THE IMPORTANCE OF HAVING AN ACCURATE MULTIPHASE FLOW CORRELATIONS PROGRAM

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ABSTRACT

In the petroleum industry, a suitable and an accurate vertical/directional multiphase flow correlation is normally required by the production engineer before completion and artificial lift design analysis can be performed with a reasonable degree of accuracy. Due to the repetitive step like nature of the calculations in a multiphase flow correlation, a simulation program is required to compute flowing pressure along the production string and wellbore. It is a wise move to check the accuracy of a simulation program at the first place because an inaccurate multiphase flow correlations program may cause severe error in facilities design.

INTRODUCTION

In the petroleum industry, a reliable multiphase flow correlation is usually used to perform the following tasks : -

- o Selection of tubing sizes.
- o Determination of maximum flowrates and wells' PIs..
- o Prediction of flowing bottomhole pressures.
- o Design of artificial lift installations at some later date.

The multiphase flow correlations that are widely used in the production engineering presently include the Hagedorn and Brown,(1) Duns and Ros,(2) Orkiszewski,(3) Beggs and Brill,(4) and Gray.(5)

Due to the repetitive step like nature of the calculations in each of the multiphase flow correlations, a simulation program is normally required to calculate flowing pressure along the production conduit and wellbore. Given the bottomhole pressure at the depth of interest, the simulation program can compute the flowing pressure along the tubing string until it reaches the wellhead pressure, or given the wellhead pressure and the depth of interest, it can calculate the flowing pressure until it reaches the predicted flowing bottomhole pressure. The accuracy of the predicted wellhead pressure or flowing bottomhole pressure is entirely dependant upon the manner in which a simulation program was written and the correlations used to calculate the fluid properties.

MULTIPHASE FLOW CORRELATIONS PROGRAM

Three types of multiphase flow correlations programs were made available to the author, namely the Multiphase Flow Correlations Program (MPCP), Multiphase Flow in Vertical Conduits (MPVC) and System Nodal Analysis Program (SNAP).

The MPCP

This simulation program is used to generate pressure traverse data along the production string and well bore, in both naturally flowing and gas-lifted wells. In the MPCP, five different correlations are available, and any or all of them may be used : -

- o Hagedorn and Brown.
- o Orkiszewski.
- o Duns and Ros.
- o Beggs and Brill.
- o Gray.

This program does not hold PVT data, instead it uses its own computed PVT data by going into the built-in PVT correlation files. The Standing's correlation(6) which was developed by using the California crude is used to predict the PVT properties.

The MPVC

This simulation program can be used to generate pressure traverse data along the production string. Though it can be used in both naturally flowing and gas-lifted wells, the main problem with the MPVC is that choice of correlation used in any studies is limited to the modified Hagedorn and Brown only.

Nevertheless, the advantage of MPVC over the MPCP is that it can be utilised to hold PVT data. If the option to enter PVT data is bypassed, the MPVC program then uses the global variables of gas gravity, oil gravity and gas-oil ratio to interactively create its own PVT data by using the Standing PVT correlation files; a characteristic which is similar to the MPCP.

The SNAP

This simulation program has a wider application compared to the MPCP and MPVC. Generally it can be used to : -

- o Size tubing to match the reservoir deliverability.
- o Calculate flowing bottomhole pressure.
- o Determine inflow performance of the reservoir.
- o Design gas lift systems or evaluate existing designs.
- o Calculate the absolute open flow potential, sandface pressure, turbulence effect of a reservoir.
- o Design gravel packs.

SNAP uses a nodal approach to model a producing system, in which the concept is based on summing the pressure drops found in each component of the system. The analysis starts at the outer boundary of the reservoir and proceed through the reservoir to the sandface, across the completion and perforations, up the tubing string, through a surface choke, through the flowline and into the separator.

Like the MPCP, SNAP does not have a PVT data option, it uses the Standing's correlation to predict PVT properties.

The main weakness of SNAP is it can only calculate pressure at one point either at the wellhead or at the depth of interest. Therefore, to compute pressure traverse along the tubing string, separate runs are required, where in each run, a selected depth must be entered together with its flowing temperature and angle of deviation at that particular point, before pressure at this point is calculated. However, SNAP is capable of generating a set of data for inflow and outflow curves. The intersection of these two curves will give the rate at which the system will flow under the given condition.

MULTIPHASE FLOW CORRELATIONS ANALYSIS

A suitable and an accurate directional/vertical multiphase flow correlation is required before completion and artificial lift design analysis can be performed with a reasonable degree of accuracy.

A number of flowing gradient surveys from an oilfield called *Imperial* had been analysed prior to the determination of the most suitable multiphase flow correlation program. In this study, the analysis were performed via the MPCP which had five different correlations as mentioned earlier. The selection of the most suitable multiphase flow correlation could be done by comparing the correlations' results (i.e. predicted flowing pressure data along the production string) with the measured flowing pressure data graphically (by plotting the pressure data against measured depth). Two types of flowing wells were involved in the analysis, namely the naturally flowing and gas-lifted wells. A few of the classic examples are shown below : -

Well Imperial-1 to Imperial-3 (Figure 1 to 3) were naturally flowing oilwells with low water cut (in the range of 0 to 8%). Analysis of the curves revealed that the Hagedorn and Brown correlation gave matches similar to actual data (i.e. with error less than six percent). But the Gray correlation was found to give poor results in most of the cases.

The Hagedorn and Brown correlation was also found to give consistently reasonable results with error less than six percent in low water-cut, gas-lifted wells. The reason for this was that the producing characteristics of continuous flow gas lift wells were essentially the same as those for a naturally flowing well. This statement was verified by Imperial-4 with a 14% water cut (Figure 4).

From the brief analysis, the Hagedorn and Brown correlation was found to be the most suitable multiphase flow correlation for naturally flowing wells and gas-lifted wells with low water cut. The analysis also revealed that the presence of small amounts of water production did not appear to have a great effect on the accuracy of the correlation.

ACCURACY OF THE MULTIPHASE FLOW CORRELATIONS PROGRAM

As mentioned earlier, three types of multiphase flow correlations programs were made available to the author. This gave the author an opportunity to check the reliability and accuracy of those simulation programs, especially the SNAP prior to utilising it in the selection of optimum tubing sizes for an oilfield.

In checking the accuracy of those simulation programs, the author had to be consistent with the input data and the type of multiphase flow correlation used, before a meaningful comparison could be made. The Hagedorn and Brown which was proved to be the most suitable multiphase flow correlation in low water-cut oilwells, was used to predict the pressure data along the production tubing. Since the MPCP and SNAP did not have the input PVT data option, thus the built-in Standing's correlation had to be used in those three programs in order to predict the PVT properties.

The author had no problem with the MPCP and MPVC because these two programs could generate pressure data along the production string in one run, under the given condition. In contrast, SNAP could only compute pressure at the depth of interest. Thus, separate runs were required, where in each run, a selected depth must be entered together with its flowing temperature and angle of deviation at that particular point, before the pressure at this point is subsequently calculated. The computed flowing pressure data were then compared graphically with the measured data, in order to observe the accuracy of the predicted flowing pressure data.

Appraisal of results revealed that the predicted flowing bottomhole pressure by the MPCP and MPVC were in good agreement, but SNAP was consistently underestimated the flowing bottomhole pressure by approximately fifteen percent. This statement was supported by Imperial-2 in Figure 5. This situation could be appreciated further by refering to Figure 6, where the liquid rate was overestimated by 2500 bbl/day via SNAP. This discrepancy would lead to severe error in facilities design.

From the brief discussion, the discrepancy might be due to the method used in writing-up the simulation program. The correlation which was used to calculate the fluid properties was not the cause of this discrepancy because the author had used the Standing's correlation consistently in the MPCP, MPVC and SNAP throughout his study.

CONCLUSION

- An accurate multiphase flow correlations program is required prior to selecting optimum tubing sizes or designing gas lift systems for an oilfield.
- The accuracy of the predicted flowing bottomhole pressure is entirely dependant upon the manner in which a simulation program is written and the correlations used to calculate the fluid properties.
- An inaccurate multiphase flow correlations program may underestimate or overestimate the computed flowing bottomhole pressure, and this phenomenon may lead to severe error in facilities design.

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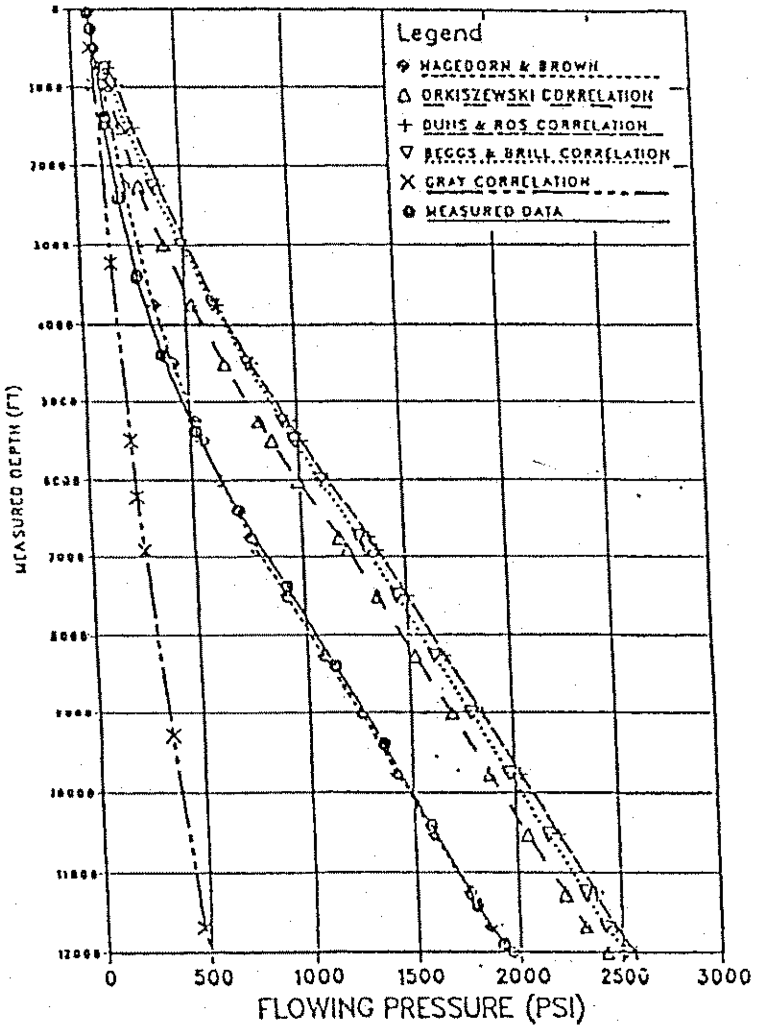

FIGURE 1

MULTIPHASE FLOW CORRELATIONS FOR

IMPERIAL-1

(GRADIENT SURVEY ON 11/08/1986)

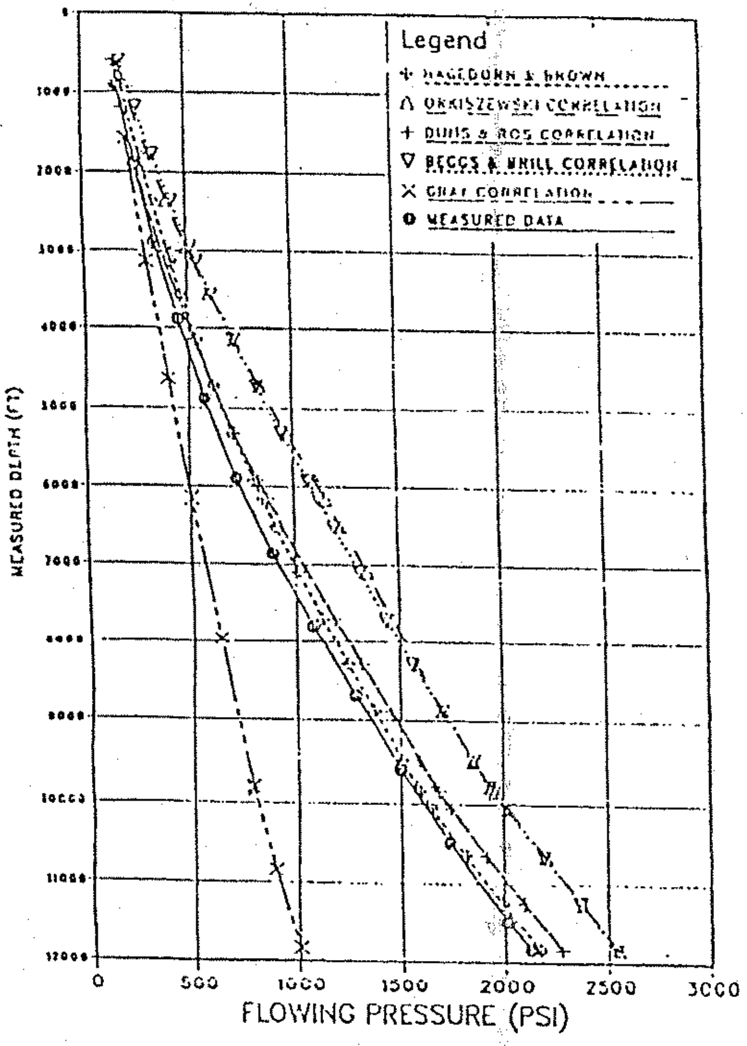

FIGURE 2

MULTIPHASE FLOW CORRELATIONS FOR

IMPERIAL-2

(GRADIENT SURVEY ON 14/12/1983)

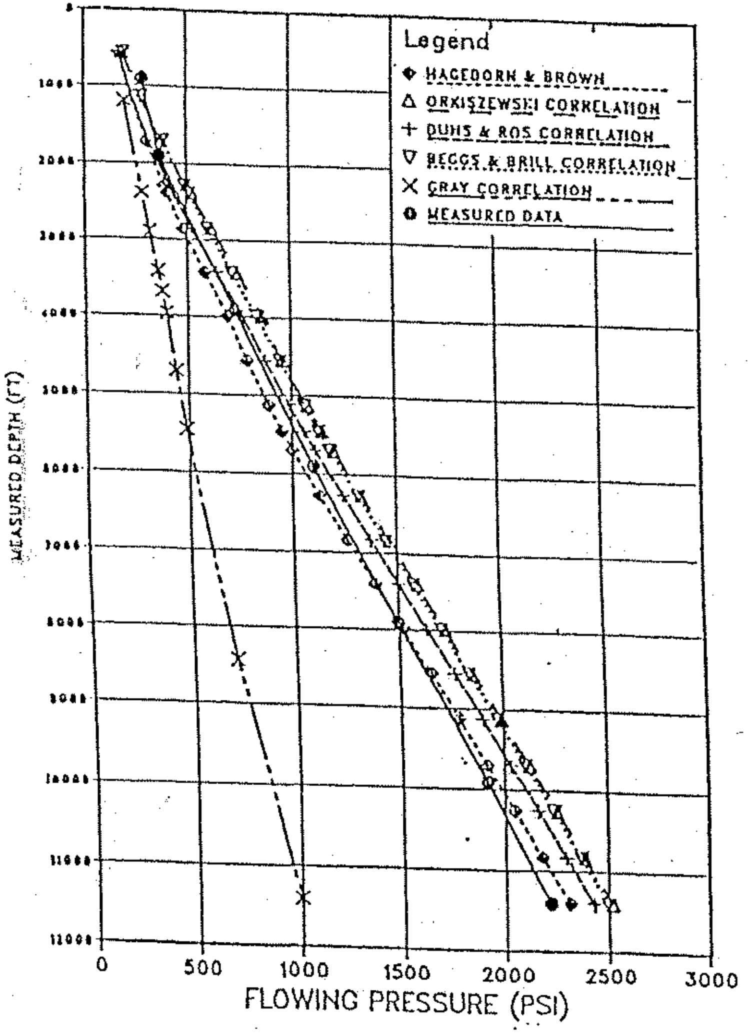

FIGURE 3

MULTIPHASE FLOW CORRELATIONS FOR

IMPERIAL-3

(GRADIENT SURVEY ON 16/03/1984)

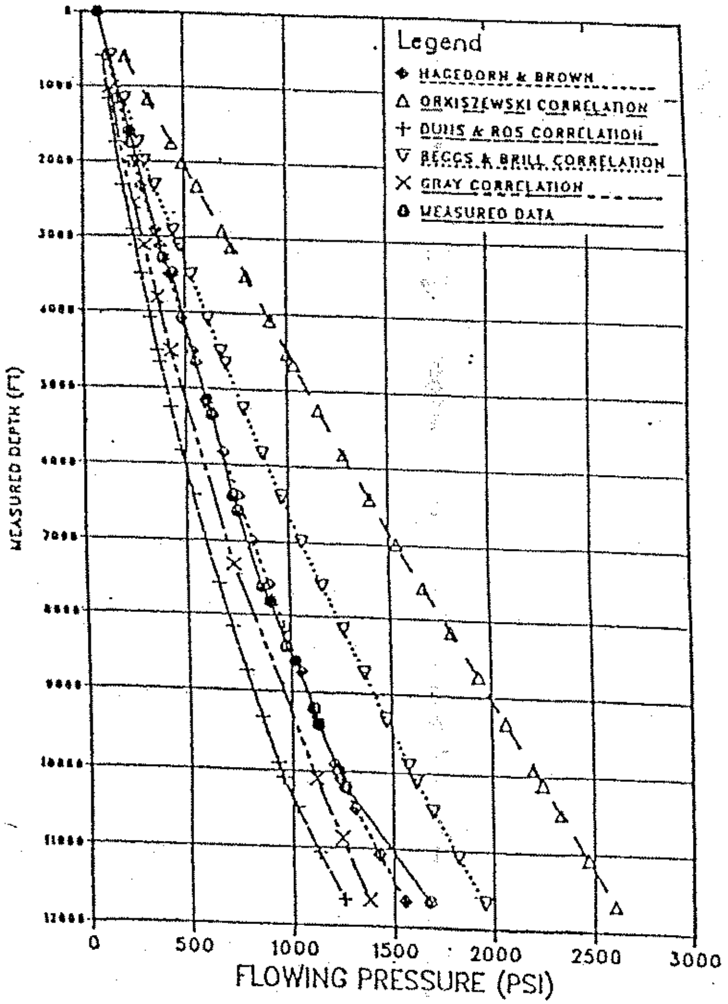

FIGURE 4

MULTIPHASE FLOW CORRELATIONS FOR

IMPERIAL-4

(GRADIENT SURVEY ON 11/08/1986)

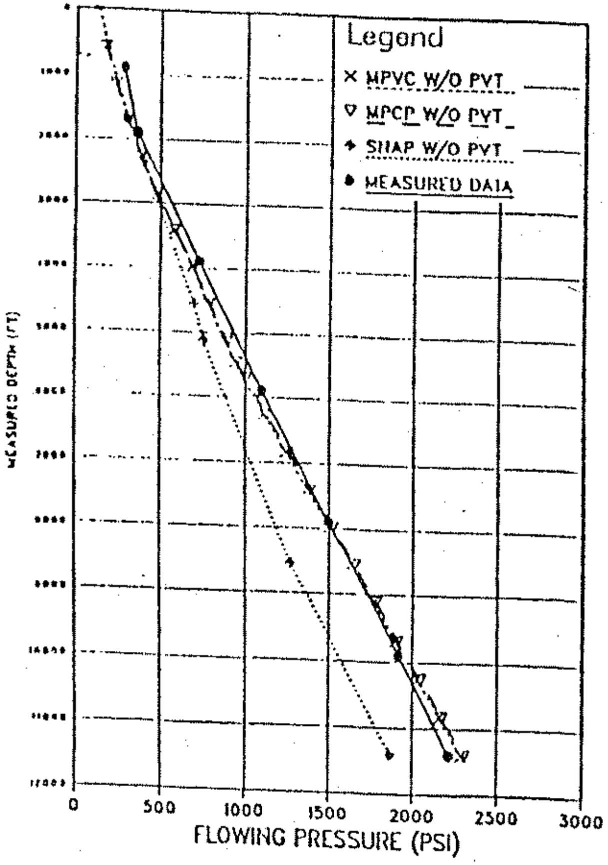

FIGURE 5

COMPARISON BETWEEN MPCP/MPVC/SNAP

FOR IMPERIAL–2

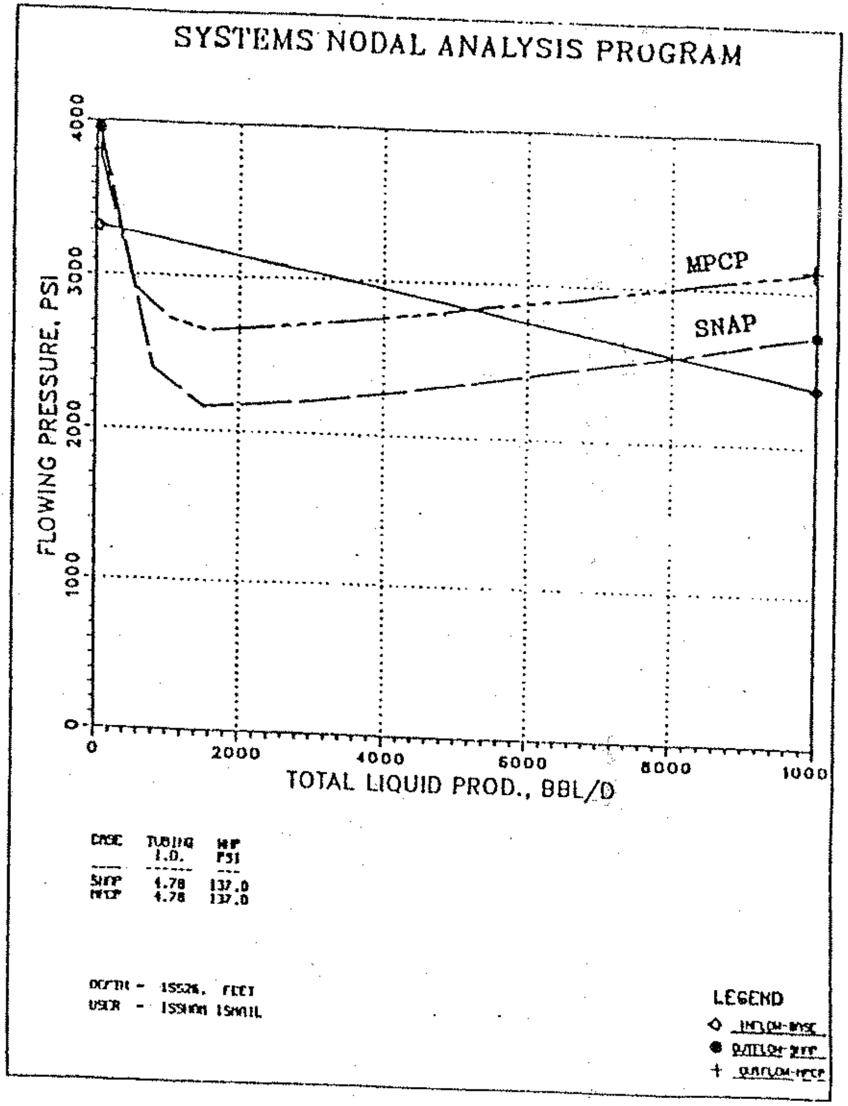

FIGURE 6

LIQUID RATES PREDICTION BY MPCP AND SNAP

FOR IMPERIAL–2