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## A Rigorous Composite-IPR Model for Multilateral Wells

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### Abstract

Use of multilateral wells for oil and gas production has gained strong momentum in the past five years. However, most of the wells do not deliver hydrocarbon fluids at expected flow rates. One of the reasons is that the well planners over-estimate the productivity of wells using inaccurate methods for predicting composite IPRs of well laterals. A more accurate method for predicting composite IPR of multilateral wells is highly desirable. This paper fills the gap.

Starting from terms that petroleum engineers are familiar with, a general mechanistic model was developed to combine the fluid flow from individual laterals. The model allows different IPRs of laterals and permits cross-flow between laterals. Pressure losses in both vertical and curvic hole-sections are rigorously considered. Oil and gas wells are treated differently. By combining the composite IPR model with Poettmann and Carpenter correlation, a computer simulator was developed for predicting multilateral well production rate. A case study with measured production rate indicated a 3.1%-error accuracy of the computer model, which is much better than other existing methods. This work provides petroleum engineers a reliable and user-friendly tool for designing and analyzing multilateral wells.

### Introduction

Although oil production using multiple-drain holes was first reported in 1960's (Borisov, 1964), popular applications of multilateral wells for producing oil and natural gas began in early 1990's (Hardman, 1993) after the modern horizontal drilling technology was developed. Salas et al. (1996) identified eight categories of main potential applications of multilateral wells. Vij et al. (1998) provided an overview of the multilateral technology and its limitations.

A literature survey indicates that two types of multilateral well models have been developed in the past two decades: (1) pure inflow models that do not consider the flow in the well laterals, and (2) inflow models that partially consider the effect of flow in the laterals. These models are reviewed as follows.

Raghavan and Joshi (1993) presented an analytical solution of well productivity for symmetric horizontal radials defined as horizontal drainholes of equal-length kicked off from the same depth in symmetrical directions. The result was an inflow equation, i.e., the effect of wellbore flow to the common kick off point was not considered.

With a semianalytical solution, Retnanto and Economides (1996) demonstrated the benefits of using symmetrical multilateral wells in low- to medium-permeability reservoirs. Again, only lateral inflow performance was considered.

Larsen (1996) presented closed-form expressions of skin factors and productivity indices of radial symmetric multilateral wells. Well Inflow was analyzed based on the distances between the midpoints of the laterals. Wellbore flow was not considered.

Salas et al. (1996) presented an inflow performance model for multilateral wells with the total skin factor lumping the effects of reservoir homogeneous and other factors. They assumed that all the wellbore segments connecting well laterals are effectively of infinite conductivity to flow (wellbore friction pressure losses are neglected).

Wolfsteiner et al. (2000) developed a general and sophisticated model for productivity of nonconventional wells in heterogeneous reservoirs. This model allows estimating effective skin as a function of position along the wellbore due to local reservoir heterogeneity. Wellbore hydraulics was not included in the model. Yildiz (2002) presented a similar solution that also neglected the effect of the wellbore friction pressure losses. Yildiz (2005) compared his 3D multilateral well model with data from an electrolytic model and Salas et al.'s (1996) model. Good agreements were observed.

Smith et al. (1997) addressed the importance of coupling the effects of fluid flow through perforations and wellbore hydraulics in reservoir simulation for multilateral well economics evaluation. Permadi (1998) investigated the effect of wellbore hydraulics on inflow performance of a stacked dual lateral well assuming single-phase flow in the wellbore.