Prevention of Fouling Conference", Univ. of Nottingham England, 1-3 April 1981

080.

THE PERFORMANCE OF A MAGNETIC WATER CONDITIONER UNDER ACCELERATED SCALING CONDITIONS

by

David Hasson and Dan Bramson

Department of Chemical Engineering,
Technion-Israel Institute of Technology,
Haifa, Israel

(Research commissioned by Mekorot - Water Supply Co. of Israel)

ABSTRACT

The performance of a magnetic treatment device was tested under well-controlled accelerated $CaCO_3$ scaling conditions. The rather accurate deposition rate data showed no effect of magnetic treatment on the scaling process. Similarly, magnetic exposure exerted no effect on the adhesive nature of the deposits. The less accurate induction period data do not exclude the possibility that magnetic treatment might have extended the induction period by about an hour.

General Background

There is a tempting appeal to devices purporting to suppress scale formation with minimal supervision and with little to no chemical and energy requirements. The method of treatment consists of simply passing the water through an electric, magnetic or ultrasonic field provided by an adequately sized device. It is asserted that such treatment can reduce the amount of scale formed and cause morphological changes, yielding a loose easily washable sludge instead of a strongly adherent deposit.

The intense controversy regarding the effectiveness of such devices has a long history [1]. Currently, there is a revival of the controversy and renewed interest stemming apparently from extensive Soviet activities in magnetic water treatment. Despite research efforts on the effect of a magnetic field on the properties of scaling waters, there is still no substantiated mechanism that could rationalize anticipation of scale inhibition phenomena [2-5].

On the applied side, claims of marked scale reduction achieved by magnetic treatment continue to persist but are countered by equally persisting reports of lack of any scale inhibition effect. A recent critical review [4] tends to the hypothesis that magnetic devices could induce scale suppression phenomena, but it also recognizes that magnetic treatment is unsupported by the minimal development requirements from a practical technology. Available data provide virtually no guidance on the performance of a magnetic device, having a given field intensity and water exposure time, under different process conditions characterizing the severity of the scaling tendency. Research results have even disagreed on whether magnetic exposure exerts a stronger effect on $CaCO_3$ crystallization at low or high concentrations of the ionic species forming this deposit.

Scope of Present Study

In response to aggresive promotion of magnetic water treatment in Israel, Mekorot, the National Water Supply Authority, initiated the present study as a public service. The general objectives of this study were to acquire first hand experience and to explore the characteristics of a magnetic treatment device under unbiased and well-controlled laboratory conditions.

Experimental Programme

Six experiments (Table 1) were performed, at different scaling potentials, to provide quantitative data on the effect of magnetic exposure on the rate of $CaCO_3$ scale deposition and the adhesive nature of the deposits. The experiments were carried out with highly scaling water flowing at room temperature. Test conditions were selected to ensure linear growth of the scale layer, thus facilitating analysis of the measurements. All tests, except one, were carried out under once-through flow conditions.

The experimental system consisted of a 1 cu.m. feed vessel, a feed pump and a 13 m long horizontal iron pipe, 1" in diameter. All tests were carried out at a velocity of 2 m/sec, corresponding to a flow rate of about 15 US gpm. A magnetic device, rated at a capacity of 25 US gpm, was supplied freely and without any reservation by a manufacturer. The device was installed in the middle of the test pipe, under the technical supervision of the supplier.

The process of scale deposition was monitored by periodically weighing the amount of scale formed on several removable test segments of the pipe (15 x 2 cm), situated upstream and downstream of the magnetic device. A comparison of the deposits formed during once-through flow on the test segments placed before and after the magnetic device, allowed accurate and unambiguous examination of the effect of magnetic exposure on scale formation. Since the deposits were exposed to the same water, the measurements were free from any uncertainty due to unavoidable experimental fluctuations.

The recycle test had the object of increasing the magnetic exposure time. The flow through the test pipe was kept at the same rate but 2/3 of the water was recycled. Under these conditions, the test segments upstream of the magnetic device were in contact with water which had received three times the magnetic exposure provided by once-through flow. The downstream segments were in contact with water of four magnetic exposures. The results of the recycle test were compared with a separate control run carried out under the same recycle conditions, but without exposing the water to the magnetic device.

Hard tap water, at room temperature, was used in the tests. Its composition was: Ca^{++} = 200-250 ppm (as $CaCO_3$), Mg^{++} = 165-175 ppm (as $CaCO_3$), T.A. = 300-340 ppm (as $CaCO_3$), pH = 7.2-7.4. The precipitation potential of $CaCO_3$ in the various tests was controlled by dosage of NaOH using a pH control system. The pH levels in the various tests covered the range from pH 9 to pH 10, providing carbonate concentrations from 90 to 400 ppm (as $CaCO_3$). Sodium sulphite dosage was used to achieve defined conditions with respect to the iron impurities that are considered by some [3] as highly relevant to the action of magnetic treatment.

The duration of the various runs (15 to 35 hours) was determined by the time necessary to obtain a scale layer having a thickness of at least 80 micron. The adhesive nature of the deposits was characterized according to the cross-cut test procedure [6]. Chemical analyses showed that the deposits contained over 92% $CaCO_3$

TABLE 1: Scaling rates and induction periods with and without magnetic treatment

Run.No.	Flow condition	pH	Magnetic treatment	Scaling rate $g/cm^2 min \times 10^5$	Scaling rate micron/hr	Induction period, min
274	Once through	10.2	No	3.33±0.38	10±1.2	-18±50
			Yes	3.33±0.40	10±1.2	71±49
282	Once through	9.6	No	2.19±0.17	6.6±0.5	59±59
			Yes	1.95±0.14	5.9±0.4	31±54
275	Once through	9.45	No	1.53±0.22	4.6±0.7	104±86
			Yes	1.50±0.19	4.5±0.6	110±77
276	Once through	9.0	No	0.52±0.10	1.6±0.3	-40±245
			Yes	0.56±0.11	1.7±0.3	118±234
278	Recycle	9.5	No	1.32±0.20	4.0±0.6	100±110
277	Recycle	9.5	Yes	1.39±0.09	4.2±0.3	154±50

Results

The data, summarized in Table 1, allow examination of the effect of magnetic exposure on the deposit growth rate and on the induction period at different scaling potentials. The values listed were obtained by linear regression of the weight measurements. The 95% confidence limits, given in Table 1, show that the accuracy of the growth rate data is quite satisfactory (about±10%). The induction period data are far less accurate. As expected, the scaling rate diminishes as the supersaturation level of the $CaCO_3$-forming species is reduced [7].

Comparison of the scaling rates with and without magnetic treatment, show that they are virtually identical. In two tests (275, 282) there is a very slight decrease in the scaling rate of the magnetically exposed water. However, this trend is unsupported by statistical tests of significance [8] and is reversed in one run (276).

All deposits were well adherent to the pipe and were unaffected by magnetic exposure. The bulk density of the deposit, roughly determined, was around 2000 kg/cu.m. The magnetic device was dismantled after the second experiment (run 275) and was observed to be scaled to the same general degree as other parts of the test pipe. It was re-installed after mechanical cleaning.

The less accurate induction period data do not either reveal a statistically significant effect due to magnetic exposure. The three first-conducted runs (274, 275, 276) demonstrate a trend for an increased induction period of about an hour in magnetically exposed water, but this trend is reversed in the last two tests (277-8, 282). Nevertheless, it is felt that the experimental data do not exclude the possibility that magnetic exposure might have exerted a real effect in extending the induction period in some of the tests.

In conclusion, it does not seem plausible to expect magnetic treatment to exert a meaningful scale suppression effect at a relatively high $CaCO_3$ scaling potential. The results of this study also reaffirm the profound influence of water composition on scaling rates and stress the need to define any scale suppression effect by parameters characterizing the scaling potential of the system. Such data are largely unavailable.

Acknowledgement

Permission of Mekorot to present this paper is gratefully acknowledged.