GENESYS INTERNATIONAL

Application Guide

Application Guide 5

Genesys CAS Calcium sulphate antiscalant

Extract from the paper "Cost saving case study using a calcium sulphate specific antiscalant." Presented at IDA World Congress 2009 on Desalination and Water Reuse, Atlantis, The Palm, Dubai 7-12th November 2009

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Genesys CAS antiscalant allows brackish water reverse osmosis (BWRO) with high sulphate feed waters to operate at higher recovery rates than with conventional antiscalant products or acid dosing. The following case study demonstrates significant savings in water and electricity due to reduced pumping requirements as a consequence of applying a speciality antiscalant product.

Application

In the last eight years the capacity of RO water production has increased by 16million m³/day; 9million m³/day is from brackish water. The limiting factor in BWRO efficiency is the percentage of product water recovered from the feed stream, (the recovery rate). In BWRO this is determined largely by the feed water quality. As the recovery rate increases the concentration of dissolved salts in the reject stream increases and precipitation of salts may occur in the membranes positioned at the rear of the plant. Scale formation results in pressure increases, reduced flow and poor permeate water quality.

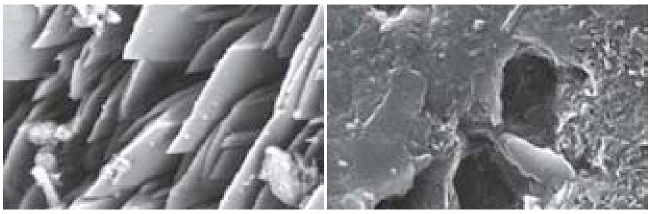

Fig 1: Blade like calcium sulphate crystals and damaged membrane surface

Deep well extraction of groundwater often results in waters with a high level of sulphate ions. Under the normal temperature conditions of membrane operation the anhydrite form occurs as blade like crystals that can damage the membrane surface. Cleaning is rarely successful making calcium sulphate one of the most damaging scaling species.

Sulphate Chemistry

The three major forms of calcium sulphate; anhydrite CaSO4, hemihydrate CaSO4~0.5H2O (plaster of Paris) and the dihydrate

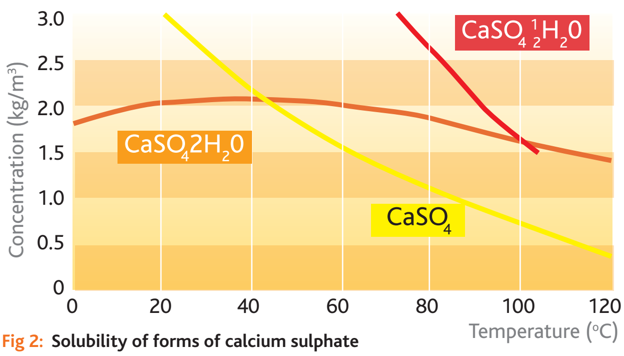

Fig 2: Solubility of forms of calcium sulphate

$CaSO_4.2H_2O$ (gypsum) have differing solubility isotherms as shown in figure 2. For RO waters the dihydrate form predominates. The solubility of calcium sulphate, is similar to calcium carbonate which decreases with increasing temperature. However whilst the precipitation of calcium carbonate scale can often be minimized by reducing the pH of the feed water, calcium sulphate solubility is independent of pH. This means that unlike calcium carbonate calcium sulphate can't be removed using acid cleaning products and that reducing the feed pH to stop scale formation is not effective.

Fig 3: Rosette formation on spacer

Studies in the Genesys laboratory in Madrid show frequent presence of crystal platelets forming in the low flow cross over points of the feed spacer (see figure 3). This feature is further demonstrated when the spacer is removed from the membrane surface during autopsy and it becomes clear the scale is deposited within the spacer layer rather than at the underlying membrane surface.

Antiscalant Development

Calcium sulphate is a strongly crystalline salt that develops from weak needle and platelet forms to highly stable rosettes, particularly in low flow areas in the membrane feed spacer. To combat this feature of crystal formation the antiscalant Genesys CAS combines threshold inhibitors with crystal distortion and dispersion agents which inhibit a variety of different scaling species and has an enhanced effect on calcium sulphate.

Case Study BWRO Plant Iran

Genesys International was asked to provide consultancy at a chemical manufacturing company in Tehran, Iran experiencing significant problems with a 7,000 m³/day two pass brackish water RO plant with brine recovery commissioned in September 2005. The system is a complex arrangement of 3 R.O. streams (see Figure 4).

First Pass Plant data

- 2 skids with 20:10 array of 6 elements/PV
- Total 360 Hydranautics CPA 3 elements
- Permeate flow 143 m3/hr, design recovery rate 63.5%
- Conventional antiscalant dosing and pH reduction from 7.5 to 7.1
- Summary of feed water analysis in table below

Calcium	785 mg/l	Silica	24 mg/l
Bicarbonate	141 mg/l	pH	7.5
Sulphate	2140 mg/l	TDS	4,745 mg/l

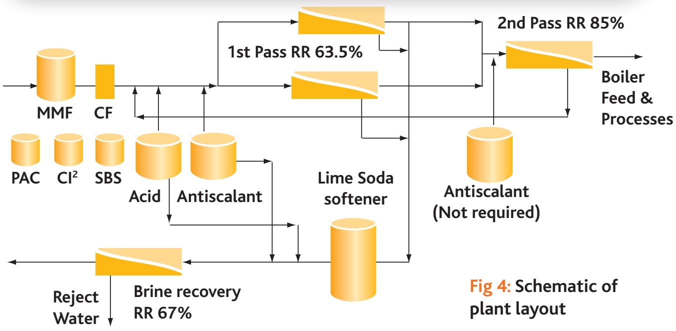

Fig 4: Schematic of plant layout

Operational issues

- Rapid calcium sulphate scale formation (see Fig 5)
- Recovery reduced to 48% from a design of 63.5%
- Increased Feed pressure 12.5 bar vs design 10 bar
- Membranes partially cleaned every 4 weeks
- Membranes replaced annually
- 132kg/day of hydrochloric acid dosed
- Conventional antiscalant dosed at 4.2 mg/l
- Brine recovery system inoperable due to rapid scale formation

Genesys International recommendations

Following a detailed site survey and feed water analysis the following recommendations were made:

- Genesys CAS replaced conventional antiscalant
- Acid dosing stopped as CaSO4 unaffected by pH
- Chlorine and bisulphite dosage stopped
- Polyaluminium chloride replaced with Genefloc GPF

Fig 5: Calcium sulphate scale

Results

- Recovery increased to 61% from 48%
- Over 1 million m³ of feed water saved per year
- Membrane cleaning frequency reduced from monthly to annually
- Brine recovery system operating at 67% recovery

Cost Savings

Using the latest Hydranautics IMSDesign RO Projection Programme pump energy demand (kWhr/m3) can be calculated for different operating conditions and recovery rates. The water and energy savings associated with increasing recovery from 48 to 61% are summarized below.

Skid 1 a	Sep-07	Feb-09
Feed Pressure Bar	12.50	12.00
% Recovery Rate	48	61
Feed Flow m3/hr	283.00	228.00
Permeate Flow m3/hr	136.00	139.00
Pump Energy kWhr/m³	0.85	0.62
Energy kWhr	240.55	141.36
Total Energy/annum kWhr	2,078,352.00	1,221,350.40
Pumping Costs/ßannum	$145,484.64	$85,494.53

Conclusions

The development of speciality antiscalants for different scaling species allows poor quality groundwater sources to be utilised economically. This paper demonstrates that the selection of the correct chemical programme and using species specific antiscalants can result in:

- Optimising the recovery rate to minimise pumping costs
- Maintaining membrane cleanliness and reducing cleaning
- frequency
- Extending the life of the membranes reducing replacement costs
- Removing large volume commodity acid, coagulant, chlorine and bisulphite dosing, which reduces operating costs and removes potential risks of chemical handling and storage to personnel and the environment.

Total Cost Saving	Skid 1a
Water Saving, m3/annum	1,121,280
Energy Saving, kWhrr	857,002 (1 skid)
Energy Costs Saving, US$/annum	$60,000
Membrane Replacement, US$/annum	$39,000
Chemical saving, US$/annum	$37,000
Total, US$/annum	$136,000

By understanding scaling mechanisms, improved antiscalants can be targeted against different scaling species. After laboratory and field testing certain development products have become important in ensuring viable economic operation of RO plant with poor quality feed water. Calculating pump energy savings with increased recovery is now possible using software developed by the membrane manufacturers. With this information the real cost benefits associated with choosing the correct antiscalant can be defined.

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