Anti-Scale Magnetic Method as a Prevention Method for Calcium Carbonate Scaling (DSL.3)

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Overview

• Scaling (definition- types-cost)
• Common Solutions for scaling.
• Advantage – disadvantage of solutions
• MTM (definition – history)
• Experiment A on MTM, objectives, method and result.
• Experiment B on MTM, objective, method and result.
• Literature survey on MTM to seek for explanation for the results obtained on Experiments A and B.
• Experiment C on retarding CaCO3, method, equipments, results.
• Discussion of results, conclusion, recommendations.
Introduction

- Scaling means the **deposition of particles** on the membrane surfaces/internal surface (MSF).
- Scaling is considered as the **biggest operating problem** in desalination plants (membrane, MSF).
- Scaling is a **selective** and a **costly** problem.
  - 10% of production cost = cost of antiscalant
  - KD 0.95 million/ year / the cost of dosing 3 mg/l Kuwait desalination plant.
  - Depositing of 0.036 inches of scale / heat exchanger will increase the energy cost of over 30%.
- Acid addition + Antiscalnt are the common solutions for scaling.
Introduction

- Acid (shifting the reaction)
  \[ \text{Ca}^{2+} + \text{HCO}_3^- \rightarrow \text{H}^+ + \text{CaCO}_3 \]
- Corrosion- CaCO\(_3\) only- required precautions- less productivity- low viability.
- Antiscalant (chemicals change the crystal/shape/size/morphology/location of precipitation/keep the crystal dispersed/suspended).
- High cost/ enhance biofouling/ loose effectiveness at high temperature (hydrolysis/harm to environment)
- MTM was proposed by different local companies as physical method/chemical composition/reduce hardness/disinfect water/prevent scale)
Magnetic Treatment Method (MTM)

- MTM has been applied as a Scale controlling Method for several decades in water systems.
- The first commercial device to be used for MTM was patented in Belgium in 1945 and used in a hot water system.
- The use of MTM has been wide spread since 1975 in water treatment in USA.
- In Kuwait local companies requested to test the effect of MTM on the chemical composition, hardness, water tasty, disinfect method (Exp A & B)
Experiment A:

To assess the effect of MTM on drinking water:
- hardness
- chemical composition
- biological contamination

Two months testing period

Two water samples were collected weekly from the two tanks.
The two samples were biologically, chemically and physically analyzed.
Experiment B (service to a local company)

- The test used a flowing seawater and tap water under open loop and closed loop circulation. The objective was to investigate the effect of MTM on the chemical composition of different types of flowing water. (seawater)

- The MTM used was ECO-peam from ECO-technology company as a source for MF

Figure 2. show the schematic diagram of the test unit (B).
The results of the experiments A & B showed similar results where no significant changes (water quality and chemistry)

- So, a literature survey conducted to seek for an explanation for the negative results obtained.

- LS showed that 31/40 experiments prove the effectiveness of MTM.

- MTM ↔ the formation of CaCO₃ particles in the bulk of scaling solution, instead of precipitating on the internal surface, particles are carried away by the water flow.

- The homogenous nucleation increased in the presence of MTM, resulting in the formation of crystals that are greater in numbers with smaller sizes.
pH, conductivity, salt passages, chemical compositions are not suitable tools for evaluating efficiency MTM.

- Similar evaluating tools were used by many other researchers also yielded a negative result.
- A new research was proposed to test the MTM in retarding scaling of CaCO₃ through increasing the retention time (suitable tool as recomm. LS)
- Retention time = maximum time where MTM can keep the particles of CaCO₃ suspended instead of precipitation
- \( \text{Ca}^{2+} + 2 \text{HCO}_3^{-1} \longrightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2 \)
**Fig. 3 schematic diagram of the test unit (C).**
Methodology

- Two tanks / water bath / digital dosing pump / variable speed pump / sensors / valves.

- CaCO₃ scaling solution (CaCO₃) was prepared by mixing 0.5 M of CaCl₂ and 0.5 M of Na₂CO₃.

- Control (PH - Temp - flow V - MFS)

- Base solution was circulated through MTM to be *magnetically treated* without mixing with CaCl₂ solution.

- Mixing time = zero time for scale formation / sampling / HCO₃⁻, analyzed / to test the effectiveness of MTM.
Effect of MTM on the Retention Time of CaCO₃

Fig. 4. Calcium carbonate concentration at 0.5 m/s velocity, pH 8.3 and 50°C at different MFS
Effect of flow velocity on MTM performance

Fig. 5. Calcium carbonate concentration at pH 8.3, 50°C, and 0.96 T magnetic fields at different velocities.
Fig. 6. Calcium carbonate concentration at 0.5 m/s velocity, pH 8.3, and 0.96 T MFS at different temperatures.
Effect of Feed PH on the Performance of MTM

Fig. 7. Calcium carbonate concentration at 0.5 m/s velocity, 70°C, and 0.96 T MFS and different pHs.
Fig. 8. The performance of 5 ppm of different antiscalants compared to the MTM in retarding CaCO$_3$ at ambient temperature.
The performance of MTM in retarding calcium carbonate depend on (flow V, T, MFS).

- The **effective** MTM **increased** as MFS **increased**.
- MTM **Increased** RT of CaCO₃ scaling at Conc. above 800 mg/s, V 0.5 m/s, MFS 0.96T by **three-fold** (10 to 50 min).
- As the **Temp.** Increased as the **RT of CaCO₃ increased** when the **temp. slightly increased** (not too much effective).
- The **PH** of Feed water has no effect on PR MTM.
- The **flow velocity** is the **key parameter** of the PR. MTM in increasing the RT of CaCO₃.