |                |          |       | Counts |                   |         |        |          |  |
| Size                  | ze /cc           |          |        | percent  |          |          |                 | 54       | Size         |          |              |            |        | /cc                  |                |          |       |        |                   | percent |        |          |  |
|                       |                  |          |        |          |          |          |                 |          |              |          |              |            |        |                      |                |          |       |        |                   |         |        |          |  |
| < 1 587,293.48        |                  |          |        | 38.34%   |          |          |                 | < 1      |              |          |              |            | 86.06  |                      |                |          |       |        | 10.50%            |         |        |          |  |
| 1-5 872,9             |                  | 2,989.01 |        | 56.99%   |          |          | 1               | 1-5      |              |          |              | 377.62     |        |                      |                |          |       | 46.05% |                   |         |        |          |  |
| 5-15                  | 5-15 65,803.19   |          |        |          | 4.30%    |          |                 |          | 5-15         |          |              |            | 45.14  |                      |                |          |       |        | 5.50%             |         |        |          |  |
| 15-30                 | 15-30 5,1        |          |        | 0.33     |          |          | 3%              |          |              | 15-30    |              |            | 162.40 |                      |                |          |       |        | 19.80%            |         |        |          |  |
| 30-50                 | 30-50 731.       |          |        | 0.05%    |          |          | •               | 30-50    |              |          |              | 148.78     |        |                      |                |          |       | 18.14% |                   |         |        |          |  |
| 50-100 0.00           |                  |          |        |          | 0.00%    |          |                 |          | 50-100       |          |              |            | 0.00   |                      |                |          |       |        |                   | 0.00%   |        |          |  |
| TOTAL                 | TOTAL 1,531,934  |          |        |          |          |          |                 |          | Т            | TOTAL    |              |            |        | 820 99.95% Reduction |                |          |       |        |                   |         |        |          |  |

Fig. 3. Particle counts.

(4) Cost is very competitive compared to other pretreatment processes (micro and ultrafiltration (MF/UF).

currently exists in water filtration, providing the efficiency of microfiltration at the cost of MMF.

## 4. Conclusions

*VORTISAND* cross-flow microsand filtration provides an efficient and cost-effective way to protect membranes and fills the technological gap that

## Reference

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