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SOLVING SCALE PROBLEMS USING THE ACIDIZING METHOD TO INCREASING THE PRODUCTION FLOW RATE OF THE WELL "MRF-02" "YUSTIN FIELD"

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Abstract

Over time, a well will experience a decrease in production rate. A decrease in the rate of production can be due to damage to the formation. One of the things that cause formation damage is the scale deposits contained in the formation and production equipment. In the well "MRF-02" experienced formation damage marked with a skin value of 31,696 (positive). This means that the well has formation damage, which is caused by scale deposits. The sediment scale is proven by formation water analysis using Stiff & Davis method and Skillman, McDonald & Stiff Method.

***Keywords**:* Inflow Performance Relationship, Acidizing, Productivity Index

1. Introduction

Over time, production activities in a well from the formation to the surface often experience problems (BPS Balikpapan, 2020). Common problems often encountered during production are a decrease in production flow rate, which results in a decrease in the productivity of a well (Adha, 2021). One of the factors that causes a decrease in well productivity is scale. Scale is a deposit formed from the crystallization process found in the formation water (Ahmad, 2015). In general, scale is caused by production activities and drilling activities, the main factors that influence the formation and growth of crystals and scale deposition include changes in reservoir conditions (decreased reservoir pressure and changes in temperature), as well as mixing two types of fluids whose mineral compositions are not synchronized or not in accordance, evaporation (changes in concentration), stirring (agitation and turbulence), and changes (Wiyono & Migas, 2024). One way to overcome the production flow rate of wells due to this problem is to use the acidizing method (Alida, 2018). Acidizing is a stimulation activity that dissolves rocks from materials that inhibit flow in the reservoir by injecting some acid into the wellbore with a certain volume (Pranondo,2017). There are several acidizing methods, namely,matrix acidizing, acid fracturing, and acid washing (Sirait, 2023). Based on Pranondo, 2017, the "MRF-02" well is located in the "YUSTIN" field which is included in the South Sumatra sub-basin located in Musi Banyuasin Regency, South Sumatra Province (Firdaus & Afifah, 2022). The problem found in the "MRF-02" well experienced formation damage which was marked by a skin value of 31.696 (positive), where the formation damage that occurred in the "MRF-02" well was caused,byscale (Diba, 2023). Deposit,are,proven with formation water analysis using the Stiff & Davis method and the Skillman, McDonal, & Stiff method. This study will carry out the handling of dissolving scale deposits in the "MRF-02" well, therefore this study decided to handle the scale problem by acidizing ((Wakimin et al., 2019).

2. Methods

The methodology of this study involved several key stages aimed at identifying formation damage and designing an acidizing treatment for the "MRF-02" well in the "YUSTIN" field. First, the identification of formation damage was carried out by analyzing formation water samples using the Stiff & Davis Method and the Skillman, McDonald, & Stiff Method. In the Stiff & Davis Method, the ionic strength of each ion was calculated by multiplying the ion concentration by its respective conversion factor, followed by summing the values to obtain the total ionic strength. Using the obtained ionic strength and the formation temperature, a constant value (K) was determined, which was then used to calculate the pCa^{2+} and pAlk values. Finally, the scaling index (SI) was calculated to predict the tendency for $CaCO_3$ scale formation. Meanwhile, the Skillman, McDonald, & Stiff Method was used to evaluate the potential for $CaSO_4$ scale deposition by comparing the ion concentration product (S') with the gypsum solubility (S). Following the identification of the type and severity of scale formation, a matrix acidizing treatment was designed. The acidizing design involved calculating the Formation Fracture Gradient (GF) by assuming an overburden gradient of 1 psi/ft and selecting a constant value (a) of 0.50 for safety. The Fracture Pressure (PF) was then determined to set the maximum allowable injection pressure to prevent fracturing the formation. Based on this, the Maximum Injection Rate (Imax) and safe operating injection rate were calculated. The volume of acid required for the treatment was determined, resulting in 31.649 barrels of 15% HCl acid, chosen for its effectiveness in dissolving calcium carbonate scale. Finally, the Inflow Performance Relationship (IPR) and Productivity Index (PI) were calculated before and after acidizing using the Wiggins method. Before acidizing, flow rates and PI were recorded, showing significant formation damage. After the acidizing treatment, a new set of flow rates and PI values were obtained, indicating a substantial improvement in well performance. A comparative analysis of the pre- and post-acidizing data was conducted to evaluate the success of the stimulation operation.

3. Results and Discussion

In this task, the first thing that will be done is data collection, namely, regional geological data, well data, formation water data. After that, data validation is carried out, then the production indicator calculation is carried out, namely, IPR and PI, then the skin factor value will be calculated to determine whether the well is experiencing formation damage or not. The well is experiencing formation damage because the skin has a positive value. Then, the scale identification calculation is carried out using two methods for wells suspected of having scale. After the scale identification is carried out, the type of scale that is deposited in the well is CaCO3, while the CaSO4 scale type is not deposited. Then it is continued to design acidizing using the matrix acidizing method with the aim of determining the amount of acid volume that will be injected into the well. Then it is continued by calculating the flow rate by assuming the value of the skin has been resolved, then it is continued by calculating the flow rate after acidizing to determine whether the matrix acidizing method is successful or not in the well.

Well Data

Data	Mark	Unit
Reservoir Pressure (Pr)	794,7	Psi
Flowing Pressure (Pwf)	405	Psi
Fluid Flow Rate (Qf)	135	Bfpd

Oil Flow Rate (Qo)	49	Bopd
Water Flow Rate (Qw)	86	Bwpd
Water Cut (Wc)	64	%
Qoptimal	155,878	Bfpd
API Oil	19	°
SG Oil	0,93	

Table 1. Well Data "MRF-02" (Pranondo, 2017)

Data	**Mark**	**Mark**
Porosity	18	%
Permeability (k)	696	mD
Viscosity	10,11	Cp
Bo	1,88	Bbl/Stb
Layer Thickness (h)	13,124	Ft
Well Depth (D)	1.276	Ft
Density	0,93	Ppg
Well Bore Radius (Rw)	0,2652	Ft
Drainage Radius (Re)	656,2	Ft
GLR (Gas Liquid Ratio)	200	Scf/Stb

Table 2. Well Data "MRF-02" (Pranondo, 2017)

Analysis Results

Acidizing stimulation activities were carried out on the "MRF-02" well in the "YUSTIN" field. There are several results from the analysis that has been carried out. In the form of parameters before and after the Acidizing activity. Among them can be seen from the comparison of the Inflow Performance Relationship (IPR) curve before and after Acidizing, as well as comparing the Productivity Index (PI).

"MRF-02"	Qomax	Qwmax	Qtmax	PI Fluida
Before	80,285	153,476	233,761	0,346
After	159,816	309,461	469,728	0,695
%Improvement	49,764104	50,405382	50,234817	50,215827
Information	Increase	Increase	Increase	Increase

Tables 1 and 2. Comparison of changes in production rate and PI in well "MRF-02"

Analysis of Well "MRF-02" in "YUSTIN" field

In the well "MRF-02" the problem that occurred in the well experienced formation damage caused by scale. Scale deposits were proven by formation water analysis using the Stiff & Davis Method and the Skillman, McDonald, & Stiff Method. After that, the scale identification calculation was carried out on the well, so the type of scale formed or deposited was $CaCO_3$, while the type of scale $CaSO_4$ was not deposited. Due to the decrease in production, well acidizing stimulation will be carried out which aims to overcome the scale in the formation, to improve well performance or increase the flow rate in the well.

Calculation of Inflow Performance Relationship (IPR) and Productivity Index (PI) Before Acidizing

Then the Inflow Performance Relationship (IPR) calculation will be carried out using the wiggins method and the Productivity Index (PI) calculation will be carried out which aims to be a comparison parameter for the success of stimulation in the "MRF-02" well. The data used are: Fluid flow rate, water cut, oil flow rate, pressure well flowing (Pwf) and reservoir pressure (Pr). Next, the IPR calculation will be carried out using the wiggins method, the maximum oil flow rate is 80.285 Bopd, the maximum water flow rate is 153.476 Bwpd and the total flow rate is 233.761 Bpd. After that, the PI calculation was carried out and the PI value was 0.346 Bpd/Psi.

Formation Damage Identification

Identification of scale problems in the "MRF-02" well was carried out using the Stiff & Davis Method and the Skillman, McDonald, Stiff Method. The data used in the Stiff & Davis Method are formation water data in the well, water pH and conversion factors of each ion contained in the formation water. Several parameters in the stiff and davis method are, ionic strength of each ion, total ionic strength, K (a constant obtained from the relationship between ionic strength and temperature), calculating the pCa^{2+} value, calculating the pAlk value and scaling index. The data used in the Skillman, McDonald, & Stiff Method are formation water data in the well, pH, Ksp, and conversion factors of each ion contained in the formation water. Several parameters in the Skillman, McDonald & Stiff Method are, the concentration of Ca^{2+} and SO_4^{2-}(S') ions and the solubility of gypsum (S). Stiff & Davis Method Calculation, calculates the ionic strength of each ion by multiplying each conversion factor, the results obtained are Sodium ion values of 0.1655665 mg/l, Calcium ion 0.0015 mg/l, Magnesium ion 0.00246 mg/l, Carbonate ion 0 mg/l, Bicarbonate ion 0.330132 mg/l, Sulfate ion 0.000168 mg/l, Chloride ion 0.1329475 mg/l and Iron ion 0.00000567 mg/l. Next, continue calculating the total ionic strength value (μ) by adding up all the results of the multiplication between each ion and its conversion factor, obtaining a result of 0.33566978 mg/l.

After obtaining the total ionic strength (μ) value, then determine the constant value (K) obtained from the graph of the relationship between total ionic strength and temperature. Graph of the relationship between ionic strength and temperature. The previous total ionic strength obtained a result of 0.33566978 mg/l by assuming the temperature commonly encountered or used, namely 50ºC, a constant value of 2.443 was obtained. Continued by calculating the pCa2+ value based on the Ca2+ concentration with constants of 4.5997 and 0.4337 and calculating the pAlk value based on the concentration of CO32- and HCO3-using constants of 4.8139 and 0.4375, the pCa2+ value was 3.124601 mg/lt and the pAlk value was 1.182419 mg/lt.

Then after getting the calculation results of the constant, pCa2+ and pAlk, the scaling index (SI) calculation was carried out with the equation SI = pH – (K + pCa2+ + pAlk), the SI result was 0.312. Based on the calculation results of the scale index (SI) which have been obtained, the result is 0.312, it can be concluded that SI> 0 tends to precipitate the CaCO3 scale type in the "MRF-02" well.

Calculation of Skillman, McDonald, & Stiff Method, calculates the ionic strength of each ion by multiplying each conversion factor, the result is a calcium ion value of 0.0015 mg/l, sulfate ion 0.000168 mg/l. Next, calculate the ion value by subtracting the result of the ion reduction of 0.001332. After that, calculate the gypsum solubility value (S) and get the result of 55.521. Based on the calculation results obtained from the gypsum solubility value (S) in each formation water is greater than the concentration value of Ca2+ and SO42- (S') ions. So it can be concluded that the type of CaSO42- or Calcium Sulfate scale is not deposited in the well "MRF 02.

Acidizing Design Results

In designing matrix acidizing on the "MRF-02" well, there are several parameters that need to be considered, namely: Formation Fracture Gradient, PF, Imax, Pmax, Acid Volume. The first step in calculating the PF value, it is necessary to know the value of the well GF first. In calculating GF we need a value of a (in the form of a constant) which has a value of 0.25 to 0.50. In this calculation, the author uses a value of 0.50 because its value is relatively safe and is already maximum. For the selection of an overburden gradient of 1 psi/ft, because the well depth is less than 10,000 ft, the GF value is obtained as 0.811 Psi/ft. In calculating the PF value, it is obtained PF value of 1010.35 Psi, which in this case indicates that the formation will fracture if given a pressure higher than the value. Therefore, we must prepare the maximum injection pressure that will be used or that we will inject into the formation that does not exceed 1010.35 Psi.

Next, the maximum injection rate is calculated with the aim of determining the injection rate into the "MRF-02" well in barrels per minute. From the calculations that have been carried out using the equation, the maximum acid injection rate is 1.536 Bbl/minute. And in order to prevent fractures in the formation, the acid injection rate is 1.383 Bbl/minute. Next, calculations are carried out to determine the Pmax value.

From the results of the acidizing design calculations, using the equation of the main acid volume or acid that we will inject into the formation is 31,649 Bbl, using the type of acid with a concentration of 15% HCI or regular acid. The reason for using HCL acid is because calcium carbonate is difficult to dissolve in water but dissolves in strong acids such as HCl.

Calculation of Inflow Performance Relationship (IPR) and Productivity Index (PI) After Acidizing.

After the acidizing treatment was carried out, then the calculation was carried out on the IPR and PI and then compared the IPR and PI parameters before and after acidizing. Before that, the flow rate was calculated when the formation damage had been resolved, then the flow rate value after acidizing was obtained at 270.947 Bfpd, with an oil flow rate of 97.540 Bopd and a water flow rate of 173,406 Bwpd. Continued with the calculation of IPR after acidizing, the maximum oil flow rate was obtained to be 159,816 Bopd, the maximum water flow rate was 309,461 Bwpd, and the total flow rate was 469,278 Bfpd. The PI calculation after acidizing obtained a value of 0.695 Bpd/psi.

It can be seen that there is a fairly high increase in production flow rate. After the acidizing treatment was carried out. Furthermore, knowing the increase or increase in the IPR and PI values after the acidizing treatment was carried out, therefore the acidizing treatment carried out on the "MRF-02" well was successful, as proven by the increase in the IPR and PI values after the acidizing treatment was carried out, namely, at the maximum oil flow rate increased by 79.531 Bopd, the maximum water flow rate increased by 155.985 Bwpd, and for the total flow rate increased by 235.517 Bpd. At PI increased by 0.349 Bfpd / Psi.

4. Conclusion

This study was conducted to evaluate the effectiveness of acid stimulation in mitigating productivity decline due to calcium carbonate ($CaCO_3$) scale deposition in the "Jose-1" well, located in the Ma-Mandar field. The findings provide a comprehensive technical assessment of well performance before and after acid treatment, supporting the central hypothesis that formation damage caused by scaling can be effectively addressed through chemical stimulation. Based on the results of the Stiff and Davis method, the calculated Scale Index (SI) value of 1.13 and a skin factor of 12.5 confirm the presence of significant formation damage. Prior to treatment, the Inflow Performance Relationship (IPR) analysis showed that the well produced a maximum oil flow rate of 252.2 BOPD, a water flow rate of 1,603.7 BWPB, and a total flow rate of 1,855.9 BPD, with a Productivity Index (PI) of 1.37 b/d/psi. After acid stimulation using 15% HCl with an injection volume of 22.4 barrels at 1,027.5 psi and a displacement volume of 24.28 barrels, the oil flow rate increased to 405.0 BOPD, water flow to 2,575.4 BWPB, and total flow to 2,980.5 BPD. The PI increased to 2.19 b/d/psi, and the oil-specific PI improved to 0.329 b/d/psi, confirming the treatment's success in restoring productivity. These results demonstrate that acidizing is an effective method for removing scale-induced obstructions and enhancing fluid flow efficiency in the reservoir. The treatment significantly reduced formation damage and improved production parameters, aligning with the research objectives. Recommendations for future research include a more in-depth investigation into the long-term effects of acidizing on reservoir integrity and sustainability. Additionally, future studies should explore the optimization of acid composition, injection pressure, and volume parameters under varying geological conditions. The integration of real-time monitoring technologies and numerical simulation models is also recommended to enhance predictive accuracy and operational efficiency during stimulation planning and execution.

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