Evaluation of Scale Deposition in Production Tubes with Direct Assessment Approach in The 'AH' Oil Field

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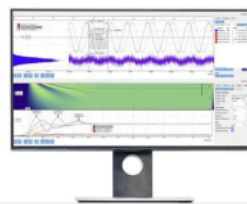
Evaluation of Scale Deposition in Production Tubes with Direct Assessment Approach in The 'AH' Oil Field

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Abstract. Scaling in the production tube can directly disrupt production, resulting in decreased production rates, pressure, and extra work on the workover, resulting in additional costs. The scale prevention method for tubing production uses an inhibitor, but many factors cause the inhibitor not to work optimally. Some scale deposes only in a particular area in the production tube due to turbulence flow, temperature, and pressure differences. The direct assessment using the Coiled Tubing Unit (CTU) will assess the calcite scale formation location based on well intervention result. The use of coiled tubing is combined with the acid injection; thus, the amount of calcite reacts with the acid in the 'tagged area' is measured to describe the amount of deposed calcite. In AH wells that have 88% water cut and with a scale index of 4.1, the estimated amount of carbonate is 15.10 kg.

Keywords: Evaluation, Scale Deposition, Production Tubes, Assesment, Oil

INTRODUCTION

Calcite Carbonate estimation is a coupling of some general principles such as changes in pressure, temperature changes, and pipe diameter changes. There is no accurate way to describe the location of carbonate formation in production tubing in the well.

The depiction of carbonate formation in production wells can provide a basis for the actions required for future wells. As long as the well produces water, the potential for scale formation will continue. Without a description of the position and number of scales formed, the solution to overcome carbonates will never be correct in terms of the chemical dose used and the methods used, such as cab-tube and SI capsule.

Coiled tubing is flexible tubing that is smaller in diameter than the production tubing, and it can cover every step-depth in the well. CTU detects the calcite scale by the tagged-in of its end on the calcite scale, and when it cannot go more in-depth, it indicates the scale deposition. However, coiled tubing alone is not sufficient to describe the volumetric size of the formed calcite scale. Novel methods are needed to achieve a better knowledge of deposes calcite deposition. When tagged-in the well injected with acid through CTU so that the acid reacts with the scale. The acid's reaction effectiveness will decrease when the mixture saturation of the dissolved calcite scales increases. The molar reaction between acid and calcite sample scale will be converted to the volumetric mass based on the CTU well intervention result.

A sample of scale is analyzed in the laboratory to give an initial parameter, then coupled with CTU well intervention result. This method is somehow similar to caliper gauge in terms of intervention, but with this method, the calcite scale's volumetric amount can be measured instead of internal diameter only.

LITERATURE REVIEW

Scale deposition is a phenomenon closely related to the solubility and deposition of a substance in a solution. According to Diaby [1], the factor influencing scale formation is an increase in temperature, which causes

degradation of the oil mixed with debris. The scale that is deposited on the walls of the production tubing forms specific characteristics; research conducted by Almutairi et al. [2] it shows that the scale acts as a heat insulator so that it increases the temperature of the production fluid inside and will form a specific temperature pattern along with the production tubing.

Scale Detection

There are many methods developed to detect the presence of scale inside the production tube. Most of the method uses imaging technique using tools, likewise reviewed by Poyet et al. [3] Several methods have been practiced to detect scales, including measuring residual inhibitors, electrochemical sensors, and Gamma-Ray measurement, Ultrasonic assessment, Nuclear Attenuation, Direct observation.

Most of the methods provided are limited to qualitative measures. Moreover, it cannot directly measure the scale formed accurately on the inside of the production tubing. A study conducted by[iii]Smith et al. [4] combines the Attenuation Total Reflectance (ATR) sensor with an inhibitor pump, the real-time reading of the scale is used as input for the operation of the inhibitor pump. Even though the sensor can catch scale formation indications qualitatively in real-time, it is only limited to the area where the sensor is installed. A study by Josang et al. [5] states that scale prefers to depose at particular positions in a production well tube where irregularities in the flow pattern occur, such as inflow control devices, gas lift mandrels downhole safety valves.

Existing observation methods are still limited to visible results such as caliper gauge results and visual observations on chokes limited to the reachable area. The use of coiled tubing to reach the production tubing area to the near-wellbore can be a novel technique in scale observation. The diameter difference between the production tubing and the coil tubing can provide an overview of the clearance conditions in a particular production tubing area, which can detect the scale by direct observation.

Analysis of Formation Water

According to Kristanto [6] , Formation water analysis aims to determine the content of cations and anions dissolved in formation water in the production process taken from the faucet on the wellhead. From the cation and anion content data using the methods of calculating the tendency to form scales, it can be seen that the tendency to form various scales is described in Chapter 3. Also, the analysis of formation water can be used to monitor the performance of scale inhibitors.

Based on a review from Zaporozec [7] regarding the presentation of water analysis results, several methods can confirm a parameter from water analysis results. The presentation results are divided into several groups: the presentation based on the classification method, the correlation method, the analytical method, and the synthetic-illustrative method.

To find the causes of the scale deposition clearly, the Stiff Diagram seems more suitable to be used. A Stiff diagram is a method that compares the anions and cations in a solution, as shown below:
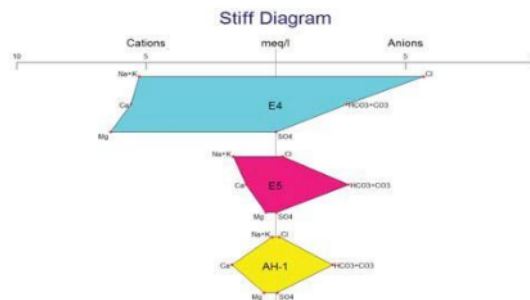

FIGURE 1. Diagram Stiff

From the Stiff diagram, a visualization of dissolved anions and cations equilibrium can be presented. For the data presented in the Stiff Diagram obtained from the results of water analysis, this water analysis results include the content of anions and cations quantitatively, then the formulation of a scale index.

In general, the scale index calculation is a quantitative method for assessing water's tendency to form scale deposits. There are various methods for calculating the scale index, including Langelier Saturation Index (LSI), Ryznar Stability Index (RSI), Puckarious Scaling Index (PSI), Calcium Saturation Index (CSI), Oddo-Tomson Index, Larson-Skold Index.

The combination of the scale index and the excellent data presentation can visualize the water's scaling potential. Therefore, these two parameters are needed so that handling the scale can be more efficient and effective.
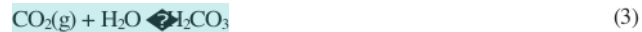
Scale Deposition

The scale formation depends on several factors that include, but are not limited to, temperature, pressures, solution saturation, and hydrodynamic behavior of the flow [8]. Moreover, at a point, there is a significant pressure drop. According to Bello [9], pressure decreases can lead to an increase in scale deposition potential. Thus a decrease in pressure will decrease the solubility of the Calcite scale in brine.

Calcite is a type of scale commonly found in deposits in production tubing. The formation mechanism is when the dissolved Calcite solution settles on the production tubing walls then forms a scale core, and the crystal core grows into a larger scale deposit. The solubility kinematics of calcite is illustrated in the following reactions.

$$Ca(HCO_3)_2 -- CaCO_3 + H_2O + CO_2 \tag{1}$$
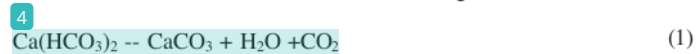
The major driving force for calcium carbonate formation is supersaturation, which depends on the brine chemistry; this can be calculated using thermodynamic models and the brine chemistry analysis data.

Besides, the effect of dissolved CO2 in the fluid also increases the scale-up factor. CO2 at high pressure will increase the solubility of Calcium ions pushed from the reservoir rock, which is assisted by Carbonic Acid formation.

$$CO_2 (g) \rightleftharpoons CO_2 (aq) \tag{2}$$

$$CO_2(g) + H_2O \rightleftharpoons H_2CO_3 \tag{3}$$

$$H_2CO_3 \rightleftharpoons H2CO_3^- + H^+ \tag{4}$$

$$HCO_3 - \rightleftharpoons CO_3^- + H^+ \tag{5}$$

If the equilibrium shifts towards the forming of CaCo3, then the scale's nucleation begins growing more prominent, as **Figure 2**.
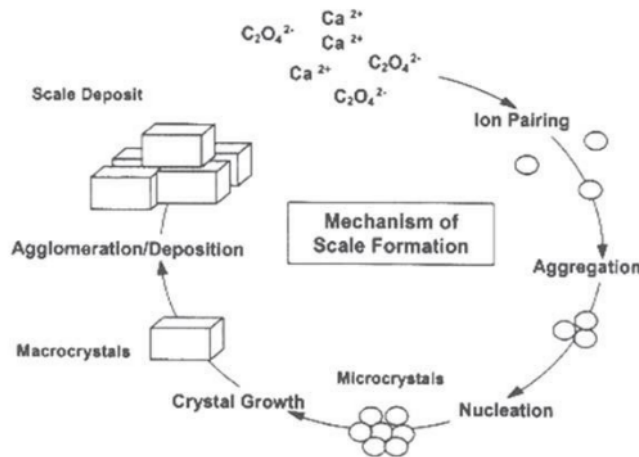

FIGURE 2. Scale Deposition Mechanism

One of the substances that are quite effective at reacting with scale, mostly carbonate, is HCL. The amount of HCL needed to fully react with scale sample until there is no residual yield can be predicted using the limiting reagent concept [10].

The mathematical formulation of the case of scale deposition in the production tubing involves the phenomenon of heat transfer and the solubility of calcium in the fluid, as formulated by Najibi et al. [11] as follows:

$$C_s = 136(10^{a+bz})$$
$$C_s = Saturation\ Concentration\ (Kg/m^3)$$
$$Where:$$
$$a = 2.047 - 0.001136T$$
$$b = -6.5832 + 0.0226T$$
$$Z = \frac{-\sqrt{I}}{1+1.s-\sqrt{I}} \qquad (6)$$
$$I = Ionic\ Strength\ (kmol/m^3)$$
$$T = Temperature\ (K)$$

METHODOLOGY

AH well is a well from a total of 35 wells in the AH field. The AH well has a total depth of 8250 ftMD or 6401 TVD. The problem with this well is the scale deposits that cover the hanger tubing to produce no fluid.

The methodology used aims to determine the number of scales formed on the production tubing using Coiled Tubing assisted by injection of Hydrochloric Acid (HCL). This study's main idea is to combine laboratory-scale research results with the results of Coiled Tubing operations in the field directly.

The laboratory testing method is used by using a water bath to simulate the same temperature in the well. The HCL will be heated to the AH well temperature and then reacted with a sample calcite scale gradually until the calcite scale reactivity goes into equilibrium, which is indicated by the absence of bubbles resulting from the reaction.

The coiled tubing will run along with the production tubing, while the shape of the production tubing is depicted in **FIGURE 3**
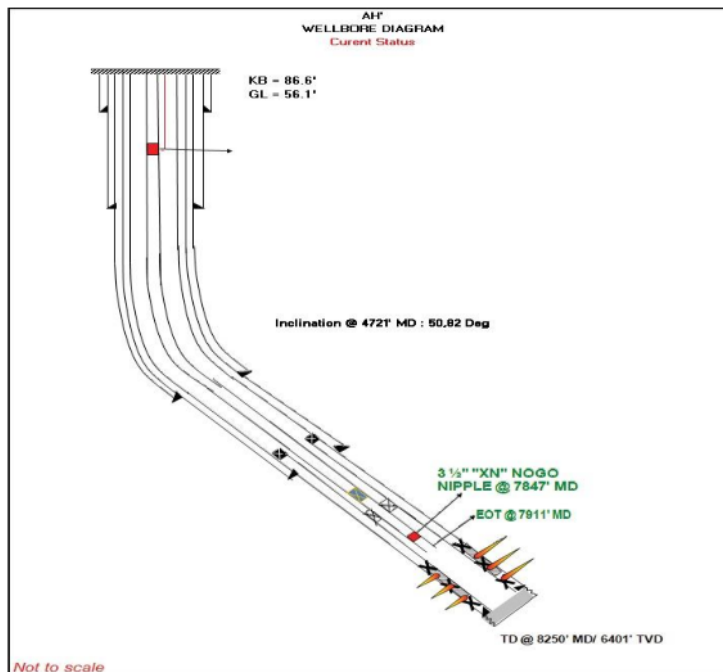

FIGURE 3. 'AH' Well Wellbore Diagram

RESULT AND DISCUSSION

The first analysis is water analysis. This water analysis aims to determine dissolved ions to describe the tendency of the composition and type of scale to be formed. This water analysis was carried out using the method according to API RP 45 for ion Ca^{2+}, Mg^{2+}, Fe^{2+}, Cl^-, Na^+, HCO_3^-, and CO_3^{2-} while for SO_4^{2-} using a spectrophotometer.

TABLE 1. Water Analysis of AH Well

Date	Ca^{2+}	Mg^{2+}	SO_4^{2-}	Fe^{2+}	Cl^-	Na^+	HCO_3^-	CO_3^{2-}
	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
Jan-19	17.23	0.42	6.87	0.00	238.11	248.05	20.79	N/A
Mar-19	18.91	0.42	6.87	0.00	305.62	318.47	25.39	N/A
Apr-19	20.59	0.42	6.66	0.00	267.42	274.19	21.19	N/A
May-19	25.63	0.42	6.25	0.00	267.42	267.33	19.79	N/A
Jun-19	25.21	0.67	7.29	0.00	248.32	251.34	16.70	5.00
Jul-19	29.00	0.42	7.08	0.00	248.32	249.30	23.39	N/A
Aug-19	21.85	0.76	7.29	0.00	248.32	255.72	20.79	2.00
Sep-19	21.60	0.92	6.87	0.00	248.32	258.09	25.49	N/A
Average	22.50	0.56	6.90	0.00	258.98	265.31	21.69	3.50

Water analysis was carried out over the past eight months on averages, and the results are the ions represented in *mg/l* units. To be depicted on the stiff diagram, it needs to be balanced using milliequivalent units per liter (*meq/l*), which describes the quantitative equivalence of an ion, so that its levels can be compared with other ions.

We also calculate the Scale Index from this water analysis that resulted in 4.1 for 'AH' well.
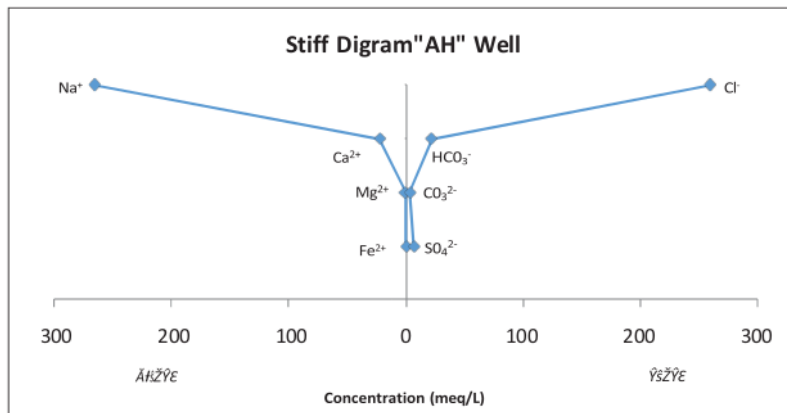

FIGURE 4. Stiff Diagram of AH Well

In the stiff diagram plot, it appears that the scaling tendency that occurs is $CaCO_3$ (Calcite) based on the dominant cation is Ca^{2+} without the detection of other scale-forming ions such as Barium and Strontium, while the sediment from sodium chloride that is formed is unlikely to be dry and well. The temperature is relatively high (up to 220 F).

The next step is projecting the number of scales samples from the production tubing to the amount of HCL used during the Coiled Tubing operation. This method is the coupling of a laboratory experiment with field operation.

TABLE 2. Limiting HCL Experiment on Scale Sample

Sample Scale Ammount (Gram)	HCL volume is used up until it is saturated (ml)
2.5	12.8
5	24.6
10	51.6
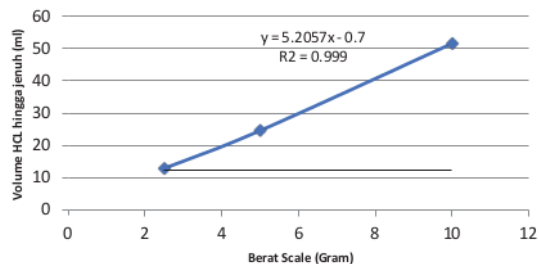
FIGURE 5. Model of Limiting HCL on Scale Sample

From the results of the saturation test of the HCL reaction with scale deposits, a plot like the one above is obtained, the plot is obtained using regression to determine trends in the data, and using the chi-square test obtained shows good results, indicating right data consistency.

The equation is then used to combine the resulting scale with the HCL used during Coiled Tubing operations in AH wells.

TABLE 3. Deposited Scale Estimation

Well Depth (ftMD)	Acid Mix Used (bbls)	Estimate of Deposited Scale (Kg)
0 - 10	10	1.59
10 - 150	15	2.38
150 - 175	10	1.59
175 - 300	5	0.79
300 - 320	25	3.97
320 - 500	30	4.77
500 - rest	0	0
Total	95	15.10

CONCLUSIONS

The problem of scaling in wells needs further attention because scaling can cause the well to stop operating. The relationship between HCL, the limiting reactant reacting in the sediment sample scale on a lab-scale, can be related to the actual scale conditions formed in the production tubing using Coiled Tubing. This method can provide an overview of the formation of scale deposits qualitatively in the production tubing. The direct assessment method with coiled tubing can still be further refined by increasing the depth determination measurement accuracy, considering that the coiled tubing in the well is not straight because of the clearance that allows the coiled tubing to bend. Otherwise, to minimize the risk of stuck, Coiled Tubing operation is limited until the No-Go nipple depth, then to predict scale deposition at near-wellbore another method to simulate scale deposition should be proposed.

ACKNOWLEDGMENTS

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