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A Case Study to Manage Troubleshooting of UF System

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Abstract -Ultrafiltration is one membrane filtration process that serves as a barrier to separate harmful bacteria, viruses, and other contaminants from clean water. An ultrafiltration water system forces water through a .02 micron membrane. Suspended particles that are too large to pass through the membrane stick to the outer membrane surface. Only fresh water and dissolved minerals pass through. Ultrafiltration plays an important role in water treatment process. This paper discuss, how to recover fouled membranes, parameters at feed to be maintained, performance checks of UF and different types of cleaning UF membranes. Large scale ultrafiltration systems are used in water treatment and waste water treatment plants, in combination with dual media filter and Reverse Osmosis system. Maintenance and recovery cleaning to be carried out on regular interval and in auto mode is necessary for maintaining the healthiness of UF system as well as feed parameters to UF to be maintained as per design specifications.

Key Words:Ultrafiltration, Membrane, chemical, cleaning, fouling.

1. INTRODUCTION

The ultrafiltration system with Hyflux Kristal UF membrane is targeting to produce 12.72 MLD (530M^3/hr.) filtrate water to feed the downstream RO system. The UF system consists of 2 trains and each train was installed with 90 UF modules of Kristal K600 series.

Table 1: UF specifications

S.No	Description	Parameters/Data
1	No of UF candles	2*90
2	Min. feed pressure required at the inlet of UF	2.5 kg/cm2g
3	Feed Tem	10-35
4	Recovery from UF	95 %
5	Mode of Operation	Dead end /Cross flow
6	Molecular weight cut off	80000-100000 Dalton (max)
7	Flux Rate	50-60LPH
8	MOC of membranes	Polysulfone /Polyether sulfone/PVDF
9	MOC of membrane Housing	SS316
10	MOC of Pressure Tubes	FRP

Fig-1: UF module at IGSTPS

2. Body of Paper

Despite having taken control & corrective measures in the clarifiers and DMF there was performance issues leading to reduction in permeate flow of the UF system and also the differential pressure reaching the limit within few hours of operation (design cut off value is 0.8 kg/cm^2). It was assumed that UF feed design limits were not met (turbidity <2 NTU), improper chemical cleanings done & also the system shutdown procedures were not practiced (preservation) as per the design & recommendations and modules would have been kept dry at times which might have resulted in reducing the permeability of the membrane fibers irreversibly. All these reasons had caused the membranes to foul heavily and it was planned to physically examine the membranes followed by integrity and bubble tests if required to assess the condition of UM membranes. As shows in Fig. 2 of UF membranes.

The Physical Test: 05 numbers of candles from both UF modules were removed. These were found heavily fouled with reddish brown layer as well as brownish black pallets, surprisingly at the outlet of membranes. The fibres of initial stage membranes were found broken and severely fouled. There might have been contaminant/dosing chemicals penetrated & clogs the pores of membranes. Analysis of pellets confirms the presence of clay and iron particles. The photographs depicting the state of UF membrane are shown below in **Fig.**-2-4:

Fig-2: Severely Fouled UF Membrane

Fig-3: Broken fibers of Membrane

Fig-4: Clay Pallets at permeate side

3. **Corrective Actions:**

a) Integrity Test (Pressure Decay Test): The integrity test methods are used to determine the integrity of membrane systems, and are applicable to systems containing membrane module configurations of both hollow fiber and flat sheet.

Based on findings of physical test it, integrity test for all UF candles was carried out as per following procedure:

I. Stop the UF system (module A and B both) and drain the UF modules by opening the feed side Drain valve.
II. Disconnect the UF membranes from the manifolds (feed, reject and permeate).
III. Install the pressure gauge close to the feed port and plug the reject side.
IV. Open the permeate port and connect low pressure air tube in to the feed side (max 10 psi) with isolation valves.
V. Slowly feed the air in to the module until reach the pressure 10 psi (feed side gauge).
VI. Once the pressure reaches 10 PSI stop the air and note the pressure for 10 min.
VII. If the pressure drops below 7 psi within holding time then module fails the test

A total of 68 UF membranes were found partially damaged (broken fibers). Subsequent bubble test was carried out to repair all defective membranes.

b) Bubble Test (Fiber Leak test): The defective membranes were repaired as per following procedures:

I. Drain the modules to be repaired and remove permeate and concentrate connections.

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II. Remove permeate and cap clamp by unscrewing the bolts and nuts.
III. Pour some water into the end socket over the top of the now-opened fibers.
IV. Open the air valve to allow about 0.5 bar of air into the module.
V. Look out for significant and continuous amounts of air bubbles coming out from any of the fibers. Mark out such fibers (with nylon wires).
VI. Turn off the air and remove the water from the socket.
VII. Coat nylon wire with quick-curing glue and re-insert the wire into the leaked fibers.
VIII. Wait for about 5-10 mins for the glue to dry before cutting off the protruding nylon wire.
IX. Reassemble the module.

All the 68 membranes were repaired by bubble method procedure. After these tests UF modules were taken into service to establish a 72 hour run before a maintenance cleaning as per design, however membranes could run for 10-20 hrs. only.

c) Other measures: Subsequently, some of the measures were taken to improve output like:

- Carried out low pH (using HCl or citric acid) and high pH cleaning (NaOH&NaOCl)-a total of 18 cleanings were done.
- The UF membranes are dead end type and with effluents (CW water) as feed the chocking at permeate side was suspected. To clean the chocking a modification was done on experimental basis by rejecting approx. 15% of permeate through forward flush line to make it cross flow type design.
- Beside above other modifications were also done like-double back washing, extended air scoring cycle time (50 sec to 90 sec) and increasing DP limit from 0.8 to 1.2 kg/cm^2.

Since the modules were unable to be recovered back with normal recovery cleanings, it was decided that a membrane autopsy be done to find out the extent of membrane fouling and identify the apt solution to recover the membranes back.

Selection Process for chemicals to be used in maintenance and recovery cleaning:

1. Autopsy:

One of the UF module was removed and the housing was cut to visualize the actual condition of the membranes inside. The fouling condition was found to be very severe with full of black sticky sludge on the surface & in between the membrane fibers as exhibited in Fig-2.

Step wise step to be taken to overcome the issue of fouling or improved chemical cleaning for the recovery of UF membranes

Fig-5: Photograph showing heavy fouling in UF Membranes

A bunch of the fibres from this module were removed/cut and subjected to soaking into different chemical formulations. The cleaning effect was monitored on hourly basis. Following respective chemical combinations to identify the effective cleaning solution:

1. HCl (pH 2) + EDTA (500 ppm)
2. HCl (pH 2) + EDTA (1000 ppm)
3. Citric acid (1.5%) + EDTA (1000 ppm)
4. Phosphoric Acid (pH 2)
5. NaOCl (400 ppm) + NaOH (pH 11.5) + EDTA (500 ppm) + SDBS (100 ppm)
6. NaOCl (400 ppm) + NaOH (pH 11.5) + EDTA (1000 ppm)
7. NaOCl (400 ppm) + NaOH (pH 11.5) + SDBS (1000 ppm)
8. NaOCl (400 ppm) + NaOH (pH 12) + EDTA (500 ppm) + SDBS (200 ppm)
9. NaOCl (400 ppm) + NaOH (pH 12) + EDTA (500 ppm) + SLS (200 ppm)

SDBS = Sodium dodecyl benzene sulphonate
SLS= Sodium laurel sulphate

Fig-6: Lab testing of different formulations for UF recovery

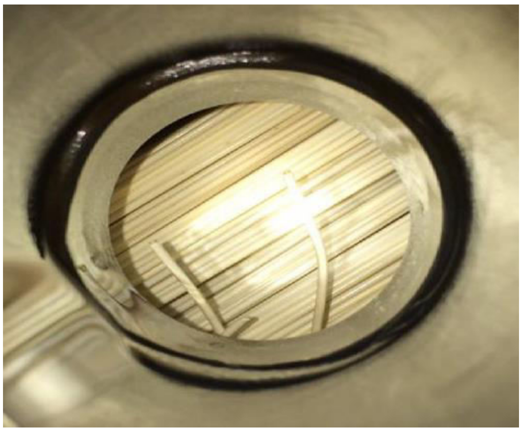

Fig-7: Cleaned Fiber in UF

Out of different combinations, Sl No. 8 & 9 were found to be most effective and rapid removal of foulants was observed. Accordingly, the recovery cleaning for UF modules(Initially #B) started with the same solution in five steps each comprising soaking, air blowing with single & double blowers, forward flush (repeated several time) and back wash. After conducting continuous recovery cleanings four high pH and one final low pH cleanings, the modules were recovered to maximum possible. Picture taken through the reject port of the cleaned membrane is shown in Fig-8.

Post to the cleaning of the UF#B, it was put for service with increasing flow till attainment of design flow. However, it was found that the DP was slightly increasing after every cycle. Analysing this further it was noticed that the backwash was not effective and then increased the air scoring by operating both the blowers together. After this, in backwash waste drain had lot of foulant/sludge being removed which was brown in colour with around 52 NTU of turbidity. After all these efforts the UF#B could run successfully for 72 hrs (144 cycles) with DP remained in limits (less than 0.8). The trends obtained during 72 hour trial showed nearly stable parameters (Fig-9).

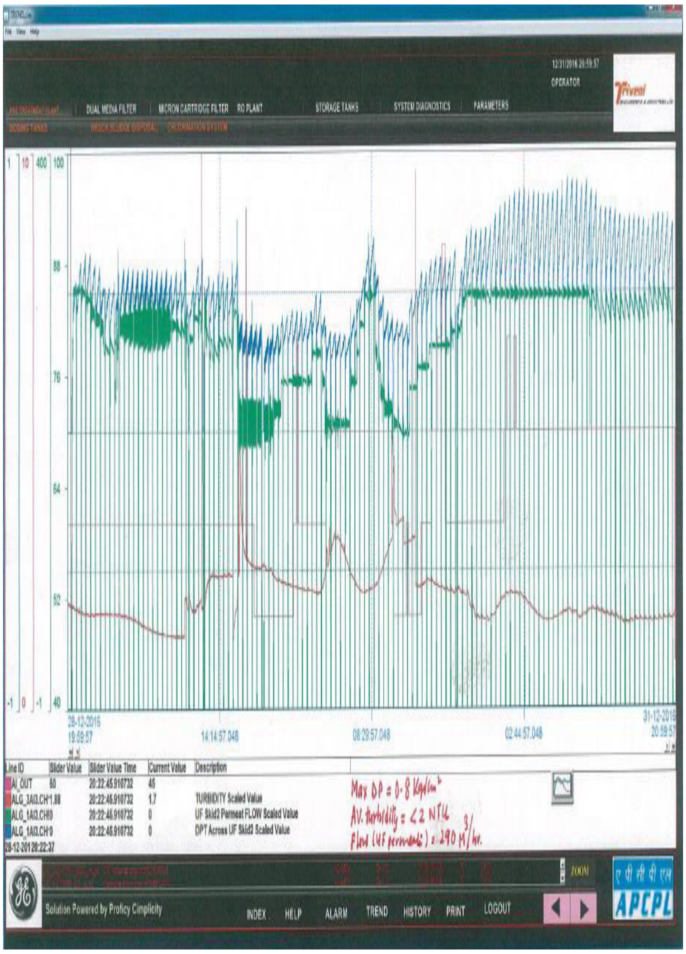

Fig-8: Trends of DP, Turbidity and flow during 72 hours operation.

3.Conclusion:

System problem Indications:

1. Increase in SDI (above three).

2. Increase in DP > 0.8 KSC or as per OEM.

3. BOD and COD.

4. Turbidity in permeate is high.

If there is change in any parameters mentioned above, isolate the system and take necessary corrective actions, specially cleaning chemical and cleaning process.

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