A New Solution Methodology to the Material Balance Equation, for Saturated Reservoirs

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Abstract

The material balance equation (MBE) is a versatile analytical tool in petroleum reservoir engineering. Solution to the MBE is put to a predictive use for predicting reservoir performance, i.e. cumulative oil production, N_p as a function of the declining average reservoir pressure, . For under-saturated reservoir (single-phase flow), the MBE presents N_p as an explicit function of pressure drawdown ; hence a direct solution of the MBE yields the average pressure, for a given N_p value. However, for multiphase flow in saturated reservoirs, the average reservoir pressure does not appear explicitly in the MBE, rather, it is implicitly present in the various pressure-dependent PVT parameters in the MBE (i.e. (B_o, B_g and R_s). Furthermore, the MBE for saturated reservoirs features the cumulative GOR term, Rp, a parameter related to Np; hence solving the MBE for saturated reservoirs typically involves cumbersome iterative schemes.

There exist in the literature various methodologies of solving the MBE with the purpose of predicting estimates of cumulative oil production, Np versus the declining average reservoir pressure, . The methodologies typically involve some multi-step iterations as the equation is solved for Np or Gp at various arbitrarily-chosen pressure nodes.

The need to solve this implicit problem without the rigor of human guesswork is the motivation for this work. This current work therefore presents a simple and computationally-cheap method for solving the MBE for the purpose of predicting estimates of cumulative oil production, Np versus the declining average reservoir pressure, .

In this new solution methodology, the philosophy of solving the MBE is analytically founded on the equality of the Left Hand Side, LHS (fluid withdrawal terms) and the Right Hand Side, RHS (fluid expansion terms) of the MBE for saturated reservoirs, and the pressure that upholds the equality.

This new solution methodology has been applied to two reservoir models and has been found to yield performance predictions that compares excellently well with predictions obtained from numerical solution (simulation) of complex fluid flow equations.

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