Journal of Mineral Resources Engineering, 9(1): 67-86, (2024)

Imam Khomeini International University
Vol. 9, No. 1, Spring 2024

نشریه مهندسی منابع معدنی
Journal of Mineral Resources Engineering (JMRE)

Research Paper

# Numerical Analysis of Well Testing Using Flow Data Taken at the Surface

**Soleimanzade A.[1], Yeganehfar M.[2], Jamshidi S.[3*]**

1- M.Sc, Dept. of Petroleum Engineering, Amirkabir University of Technology, Tehran, Iran
2- M.Sc, Dept. of Energy Systems, Khajeh Nasir Tusi University of Technology, Tehran, Iran
3- Associate Professor, Dept. of Petroleum Engineering, Sharif University of Technology, Tehran, Iran

**Received: 25 Oct. 2022** **Accepted: 15 Jul. 2023**

***Abstract:*** Well-testing is the analysis of reservoir and well behavior based on time. Obtaining the true value of changes in reservoir parameters plays a major role in creating an accurate and current model of the reservoir. The most crucial factor in achieving this objective is pressure, which is determined by a downhole pressure gauge. Operational issues and additional expenses are brought on by the use of pressure gauges at the well's bottom for the employer company. Surface well testing, which installs flow and pressure measurement devices at the wellhead, is another approach to well testing. The benefits of this technology include a significant cost reduction, ease of installation and data collection, easier operations, reduced risk, the ability to collect data for extended periods of time, and the ability to determine the impact of borders in large reservoirs. The difficulty of calculations and the insertion of errors as a result of the impact of well-column circumstances on the recorded data are the method's most significant issues. In this study, using Pipesim software, data obtained at the surface of a well located in a conventional undersaturated oil reservoir is converted to bottom-hole data, then analyzed, and finally, the properties of the reservoir are obtained. In comparison to the conventional well test method, the results demonstrate that the surface well test method can accurately forecast permeability, skin, productivity index, average pressure, and reservoir radius with error rates of 6.2, 17.3, 4, 7, and 13.3%, respectively.

***Keywords:*** Well testing, In situ pressure gauge, Surface well testing, Pipesim, Two-phase flow calculation.

**How to cite this article**
Soleimanzade, A., Yeganehfar, M., and Jamshidi, S. (2024). *"Numerical Analysis of Well Testing Using Flow Data Taken at the Surface"*. Journal of Mineral Resources Engineering, 9(1): 67-86.
DOI: 10.30479/JMRE.2023.17961.1610

*Corresponding Author Email: *jamshidi@sharif.edu*

## INTRODUCTION

Well testing is a well-established method for estimating reservoir dynamic parameters and determining well behaviour under different production stages by measuring pressure and flow rate [1]. Permanent recording of bottom hole pressure using a downhole pressure gauge is not always operationally possible, particularly in the case of horizontal/high deviated wells for safety and cost-effective reasons [2]. An alternative to conventional well testing, which installs flow rate and pressure monitoring equipment at the wellhead, is surface well testing. The surface well testing approach was used by Min Ho et al. [3] in a gas well. Compared to standard well testing, the researchers' findings correctly anticipated the properties of the gas reservoir. In this study, data collected at the well's surface during testing by Halliburton Drilling Company was converted to bottom hole data using Pipesim software during well shut-in. These bottom-hole data were then analyzed to determine the reservoir's properties and were compared to the results of conventional well-testing. The benefits of this approach include a significant cost reduction, ease of installation and data collection, simpler operation, the removal of running tools risk, the ability to gather data over extended time periods, and the ability to assess the impact of the border in large reservoirs [4]. The most important drawbacks of this method are the complexity of calculations and the entry of errors due to the effect of well-column conditions in the recorded data.

## METHODS

In this study, an oil well was selected with pressure transient tests conducted with surface and downhole pressure surveys. To record surface pressure, a thermally compensated quartz pressure gauge was used in conjunction with a properly designed and executed test procedure. Pipesim software is used to simulate the production string, and the simulated model is finished by specifying the reservoir and fluid properties. The pressure drop is then computed. It is possible to find a suitable two-phase empirical correlation that describes the two-phase fluid flow inside the well more accurately than other correlations by using the information obtained from a number of pressure gauges installed at various depths and relatively close to the earth's surface, along with flow data that includes oil and gas flow rate, the ratio of gas to oil production, and the recorded well pressure. The bottom well pressure calculation error will ultimately be reduced, and the accuracy of calculating the unknown parameters will increase if this correlation is used instead of the software's default correlation. The bottom hole pressure is obtained by entering the wellhead pressure in the Pipesim program. A comparison of field data between calculated bottom-hole pressures from surface gauges and measured bottom-hole pressures from downhole gauges, as well as the analysis that followed, will be made. In the well-test analysis, the permeability, skin, false pressure, and productivity Index were calculated using the Horner technique. The reservoir radius was determined using the extended Musket method, and the average pressure was determined using the MBH method. The research method's flowchart is depicted in Figure 1.

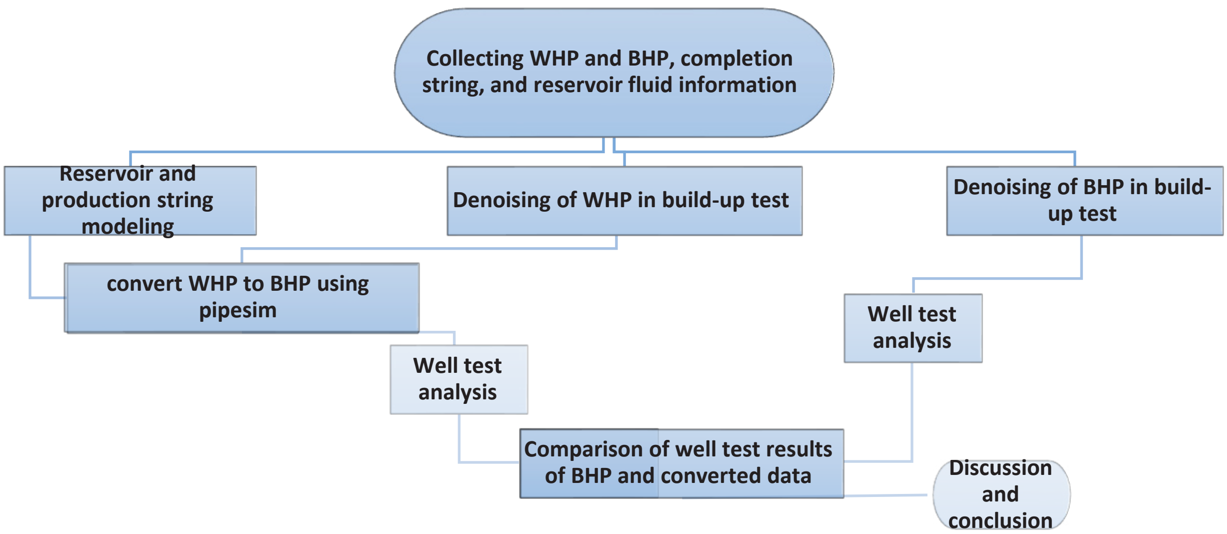


**Figure 1.** Flowchart of research method

## FINDINGS AND ARGUMENT

Figure 2 compares the Horner plot for transient period data from conventional well test operations as well as the surface well test operation. The measured and converted BHP curves were nearly parallel, showing that a satisfactory build-up trend was attained during conversion.

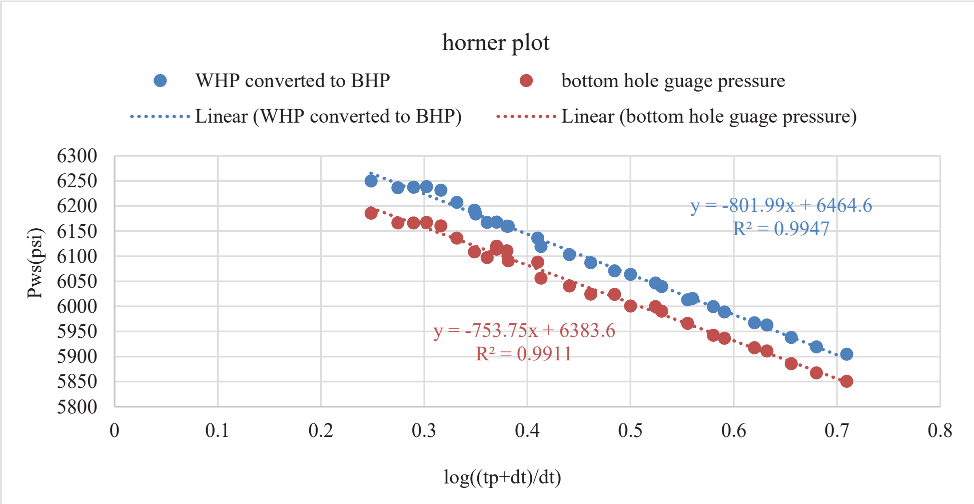


**Figure 2.** Horner plot of surface and conventional well test transient data

The study of surface and conventional well test results is summarized in Table 1. The permeability value identified by the laboratory's examination of the core sample is given, and it is in strong accord with the findings of the surface and conventional well testing [5]. The similarity of the projected parameter values between the conventional well testing method and surface well testing demonstrates surface well testing's correctness in forecasting reservoir features.

**Table 1.** Evaluation of the estimated properties using two surface and conventional well testing techniques

| Desired parameter | Surface well-testing result | Conventional well testing result | Laboratory result | Percentage error |
|---|---|---|---|---|
| Permeability | 17.29 Md | 18.43 Md | 15 Md | 6.2 |
| Skin | -0.81 | -0.98 | - | 17.3 |
| Average pressure | 6710.65 psi | 6269.81 psi | - | 7 |
| Productivity index | 1.31 | 1.26 | - | 4 |
| Reservoir radius | 444/80 ft | 392/48 ft | - | 13.3 |

Because the pressure build-up test was chosen to carry out the surface well test operation, the calculation of the pressure drop along the well is limited to the gravity pressure drop. The bottom hole pressure may be calculated more precisely using wellhead pressure because of the reservoir's single phase of fluid and the low GLR of the analyzed well. While the pressure drop calculations for single-phase fluids are relatively simple, they become quite complicated when other phases are introduced. These complications make it almost impossible to obtain analyzable data from the surface of oil wells that are below the bubble point of the reservoir [6]. Producing wells may slug, have liquid hold-up, have a standing liquid column, or behave in other fashions that are difficult, if not impossible, to model.

## CONCLUSIONS

The findings of this study demonstrate that surface well testing is capable of accurately predicting the reservoir parameters for the oil reservoir. The surface well test method predicts parameters like permeability and skin, which are not dependent on the absolute value of the pressure at the bottom of the well and are only obtained from the analysis of the pressure difference in terms of time, more accurately than other reservoir parameters. As long as fluid communication/continuity can be established between the surface and the completion, the relative pressure change over time should be accurate. Oil wells must flow at conditions that avoid segregated multi-phase flow. The surface well testing method can produce more accurate findings if certain factors are taken into account. Among these factors, we may point out the requirement for employing pressure gauges with excellent precision, because the pressure at the well's bottom is calculated indirectly. Additionally, well pressure gauges should be installed at a location that is less interfered by the noise of daily production operation. It is advisable to run the test under a buildup of pressure. The presence of an information source in the bottom or at least in the middle of the well is particularly beneficial while conducting surface well testing operations and data analysis, since it helps to improve the simulation's accuracy and adjust it to the current conditions. In general, it can be said that the surface well testing approach is subject to considerable uncertainty in wells with two-phase flow and various flow regimes and should be utilized with extreme caution in such wells.

## REFERENCES

[1] Pityuk, Y. A., Akmurzina, G. R., and Davletbaev, A. Y. (2020). *“Development of an Approach for Well Testing in Real Time”*. SPE Russian Petroleum Technology Conference, SPE-201898-MS.

[2] Fair, C., and Redman, M. (2002). *“Gas condensate and Oil WellTesting from the surface”*. SPE Annual Technical Conference and Exhibitation, San Antonio, Texas, 29 September- 2 October.

[3] Vo, M., Yu, Y., Lv, J., and Zhang, J. (2020). *“Surface Pressure Data for Well-Test Analysis at A Joint Venture Gas Project in Sichuan”*. Proceedings of the International Field Exploration and Development Conference, 10: 1896-1909.

[4] Hollaender, F., Shumakove, Y., and Karacali, O. (2019). *“Well Testing to Full Potential: Lessons Learned and Best Practices for High-Rate Wells”*. Abu Dhabi International Petroleum Exhibition & Conference, Abu Dhabi, UAE, SPE-197754-MS.

[5] Mikhail, S. T., Evgeniy, A. G., and Vladimir, V. P. (2022). *“Permeability Evolution of Porous Sandstone in the Initial Period of Oil Production: Comparison of Well Test and Core flooding Data”*. Energies, 15: 37-61.

[6] Nwanwe, C. C., and Duru, U. I. (2022). *“Comparison and performance Analysis of Models for Predicting Multiphase flow Behaviours in Wellbores”*. International Journal of Petroleum and Geoscience Engineering, 2022: 1-20.