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Article

Comparative analysis in mature fields through water exclusion in copano 41 and 45 wells of the Macuspana-Muspac asset

Análisis comparativo en campos maduros a traves de la exclusión del agua, en los pozos copano 41 y 45 del activo Macuspana - Muspac

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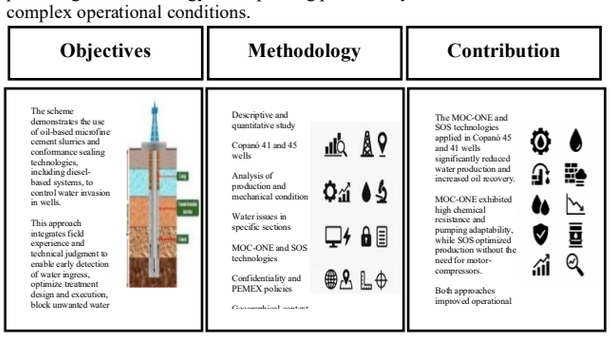
Abstract

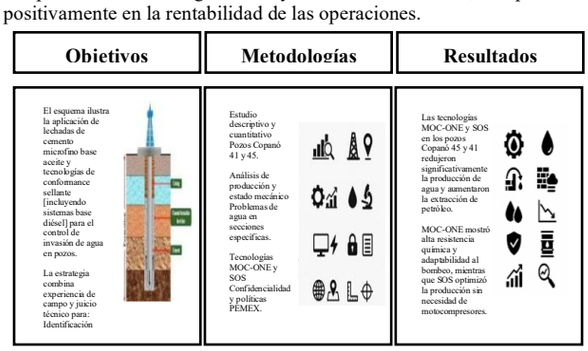
This non-experimental study assesses the effectiveness of Conformance Sealant Technologies, specifically the MOC-ONE and SOS systems, in wells Copanó 41 and 45 of the Macuspana-Muspac Asset in southeastern Mexico. The methodology involved injecting a micro-fine oil-based cement slurry combined with NO_2 gas to seal water-producing zones. Results showed a substantial reduction in water cut, decreasing from 80% to 48%, which led to increased oil production and enhanced operational efficiency. The MOC-ONE system demonstrated high chemical resistance and adaptability to pumping conditions, while the SOS system allowed continuous production without relying on motor-compressors. Successful implementation of these technologies in the challenging environment of this mature field underscores their potential to optimize hydrocarbon recovery and control water production in similar reservoirs. These findings highlight not only technical effectiveness but also the potential economic benefits, providing a viable strategy for improving profitability in mature oil fields with complex operational conditions.



Water exclusion, mature fields, enhanced oil recovery.

Resumen

Este análisis no experimental evalúa la eficacia de las Tecnologías de Conformance Sellante, específicamente los sistemas MOC-ONE y SOS, en los pozos Copanó 41 y 45 del Activo Macuspana-Muspac, en el sureste de México. La metodología consistió en la inyección de una lechada de cemento microfino base aceite y gas NO_2 para sellar zonas productoras de agua. Los resultados demostraron una reducción significativa del corte de agua, desde un 80% hasta un 48%, lo que a su vez incrementó la producción de petróleo y mejoró la eficiencia operativa. El sistema MOC-ONE mostró alta resistencia química y adaptabilidad al bombeo, mientras que SOS permitió mantener la producción sin necesidad de moto-compresores. La exitosa aplicación de estas tecnologías en las condiciones extremas de este campo maduro subraya su potencial para optimizar la recuperación de hidrocarburos y gestionar la producción de agua en yacimientos similares, impactando positivamente en la rentabilidad de las operaciones.



Exclusión de agua, campos maduros, recuperación mejorada de petróleo.

Area: Dissemination and universal access to science

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Introduction

In the early 1990s, certain alternatives in cementing technologies for producing wells began to be explored, using oil-based micro-fine cement slurries as the technique. Although the initial treatments were successful, results declined due to field-related variables. Currently, treatments have been modified, and certain components have been introduced to serve as diesel-based sealants, such as the MOC-ONE and SOS systems.

The ten main basic water problems affecting production in mature fields have been identified, including: casing leaks, production tubing or packer leaks; channeling behind the casing; dynamic water-oil contact; flooded zone without transverse flow; fractures or failures between injector and producer wells; fractures or failures in a water layer; coning or cusp formation; poor sand sweep; gravitational segregation; and flooded zone with transverse flow.

Background

Currently, for every barrel of oil extracted, barrels of water are generated, which implies an annual expenditure exceeding 40 billion dollars to manage unwanted water. This situation affects both hydrocarbon production and treatment. Globally, 75% of well production is water, with daily production exceeding 250 MMBPD. By 2035, oil production is expected to reach 97 million barrels and water production 300 million barrels, with significant savings possible by reducing water production. In some sectors of the North Sea, water production increases in the same proportion as oil production rates decrease in the reservoirs. [Bailey, 2000]

It is proposed that, when extracting oil from a reservoir, at some point water from an underlying aquifer or from injection wells combines and is produced together with the oil. This movement of water through the reservoir is known as the water cycle. [Bailey,2000]

Numerous and varied criteria have been proposed to calculate the costs related to unwanted water production. These costs are estimated to range between 5 and over 50 cents per barrel of water, depending on these criteria and the specific operational conditions. [Reyna, 2023]

Objectives

To convey field experiences and the application of sound judgment on how to perform these operations through the use of ultra-fine oil-based cement slurries or conformance sealing technologies, including diesel-based systems.

Specific Objectives

1. Timely identification of the water invasion problem.
2. Designing an appropriate treatment and suitable application technique for the technology.
3. Blocking the water flow while avoiding damage to the production zone.
4. Delaying water coning in well production.

Methodology

This descriptive and quantitative study analyzes data from Copano 41 and 45 wells using repair reports and technology tests. It evaluates production and mechanical status, identifying water issues through comparative analysis.

Focus is placed on MOC-ONE and SOS technologies. The study is academic, respecting PEMEX policies and document confidentiality. It centers on the Macuspana-Muspac production asset in Pichucalco, Chiapas. Copano 41 is located at 52.908 m above sea level, with detailed mechanical and geographic characteristics provided.

Results

MOC-ONE TECHNOLOGY TEST IN COPANO 45

The study is descriptive and quantitative, focused on analyzing information related to the Copanó 41 and 45 wells, using specific repair reports and technological tests. Data on production and the mechanical condition of both wells will be evaluated, identifying water-related problems in different sections through comparative analysis. Emphasis will be placed on the application of MOC-ONE and SOS technologies to improve water management.

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The study is limited to academic purposes, respecting the policies of Petróleos Mexicanos [PEMEX] and ensuring the confidentiality of internal documents. It specifically addresses the Macuspana-Muspac production asset, which includes these wells, located in Pichucalco, Chiapas. Copanó 41 is situated at 52.908 m above sea level, and its mechanical and geographic characteristics will be detailed, with specific coordinates provided for a comprehensive analysis of the production context and its impact on the region.

Box 1

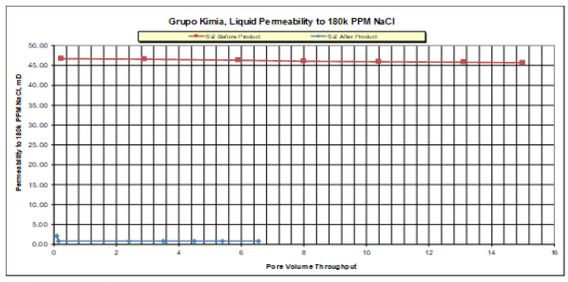

Figure 1

Laboratory test of permeability in Copanó 45 well, Kimia S.A. de C.V. Group, MACUSPANA-MUSPAC Production Asset, 2016.

Admission test of moc-one technology in copanó 45 well

An admission test was conducted with rates of 3–5 bpm, using a total volume of 112 bbls [17.8 m³], initial pressure of 573 psi, and final pressure of 0 psi.

The scheduled volume was adjusted because a pressure of 0 psi was observed, so it was not necessary to pump additional fluid into the well.

Box 2

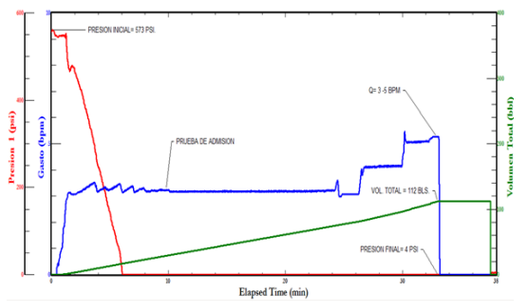

Figure 2

Fluid admission rate test in the well, Kimia S.A. de C.V. Group, MACUSPANA-MUSPAC Production Asset, 2016.

Moc-one technology treatment

As shown in the graph, only friction pressures were observed in the pumping lines; there was no backpressure during the system pumping, which indicates that there was no premature activation of the system. The displacement volume was adjusted from 25 m³ to 20 m³ [5 m³ of spacer plus 15 m³ of treated water] due to the well's admission conditions and to avoid over-displacement of the system.

The TR was maintained throughout the treatment, averaging 1400 psi, which indicates that no fluid entry occurred in the annular space.

Box 3

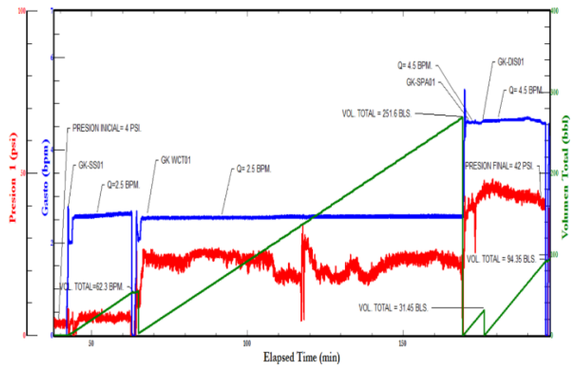

Figure 3

Fluid pumping test in Copanó 45 well, Kimia S.A. de C.V. Group, MACUSPANA-MUSPAC Production Asset, 2016.

Production behavior

During this phase of analysis, the volume of water extracted from the oil well initially showed high values, with percentages of 80% and 81% at the end of October and the beginning of November 2016.

However, from November 16, a notable reduction in water production was observed, reaching 53%. This decline continued more markedly on November 17, when water production dropped to 49%, allowing oil extraction to slightly exceed water production for the first time in the analyzed period.

Later, on November 30, a slight increase in water production was observed, reaching 57%, although it did not return to the high levels seen at the end of October and the beginning of November. In the first days of December, water production stabilized around 49% and 48%, reaffirming a downward trend compared to the initial records.

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The oil well activity during the studied interval reflects a significant decrease in the amount of water extracted, resulting in an increase in oil production.

This phenomenon may suggest that the well has improved its efficiency or that more effective water management methods have been adopted. This is illustrated in the table and figures presented below.

Box 4

Table 1

Water production behavior in the well, Kimia S.A. de C.V. Group, MACUSPANA-MUSPAC Production Asset, 2016

Fecha	Qliq	Qo	Qw	%Agua
22-oct-16	437	89	348	80%
04-nov-16	326	63	263	81%
16-nov-16	279	132	147	53%
17-nov-16	355	180	175	49%
30-nov-16	236	102	134	57%
01-dic-16	234	119	115	49%
05-dic-16	232	121	111	48%

Box 5

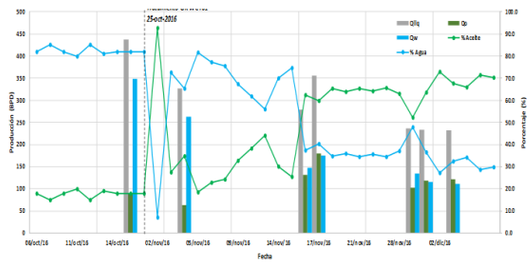

Figure 4

Performance in production with GK WCT01 treatment, Kimia S.A. de C.V. Group, MACUSPANA-MUSPAC Production Asset, 2016.

Box 6

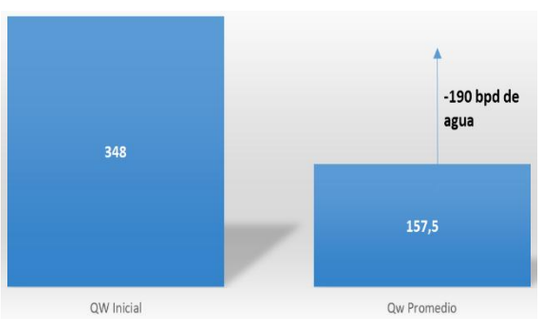

Figure 5

Water Production in Barrels per Day [BPD], Grupo Kimia S.A. de C.V., MACUSPANA-MUSPAC Production Asset, 2016.

System evaluation

Based on the observed characteristics of the oil well, the following points should be considered. The system exhibits a gradual response when it comes into contact with water, which promotes moderate and deep infiltration into formation fractures and relevant micro-annular areas.

This property is advantageous for selective water sealing, as it hardens exclusively in sections where water-bearing strata are present, increasing well effectiveness.

Additionally, the system's resistance to acidic conditions ensures the durability and stability of the treated formations, even under chemically aggressive environments. The ability to be pumped through flexible tubing [FT] adds adaptability to the system, allowing its application in various well configurations.

These characteristics demonstrate that the well has an enhanced capacity to manage water production, reducing its presence in hydrocarbon-producing zones and improving the selectivity of water sealing. Acid resistance and ease of pumping through FT reinforce these advantages, making this system a robust and effective solution for optimizing well production.

Box 7

Table 2

Reaction Activation Times of Brine Types, Grupo Kimia S.A. de C.V., MACUSPANA-MUSPAC Production Asset, 2016.

Tipo de Salmuera	Densidad	Ppm	Tiempo de Activación [min]
Agua de perforación	1.024	2,857	19:24
Agua de mar	1.041	19,047	22:36
Salmuera Cloruro de calcio al 37%	1.20	187,618	55:36
Salmuera Cloruro de calcio al 18%	1.15	107,618	29:48
Salmuera Cloruro de calcio al 5%	1.06	33,333	22:48
Salmuera Bromuro de calcio	1.26	134,761	26:00
Salmuera Bromuro de calcio	1.18	78,095	20:23

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Box 8

Table 3

Penetration Capacity of Cement Types, Grupo Kimia S.A. de C.V., MACUSPANA-MUSPAC Production Asset, 2016.

Tipo de Cemento	Densidad [gr/cc]	Ancho de la Fisura [Pulg]	Porcentaje de la lechada penetrando a través de la fisura [%]
Micromatrix cement	1.45	0.006	91
Clase H	1.97	0.006	0
ΔP= 90 psi		Temperatura= 24 $_0$C	

Box 9

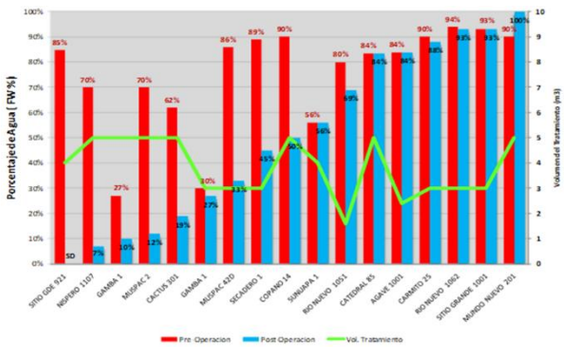

Figure 6

Background on the Application of Moc-ONE Technology in Different Wells of the Integrated Asset, Grupo Kimia S.A. de C.V., Macuspana-Muspac Production Asset, 2016.

Box 10

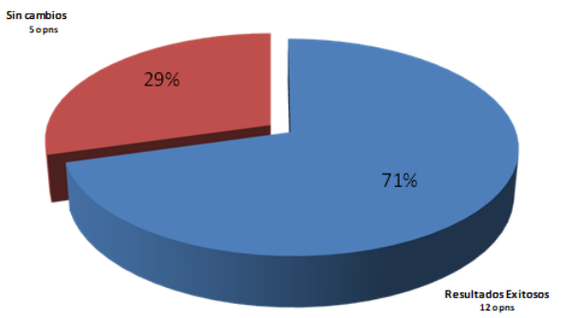

Figure 7

Succ3ess Rate of Moc-ONE Technology Operations in Different Wells of the Integrated Asset, Grupo Kimia S.A. de C.V., Macuspana-Muspac Production Asset, 2016.

SOS technology test in the copanó 41 well

The objective was set to restore a well to produce 150 bpd of oil and 1.0 MMcf/d of gas, in accordance with PEP's strategic goals.

Production analysis shows a strong start, with stability up to 90 days, followed by an increase in gas production and then a decline.

Strategic interventions have revitalized oil production; however, since 2004, gas production has decreased and water production has increased, indicating the need to adjust the strategies.

Box 11

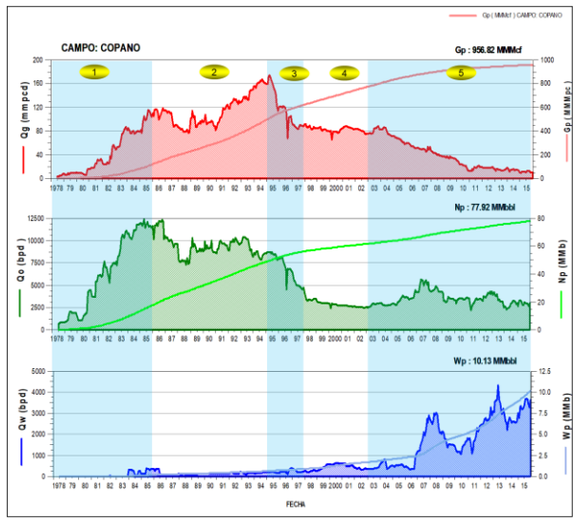

Figure 8

Historical Production Behavior of the Copanó Field, Copanó 41 Well Project, Macuspana-Muspac, 2016.

Box 12

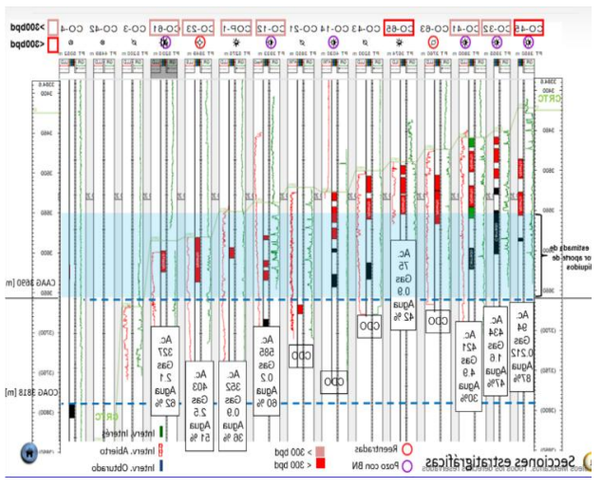

Figure 9

Stratigraphic Behavior of the Copanó Field, Copanó 41 Well Project, Macuspana-Muspac, 2016.

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Discussions

Currently, the fields of the Muspac Asset exhibit static pressures of 50–100 kg/cm², where operational conditions have been adjusted for well treatment. A novel approach includes the use of volumes up to 6 m³ and prior bore cleaning with mechanical tools. It is recommended to test admission using centrifuged diesel and, when using nitroglycerin pumps, to prevent blockages with diesel or nitrogen.

To evaluate the need for additional treatments, radioactive tracers and over-displacement of the initial treatment are suggested. Logging of traced zones is crucial to define areas of effective placement.

In the analysis of wells from the Macuspana-Muspac asset using MOC-ONE technology, a 20% to 35% reduction in water production was observed, resulting in an increase in oil production. This change, in addition to improving efficiency, has a positive impact on costs and the operation's economics by reducing expenses related to water handling. Moreover, MOC-ONE technology not only provides an economic benefit but also promotes a more sustainable operation. Based on the results, it is suggested to continue implementing this technology in other wells with similar characteristics, accompanied by continuous monitoring to optimize results.

Previous experiences demonstrate that a data- and experience-based approach can improve the effectiveness of treatments applied in wells, contributing to better resource management in the petroleum industry.

Conclusion

The Oil-Based Ultra-Fine Cement Slurry system and SOS technology are effective strategies for water control in wells. These systems have reduced water cut to very low levels and allow production to remain open without the need for motor compressors, resulting in significant cost savings.

To optimize flow after treatment, it is recommended not to overproduce the interval.

Some recommendations include: identifying the source of water through cementing logs and PLT or PT analysis; using curve plots for diagnostic purposes; combining RPM to saturate zones of higher contribution before applying the Ultra-Fine Cement treatment; and, if additional treatment is required, inducing the well to attract water again.

In the Madura Macuspana-Muspac field, advanced technologies were implemented, highlighting the Copanó 41 well, which showed a significant increase in production after a minor repair. In 2016, SOS technology was applied, achieving a 20%–35% reduction in water production and a 10% increase in oil production, suggesting favorable economic viability for the future.

The Copanó 45 well, which underwent a major intervention using MOC-ONE technology, also showed a significant decrease in water production. The key is selecting the appropriate intervention to maximize benefits. Both SOS and MOC-ONE systems have proven effective, improving profitability and operational efficiency.

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