CHAPTER I

INTRODUCTION

In petroleum industry, a production well is drilled and completed to move the reservoir fluid into the wellbore and through the production string until it reaches the surface. Movement or transport of these fluids requires energy to overcome friction losses in the system and to lift the products to the surface.

Therefore, the calculation of pressure drop along the production system must be solved with a high degree of calculation accuracy. A number of correlations are available for predicting pressure drop during multiphase flow. The validity of the correlations is limited to the quality and scope of the data upon which they are based. Therefore, some correlations perform quite well for cases in the range of the data used in developing the correlation but fail for other applications.

Boyun Guo[1] has developed a systematic approach to modeling of gas, water, oil, and solid particle four-phase flow in boreholes. This model was first published in drilling literature and coded in a spreadsheet program.

First, Guo[2] derived a simple mechanistic model for simulating gas-liquid-solid three-phase flow in coalbed methane (CBM) wells. In this case, liquid holdup effects were considered by applying a tuning factor to friction factor. The tuning factor was defined as a function of gas-liquid ratio (GLR) and vertical depth. The derived model for CBM wells was coded in a spreadsheet program and calibrated with measurements from a full size physical well model. Then, this calibrated model was compared with other models using field measurements obtained from CBM dewatering operations. The results proved that the Guo's model is accurate for upward flow of CBM gas and water in a $2\frac{7}{8}$ tubing. But, Guo has said that this model needs to be tested, and further tuned if necessary, for other well conditions.

Then, this technique was applied to investigate the applicability of Guo's four-phase flow model[3] to simulation of two-phase (gas and oil) flow in oil wells. This case demonstrated that a mechanistic model originally developed for modeling gas, water, oil, and solid particle four-phase flow in drilling could be employed for establishing IPR of both high and low GOR oil wells when bottom hole pressure measurements are not available. However, only a few conditions have been used in the evaluation.

This study is intended to investigate the applicability of Guo's four-phase flow model to two-phase and three-phase flow wells under different conditions and improve its accuracy. Firstly, 208 data sets are collected from published SPE papers. Then, these data sets are used to calculate the bottomhole flowing pressures (BHFP) from the known wellhead flowing pressures (WHFP) by Guo's model and six other multiphase flow correlations (Duns and Ros (original)[4], Duns and Ros (modified)[5], Hagedorn and Brown[6], Fancher and Brown[7], Orkiszewski[8], and Beggs and Brill[9]) available in PROSPER, a commercial fluid flow program, for various well conditions. The calculated bottomhole flowing pressures obtained by Guo's model and multiphase flow correlations are compared with the measured BHFP. A statistical analysis of the predictions is then performed with the following statistical parameters: the average relative error, the average absolute error, and standard deviation. To improve Guo's model, the following five modifications are considered:

1) modification of Guo's model with tuning factor
2) modification of Guo's model with Z factor with and without the tuning factor
3) modification of Guo's model with R_s and B_o with and without the tuning factor
4) modification of Guo's model with Z, R_s, and B_o with and without the tuning factor
5) modification of Guo's model with incremental calculation with and without the tuning factor (Calculation is done for each small section instead of one single calculation for the whole pipe length).

Then, the modified Guo's four-phase flow models are compared against six other multiphase flow correlations. In these comparisons, the statistical parameters such as average absolute error and standard deviation are analyzed using different groupings based on gas-liquid ratio (GLR), tubing ID, API gravity, liquid flow rate, and gas flow rate. The average absolute error is used as an indicator of the accuracy in this study. Then, the modified Guo's models are evaluated for their range of applicability for each grouping.