CHAPTER 1

INTRODUCTION

Estimation of the OGIP and recoverable reserves of commingled gas reservoirs has been investigated extensively. The classical techniques of volumetric calculation, material balance equation, and decline curve analysis have been examined and proposed. All these techniques have limitations owing to the nature of commingled reservoirs. The volumetric calculation is often a rudimentary estimate and is unreliable unless an accurate geologic model and production acreage is already established. The material balance equation or the *p/z* plot is also inherently flawed when applied to commingled reservoirs with unequal initial layer pressures as the stabilized pressures are hardly or never achieved in pressure build-ups. Without these lengthy shut-in or build up period, the material balance method normally underestimates the gas in place. Application of the decline curve analysis in tight gas reservoirs also proved to be inadequate due to the fact that the decline portion representing the pseudo-steady state production is often difficult to distinguish. For multi-layered commingled reservoirs, extrapolation of early rate versus cumulative production normally underestimates recoverable reserves. On the other hand, extrapolation of the late rate versus cumulative production data with the empirically derived decline factor may overestimate recoverable reserves.

Another limitation of the material balance and decline curve analyses is that they only provide the total OGIP of the whole commingled reservoir system. Knowledge of the OGIP estimates of the component layers is vital for better well production management and optimization. Thus, OGIP determination of the individual reservoirs of a commingled system has aroused considerable interest over the past decades.

El-Banbi and Wattenbarger[1,2] proposed a technique called the Layered Stabilized Flow Model (LSFM) to estimate the OGIP of each component layer of a commingled gas reservoir. It combines the material balance equation with the stabilized gas flow equation to determine the OGIP of the commingled layers. The LSFM predicts a "model production rate" for each component layer and sums up these layer rates to come up with a "total model rate" for the commingled system. This model rate is then history matched against the actual production rate of the well. In order to get a good match, the difference between the model and actual production rates is minimized through a multi-variable optimization routine.

By solving the material balance equation and the stabilized gas flow equation simultaneously, the reservoir pressure need not be measured which gives the LSFM its inherent advantage.

The main purpose of this study is to investigate the applicability of the LSFM to analyze commingled gas reservoirs and predict their performance. Enhancements were introduced in the model by using normalized pseudo-pressures in the stabilized flow equation and by using Gauss-Marquardt's algorithm for the non-linear regression technique in the history matching. Five cases were investigated which included two actual field cases from the Gulf of Thailand. Comparison with other methods was done in order to verify the efficiency and reliability of the results obtained from the model.