

Genairclean RO Membrane Cleaning

Trial Period

September 2013 to May 2014

Site

Water Reuse system, UK

For full trial details and results please download paper 'Microbubble RO membrane cleaning reduces fouling on WWRO plant' at www.genesysro.com.

Background

A Brackish Water Reverse Osmosis (BWRO) system with a history of rapid and consistent membrane fouling was selected to trial the new 'Genairclean' micro-bubble multi-mechanism RO membrane cleaning method. The plant reclaims process waste water which contains bacteria, soil, clay, bacteria, detergents and chemicals used in the wash-down and factory cleaning in place (CIP) systems. The waste water treatment and reuse system incorporates an advanced membrane bioreactor, ultra-filtration (UF) and RO plant to treat and purify the water for reuse and discharge.

System description

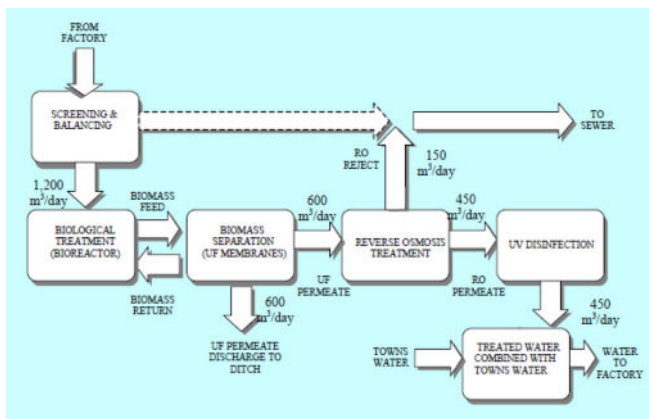


Fig 1: Water reuse system overview

Waste water is screened and balanced in aerated tanks then fed to an advanced membrane bioreactor (AMBR), biomass separation using Ultrafiltration membranes, reverse osmosis (RO) and ultraviolet (UV) disinfection. (Fig.1) A maximum of 1,400 m³/day of waste water can be produced by the factory, all of which is treated by the AMBR. After RO and UV disinfection, up to 450m³/day of treated water is sent to the mains water tank for blending prior to use in salad washing and process water.

The plant treats an influent COD total to the balancing tank of up to 480kg/day; depending on factory production. The RO plant consists of 30 Hydranautics ESPA2 LD 8" membrane elements arranged in five pressure vessels with a 3:2 array designed to operate at 75% recovery.

System operation

The RO plant was commissioned in 2004 and has experienced significant membrane fouling, especially during periods of peak production. The results of autopsies on membrane elements and cartridge filters proved that the foulant is mainly organic and microbiological in origin. Aluminosilicates are present as clay and soil from the salad washing process and also calcium phosphate deposits. The feed pressure required to maintain permeate production continually increases due to the build up of foulant on stage 1. The membranes are changed every 18-24 months.



Fig 2: Ultrafiltration (UF) Membrane Installation
Each Membrane Module consists of 300 + 8mm tubes with 27m² surface area



Fig 3: BWRO System

RO Technical Data

RO Technical Data	Actual	After Genairclean
Feed Flow m ³ /hr	19.71	24.47
Permeate Flow m ³ /hr	13.98	17.30
Recovery	70.9%	70.7%
Feed Pressure bar	13.02	8.74
Permeate Cond μS/cm	12.7	12.8
Norm Diff Pressure bar	4.57	0.63
Norm Diff Pressure 1st Stage bar	4.01	0.49
Salt Rejection	98.7%	99.1%
Cleaning frequency days	10.5	50-70

Previous Cleaning Regime

Since commissioning different cleaning technologies have been adopted to reduce the effects of fouling and extend system availability. Prior to the trial the CIP procedure included biocide pre-treatment (Genesol 30) followed by high pH (Genesol 40) and low pH (Genesol 38) chemicals.

The same CIP procedure was adopted during the trial, with the chemicals being replaced by Genesol 704 (high pH) and Genesol 701 (low pH), see Table 1 for details:

Product	Description	Mode of use	Chemical CIP concentration
Genesol 701	Powder acidic high ionic strength detergent chelant surfactant cleaner with effervescents	Temp - 20-25°C pH 2.5 - 4	1% (w/v)
Genesol 704	Powder alkaline high ionic strength detergent chelant surfactant cleaner with effervescents	Temp - 35-40°C pH 11-13	1% (w/v)
Genesol 38	Liquid mild acid cleaner	Temp - 20-25°C pH 2.5 - 4	2-3% (v/v)
Genesol 40	Liquid alkaline cleaner	Temp - 35-40°C pH 11-13	2-3% (v/v)

Table 1: Comparison of cleaning methods before and during Genairclean trial

Conventional Cleaning – Genesol 40 applied to remove clay, organics and biofilm. This is followed by an acidic clean with Genesol 38 to remove calcium carbonate and phosphate scale and metal oxides and hydroxides. This procedure normally took 6-8 hours depending on the severity of fouling and available downtime.

Trial 1 – New Cleaners 704 & 701 are high ionic strength powders containing detergents, surfactants and chelants combined with effervescing agents to give multiple cleaning mechanisms. They are 100% active formulations; only a 1% solution is required. CIP using the new cleaners took the same amount of time as the previous procedure.

No change in pH and colouration was observed with Genesol 701 confirming that the major foulant was in the 1st stage of the plant. It was therefore decided to continue the trial using only Genesol 704. This reduced subsequent CIP time to 4 hours.

Trial 2 – Genesol 704 combined with microbubbles – In order to further enhance the cleaning effect, an air induction device was installed. When combined with Genesol 704 this system produces a suspension of mini, midi and micro-bubbles (between 5 and 500µm in size). The microbubble generator device is installed on a bypass loop on the CIP system. Initially a similar cleaning procedure was followed to that described above but recirculation and soak times were reduced based on laboratory and pilot plant test results.

The CIP procedure has been optimised to a 20 minute warm permeate recirculation, 20 min recirculation of a 1% CIP solution at 35-40°C followed by a 20 min soak. During soaking normal osmosis causes permeate to flow back through the membrane enhancing deposit removal.

After soaking the microbubble generator is activated for 20 minutes while CIP solution is recirculated. All steps were repeated twice, followed by final permeate.

Results

The graph in Fig. 4 shows the reduction in normalised differential pressure on stage 1 of the RO plant. From January 2013 to 1st June 2013 conventional cleans using Genesol 38 & 40 were carried out every 10.5 days on average. Permeate production and normalised differential pressure (ndP) was temporarily restored but rapid refouling occurred. New membranes were installed in March and May but rapid refouling and increased ndP occurred.

In June using Genesol 701 and 704 improved performance was observed with ndP stabilising at 2.5 bar after one month of operation. This was a significant improvement on previous procedures, however refouling was still rapid with CIP every 11-13 days.

On the 3rd October air induction combined with Genesol 704 commenced. After 3 cleans a significant improvement in ndP was observed with CIP every 12.5 days. After six cleans stage 1 ndP reduced from 4.5 bar to <1 bar. From January to April 2014 CIP frequency was reduced from every 10.5 days to 31.6 days, currently CIP process occurs >50 days.

The sudden increases in operational dP is thought to be due to the presence of biofilm and clays being only partially removed by previous methods. The Genairclean system removes more deposits reducing surface roughness so the post CIP fouling rate is much slower. We believe that this method also enhances biofilm removal, significantly reducing the surviving microbial population slowing biofilm reformation. No loss of salt rejection was detected and permeate flow has improved from 14m³/hr to 17.3 m³/hr.

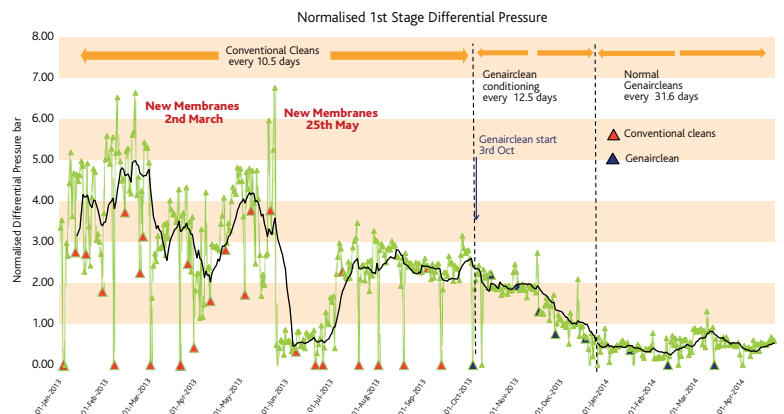


Fig 4: Graph of differential pressure over time using different cleaning methods.

Conclusions

- ◆ ndP reduced to 2.5 bar using Genesol 701 & 704 alone
- ◆ Applying microbubbles with Genesol 704 reduced ndP from 4.6 bar < 1 bar.
- ◆ Cleaning frequency was reduced from every 10 days to 50-70 days.
- ◆ Membrane life expectancy has been extended.
- ◆ CIP duration reduced from 6-8 hours to 4-5 hours.
- ◆ Operational savings include reduction in chemical use, energy, man hours and waste disposal.