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Static Modeling of Oil filed Mineral Scales: Software Development

Abbasi*, S., Parvazdavani, M.
Researcher of Research Institute of Petroleum Industry (RIPI)
Email: Abbasis@ripi.ir

Abstract

Mineral scale deposition in near wellbore regions of injection wells is one of the main challengeable issues during the water injection process which magnify the importance of robust models in predicting the amount of mineral scale deposition such as calcium sulfate. One of the main challenges of $CaSO_4$ scale is in carbonated reservoirs in which sensitive behavior was observed in related to contribution of both calcium and sulfate ions in carbonated and sulfated scale reactions. This defect is mirror of wrong procedure and value in estimation of first kind/value of precipitant contributed in scale deposition reactions (ions competition) as well as inconsistent temperature/pressure dependent coefficients of prediction model.

The objective of this study is to develop a model that can accurately predict the formation and amount of $CaSO_4$ scale as the dominant scale in multicomponent aqueous systems by three major tools; utilization the best temperature and pressure dependent thermodynamic interactive ion coefficients (MSE Model: Pitzer), developing our fine-tuned iterative mathematical solver and verification the results of model by accurate experimental data.

The results showed that at the optimum value of precipitant (10%) in scale deposition reactions and by defining the best temperature and pressure dependent coefficients, we can attain the best accuracy in prediction of $CaSO_4$ scale deposited amount (less than 0.06 % as relative error compared to commercial software with 36 % overestimation and 22 % underestimation).

The output of this study is developed software leading to more accurate prediction the amount of promising scales in near wellbore regions or pipeline.

Keywords: $CaSO_4$ Scale, Laboratory Static Jar tests, Iterative mathematical solver, Pitzer thermodynamic model, Ions' binary interactive coefficient

Introduction

Seawater injection is one of the common methods used in IOR usually applied in offshore oil fields to maintain reservoir pressure and improve secondary recovery. Scale deposition is one of the most serious oil field problems that inflict water injection systems. Super-saturation can be generated in water by changing the pressure and temperature conditions or by mixing two incompatible waters. Scale can develop in the formation pores near the wellbore-reducing porosity and permeability and consequently productivity and injectivity. Among the common scales,calcium sulfate scale poses a unique problem for the salts under consideration because it occurs with one of three different phases. Gypsum, the most common scale formed occurs at relatively low temperatures. At high temperatures (above 100 ° C), the stable phase predicted is anhydrite ($CaSO_4$). However, hemi-hydrate has been known to form at 100 to 121 ° C.

Therefore authentic estimation of mineral scales precipitation is required. The main difficulty in scale prediction modeling lies in distinguishing the ions competition behavior of multicomponent mixtures. One of the main defects in previous studies is related to wrong procedure in sequence and value of precipitants taken part in mineral scale deposition reactions in each stage of modeling.

The objective of this study is to develop a model that can accurately predict the formation of $CaSO_4$ scale deposition as well as mineral scales in multicomponent aqueous systems by three major tools; huge experimental data bank including the implemented static tests, gathered temperature and pressure dependent coefficients and fined tuned iterative mathematical solver in which the previous described defect was removed.

Experimental Static Test

In order to obtain the anhydrite scales at different ratios of injection to formation water, Na_2SO_4 and $CaCl_2$ was used to provide required divalenets for water phase (see table 2 for compositions of water phase). After that, formation water and injection one with different ratios was mixed and after optimum time the solution was filtered with 0.45 micrometer paper filter. Filter warmed in oven is optimum time and temperature. The dried filter was weighed and amount of scales based on (mg/L) was calculated. Figure 1 shows the stability of formed scale regarding the time.

Table2. Composition of synthetic waters for prediction of individual scale formation

Formation water	Value (mg/L)	Sea water	Value (mg/L)
Calcium	12244	Sulfate	7000
Chloride (Brine)	129758	Sodium	1627
Sodium (Brine)	84068		
Chloride (Calcium)	21734		

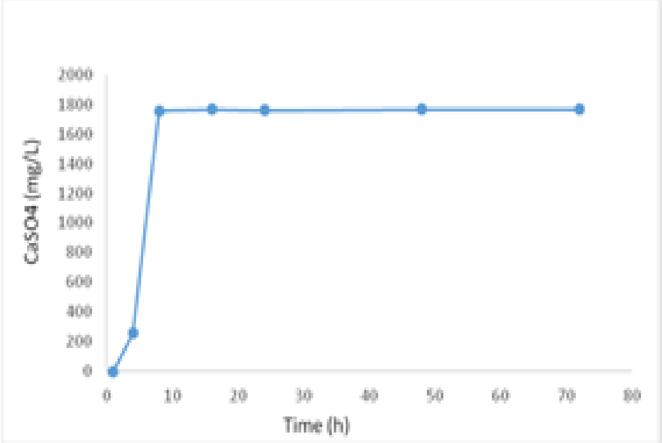

Figure1.Effect of time on formation of Anhydrate scale

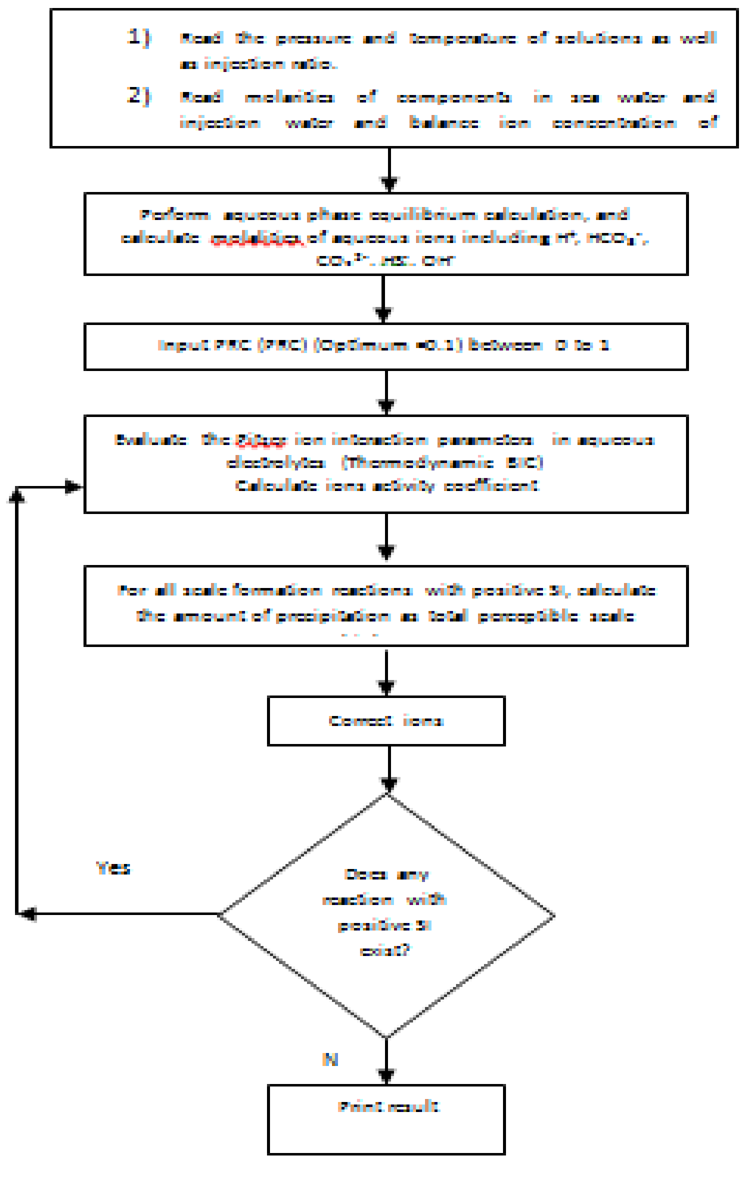

Figure2.Applied algorithm in mineral scale

Computational Model

Pitzer model was used to predict the formed CaSO4 scale due to incompatibility. The used algorithm was shown in Figure 2.

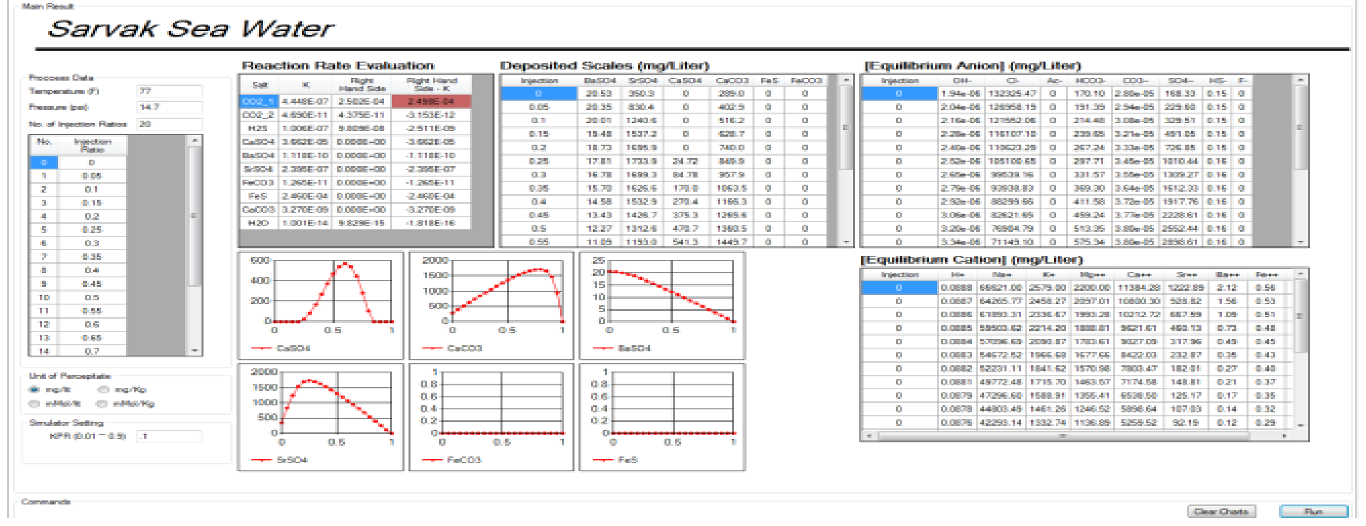

Figure3. Executive output window of developed software

Results and Discussions

The result of comparison of $CaSO_4$ solubility in pure water has been as well as real mixing waters are shown in figure 3 and4.

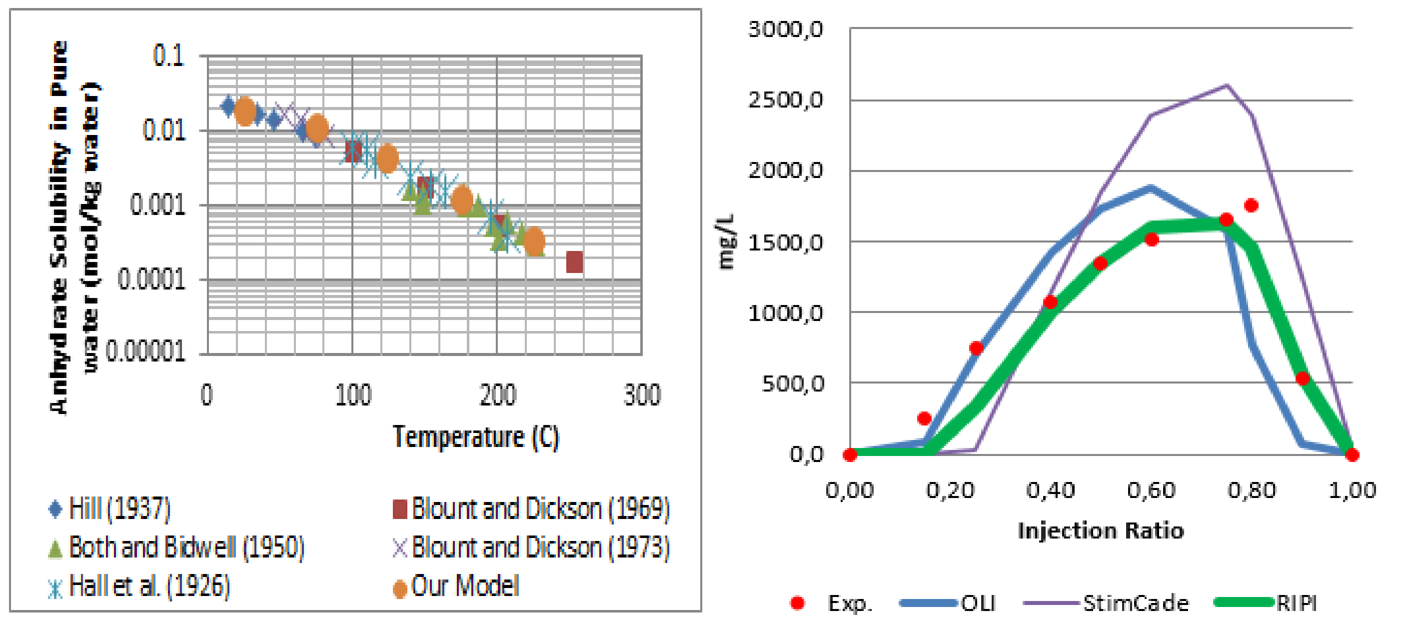

Figure4 and 5. Prediction of solubility and scales for CaSO4 in pure water (4) and real waters (5)

Conclusions

- ❑ At the optimum value of precipitant (10%) in scale deposition reactions and by defining the best temperature and pressure dependent coefficients, less than 0.06 % as relative error was observed compared to commercial software with 36 % overestimation and 22 % underestimation in prediction of $CaSO_4$ scale deposited amount.
- ❑ The origin of sensitive behavior in $CaSO_4$ scale prediction is related to contribution of both calcium and sulfate ions in carbonated and sulfated scale reactions (Ions competition).