American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-7, Issue-11, pp-81-85
www.ajer.org
Research Paper Open Access

Simulation of Pressure Drop in Oil Wells for Guo–Ghalambor Model

Iluska Marques[1], George Simonelli[2]
[1]*B. S degree in Gas and Petroleum Engineering, Jorge Amado University, Brazil*
[2]*Department of Materials Science and Technology, Federal University of Bahia, Brazil*
Corresponding Author: Iluska Marques

ABSTRACT: *In the vertical multiphase flow in an oil well, knowing the pressure gradient is indispensable since it is able to reveal the variation of the pressure in each section of the tubing in relation to its depth, thus being able to identify the necessary pressures to control the flow, solve problems of flow, among others. Guo-Ghalambor developed a correlation capable of predicting the pressure drop along the tubing. The calculations are made considering the flow of four components: water, oil, gas and sediments; the last one being the factor that differentiates this correlation from other existing ones. In most multiphase flow correlations, the solids present are neglected. In this research, an Excel® spreadsheet was developed to simulate a multiphase flow problem found in the literature. The results showed that the spreadsheet is suitable to quickly simulate the pressure drop in an oil well that has a four-phase multiphase flow.*

KEYWORDS *Guo-Ghalambor, oil well Performance, Multiphase Flow, Spreadsheet*

Date Of Submission:02-11-2018 Date Of Acceptance: 16-11-2018

I. INTRODUCTION

For hydrocarbons to reach the surface, the available energy at the bottom-hole must be enough to overcome the hydrostatic, friction, and acceleration pressure losses.

The basis for any calculation of fluid flow is an energy balance for the flow in the fluid between two points. [1] The general energy equation is first developed using the principles of thermodynamics and is then modified to the form of the pressure gradient equation. [2]

The pressure gradient in the tubing is the result of the sum of the gradient due to elevation, the gradient due to friction and the gradient due to acceleration [3]. The hydrostatic portion of the pressure gradient is expressed as a function of the fluid density. The second portion, that of the gradient due to friction, depends on the characteristics of the fluids, the piping and the flow. The higher the flow rate, the greater the friction loss [3]. Finally, the third portion, referring to acceleration, is neglected whenever the fluid is incompressible.

From the general energy equation, numerous empirical and mechanistic correlations were calculated to calculate the pressure drop, considering different slopes and conditions of the fluid along the length of the pipe.

Poettmann and Carpenter (1952) [4] were the first to develop a method for predicting pressure loss in a flow containing: gas, oil, and water. This model was based on relatively low rate flow data that is not applicable to high rate flow conditions. [1]

For flows with higher rates, Baxendell and Thomas (1961) [5] developed a correlation with considerations like those of Poettmann and Carpenter, both do not consider the flow regime and the velocity difference between the phases, if gas and liquid flow are at equal speeds. Francher and Brown (1963) [6] also chose not to consider the velocity between the phases and the flow regime in which the water-oil-gas mixture flows.

In the absence of detailed studies on multiphase flow considering the presence of solids, Guo-Ghalambor (2005) [7] created a correlation for the calculation of pressure loss in tubing of a four-component flow, water-oil-gas-sand, assuming no slip and not considering the fluid flow regime.

Other authors such as Duns and Ros (1963) and Orkiszewski (1967) [8,9] have produced more detailed correlations and are able to describe methods for identifying the flow regime, phase difference between velocity and friction. Hargerdom and Brown (1965) [10] They developed a correlation for the calculation of the pressure gradient in vertical flows of light oils from data from a 500 m deep experimental well [11]. The model of Beggs and Brill (1973) [12] can calculate the pressure gradient at any slope and is applicable in all flow regimes, being this model one of the most used.

The present work had the objective of elaborating a spreadsheet to simulate the Guo-Ghalambor method for calculating the pressure drop, using Excel® as a calculation tool. The equations for the determination of pressure differential in a multiphase flow are extremely complex, currently the best way to obtain fast and accurate results is using computer models and software developed for this purpose; those models being increasingly used in the oil and gas sector.

II. MATERIAL AND METHODS

According to Guo-Ghalambor (2005), the Equation (1) calculates the pressure gradient in the pipe containing water, oil, gas and sediments.

$$144b(P-Phf)+\frac{1-2bM}{2}ln\left|\frac{(144P+M)^2+N}{(144Phf+M)^2+N}\right|-\frac{M+\frac{b}{c}N-bM^2}{\sqrt{N}}\left[\tan^{-1}\left(\frac{144P+M}{\sqrt{N}}\right)-\tan^{-1}\left(\frac{144Phf+M}{\sqrt{N}}\right)\right]=a(\cos\theta+d^2e)L \quad (1)$$

Being,

P = Pressure, psia.

Phf = Tubing head pressure, psia.

L= conduit length, ft

Equations (2) to (8) also created by Guo-Ghalambor (2005) find the necessary variables for the calculation of Equation (1)

$$a=\frac{0.0765\gamma_g q_g+350\gamma_o q_o+350\gamma_w q_w+62.4\gamma_s q_s}{4.07T_{av}q_g} \quad (2)$$

$$b=\frac{5.615q_o+5.615q_w+q_s}{4.07T_{av}Q_g} \quad (3)$$

$$c=0.00678\frac{T_{av}q_g}{A} \quad (4)$$

$$d=\frac{0.00166}{A}\left(5.615q_o+5.615q_w+q_s\right) \quad (5)$$

$$e=\frac{f_M}{2_gD_H} \quad (6)$$

$$M=\frac{cde}{\cos\theta+d^2e} \quad (7)$$

$$N=\frac{c^2e\cos\theta}{(\cos\theta+d^2e)^2} \quad (8)$$

where,

A= cross-sectional area of conduit, ft2

D_H= hydraulic diameter, ft

f_M =Darcy–Wiesbach friction factor (Moody factor)

g =gravitational acceleration, 32:17 ft=s2

$q_{g=}$gas production rate, scf/d

$q_{o=}$oil production rate, bbl/d

$q_{s=}$sand production rate, ft3=day

$q_{w=}$water production rate, bbl/d

T_{av} =average temperature, °R
γ_g = specific gravity of gas, air = 1
γ_o = specific gravity of produced oil, freshwater = 1
γ_s = specific gravity of produced solid, fresh water =1
γ_w = specific gravity of produced water, fresh water =1

In Equation (6), to find the value of the variable (e) first calculate the fanning friction factor for two phases (f2f) described in Equation (9), when it is multiplied by four, we obtain the factor of Moody's friction, however, in this case the value will be multiplied by 4 twice, since this flow refers to four phases.

$$f2f = 10^{1,444-2,5log(D\rho V)} \quad (9)$$

$$D\rho V = \frac{1,4737 \; X \; 10^{-5} \; Mq_o}{D} \quad (10)$$

$$f_M = 4*4*f2f \quad (11)$$

Given all the variables involved in Equations (2) to (11) one can then apply them in Equation (1) and obtain the estimated value for bottom-hole pressure.
All the equations presented here were used in the production of a spreadsheet created in the Excel® program, so that the results are obtained quickly and accurately.

II.I METHOD APPLICATION

To produce the calculations in the developed simulator, we used input data found in the book Petroleum Production Engineering, by Guo, Lyons and Ghalambor (2007).

The case under study consists of a well with a depth of 7000 ft and a wellhead pressure of 300 psia, in this pipe with internal diameter equal to 1.995 in., a fluid containing water, oil, gas and sediments flows, presenting temperatures ranging from 160 to 100 ° F from the bottom-hole to the surface respectively, and the average of the inclination angle being 20 °. It is known that:
$q_{g=}$5,555 scf/d
γ_g =0.7 Air =1
$q_{o=}$1000 stb/d
γ_o = 0.85 H_2O=1
$q_{w=}$300 bbl/d
γ_w = 1.05 H_2O=1
$q_{s=}$1 ft^3/d
γ_s = 2.65 H_2O=1

Equation (1) requires that the dimensionless variables (a, b, c, d, e, m, n) be found through other equations created by Guo-Ghalambor (2005). These variables are based on the fluid properties and angle of Pipe Tilt. Substituting all the variables obtained in the first one into Equation (1), we find bottom-hole pressure. The pressure loss in the total system will be the difference between the final and the initial pressure (Pwf - Phf), this difference is the sum of all the pressure drops occurring in all the components of the production system from the bottom-hole to the surface.

III. SIMILATIONS AND RESULTS

By using the Excel® tool, by applying the equations in the cells of a spreadsheet, a computational simulator capable of predicting the pressure differential in a four-phase multiphase flow in the tubing can finally be elaborated.

With the initial data available, the necessary variables were calculated and implemented in their respective cells and later replaced in Equation (1). Figure 1 below presents the worksheet filled with the initial data and the variables obtained through the calculations

Fig. 1. Input and calculation data of the variables

initial data	US Field Units	
Total measured depth:	7.000	ft
Average inclination angle:	20	deg
Tubing I.D.:	1,995	in.
Gas production rate:	5.555	scfd
Gas specific gravity:	0,7	air=1
Oil production rate:	1000	stb/d
Oil specific gravity:	0,85	H_2O=1
Water production rate:	300	bbl/d
Water specific gravity:	1,05	H_2O=1
Solid production rate:	1	ft^3/d
Solid specific gravity:	2,65	H_2O=1
Tubing head temperature:	100	°F
Bottom hole temperature:	160	°F
Tubing head pressure:	300	psia

US Field Units		
A =	3,124319625	in^2
D =	0,16625	ft
T_{av} =	622	°R
cos(θ) =	0,939701414	-
(Dρv) =	36,18835628	-
f_M=	0,056454406	-
a =	0,027277695	-
b =	0,000519139	-
c =	7498,056093	-
d =	3,894292121	-
e =	0,005616493	-
M =	151,1269376	-
N =	268139,9127	-

Bottom hole pressure		
PWF	2.747	Psia

Source: Own author

The calculation of the Section Area was necessary, since only the inner diameter of the pipe was offered as the initial data, this calculation was done using the geometric equation for the area of the circle. The pipe diameter was 1.995 in, but for simplicity of calculation, it was necessary to convert the unit from "in" to "ft", so the internal diameter of the pipe was calculated at 0.16625 ft.

The DρV was found to obtain the fanning friction factor of four phases, to later find the friction factor of Moody. Both values found were satisfactory and like that found in the worksheet created by Guo-Ghalambor.

Using Equations (2) to (8), the other variables needed to calculate Equation (1) were obtained; the values obtained were identical to those found by Guo, Lyons and Ghalambor (2007). The estimated value of the bottom-hole pressure (pwf) was then calculated using Equation (1), the value found in this study was 2746.926 psia, a value like that found by Guo, Lyons and Ghalambor (2007).

In this way, the results found in this project were satisfactory and present great compatibility with the results of Guo, Lyons and Ghalambor (2007), proving the efficiency and speed from the simulator. Advances in studies and developments of computational models have facilitated the ways of solving complex mathematical calculations, making the whole process easier and more dynamic in search of better results obtained quickly.

IV. CONCLUSION

Knowing previously the pressure gradient along the pipe is of extreme importance for the correct functioning of the oil production to improve the performance of the well. Increasing the achievable oil production rate, since the oil flow is directly related to the pressure drop in the system can also prevent accidents that can cause partial or total loss of well, damage to the rock formation, among others.

After a detailed study of the Guo and Ghalambor method for calculating the pressure drop, it is concluded that this correlation is efficient with respect to the flow of the four compositions, being water, oil, gas and sediments. This study, considering the presence of sediments, presents a great differential, since the sediments are neglected in other existing correlations, and there are no in-depth studies on this type of flow.

The work presented testifies to the efficiency of this method, giving space for further studies and more detailed models to be created in order to predict the pressure drop in the oil production system by flowing liquids, gas and solids using a free and accessible tool as Excel® or more advanced software that perform this same type of calculation, making this process faster, more dynamic and efficient.

ACKNOWLEDGEMENTES

First to God, my best friend. To my wonderful parents, Alecsandra and Arthur, my greatest inspirations. To my love, Antonio, for the support, and especially my mentor George Simonelli for all the time dedicated and teachings that have become fuel for future research.

REFERENCES

[1]. A. Akintola, U. Akpabio, O. Mary-Ann1. Pressure Gradient Prediction of Multiphase Flow in Pipes. British Journal of Applied Science & Technology.

[2]. A. Benther, Análise do comportamento das curvas de pressãorequeridanaprodução de poços de petróleo. master's thesis, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, 2014.

[3]. J.E. Thomas, Fundamentos de engenharia de petróleo(Rio de Janeiro, RJ: Interciencia, 2004)

[4]. Poettman, F. H. and Carpenter, P. G.: "The Multiphase Flow of gas, Oil and Water Though Vertical Flow Strings with Application to the Desing of Gas-Lift Installations, "Drill. And Prod. Prac., API 1952. 257-317.

[5]. Baxendell, P. B. and Tomas, R.: "The Calculation of Pressure Gradients in High-Rate Flowing Wells," J. Pet. Tech. (Oct., 1961) 1023-1028.

[6]. Fancher, G. H., Jr. and Brown, K. E.: "Prediction of Pressure Gradients for Multiphase Flow in Tubing," Society of Petroleum Engineers. 1963. 59-69.

[7]. B. Guo, W.C Lyons, A. Ghalambor, Petroleum Production Engineering: A computer- Assisted Approach. (Huston, Tx: Gulf Publishing, 2007)

[8]. Duns, H., Jr. And. Ros, N. C. J.: "Vertical Flow of Gas and Liquid Mixtures in Wells," Proc., 6th World Pet. Congress .1963, 451.

[9]. Orkiszewski, J.: "Predicting Two-phase Pressure Drop in Vertical Pipes", Jornal of Petroleum Tech., June 1967, pp. 829-838.

[10]. Brown, K. E. and Hagedorn, A. R., Experimental Study of Pressure Gradients Occumng During Continuous Two-Phase Flow in Small-Diameter Vertical Conduits. Journal of Petroleum Technology, Abril de 1965, pp. 475-484.

[11]. H.D, Beggs. J.P Brill. A study of two phase flow in inclined pipes. Journal of Petroleum technology, 1973, pp. 607-617.

[12]. F. Pacheco et al. Identificação de padrões de escoamentomultifásico e determinação da perda de carga com o auxílio de redes neurais. 4º PDPETRO, Campinas, SP, Outubro de 2007.

Iluska Marques. "Simulation of Pressure Drop in Oil Wells for Guo–Ghalambor Mode. "American Journal of Engineering Research (AJER), vol. 7, no. 11, 2018, pp. 81-85