ECONOMIC EVALUATION OF ARTIFICIAL LIFT METHOD IN 103A FIELD, LIBYA

OMAR AHMED YOUNUS JIBREEL ECONOMIC EVALUATION OF ARTIFICIAL LIFT METHOD IN 103A FIELD, LIBYA NEU 2021

A THESIS SUBMITTED TO THE INSTITUTE OF GRADUATE STUDIES OF NEAR EAST UNIVERSITY

By
OMAR AHMED YOUNUS JIBREEL

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Petroleum and Natural Gas Engineering

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Approval of Director of Institute of Graduate Studies

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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To my parents…

ABSTRACT

This study seeks to evaluate the economics in Zueitina oil field for A7 and A3 wells in Libya by using the artificial lift methods. The research examines, challenges associated with the use of artificial lift methods and corresponding mitigating strategies. The study as well assessed impacts of artificial lift methods on the economy and used secondary data, which was provided by Zueitina Oil Company. Oil industry's commercial software – PIPESIM was made, to analyze data and present the results. The results show the challenges of artificial lift methods and evaluation of the economy.

Other objectives of the study: to determine the scope of the use of pumped / off-pump production methods, to examine the difficulties associated with their use and the less important factors corresponding to them, and to make an economic analysis and to find the right method.

Moreover, the economic evaluation by artificial lift methods were critically assessed for the determination of the extent of using selected artificial lift method. Furthermore, it was examined the challenges associated with the use of artificial lift methods and corresponding justifying approaches and valuation of the economic evaluation. Natural flow carried on until the water cut reaches 30%. Then gas lift method has to be applied till to the water cut spreads to 70%. The low cost of gas lift method make it very suitable for desired wells to be turned to ESP when W/C increase to 70% to keep the same rate of production.

Keywords: Artificial lift; Zueitina oil field; A7 and A3 wells; pipesim; electric submersible pump

ÖZET

Bu çalışma, Libya'daki A7 ve A3 kuyularının Zueitina petrol sahasındaki ekonomisini yapay kaldırma yöntemlerini kullanarak değerlendirmeyi amaçlamaktadır. Araştırma, yapay kaldırma yöntemlerinin ve buna karşılık gelen hafifletme stratejilerinin kullanımıyla ilgili zorlukları incelemektedir. Çalışma, yapay kaldırma yöntemlerinin ekonomi üzerindeki etkilerini de değerlendirdi ve Zueitina Petrol Şirketi tarafından sağlanan ikincil verileri kullandı. Petrol endüstrisinin ticari yazılımlarında olan PIPESIM, verileri analiz etmek ve sonuçları sunmak için kullanılmıştır. Sonuçlar, yapay kaldırma yöntemlerinin zorluklarını ve ekonomisinin değerlendirilmesini göstermektedir.

Çalışmanın diğer amaçları: pompalı/pompasız üretim yöntemlerinin kullanım kapsamını belirlemek, kullanımları ile ilgili zorlukları ve bunlara karşılık gelen daha az önemli faktörleri incelemek ve ekonomik bir analiz yapmak ve doğru olanı yöntemi bulmaktır.

Ayrıca, seçilen yapay kaldırma yönteminin kullanım kapsamının belirlenmesi için yapay kaldırma yöntemleriyle ekonomik değerlendirmesi analiz edilmiş ve değerlendirilmiştir. İlave olarak, yapay kaldırma yöntemlerinin kullanımıyla ilgili zorluklar ve buna karşılık gelen gerekçelendirme yaklaşımları ve ekonomik olarak incelenmiştir. Su kesimi %30'a ulaşana kadar doğal akış devam ettirilmelidir. Daha sonra su kesimi %70'e kadar yükselene kadar gaz kaldırma yöntemi uygulanmalıdır. Gaz kaldırma yönteminin düşük maliyeti, aynı üretim oranını korumak için su kesimi %70'e yükselene kadar devam etmelidir. Daha sonra aynı üretim performansının devam etmesi için kuyuların ESP'ye çevrilmesi çok daha uygun olacaktır.

Anahtar Kelimeler: Yapay kaldırma; Zueitina petrol sahası; A7 ve A3 kuyuları; pipesim; elektrikli dalgıç pompa

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LIST OF ABBREVIATIONS

ALM:	Artificial Lift Method
Cap Ex:	Capital Expenditure
ESP:	Electric Submersible Pump
F:	Fahrenheit
GLM:	Gas Lift Method
GOR:	Gas Oil Ratio
IPR:	Inflow Performance Relationship
Ope Ex:	Operation Expenses
PCP:	Progressive Cavity Pump
PI:	Productivity Index
POT:	Payout Time
PSIG:	Pound Square Inch Gauge
PV:	Present Value
PVT:	Pressure Volume Temperature
SCF:	Standard Cubic Feet
STB:	Stock Tank Barrels

CHAPTER 1
INTRODUCTION

Given the fact that petroleum industry is encountering great challenges in the search, drilling, production and management of the black gold. Barring the numerous challenges, petroleum engineers are capable of producing the oil and gas from the very harsh and cumbersome situation. Today, varying artificial lift methods with addition to modern artificial techniques that are in distinction with the traditional artificial lift methods technologies (Electric Submersible Pump, Sucker Rod Pump, and Progressive Cavity Pump) and how they have evolved (Ben Amara, 2016).

Nowadays some barely productive oil fields which have remained undeveloped because their economic sensitivity, could be fertile, but only if operated at a relatively low overhead and operating costs (Adamu et al., 2013).

The Society of Petroleum Engineers (SPE) says that producing oil fields are discoveries that have not been fully produced as a result of several factors, including geology and other factors such as the availability of modern technologies as well as the appropriate infrastructure to produce these fields and increase their production rates for a very long period of time, as well as the lack of Infrastructure in the vicinity and high development costs.

Novak et al. (2017) explained the three factors affecting artificial lift methods as: Production rate, Downhole flowing pressure and Gas-liquid ratio.

According to Svalheim (2004), barely productive field that might be unprofitable for development at a given period of time can become commercially viable under some technical changes and economic profits. Artificial Oil lift methods and electric submersible pumps (ESP) are used to optimize the oil and gas production.

1.1 Thesis Problem

Zeng (2018), defines artificial lift methods (ALM) as the technology used to lift the accumulated oil from wells, in order to aid their performances. This study of artificial lift methods intends to provide solution to problem of barely productive decrease by maximizing the expected net present value. Different wells will be use to compare between two methods, which ALM to deploy, and their installation. Both models are applied to determine the artificial lift plan (ALIP) for some hypothetical cases constructed based on the Wells for Zueitina A7 and A3 in 103A plan. Some of the study which will be needed to evaluate the selection of artificial lift methods for barely productive oil well should include: Energy efficiency, lift time cost, operational costs, and capital investment. While the selection process of the artificial lift methods processes are totally based mostly on the expenditure elements such investment costs, operational costs and revenue costs. The Net Present Value and Return On Investment methods avail us the facility of using economical method for a well. Such economic measurements do the arithmetic of the   screened method that company actually need (William, 2014).

1.2 Aim Of The Thesis

The broad aim of this study is critically assess the economic evaluation by artificial lift methods. The specific aims of this study were to;

a. Determine the extent of use of artificial lift methods.
b. Examine the challenges associated with the use of artificial lift methods and corresponding mitigating strategies.
c. Assess the economic evaluation by artificial lift methods.

1.3 The Importance of the Study

Outcome of this study is expected to serve as a secondary data to future researchers who intend to deal with Economic evaluation of artificial lift methods. It also aid the layman in the understanding and using artificial lift methods techniques and it will help students from other field in understanding and using these techniques. Also it helps the natural gas experts to effectively utilize artificial lift methods to carry out possible economic evaluation. Finally it broadens the mind and knowledge of people and entities like natural gas experts, petrol chemical engineers, stakeholders, researchers and others who are interested in the importance of economic evaluation of artificial lift methods.

The following research questions have been formulated about contributions of Artificial lift methods on the performance of the Libyan economy:

What are the most common forms of artificial lift methods?

What is the impact of artificial lift methods on the economy?

To what extent does benefit of artificial lift methods outweigh the cost?

1.4 Limitation of the Thesis

Early stage depletion of artificial lift system may look shabby from an economic perspectives. Key users of artificial lift methods are rising through the heavy oil production, and presence of huge volume of oil and gas reservoir.

This study comprised of a various artificial lift methods, such as electrical submersible pump (ESP) and gas lift methods with critical focus on the economical evaluation performed on a carefully selected well – from the 103A oil field. In this piece, we carefully observed 103A field by conducting design runs through actual field data collected in January 2003 before the field was commercialized. Economic evaluation was done to get future prospects, as well as changing the oil well from producing with natural lift to artificial lift methods of ESP.

1.5 Overview of the Thesis

The study focused on the economic evaluation through various artificial lift methods, benefits, uses and techniques. This study is an empirical review, which lays emphasis on economic evaluation as a result of the application of varying artificial lift methods. In this, study accessed the relationship that exists between the economic development and different artificial lift. The respondents are business firms, who utilize artificial lift such as the ESP and gas lift.

CHAPTER 2
RELATED RESEARCH

2.1 Artificial Lift

The aim of initiating and improving well operation and oil production is called artificial lift method, which means to increase liquid flow in an oil producing well. Artificial lift is any method, which add energy to the fluid compartment in wellbore. This is normally achieve by use of a mechanical tool on the oilfield (Paital et al., 2007).

The artificial lift is required in wells if there is low pressure in the reservoir to move the reservoir fluids to the surface. If the oil reaches to the surface this is called naturally flowing oil wells.

Gas lift methods are used to lift the oil from the wellbore to the surface by initiating a pump pressure below the well or injecting the pressurized gas. Here gas mingles with the well reserve fluid collected in the wellbore and depletes the lower hole pressure. While the Electric Submersible Pump (ESP) methods are also used to lift oil from well bore to the surface, but rather than injecting pressure, the ESP requires a very enormous amount of electric (Naguib et al., 2000).

In oil well, produced fluid might either be oil and water, but with pressure of some amount of gas. When an oil reserve has low energy for gas, oil and water movement from wells at a required rates, alternative production method will help, gas as well as water injection for pressure for additional recovery method to maintain oil well productivity. Though artificial lift is required when reservoir do not produce at expected rates or totally case production. Lift procedure moves energy in the downhole well bore to reduce the hydrostatic weight on formations, in order to make available reservoir energy provide inflow , as well as commercial hydrocarbon that can either be boosted or diffuse. Artificial lift also improves oilwell activities by reducing the bottom hole pressure which wells become neglected over.

2.1.1 Types of artificial lift

The major forms of artificial lift are:

1. Sucker-rod (beam) pumping

2. Electrical submersible pumping (ESP)

3. Gas lift and intermittent gas lift

4. Reciprocating and jet hydraulic pumping systems

5. Plunger lift

6. Progressive cavity pumps (PCP)

The common artificial lift types which used are ESP and Gas lift. These six artificial lift method as shown in Figure 2.1. (Hullio et al., 2018).

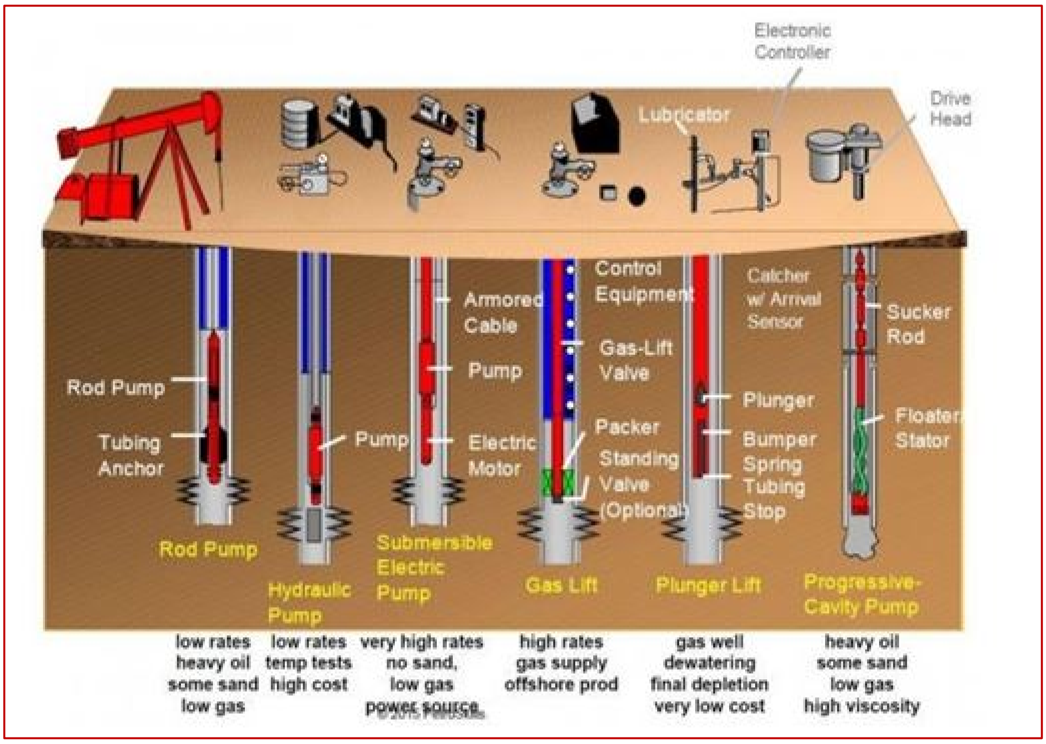

Figure 2.1: The six primary artificial lift methods (Hullio et al., 2018)

2.2 Gas Lift Methods (GLM)

Gas lift is a widely used artificial lift method used to artificially lift oil or water from wells where there is insufficient reservoir pressure to produce the well. The gas lift systems are less efficient in deeper oil wells.

Gas lift method always increase the degree of flow constraints caused by paraffin and increasing water cut in the well. In addition, this method requires an ample of gas to be stored at the outer surface. The gas that is filtered and vented is cumbersome to reinject, and the one that is reinjected immediately got affected by oxygen, carbon, as well as hydrogen sulphide that can erode production string elements (Clegg, 1988).

Gas lift methods are used to lift the oil from the wellbore to the surface by initiating a pump pressure below the well or injecting the pressurized gas. Here gas mingles with the well reserve fluid collected in the wellbore and depletes the lower hole pressure. The gas lift system is seen in Figure 2.2 (Vinegar, 2004). Gas lift valves control the gas coming into string to lift up the fluid to the surface.

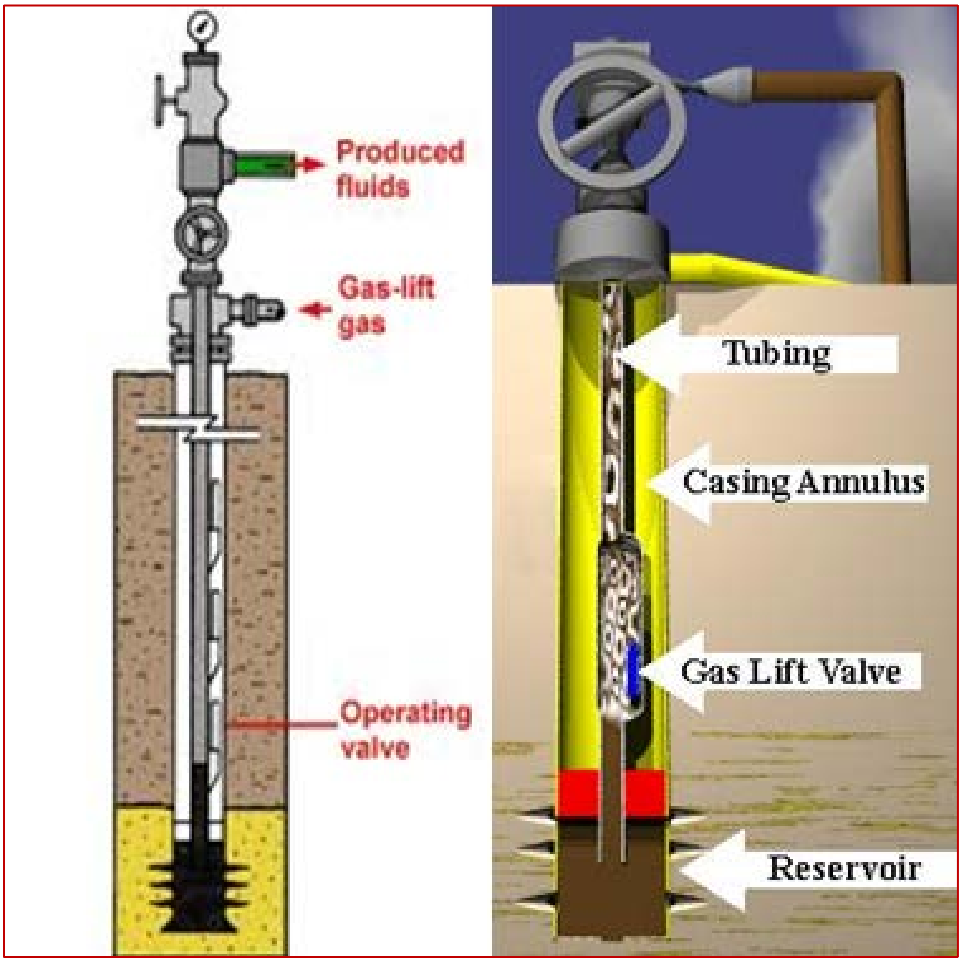

Figure 2.2: Gas Lift System (Vinegar, 2004)

The two major types of gas lift are continuous and intermittent gas lift. These are explained below :

2.2.1. Continuous gas lift

Involves continuous injection of gas into well to increase draw down with objective of lightening the liquid compartment, thus increasing bottom hole pressure. This system is only applicable to wells with lower than optimum natural GLR, and oil reservoir pressure higher to maintain desired flow rate when the GLR increased.

2.2.2 Intermittent gas lift

Involves gas is injection under a column of liquid to diffuse liquid to the surface. The operation occurs repeatedly at sufficient amount of liquid. The drawback of this form of gas lift include, cycle time that can be reached at interval of a successive liquid production, as well as the volume of liquid, which can be effectively lifted as liquid. Gas become weak through slug, and part of the liquid are reverted.

2.3 Electric Submersible Pump Methods

Study showed that 15 to 20 percent of about one million wells across the word depend on electric submersible pump, a form of artificial lift system for oil production. Also the electric submersible pump ESP systems are the most popular artificial lift method.

ESP method is quite effective since it helps the oil well owner to measure and know the amount of the oil in reservoir, as well as be able to reach optimum production, in order to evaluate the economy (Alvarado, 2010).

ESP string contained several elements from the bottom hole, it has a motor, a set of seals used in protecting the motor, during pump. The motor is loaded with varying speed drive, transformer as well as electric cable.

2.3.1 Elements of ESP

- **Motor :** there are three major types of motor, which are: radial flux, axial flux, as well as transverse flux. The axial flux motor required optimization only when the length to diameter is low. This is because many stators and rotors are used to give the required power at a restricted diameter. The example of an axial flux motor with many rotor and stator exist. It is however hard to supply and limit the motor inside a deep well. Axial motor also has a lower reliability. With this, it is recommended that axial flux as well as transverse flux motor are less suitable ESP applications. Though, some past literature review focused on these categories of motors inferred that axial flux and transverse flux motors were less good for high speed and speed applications.

- **Protector :** provides a boundary between motor oil and well fluids to allow operation in a deviated or gaseous wells. The protector comes in different materials, which are dependent on the application. Based on the characteristics of a seal, the protector as well serves as an oil reserve for motor, by stabilizing the internal pressure of the well fluid, and carrying the loaded thrust of the pump.
- **Intake :** is the point at which well fluid passes into the Electric Submersible Pump System. Caution must be adhered during a submersible pump intake design, due to the fact that it is a necessary point in the system, which when not well designed correctly could result in all kinds of problems. The three types of intake are: Standard Intakes, Integral , and gas separators .
- **Pump :** is a tool that has a hermetically sealed motor attached to the electric submersible pump body. The entire assembly is dipped inside the fluid awaiting pump. Advantage of pump is that it avoids cavitation, the issue associated with higher elevation discrepancy between pump as well as fluid surface. The submersible pumps pushes fluid to the surface rather than jetting pumps that brings create a space and depend on the atmospheric pressure.
- **Electric Cable :** is responsible for the transmission of the needed surface power to the electric submersible pump motors. Generally, it is clamped to the operation tubing from under the wellhead to the ESP unit due to the fact that it is not made to support own weight. It is a uniquely constructed multi-phase power cable made for down hole well surrounding.

There are two types of cables:

1. Flat cable that using in limited space annuals.
2. Round cable, that using in normal space between casing and tubing.

•The ESP elements are illustrated in Figure 2.3. (Bowers, 2005).

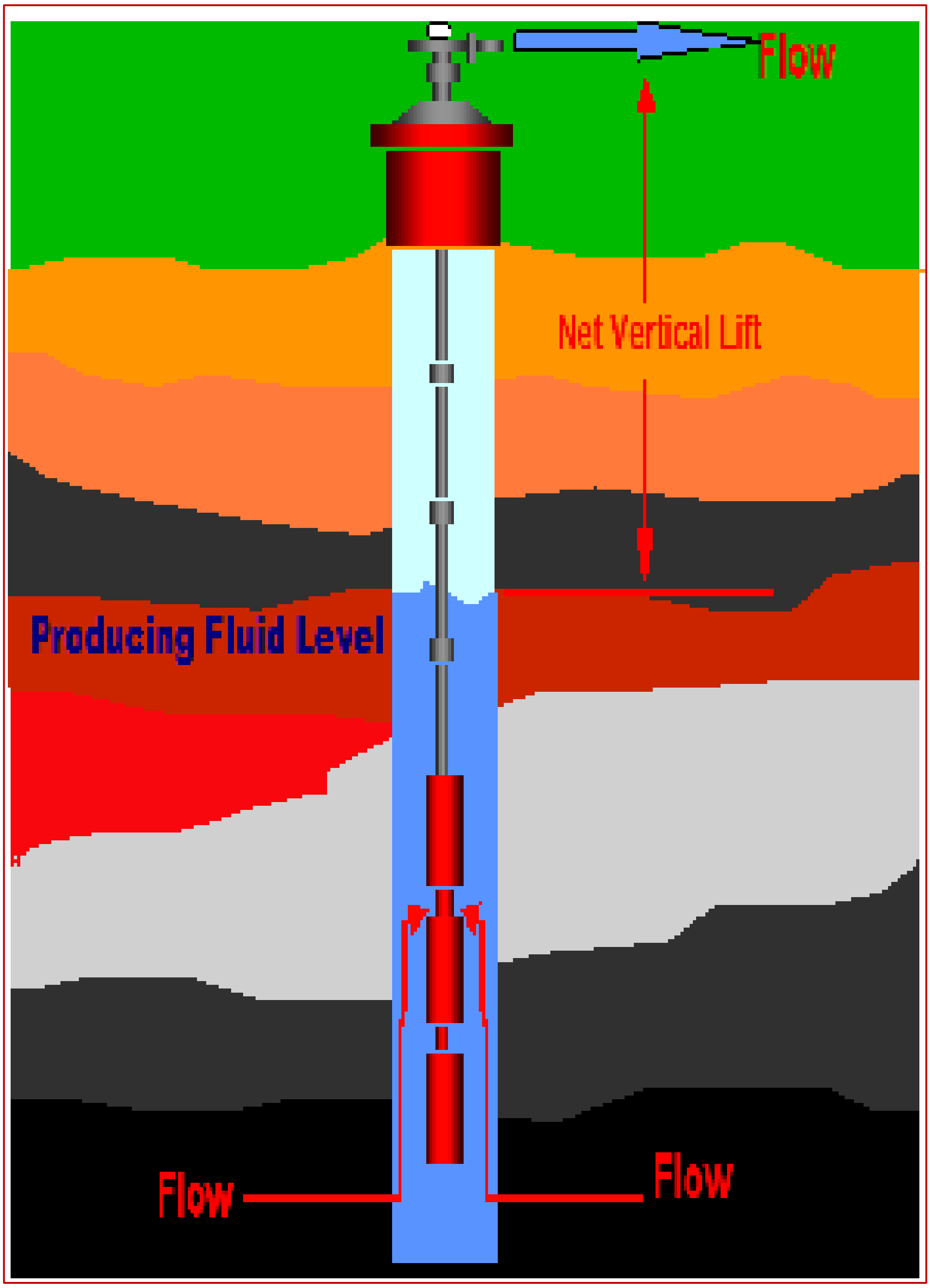

Figure 2.3: Electric submersible pump elements (Bowers, 2005)

Comparison between gas lift and ESP as in Table 2.1 (Ebrahimi, 2010).

Table 2.1: Gas lift methods and electric submersible pump comparison (Ebrahimi, 2010)

Gas Lift Methods	**Electric Submersible Pump**
It doesn't require electricity to lift gas from oil well to outer surface	Huge amount of electricity is required to pump oil from oil well into outer surface.
There is interaction with the oil well.	There is little or no interaction with the oil well.
Gas is injected into the well through the annulus.	Pressure enter the oil well through electrical force.
Well produces higher flow rates of oil, when artificial lift methods are used.	Well produces high flow rates of oil, when electric Submersible Pump is used.
It's less Expensive	It's expensive
Gas lift works efficiently for a small range of production rates.	ESP works better for a wider range of production rates.
Not effective when pressure gets too low.	Pumping action continues with electric.
It takes a lot of time injecting pressure in well.	Fast pump with stable electricity.

Continuous Gas Lift on the other hand is considered as an extension of the natural flow. The process unlike the intermittent gas lift tend to inject gas at the deepest point possible in the annulus with the aim of reducing liquid density and minimize the weight of the fluid column above the formation, increasing the flow rate.

2.4. Other Artificial Lift Sub Methods

At least 60 percent of oil producing fields required particular type of induced lifting technology to recover oil from the underground bottom hole. This ranging artificial lift techniques are being used, such as plunger lift, gas lift, beam rod pumps, progressive cavity pumps (PCP) otherwise known as electric submersible pumps.

2.4.1 Beam rod pumps

The Beam rod pump is also known as sucker rod pump and it's defined as a type of artificial lift methods, which makes use of a surface force to induce pressure into the bottom hole pump. With a beam or sucker assembled on the earth surface, to then apply a reciprocal motion that is then converted to a nonlinear motion in a rod-sucker string, which is connected to the bottom hole pump. Such pump comprises of a plunger, as well as valve assemble together to impart nonlinear fluid flow. Based on her long history, beam rod pumping is a well-known variety of artificial lift. Not less than 2/3 of the oil producing oilfields globally make use of this type of lift method. The drawbacks of this method is revealed with a more deviated oil well (Adamu et al., 2013).

2.4.2 Plunger lift

Artificial lift methods are used mainly in gas compressed wells to eliminate relatively little volumes of water. Basically, plunger lift method uses a mechanical interface that mediate in the produced gas and water. It makes use of the force present in the well for lift, water is then pushed to the outer surface by the flow of a free-moving piston, which moves from the underground of the well to the surface. The interface removed water that boosts the well lifting effectiveness. Thus, the decrease in the average flowing underground pressure increases inflow. Plunger moves is usually provided through gas formation in the casing at the period which a well is shut. When the oil well gets opened, tubing pressure reduced, then stored gas in casing flows through the final tubing process and then pushes plunger into the earth surface (Alvarado, 2010).

2.4.3 Progressive cavity pump

The Progressive Cavity Pump is a replica of the Electric submersible pump. Progressive Cavity pump comprised of helix shaped well bore, which circulate in the same helix shape cavity. Circulation of well bore provides cavities with a pressure negative to dilate and contract, pushing water over the pump. The process is effective when it comes to the extraction of crude oil at high magnitude. Meanwhile, progressive cavity pump are prone to wear and tear from used materials and which are limited to the depth of oil well of about 5000-ft. Just like other artificial lift methods, the progressive cavity pump cannot perform efficiently in a deeper well (Ebrahimi, 2010).

2.5 Factors Affecting Choice of Artificial Lift Method

There are various factors to be considered when artificial lift methods is to be effectively used. These factors carefully highlighted below :

1- Production system size

2- Production rate, as well as maximum size of production tubing.

3- The annular and tubing safety systems.

4- Deviation such as doglegs, both planned and unplanned and Producing formation

depth.

5- Nature of the produced fluids e.g gas fraction and sand/wax/asphaltene production.

6- Well inflow features and attributing effects.

2.6 General Approach to Oil Exploration

In the past, oil lift during exploration are done, traditionally. The artificial lift is an essential quest for the survival and success of any modern oil well. In recent times, businesses have more oil exploration opportunities than ever (Ebrahimi, 2010). Artificial lift serves as means to help the a oilfield owners, as well as petroleum engineers achieve their short and long term goals, balance their operations, fulfill their obligations to various relevant markets and also ultimately stay ahead in the global oil environment.

Artificial lift is the most primary element with which an oil well owners uses to reach production optimization by increasing the pressure in reservoir.

Artificial lift method is a new approach to oil production, not only that traditional oil search was boosted by some new form of gas lift elements (Obeadalla and Abdelmagd, 2013).

It has its own features, advantages and dynamics, which should be understood in order to be able to effective select artificial lift techniques and strategies. Gas lift elements can also be classified in various ways; which are gas lift methods and the electric submersible pump.

Artificial lift methods are used to lift the oil from the wellbore to the outer surface by initiating a pump pressure below the well or injecting the pressurized gas. Here gas mingles with the well reserve fluid collected in the wellbore and depletes the lower hole pressure. While the Electric Submersible Pump ESP methods are also used to lift oil from well bore to the surface, but rather than injecting pressure, the ESP requires a very enormous amount of electric (Naguib et al., 2000).

The gas lift method is sub divided into the intermittent non intermittent or continuous gas lift method. The Intermittent gas lift is the normal gas lift method in gas lifted oilfields that formation pressures decreased to a level where continuous flow is not possible. An intermittent gas lift is effective for oil wells with high formation pressures, but relatively small productivities. Averagely, 10% of gas lifted wells are put on intermittent lift (Ebrahimi, 2010).

2.7 Economic Evaluation and Impact on Artificial Lift

The ultimate aim of adopting artificial lift method is to continuously put in new technology, while retaining the traditional ones that are effective, as well as providing oil to the global market all year round and ensuring stable economy (Guo et al., 2007).

The economic aspect of this research is based on the oil price of about $63/barrel, with gas price of $5/Mscf and electrical current at just $0.05/KWH. The study system is based on A7 well. The present value (PV10%) is usually utilized in the oil and gas firms evaluation in order to explicitly state the total number of all cash flow annually succeeding each amount, which had been reduced by 10% compounded annual interest. This simply means the loan capital for the reducing the subsequent amount is put at 10% per annum. Also the payout time POT is said to be the period from the first capital investment deposit until the cumulative net cash flow yields positive.

The way technology comes with opportunities, as well as problems to the mankind, same way artificial lift methods creates both positive, as well as negative impact. Engineers were elated to create the artificial lift methods because of its positive impacts such as : Artificial lift methods sure can handle large volume of solids with less issues.

Artificial lift is fairly flexible-convertible from ranging lift methods, as well depreciate it's unobtrusive in urban sites, the power source of Artificial lift can be remotely located, it's easy to obtain down hole pressures as well as gradients and the crooked holes in gas lift present no issue.

These same engineers are now faced with some of the negative impact of the artificial lift methods, such as: the inefficiency of lifting in a small fields, it's also difficult to lift emulsions and viscous crudes, the issues of gas freezing and hydration, artificial lift methods creates problems of dirty surface lines, it's cumbersome to without engineers supervision and there is safety problem with high pressure gas well.

CHAPTER 3
THEORETICAL FRAMEWORK

3.1 Scholars Reviews

Energy that drive oil from reserves to the surface generally comes from either of water drive, solution gas drive, gas cap drive, gravity segregation and a combination of these five mechanisms (Khamehchi et al., 2014).

Oil have submerge as one of the single most essential goods that holds the position of key sector in virtually all economies of the world. All households in today world need oil or its products to survive and obviously if the production of oil in any nation is insufficient, such nation must import the resources at whatever cost it takes. Study shows that crude Oil has about 50% share to meet the global energy requirements (Darrat, 1996).

Sagar et al. (2016) pointed out that crude oil is the most essential commodity and also the most traded good which has most impact on an economy. The most common sub product is Petroleum and this is compared to gold, in Africa, it's called Black gold, due to its exhaustibility and economic value.

Munisteri and Kotenev (2013) definition of ripped oil well “a ripe oil well is one that is considered fully matured. Though might be redevelopment of land but in general an oil well development plan has been implemented. Hirsch et al. (2006) have established a new method for finding the ideal gas injection rates for a group of continuous gas lift oilfields to maximize the production rate.

Artificial lift is the main body of varying lift methods that increases production rate by decreasing the pressure through the injection of gas from the outside into the oil well. The use of gas lift techniques is to enables the fluid to flow from the reserve to the earth surface, as well as making oil available all year round. Applying gas lift to an oil well already in production from the natural pressure gradient increases the fluid production.

If the reservoir pressure is lesser than BHP of the well, the fluid in the such well would not be able to flow to the surface facility, as such there is cease or deficit in production. Gas injection decreases the weight of fluid density in the oil well. The reduction in density weight let the well able to produce, as gas is injected by the lifting valve.

According to Ghareeb et al. (2007) The extended gas injection shows fluid and limit the burden. The remaining fluid is used as pistons, which allows the oil to flow to the surface.

The techniques of gas lift ensure that fluids are flown to the surface, by decreasing the pressure below for higher pressure within the reserve and below the oil well. The decreased pressure in the oil well through injected gas then increases the oil production.

This study assesses gas lift while taking into account system restrictions. During optimization, a genetic algorithm was employed to overcome the limitations of locally optimal solutions, and oil output was estimated using the optimum gas lift allocation.

Because a reservoir simulator cannot account for the additional pressure loss from the wellbore and surface facilities when estimating oil production, a multiphase flow simulator was used with a reservoir simulator to realistically estimate the oil production rate.

The gas lift method increases oil production level through injection of compressed gas into the sub surface section of tubing inside the well (Camponogara & Nakashima, 2006). The main objective of gas lift design and production optimization is to allot a constrained amount of gas so as to maximize oil production rate, in other words reach optimum production.

Jung and Lim (2016), insisted that optimization should not only be on production, but the gas lift allocation as well is essential since unreasonable gas injection rate can decrease to minimal level oil production rate.

The theory also states that gas lift allocation was optimized, so that maximization of the oil production is possible with the use of a general algorithm under the constraints challenges of the gas lift methods.

The gas production level with optimized lift allocation was forecasted. A multiple flow model was integrated a model for an effective forecast of the oil produced in gas lift method. Jung et al. (2016) showed that the gas production could be induced through optimization of the gas lift allocation itself, and this would bring about oil production level forecast with the optimum gas lift allocation for the gas lift strategies.

It is now believed that when natural medium becomes ineffective for driving oil to surface, a new form of energy is required to complement the natural medium, the term referred to "artificial lift methods". Nabhani (2012) in his research revealed that the convention production, mostly has occasioned the incessant flaring of associated gas, due to the expensiveness of transferring oil to the market. Today policy makers have made laws to forestall gas flaring due to environmental hazards from hydrocarbons. The theory of Obeadalla and Abdelmagd (2013) confirmed that a good water management system will be great to avoid the problem of environmental hazards.

3.2 Empirical Review

The world artificial lift market is expected to expand at 5.32% Compound Annual Growth Rate by 2026 Key users of artificial lift method (Smith, 2009). There are rising through the heavy oil production, and presence of huge volume of oil and gas reservoir. United States, China, Canada, and Argentina are the key players in shale production market. America is the largest producer of shale gas. By 2040, forecaster has predicted that, it will produce 80 billion cubic feet (bcf) of shale gas.

Canada, Saudi Arabia, Venezuela, America, Mexico, Brazil, Russia, and China are currently the most active heavy oil producing nations. Large number of reserves are present especially in the Middle East and Africa, which is driving the artificial lift methods market. Though, the challenges such as static oil prices and unavailability of experts are going to hindering the global artificial lift users.

Another key challenge is associated to re-development of barely productive oilfields and keeping offshore oil exploration might lead to lucrative business opportunities in the world artificial oil lift market.

Artificial lift methods market has been partitioned on ranging heads, such as type, application mechanism, and location. Type is the head that states the market being classified into Rod lift, Electric Submersible Pump methods ESP, PCP, Gas lift, plunger lift and hydraulic pumping to mention few. A noticeable among these type is rod lift, which is expected to dominate the artificial lift market because it can be used for a varying range of production rates, as well as operating conditions. Another reason, why the rod is going to dominate is the fact that, it is easy to operate, less expensive, find application majorly in inclined, deep, and horizontal oil land.

The second head, artificial lift methods market by mechanism is divided into gas assisted and pump assisted. The Pump assisted is apprised to hold the largest share because rod lift, ESP, and PCP pumping systems.

In application basis, artificial lift methods market is divided into offshore and onshore. Onshore on one hand is expected to take over artificial lift market. Offshore on the other hand is expected to grow at fastest rate because of rising investments in the sector, especially in Africa.

Focus is more on the Artificial lift methods market by location as empirical review of the study required. This is divided into Pacific, Asia, North America, Europe, the Middle East, Africa, and South America.

The market research future, also predicted that the Northern part of America is probably going to hold a huge share by 2023, due to rising number of mature oil wells within their domain. United States is a key player in America for artificial lift methods because of her rising exploration and refining through unconventional sources. In North America should also know that, Rod lift will dominate the artificial lift methods market through type head. Africa and Middle East are probably going to grow faster within the period of forecast due to the presence of huge volume of reserves within their domain.

Libya has one of the largest oil reserve in Africa. The country as well rank best on the list of oil supplier to Europe from Africa. Libya has proven oil reservoir of about 39 billion barrels and a production capacity of 1.4 million barrels a day (Nashawi, 2010).

Countries such as Germany, Spain, Italy as well as France account to 74 percent on Libya’s oil. The economy of Libya is strictly oil based, with about 95 percent upon foreign currency.

There was a sharp drop in the Libyan oil revenue in 1998. Also the country recorded higher revenue of about $13.4 billion in the year 2003, from her initial meager revenue of $ 5.9 billion in 1998.

The effect of higher oil boom was noticeable within 2003 and 2004 with real gross domestic product (GDP) of about 9.8 percent and 7.7 percent, respectively.

Libya claimed oil reserve of 29.8 billion barrels in 1999. With 7 billion increment which was 22.8 billion barrels in 1986 and similar till 1994. According to Guth and Ginsberg (2004), Libya has total observed oil reserves of 39 billion barrels.

The National Oil Corporation NOC, stated in their report that Libya remains highly undiscovered, which makes it has an excellent potential for more oil to be explored.

Oilwells in Libya are geographically situated in the West (Samah, Beida, Raguba, Dahra-Hofra, Bahi); in the north (Wafa, Heteiba and Nasser) and the East Libya (Sarir, Messla, Gialo, Bu Attifel, Intisar, Amal Overall and Nafoora-Auguia).

For this study, Features and thinner The company's production is 57,000 barrels per day from zuetina fields (zalla,sabah, alhkeem ,althahab and 103), in addition to about 13,000 barrels per day from the share of the company's owners (the Nafoura field), as well as the manufacture of up to 28,000 barrels / day of gas condensate, the production rate of energy generated in the fields company is 42.0 MW per day. The amount of desalinated water is 1350 cubic meters per day . The company’s workforce, at the first quarter of 2006, reached 2405 users, representing national labour, including users of the Zueitina oil port, from which also export the crude and condensate to the shares of some other companies such as Eni, Wintershall and OMV, The percentage of what is exported from the Zueitina oil port reaches about 20% of the total exports of Libya of crude oil, Zueitina Company supplies the local market needs from gas through the Brega Oil Company.

With the success from the A1 well, Zueitina oil Company in 1967 drilled seven additional wells to cushion the effect of production optimization. They measured maximum liquid drop in A8 well test, which is an indication that well contains high water Observers said that there is a varying depth in the oil wells. An average gravity was about 0.80 (air=1) and the liquidity level was about 37° API . It is observed that in recent times most of Zueitina

A7 and A3 lift are based on artificial lift methods of both the Electric submersible pump as well as gas lift techniques.

3.3 Summary and Gap in Literature

The study is aimed at establishing the evaluation of Libyan economy by artificial lift methods. We discussed how various global economies utilizes the artificial lift methods and discussed about the factors affecting choice of artificial lift methods. Key users of artificial lift methods are increasing through the heavy oil demand, and presence of huge volume of oil and oil reservoir.

Countries such as Germany, Spain, Italy as well as France account to 74 percent of Libya’s oil. The economy of Libya is strictly oil based, with about 95 percent upon foreign currency. The major challenges noticed were falling oil prices and major unexplored oilfields.

CHAPTER 4
METHODOLOGY

This chapter is concerned with research design and methodology adopted to adequately collect and analyze data efficiently in order to proffer solutions to problems. It also focuses on the population study area and the sampling size including the validity and reliability of research instrument

4.1 Area of Study

The study will cover various artificial lift methods market key players in the Middle East, Africa, with a special focus on North Africa, Libya precisely. This thesis would work on Zueitina oil firm's A7 and A3 wells The selection of Middle East and Africa and Libya particularly is based on the fact that they are the locations where most oil product are domicile.

4.2 Research Design

An organized secondary data was collected from the Zueitina oil company, which critically outlines the oil lift by artificial methods in wells A7- A3 and evaluation of economy and lays emphasis on scope of research.

4.3 Research Instrument

Secondary data was the main research tool used in the course of this study. Data from Zueitina oil company would be collected and analyzed carefully to obtain relevant and reliable information about economic evaluation by artificial lift methods.

4.4 Data Analysis Techniques

The analysis of data which was gotten from secondary data and is done using the petroleum software named Pipesim.

CHAPTER 5
DATA ANALYSIS AND PRESENTATION

5.1 PIPESIM Introduction

The PIPESIM software is a gradual multiphase flow model utilized strictly for the analysis and design of oil and gas operational systems. The intense and effective model algorithms of PIPESIM software allow operators the opportunity to optimize production and injection system (Nardone, 2009).

PIPESIM simulation multiphase moves from the reservoir up to the surface facilities in order to allow for a comprehensive production, as well as injection system analysis.

A PIPESIM is often a method used by reservoir owner, production expert, and oil facilities engineers and supervisor. The PIPESIM software can be used to design artificial lift methods, simulate a well performance. It is also used to conduct a nodal system analysis as in Figure 5.1. Nardone, (2009), simulate a pipeline facilities, as well as networks, analyze reservoir development plans, and production optimization.

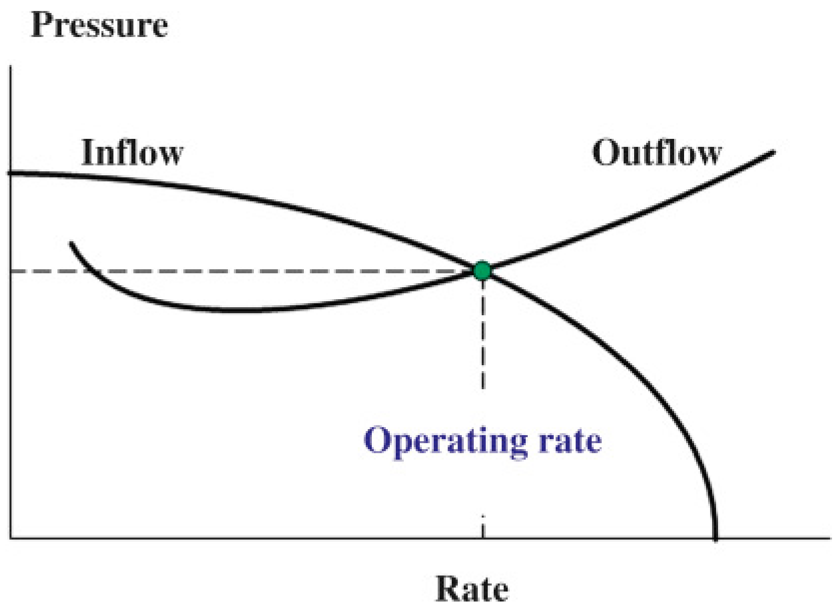

Figure 5.1: Nodal analysis (Nardone, 2009)

5.2 PIPESIM Software Modelling

The simulation of the oil wells are prepared on a PIPESIM software for simulating the naturally flowing well, Electric Submersible Pump, as well as gas lift system. The simulated model of the oil well was made through inputting the elementary characteristics of the oil well like reservoir properties, PVT properties, production data and down hole equipment data.

This paper explained a producing oil well located in field in Libya . We have determined the performance of these wells using Nodal analysis, to check and compare the black oil fluid using match IPR data and laboratory data. We also analyze the characteristics of the well using increasing water, as well as evaluate the varying options to execute gas lift and install the Electric Submersible Pump at a later days when these wells are unable to naturally flow. In this case, no artificial lift method is selected. As such the black oil model is selected with oil and water as the flowing fluids.

5.3 Building the Well Model

Build the well model developed by inputting the basic well characteristics and behavior such as: tubular properties, deviation survey, down hole equipment reservoir properties, detail and production data.

The wells data has provided the tubular data , IPR data , the PVT data , the surface, down hole equipment as in Table 5.1.

Table 5.1: Data from Wells A7 and A3

Oil wells	**A7**	**A3**
Perforations Middle, ft KB	10155	10241
Casing Size, in	7	7
Casing Weight, lb/ft	26	26
Casing Grade	N80	N80
Liner	Nil	Nil
Tubing Size, in	3 ½	3 ½
Tubing Weight, lb/ft	9.3	9.3
Packer, FT	9965	9945
Reservoir Temperature, ˚F	240	240
Reservoir pressue, psig	3117	3117
PI, STB/d/psi	5	4.8
Well-head Pressure, psig	200	170
WHT, ˚F	110	92
WC, %	10	15
API	37	37
GOR, scf/stb	500	410
Bubble Point, psig	2180	2180
Gas Gravity, air= 1	0.8	0.8
Water Gravity, water = 1	1.051	1.051

5.3.1 Tubular input data

7 in CSG and 3.5 TUB are set as input data for tubular, at this step the size of the tubing and casing that had been run in the well (Figure 5.2).

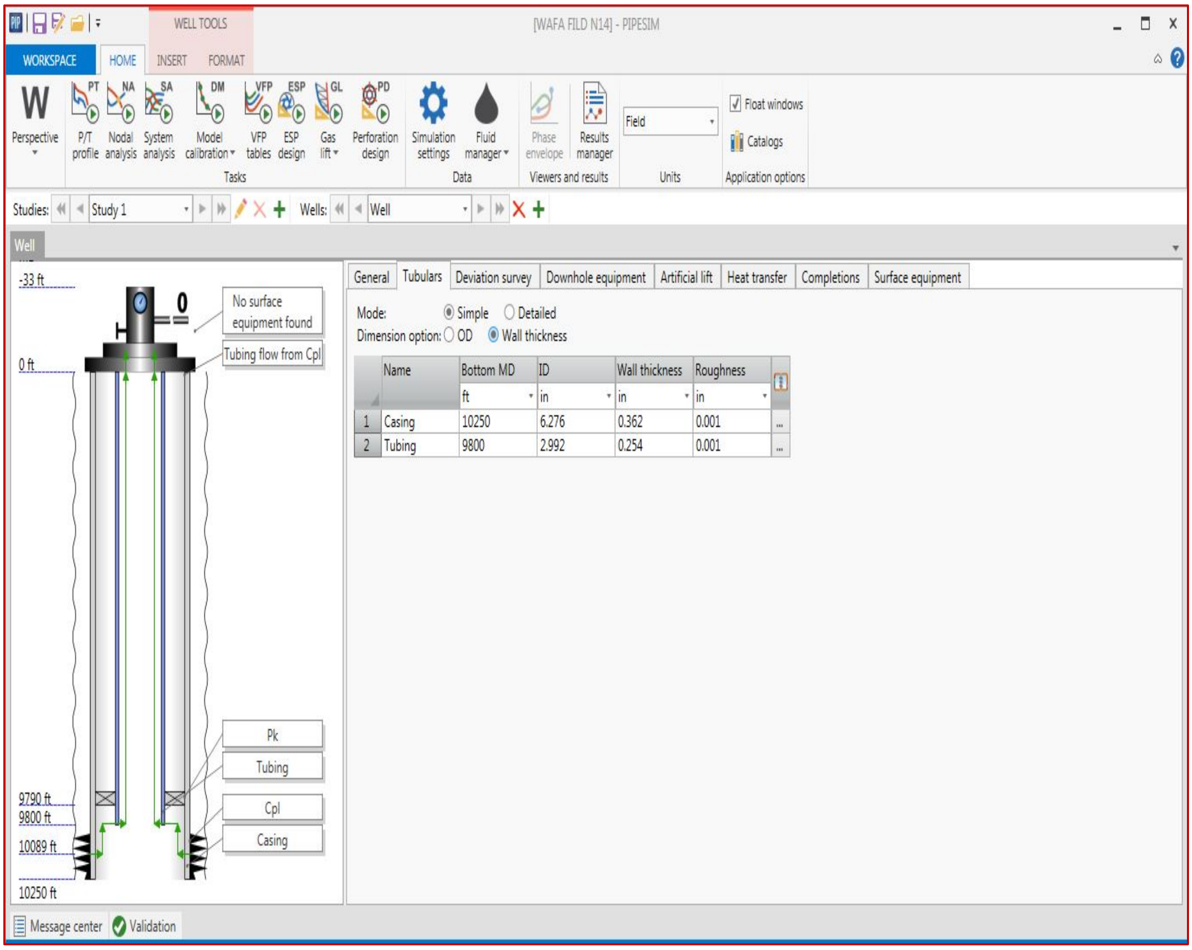

Figure 5.2: Tubular data screen to the wells in pipesim

5.3.2 Deviation input data

To build up the well schematic for the vertical well the total vertical depth and inclination of the well to determine the shape of the well and the angle of inclination to the well (Figure 5.3).

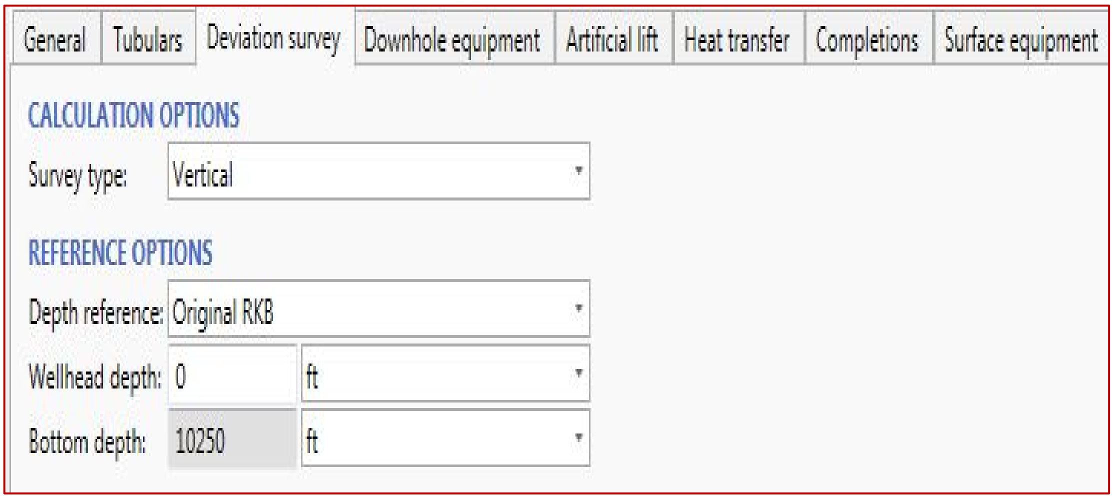

Figure 5.3: Deviation data screen in pipesim

5.3.3 Down hole equipment

For the down hole equipment, 7 in packer to be run at determined depth, to isolate the fluid communication between casing and tubing (Figure 5.4).

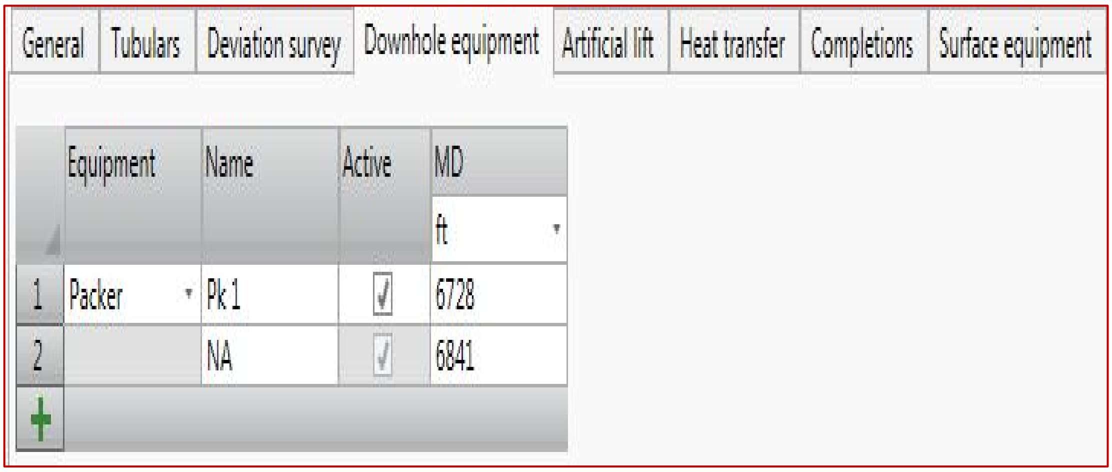

Figure 5.4: Down hole input data screen in pipesim

5.3.4 Heat transfer input data

To configure the heat transfer during the well performance, these parameters in the heat transfer table that indicate the difference between surface and subsurface temperature (Figure 5.5).

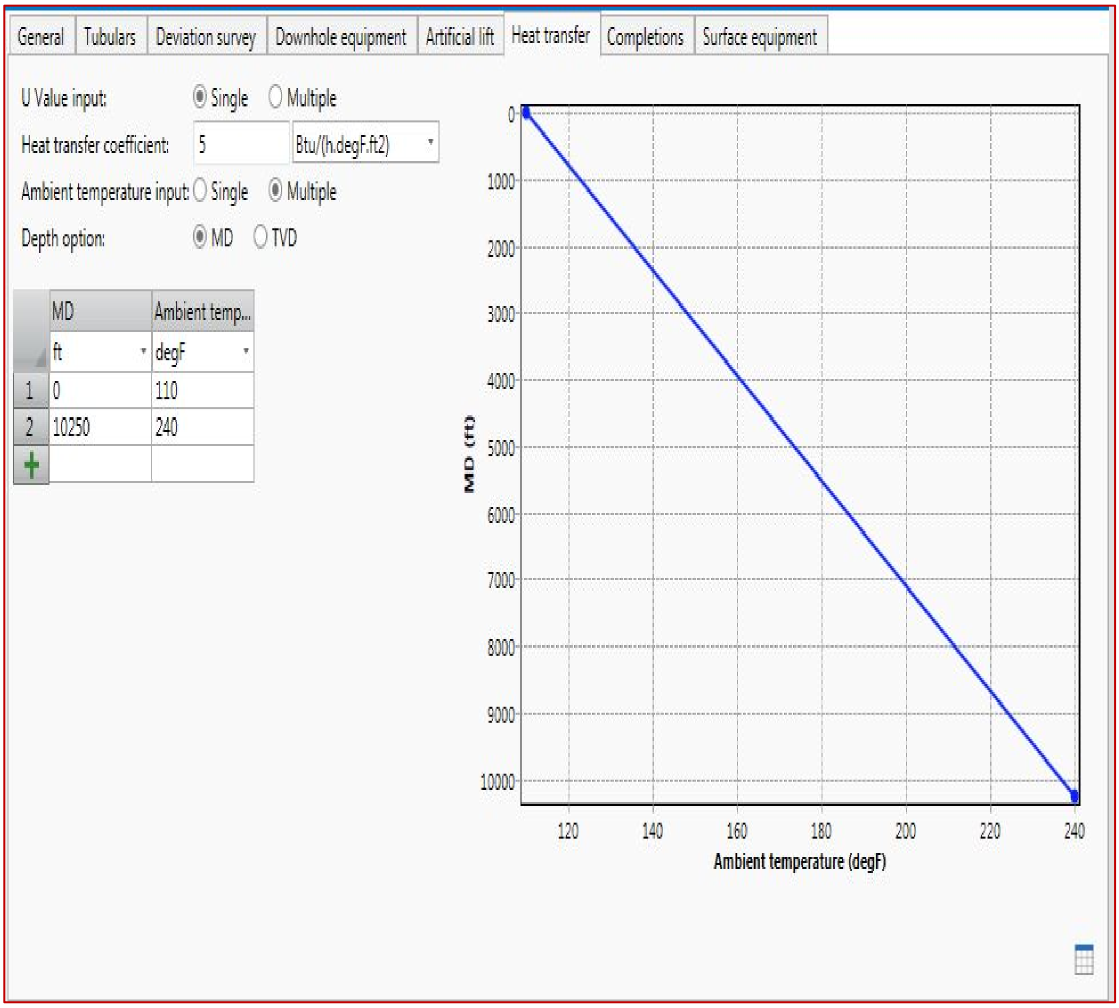

Figure 5.5: Heat transfer input data screen in pipesim

5.3.5 Completion input data

The IPR preview plot appears when inputting the reservoir and fluid data for the well (Figure 5.6).

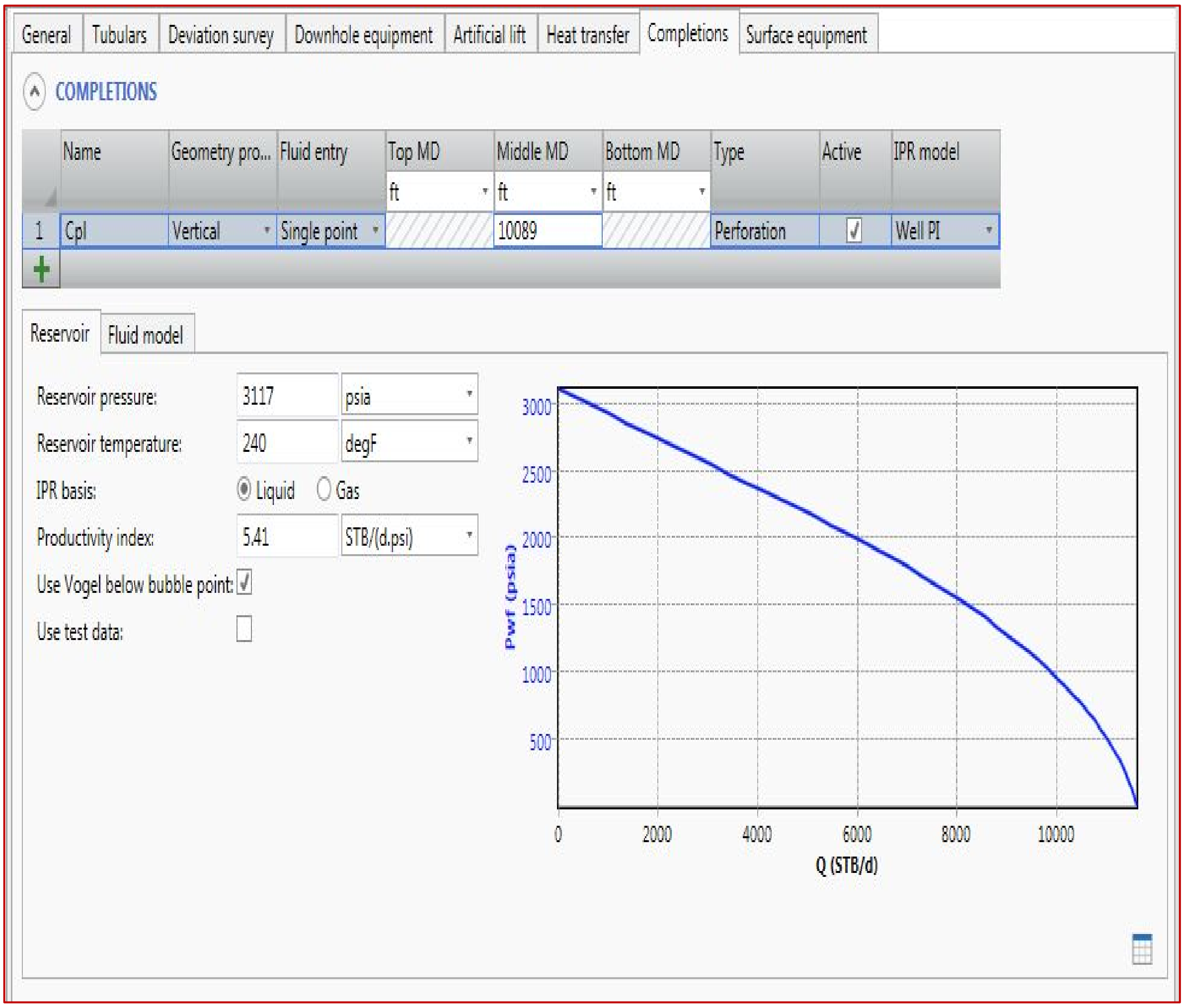

Figure 5.6: Completion data screen in pipesim

5.4 Perform a Nodal Analysis

Perform a nodal analysis work for a given wellhead pressure, so as to determine the absolute open flow potential (AOFP) of the oil well, as well as the intersection of the inflow and outflow curves.

This inflow performance relationship (IPR) curve shows the P-Q relationship for the reservoir, simulated with the well Pl equation (Figure 5.7).

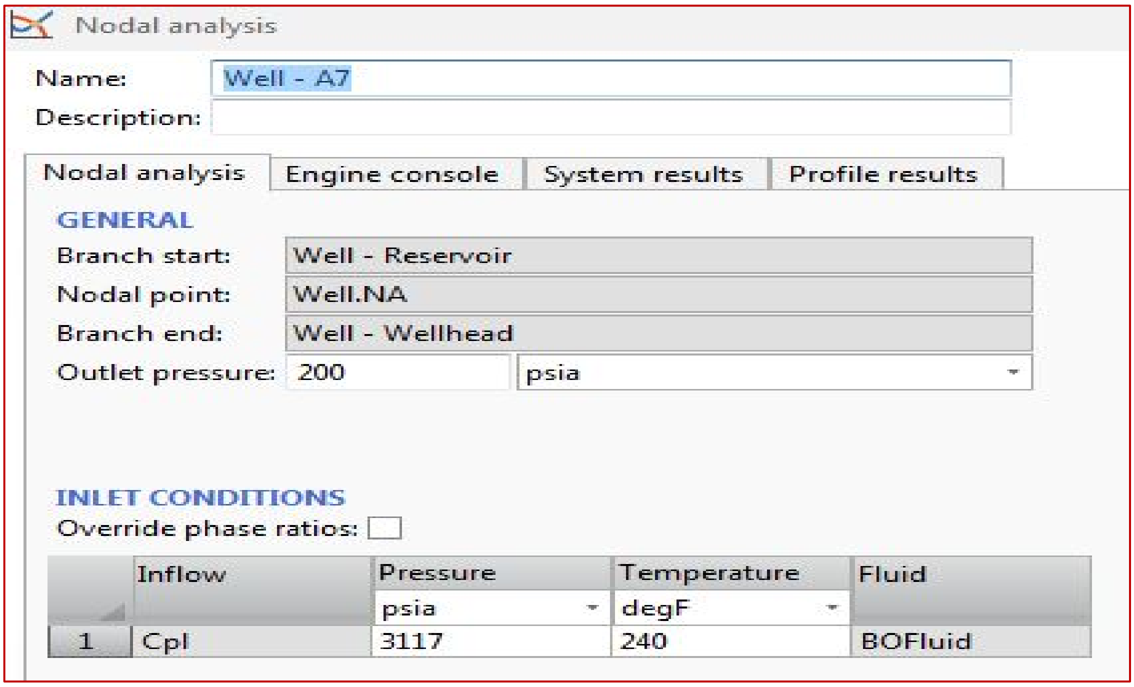

Figure 5.7: Nodal analysis data screen

The Nodal Analysis system plot appear graphical intersection of both curves is known as the solution, intersection of the inflow and outflow curves or operating point. The point represents the forecasted rate and flowing underground hole pressure from the oil well, completed with the tubing explained by the outflow and in the reserve completion explained by the inflow.

The forecasted naturally works on doubt based on restriction on the quality of data, as well as the models in utilization, particularly the multiphase flow correlations equation.

In simple term; the better the model quality and data, the better the forecasted rates and flowing pressures.

PIPESIM Software presents the option to tune PVT correlations equation to match lab data measurement, as well as the option to calibrate the multiphase flow correlations with the measures in field, the operating point before calibration to A7 (Figure 5.8) and A3 (Figure 5.9).

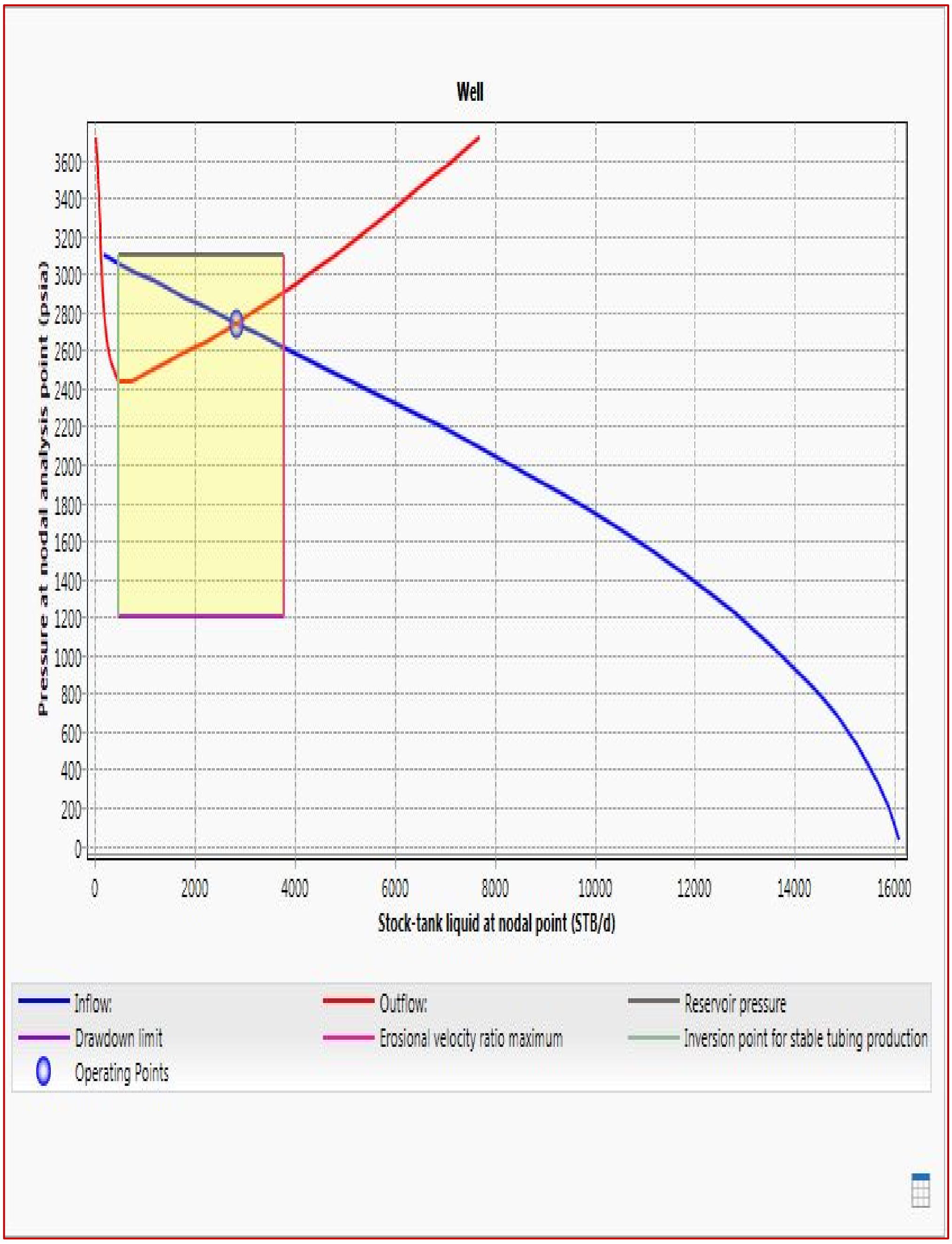

Figure 5.8: Operating point before calibration screen in Well A7

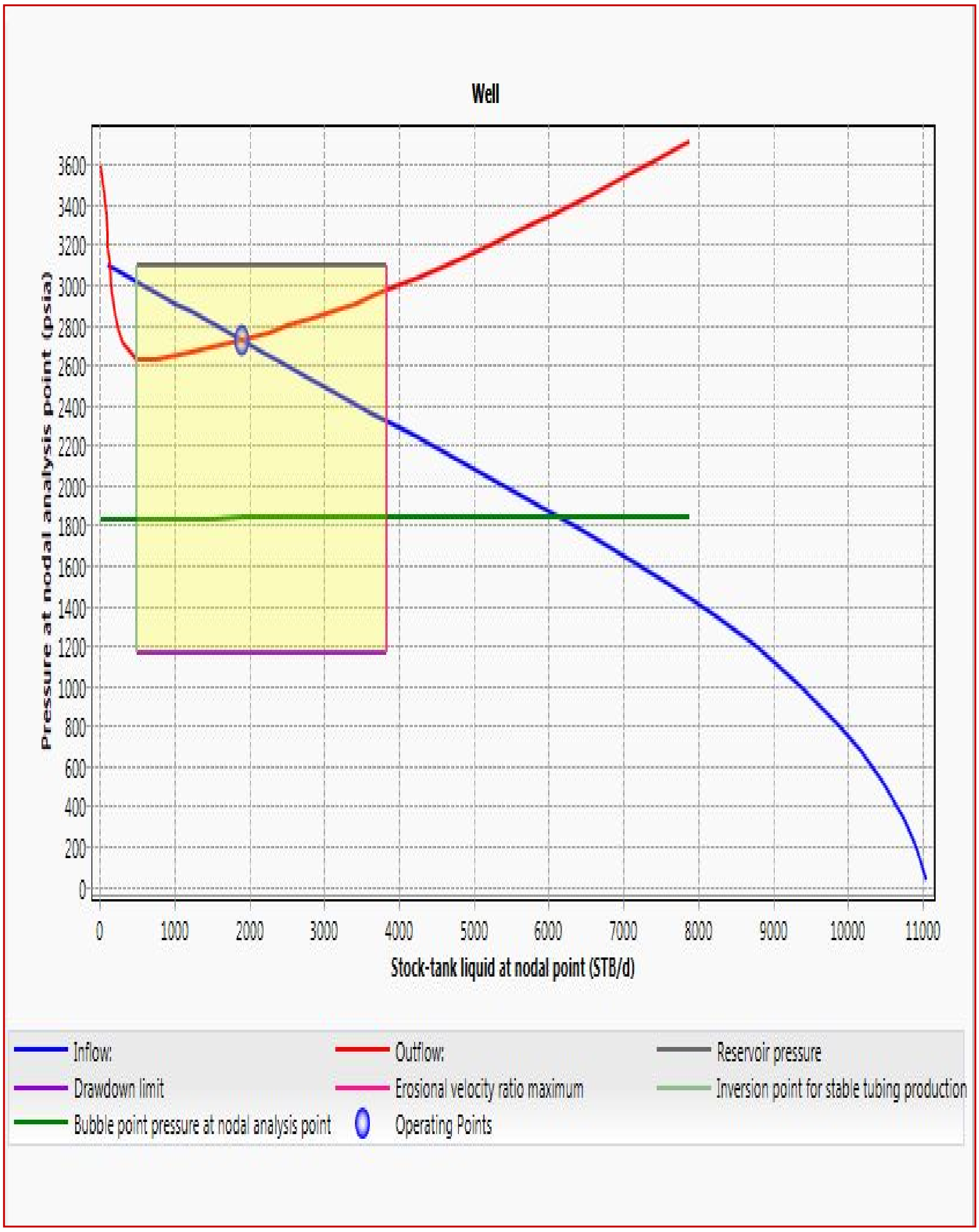

Figure 5.9: Operating point before calibration screen in Well A3

When run the data before calibration there is differences in the results as shown in Table 5.6.

Table 5.2: Result before calibration for A7 and A3

Name	A7	A3
Operating Point Flow rate	2835.568	2120
Operating Point BHP	2526.	2572.620
Absolute open flow pressure	20000	18000

5.5 Black Oil Fluid Calibration

Black oil fluid properties, which is also referred to as PVT properties are forecasted by correlations developed by fitting experimental fluid data with arithmetical models. A lot of correlation equations have been written over the years based on experience and experimental datasets covering Manu fluid properties.

PIPESIM software provides functionality to pair laboratory data and PVT fluid properties to increase the accuracy of fluid property solutions and cushion the overall simulation forecast, especially over the range of temperature and pressures for the method being simulated. Black oil fluid calibration input data is shown in Figure 5.10.

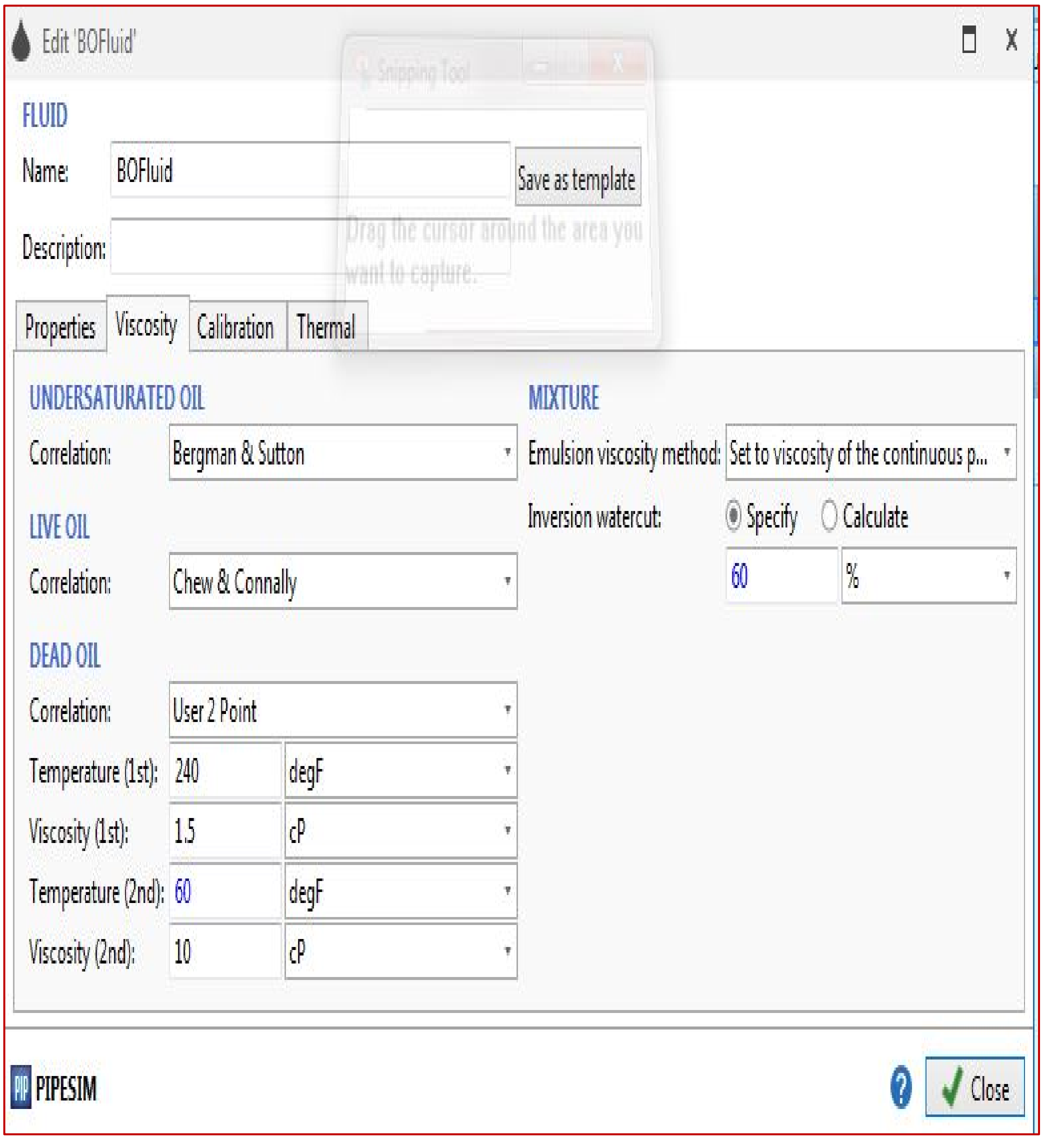

Figure 5.10: Black oil fluid calibration screen in pipesim

5.6 Sensitize on the well PI to match performance

The last step in the well build up is that of the IPR/VLP pairing section. As the VLP is now paired and trusted, we must then examined whether or not the published liquid rate at the earth surface of the well is tested, meaning the intersection between the IPR and the VLP curve is almost the same with the operating point (Figure 5.11and Figure 5.12).

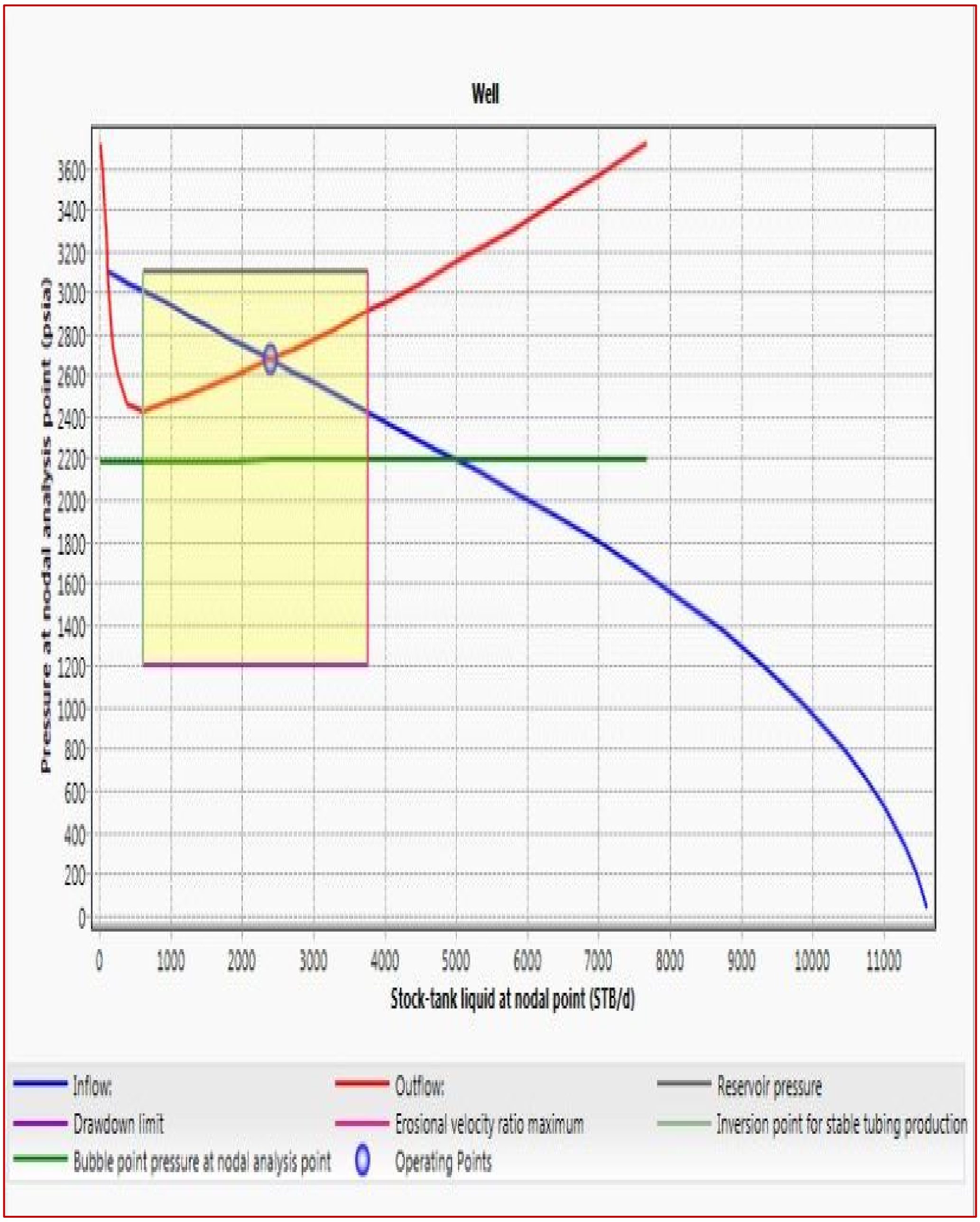

Figure 5.11: Operating point after calibration screen in well A7

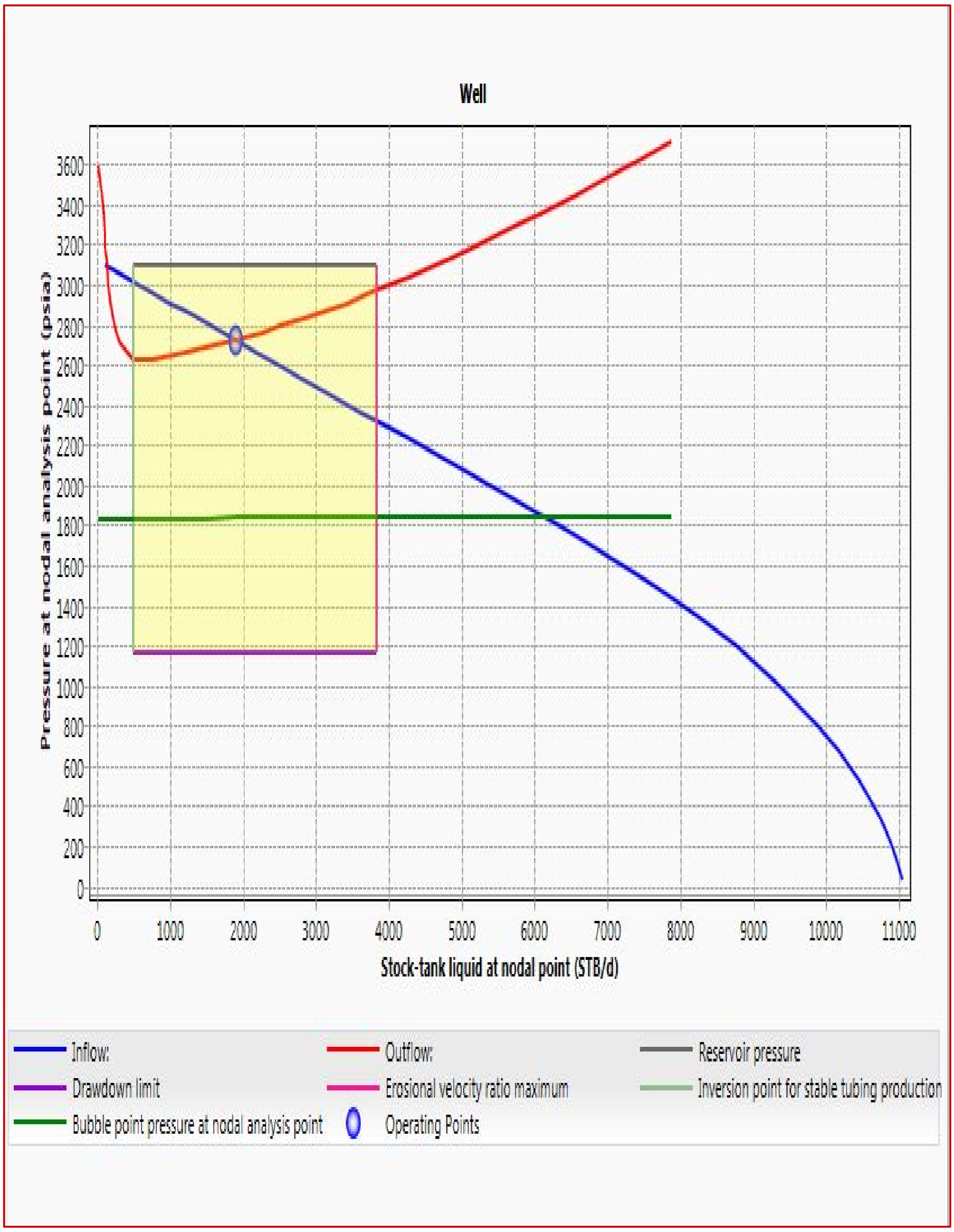

Figure5.12: Operating point after calibration screen in well A3

After applied the real data from the oil field, there are some difference on the results as shown in Table 5.3.

Table 5.3: Result after calibration in Wells A7 and A3

Name	A7	A3
Operating Point Flow rate	2435.7	1890
Operating Point BHP	2647.6	2723
AOFP	20000	18000

5.7 Well Performance Analysis

Water-cut sensitivity analysis

The water cut explained the volume of water present in the fluid column and is represented in percentage.

We must evaluate how the method react to changing operating conditions after the initial design creation. We know that when we increase water production, our oil wells performance is affected, though this might either affect positively or negatively. As a result of this, water production is inevitably required in well design.

In some scenarios in the production stage of an oil well, we might experience a possible insufficient reservoir pressure to lift the fluid to the earth surface, when the water cut got to a particular limit. Such a situation occurs because water has a density that is higher than oil, which create the theory - as the water cut increases, the hydrostatic pressure losses also increases. The Figure 5.13 and Figure 5.14 shows the water cut analysis.

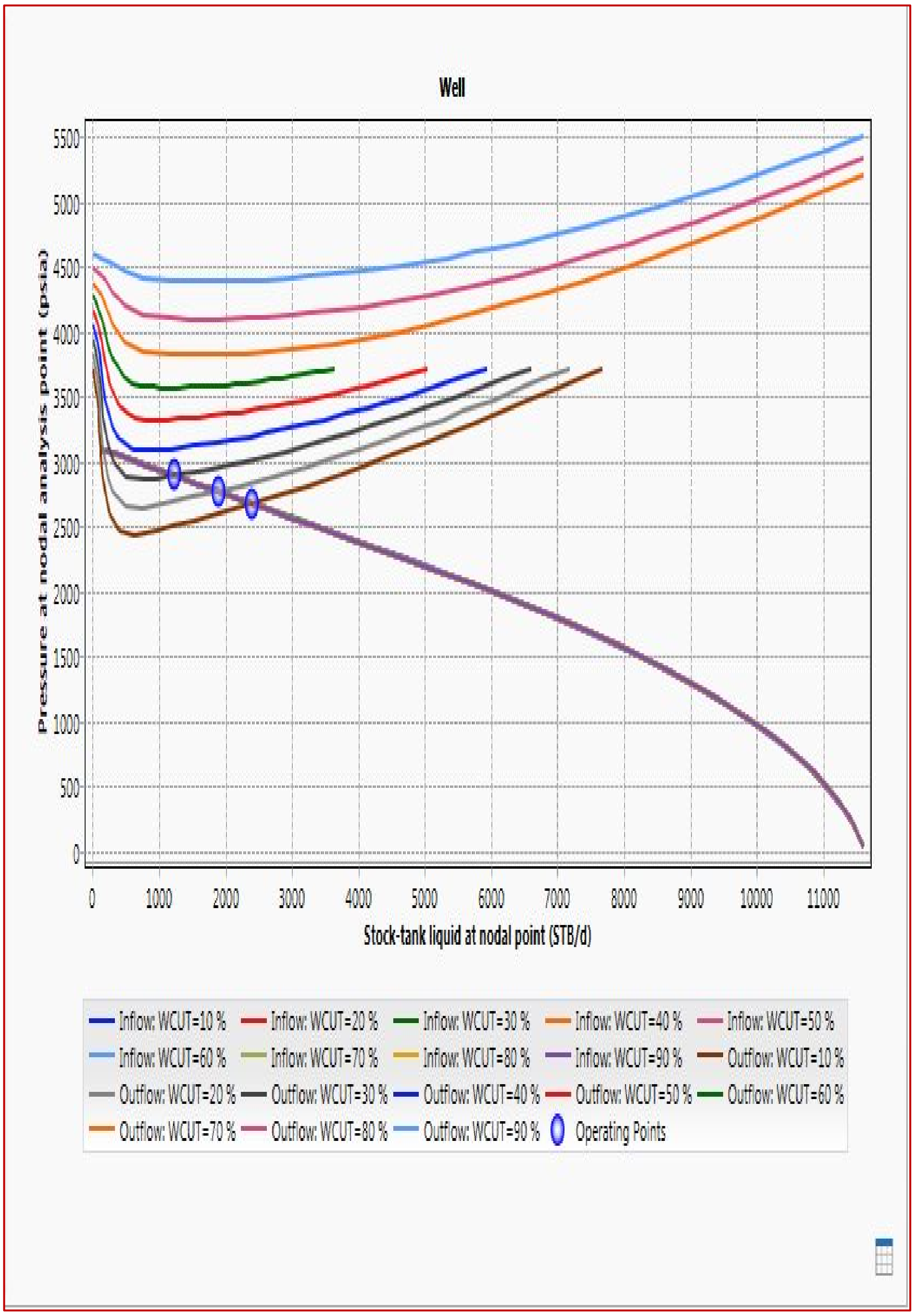

Figure 5.13: Water cut sensitivity analysis screen in well A7

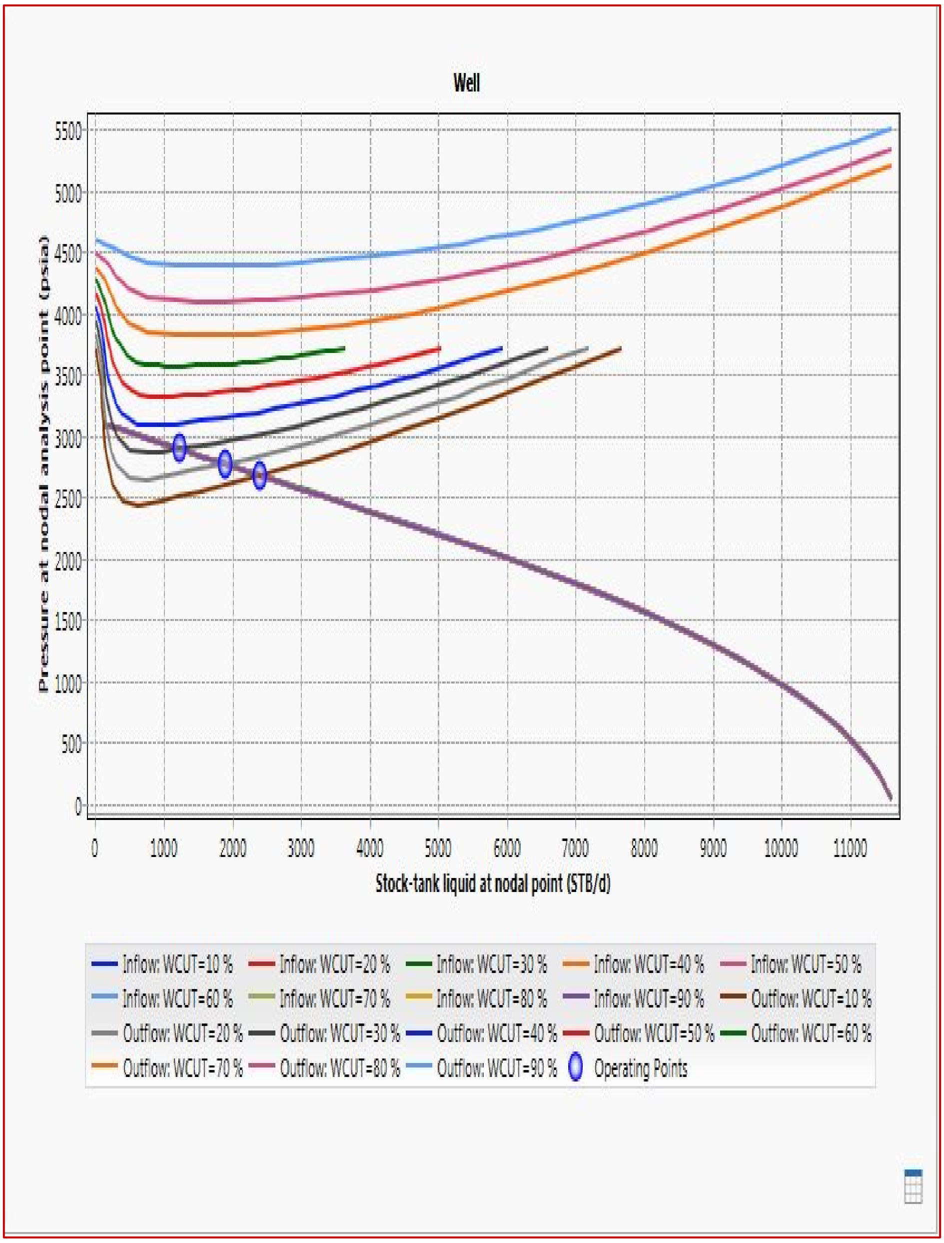

Figure 5.14: Water cut sensitivity analysis screen in well A3

5.8 Artificial Lift

5.8.1 Gas lift design

The main principle behind gas lift injection in an oil well is to lower the density of the fluid in the tubing. This brings about a reduction of the hydrostatic component of the pressure gradient above the point of injection with a lower bottom hole pressure.

When the bottom hole pressure was decreased, the reservoir drawdown increases reservoir; thus, production rate. The gas lift design data are given in the Table 5.4.

Table 5.4: Gas lift data in wells A7and A3

Name	**A7**	**A3**	**Unit**
OLP	200	170	(psia)
QI	0.5	0.5	(mmscf/d)
Sg	0.8	0.8	%

5.8.2 Evaluation of gas lift performance

Here, PIPESIM software examines how the well responds to gas lift system by introducing a gas lift injection point very close to the bottom of the tubing and above the packer.

PIPESIM also determines if these wells can deliver the required liquid production rate of 2435.7 STB/d at 40% water cut, with a maximum gas injection rate at 0.5 mmscf/d.

The system analysis task is used to evaluate a range of cases with varying gas injection rates and produced fluid water cut values as illustrated in Figure 5.15.

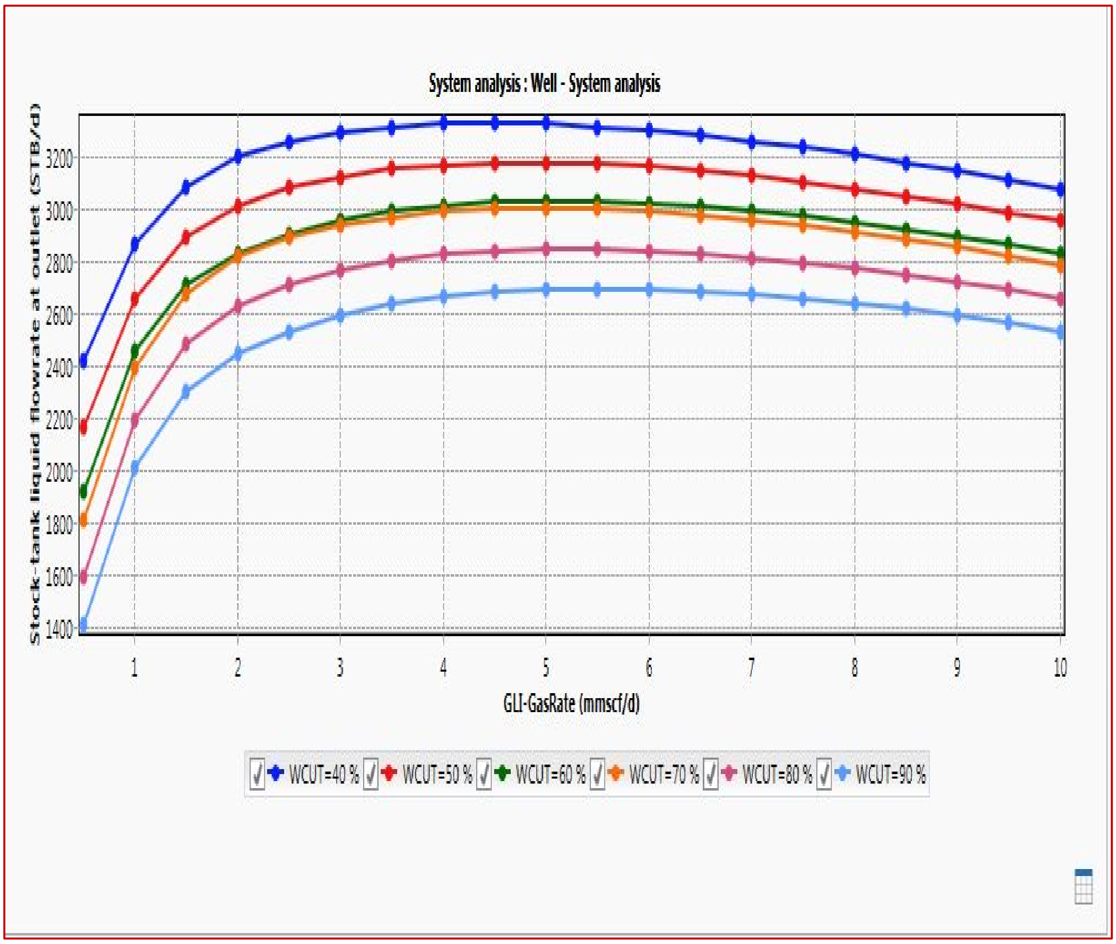

Figure 5.15: Gas lift performance screen in Well A7 and Well A3

5.8.3 Gas lift valves design

The pressure and depth plot illustrating the valve spacing design is shown in the Figure 5.16. Positioning of the valves, valves' opening and closing pressures and mainly the flowing pressure gradient in the tubing are visible. The effect of gas lift is seen at below and above of the injection point and instillation of valves in the wells A7 and A3 (Figure 5.16 and Figure 5.17).

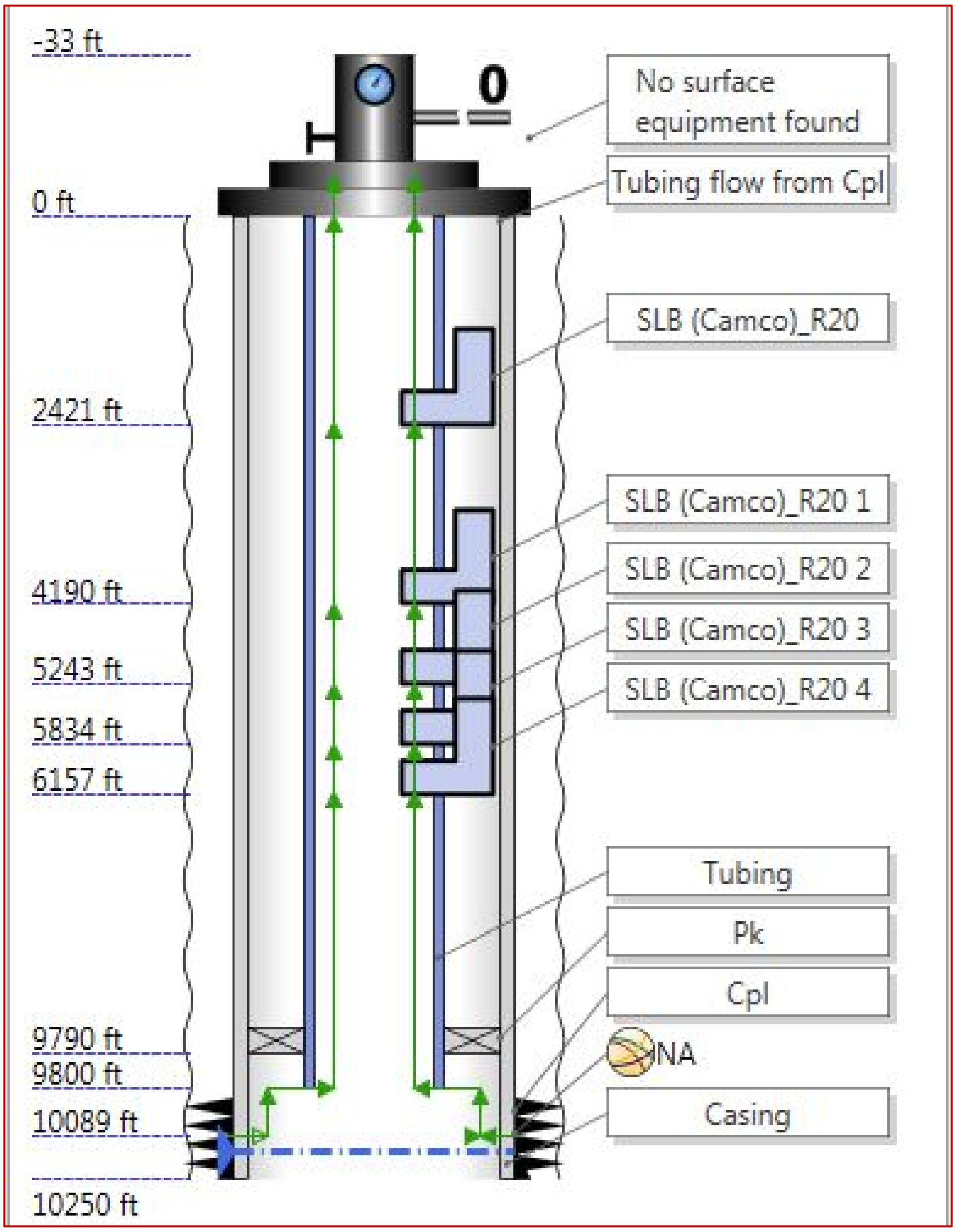

Figure 5.16: Instillation gas lift valves design in Well A7 screen

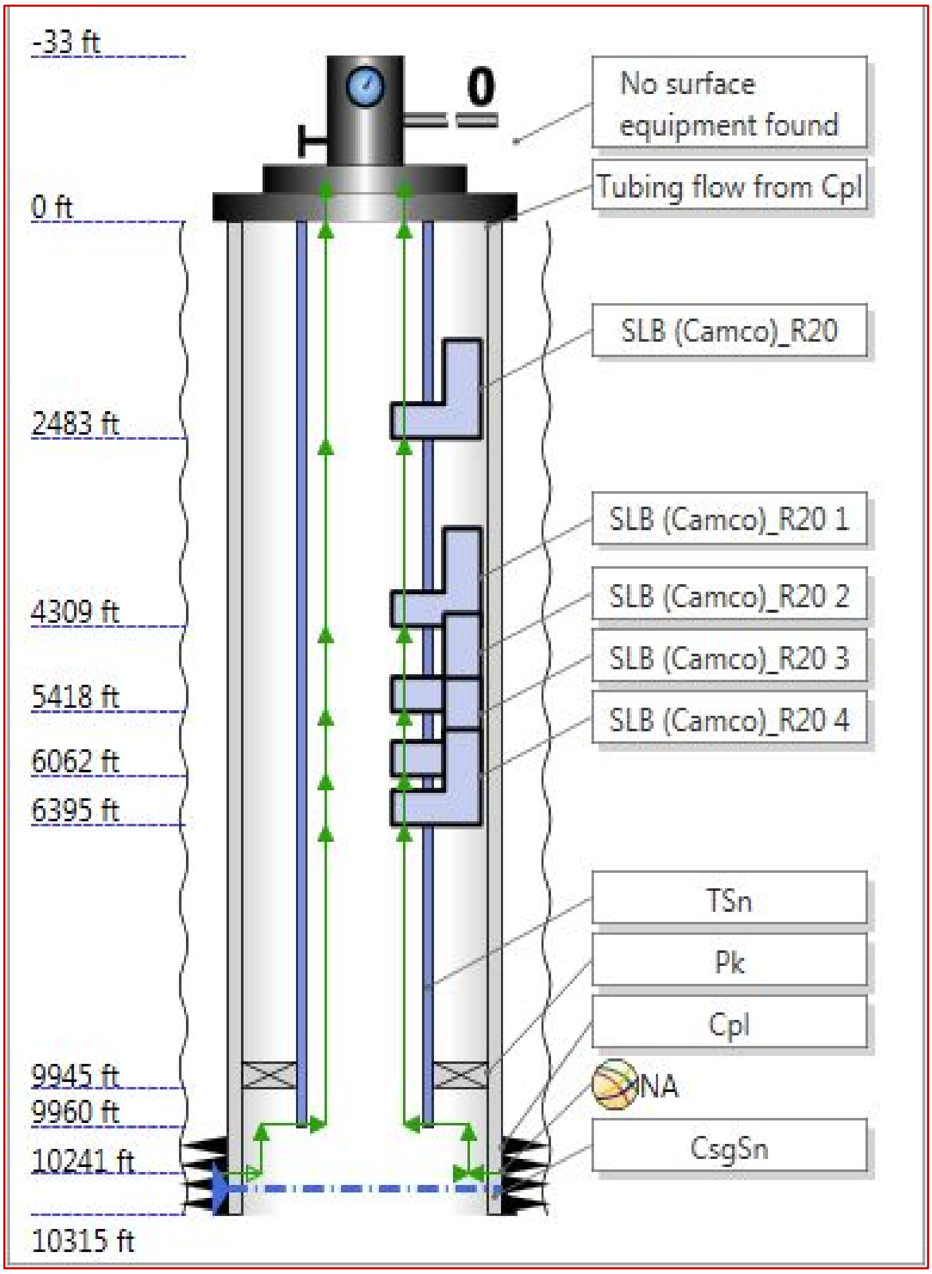

Figure 5.17: Instillation gas lift valves design in Well A3

5.8.4 Water-cut sensitivity analysis for gas lift system

The increasing in water cut in the well affect gas system significantly during the production while increasing water cut, where due to increasing water cut, where the production rate is decreasing due to the water cut (Figure 5.18 and Figure 5.19).

.

	Case
1	WCUT=40 % Flowrate=2278....
2	WCUT=45 % Flowrate=2144....
3	WCUT=50 % Flowrate=2012....
4	WCUT=55 % Flowrate=1884....
5	WCUT=60 % Flowrate=1761....
6	WCUT=65 % Flowrate=1766....
7	WCUT=70 % Flowrate=1646....
8	WCUT=75 % Flowrate=1532....
9	WCUT=80 % Flowrate=1424....
10	WCUT=85 % Flowrate=1325....
11	WCUT=90 % Flowrate=1237....

Figure 5.18: Water-cut sensitivity analysis for gas lift system in Well A7

	Case
1	WCUT=10 % Flowrate=3067....
2	WCUT=20 % Flowrate=2820....
3	WCUT=30 % Flowrate=2565....
4	WCUT=40 % Flowrate=2314....
5	WCUT=50 % Flowrate=2068....
6	WCUT=60 % Flowrate=1836....
7	WCUT=70 % Flowrate=1709....
8	WCUT=80 % Flowrate=1498....
9	WCUT=90 % Flowrate=1312....

Figure 15.19**:** Water-cut sensitivity analysis for gas lift system in Well A3

5.8.5 Electric submersible pump design

The electric submersible pump ESP is a multiphase centrifugal pump, which is able to produce a significant boost in pressure to produce large volumes of reservoir fluids. Each stage of the ESP contain the impeller and a diffuser mounted on a shaft.

When the shaft rotates, centrifugal forces created by the impellers imparts kinetic energy on the fluid, which the diffusers then convert its kinetic energy to pressure that boosts the fluid as it naturally flows through the pump to the discharge.

5.8.6 Electric submersible pump input and output data

PIPESIM allows us to install the electric submersible pump ESP on a well as the artificial lift system. In this case, ESP is chosen from the method summary part as the artificial lift method.

Now for design the ESP, the software provides the selection pump, motor and cable for the well. Thus, making it very simple to select all three parts from the database of the PIPESIM. The pump selected from the database which shows maximum performance of the ESP as shown in the Figure 5.20 and ESP design in Figure 5.21, to A7 and A3 wells.

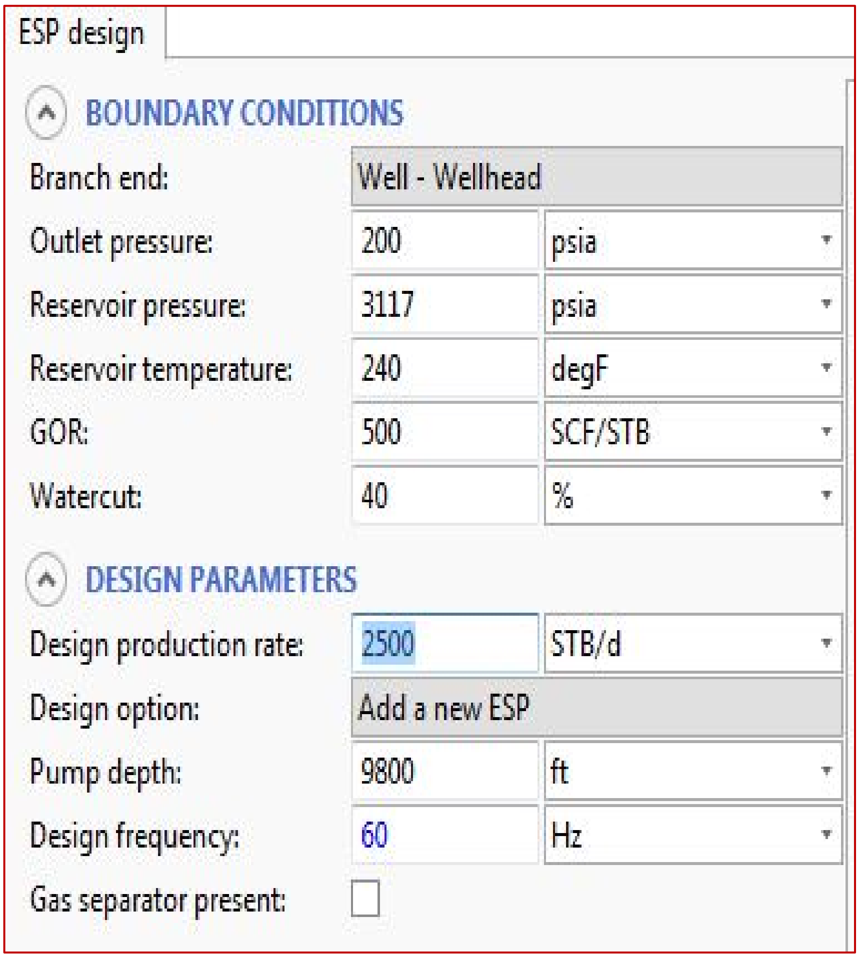

Figure 5.20: ESP data input screen for A7 and A3 wells

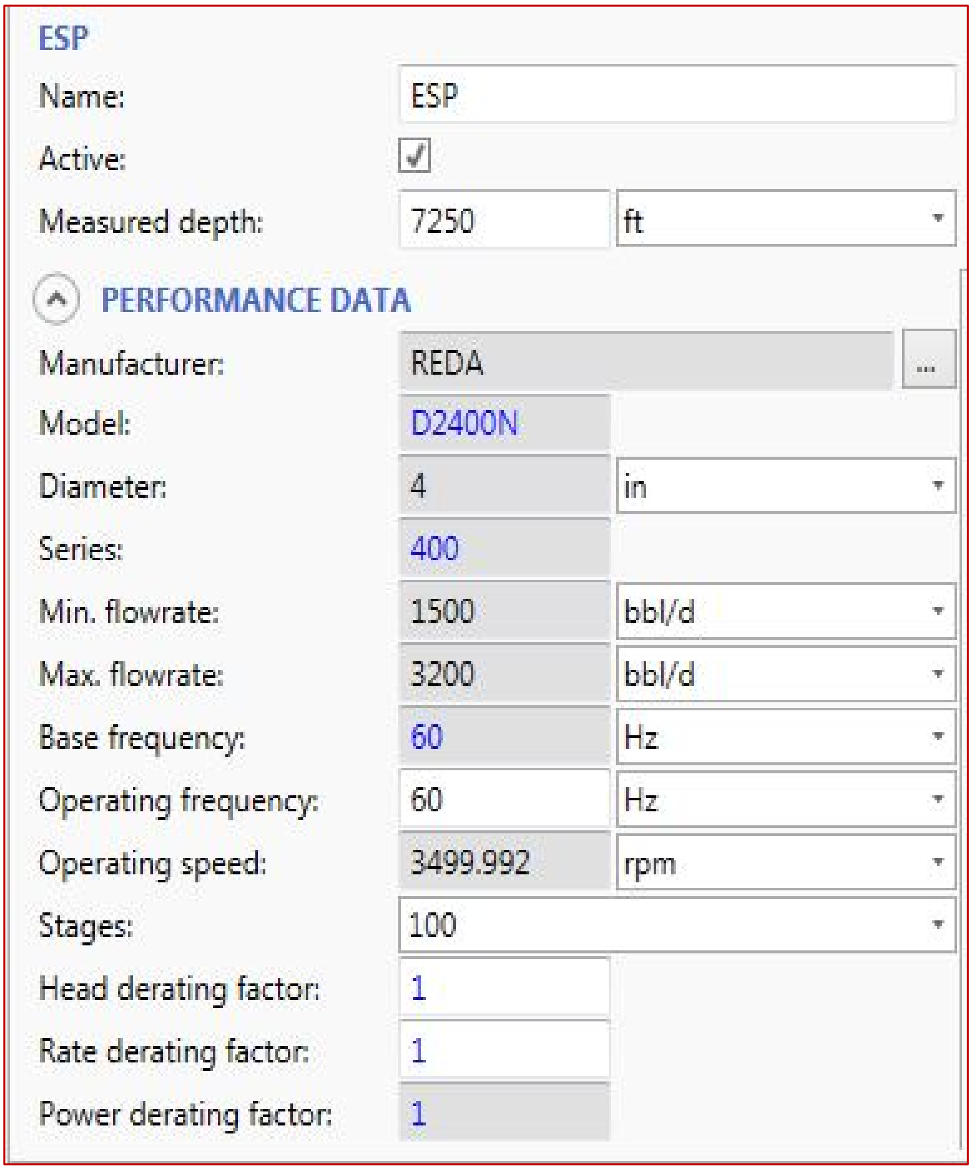

Figure 5.21: ESP design screen for A7 and A3 wells

5.8.7 Efficiency pump performance

The performance curve is to determine the head, efficiency, and power requirement for one stage of this pump, operating at 60 Hz. All these calculations are based on pump curves provided by the manufacturer data, which use water as the reference fluid (Figure 5.22 and Figure 5.23).

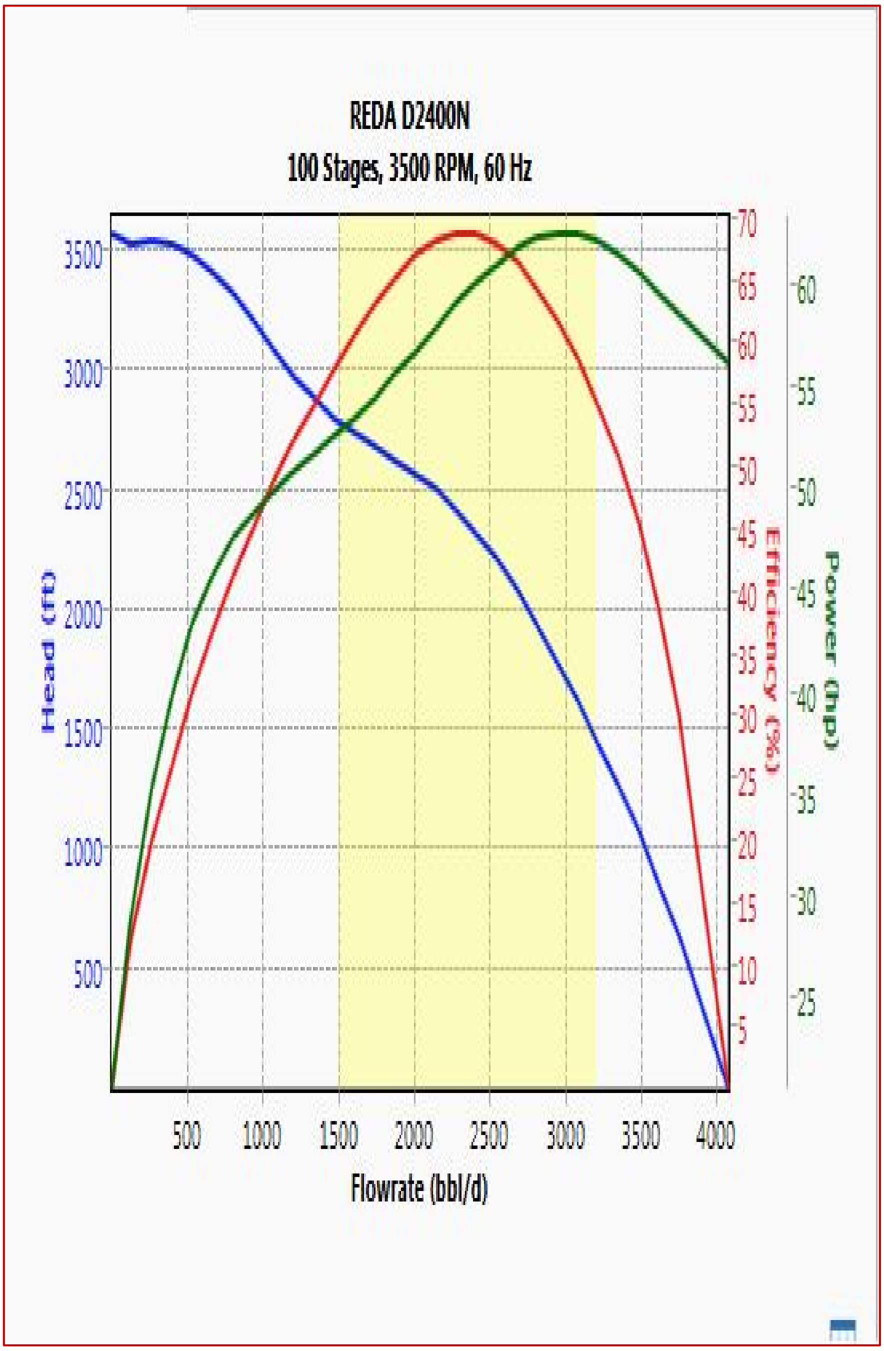

Figure 5.22**:** Pump performance screen for Well A7

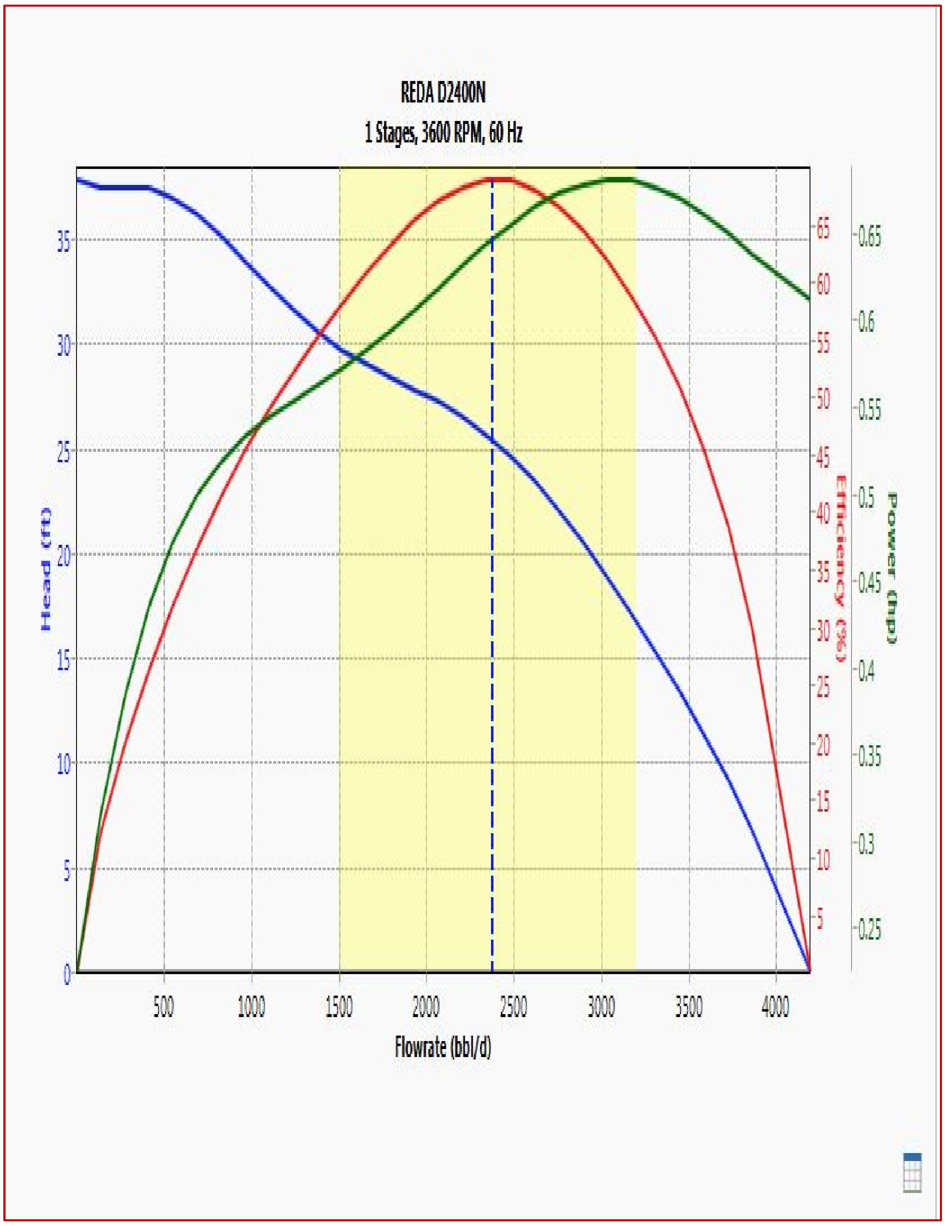

Figure 5.23: Pump performance screen for Well A3

5.8.8: Result of using gas lift design and ESP design for A7and A3 Wells

The volume of oil produced by each method in a day is shown in Table 5.5. The income from one year of oil is then calculated. The result of running ESP and gas lift and how many barrels for each one prduce daily.

Table 5.5: Result of using gas lift design and ESP design for A7 and A3 Wells

Name	A7	A3	Unite
Gas lift design	2330	2314	St bbl/day
ESP design	2600	2400	St bbl/day

5.9 Economic Evaluation

In this findings, it is observed that a feasibility of switching oil wells from Gas Lift (GL) production method to electric submersible pump ESP method. Through our secondary data, this information is obtained from the evaluation on the present value (PV10%) and pay out time, POT.

Though, the present value (PV10%) is usually utilized in the oil and gas firms evaluation in order to explicitly state the total number of all cash flow annually succeeding each amount, which had been reduced by 10% compounded annual interest. This simply means the loan capital for the reducing the subsequent amount is put at 10% per annum. Also the payout time POT is said to be the period from the first capital investment deposit until the cumulative net cash flow yields positive.

The result showed that wells in question are previously operating on gas lift system and the data show collected is seeking for their switching to the electric submersible pump methods ESP. There are two alternatives possible, which are to either do nothing or go ahead with switching to the electric submersible pump ESP.

Also findings revealed that if operators decide to do nothing, the annual costs would include: maintenance of underground equipment gas lift valves. If operators decide to switch to electric submersible pump ESP, the associated costs would include the five gas lift pull out cost, and run ESP set such as centrifugal pump, seal section (protector), motor, cable, switch board, the junction box, lastly motor lead. From the finding a summarization of formulas are shown in Table 5.6 (Ohia, 2012).

Table 5.6: Illustrated the economic formulas (Ohia, 2012).

Alternative	Do nothing	Switch to ESP
Investment	Nil	GL system's pull out + ESP system cost
Gross Revenue	Oil rate × Oil price	Oil rate × Oil price + Gas rate × Gas price
Total operating cost	Gas rate × Gas price	Wattage × Watt price
Net cash flow, NCF		Gross revenue - Total cost
PV(10%)		$NCF/(1+i)^n$
CDNCF		∑PV(10%)

Economical aspect of the study is posed on the oil price of about $63/barrel, with gas price of $5/Mscf, electrical current at just $0.05/KWH. The study systems are based on wells A7 and A3.

5.9.1 Capital expenditure and operation expenses

After carrying on modeling framework and finding the operational profile for both the techniques and this is the basis of this study. The second objective of this paper is the total economic evaluations of the artificial techniques utilized for oil wells.

With economic evaluation, we took into consideration the capital costs, production costs, income costs, and other cost. Prior to conclusion, a total economic assessment carried out. This simply imply that the profitability of artificial lift methods will be the final features of selection.

In the Table 5.7 capital expenditure of electric submersible pump ESP and Gas Lift of A7 and A3 oil wells are shown. The studies show that the cost of equipment, maintenance and surface equipment for the industrial lift of ESP is less than the cost of using a Gaslift.

Table 5.7: CapEx of ESP and gas lift for A7 and A3 oil wells

Services	Cost of ESP ($)	Cost of Gas Lift ($)
Artificial Lift Equipment	118,30	159,387
Installation/Workover	39,000	27,000
Surface Equipment's	142,800	179,100
Electric Surface Equipment's	80,000	93,300
Metering	30.000	57,000

,

While in the operational cost (Operation expenses) of each of the artificial lift of (ESP and Gas lift) shows a rise in the cost of using ESP for each of A7 and A3 wells as shown in the Table 5.8.

Table 5.8: OpEx of ESP & Gas Lift forA7 and A3

Services	**Cost of ESP ($)**	**Cost of Gas Lift ($)**
Horse Power per Annum	1,000,300	690,500
Running Cost	693,000	689,000
Maintenance cost	827,273	599,000
Water Treatment	489,000	489,000

5.9.2 The economic analysis result

The present value of both Artificial Lift can be easily calculated. As a result, the net present value of ESP is far greater than the PV of gas lift. blatantly demonstrates that ESP is the superior option to be chosen for the well because it will provide a large sum of money income by producing more oil and spending less. The Table 5.9 shows the PV of the ESP and Gas lift.

Table 5.9: Economic analysis results for A7 and A3

Well	Gas lift			When Switch to ESP		
	PV(1O%)	CDNCF	POT	PV(1O%)	CDNCF	POT
A7	110744.5176	221489.0352	5	447833.49	572215	8.5
A3	130500.6120	230489.1534	6.9	550712.30	620321	10

5. 10 Results and Discussions

By entering the basic well features like PVT elements, reservoir components, down hole equipment components and production data. In this case, there is not artificial lift system chosen. Thus, Black Oil Model is chosen with oil and water as flowing fluids.

Due to increasing water cut to 30% artificial lift method has been run to get the required production rates.

Run gas lift system in A7 and A3 wells that mean cost of run five gas lift mandrels and surface compressing system to inject gas from annulus to string where in economic terms of OpEx and CapEx , OpEx for gas lift system include horse power per Annum 690,500$, Running Cost 689,000$, Maintenance cost 599,000$, and Water Treatment 489,000$. The CapEx stand of Artificial Lift Equipment 159,387$, Installation/Work over 27,000$, Surface Equipment 179,100$, Electric Surface Equipment’s 93,300$ and Metering 57,000$.

To change the production of the well from natural production to Artificial Lift production, this requires rig to change the completion of the well and pull the old pipes and run the industrial lifting equipment for both ESP set as, a pump, motors, protector, intake and cable , Gas Lift system and run Gas lift valves and thus an increase in cost.

OpEx and CapEx for ESP system include horse power per Annum 1,000,300$, Running Cost 693,000$, Maintenance cost 827,273 $, and Water Treatment 489,000. The CapEx stand of Artificial Lift Equipment 118,30$, Installation/Workover 39,000$, Surface Equipment’s 142,800$, Electric Surface Equipment’s 80,000$ and Metering 30.000$.

Gas lift system with five gas lift valves was suitable to produce the well at desired rates but due to increasing in water cut to more Than 70%, ESP system had been run.

Sequel to the modeling and economic evaluation of the ESP and the Gas lift system on the well, the discounted oil rates for the lifting techniques were gotten. The production flow rate of the ESP at 2435.7 STB / D in 40 percent water reduction, and oil production rate of Gas Lift at similar water cut. After increasing in water cut up to 80% the production rate was reduced. In addition, the ESP's PV (10%) and POT for A7-A3 are 447833.49$, 550712.30 and 8.5$,10$ per year, while for gas lift are PV(1O%) 110744.51$, 130500.6120$ and POT is 5, 6.9 years.

According to (Hullio et al.2018) . Sequel to the simulation and economic assessment of the ESP as well as Gas Lift on dead oil well , the discounted production rates for both lift techniques were received. The flow rate of the ESP was 1310.3 STB / D in 35% water cut, while the flow rate of the gas lift was 1011.5 STB / d in 35 percent water cut. Also the Gas lift PV for A7 and A3 as well as 110744.5176and 130500.6120 respectively, while the PV for ESP $447833.49 and $550712.30 to A7 and A3 as well.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes study from the data analysis; conclusion and recommendations for the thesis. It also highlights limitations of the study and finally gives suggestions for subsequent research works.

The study's main goal is to evaluate the economic evaluation using artificial lift methodologies rigorously. The particular goals of this study are as follows: determining the scope of usage of artificial lift techniques, investigating the obstacles associated with the use of artificial lift methods and corresponding mitigation strategies, and assessing the economic evaluation by artificial lift methods.

In general, the study was able to evaluate the economy by artificial lift methods such as the gas lift (GL), as well as the electric submersible pump (ESP). Using PIPESIM analysis software to run simulations on the Zueitina oil company's A7-A3 wells. It indicates that the artificial lift methods has significant effect on the economy of Libya.

6.1 Conclusions

The conclusions of the evaluation of artificial lift application in Zueitina oil company's Wells A7-A3 are:

1. Increasing the water cut to more than 30% caused death of the well due to high liquid column weight creating back pressure on bottom hole, at this point an artificial lift is needed to produce the well.
2. Low cost of gas lift method and percentage of(PV10%) which equal to 110,744$ - 130,500.61$ make it is very suitable for desired wells but ESP should be run when W/C increase to 70% to keep the same rate of production.
3. The selection of artificial lift system must be suitable to pass over both total production rate of the desired well and total well depth through initial well screening;
4. To compare between these two methods for selecting the best one of them for a given

well, this requires a performance analysis carried out by a production analysis software and economic analysis.

5. To conclude that gas lift and electric submersible pump are the best known artificial lift system that suitable for wells in the 103A field.

6.2 Recommendations

Recommendations were on the general analysis and outcome of the A7-A3 wells. The recommendations are as follows :

1. Based on the economic and operations point of recommendations view, gas lift was recommended as a best artificial lift method.
2. Based on production point of view and gross profit, ESP system was recommended as best artificial lift system.
3. During the production progress, when the water cut rises, it would be recommended to replace gas lift by the ESP method.

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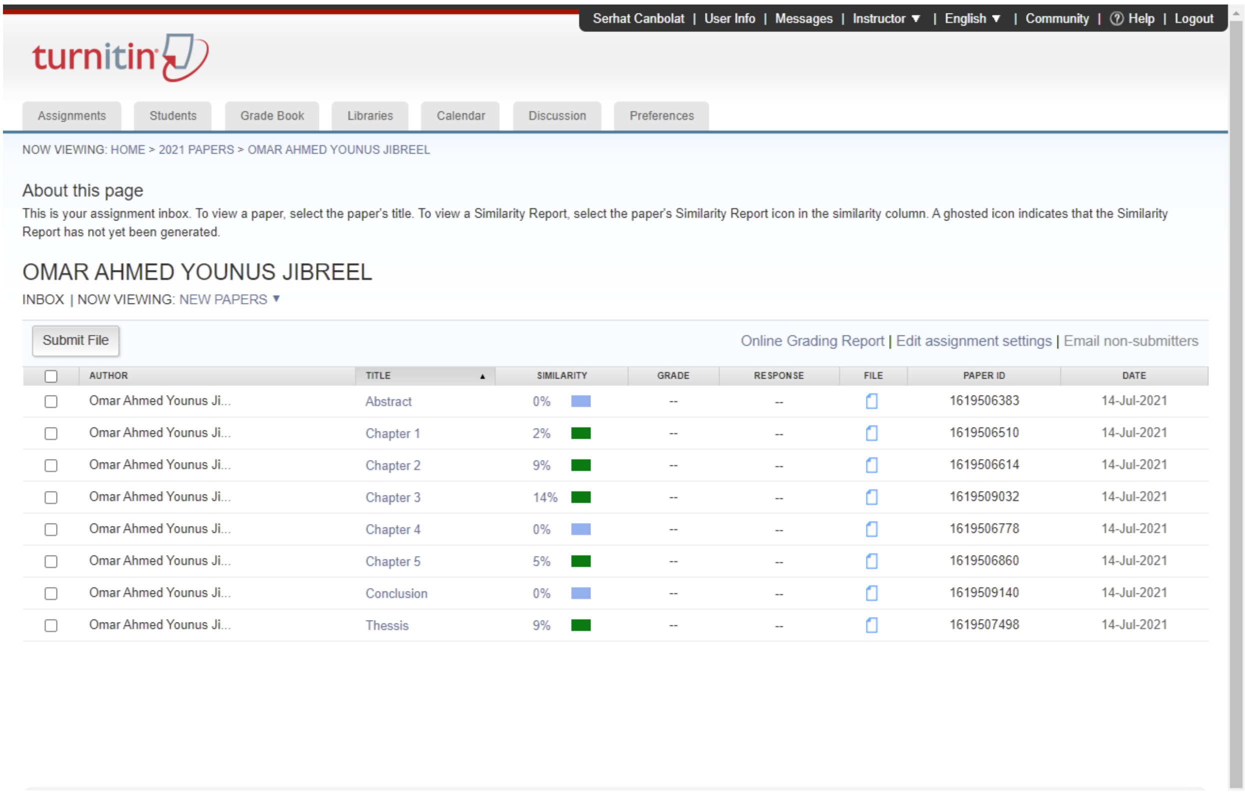
APPENDICES

APPENDIX 1

SIMILARITY REPORT



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Supervisor: Prof. Dr. Cavit Atalar

Co-Supervisor: Assist. Prof. Dr. Serhat Canbolat

APPENDIX 2

ETHICAL APPROVAL LETTER

YAKIN DOĞU ÜNİVERSİTESİ

ETHICAL APROVAL DOCUMENT

Date: 24/06 /2021

To the **Institute of Graduate Studies**

The research project titled "**ECONOMIC EVALUATION OF ARTIFICIAL LIFT METHOD IN 103A FIELD, LIBYA**'' has been evaluated. Since the researcher will not collect primary data from humans, animals, plants or earth, this project does not need through the ethics committee.

Title: Prof. Dr.

Name Surname: Cavit ATALAR

Signature:

Role in the Research Project: Supervisor

Title: Assist.Prof. Dr.

Name Surname: Serhat CANBOLAT

Signature:

Role in the Research Project: Co-Supervisor