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Well Performance Analysis Using Nodal Analysis and Prosper- AbuAttifel Field, Libya

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ABSTRACT

Purpose: This study evaluates well-performance using nodal analysis and PROSPER, with the AbuAttifel field in Libya used as the case study.

Materials and Methods: Reservoir, PVT, completion, well-test, and production data were assembled for well-performance modeling. PROSPER was used to build the well model, generate inflow performance (IPR) and vertical lift performance (VLP) relationships, and examine the operating point. The detailed source results are presented for Well A8.

Results: The Well A8 data set includes a skin factor of 4.8, productivity index of 4 STB/day/psi, static bottom-hole pressure of 6369 psi, total liquid rate of 1869 bbl/day, water cut of 93.6%, wellhead pressure of 1040 psi, GOR of 4000 scf/STB, and oil gravity of 42 API. The VLP–IPR plot indicates an intersection near 7,600 STB/day and approximately 2,080 psi, as read from the source figure.

Conclusion: The study demonstrates the use of nodal analysis and PROSPER to integrate reservoir inflow and wellbore/outflow behavior for production-system evaluation. The source document provides a detailed model setup and Well A8 results; numerical sensitivity results for alternative operating conditions are not reported in the supplied thesis. *(J Multidiscip Eng 2026;1:53-58)*

Keywords: Nodal analysis, well performance, PROSPER, inflow performance relationship, vertical lift performance.

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1. INTRODUCTION

Production performance in oil and gas wells is governed by the interaction between reservoir inflow and the pressure losses required to transport fluids to the surface. The supplied thesis describes the production system as a sequence of interacting components including the reservoir, wellbore, tubing string, chokes and valves, surface flow line, and separator. The combined performance of these components provides a basis for production optimization. Nodal analysis is presented in the source as a systems-analysis approach for evaluating interacting production-system components. Its application to producing wells was proposed by Gilbert (1954).[1] In the well-performance framework, the inflow performance relationship (IPR) describes the relationship between production rate and flowing bottom-hole pressure, whereas the outflow or vertical-lift relationship describes the pressure

required to move produced fluids through the wellbore and surface system. The study objective is to optimize well performance and maximize

production rate using nodal analysis, understand IPR and vertical-lift performance, develop a well-performance model using PROSPER, simulate Operating conditions, and evaluate.

Development options for oil-production optimization. The source thesis identifies AbuAttifel field as the case study and reports detailed model and result information for Well A8.

The study is motivated by the decline in oil production and reserves and the need to evaluate well productivity under changing reservoir and production conditions.[2]The thesis also emphasizes that reservoir pressure, water cut, GOR, tubing geometry, wellhead pressure, and other system parameters can change well behavior and therefore need to be represented in performance analysis.[3]

2. MATERIALS AND METHODS

2.1 Study design and data collection

The study follows a well-performance modeling and nodal-analysis workflow. The source describes collection of reservoir properties, PVT data, production data, completion data, and well-test information, followed by well-model construction and performance matching in PROSPER.[4] The reported analysis covers well-by-well performance for 54 wells in AbuAttifel field, while the detailed numerical results supplied in the thesis are presented for Well A8.

The source identifies the following principal data requirements: permeability, porosity, reservoir pressure, reservoir temperature, net pay thickness, reservoir depth, viscosity, skin factor, water saturation, formation compressibility, and drainage area. These are obtained from cores, logs, pressure surveys, well tests, PVT studies, well files, correlations, production data, and related sources as listed in the thesis.[5]

2.2 PROSPER well model

PROSPER was used to construct the well-performance model and evaluate tubing and pipeline hydraulics, temperatures, reservoir inflow, and vertical-lift performance. The model workflow described in the thesis comprises five principal areas: Options, PVT Data, Equipment Data, IPR Data, and Calculation Summary. The PVT model uses a black-oil characterization;

Equipment data define the downhole and surface configuration; and the IPR section defines the reservoir inflow model.

2.3 Nodal-analysis framework

The nodal-analysis procedure combines IPR and outflow/VLP relationships at a selected node. The operating condition is represented by the intersection of the inflow and outflow curves. The thesis explains that if the curves no longer intersect, the well cannot sustain natural flow and an additional pressure differential may need to be supplied by artificial lift.

$$q = \mathrm{PI}(\mathrm{P_r} - Pwf) \ldots..(1)$$

Equation 1. Linear IPR relationship reported in the source thesis.

For gas inflow, the thesis presents a pressure-squared relationship and a Bureau of Mines form incorporating an exponent n to represent non-Darcy effects. For two-phase inflow, the thesis presents the Vogel relationship.[6]

These relationships form the theoretical basis for constructing the inflow curve used in the nodal analysis.

2.4 Case-study input data

The detailed Well A8 data reported in the source are summarized in Tables 1–3. The completion configuration includes a 4.5-in string at 8,235 ft MD, a 3.5-in string at 12,640 ft MD, and 7-in casing with 6.094-in ID at 13,550–13,710 ft. The MPP is reported at 13,630 ft.

Table 1: Well A8 flow-regime and production data.

Parameter	Value	Unit
Skin	4.8	----
PI	4	STB/day/psi
SBHP	6369	Psi
Choke	40	in/64
QT	1869	bbl/day
Water cut	93.6	%
WHP	1040	Psi
WHT	93	°F
BHT	283	°F
GOR	4000	scf/STB
Oil API	42	API
Gas gravity	0.74	----

Table 2: Well A8 completion data.

MD (ft)	String ID (in)	String OD (in)	Casing ID (in)	Casing OD (in)	Description
8235	4.5	3.958	/	/	/
12640	3.5	2.992	/	/	/
13550	/	/	6.094	7	Top per
13710	/	/	6.094	7	Bot per
13630	/	/	/	/	MPP

Table 3: Well A8 reservoir and PVT data.

Data group	Parameter	Value / Unit
Reservoir	Porosity	14.5%
Reservoir	Permeability	79md
PVT	Salinity	11700ppm
PVT	FVF	2.1 bbl/STB
PVT	Viscosity	0.231 Cp

3. THEORY AND CALCULATION

3.1 Theoretical Framework

The performance of a production well is governed by the interaction between the reservoir inflow capability and the pressure losses occurring throughout the production system. In well-performance analysis, the reservoir contribution is represented by the Inflow Performance Relationship (IPR), which describes the functional relationship between the production rate and the flowing bottom-hole pressure (\(P_{wf}\)). The IPR curve represents the ability of the reservoir to deliver fluids into the wellbore under different pressure drawdown conditions.

For liquid-producing wells, the Productivity Index (PI) is commonly used to quantify well productivity. It represents the production rate obtained per unit pressure drawdown and provides an indication of the reservoir–wellbore flow efficiency. The theoretical framework also considers the Absolute Open Flow Potential (AOFP), defined as the theoretical maximum production rate corresponding to a flowing bottom-hole pressure approaching zero.

The reservoir inflow relationship must be evaluated together with the production-system outflow behavior. The outflow performance, commonly represented by the Vertical Lift Performance (VLP) relationship, accounts for the pressure losses associated with fluid movement

Through the wellbore and surface facilities. These pressure losses are affected by several parameters, including hydrostatic pressure, frictional losses, acceleration effects, tubing geometry, wellhead pressure, gas–liquid ratio, water–oil ratio, and other production-system characteristics.

The combination of the IPR and VLP relationships forms the basis of nodal analysis, which is widely applied for optimizing well performance. The stable operating condition of a producing well is obtained at the intersection between the inflow and outflow curves, where the reservoir deliverability is balanced with the requirements of the production system.[7]

3.2 Well Performance Modelling Using PROSPER Software

For the Abu Attifel field case study, a comprehensive well-performance model was developed using the PROSPER simulation environment. The model incorporates the available reservoir, PVT, completion, and well-test data to reproduce the production behavior of Well A8.

The modelling workflow includes:

- Definition of fluid properties and PVT characteristics.
- Selection of appropriate fluid correlations.
- Construction of the inflow performance model (IPR).
- Development of the wellbore and tubing outflow model (VLP).
- Generation of the combined VLP–IPR relationship.
- Identification of the stabilized operating point.

The general workflow adopted for well-performance optimization is illustrated in (Fig. 1), showing the interaction between reservoir inflow analysis, production-system modelling, and optimization procedures.

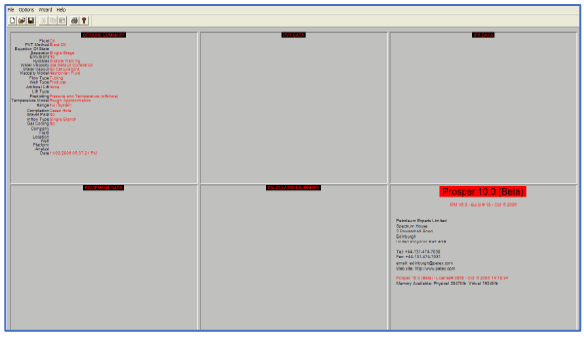


Fig. 1: Well-performance optimization methodology reproduced from the supplied thesis.

The PROSPER software environment used for developing the Well A8 model is presented in (Fig. 2) The interface provides access to the different modelling modules required for reservoir, completion, and production-system analysis.

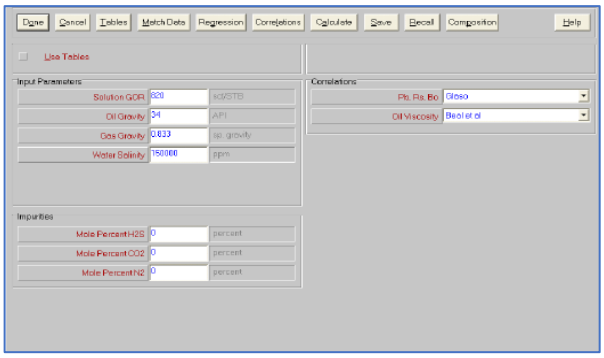


Fig. 2: PROSPER main screen used in the well-model workflow.

1.3 Input Data and Model Preparation

Accurate well-performance prediction requires reliable input data describing the reservoir and produced fluids. The PVT parameters used in the model include the main fluid properties required for calculating pressure-volume-temperature behavior and phase characteristics. The PVT data entry procedure implemented in PROSPER is shown in Fig. 3.

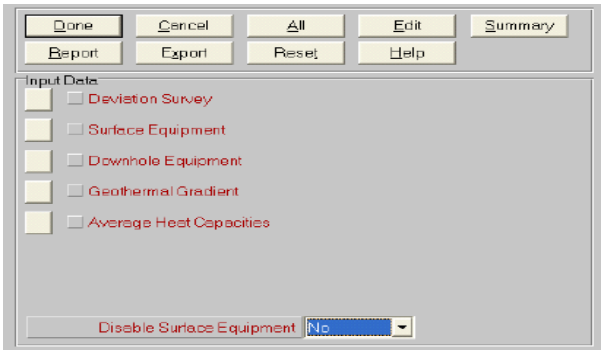


Fig. 3: PVT data input in PROSPER.

The inflow model was developed using the available reservoir and well-test information. The IPR calculation considers the relationship between production rate and flowing bottom-hole pressure to estimate reservoir deliverability under different operating conditions. The IPR input parameters used in the Well A8 model are presented in Fig. 4.

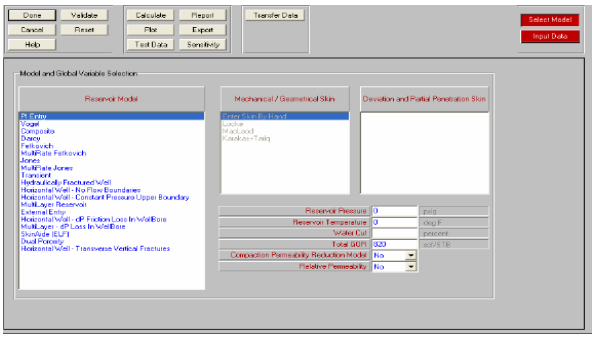


Fig. 4: IPR model input parameters defined in PROSPER for Well A8.

1.4 IPR and VLP Analysis

The calculated IPR curve generated by PROSPER represents the reservoir inflow capability, while the VLP curve represents the pressure requirement of the production system to transport fluids from the reservoir to the surface. The generated IPR curve for Well A8 is presented in Fig. 5.

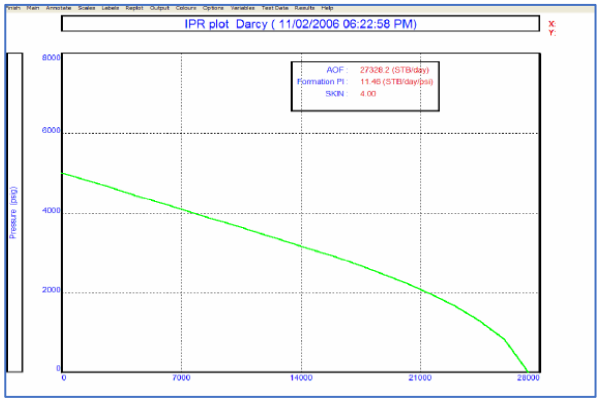


Fig. 5: IPR plot generated in PROSPER.

The final nodal analysis combines the reservoir inflow and production-system outflow relationships. The intersection point between the IPR and VLP curves represents the stabilized operating point of the well, where the reservoir supply rate equals the production-system capacity. The VLP–IPR relationship obtained for Well A8 is shown in Fig. 6.

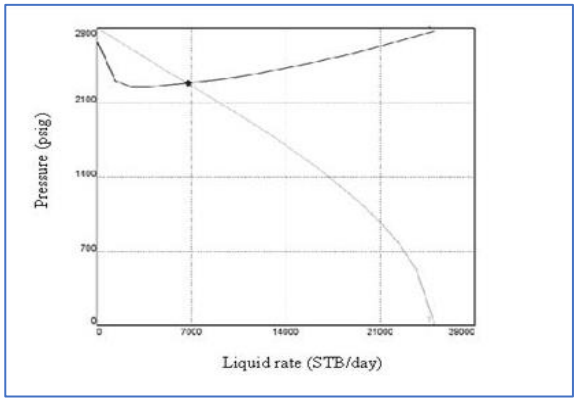


Fig. 6: VLP–IPR relationship for the Well A8 model.

4. RESULTS AND DISCUSSION

The supplied thesis reports well-by-well performance analysis for 54 wells in AbuAttifel field, but the detailed results section provided in the source presents Well A8 as the worked case. Well A8 has a reported total liquid production rate of 1,869 bbl/day and a water cut of 93.6%, together with a wellhead pressure of 1,040 psi. The reported static bottom-hole pressure is 6,369 psi and the productivity index is 4 STB/day/psi.

The high water cut and the reported skin factor of 4.8 are important characteristics of the presented well case because both affect the pressure-rate relationship and therefore the predicted well operating behavior. The model also uses a GOR of 4,000 scf/STB, oil gravity of 42 API, gas gravity of 0.74, and the reported temperature and pressure data.

4.1 The nature and characteristics of the study

The detailed Well A8 model uses a porosity of 14.5% and permeability of 79 md. The PVT inputs include salinity of 11,700 ppm, formation volume factor of 2.1 bbl/STB, and viscosity of 0.231 cP. The completion configuration includes tubing and casing dimensions and measured depths as listed in Table 2.

4.2 VLP–IPR operating point

The VLP–IPR figure in the supplied thesis shows the inflow and outflow curves intersecting at approximately 7,600 STB/day liquid rate and approximately 2,080 psi pressure when read from the plotted axes. This intersection represents the modeled operating point for the presented case. The source does not provide a tabulated value for

This intersection, so the values are treated as approximate graphical readings rather than independently calculated results.

4.3 Interpretation of the optimization approach

The case demonstrates the central purpose of nodal analysis: changes in reservoir, completion, tubing, choke, or surface conditions can shift either the inflow or outflow relationship and consequently change the operating point. The thesis identifies sensitivity analysis as part of the intended PROSPER workflow, including evaluation of operating conditions and development options. However, the supplied results section does not report a numerical sensitivity matrix or a final optimized choke/tubing configuration. Therefore, no additional optimization gain is claimed here.

5. CONCLUSION

The extracted case study shows how nodal analysis and PROSPER can be used to integrate reservoir inflow and wellbore/outflow behavior for evaluation of well performance in AbuAttifel field. The source reports analysis of 54 wells and provides detailed model inputs and results for Well A8. The well is characterized by a skin factor of 4.8, productivity index of 4 STB/day/psi, static bottom-hole pressure of 6,369 psi, total liquid rate of 1,869 bbl/day, and a water cut of 93.6%. The PROSPER model combines PVT, completion, IPR, and VLP information, and the supplied VLP–IPR plot indicates an operating intersection near 7,600 STB/day and 2,080 psi. The source establishes the modeling framework but does not provide sufficient numerical sensitivity results to substantiate a specific optimized operating change; such results would be required for a complete quantitative optimization assessment.

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AUTHOR CONTRIBUTIONS

Salsabil S. Al Ahresh: Conceptualization, methodology, writing – original draft, literature review, investigation, data curation, manuscript preparation, and final approval of the manuscript. **Ream K. Dra:** Investigation, data curation, validation, manuscript preparation, critical review, writing – review & editing, and final approval of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflicts of interest concerning the research, authorship, and publication of this article.

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