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WELL PERFORMANCE SKIN

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ABSTRACT

When considering the performance of oil wells, it is frequently assumed that the productivity index can be used to estimate a well's performance. Oil well performance analysis can be more valuable when the calculations, simulations, modeling, and monitoring of production metrics are evaluated in an environment that allows geoscience and engineering teams to share all relevant information and collaborate on analysis. Today, visualization and analysis software solutions enable reservoir engineers to develop forecast estimates and optimize production more efficiently because all additional data acquired throughout the life of an oil well can be assimilated in a common environment as it becomes available.

Keywords: Productivity, well, IPR, skin factor, well deliverability, localized pressure, flow rate, damaged zone

INTRODUCTION

Well performance is the important stage of oil industry and used to estimate the productivity of well in beforehand due to the economic efficiency. However this stage placed between well completion and production processes. In order to assess the well a few methods is used widely such as calculation of IPR, isochronal test, multirate test and future performance techniques. The capability to define the whole inflow performance of the well is a fundamental prerequisite for well analysis. It is necessary to gather accurate well test results. The well performance can be completed by using models for other well components. Besides that, during the production and completion of oil and gas permeability around the wellbore can be reduces due to small particles which are entering formation and this zone is referred as skin zone. To overcome this issue different well stimulation methods applied to the well. Skin is a parameter to measure the health of the reservoir. Skin can be measured by well tests.

Inflow Performance

A well's inflow performance relationship (IPR) is the relationship between the production rate and the flowing bottom hole pressure. Fluid inflow rate is frequently assumed to be proportional to the difference between reservoir pressure and wellbore pressure for oil wells. This assumption leads to the Productivity Index, which is a straight line relationship derived from Darcy's law for steady state flow of an incompressible, single phase fluid (PI). This assumption, however, is only valid above the bubble point pressure.

Vogel's inflow performance relationship

Vogel was the first to present an easy-to-use method for predicting oil well performance. His empirical inflow performance relationship is given by and is based on computer simulation results.

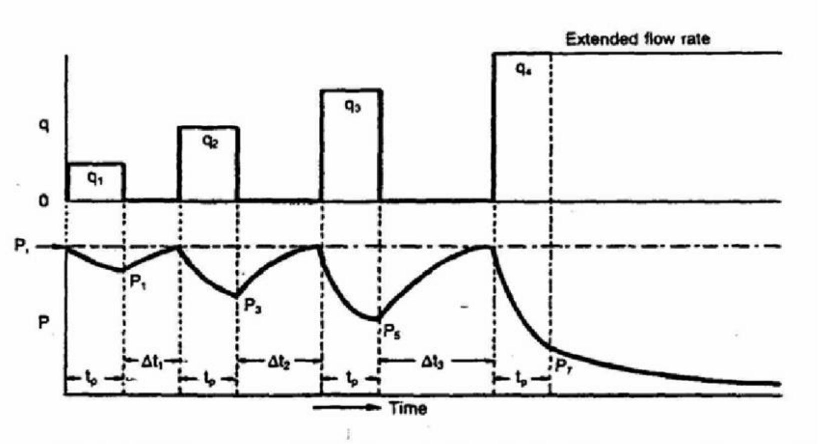
$$\frac{q_o}{q_{o,\,\max}} = 1 - 0.2\left(\frac{p_{wf}}{\overline{p}_R}\right) - 0.8\left(\frac{p_{wf}}{\overline{p}_R}\right)^2 .$$

To apply this relationship, the engineer must first calculate the oil production rate and flowing bottomhole pressure from a production test and then estimate the average reservoir pressure at the time of the test. With this information, the maximum oil production rate can be estimated, and the production rates for other flowing bottomhole pressures at the current average reservoir pressure can be estimated.

Isochronal test

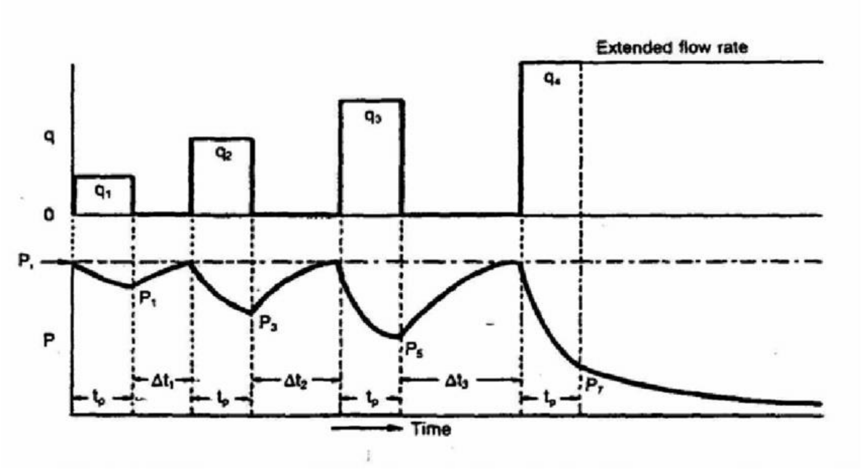
The isochronal test is a set of single-point tests designed to estimate stabilized deliverability characteristics without actually flowing the well for the amount of time required to achieve stabilized conditions at each rate.

- includes a number of equal-duration flow phases
- every flow period should start at static reservoir conditions
- utilizing different flow rates for each flow period until pressure is stabilized
- keep the ultimate flow rate constant.



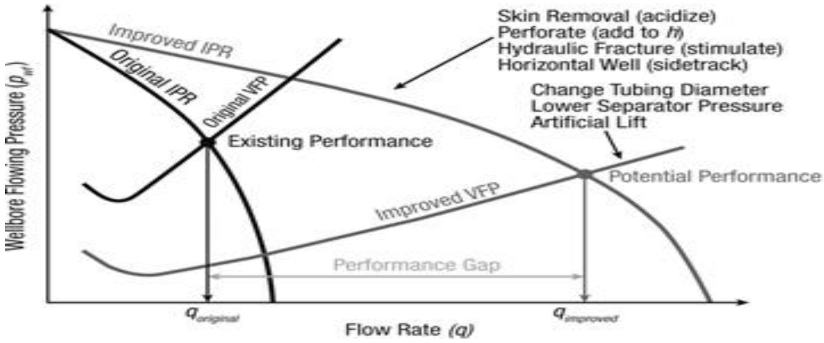
Modified Isochronal Test

The modified isochronal test is carried out similarly to the isochronal test, with the exception that the shut-in periods are of identical length. The length of the shut-in times should be more than or equal to the flow periods. The shut-in sandface pressures recorded immediately prior to each flow phase are used in the test analysis instead of the average reservoir pressure because the well does not rise up to average reservoir pressure after each flow period. The modified isochronal test therefore has a lower accuracy than the isochronal test. The modified isochronal test becomes more accurate as the shut-in periods' length increases. Again, a final stabilized flow point is typically achieved at the end of the test but is not necessary for data analysis.



Graphic Illustration of IPR and VPR

Graphing the inflow performance relationship (IPR) and vertical flow performance allows many aspects of the petroleum production system to be considered at the same time (VFP). Both the IPR and the VFP are related to the wellbore flowing pressure and the surface production rate. The IPR and VFP each represent what the reservoir and well can produce. When the IPR and VFP intersect, as shown in Figure, they result in well deliverability, which expresses what a well will actually produce under a specific operating state. The job of a petroleum production engineer is to maximize well deliverability while minimizing costs. It is critical to comprehend and assess the factors that govern these interactions.



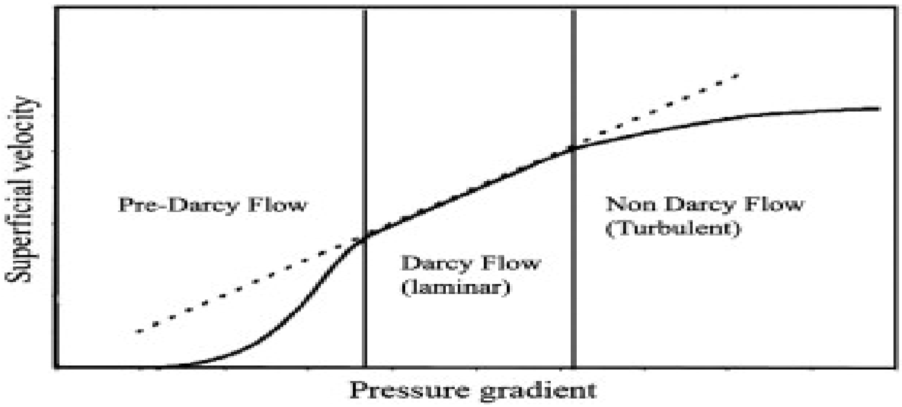
Multirate Tests

Jones, Blount, and Glaze also proposed a multirate test method for incorporating non-Darcy flow effects. The fundamental equation for describing the flow of oil is:

$$\frac{\bar{p}_R - p_{wf}}{q_o} = a + bq_o,$$

where a denotes laminar flow coefficient and b denotes turbulence coefficient To use the method, similar to Fetkovich's method, multiple rate test information must be obtained. On coordinate paper, a straight line should be obtained by plotting the ratio of pressure difference to flow rate vs. flow rate. The intercept of the plot is the laminar flow coefficient a, while the slope of the curve yields the turbulence coefficient b. After determining a and b, the flow rate at any other flowing wellbore pressure can be calculated by solving:

$$q_o = \frac{-a + \sqrt{a^2 + 4b\left(\overline{p}_R - p_{wf}\right)}}{2b}.$$



Future Performance Methods

After a petroleum engineer has estimated a well's current productive capacity, it is frequently desired to predict future performance for planning purposes. Standing was among the first to address IPR prediction of future well performance. He used Vogel's IPR in conjunction with a modified multiphase productivity index to predict future well performance. Unfortunately, his relationship necessitates a thorough understanding of fluid properties and relative permeability behavior. This makes Standing's method difficult to apply because saturations, relative permeabilities, and fluid properties must be estimated at a future reservoir pressure.

$$\frac{q_{o,\max,f}}{q_{o,\max,p}} = \frac{\overline{p}_{r,f}}{\overline{p}_{r,p}}\left(\frac{\overline{p}_{r,f}}{\overline{p}_{r,p}}\right)^{2n} = \left(\frac{\overline{p}_{r,f}}{\overline{p}_{r,p}}\right)^{2n+1}.$$

For three phase:

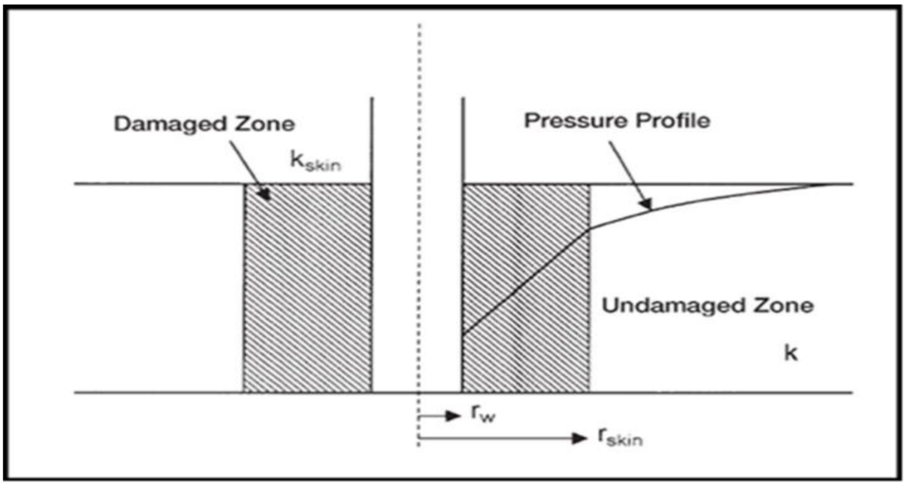
$$\frac{q_{o,\max,f}}{q_{o,\max,p}} = 0.15\frac{\overline{p}_{r,f}}{\overline{p}_{r,p}} + 0.84\left(\frac{\overline{p}_{r,f}}{\overline{p}_{r,p}}\right)^2.$$

$$\frac{q_{w,\max,f}}{q_{w,\max,p}} = 0.59\frac{\overline{p}_{r,f}}{\overline{p}_{r,p}} + 0.36\left(\frac{\overline{p}_{r,f}}{\overline{p}_{r,p}}\right)^2.$$

Skin factor and related concepts

During drilling, completion, or workover operations, it is not uncommon for materials such as mud filtrate, cement slurry, or clay particles to enter the formation and reduce permeability around the wellbore. This is known as wellbore damage, and the region of altered permeability is known as the skin zone. This zone can range in size from a few inches to several feet away from the wellbore. Many other wells are stimulated by acidizing or fracturing, which raises permeability near the wellbore. As a result, permeability near the wellbore is always different from permeability away from the well, where the formation has not been influenced by drilling or stimulation.

Damage to the formation can result in an additional localized pressure drop during flow. This additional pressure drop is known colloquially as pskin. Well stimulation techniques, on the other hand, typically improve the properties of the formation and increase permeability around the wellbore, resulting in a decrease in pressure drop. The skin effect is the result of changing the permeability around the well bore.



Representation of positive and negative skin factor

Figure describes the differences in the skin zone pressure drop for three possible results:

- First Outcome:

Δpskin > 0, illustrates an additional pressure drop due to wellbore damage, i.e., kskin < k.

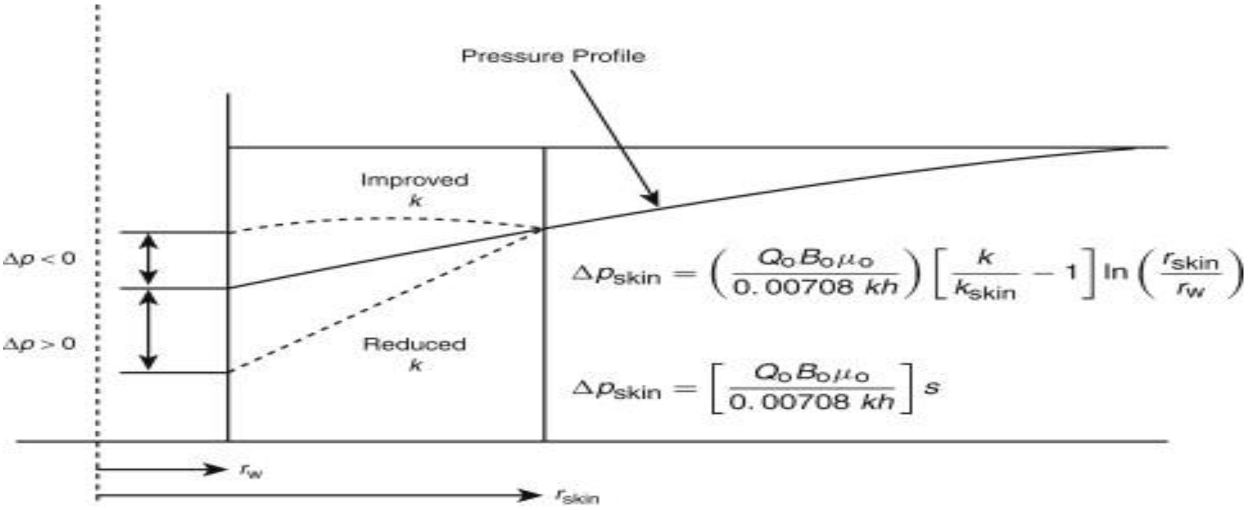
- Second Outcome:

Δpskin < 0, indicates less pressure drop due to wellbore improvement, i.e., kskin > k.

- Third Outcome:

Δpskin = 0, shows that the wellbore condition has not changed, i.e., kskin = k.

Hawkins proposed that the skin zone's permeability, kskin, is uniform and that the pressure drop across the zone can be approximated by Darcy's equation. Hawkins proposed the following strategy:

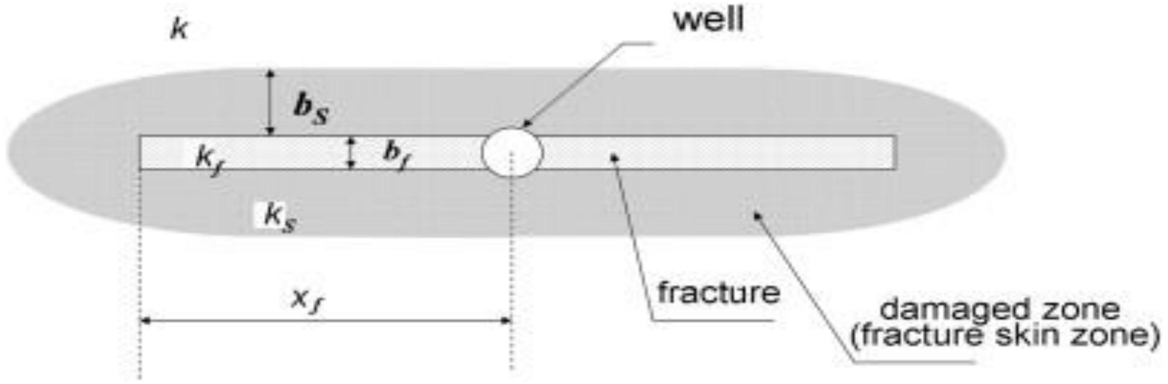


There are only three possible outcomes in evaluating the skin factor s:

- Positive Skin Factor, $s > 0$ In the presence of a damaged zone close to the wellbore, kskin is less than k, resulting in a positive number for s. The skin factor increases in magnitude as kskin decreases and the extent of the injury rskin deepens.
- Negative Skin Factor, $s < 0$ When the permeability around the well kskin is greater than the permeability of the formation k, a negative skin factor exists. This negative aspect indicates that the wellbore's condition has improved.
- Zero Skin Factor, $s = 0$ Zero skin factor occurs when no changes in the permeability around the wellbore is observed, i.e., kskin = k.

Fracture Skin Factor and Its Effect

Several hundred or even thousand cubic meters of fracturing fluid are frequently injected into the formation during fracturing operations, particularly large-scale fracturing, at a high pumping rate and pressure. When the formation is fractured and a large fracture is formed, the fracturing fluid seeps into the fracture surface, damaging and polluting the formation at the same time.



CONCLUSION

A knowledge of formation flow capacity and damage is necessary to determine reliable values of gas well deliverability. This information is usually acquired by pressure buildup or drowdown tests. However, in low-permeability reservoirs, the long time required to conduct such tests is frequently prohibitive. For this reason, attention has been directed toward employing variable-rate tests that do not require well shut-down. Hence, the skin factor is the always focus to observe and maintain the productivity of oil and gas wells throughout the lifecycle. Year by year, novel research done on this topic and tried to find the optimum ways to extract a high quality of oil/gas by aoiding damage formation.

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