REPUBLIC OF IRAQ
MINISTRY OF HIGHER EDUCATION
AND SCIENTIFIC RESEARCH
UNIVERSITY OF MISAN
COLLEGE OF ENGINEERING
PETROLEUM DEPARTMENT

Study of PVT properties for an Iraqi Oil Field by PVTp software

Project

Submitted to the Department of Petroleum Engineering,
University Misan , In Partial Fulfillment of Degree
Requirements Bachelor of Science in Petroleum Engineering

By

Abbas Hussein Heneidi

Ali Radi Kassal

Ali Maher Hadi

Ali Salman Ghazi

Supervisor By : Ali Nour alden

2024 A.D 1445 A.H

بسم الله الرحمن الرحيم

(يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ

وَالَذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ)

صدق الله العظيم

(سورة المجادلة ايه ١)

Dedication

To my father, mother, brothers, sisters, and my Friends.

LIST OF CONTENT :

ABSTRACT

Reservoir fluids properties are very important in reservoir engineering computations. Ideally, those properties should be obtained from actual measurements. Quite often, however, these measurements are either not available, or very costly to obtain. In such cases, empirically derived correlations are used to predict the needed properties. Last decade, researchers utilized neural networks to develop more accurate PVT correlations.

This study evaluated most of the popular empirical PVT correlations showed in literature using 52 laboratory reports from Mishrif reservoir crudes in the southern Iraqi fields, the results showed that these correlations did not adequately predict the PVT properties for Mishrif reservoir. Therefore, in this study two methods are used for predicting the PVT properties for the Mishrif reservoir crudes in the south Iraqi oil fields. This study developed new empirical PVT correlations for the Mishrif reservoir oils as a function of commonly available field data. Correlations have been developed for bubble point pressure, solution gas oil ratio at bubble point, oil formation volume factor at bubble point, dead oil viscosity, saturated oil viscosity, undersaturated oil viscosity, and undersaturated oil compressibility using Statistical Analysis System (SAS) by applying nonlinear multiple regression method. For the development of these correlations, a wide range of data have been covered, more than 52 PVT reports from the Mishrif reservoir collected from 9 oil fields in the southern part of Iraq. It was found that the new correlations estimate PVT properties for Mishrif reservoir crudes in the southern Iraqi oil fields much better than the published ones.

Chapter One

INTRODUCTION

Introduction

Reservoir fluid properties form one of the many bases in petroleum engineering calculations. The evaluation of oil and gas reserves, fluid flow through porous media, multiphase flow in pipe, surface and subsurface equipment design, and production system optimization are dependent strongly on reservoir fluid physical properties. Those properties may be measured experimentally in a PVT (pressure-volume- temperature) laboratory or they may be estimated by using empiricalcorrelations.

The most accurate method for determining the behavior of these fluids is a laboratory PVT analysis; however, the evaluation of exploratorywells and the advanced design of equipment often require an estimate of the fluid behavior prior to obtaining a representative reservoir sample. Also, experimental data is often unavailable in reservoirs which do not warrant the cost of an in depth fluid study. Empirical correlations areoften used for such purposes.

Correlations are also required for the calculation of multiphase flow pressure gradients that occur in pipe. These calculations require the prediction of the fluid properties at various pressures and temperatures. Even through laboratory measurements of these properties may be available as a function of pressure, they are usually measured under isothermal conditions. The behavior of these properties as a function of temperature is usually predicted by using empirical correlations. The accuracy of empirical PVT correlations is often limited because reservoir fluids consist of varied and complex multi-component systems.

1.1 Research objectives

The study aims to achieve several points as follows:

1. Conduct an evaluation and study of the PVT inspection system's correlations, which are consistent with the data of the research sample in the southern oil fields in Iraq.

2. Work to find effective treatment methods for bubble point pressure, the proportion of dissolved gas oil at bubble point pressure, the volume factor of oil formation at bubble point pressure, and the viscosity of the oil (viscosity of dead oil, viscosity at bubble point, and viscosity above bubble point) and below saturated oil. Compressibility using non-linear regression method (traditional models) which is part of Statistica 6.0 using Mishrif reservoir data.

3. Develop new artificial neural network (ANN) models to estimate the bubble point pressure, the proportion of gas oil dissolved at the bubble point, the volume factor of oil formation at the bubble point, the viscosity of dead oil, the sub-viscosity of saturated oil, and the sub-compressibility of saturated oil, using the ANN (ANN), Back Propagation (BPN) algorithm, part of a mathematics laboratory program using Mushrif reservoir data in the southern Iraqi oil fields.

4. Study of characteristics Physical properties of hydrocarbons for

Optimization of extraction and production processes in The future

1.2.Application and experimentation

The data collected in this study are from the three southern oil field reservoirs: Buzurgan (Bo), Halfaya (Hf), and Amara (Am).

1.3 Neural network simulation or SNN

This network, which represents a type of artificial intelligence, is a computer model that attempts to mimic simple biological learning processes and mimic specific functions of the human nervous system. It is an adaptive and parallel information processing system, capable of developing associations, transformations, or mappings between objects or data. It is also the most popular intelligent pattern recognition technique for data. The basic elements of a neural network are neurons and their connection strength (weight). A learning algorithm takes an initial model with some "prior" connection weight (usually random numbers) and produces a final model by numerical iteration. Hence learning means deriving back-connection weights when matching performance criteria (e.g. mean square error is less than a certain tolerance value). Learning can be done by a “supervised” or “unsupervised” algorithm. The first requires a set of known input and output data patterns (or training pattern). This is commonly known as the feedforward model, in which no side or back connections are used.

This network has an information processing system that has common performance characteristics with biological neural networks. Artificial neural networks were developed based on the following assumptions:

This network is a translation of an artificial intelligence algorithm and is therefore an automation process

1. Information is processed in many simple elements called neurons.
2. Signals are passed between neurons via communication links.
3. Each communication link has an associated weight, which, in a typical neural network, multiplies the transmitted signal.
4. Each neuron applies an activation function (usually nonlinear) to its net

input (the sum of weighted input signals) to determine its output signal

1.4.Petroleum reserves and analysis

In order to determine the phase behavior of petroleum reserve fluids, standard methods have been designed to model the phase behavior of these fluids at different stages during processing. The phase behavior is completely different from pressure, volume and temperature (PVT, pressure, volume and temperature) and modeling, characterization and composition analyzes in order to simulate these properties in the laboratory. Several oil companies have jointly developed the PVT method, Data obtained from phase behavior tests of petroleum reserve fluids contain practical information necessary to maintain optimal design and cost-effective activities in an oil processing plant."[1]

Briefly, pressure volume temperature (PVT) analysis is performed to determine the fluid behavior of an existing well and the properties of petroleum natural gas samples. The time it takes to get hydrocarbons out of the ground is a factor that increases the cost of wells. Increasing the cost of oil and gas work reduces the profit margin of the project. Characterizing the oil and gas mixture in the reserve is crucial to understanding how easily hydrocarbons will exit the well in the current situation. Geologists must find the most cost-effective extraction methods.

The pressure, volume and temperature method is applied in almost every step of the hydrocarbon extraction process. Through these tests, the bubble point of the fluid is determined to understand the fluid movement system in the oil well.which determines phase behavior, using experimental data for fluids.

1.5.Initial description[1]:

Knowing the properties of fluid flow within the producing layer is considered the basis for reservoir studies, and this depends on knowing the properties of fluids within stratigraphic conditions, which can be determined accurately by taking samples of stratified oil within stratigraphic conditions and studying them in detail and accurately using a special station called the PVT station, which It relies on measurements of pressure, volume, and temperature simultaneously. By taking the underground oil sample and transferring it to the laboratory cylinder and then to the PVT cell, in addition to detailing the various measurements that

are conducted with the aim of obtaining an integrated report from which all the necessary data can be obtained in order to conduct the various storage studies with the aim of investing oil reservoirs with the best possible return.

1.5.Initial description[1]:

and accurately using a special station called the PVT station, which It relies on measurements of pressure, volume, and temperature simultaneously. By taking the underground oil sample and transferring it to the laboratory cylinder and then to the PVT cell, in addition to detailing the various measurements that are conducted with

---

the aim of obtaining an integrated report from which all the necessary data can be obtained in order to conduct the various storage studies with the aim of investing oil reservoirs with the best possible return.

1.6.PVTP [*2]:

is a tool for the production or reservoir engineer to use to predict the effect of process conditions on the composition of hydrocarbon mixtures with accuracy and speed. The compositional behaviour of complex mixtures including gas mixtures, gas condensates, retrograde condensates, volatile oils and black oils can be interpreted and predicted with confidence. The PVT package can be used as a stand-alone analytical tool, or can be used to generate tables of fluid properties, reduced compositions or matched parameters (Tc, P, ω Volume Shift Parameters and Binary Interaction Coefficients) for other applications such as reservoir simulators, well analysis packages, up to production process simulator. As the industry integrates their reservoir, production wells, surface gathering network and process models together having consistent PVT characterizations that can be used at all levels in the system is fundamental.

A reservoir engineer will typically have a characterization with up to five pseudos, while the process engineer wants to model each component. PVTP enables a representative characterization to be developed for both engineering needs:

The ability to manipulate and predict compositional changes using two distinct methodologies

The Black Oil Model

The Equation of State Model - EoS

- Characterise Fluid Behaviour using EoS to Optimise Recovery

Fluids.

1.7.. Overview

The objective of training the network is to adjust the weights so that application of a set of inputs produces the desired set of outputs. For reasons of brevity, these input-output sets can be referred to as vectors. Training assumes that each input vector is paired with a target vector representing the desired output; together these are called a training pair. Usually, a network is trained over a number of training pairs.

Before starting the training process, the weight must be initialized to small random numbers. This ensures that the network is not saturated by large values of the weights, and prevents certain other training pathologies. For example, if the weights all start at equal values and the desired performance requires unequal values, the network will not learn.

Training the back-propagation network requires the steps that follow6:

Step 1.Select the training pair from the training set; apply the input vector to the network input.

Step 2.Calculate the output of the network .

Step 3.Calculate the error between the network output and the desired output (the target vector from the training pair).

Step 4.Adjust the weights of the network in a way that minimizes error.

Step 5.Repeat steps 1 through 4 for each vector in training set until the error for the entire set is acceptably low.

The operation required in step 1 and 2 above are similar to the way in which the trained network will ultimately be used; that is, an input vector is applied and resulting output is calculated. Calculations are performed on layer- by-layer basis. In step 3, each of the network outputs is subtracted from its corresponding component of the target of the network, where the polarity and magnitude of the weight changes are determined by training algorithm6.

After enough repetitions of these four steps, the error between actual outputs and target outputs should be reduced to an acceptable value, and the network is said to be trained. At this point, the network is used for recognition and weights are not changed.

It may be seen that step 1 and 2 constitute “forward pass” in that the signal propagates from the network input to its output. Step 3 and 4 are a “reverse pass”; here the calculated error signal propagates backward through the network where it used to adjust weights.

CHAPTER TWO

LITERATURE REVIEW

Historical presentation within previous studies

This chapter presents most of the existing correlations related to the PVT properties of crude oil. These are bubble point pressure (Pb), solution gas oil ratio at bubble point (Rsb), oil formation volume factor at bubble point [FVF] (Bob), viscosity above bubble point [Under saturated oil viscosity](μoa), viscosity at bubble point [Saturated oil viscosity] (μob), dead - oil viscosity (μod) and oil compressibility above bubble point (Co).

2.1 Empirical Correlations and Evaluation Studies

Last six decades, engineers realized the importance of developing and using empirical correlations for PVT properties. Studies carried out in this field resulted in the development of new correlations.

2.1.1 Bubble point pressure

The bubble point pressure P_b of a hydrocarbon system is defined as the highest pressure at which a bubble of gas is first liberated from the oil. Since the 1940's engineers have realized the importance of developing empirical correlations for bubble point pressure . Studies carried out in this field resulted in the development of new correlations. Bubble point pressure is empirically correlated as a function of solution gas-oil ratio, gas density, oil density and temperature. This literature review considers work done by the following authors:

2.1.1.1 Standing Correlation

In 1947, Standing[8] developed correlations for estimating bubble point pressure. He used 105 experimentally determined data point obtains from 22 different crude oil/natural-gas mixtures from California field .The correlation treated bubble point pressure as a function of the reservoir temperature, gas oil ratio, oil gravity and gas gravity. Standing correlation was the first to use these four parameters, commonly used after his work in developing correlations. He reported an average error of 4.8%.The standing correlation is:

$$Pb = 18.\ 2[(\frac{Rsb}{\gamma g}10\ (0.00091T—0.0125\ \gamma_{API}) — 1.\ 4] \quad 2.1)$$

2.1.1.2 Vasquez and Beggs Correlation

In 1980, Vasquez and Beggs[9] developed a new correlation for bubble point pressure based on mathematical rearrangement of their solution gas oil ratio correlation which was developed using 5008 data point taken from 600 laboratory PVT analyses from various field all over the world. The Visquez and Beggs correlation is:

$$Pb = [\frac{C1Rsb}{\gamma_{gs}} 10 \frac{-C3\gamma ABI}{(T+460)}]1/C\ 2 \qquad 2.2$$

where:

API≤ 30	API> 30
C1=27.64	56
C2=1	1.18
C3=11.17	10.39

2.1.1.3 Glaso Correlation

In 1980, Glaso[10] deveoped new correlation for estimating bubble point pressure. He used data based on 45 oil samples from North Sea crude. Glaso reported an average absolute error of 1.28%.The Glaso correlation

2.1.1.4 Al-Marhon

In 1988, Al-Marhon[12] developed an empirical correlation for determining bubble point pressure using 160 experimentally obtained data points from the PVT analyses of 69 bottom hole fluid samples from Middle East oil reservoirs and expressed as functions of reservoir field data. Al-Marhon reported an average absolute error of 3.66%. He used nonlinear regression methods to develop the following correlations:

$$Pb = C_1 Rsb^{C_2}\, yg^{C_3}\, yo^{C_4}\, (T + 460)^{C_5} \qquad 2.6$$

where:

Coefficient	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**
Value	**5.38088e-3**	**0.715082**	**-1.87784**	**3.1437**	**1.32657**

2.1.1.5 Petrosky and Farshad Correlation

In 1993 Petrosky[13] and Petrosky & Farshad[14] presented a bubble point pressure correlation similar to standing[8] correlation with new calculated constants for the Gulf of Mexico using 90 data point obtained from 81 laboratory PVT analyses from more than 32 reservoirs located offshore Texas and Louisiana. The bubble point pressure correlation was developed using nonlinear regression and it predicts bubble point pressure with average absolute relative error of 3.28%.Petrosky and Farshad bubble point correlation is:

$$Pb = 112.727 \left[\frac{R_{sb}{}^{0.5774}}{\gamma_g^{0.8439}}\ 10^{X}\ - 12.34\right] \qquad 2.7$$

where: $X = 4.561 \times 10^{-5}\ T^{1.3911} - 7.916 \times 10^{-4}\ \gamma API^{1.54}$

2.1.2 Solution Gas Oil Ratio at bubble point

The solution gas –oil ratio R_S is defined as the number of standard cubic feet of gas that will dissolved in one stock-tank barrel of crude oil at certain pressure and temperature. The solution gas-oil ratio is a strong function of pressure, temperature, API gravity and gas gravity. The correlation for solution gas-oil ratio is usually derived from bubble point pressure correlation.

2.1.2.1 Standing Correlation

In 1947, Standing[8] developed correlation for determining the solution gas-oil ratio for California crude oils as a function of pressure, gas specific gravity, API gravity and system temperature. Standing correlation for solution gas oil ratio is rearrangement of his correlation for estimating the bubble point pressure.

2.1.2.2 Laster Correlation

In 1958, Laster[19] presented a new correlation for calculating solution gas-oil ratio at bubble point using 158 data points from 137 different crude oil systems from US, Canada, and south America. Laster solution gas-oil ratio correlation is:

$$\mathbf{Rsb} = \frac{132755\,\gamma_O\ yg}{MO(1-yg)} \qquad 2.16$$

where: Mo: effective oil molecular weight.

<u>Effective Oil Molecular Weight</u>

$$M_O = 630\text{-}10\gamma_{API} \qquad (API \leq 40) \qquad 2.17$$

$$M_O = 73{,}110(\gamma API)^{-1.562} \qquad (API > 40) \qquad 2.18$$

<u>Bubble Point Pressure</u>

<u>Factor</u>

$$\mathbf{Pf} = \frac{pb\,yg}{(T+459.67)} \qquad 2.19$$

2.1.2.3 Vasquez and Beggs Correlation

In 1980, Vasquez and Beggs[9] developed new correlation for calculating solution GOR. The correlation was obtained by regression analysis using approximately5008 measured gas-oil ratio data points taken from 600 laboratory PVT analyses from various field all over the world. Based on oil gravity, the measured data were divided into two groups. This division was made at the value of oil gravity of 30° API. The new correlation has the following form:

$$\mathbf{Rsb} = \left[\frac{\gamma gs\, Pb^{C2}}{C1}\ 10^{\frac{C3\,\gamma_{API}}{(T+460)}}\right] \qquad 2.22$$

Coefficient	API≤ 30	API> 30
C_1	**27.64**	**56.060**
C_2	**1.0937**	**1.187**
C_3	**11.172**	**10.393**

2.1.2.4 Glaso Correlation

In 1980, Glaso[10] proposed a correlation for estimating the gas- oil ratio as a function of the API gravity, gas specific gravity, pressure and temperature. The correlation was developed from studying 45 North Sea crude oil samples. Glaso reported an average error of 1.28%.

Coefficient	ApI< 30	API>30
A	**1.115**	**0.256**
B	**0.702**	**0.782**
C	**19.620**	**20.294**

2.1.3 Oil Formation Volume Factor at bubble point

Oil formation volume factor (FVF) is defined as the number of reservoir barrels of oil and dissolved gas that must be produced to obtain one stock barrel of stable oil at the surface (rb/stb). The oil formation volume factor is a strong function of pressure, temperature,oilgravity and gas gravity. Most of the published empirical Bo correlations utilize the following generalized relationship:

$$Bo=f\,(Rs,\ \gamma_{o},\ \gamma_{g},\ T)$$

2.1.3.1 Standing Correlation

In 1947, Standing[8] developed correlation for calculating the oil formation volume factor as a function of solution GOR, gas specific gravity, oil gravity and system temperature. The correlation was developed using the same data which used to develop his bubble point and solution gas oil ratio correlations. An average error of 1.2% was reported for the correlation. The standing oil FVF correlation is:

$$Bob = 0.9759 + 0.00012\ [\underline{Rs}\ (\frac{\gamma g}{\gamma o})^{0.5}\ 1.25(T - 460)]^{1.2}$$

2.1.3.2 Vasquez and Beggs Correlation

In 1980, Vasquez and Beggs[9] developed new correlation for estimating oil FVF at bubble point as a function as Rs, γ_{o}, γ_{g} and T. The correlation developed using same data which was used in developing their bubble point pressure correlation.

Vasquez and Beggs reported an average error of 4.7% for the following correlation:

$$B_{ob} = 1.0 + C_1 R_s + (T-520)\left(\frac{API}{\gamma gs}\right)[C_2 + C_3 R_s] \qquad 2.33$$

where

Coefficient	API≤ 30	API> 30
C_1	4.677×10^{-4}	$4.670\ 10^{-4}$
C_2	1.751×10^{-5}	$1.100\ 10^{-5}$
C_3	-1.811×10^{-8}	$1.337\ 10^{-9}$

2.1.3.3 Glaso Correlation

In 1980, Glaso[10] developed new correlation for calculating oil formation volume factor at bubble point pressure using the same data was used to develop a correlation for bubble point pressure. The new correlation for oil FVF has the following form:

$$Bob = 1.0 + 10^{A} \qquad 2.34$$

where:

$$A = -6.58511 + 2.91329\,(\log Bob^{*}) - 0.27683\,(\log B_{ob}^{*})^{2} \qquad 2.35$$

Bob* is correlating number and is defined by the following equation:

$$Bob^{*} = Rs\left(\frac{\gamma g}{\gamma o}\right)^{0.526} + 0.968(T-460) \qquad 2.36$$

2.1.2.4 Al-Najjar et al. Correlation

In 1987, Al-Najjar et al.[11] developed correlation for oil formation volume factor for different Iraqi oil reservoirs using the same data which used in developing bubble point pressure correlation. Al-Najjar correlation has the following form:

$$\mathbf{Bob = 0.96325 + 4.9 \times 10^{-4}\, F} \quad 2.37$$

where:

$$\mathbf{F = Rsb}\left(\frac{\gamma g}{\gamma o}\right)^{0.5}\mathbf{+1.25\, T} \qquad 2.38$$

2.1.3.5 Al-Marhon

In 1988, Al-Marhon[12] developed an empirical correlation for estimating oil FVF at bubble point for Middle East oils using nonlinear multiple regression analysis and trial and error method based on the same data set which was used for developing his bubble point pressure correlation in 1988. The average absolute relative error was 0.88%.The correlation does not conform to the limiting condition at GOR=0 and temperature=60 F, the expected value should be 1 at least but the correlation gives 0.9458. Al-Marhon proposed the following expression:

$$\mathbf{Bob = 0.47069 + 0.862963 \times 10^{-3}\, T + 0.182594 \times 10^{-2}\, F}$$

$$\mathbf{+ 0.318099 \times 10^{-5}\, F^{2}} \qquad 2.39$$

2.2 Artificial Neural Network

An artificial neural network is a parallel-distributed information processing models that can recognize highly complex patterns within an available data. In recent years, neural network have gained popularity in petroleum application. Many authors discussed the applications of neural network in petroleum engineering. Few studies were carried out to model PVT properties using neural network.

In 1997, Gharbi and Elsharkawy[37]published neural network models for estimating bubble point pressure and oil formation volume factor for Middle East crude oils. They used two hidden layers neural networks to model each property separately. The bubble point pressure model had eight neurons in the first layer and four neurons in the second. Both models were trained using 498 data sets collected from literature and unpublished sources. The models were tested by other 22 data points from the Middle East. The results showed improvement over the conventional correlations methods with reduction in the average error for the bubble point pressure and oil formation volume factor.

In 1997, Gharbi and Elsharkawy[38] presented another neural network model for estimating bubble point pressure and oil formation volume factor for universal use. They used three-layer neural network model to predict the two properties. They developed the model using 5200 data sets collected from all over the word representing 350 different crude oils. Another set of data consisting of 234 data sets was used for verifying the results of the model. The reported results for the universal model showed less improvement than the Middle East neural model over the conventional correlations. The bubble point pressure average error was lower than that of the conventional correlations for both training and test data. The oil formation volume factor on the other hand was better than conventional correlations in term of correlation coefficient. The average error for the neural network model is similar to conventional correlations for training data and higher for test data than the best performing conventional correlation.

In 1998, Elsharkawy[39] presented a new technique to model the behavior of crude oil and natural gas system using a radial basis function neural network model (RBFNM). The model can predicted oil formation volume factor, solution gas-oil ratio, oil viscosity, saturated oil density, undersaturated oil compressibility, and evolved gas gravity. He used differential PVT data of 90 sample for training and another 10 novel samples for testing the model. Input data to the RBFNM were reservoir pressure, temperature, stock tank oil gravity, and separator gas gravity. Accuracy of the model in predicting the solution gas-oil, oil formation volume factor, oil viscosity, saturated oil density, undersaturated oil compressibility, and evolved gas gravity was compared for training and testing samples to all published correlations. The proposed model is much accurate than these conventional correlations in predicting the properties of the oils.

In 1999, Al-Shammasi[16] published a study on neural network model for estimation of bubble point pressure and oil FVF at bubble point. The bubble point model was developed using 137 global data sets for testing trained models, and 1106 for training. The model has two hidden layers, five nodes in first layer and three in the second layer. The neural model performance shows average absolute error of 15.08%. The oil FVF at bubble point model was developed using 180 global data set for testing and 1165 for training. The model has an average absolute error of 11.68%.

In 2001, Osman et al.[40] presented an artificial neural network model for predicting the oil formation volume factor at bubble point. The model was developed using 803 published data from the Middle East, Malaysia, Colombia, and Gulf of Mexico. One-half of the data was used to train the network, one –quarter to cross-validate the relationships established during the training process and the remaining one-quarter to test the model. The present model provides predictions of the formation volume factor at the bubble point pressure with an absolute average percent error of 1.789 %.

In 2002, Al-Marhon and Osman[41] presented new models developed to predict the bubble point pressure and the formation volume factor at bubble point pressure. The models were developed using 283 data sets collected from Saudi reservoirs. These data were divided into three groups: the first was used to train the ANN models, the second was used to cross-validate the relationships established during the training process and, the last was used to test the models to evaluate their accuracy and trend stability. Result show that the developed models outperform the published correlations in term of absolute average percent relative error, and standard deviation.

In 2005, Al-Marhon and Osman[42] used both back propagation (BPN) and Radial Basis Function (RBF) networks. RBF used to develop the general ANN model to predict brine density.

CHAPTER THREE

DATA PREPERATIONANDDESCRIPTIO NAND calculate the current PVT

DATA PREPERATION AND DESCRIPTION

A black oil reservoir fluid study involves a series of laboratory procedures designed to provide values of physical properties (e.g., density, gas gravity, oil viscosity, bubble point pressure, solution gas -oil ratio, and oil formation volume factor). A "study" typically consists of five main procedures performed on a sample of reservoir fluid: composition analyses, a flash vaporization test, a differential vaporizationtest, separator tests, and measurement of oil viscosity. Standard laboratory PVT tests are carried out on the basis that two different thermodynamic process; flash and differential liberation; occur as reservoir fluid are produced to the surface.

Differential liberation is defined as a process where gas is removed from contact with the oil as it release from solution. By contrast, in aflash liberation of gas, all of the produced gas remains in contact with the oil, at equilibrium conditions. The database used in this study constructed from PVT reports which were provided by the Ministry of Oil using the results of flash vaporization test, differential vaporization test, and measurement of oil viscosity.

Data Description

The data used in this study were obtained from Mishrif reservoir for several southern Iraqi oil fields. Table (3-2) presents the description of data utilized in this study with ranges of bubble point pressure, solution gas oil ratio, reservoir temperature, oil formation volume factor at bubble point, oil viscosity above bubble point, viscosity at bubble point, dead oil viscosity, isothermal compressibility above bubble point, gas relativedensity, and API oil gravity. The number of PVT samples collected was 53 samples, one of these samples exclude because it was unrepresentative sample. Number of samples used for bubble point pressure, solution gas oil ratio, oil formation volume factor was 52 oil samples, while the number of PVT sample used for viscosity correlations was 43 oil samples. The sources of data are showing in the Table (3-1).

Table 3-1 Sources of Data for the Mishrif Crude Oil Used

Field	Number of
North Rumaila (R)	3
South Rumaila (RU)	10
Zubair (Z)	5
West Qurna (WQ)	5
Buzurgan (Bu)	7
Halfaya (Hf)	10
Fuqah (Fq)	3
Amara (Am)	4
Nasria (Ns)	6

Table 3-2 Range of Data for the Mishrif Crude oil Used

Property	Minimum Value	Maximum value	Mean
Pb(psia)	1104.7	3257.544	2335.19983
GOR(SCF/STB)	337.0123	757.5196	556.8827
OFVF(RB/STB)	1.2244	1.5124	1.350463
Reservoir	159.8	240.08	194.0366

TEMP(F°)			
γg(air=1)	**0.854722**	**1.183**	**0.967681**
Oil density (API°)	**18.5**	**29.3**	**23.8446532**
μod(cp)	**3.1664**	**16.86745**	**6.409146**
μob(cp)	**0.63**	**3**	**1.403558**
μoa(cp)	**0.633**	**4.519**	**1.7069154**
Co($psia^{-1}x10^{-6}$)	**5.3976**	**13.7898**	**8.17142**

3.1 Data Validation

Although standard laboratory procedures are accurate in most cases, there are always experimental errors. These errors may be human errors or errors occurring due to the techniques and equipment which were used in the laboratory.

To check the quality of database and their accuracy, three tests were used, which are based on the material balance principle:

1-Resevoir material balance test43.

2- Bubble point density test43.

3- Surface-reservoir fluid density Ratio32.

3.1.1 Reservoir Material Balance Test

The following equation used for this test43:

Mot = Mor + Mg   3.1

where:

Mot = Vot. ρot   3.2

Mor = Vor. ρor   3.3

$Mg = \sum n \quad Vgi.\ \rho gi$ 3.4

Mot=Mass of total reservoir oil transferred to PVT cell, grams Mor= Mass of residual oil after differential separation, grams.

Mg= Mass of total gas liberated from differential separation, grams.

Vot= Volume of total oil transferred to the PVT cell, cm3.

Vor= Volume of residual oil after differential separation cm3. Vg= volume of gas liberation in differential liberation cm3. ρot = density of total oil transferred to the PVT cell, gm/cm3.

ρor =density of residual oil after differential separation, gm/cm3.

ρgi =density of gas liberation in (i) of differential liberation gm/cm3.

The absolute percentage deviation (D1) was determined to compare the calculated and measured mass of total reservoir oil transferred to PVT cell (Mot).

$$D1 = ABS \left[\frac{(Mor+Mg)-Mot}{Mot}\right] * 100\% \qquad 3.5$$

3.1.1 Bubble Point Density Test

The following equation used for this test43:

$$\rho_{obc} = \frac{(\rho or + \sum_{i=1}^{n} Ri.\rho gi)}{Bobm}$$

where:

ρ_{or} =density of residual oil after differential separation, gm/cm3.

Ri = Gas-Oil Ratio at stage (i) = GORi-GORi-1, cm3.
ρgi =density of gas liberation in (i) of differential liberation gm/cm3.
Bobm =measured oil formation volume factor at bubble point, cm3/ cm3.

$$D2 = ABS \left[\frac{(\rho obc - \rho obm)}{\rho obm}\right] 8\ 100\ \% \qquad 3.7$$

Vot= Volume of total oil transferred to the PVT cell, cm^3.
Vor= Volume of residual oil after differential separation cm^3.Vg= volume of gas liberation in differential liberation cm^3. ρot = density of total oil transferred to the PVT cell, gm/cm^3.
ρor =density of residual oil after differential separation, gm/cm^3.

ρgi =density of gas liberation in (i) of differential liberation gm/cm^3.
The absolute percentage deviation (D_1) was determined to compare the calculated and measured mass of total reservoir oil transferred to PVTcell (Mot).

3.1.1Surface-Reservoir Fluid Density Ratio

The following equation used in this test[32]:

$$\textbf{Bobc} = \frac{(\rho_{STO+0.0135\ Rs\gamma g\ )}}{\rho obm}$$

Where:

ρ_{STO} = density of the stock

tank oil, lb/cu ftRs = gas-oil

ratio, SCF/STB

γ_g = gas specific gravity, weighted average (air=1)

ρ_{obm} = measured oil density at bubble point, lb/cu ft

Equation 3.8 is a material balance of surface conditions .

$$D3 = \left[\frac{(B_{obc-}B_{obm}}{Bobm}\right] * 100\% \qquad 3.9$$

The value of D_1 and D_2 and D_3 must be less than [5%] so that theexperimental results are considered acceptable.The values of D1 and D_2 and D_3 for all data that are used in this workare given in table 3.3

A sample of each test is given in appendix A.

Table 3-3 Data Validation

Field	WELL	Absolute Err% Reservoir Material Balance TestD1%	Absolute Err% Bubble Point Density TestD2%	Absolute Err% Surface-Reservoir Density TestD3%
North Rumaila	**R-81**	**0.970336**	**0.968305**	**1.505853**
North Rumaila	**R-124**	**1.366559**	**1.368296**	**1.570372**

North Rumaila	**R-334**	**2.71243**	**2.705817**	**2.790301**
South Rumaila	**Ru-20**	**2.26644**	**2.255552**	**2.170327**
South Rumaila	**Ru-21**	**0.432325**	**0.431577**	**3.776796**
South Rumaila	**Ru-29(DST1)**	**1.943912**	**1.949743**	**2.044886**
South Rumaila	**Ru-29 (DST2)**	**1.360149**	**1.357504**	**1.435792**
South Rumaila	**Ru-71**	**0.000065**	**0.006434**	**0.004713**
South Rumaila	**Ru-105 (DST1)**	**0.42073**	**0.418222**	**0.338372**
South Rumaila	**Ru-105 (DST2)**	**1.766306**	**1.765766**	**1.819921**
South Rumaila	**Ru-130**	**3.266135**	**3.225993**	**3.28614**
South Rumaila	**Ru-133**	**2.738269**	**2.701852**	**2.734614**
South Rumaila	**Ru-268**	**2.606826**	**2.512197**	**2.576181**
Zubair	**Z-1**	**0.807906**	**0.810169**	**0.900419**
Zubair	**Z-32 (DST1)**	**1.006358**	**0.999677**	**1.06518**
Zubair	**Z-32 (DST2)**	**1.144176**	**1.147426**	**1.884**

Zubair	**Z-36**	**0.079391**	**0.080188**	**0.009743**
Zubair	**Z-42**	**1.094138**	**1.102925**	**1.169422**
West Qurna	**WQ-60**	**2.557906**	**2.558998**	**2.509421**
West Qurna	**WQ-13 (DST1)**	**1.321062**	**1.32372**	**1.805034**
West Qurna	**WQ-13 (DST2)**	**0.160764**	**0.163087**	**0.220993**
West Qurna	**WQ-13 (DST3)**	**1.631452**	**1.747247**	**1.377786**
West Qurna	**WQ-233**	**4.548371**	**4.544358**	**4.575469**
Buzurgan	**Bu-1**	**0.42346**	**0.433369**	**0.5254**
Buzurgan	**Bu-3**	**0.03518**	**0.036654**	**0.095136**
Buzurgan	**Bu-5**	**0.001496**	**0.003406**	**0.095136**
Buzurgan	**Bu-6 (mc1)**	**3.632659**	**3.633612**	**3.732764**
Buzurgan	**Bu-6 (mc2)**	**0.971475**	**0.969583**	**0.980336**
Buzurgan	**Bu-10**	**0.17150**	**0.172511**	**0.250786**
Buzurgan	**Bu-12**	**2.179621**	**2.178008**	**2.264149**

Halfaya	**Hf-1 (DST1)**	**1.77053**	**1.77425**	**1.857347**
Halfaya	**Hf-1 (DST2)**	**2.184187**	**2.186352**	**2.256279**
Halfaya	**Hf-1 (DST3)**	**0.515825**	**0.54958**	**0.636884**
Halfaya	**Hf-1 (DST4)**	**0.646604**	**0.64218**	**0.64299**
Halfaya	**Hf-1 (DST5)**	**0.036816**	**0.030593**	**0.025444**
Halfaya	**Hf-3 (DST1)**	**1.505411**	**1.498865**	**1.556537**
Halfaya	**Hf-3 (DST2)**	**2.803839**	**2.818876**	**2.904234**
Halfaya	**Hf-3 (DST3)**	**4.422477**	**4.419648**	**4.491703**
Halfaya	**Hf-3 (DST4)**	**0.971737**	**0.979274**	**1.064739**
Halfaya	**Hf-3 (DST5)**	**3.260039**	**3.25797**	**3.31782**
Fuqah	**Fq-3**	**1.705126**	**1.712535**	**1.786073**
Fuqah	**Fq-4**	**4.873427**	**4.848608**	**4.978425**
Fuqah	**Fq-5**	**1.760621**	**1.770988**	**1.836434**
Nasria	**Ns-1 (DST1)**	**3.794236**	**3.793135**	**3.852846**
Nasria	**Ns-1 (DST2)**	**1.702388**	**1.710075**	**1.768739**

Nasria	**Ns-3 (DST1)**	**0.724926**	**0.736852**	**0.801925**
Nasria	**Ns-3(DST2)**	**1.964939**	**1.961073**	**2.010502**
Nasria	**Ns-3 (DST3)**	**3.065733**	**3.069751**	**3.003118**
Nasria	**Ns-4**	**0.310765**	**0.305338**	**0.385461**
Amara	**Am-1**	**3.758389**	**3.795908**	**3.840105**
Amara	**Am-2**	**0.992341**	**0.983212**	**1.068903**
Amara	**Am-3**	**0.535126**	**0.531498**	**0.438663**

calculate the current PVT

The purpose of this chapter is to provide perspective idea of why thiswork proposes new correlations.

This is done by illustrating the behavior of the most popular correlations as compared to the used data in "bubble point" for bubble point, solution gas oil ratio at bubble point and oil formation volume factor at bubble point correlations, and "below bubble point" for dead oil viscosity correlation (at atmospheric pressure andsystem temperature), and "above bubble point" for undersaturated oilviscosity and isothermal oil compressibility correlations.

The existing correlations for these properties (as shown in Chapter 2) are based on reservoir temperature (T), bubble point pressure(Pb), stock tank oil gravity(API), solution gas-oil ratio at bubble point(Rsb),gas gravity(γ_g), dead oil viscosity(μ_{od}) and saturated oil viscosity(μ_{ob}). Since the correlating parameters and the correlated properties are available in standared PVT report, the accuracy of a particular correlation have been checked by compartion with data in a PVT lab report.

The most popular correlations are applied in the used database and the results are presented as crossplot and statistical analysis. Crossplot is a plot of the calculated values from the correlation versus experimental values from the PVT report.A perfect correlation would plot as a stright line with slope of 45°.Statistical analysis was used to evaluate the performance of the correlations. The standard deviation and average absolute percentage error were the major statistical parameters used as a comparative criteria for the testing of evaluated correlations. Evaluation of Bubble Point Pressure Correlations

In this section, Standing[8], Glaso[10], Vasquez and Beegs[9], Petrosky and Farshad[14], Al-Marhon[12], Al-Najjar[11], Velard[15], Al-Aboodi[18] and Al-Shammasi[16, 17] correlations for bubble point pressure are evaluated using 52 data points. All of the above correlations for Pb are based on(T), (API), (Rsb), and (γ_g). Statistical error analysis was used to evaluate the performance of the correlations. The statistical accuracy of bubble point pressure is shown in Table (4.1).Cross plot analysis show the performance of the correlations in Figures (4.1) through (4.9).

Table 4.1Statistical Accuracy of Bubble Point pressure, Pb (Various Correlations)

Correlation	AAERR %	SD %
Velarde[15]	4.253732	4.96529
Al-Najjar[11]	4.606703	5.428116
Al-Marhoun[12]	8.481473	5.944776
Al-Shammasi[16, 17]	12.68183	5.61652
Standing[8]	14.82187	7.77427
Petrosky& Farshad[14]	16.615	5.6025
Vasquez & Beggs[9]	26.4219	8.34676
Al-Aboodi[18]	32.79324	12.7474

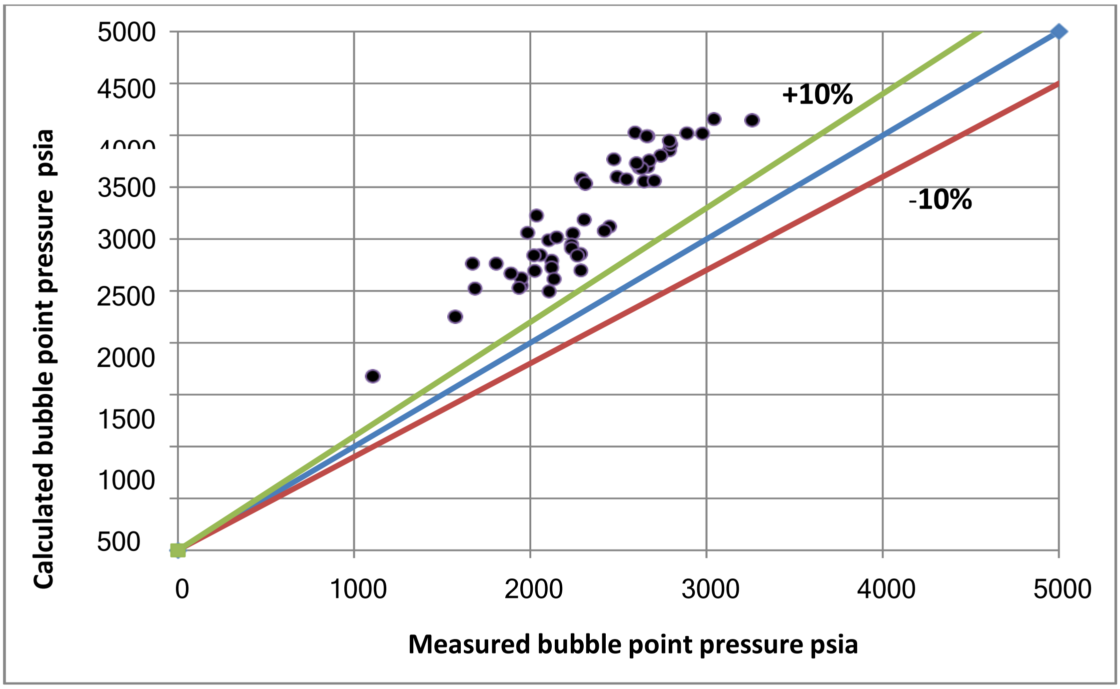

Fig.4.1 Cross Plot for Bubble-Point Pressure, Pb (Glaso's (Correlation[10])

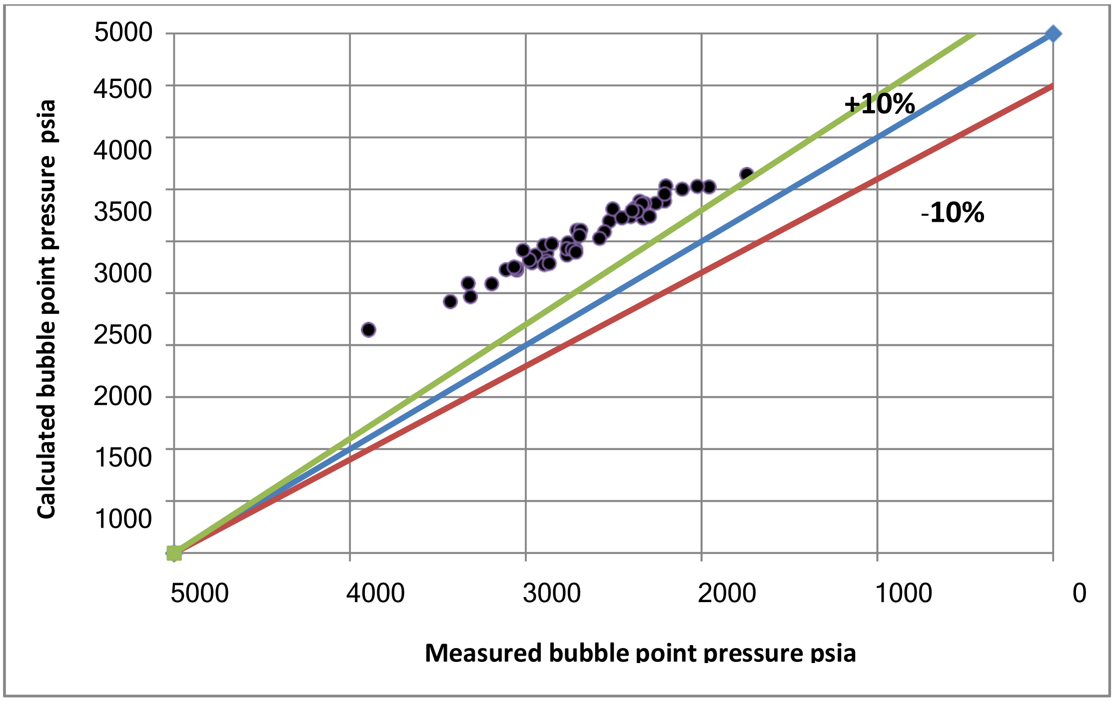

Fig.4.2 Cross Plot for Bubble-Point Pressure, Pb (Al-Aboodi's Correlation[18])

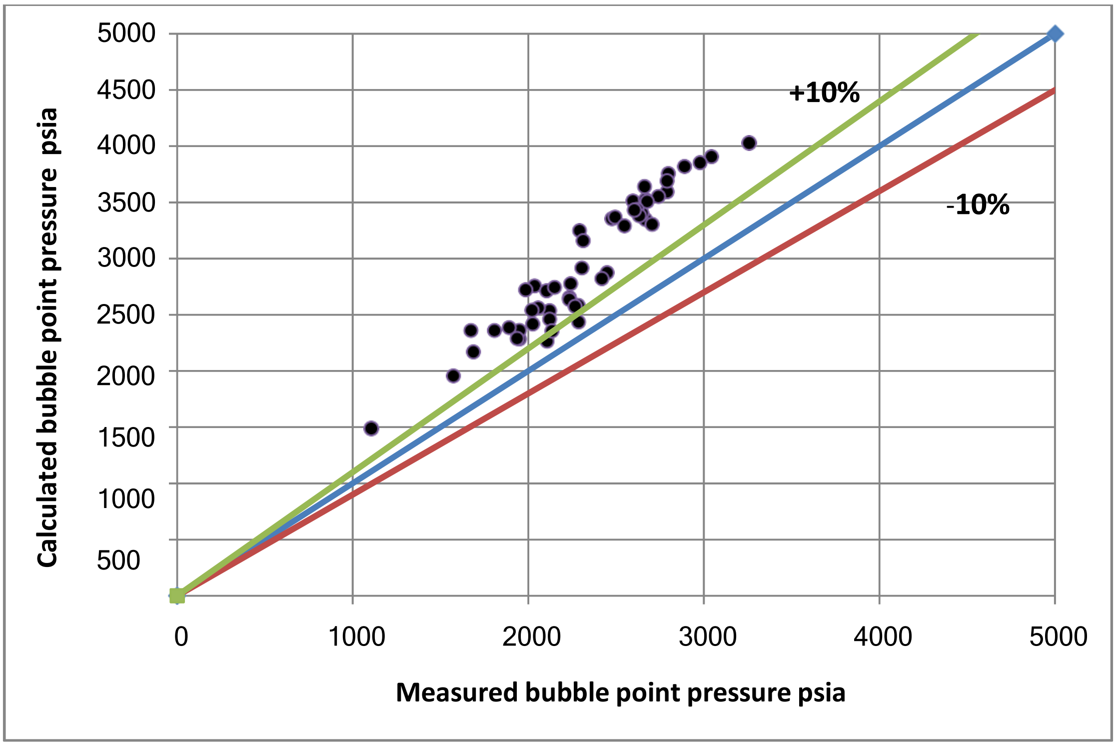

Fig.4.3 Cross Plot for Bubble-Point Pressure, Pb (Vasquez &Beggs's Correlation[9])

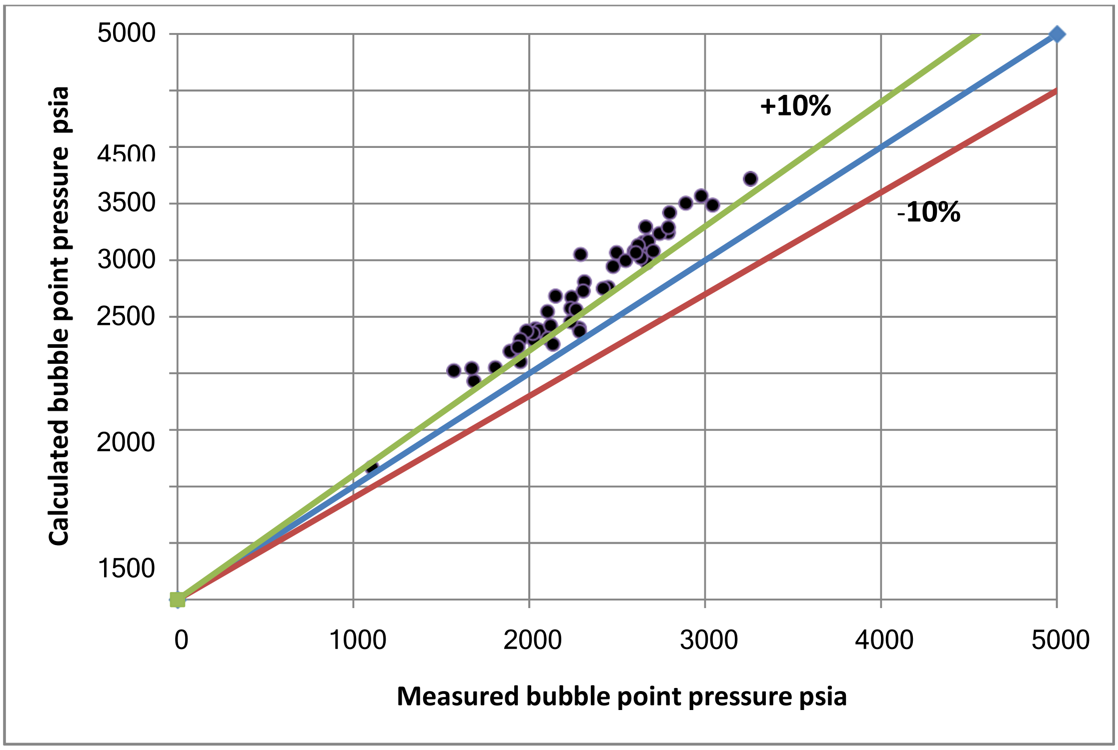

Fig.4.4 Cross Plot for Bubble-Point Pressure, Pb (Petrosky &Farshad's Correlation[14])

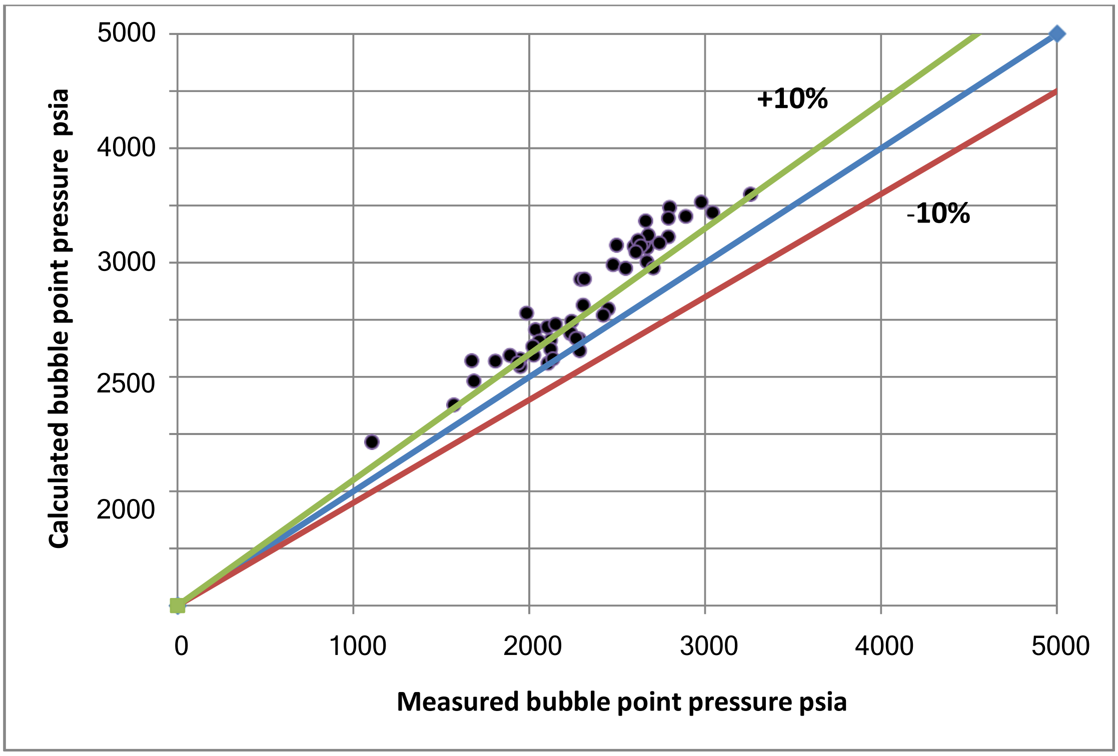

Fig.4.5 Cross Plot for Bubble-Point Pressure, Pb (Standing's Correlation[8])

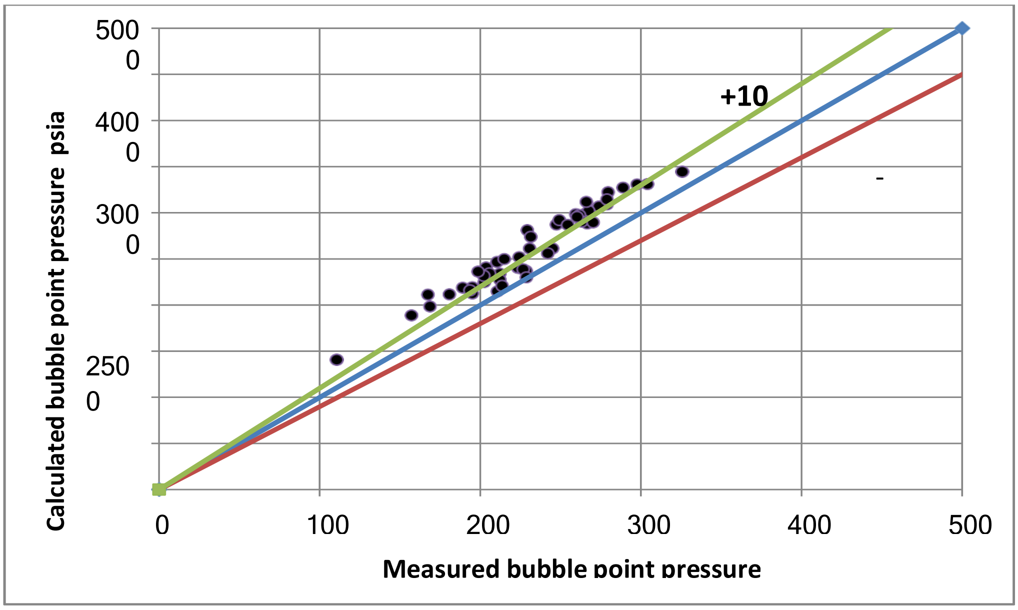

Fig.4.6 Cross Plot for Bubble-Point Pressure, Pb (Al-Shammasi's Correlation[16, 17])

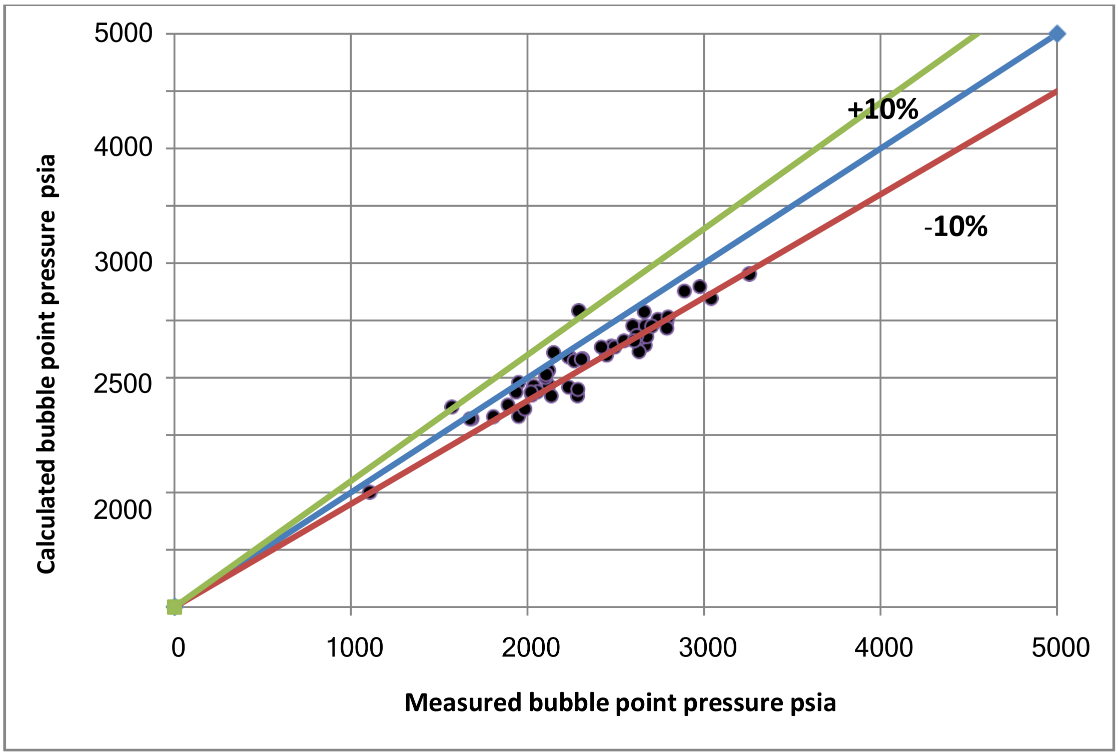

Fig.4.7 Cross Plot for Bubble-Point Pressure, Pb (Al-Marhon's Correlation12)

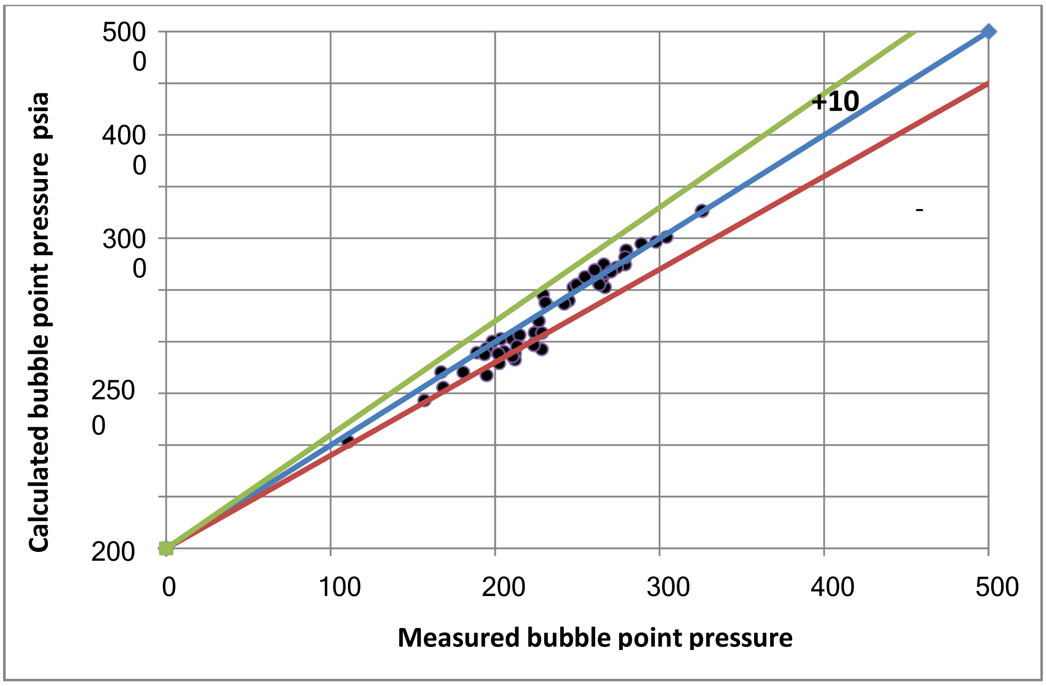

Fig.4.8 Cross Plot for Bubble-Point Pressure, Pb (Al-Najjar's Correlation11)

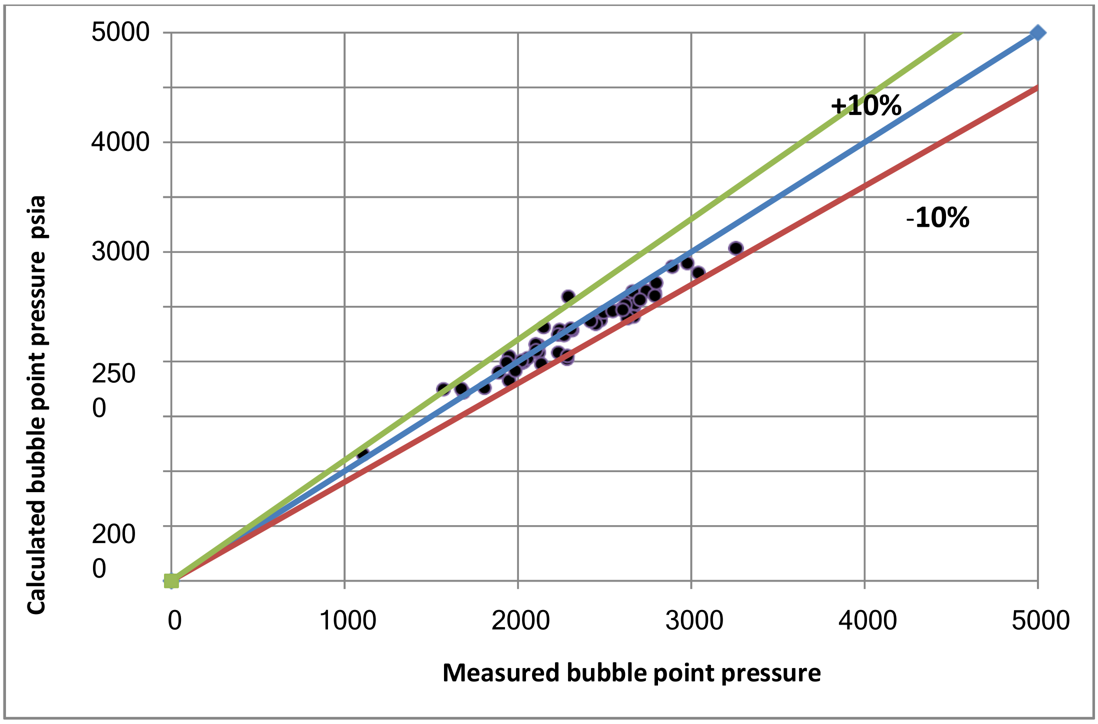

Fig.4.9 Cross Plot for Bubble-Point Pressure, Pb (Velard's Correlation[15])

As can be seen from Table (4.1) and Figures (4.1) through (4.9) Velard's correlation performs the lowest average absolute relative error and also appears to be more consistent (best standard deviation).However,in all cases the errors in calculated values have been considered momentous and permitting further effort to develop an improved correlation. So that Velard's correlation may be used to develop the new bubble point pressure correlation for Mishrif reservoir.

3.1Evaluation of Solution Gas-Oil Ratio Correlations

In this study, Standing[8], Glaso[10], Vasquez and Beegs[9], Lasater[19], Petrosky and Farshad[14], Al-Marhon[12], Al-Aboodi[18], and Al-Najjar[11] correlations for solution gas oil ratio are evaluated using Mishrif reservoirdata. As have been mentioned earlier, most of the correlations for gas-oil ratio are simply the bubble point pressure correlation and solved forsolution gas oil ratio. The statistical accuracy of solution gas oil ratio is

Correlation	AAERR %	SD %
Al-Najjar[11]	9.10867	8.073319
Al-Aboodi[18]	9.219902	11.23628
Al-Marhoun[12]	13.41007	9.471504
Standing[8]	14.7226	7.01194
Petrosky& Farshad[14]	15.4874	4.763984
Vasquez & Beggs[9]	22.2255	5.85063
Lasater[19]	26.51304	32.8703
Glaso[10]	32.491	6.18778

shown in Table 4.2.Cross plot analysis explain the performance of the correlations in Figures (4.10) through (4.17).

Table 4.2 Statistical Accuracy of Gas-Oil Ratio at P_b, R_{sb} (Various Correlations)

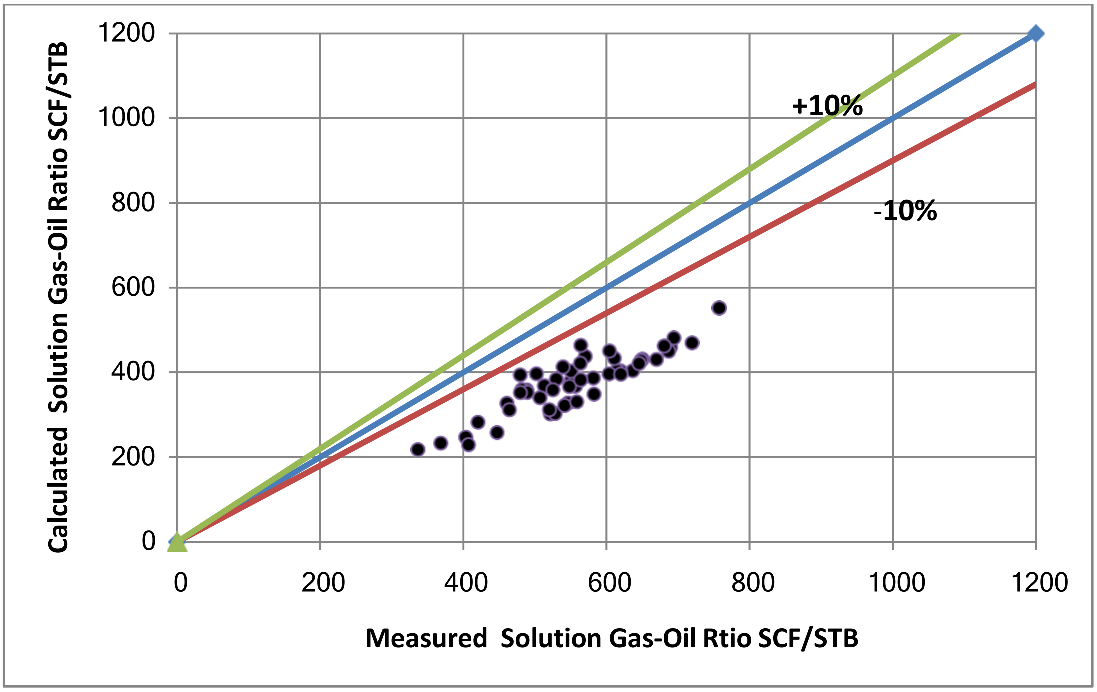

Fig.4.10 Cross Plot for Solution GOR at Pb, Rsb (Glaso's Correlation[10])

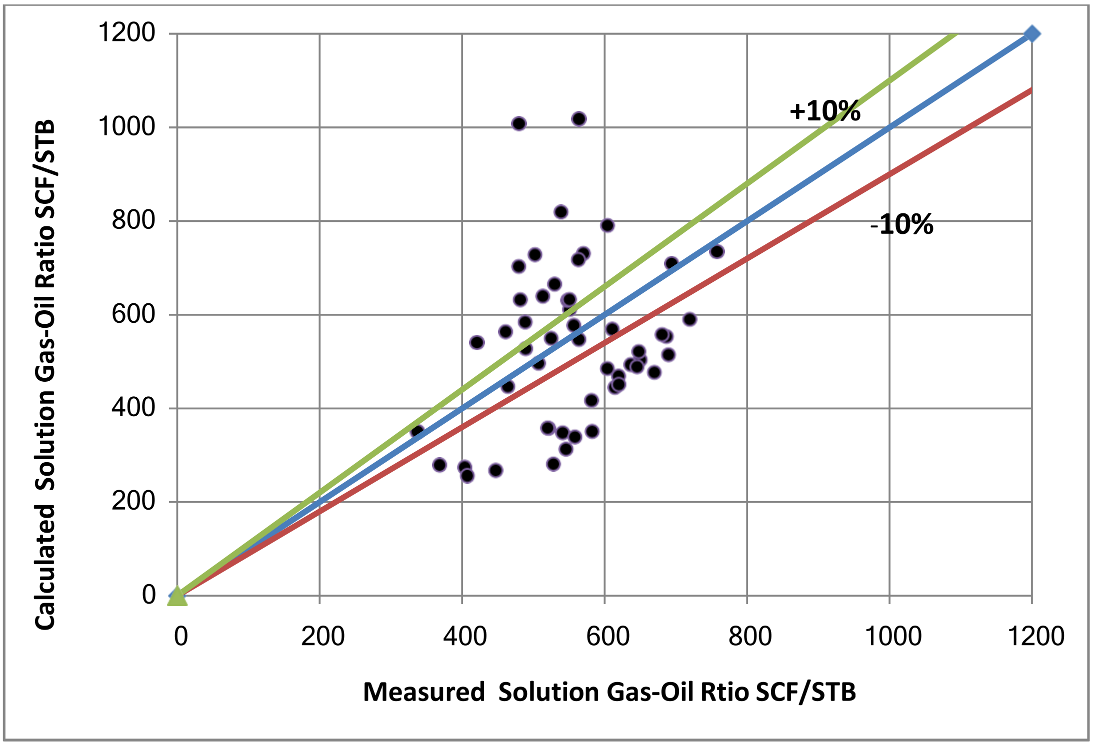

Fig.4.12 Cross Plot Solution GOR at Pb, Rsb (Lasater's Correlation[19])

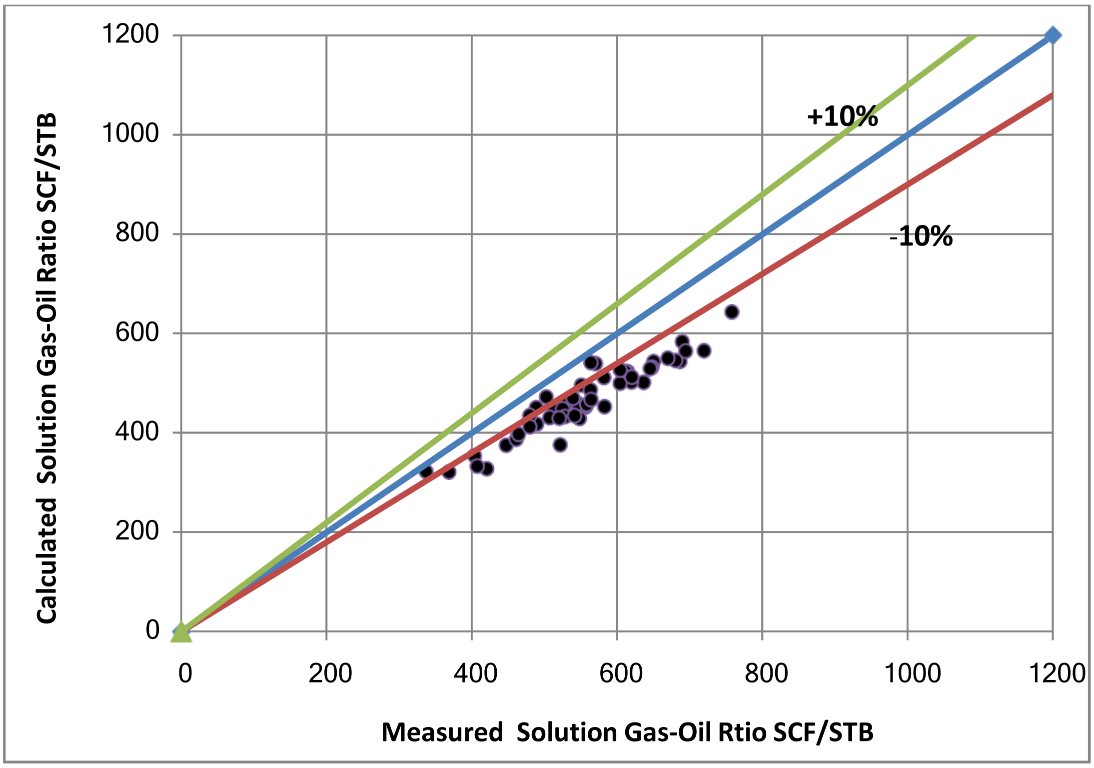

Fig.4.13 Cross Plot for Solution GOR at Pb, Rsb (Petrosky &Farshad's Correlation[14])

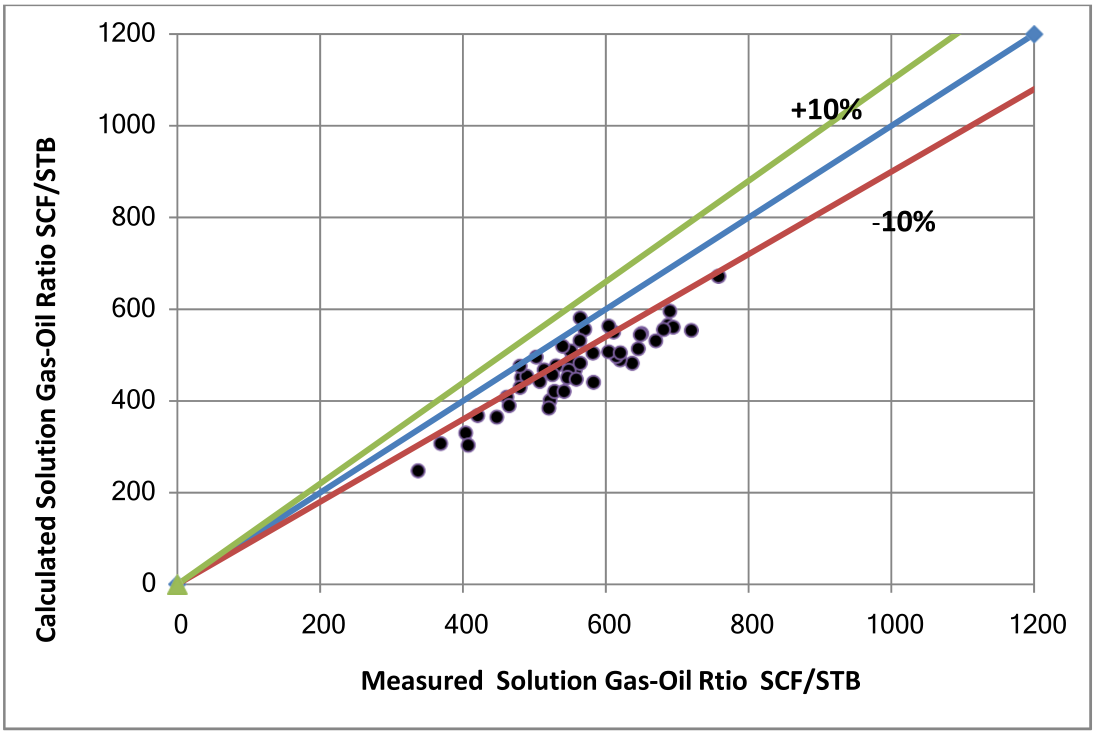

Fig.4.14 Cross Plot for Solution GOR at Pb, Rsb (Standing's Correlation[8])

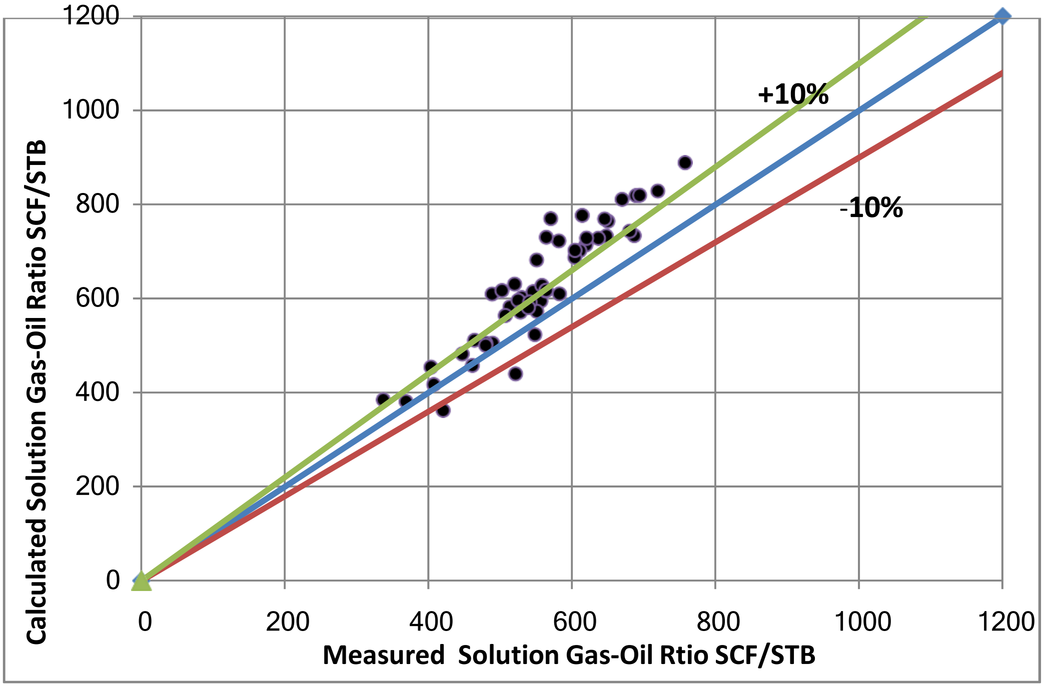

Fig.4.15 Cross Plot for Solution GOR at Pb, Rsb (Al-Marhoun's Correlation[12])

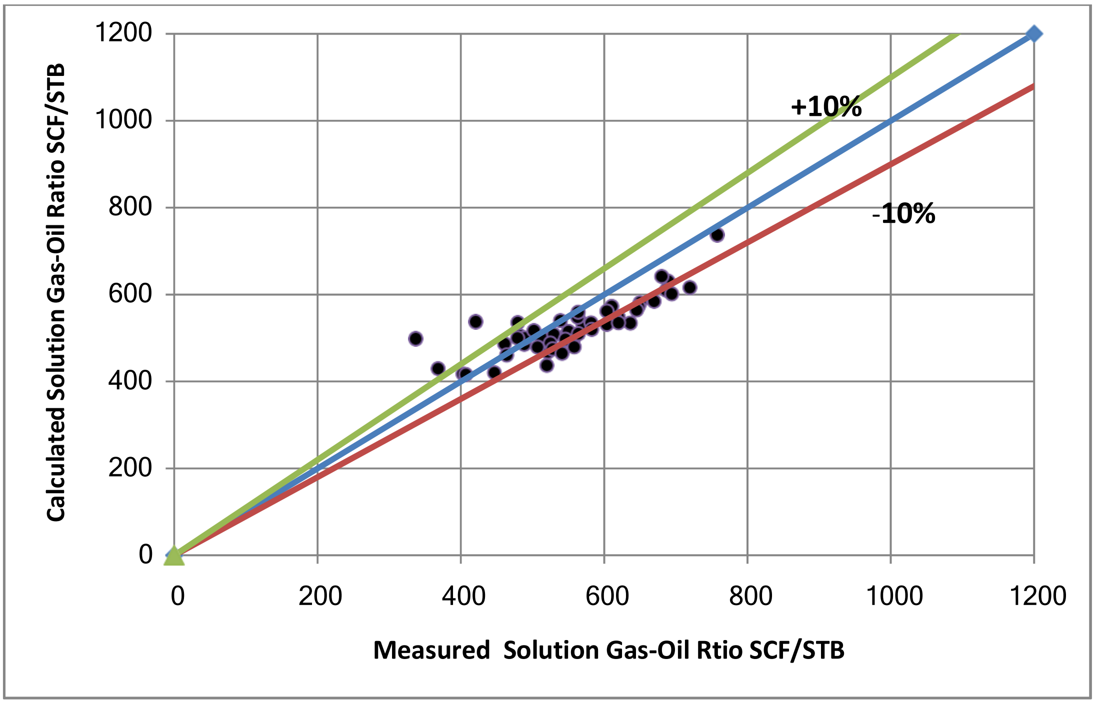

Fig.4.16 Cross Plot for Solution GOR at Pb, Rsb (Al-Aboodi's Correlation[18])

CHAPTER FOUR

CONCLUSIONS AND RECOMINDATIONS

Conclusions:

The following conclusions were drawn from this study

1.Most of the empirical PVT correlations showed in literaturesand evaluated in this study, which developed for crude oils fromseveral geographic locations around the world, often do notadequately predict the behavior of crudes of Mishrif reservoir in the southern fields of Iraq.

2.New empirical PVT correlations for Mishrif reservoir crudes in the southern Iraqi oil fields have been developed for Pb, Rsb, Bob, μ_{od}, μ_{ob}, μ_{oa}, and Co using nonlinear multiple regression method. The new developed correlations all exhibited significantly best statistical accuracy than the published correlations which were evaluated in Chapter Four.

3.The new bubble point oil formation volume factor correlation provided the best accuracy of the correlations evaluated; however, the published correlations also produced excellent estimates of bubble point oil formation volume factors.

4.New models were developed to predict the bubble Pb, Rsb, Bob,μ_{od}, μ_{oa}, and Co for Mishrif reservoir crudes in the southern Iraqi oil fields. The models were based on artificial neural networks. All the developed ANN models was tested using independent data which was not used in training these models, and the results of the testing show that the developed models

5.predict the PVT properties in good accuracy with low average absolute relative error.

Recommendations:

1- Future studies consider black oils with significant quantities of impurities such as carbon dioxide, hydrogen sulfite, and nitrogen.

2- A future work is recommended in developing new empirical correlations and New ANN models to predict the PVT properties for another Iraqi reservoir and compare the results with the present study.

REFERENCES

1-Hanafy, H.H., Macary, S. A., Elnady, Y.M., Bayomi, A. A. and Elbatanony, M. H.: "Empirical PVT Correlation Applied to EgyptianCrude Oils Exemplify Significance of Using Regional Correlations," SPE37295, Oilfield CHEM. INT. SYMP (Houston, 2/18-21/97) PROC pp 733-737.

1-Bishop, C.: "Neural Networks for Patern Recognition," OxfordUniversity Press, NY (1995).

2-Laurene Fausett: "Fundamentals of Neural Networks," Prentice Hall,NJ, USA, 1996.

3-Hornik, K.: "Multilayer Feed forward Networks are Universal Approximators," Neural Networks, (1989), Vol.2359.

4-Varotsis N., Gaganis V., Nighswander J., and Guieze P. .: "A Novel Non-Iterative Method for the prediction of the PVT Behavior of reservoirfluids," paper SPE 56745 presented at the 1999 SPE Annual Technical Conference and Exhibition, Houston, Texas, October 3-6.

5-D. K. Chaturvedi: "Soft Computing Techniques and its Applications in Electrical Engineering," Studies in Computational Intelligence (SCI) **103**,1-10(2008)

6-Mahdi A. Khalaf.: "Mishrif Formation; Its Extending, Its equivalent formation, type of its oils," Ministry of Oil, Reservoir and field development directorate.

7-tanding, M.B.: A Pressure-Volume-Temperature Correlation for Mixtures of California and Gases, Drilling and production practice, API (1947), p.275-287.

8-Vasquez, M.E. and Beggs, H.D.: “Correlation for Fluid Physical property Prediction,” Journal of Petroleum Technology, JPT. (June1980), p. 968-970.

8-Glaso, O.: “Generalized Pressure-Volume-Temperature Correlations,” JPT (May 1980), P.785-795.

9-Al-Najjar, H.S., Abu-Alsoof, N.B and Al-Khalisy, K.M.:“Correlations for Bubble Point Pressure, Gas Oil Ratios and Formation volume factors for Iraqi Crude Oils,” Petroleum Research Center, Council of Specific Research, Jadriiyah, Baghdad, Iraq. July, 1987. PP 13-22.

10-Al-Marhoun, M.A.: “PVT Correlation for Middle East Crude Oils,” JPT (May 1988), P.650-666.

11-Petrosky, G.: “PVT Correlations for Gulf of Mexico Crude Oils,” MSThesis, University of Southwestern Louisiana, Lafayette, LA (1990).

12-Petrosky, G.E. and F.F. Farshad.: “ Pressure-Volume-Temperature correlation for Gulf of Mexico , ” SPE paper # 26644, 1993, P.395-406

13-J.Velarde, T.A. Blasingame, W.D. Mccain, JR.: “Correlation of BlakeOil Properties at Pressures below Bubble point Pressure-A NewApproach,” JCPT. Special Edition 1999, Volume 38, No. 13.

14-Al-Shammasi. A.A.: “Bubble Point Pressure and Oil Formation Volume Factor Correlations,” paper SPE 53185 presented at the 1999SPE Middle East Oil Show, Bahrain; 20-23 February.

15-Al-Shammasi.A.A.: “A Review of Bubble Point Pressure and Oil Formation Volume Factor Correlations,” paper SPE 71302 presented at the April 2001 SPE Reservoir Evaluation & Engineering.

16Rasha, R. Al-Aboodi: “PVT Correlations for Selected Iraqi Oil Fields,” MS Thesis, University of Baghdad, April (2008).

17-Lastaer, J.A.: “Bubble Point Pressure Correlation,” Trans., AIME (1958), p.213, 379-381.

18-Al-Marhon, M.A.: “New correlation for formation volume factor ofoil and gas mixture," The Journal of Canadian Petroleum Technology, March 1992, Volume 31, No.3.

19-Beal, C.: "The Viscosity of Air, Water, Natural Gas, Crude Oil and ItsAssociated Gases at Oil Field Temperature and Pressure," *Trans*., AIME (1946) **165**, 94-112.

جمهورية العراق

وزارة التعليم العالي

والبحث العلمي

جامعة ميسان

كلية الهندسة

إدارة البترول

دراسة خصائص حقل نفط

عراقي بواسطة برنامج PVT

مشروع

مقدم إلى قسم هندسة البترول،

جامعة ميسان استكمالاً جزئياً للشهادة

المتطلبات بكالوريوس العلوم في هندسة البترول

أعداد الطلبة :

عباس حسين هنيدي

علي ماهر هادي

علي راضي گصل

علي سلمان غازي

مشرف البحث : الأستاذ علي نور الدين

الخلاصة :

خصائص سوائل المكمن مهمة جدا في حسابات هندسة المكمن. من الناحية المثالية ، يجب الحصول على هذه الخصائص من القياسات الفعلية. ومع ذلك ، غالبا ما تكون هذه القياسات إما غير متوفرة أو مكلفة للغاية للحصول عليها. في مثل هذه الحالات ، يتم استخدام الارتباطات المشتقة تجريبيا للتنبؤ بالخصائص المطلوبة. في العقد الماضي ، استخدم الباحثون الشبكات العصبية لتطوير ارتباطات خاصة أكثر دقة.

قيمت هذه الدراسة معظم الارتباطات التجريبية التجريبية الشائعة التي أظهرت في الأدبيات باستخدام ٥٢ تقريرا مختبريا من خدوش خزان مشرف في الحقول الجنوبية العراقية ، وأظهرت النتائج أن هذه الارتباطات لم تتنبأ بشكل كاف بخصائص خزان مشرف. لذلك ، في هذه الدراسة ، يتم استخدام طريقتين للتنبؤ بالممتلكات الخاصة لخزان مشرف في حقول نفط جنوب العراق. طورت هذه الدراسة ارتباطات تجريبية جديدة لزيوت خزان مشرف كدالة للبيانات الميدانية المتاحة بشكل شائع. تم تطوير الارتباطات لضغط نقطة الفقاعة ، ونسبة زيت غاز المحلول عند نقطة الفقاعة ، وعامل حجم تكوين الزيت عند نقطة الفقاعة ، ولزوجة الزيت الميتة ، ولزوجة الزيت المشبعة ، ولزوجة الزيت غير المشبعة ، وانضغاط الزيت غير المشبعة باستخدام نظام التحليل الإحصائي (ساس) من خلال تطبيق طريقة الانحدار المتعدد غير الخطي. من أجل تطوير هذه الارتباطات ، تمت تغطية مجموعة واسعة من البيانات ، أكثر من ٥٢ تقريرا خاصا من خزان مشرف تم جمعها من ٩ حقول نفط في الجزء الجنوبي من العراق. وقد وجد أن الارتباطات الجديدة تقدر خصائص الجندي لخزان مشرف .في حقول النفط في جنوب العراق أفضل بكثير من تلك المنشورة