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Estimating the productivity index for some libyan wells using prosper and kappa saphir softwear

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A B S T R A C T

Pressure buildup tests are one of the most common types of transient tests. In these tests, the well is produced at a constant rate for an extended period to achieve a stable pressure distribution, and then it is shut-in. Proper well shut-in is crucial as incorrect procedures can lead to inaccurate calculations. This study aims to interpret the pressure transient behavior in vertical wells that underwent pressure buildup tests for the bu-attifel field. The main objectives of the study involves analyzing the pressure buildup tests of three wells using KAPPA SOFTWARE, to estimate the permeability and skin factor for each well. Subsequently, the productivity index of each well is estimated using PROSPER SOFTWARE. Based on the derived parameters from the pressure buildup tests, the obtained results are compared with new production test data. Following that, a sensitivity analysis is performed for permeability and skin factor to diagnose the well condition and enhance productivity. We have obtained the results of the well-test analysis, and they are as follows: (A1=12.75 md), (A13=10 md), (A57=176 md). For permeability with positive skin factor values and the reservoir pressure, the results are: (5569 psi, 6232 psi, 6170 psi). Based upon the outcome, the productivity index for the wells was improved after comparing it with the new production test data. Sensitivity analysis was conducted to identify the factors influencing the productivity index of the wells.

تقدير مؤشر الإنتاجية باستخدام المعادلات

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الكلمات المفتاحية:
اختبار الآبار
اختبارات تراكم الضغط
برنامج بروسبر
برنامج كابا
مؤشر الإنتاجية

الملخص

تعد اختبارات تراكم الضغط أحد أكثر أنواع الاختبارات العابرة شيوعًا. في هذه الاختبارات، يتم إنتاج البئر بمعدل ثابت لفترة ممتدة لتحقيق توزيع مستقر للضغط، ومن ثم يتم إغلاقه. يعد إغلاق البئر بشكل صحيح أمرًا بالغ الأهمية لأن الإجراءات غير الصحيحة يمكن أن تؤدي إلى حسابات غير دقيقة. تهدف هذه الدراسة إلى تفسير سلوك الضغط العابر في الآبار العمودية التي خضعت لاختبارات الضغط المتراكم لحقل بو الطفل. تتضمن الأهداف الرئيسية للدراسة تحليل اختبارات تراكم الضغط لثلاثة آبار باستخدام برنامج ECRIN لتقدير النفاذية وعامل الجلد لكل بئر. وبعد ذلك، يتم تقدير مؤشر الإنتاجية لكل بئر باستخدام برنامج PROSPER استنادًا إلى المعلمات المشتقة من اختبارات تراكم الضغط، وتتم مقارنة النتائج التي تم الحصول عليها مع بيانات اختبار الإنتاج الجديدة. بعد ذلك يتم إجراء تحليل الحساسية للنفاذية وعامل الجلد لتشخيص حالة البئر وتعزيز الإنتاجية في هذه الآبار. لقد حصلنا على نتائج تحليل اختبار الآبار وهي كالتالي (A1=12.75 md) و (A13=10 md) و (A57=176 md) للنفاذية ذات قيم عامل الجلد الموجبة وضغط المكمن (5569) رطل لكل بوصة مربعة، 6232 رطل لكل بوصة مربعة، 6170 رطل لكل بوصة مربعة). وبناء على هذه النتائج تم تحسين مؤشر الإنتاجية للآبار بعد مقارنته ببيانات اختبار الإنتاج الجديد، كما تم إجراء تحليل الحساسية للتعرف على العوامل المؤثرة على مؤشر الإنتاجية في هذه الآبار.

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1. Introduction

In the production system, engineers in the oil and gas sector face complex engineering challenges related to increasing production, improving efficiency, and reducing costs. These challenges require the utilization of engineering knowledge and technology to analyze current operations and develop innovative solutions to maximize the utilization of oil resources [1][2]. The role of engineers in improving productivity begins with analyzing and evaluating current production processes in oil fields. Monitoring, measuring, and data analysis techniques are used to understand the performance of wells, and the overall extraction process. Obstacles that negatively impact productivity, such as Rock formations and unwanted solid deposits, are identified [3][4][5]. Through analysis and evaluation, engineers work on developing innovative engineering solutions to enhance productivity. This may involve designing advanced drilling techniques, improving fluid flow, and implementing flow and pressure control technologies. They aim to increase production rates, reduce costs, and enhance operational efficiency in the oil and gas industry [6][7][8]. The internal flow performance (IPR) is considered a key factor influencing the production process in oil fields, and understanding internal flow performance (IPR) is crucial for production engineers. It helps them determine the optimal reservoir pressure and estimate the expected flow rate from the well. By studying internal flow performance (IPR), engineers can improve production design and select appropriate technologies to increase production efficiency and enhance well performance [7][8][9][10].

2. Methodology

Several steps were run to reach the main objectives of this paper. These steps start with gaining technical and practical knowledge regarding aspects of well-testing and production engineering. Then proceed through software training for PROSPER & KAPPA software. The last step is processing data for three wells to be suitable for the project objectives. The process is summarized as follows:

1. Data collection by: (PVT data, well production test, pressure test data …etc.)
2. Analysis of the build-up tests to obtain well and/or reservoir data, e.g., reservoir permeability (K), skin factor (S), average reservoir pressure (Pavg.) ... using ECRIN software.
3. Using production test data estimate the well productivity index (Pl) by PRSOPER software.
4. Comparison of the results obtained from BU's data with production of test data.
5. Run sensitivity analysis of different parameters such as permeability, skin factor ... etc. To explain the effect of each parameter on well productivity index.
6. Perform well productivity performances using PROSPER to diagnose main reservoir or well factor that effected well productivity.

3. Results and discussion

3.1. Well Analysis and Results

3.1.1. Buildup Test Analysis (Well A13)

An analysis was performed on the pressure buildup data collected from well A-13, the goal of the test is to determine the permeability (K), skin (S), average reservoir pressure (P) and flow efficiency (FE). The well was producing at a rate of about 4183.00 STB/day oil, production time 22.1hrs.was calculated since the well was first produced. The analysis was started by inserting the main well data and PVT data of the well. Then, inserting the flow and shut-in periods. The well produced 4183 STB/D during 22.1hrs. while the shut in lasted for 22.9830 hrs. The third step was inserting the pressure test data (pressure and time) of well A-13. After completing the insertion of all required data, the ECRIN will develop the semi-log plot and log-log plot to start the analysis of the test to perform different models to determine the well parameters. The usage of various models in ECRIN is to have a good fitting. After running several runs the model was (homogeneous reservoir and infinite boundary reservoir model), as shown in Figures 1 and 2.

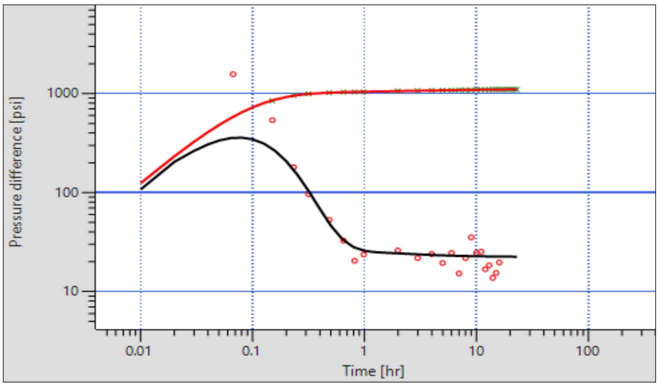

Fig. 1: loglog plot for well A13

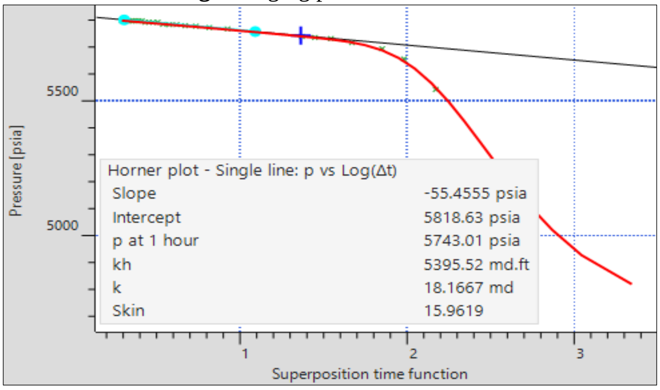

Fig. 2: Horner plot for well A13

After completion of the model analysis of well A-13, the results were: Reservoir permeability (18.16md), skin factor is positive (15.96), and finally reservoir pressure (5803) this was run in (1989)

3.1.2. Well Production Model (Well A13)

The Start data input was by inserting the PVT data from PVT report and running the models to select best correlation to work in the model. After completing the inserting of the data to build the well model, the output of the PVT modelling is as follows:

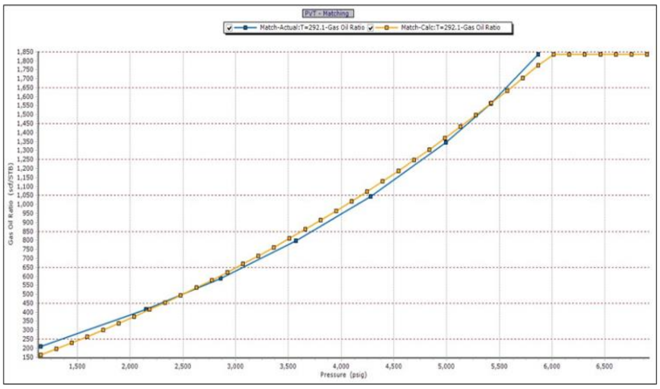

Fig. 3: Pressures vs Gas Oil Ratio A13

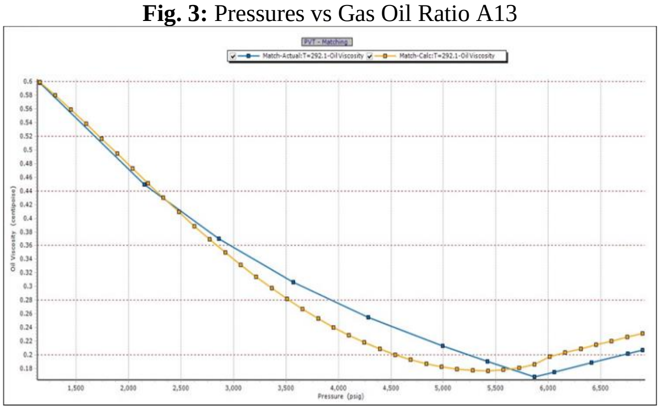

Fig. 4: Pressures vs oil viscosity A13

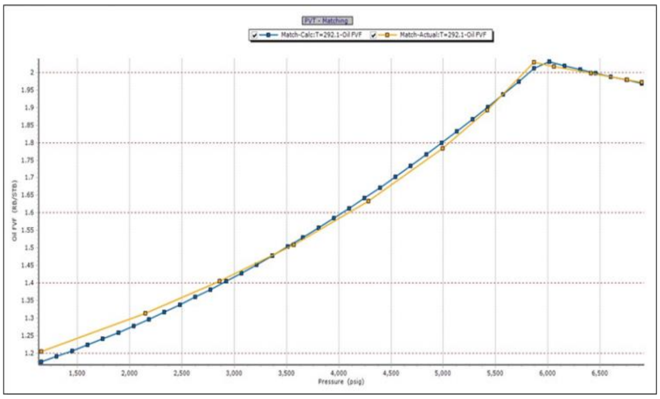

Fig. 5: Pressures vs Oil FVF A13

The Figures (3), (4) and (5) show matching results of PVT data as compared with laboratory results using empirical correlations. The next step in building the model is entering EQUIPMENT DATA (Deviation Survey, Downhole equipment, Geothermal gradient). Then (IPR/VLP "Quality Check"). Enter the buildup data and its production data to run the models, and then select the best correlation to work the model. The best correlation was chosen, and it was Orkiszewski.

Match the data from IPR/ VLP (A13)

The objective of this process is to match the data from Inflow Performance Relationship (IPR) and Vertical Lift Performance (VLP) curves. When the data is matched, the error rate for each parameter such as liquid Rate (10%), Bottom hole flowing pressure (1.5%), is displayed. We can make adjustments to the IPR data in order to reduce the error rate as shown in Figure (6).

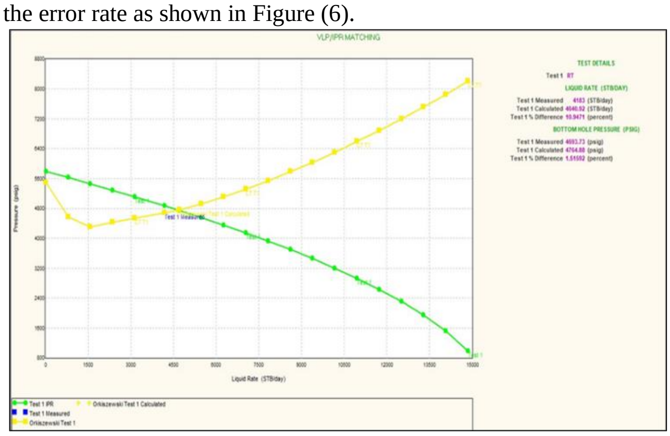

Fig. 6: Match the data from IPR/ VLP all well system A13

There is no fixed method for adjusting the IPR data, and we were uncertain about the reservoir pressure. Therefore, we adjusted the reservoir pressure from (5803) to (5613) and reduced the error rate as shown in Figure (7).

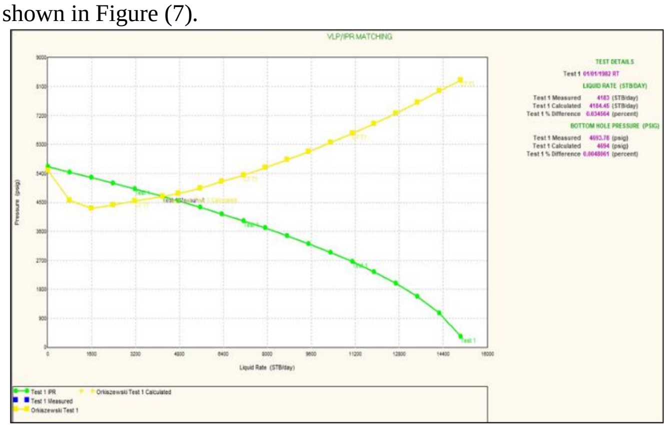

Fig. 7: After Match the data from IPR/ VLP all well system A13

After completing the well modeling the IPR/VLP and productivity estimation were worked on using two methods of production and pressure tests:

Table. 1: Test Type: Production Test

Parameters	Value
Reservoir pressure	6232 psi
GOR	2063(Scf/bbl)
WC	70.6%
Wellhead Pressure	847 psi
Oil Rate	1056 STB/D
Water Rate	2537 bbl
Liquid Rate	3593 bbl/day
Bottom hole flowing pressure	4477 psi

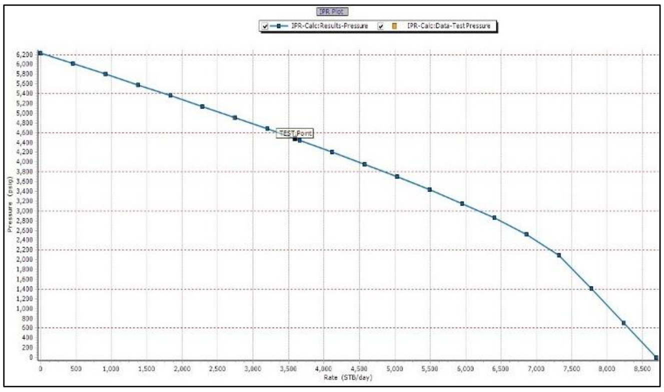

Fig. 8: IPR plot for well A-13 using Production Data

Table. 2: Test Type: Buildup Test

Parameters	Value
Reservoir pressure	5613 psi
Reservoir thickness	297 ft
Drainage radius	753.399 ft
Permeability	18.166 md
Skin	+15.96

IPR / VLP curve plotting using PROSPER as shown in Figure (12).

As comparing the PI and IPR /VLP curve from the two tests, the current production test shows that the well productivity was reduced from the last pressure test. Therefore, there was a need to diagnose the main parameter that reduced productivity to solve and improve the parameter, PROSPER was used for selectivity analysis.

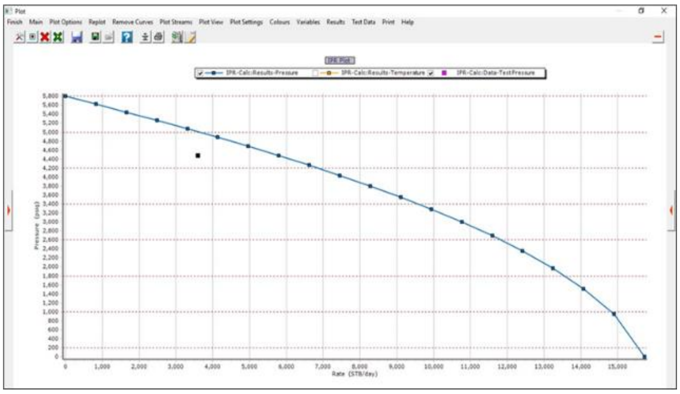

Fig. 9: IPR plot for well A-13 using Pressure test Data and test point form production

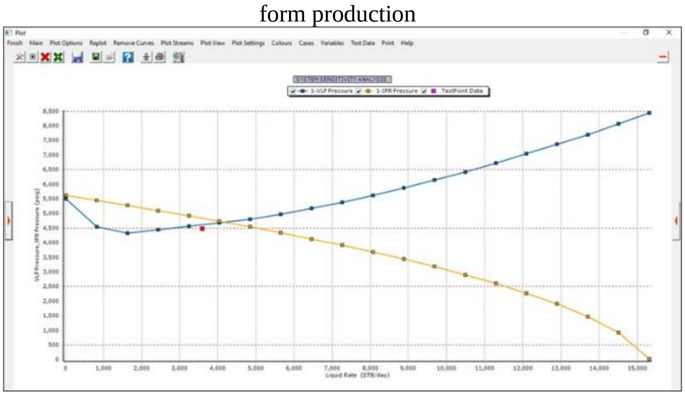

Fig. 10: IPR and VLP plot for well A13 using Pressure test Data and test point form production

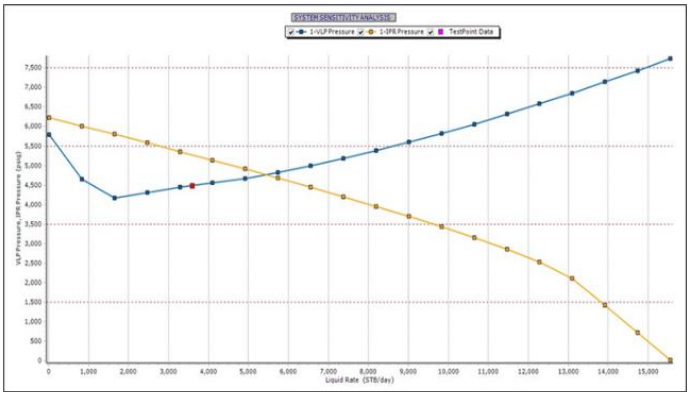

Fig. 11: before Sensitivity IPR plot for well A-13

Sensitivity analysis used three parameters (reservoir pressure, skin, and permeability) to diagnose the main reason for reduced productivity by comparing the results with the production test point. (Red point) as shown in Figure (12)

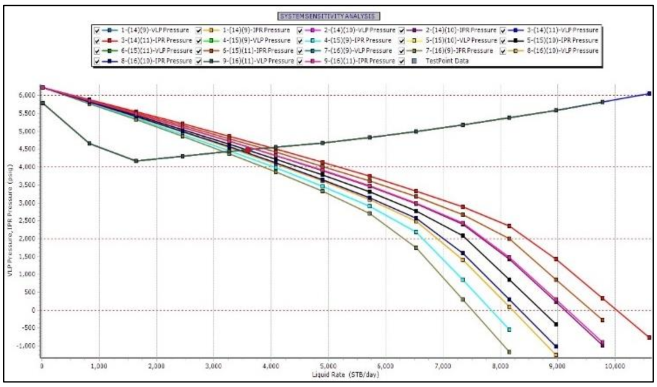

Fig. 12: Sensitivity analysis plot for well A-13

After running the first sensitivity analysis using different values for skin, permeability, and a constant reservoir pressure, one of the results showed a match with the operating point. So, the number of results was reduced to obtain the curve that matches the operating point. as shown in Figure (13).

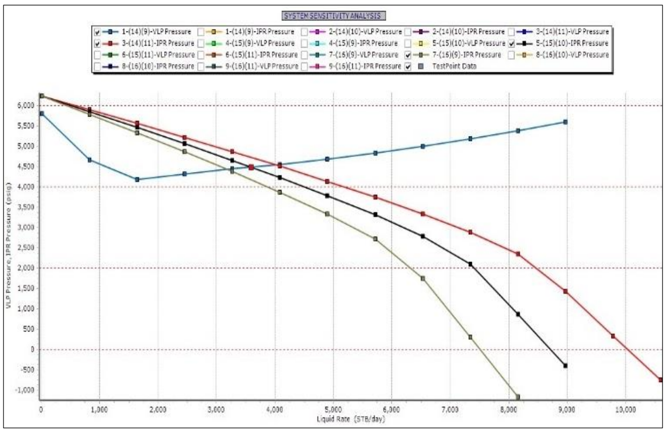

Fig. 13: Sensitivity analysis plot for well A-13

The final sensitivity analysis that represents the well production conditions shows the well status that the well damaged due to reduce the low reservoir permeability from 18.166 md to 10 md and slight improvement in the skin factor, from 15.96 to 15 as shown in Figure (14)

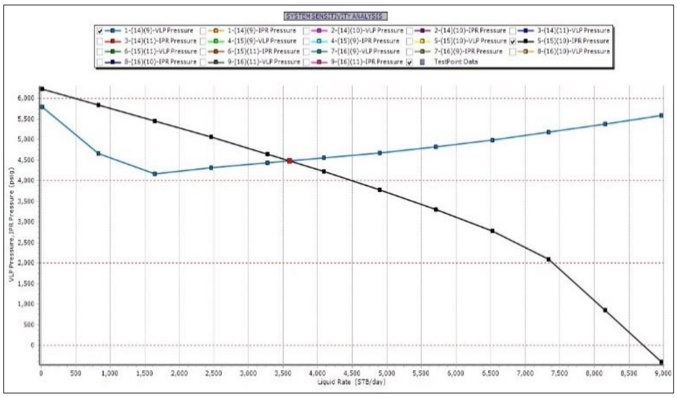

Fig. 14: Final Sensitivity analysis plot for well A-13

As comparing the results between the production and pressure test the results show that the main factor that reduced the well productivity is decreasing the reservoir Permeability, so recommended to stimulation job to improve the productivity and maintain the water cut to avoid increase water production.

Table. 3 : Comparison of Results (production and pressure tests) A13

Test type	Skin	Permeability	P.I A	P.I I
#	#	(md)	STB/D/psi	STB/D/psi
Buildup	15.96	18.16	4.73	14.95
production	15	10	2.14	6.59

3.1.3. Well Analysis and Results (Well A-1)

An analysis was performed on pressure accumulation data collected from well A1, permeability (130) md, and skin (12.7) were determined by Horner's method

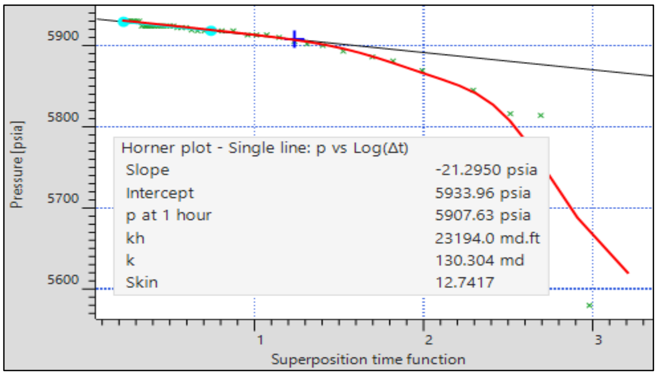

Fig. 15: Horner plot for well A-1

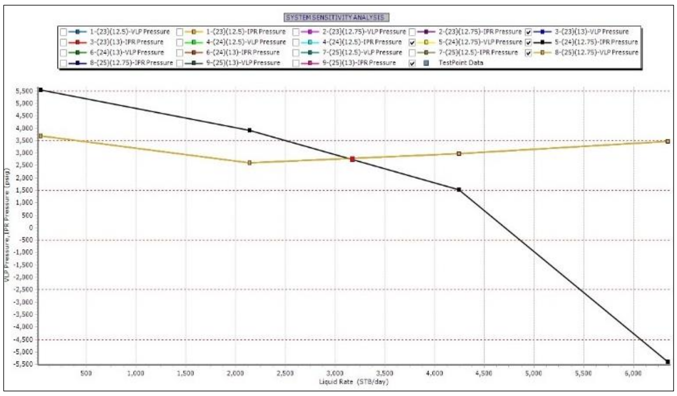

Fig. 16: Final Sensitivity analysis plot for well A-1

The final sensitivity analysis for well A-1 shows the following results

Table. 4: Final Sensitivity values for A-1

Parameters	Value
K	12.75md
S	24+
PI	1.32STB/D/psi

As comparing the results between the production and pressure test the results show that the main factor that reduced the well productivity is High decline the reservoir Permeability

Table. 5: Comparison of Results (production and pressure tests) A1

Test type	Skin	Permeability	P.I A	P.I I
#	#	(md)	STB/D/psi	STB/D/psi
buildup	12.7	130	20.46	51.13
production	24	12.75	1.322	5.35

3.1.4. Well Analysis and Results (Well A57)

An analysis was performed on pressure accumulation data collected from well A57, permeability (183) md, and skin (84) were determined by Horner's method.

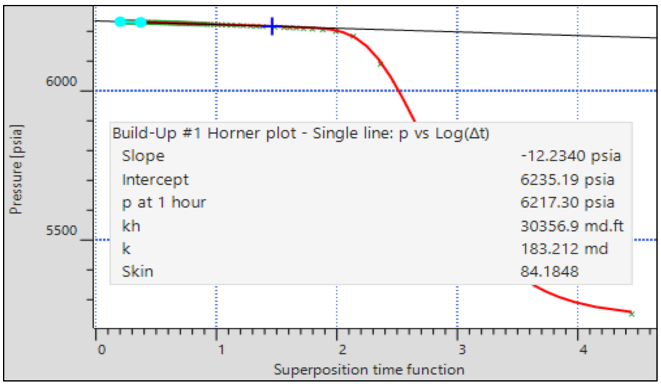

Fig. 17: Horner plot for well A-57

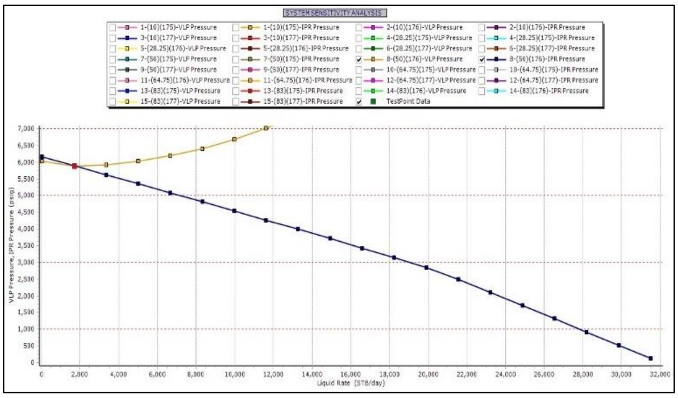

Fig. 18: Final Sensitivity analysis plot for well A-57

The final sensitivity analysis for well A-57 shows the following results:

Table. 6: Final Sensitivity values for A-57

Parameters	Value
K	176md
S	50+
PI	6.04STB/D/psi

By comparing the results between the production and pressure test the results show, the main factor that improved the well productivity was decreasing the skin factor.

Table. 7: Comparison of Results (production and pressure tests) A57

Test type	Skin	Permeability	P.I A	P.I I
Buildup	84	183 md	3.88STB/D/psi	40.75STB/D/psi
Production	50	176 md	6.04STB/D/psi	41.64STB/D/psi

4. Conclusions

1. Productivity index can be obtained from two methods: firstly from well pressure test data, and secondly from the well production test data.

2. Well build up test analysis of A-13 shows that the productivity index is 4.73 STB/D/psi. However, after using production data the productivity index is 2.15 STB/D/psi. This indication of reduced production is due to damaged reservoir reduced permeability. The permeability was first recorded at 18.16md and has later on reached 10md.

3. Well build up test analysis of A-1 shows that productivity index is 20.46 STB/D/psi. Moreover, after using production data the productivity index is 1.322 STB/D/psi. This is an indication of production reduction due to reservoir formation damage and reduced permeability from 130 md to 12.75md.

4. Well build up test analysis of A57 shows that the productivity index is 3.88 STB/D/psi. After using production data the productivity index was 6.04 STB/D/psi. This is a clear sign of improved production with a reduced skin factor from (84 md to 50md).

5. Recommendations

- The results indicate there is a significant impact on the flow rate and productivity index, given by the permeability of the rock and skin factor. Increasing the permeability of the rock increases the flow rate, and reducing the skin factor also increases the flow rate, thus increasing the productivity index. Based on this, it is advised to study all the factors that affect the productivity index.
- Given the outcome of both wells A-13 and A1, the main factor that reduces the well productivity is decreasing and damaging the reservoir permeability. It is recommended to stimulate them to improve their productivity, plus maintaining water cuts to avoid increased water production.
- Considering the findings in well A-57 the main factor that increases the well productivity is decreasing the skin factor. There is also data showing an increase in the percentage of water cuts, which reaches 94%, as the water production is much greater than oil. Therefore it is recommended to control the water cuts to improve the oil flow.

6. Nomenclature

FE = Flow Efficiency
GOR = Gas Oil Ratio, (Scf/bbl).
IPR =Inflow performance relationship.
K = Permeability (md).
PVT= Pressure, Volume, Temperature.
PI = Productivity Index (STB/D/PSI).
PIA = Productivity Index Actual, (STB/D/PSI).
PII = Productivity Index Ideal, (STB/D/PSI).
S = Skin Factor.
VPL = Vertical Lift Performance relationship.
WC = Water Cut

7. References:

[1]- Economides, M. J., Hill, A. D., Ehlig-Economides, C., & Zhu, D. (2013). Petroleum Production Systems (2nd ed.). Prentice Hall.

[2]- Guo, B., Lyons, W. C., & Ghalambor, A. (2007). Petroleum Production Engineering: A Computer-Assisted Approach. Gulf Professional Publishing.

[3]- Ahmed, T. (2018). Reservoir Engineering Handbook (5th ed.). Gulf Professional Publishing.

[4]- Devold, H. (2013). Oil and gas production handbook: An introduction to oil and gas production, transport, refining and petrochemical industry. ABB Oil and Gas.

[5]- Lake, L. W. (2006). Petroleum engineering handbook (Vol. I). Society of Petroleum Engineers. Richardson TX - USA

[6]- Fanchi, J. R. (2010). Integrated Reservoir Asset Management: Principles and Best Practices. Gulf Professional Publishing.

[7]- Rahuma, K. M., Sondi, F., Milad, M., and AbuGheit, M. (2013). Compariso between spreadsheet and specialized programs in calculating the effect of scale deposition on the well flow performance. Journal of Petroleum & GasEngineering, 4(4), 69-80.

[8]- Alhaj, Haiat K., Laila D. Saleh, and Rabia Hunky. "Transient Pressure Analysis and Productivity Index Estimation in Horizontal Wells." (2020).

[9]- Ke, W., Luo, W., Miao, S., Chen, W., and Hou, Y. (2023). A Transient Productivity Prediction Model for Horizontal Wells Coupled with Oil and Gas Two-Phase Seepage and Wellbore Flow. Processes, 11(7), 2012.

[10]- Urayet AA (2000). "Transient Pressure Analysis". Part of the Technical Program Organized for the Petroleum Engineering Department, University of Tripoli, Tripoli.