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Study of Well Stimulation by using Acidizing Techniques in Abu Attifel Field

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الملخص

يستخدم تحفيز الآبار لزيادة إنتاجية النفط والغاز. تستخدم طريقة التحميض لمعالجة أضرار الآبار بناءً على نوع الصخور المناسب. في هذه الدراسة ، تم تطبيق طريقة التحميض في تكوين حقل أبو الطفل لتقليل الضرر وإزالة القشور في نسيج الصخور. نظرًا لطبيعة نوع الصخور ، فإن تكوين الكربونات هو عبارة عن نسيج صخري رئيسي موجودة في خزان أبو الطفل. حمض الهيدروكلوريك هو الحمض المناسب المستخدم في علاج تلف تكون الكربونات. المعايير المستخدمة لتحديد معالجة تلف البئر هي قياس معدل التدفق وضغط التدفق في قاع البئر (Pwf) ومحتوى الماء قبل المعالجة وبعدها. تم تقدير نسبة انفط الى الغاز بناءً على الخصائص المقاسة قبل المعالجة وبعدها. تشير النتائج إلى أن معدل التدفق بعد المعالجة زاد وتحسن ، وزاد ضغط التدفق في قاع البئر (Pwf) أيضًا بعد المعالجة ، وينخفض محتوى الماء بعد المعالجة.

Abstract

Well stimulation is used to increase oil and gas productivity. Acidizing method is used to treat well damage based on proper rock type.In this study, acidizing method is applied in Abu-Attifel field formation to minimize the damage and remove scale in rock matrix. Due to the nature of rock type, sandstone formation is a major rock matrix existed in Abu- Attifel reservoir. Hydrochloric acid is the proper acid used to treat sandstone formation damage.The criteria that used to determine the treatment of well damage is the measurement of flow rate, bottom hole flowing pressure (Pwf), and water content before and after treatment. Gas oil ratio was estimated based on measured properties before and after treatment. The results suggest that the flow rate after treatment increased and improved, the bottom hole flowing pressure (Pwf) is increased also after treatment , the water content is decreased after treatment.

Keywords: Well stimulation. Acidizing treatment. Well damage.

1. Introduction

The production of oil and gas from subterranean reservoirs is affected by a large amounts of associated water that dissolved salts and gases, Under certain conditions these salts precipitate and cause scale deposition.The scale formation in water oil boundary will rise over time and channelling from water permeable zones causing increased water to be produced instead of oil and gas due to scale precipitation [1].

Scale deposition decrease oil and gas production and increase costs owing to equipment failure and maintenance of scaled equipment [2]. To increase oil and gas production the well need to be stimulated. Stimulation Methods in general means of increasing well productivity. In other words, well is fully completed, further stimulation is necessary to achieve the planned productivity Several methods may be applied, depending on the individual situation (. techniques and materials.) There are three principal stimulation methods: Acidizing, Nitro-shooting, and Hydraulic Fracturing Acidizing: is the injection of acid into an acid-soluble zone where as dissolving action enlarges existing voids and thereby increases the permeability of the rock formation.

Acidizing matrix is performed below fracturing rate and pressure. Acid flows through the matrix with reactions taking place in existing pores and natural fractures [3].

When using acid for removal of suspected damage, scale, clays, or some formation rock may be dissolved from the existing flow channels. Only minor increases in productivity will result from this unless damage actually exists [5].

2. Geological Setting of Abu Attifel Field

Abu-Attifel field was the first "giant oil field" discovered in the year 1967, with a total design capacity of 250,000bbl/day. The field is located 60 Km east of Jallo city. Crude oil is pumped through the main pumps to Entsar Field that belongs to Zueitina Oil Company (ZOC) then to the port of Zueitina. [9] .

The Objective of this Study is to evaluate the effect of the stimulation method in treatment of well damage as acidizing method used in Abu-Attifel field formations to minimize the damage and remove the scales to improve well productivity.

The Field located in sirte basin (Figure: (1)) which the reservoir rocks types deposition is Pre-Upper Cretaceous sandstones. The primary trap in the field ranges from anticline (the most common type), nose, and fault block, to reef and wedge-out/truncation Together, they reflect the tectonic history of the basin, with Mesozoic pre-graben arching, pre-Late Cretaceous faulting and nonmarine sedimentation, Late Cretaceous graben development, represented by several arms, and, to a less extent, Eocene-Neogene sag

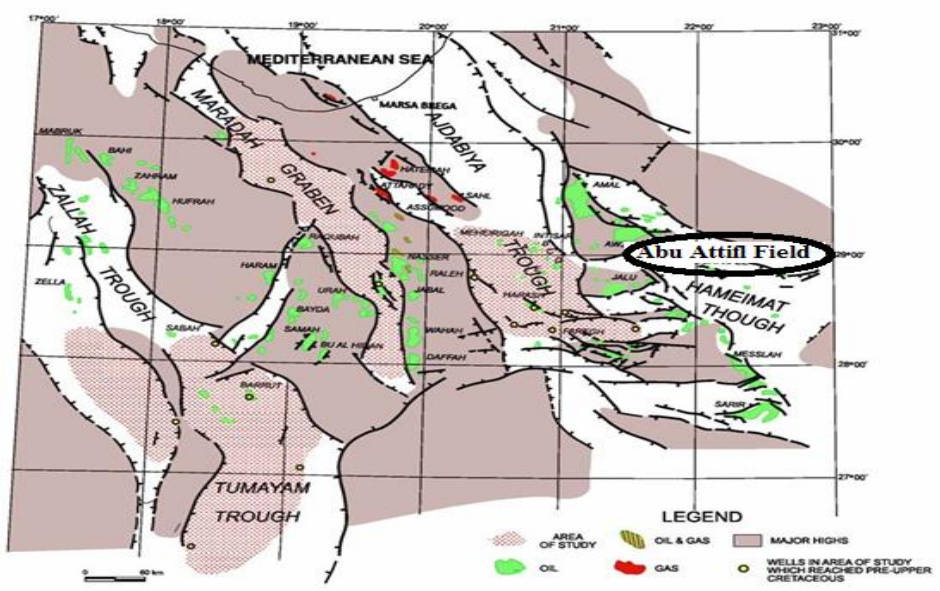

Figure: (1) Map shows Abu Attifel Field location

3. Materials and Methods

3.1 Acidizing treatment

A mineral acid (or inorganic acid) is an acid derived from one or more inorganic compounds. All mineral acids form hydrogen ions and the conjugate base when dissolved in water. Hydrochloric acid. is the most common acid used in a well stimulation and it is the primary acid used to treat carbonate formations. The HCL acid used in Abu-Attifel Field treatment is normally 15% by weight, however, acid concentration may vary between 5% and about 35%. HCL is used to dissolve carbonates such as limestone and dolomite [7] .

HCL reacts with limestone or other carbonates such as dolomite also additives used in the acid, which include: Corrosion inhibitors:

The main function of corrosion inhibitors is to retard corrosion of casing and tubing. Non-emulsifying agents: are often added to prevent formation of an oil-acid emulsion during the stimulation treatment. Such emulsions, if formed, are often highly viscous and cause permeability damage. Since HCL does not react with silicates, it will not dissolve mud cake. Special solutions called mud acids have been developed for this purpose; a common type is a mixture of HCL + HF (hydrofluoric acid), Hydrofluoric acid (HF). has the ability to dissolve

silica (sand) or silicates such as clays, silt, shale and feldspars. HF is normally used in combination with HCL, common ratios show in Table-1

Table-1 Ratios of mixtures

Mixture Type	HCL%	HF%
A	**12**	**3.0**
B	**13.5**	**1.5**
C	**6.0**	**1.5**
D	**3.0**	**0.5**

It is employed exclusively in sandstone acidizing treatment to dissolve formation clays which have migrated into the pore channels from drilling and completion fluids. Fast reaction time and precipitants make HF acid undesirable in carbonate containing sands having more than 20% solubility in HCl. HF acid should never be used in carbonate formations [6] .

Organic acids is an organic compound with acidic properties. The most common organic acids are the carboxylic acids, whose acidity is associated with their carboxyl group COOH, sulfonic acids containing the group, whom are relatively stronger acids and alcohols that with OH, which can act as acids but are usually very weak. The relative stability of the conjugate base of the acid determines its acidity. Acetic acid is used as organic acids used in acidizing treatment: Acetic acid. (CH3COOH) is a weakly-ionized, slow-reacting organic acid [8].

Acid Additives is any material blended with acid to modify its behaviour. Because acid is so naturally corrosive, the development of an additive to reduce acid attack on steel pipe was the first requirement for successful acidizing Surfactants which are chemicals composed on an oil soluble group, Hydrophobic group, water-soluble group, and hydrophilic group.

Corrosion inhibitors are used to prevent corrosion in equipment. When inhibited acid is pumped into a well, the acid will react with the tubing and cause severe corrosion and possibly complete disintegration of the tubing Tabble-2 shows properties of hydrochloric acid with different percentage.

Table -2 Properties of hydrochloric acid (HCL)

HCL%	Specific gravity	Density Ib/ft^3	Density Kg/m^3
1	**1.008**	**62.66**	**1003.6**
3	**1.0147**	**63.28**	**1013.5**
5	**1.0248**	**63.91**	**1023.6**
7.5	**1.0376**	**64.6**	**1034.3**

Acid treatment:

Hydrochloric HCL reacts with limestone or other carbonates rocks according to the following reaction:

$$2HCL + CaC03 = CaCL2 + H20 + C02$$

It is less effective at removing calcium magnesium carbonate (dolomite)

$$CaMg(CO3)2 + 4\ HCl = CaCl2\ \ MgCl2\ 2 + CO2\ 2 + H2O$$

Sandstone formations acid treatment

The hydrofluoric acid HF react with silica

$$4\ HF + SiO2\ = Si\ F4 + 2\ H2O$$

$$SiF2 + 2HF = H2SiF4\ \ (Flu\ silicic\ Acid\ )$$

Organic Acids treatment

$$2HCH_3CO_2 + CaCO_3 \leftrightarrow Ca(CH_3CO_2)_2 + H_2O + CO_2$$
$$HCO_2H + CaCO_3 \leftrightarrow Ca(HCO_2)_2 + H_2O + CO_2$$

The main area of Abu-Attifel field which is producing from the Upper and lower Nubian Sandstone (Cretaceous Sediments) affected by two problems 1-well damage evaluated by the value of the skin factor (S) rated using the following scale:

No damage	$Kd=K$	and	$S=0$
Damaged wells	$Kd<K$	and	$S>0$
Stimulated wells	$Kd>K$	and	$S<0$

Where: - K=Absolute permeability (md).
Kd =Damage permeability (md).
S=Skin factor

The scale deposition problem is affecting Abu-Attifel production since long time. A lot of scale removal jobs have been done on a dozens of wells. There for acidizing treatment has been utilized in order to enhance the production of well that have shown a reduction in production.).

4 Results and Discussion

This study will illustrate and analysis of the effect of acidizing treatment on two wells at several time periods, well No. A7 and well No. A4.The acquired data has shown that well A7 has undergone three acidizing procedures with technical process at various time periods which are as follows:

4.1 Well No. A7

4.1.1 Treatment Procedure

During April 2002-Sepemper 2004 well No. A7 has undergone 4 scale removal procedures and improvement of well damages using acidizing treatment. The results of treatment procedures were taken from Abu-Attifel field first procedure is shown in Table-3.As seen in Table -3 the results of scale removing after acidizing treatment improve the oil production flow rate and gas oil ratio (GOR).

Table-3 Scale removing damage procedures conducted between April 2002-Septemper 2004

Procedure	Date	Pwf (psi)	FlowRate (b/d)	GOR (scf/stb)	Wc (%)	Remarks
1	Apr-02	870	743	743	56	Before
	May-02	910	3542	910	39.4	After
2	Dec-02	1000	965	1000	54.3	Before
	Feb-03	1600	1773	1600	37.4	After
3	Jan-04	850	1422	850	50.9	Before
	Feb-04	900	3652	900	40.2	After
4	Jul-04	950	2076	950	51.1	Before
	Sep-04	930	2923	930	46.5	After

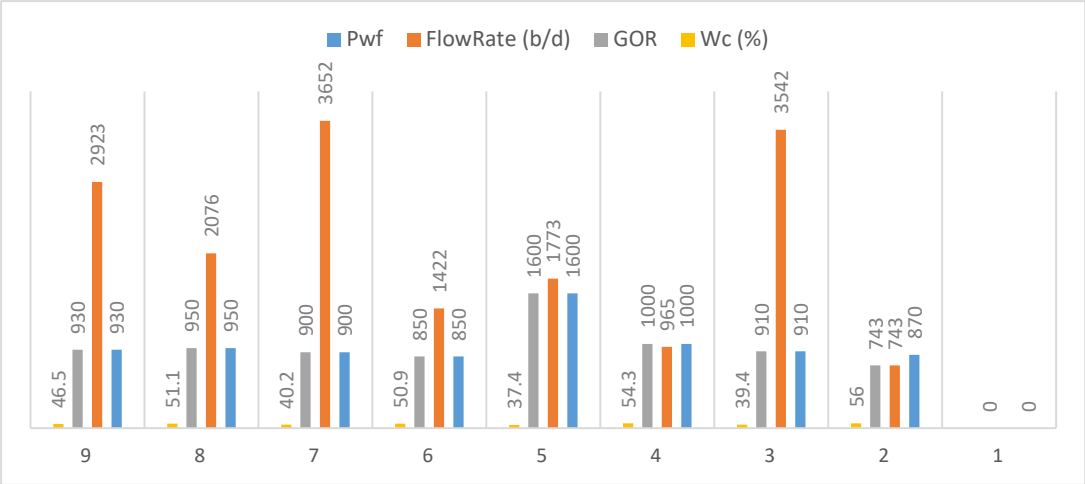

Figure.2 Comparison between Several properties before and after treatment

4.1.2 Low rate improvement

As shown in Table 3, each acidizing treatment procedure has increased the oil flow rate i.e. increased production. This enhancement was most evident during the second procedure, where it led to a 60%increase in oil flow rate. However, this enhancement in flow rate has shown a steady decrease with every acidizing procedure conducted. This is made especially clear during the last procedure where it has led to only 13.19% increase in flow rate. To further illustrate the effect of acidizing treatment on oil flow rate, Figure-1 shows a comparison between flow rate, gas oil ratio and well pressure before and after treatment.

Figure-2 shows the flow rate before and after treatment. As shown in Figure-2 a solid line represents the percentage of treatment and a dashes line shows post production

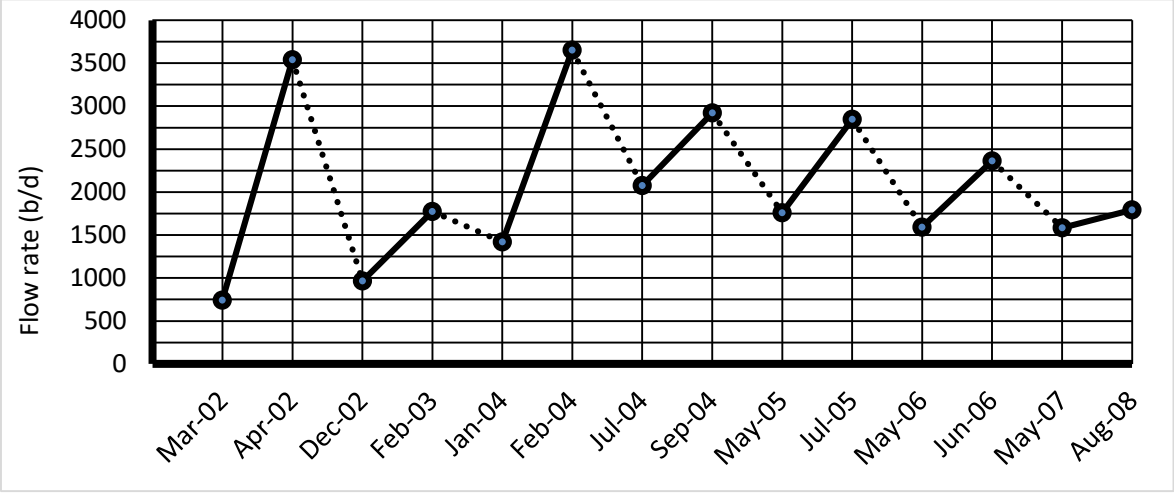

Figure .3 Flow rate improvement after treatment procedure

4.1.3 Gas Oil Ratio (GOR) and Water Cut (Wc)

Also as seen in table-3, GOR and Wc, there has been no obvious pattern in the acquired data to show the effect of acidizing procedure on these parameters. However, the GOR and Wc have shown a decrease with most of the procedures (which is desirable), yet the magnitude of this

decrease has decreased slightly. Figure-3 shows the variation in Wc at each procedure Well Pressure (bottom Hole Flowing Pressure) Pwf

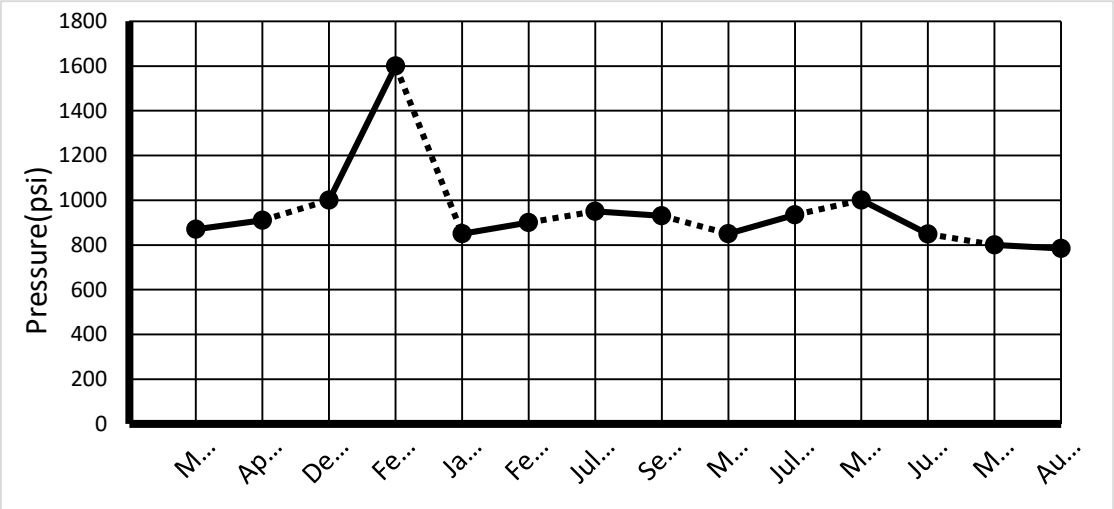

Figure.4 Variation in Pwf at each acidizing procedure Second Treatment Procedure 22 February-1 March 2009

The well pressure (Pwf) has shown very small changes during each process with one exception during the 3rd of February 2003 where it shows a significant increase. However, this increase is likely Not to be due to the acidizing process and other factors may have been the cause of it. Further investigation would be needed to confirm the cause; however, this investigation is outside of this study therefore it is not discussed.

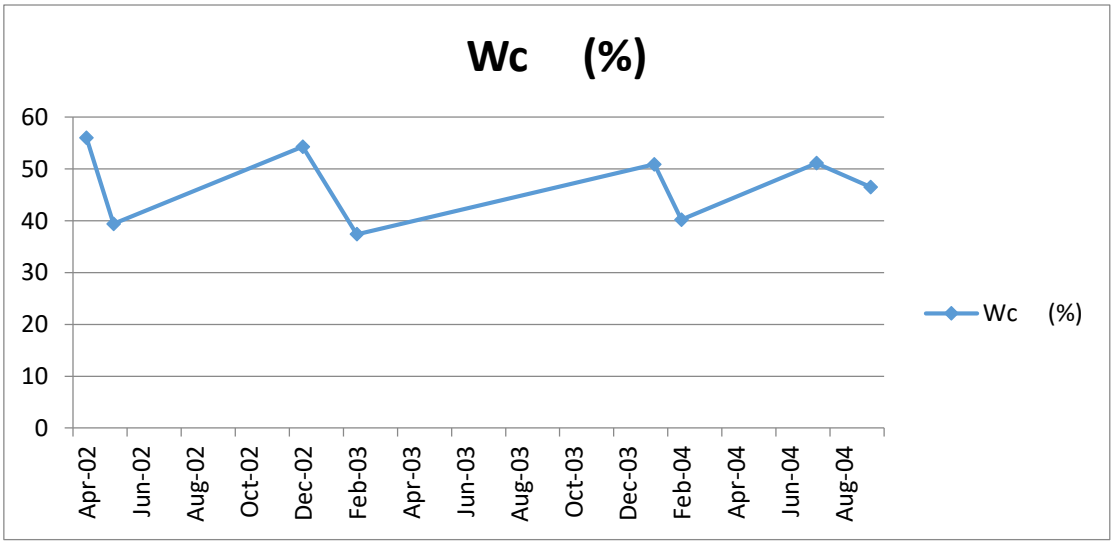

Figure .5Water Cut before and after treatment

During February 2009 an acidizing process was conducted that started on the 22th. Data from the well was taken at 7 times during the month to study the enhancement in production. Table below shows the data acquired during this period.

Table-4 Scale removing damage procedures conducted in Februry 2009

Time (year)	P_{wf} (psi)	Flow rate (b/d)	GOR (scf)	wc%
22/2/2009	965	263	2130	88..0
23/2/2009	875	439	2720	85.9
25/2/2009	810	609	2118	81.4
26/2/2009	805	688	2058	79.5
27/2/2009	805	798	2005	80.3
28/2/2009	805	817	2143	79.9
1/3/2009	800	866	2010	79.5

Results have shown that the oil flow rate increased steadily every day after the acidizing treatment process was conducted. However, the rate of increase in flow rate decreased after each day, where at the first day it increased 66.92% and on the final day it only increased 6%. The overall enhancement during this period was 229.28%, this shows that acidizing treatment process can help improve the production of oil wells that were damaged significantly. Figure-5 helps illustrate this enhancement in oil flow rate during this period.

Figure.6 Enhancement of oil flow rate in well A7 due to acidizing treatment during 22 Feb-1 Mar.The previous table also shows that the GOR has shown a strong increase during the first day after which it decreased to near its original levels and remained relatively steady at this level. As for the Wc, it has shown a strong decrease until the 26th, after which it remained at this level. To illustrate the well pressure during this period, figure below is used. As it can be seen, the well pressure decreased strongly during the first day and then remained at the same level throughout the time period

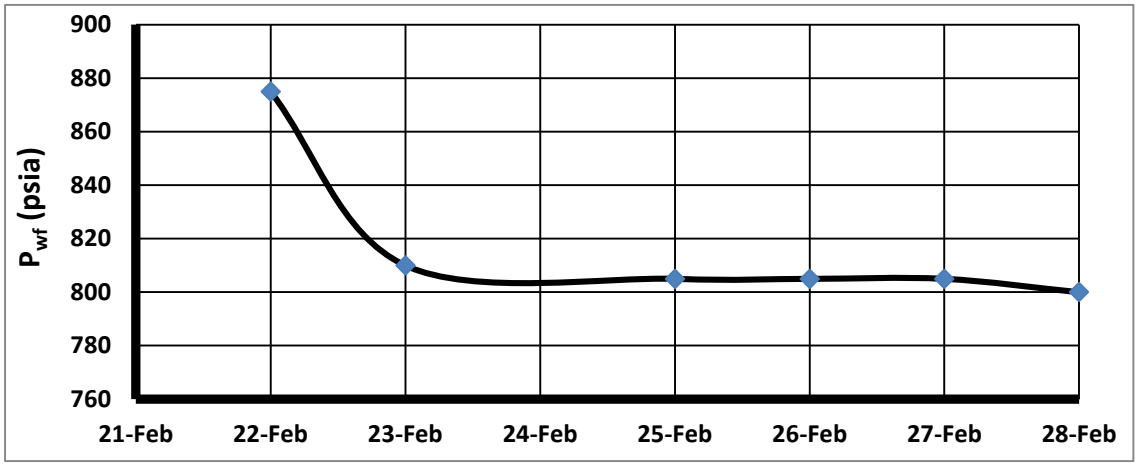

Figure.6 Variation in Pwf during the acidizing process (22 Feb-1 Mar)

4.2 Well No A4

Well A4 has undergone two scale removal procedures via acidizing treatment, the first one during April 2004 and the second one during January 2005. Table-5 shows the results of these processes.

Table-5 . The flow rate after and before scale removal

Procedure	Date	P_{wf}(Psi)	Flow rate (b/d)	GOR (Scf/Stb)	WC %
1	14/04/2004	1000	4274	2044	65.9
	11/10/2004	1115	7407	1930	50.2
2	21/01/2005	900	5558	1747	63
	24/04/2005	900	5421	1836	65.8

Results from the Table-5 shows that the first scale removing procedure has led to a 73.30% increase in oil flow rate, which shows a success in the acidizing treatment process. However, the second procedure has led to a small decrease in production, where the oil flow rate has dropped by 2.46%, this shows that the acidizing treatment process was unsuccessful in enhancing the well's production. The GOR has shown a small decrease during the first procedure (5.56%), however, during the second procedure it increased by 5.09%. The Wc has shown similar behaviour to that of GOR, where in the first procedure it decreased by 23.82% and during the second procedure it increased by 4.44%. as for the Pwf it increased slightly during the first procedure and remained steady during the second.

5 Conclusions

Experimental measurement work was carried out to study the effect of well stimulation. Hydrochloric acid as acidizing material is good for treatment of precipitated scale in rock formation of Abu- Attifel reservoir. Well stimulated by increasing flow rate, and decreasing water content. The bottom hole flowing pressure is increased means improvement of well productivity

Hydrochloric acid injected on plugged rock zone to dissolve scales and enlarge voids in rock formation by improving permeability of the zone. The best results recorded in the whole treatments in October 2004 which water cut is 50.2% and flow rate 7407 b/d

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