WATER RESEARCH COMMISSION

July 2013
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Drinking water

Floating media flocculation as pre-treatment for capillary ultrafiltration

A WRC-funded study followed on previously completed Commission research into floating media separation technology for drinking water applications.

Innovative technology

Floating media separation (FMS) technology was originally developed and patented in South Africa in 1986. The technology, which combines settling and media filtration in one operation, found niche applications in South Africa in the mining industry and in effluent treatment.

In the early 2000s, a WRC-funded study was conducted at the Nahoon dam of Amatola Water (Project No. K8/1527) where the operability and performance of a locally fabricated ultrafiltration (UF) process was evaluated on water which had a very high turbidity (180 NTU).

The pre-treatment technique used, coagulation followed by floating media flocculation (FMF), proved sufficient to produce drinking water and the research was successfully concluded. However, problems were initially experienced in maintaining consistent FMF performance which was ascribed to the media experimented with. At the end of the study the question still remained: 'what is a suitable medium or what should the physical and chemical properties of an adequate, suitable or preferred filter medium be?'

Part of this latest WRC study was therefore dedicated to systematic studies to establish whether size or shape of the granules used as media was indeed important. It was furthermore considered important to determine what the more prominent parameters in the operation of a FMS were. Other aspects concerning the operation of the FMS concerned water conservation. Water loss during backwash of buoyant media filters is much less than is the case with sand filters.

Seeing that water is a scarce commodity in South Africa, different backwash protocol was considered and evaluated in order to develop an adequate back-wash protocol to minimise water consumption.

Part of the research and development conducted was to enhance the capillary membrane UF process technology, the main outcome of that developmental process being the introduction of forced and gravity induced two-phase flow to improve the efficiency of the membrane backwashing protocol. The method of securing the UF modules to the manifold and the manifolding method itself was also revisited to reduce the incidence of membrane blocking during filtration.

The work on the development of FMF as a pre-treatment was concluded by designing the FMF into a pre-treatment process. By careful arrangement of the feed and backwash streams, it was demonstrated that an UF process can be operated at the high recovery rations characteristic of FMF.

Filtration media

The initial approach taken was to consider various means to alter the chemistry of the buoyant media, determine whether size and shape of media had an effect on FMF performance and develop and evaluate an adequate backwash protocol to minimise water consumption. The final thrust of the work was the development and evaluation of the efficacy of FMF as a pre-treatment operation for CUF.

Capillary membrane UF technology was also enhanced during this study, resulting in the introduction of forced and gravity-induced two-phase flow to improve the efficiency of membrane backwashing. The method of fastening the module to the manifold and the method of manifolding itself were also redesigned.

The FMS process was tested at laboratory scale as pre-treatment to UF (Figure 1) and the effects of altering media geometry and chemical properties. Alteration of geometric properties was the more successful of the two approaches.

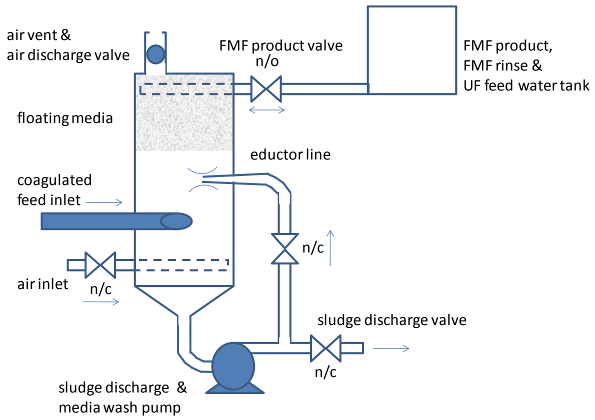

Figure 1
Schematic layout of the FMF process, operating as a pre-treatment for UF.

Factorial experiments, in which the factors included granule geometry, filter bed depth, rising velocity and coagulant concentration were conducted. It was concluded that small, lace-cut media were better suited for FMF, with smaller-sized granules the ultimate material of choice.

The studies showed that FMF removal efficiency improved if the filter media granules were 1-2 mm diameter. Removal efficiencies were improved further by preparing extruded media granules by a lace-cut technique rather than by a die-face cut technique.

An advantage of FMF is that much less water was needed to backwash than in conventional sand filtration. The specific gravity of the media in FMF is typically 0.92-0.95, whereas the specific gravity of sand is typically around 2.0. The FMF filter bed was therefore very easily expanded by flowing water in the reverse direction from the top to the bottom of the filter. More vigorous washing of the filter bed was achieved by bubbling air through the bed and by recycling the liquor in the filter by means of an external slurry pump through eductors positioned inside the filter.

Tandem FMF-UF process technology

The FMF process was originally developed to treat industrial waters that contained significant levels of suspended solids, hence the FMF's capacity to clarify water is underutilised when treating low-turbidity feed. It is therefore possible to blend all process rinse and backwash effluents with the feed for re-treatment and thus increase the overall recovery of water achieved. The way the FMF-UF recycle process was operated to maximise water recovery is shown in Figures 2 and 3.

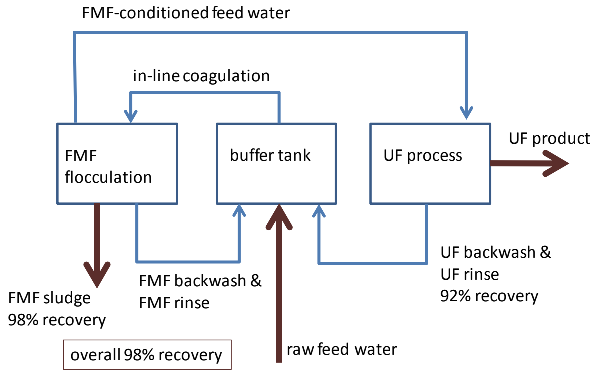

Figure 2
Process layout to increase water recovery to 98%+ in a UF process treating surface water to drinking standards.

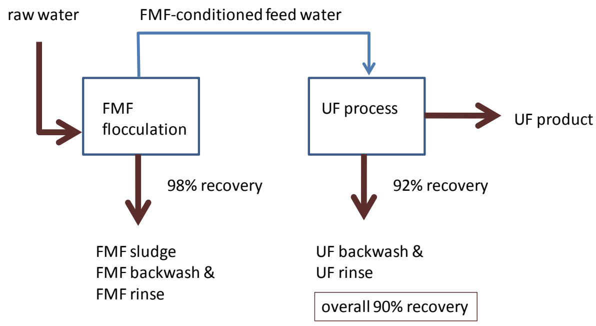

Figure 3
Conventional pre-treatment where each operation generates separate waste streams.

The rinse and backwash water from both the FMF and UF processes, which would normally go to waste, was diverted to a buffer tank, which also received the feed. This increased the suspended solids load on the FMF, but did not perturb the process.

Further, a large proportion of the backwash water originating from the UF process contained fragments of filter cake which settled rather than rose to the filter bed with the influent, thereby reducing the load on the FMF bed. Backwash of the FMF commenced at regular intervals. The recovery of the UF loop within the process was typically 90% to 92%, depending on the frequency and duration of the backwash, and on the volume of water used during rinse and flush operations.

When each unit was operated as stand-alone, the FMF operated at 98% recovery, and the UF process typically at 92%. The overall recovery of the FMF-UF process in this case was only 90%, however, operating the FMF-UF tandem process on water of around 4 NTU allowed a recovery of 98,5% to be achieved with a filtration run of eight hours.

Conclusion

A number of conclusions emanate from the study:

- FMF is very suitable as a technology by which the feed water to the UF can be treated. The concentration of colloidal and dissolved solids in the feed is reduced to concentration levels amenable for direct or dead-end UF. The UF membranes responded very well to the backwash regime developed. The absence of pieces of the customary congealed film in the UF backwash led to a new understanding of beneficial UF feed water 'conditioning' that results from FMF pre-treatment.
- A very effective and 'water wise' backwash and bed-rinse method was developed and tested for FMF. The air-scouring and media circulation technique minimises water consumption during backwash.
- Small (1 to 2 mm), sharp-edged media granules improved FMF performance compared with larger (2 to 4 mm), round-edged granules. This is excellent, since the void-volume of filtration beds containing smaller-sized beads is also lower. Powdered, polymer flakes, buoyant media resulted in the best filter performance.
- Depth filtration/flocculation is the mode of suspended/flocculated solids removal when granular filter media is used. Surface filtration is the mode of suspended/flocculated solids removal when powdered media is used. Surface filtration causes the first few centimetres of the bed to congeal into a layer which sinks to the bottom of the FMF at the onset of backwash. This is the direct cause of media loss.
- The water recovery of the combined FMF-UF tandem process can be improved from 92% to more than 98% by collecting the rinse and backwash water for retreatment by FMF.

This technology has since been patented, and is now being tested at full scale.

Further reading:
To order the report, ***Floating media flocculation as pre-treatment for capillary ultrafiltration in drinking water treatment*** (**Report No. 1527/1/12**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za, or Visit: www.wrc.org.zato download a free copy.