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Solving a gas-lift optimization problem by applying Auto-Boost technology in Hassi Messaoud oil field

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With God's grace first and foremost,

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Dedication

In the Name of Allah, The most Merciful, The Most Passionate

To my family, for their endless love and encouragement ; to my classmates, for our shared pursuit of knowledge ; and to my friends, for their constant support and the joy they bring to my life ; To my dear colleagues, Abderaouf and Anes.I am deeply grateful to you all.

Hassen Abdelkader Bilal

My dear Parents who have given me everything, and to whom I owe every success.

To my dear brothers. To My Dear Sisters

To my whole family TIDJANI

To my dear friends

To my dear colleagues, Abderaouf and Bilal.

TIDJANI ANES

We dedicate this modest work to :

My dear Parents, to whom I owe all the success in my life.

To my dear brothers and sisters

To my family BOUKHALFA

To my dear friends

To my colleagues in this work, Anes and Bilal.

BOUKHALFA ABDERAOUF

ملخص:

بعد فترة طويلة من الإنتاج، لن يكون ضغط المكمن كافيًا لرفع السوائل إلى السطح ولن يكون الإنتاج مجديًا اقتصاديًا. للحفاظ على الإنتاج، تم تطبيق عدة طرق للرفع الاصطناعي، مثل الضخ والغاز الرافع. تمثل طريقة التفعيل بواسطة الغاز الرافع 45% من الإنتاج في حقل حاسي مسعود، وهو موضوع دراستنا. تعتمد هذه الدراسة على تقييم كفاءة تطبيق Autoboost للآبار المنتجة المختارة (HGANE 2) و (HGANE 7)لاستعادة وزيادة إنتاج النفط الأولي لهذه الآبار. تعتمد منهجية عملنا على جمع البيانات إكمال البئر، بيانات اختبار البئر، بيانات (PVT) ثم، تم إجراء تحسين لمعايير الغاز الرافع باستخدام برنامج PIPESIM من خلال إنشاء نماذج أداء التدفق الداخلي وأداء الرفع العمودي للتقليل من خسائر الضغط العمودي. أظهرت النتائج زيادة بمقدار 5.3م^3 و4.14 م^3 للبئر HGANE 2 و HGANE 7على التوالي. يمكن أن تساعد نتائج هذا العمل في تنشيط الآبار الخارجة عن شبكة الغاز الرافع بشكل أكثر اقتصادي وتحقيق الاستغلال المطلوب للنفط.

الكلمات المفتاحية : ضغط المكمن، طرق الرفع الاصطناعي، الغاز الرافع، حقل حاسي مسعود، تطبيق Autoboost، الآبار المنتجة، الاسترداد الأولي للنفط، جمع البيانات، إكمال البئر، بيانات اختبار البئر، التحسين، برنامج PIPESIM، التدفق الداخلي، أداء الرفع العمودي.

Résumé :

Après une longue période de production, la pression du réservoir ne sera plus suffisante pour soulever les liquides jusqu'à la surface et la production ne sera plus économiquement viable. Pour maintenir la production, plusieurs méthodes de levage artificiel ont été appliquées, telles que le pompage et le gas lift. Le mode d'activation par gas lift représente 45 % de la production dans le champ de Hassi Messaoud, qui est l'objectif de notre travail. Cette étude est basée sur l'évaluation de l'efficacité de l'application d'Autoboost pour les puits producteurs candidats sélectionnés (HGANE 2 et HGANE 7) pour restaurer et augmenter la récupération initiale de pétrole de ces puits. La méthodologie de notre travail est basée sur la collecte de données (achèvement de puits, données de tests de puits, données PVT). Ensuite, une optimisation des paramètres de gas lift en utilisant le logiciel PIPESIM a été réalisée en créant des modèles de performance d'écoulement entrant et de performance de levage vertical pour optimiser les pertes de pression verticale. Les résultats montrent un gain de 5.3 m^3 et 4.14 m^3 pour les puits HGANE 2 et HGANE 7 respectivement. Les conclusions de ce travail peuvent aider à activer les puits hors du réseau de gas lift de manière plus économique et à fournir la récupération de pétrole souhaitée.

Mots clés : Pression du réservoir, Méthodes de levage artificiel, Gaz lift, Champ de Hassi Messaoud, Application Autoboost, Puits producteurs, Récupération initiale de pétrole, Collecte de données, Achèvement de puits, Données de tests de puits, Optimisation**,** Logiciel PIPESIM, performance d'écoulement entrant, Performance de levage vertical, Pertes de pression verticale**.**

Abstract :

After a long period of production, the reservoir pressure will not be sufficient to lift the liquids to the surface, and production will not be economically viable. To maintain production, several artificial lift methods were applied, such as pumping and gas lift. The gas lift activation mode represents 45% of production in the Hassi Messaoud field, which is the objective of our work. This study is based on the evaluation of the efficiency of Autoboost's application for the selected candidate producer wells (HGANE 2 and HGANE 7) to restore and increase initial oil recovery for these wells. The methodology of our work is based on data collection (well completion, well testing data, and PVT data). Then, an optimization of gas lift parameters using PIPESIM software was carried out by creating inflow performance relationship and vertical lift performance models to optimize vertical pressure losses. The results show a gain of 5.3 m³ and 4.14 m³ for wells HGANE 2 and HGANE 7, respectively. The findings of this work can help to activate wells outside the gas lift network more economically and achieve the desired oil recovery.

Key words: Reservoir pressure, Artificial lift methods, Gas lift, Hassi Messaoud field, Autoboost application, Producer wells, Initial oil recovery, Data collection, Well completion, Well testing data, Optimization, PIPESIM software, Inflow performance relationship, Vertical lift performance.

Chapter I : Nodal Analysis

Chapter II : General information of gas lift

Chapter III : Autoboost technology

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Abbreviation

HMD : Hassi Messaoud

GLRt : Gas Liquid Ratio

GOR : Gas-Oil Ratio

BP : Low Pressure

HP : High Pressure

TEG : Triethylene Glycol

DEG : Diethylene Glycol

SPM : Side Pocket Mandrel

COVS : Casing-Operated Valves

TOVs : Tubing-Operated Valves

IP : Inflow Performance

GLR : Gas-Liquid Ratio

HMD : Hassi Messaoud

IPR : Inflow Performance Relationship

VLP : Vertical Lift Performance

Q : Flow rate

P : Pressure

∆P : Pressure drop

Pr : Reservoir pressure

Pb : Bubble point pressure

P_{wf} **: Dynamic bottomhole pressure**

PVT : Pressure, Volume, Temperature

Fig : Figure

RPM : Rapid Production Module

BBK : Bir Berkin

LPP : Liner pre perfored

DST : Drill Stem Test

MD : Measured depth

KOP : kick off point

VS : Vertical section

TVD : Total vertical depth

RMS : Reynolds Mean Squared

General Introduction

The development of the modern economy is reflected in an ever-increasing consumption of energy. Hydrocarbons, namely crude oil and gas, are today the most widely used source of energy. Researching and exploiting natural resources are the primary requirements for a country's development.

Hydrocarbons, particularly crude oil, are currently the underground resources that contribute largely to Algeria's development and represent the most economical and attractive form of energy worldwide. **[1]**

The objective of all producing countries is to strive for maximum recovery of reserves in place by utilizing all available recovery methods. Among these methods, Artificial lifting methods or well activation techniques aim to maintain and improve production, And the most commonly used activation method in Algeria is gas lift. **[2]**

Problematics of the study

The production of hydrocarbons in Algeria faces numerous operational challenges, requiring substantial investments. The problematic lies in the considerable distance of peripheral fields from the pressurized Gas Lift network, rendering it impossible to activate candidate wells by gas lift. In our study, we focus on optimizing the production of specific wells within the Hassi-Messaoud field and answer the following questions :

What is the technology that allows the activation of wells far from the gas lift network ?

Was this technology utilizing successful technically and economically ?

What problems can this technology solve ?

Memory organization

We describe the steps taken to reach our objective in the following chapters :

- The first chapter discusses nodal analysis, including its procedure, purpose, and application, as well as the inflow performance relationship and vertical lift performance.
- Chapter Two provides an overview of gas lift, their principle, type and these applications and the parameters and problems related to the gas lift.
- The third chapter delves into the technology of AutoBoost, detailing its principles, installation procedures, process flows, applications, and discussing the potential benefits and challenges of AutoBoost.

- The fourth chapter, which discusse a Solving a gas-lift optimization problem by applying Auto-Boost technology in HMD fields using created model in pipesim.

Finally, we will conclude the manuscript with a general conclusion that will take up the main results of this work, while proposing some recommendations for improving oil production.

Chapter I

Nodal Analysis

INTRODUCTION

Nodal analysis is a method used to evaluate well performance, enabling us to identify production issues and enhance productivity.

A production well is drilled and completed to extract oil, gas, or water from the reservoir to the surface. To overcome pressure losses (such as friction) within the production system (tubing, gathering lines) during fluid extraction, energy is required. The fluids must move from the reservoir (porous medium), through the pipeline system (tubing, gathering lines), and finally into the separators.

I.1 Notion on nodal analysis

Nodal analysis is a methodology used in the petroleum production system to determine the flow rate and production pressure of fluids at a given node. It can be used to estimate flow rates, predict future production, evaluate well performance, or diagnose problems. This methodology involves combining the reservoir's capability to produce fluids from the bottom of the well with the tubing's capacity to transport the effluent to the surface.

The flow of fluids within the petroleum production system can be subdivided into four phases :

1. Flow within the porous medium.

2. Completion (stimulation, perforation, and gravel pack).

3. Flow within the vertical or deviated tubing (restriction, safety valve).

4. Surface flow within the gathering networks (nozzles, pipes, valves). **[3]**

I.2 Objectives of Nodal Analysis

The objectives of nodal analysis are :

- Determine the flow rate at which an oil or gas well will produce, taking into account the limitations of the well's geometry and completion (initially through natural depletion).
- Identify the conditions under which a well will cease to produce, which may be related to time.
- Define the appropriate time for the installation of an artificial lift mechanism and assist in the selection of the activation method.

- Optimize the system to produce at a planned flow rate.
- Verify each component in the production system (determine if it affects the production flow rate negatively or positively). **[4]**

I.3 Different Positions of the Node

To simulate the fluid flow in the system, it is necessary to divide the system into distinct nodes that separate the elements of the system (equipment sections). These nodes are placed in parts that are defined by different equations or correlations.

Fig I.1 shows the different locations of the node :

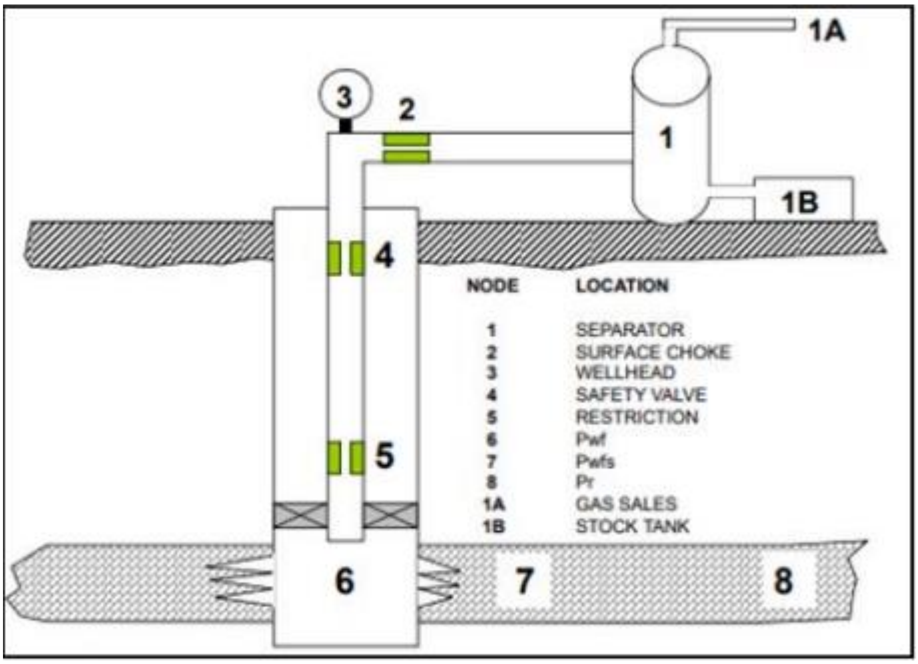


Fig I.1: Different Positions of the Nodes [5]

- Node 1 (Separator) : Placing the node at the separator allows for the study of the effect of separator pressure on well performance.
- Node 2 (Choke) : Positioning the node at the choke helps to analyze its impact on well performance and control the production rate.
- Node 3 (Wellhead) : Choosing the node at the wellhead enables the examination of the effect of the gathering line diameter on well performance.

- Node 6 (Bottomhole) : Placing the node at the bottom of the well allows for the study of the impact of the Inflow Performance Relationship (IPR) and tubing diameter on well performance.
- Node 7 (Perforations) : Positioning the node at the perforations enables the analysis of the effect of perforation density on well performance.
- Node 8 (Reservoir) : Placing the node in the reservoir allows for understanding the impact of reservoir depletion on well performance. **[6]**

I.4 Nodal Analysis Procedure

The procedure involves selecting a node in the well and dividing the system at that node. All components upstream of the node make up the Inflow section, while the Outflow section comprises all elements downstream of the node.

The procedure is as follows :

- Select the components to optimize.
- Choose the location of the node.
- Develop expressions for the inflow and outflow.
- Obtain the necessary data for constructing the Inflow Performance Relationship (IPR) and Vertical Lift Performance (VLP).
- Determine the effect of changing the characteristics of the selected components by plotting the inflow or outflow.

The behavior of each component in the system is directly related to the flow rates and pressure losses. The flow rate throughout the system can be determined once the following conditions are met :

1. The flow entering the node equals the flow exiting the node.

2. There can be only one pressure at a node.

Once the node is selected, the pressure at this node is determined by :

Inflow Equation :

$$P_r - \Delta P_{res} = P_{wf} \qquad \textbf{(I.1)}$$

Outflow Equation :

$$P_{sep} + \Delta P_{tbg} + \Delta P_{pipe} = P_w \qquad \textbf{(I.2)}$$

The pressure drop in any component varies with the flow rate Q. A representation of pressure versus flow rate produces two curves, and their intersection will provide a point that satisfies the two conditions mentioned above ; this is the operating point of the system. **[4]**

I.5 The Vogel Method

The main objective of VOGEL was to simulate two-phase flow through a reservoir into a well. Two-phase flow occurs when the reservoir pressure is lower than the bubble point pressure (Pr<Pb). VOGEL established an empirical relationship to characterize this type of flow.

$$\frac{Q_0}{Q_0\,(max)} = 1 - 0.2\left(\frac{P_{wf}}{P_r}\right) - 0.8\left(\frac{P_{wf}}{P_r}\right)^2 \qquad \textbf{(I.3)}$$

Q_0: Input rate corresponding to P_{wf}.

Q_0 (max):Maximum inflow rate, corresponding to zero dynamic pressure ($P_{wf} = 0$).

P_{wf}:Dynamic bottom hole pressure.

P_r:Approximate reservoir pressure.

I.6 Inflow Performance Relationship (IPR)

Constructing the IPR curve is crucial in production. This curve represents the ability of a well to produce fluid from the reservoir to the bottom of the well (the case of the bottomhole node). **[5]**

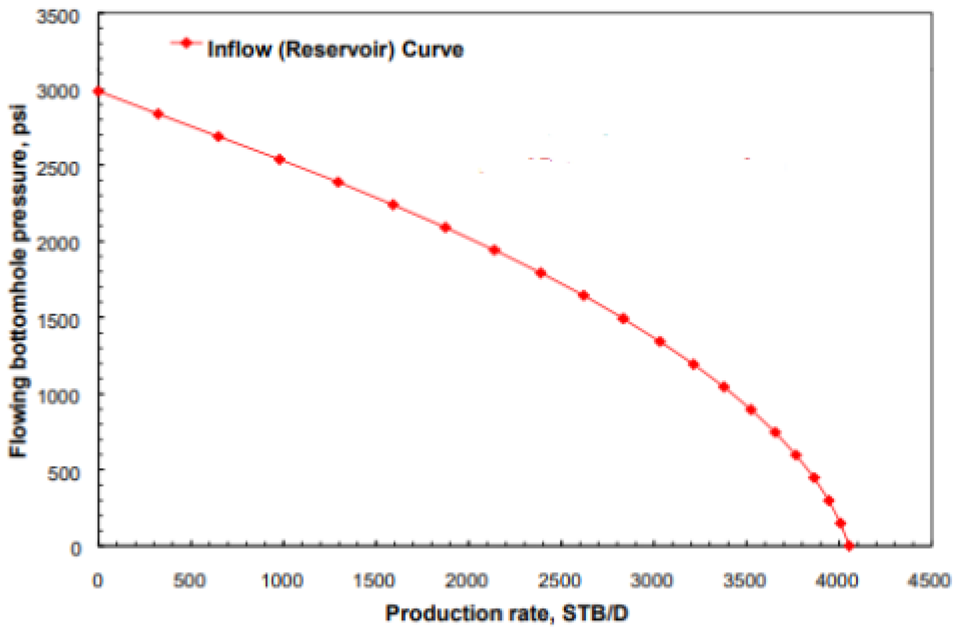


Fig I.2: Inflow Performance Relationship (IPR) Curve [5]

The parameters that affect the IPR curve are as follows :

- Petrophysical properties.
- PVT properties.
- Reservoir pressure.
- Well geometry.
- Dynamic bottomhole pressure. **[7]**

I.7 The operating point of a well

The flow from the reservoir to the well depends on the pressure gradient between the reservoir and the bottom of the well Pr-Pwf (drawdown), which is graphically represented by the IPR curve. While the IPR represents what the reservoir can deliver to the bottom of the well, the VLP (Vertical Lift Performance Relationship) represents what the well can deliver to the surface. **[6]**

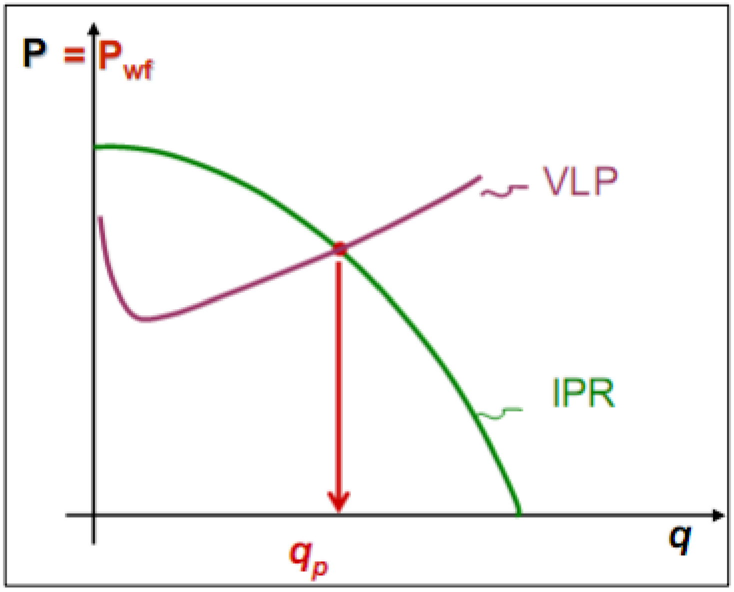


Fig I.3: IPR and VLP in a production system [6]

I.8 Vertical Lift Performance (VLP)

The VLP curve depicts the installation's capacity and its influence on flow based on the generated pressure losses. It is plotted using dynamically calculated bottomhole pressures through correlations that provide vertical pressure losses based on various flow rates. **[6]**

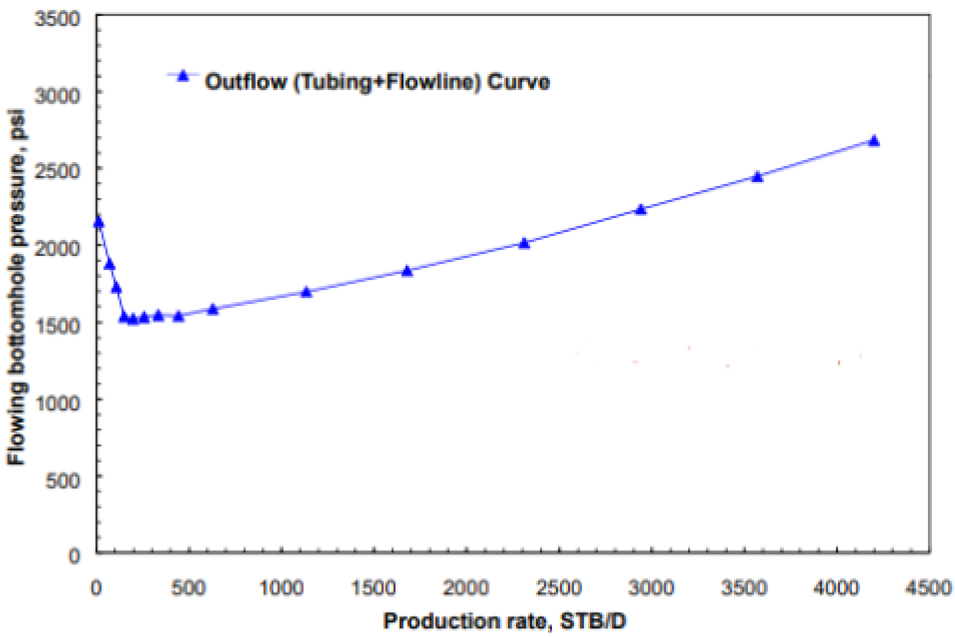


Fig I.4: Vertical Lift Performance (VLP) Curve [5]

The intersection of the IPR with the VLP yields the operating point.

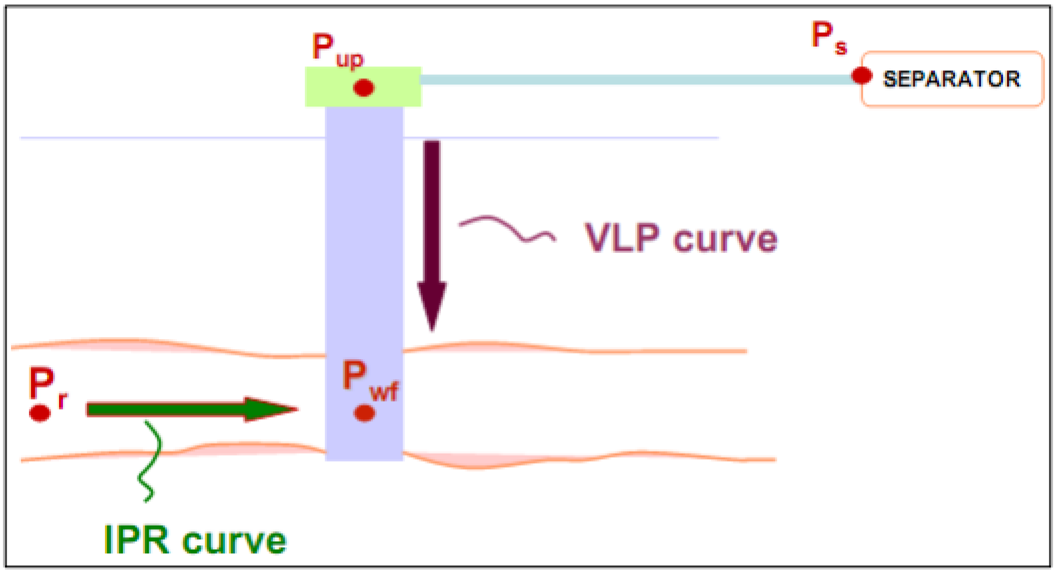


Fig I.5: IPR and VLP in a production system [4]

Chapter II

General information of gas lift

Introduction

This chapter provides general information about the gas lift, especially the way it works as well as its impact on the production of oil. On the other hand, the different types of gas lift will be reviewed, mainly the different completion which has an effective role in affecting the gas lift, In addition its important application and the main gas lift parameter. Finally, the most problems facing gas lift in HMD.

II-1 Definition and Principle of gas lift

This is the most widely used activation method worldwide. It is an artificial lift system where gas is injected into a produced well casing to help lift liquids up to the surface through the production tubing. Gas lift uses high-pressure compressed air as an external source of energy. The principle of gas lifting is to inject gas as deeply as possible to lighten the column of fluid contained in the tubing. This is similar to adding power at the bottom of the hole to help the reservoir produce the effluent it contains, up to the separator.

The amount of gas to be injected must not exceed a limit beyond which its effectiveness decreases. We speak of optimum GLRt (GLRt = Gas Liquid Ratio). The optimum GLRt is the ratio between the volume of gas (injected + produced) and the liquid produced when the well reaches its maximum production. **[8]**

II-2 Types of gas lift

There are several parameters to classify gas lift. We can cite:

II-2-1 Depending on the injection mode

II-2-1-1 Continuos Gas lift

This is a method that enhances the natural process of oil production by associated gas (free or dissolved in the reservoir) through gas injection into the tubing or annulur. The injection point and injection flow rate are determined to alleviate the load. The effluent column must be wide enough to achieve a sufficiently low bottom hole pressure according to the desired flow rate. Continuous gas lift can be adapted to a wide range of production conditions in gas wells, including high angle wells, wells with high gas-oil ratio, and wells with sand, wax, or scale. However, it is not suitable for heavy oil or emulsion wells. (Fig II.1) **[9]**

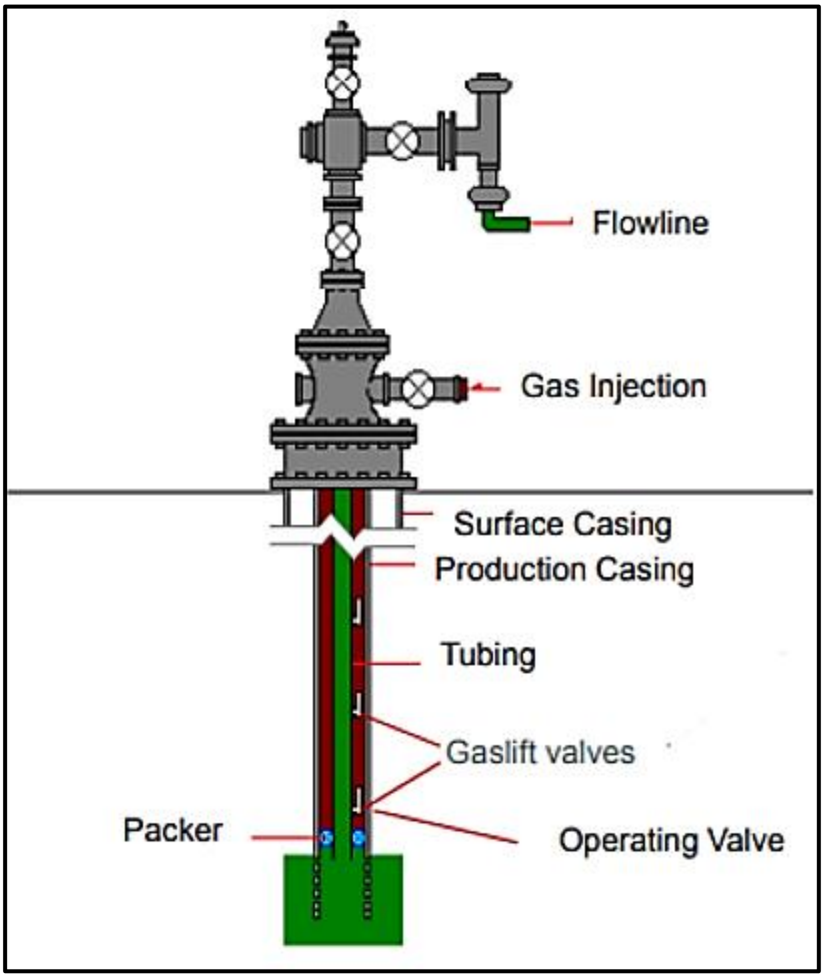


Fig II.1: Principle of continuous gas lift [2]

II-2-1-2 Intermittent Gas lift

This technique Fig (II.2), although rarely used, finds its application for very low flows, especially when it is necessary to maintain very low pressure at the bottom of wells. In this method, high-pressure gas is injected from the surface into the tubing through a motorized valve (starter). The gas is then utilized to lift the oil to the separator. The injection process occurs intermittently, with two periods utilized: a production period and a shutdown period. During the production period, when oil is being produced, the gas flows from the compressor to the gas pipeline and then enters the tubing via the starter. The high-pressure gas opens the gas lift valve and enters the tubing to propel the oil upward. **[9]**

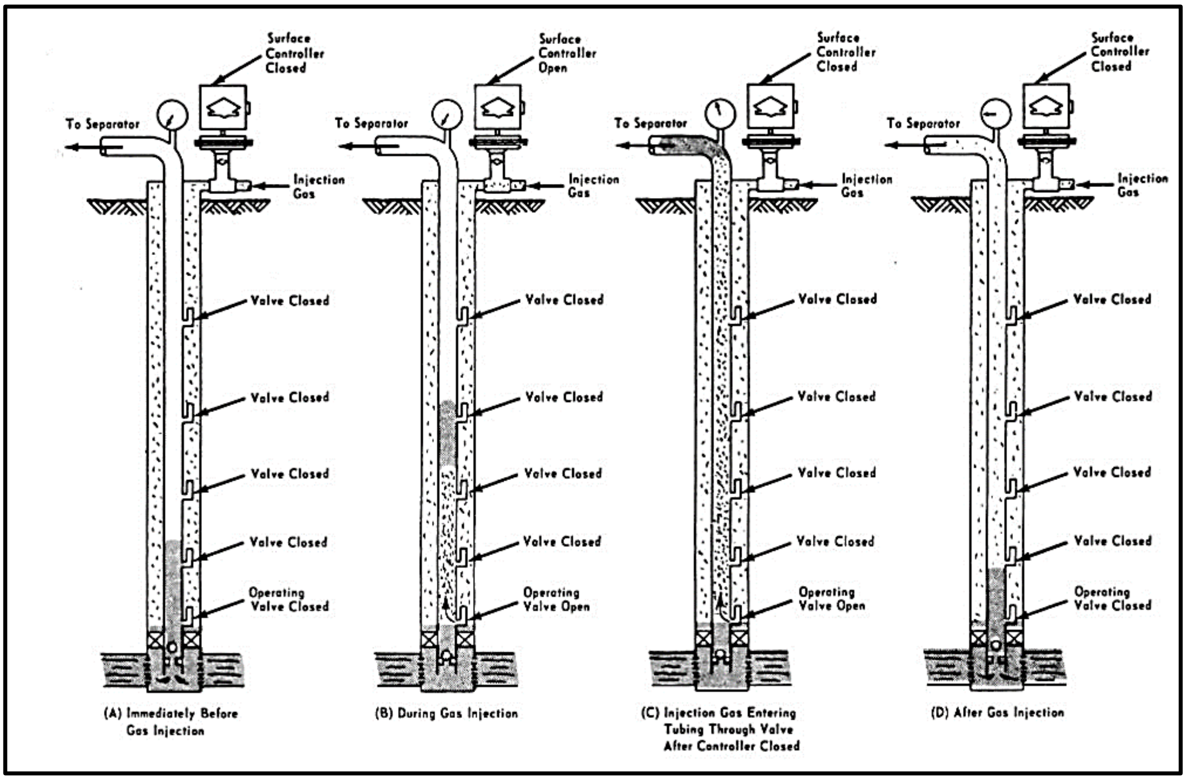


Fig II.2: Principle of intermittent gas lift [9]

II-2-2 according to the injection circuit

The gas used either comes from the gas-oil ratio (GOR) of the oil reservoir in question or from gas wells available in the vicinity. These injection circuits are distinguished by:

II-2-2-1 Closed circuit

The gas lift process reuses the produced gas recovered from the separators. After undergoing treatment phases, this gas is compressed and reinjected back into the production wells. **[10]**

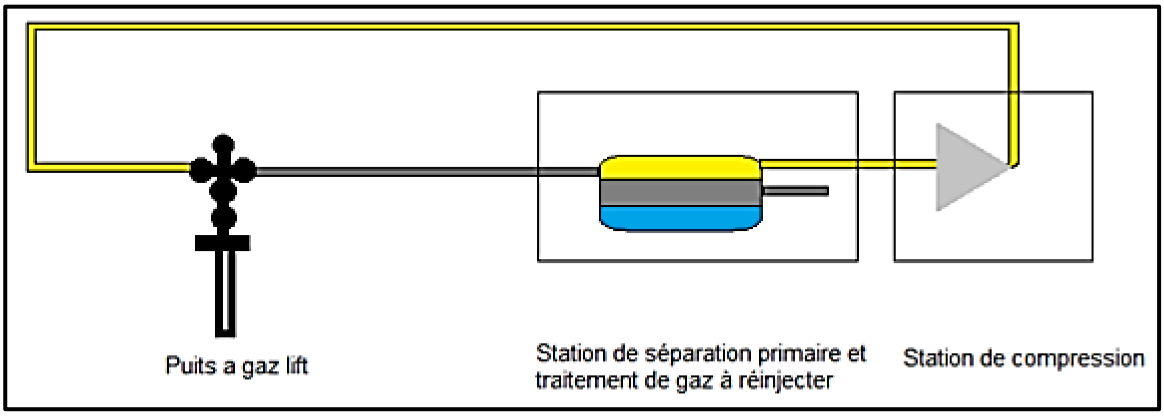


Fig II.3: Closed-circuit gas-lift [10]

II-2-2-2 Open circuit

Treated gas from a gas reservoir is used in the gas lift process. Once used, this gas is burned to the torch or sold.

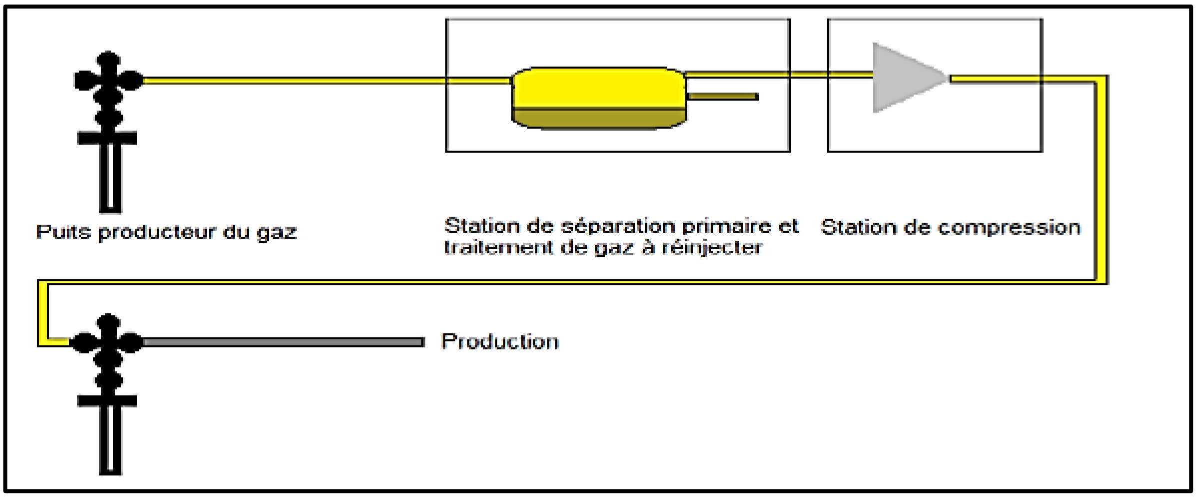


Fig II.4: Open-circuit gas-lift [10]

II-2-2-3 Auto gas lift

This type of gas lift represents a very special case, since the reservoir oil is lifted through the gas produced from a gas reservoir located above and penetrating into the production column by perforation and injection device between two packers. **[10]**

II-3 Different completion of gas lift

The gas lift can be used as a simple completion or as a multiple completion and the production of wells can be direct or inverse.

II-3-1 Completion for direct gas lift

In this case the injection of gas is done by the annular, and the production by the Tubing, it is the most usable and the most widespread mode, because it allows to make a better optimization and handling of equipment, as well as intervention operations.

II-3-1-1 SPM completion

Are a common and versatile method for enhancing oil and gas production in wells that have experienced a decline in natural flow.

Gas injection is carried out in the annular tubing-casing and through SPM valves and the production is done through the tube. SPMs provide a reliable and flexible way to inject gas into the tubing at specific depths, lifting fluids to the surface more efficiently.

SPM dump valves and orifice are typically operated using cable systems for tubing with a nominal diameter of 2"7/8 and larger. **(**Fig II.5) **[8]**

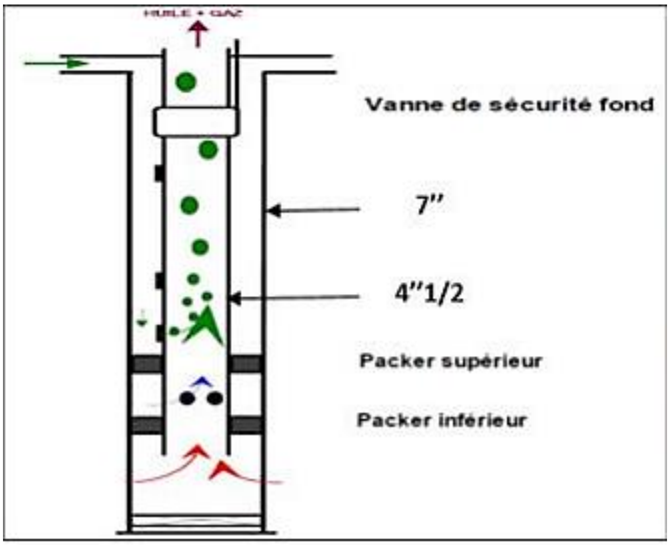


Fig II.5: SPM completion [6]

II-3-1-2 A 2"7/8 String completion

In this completion, a 2"7/8 string is inside a 4"1/2 tubing. Gas is injected into the annular space between the 4"1/2 tubing and the 2"7/8 string, while oil is produced from the inside of the 2"7/8 string. (fig II.6) **[8]**

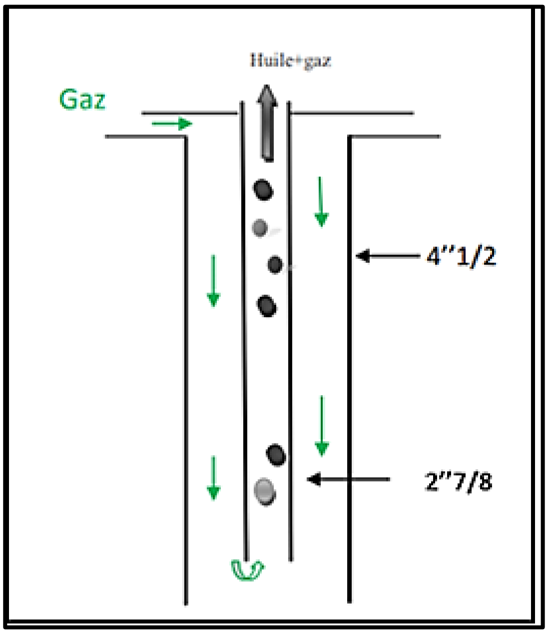


Fig II.6: A 2"7/8 String completion [8]

II-3-1-3 A 2"7/8 string completion with desalination

Combining gas lift and water injection in the same annular space between the 4"1/2 tubing and the 2"7/8 string is an innovative approach that can enhance oil and gas production while simultaneously treating produced water through desalination. **[8]**

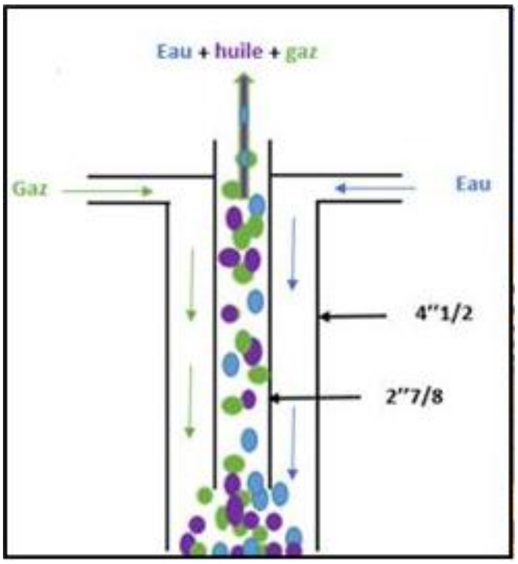


Fig II.7: A 2"7/8 String completion with desalination [8]

II-3-2 Completion for reverse gas lift

II-3-2-1 Concentric tubing string

In the well, the gas is injected into a small concentric tube called "macaroni", is generally descended with a snubbing unit. This type of profile is very common because it helps to avoid a heavy workover in wells where the gas lift was not planned at the end of the drilling, this solution is usually used. The placement of a concentric tube is a Simple and affordable method to activate the well.
The most commonly used macaroni in Algeria is 1.660 ″ and 1.9 ″ .**[8]**

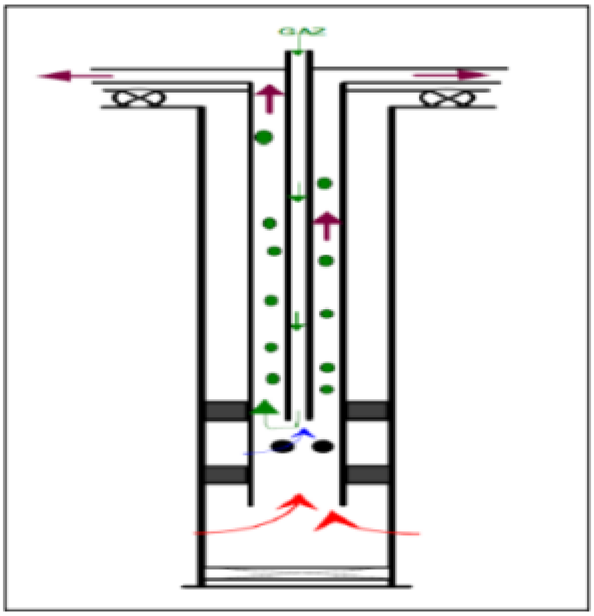


Fig II.8: Completion of Concentric Tubing [8]

II-3-2-2 Gas lift with production in the casing

It is possible to create wells for very high flows where the reservoir production is injected directly into the casing with gas injection into the tubing. This process has some imperfections:

- It requires a considerable amount of gas.
- Measurements cannot be carried out on the side of the effluents.
- In addition to the risk of corrosion of the casing and its integrity, the well is poorly designed for the intermittent gas lift.
- The design and devices are unique.

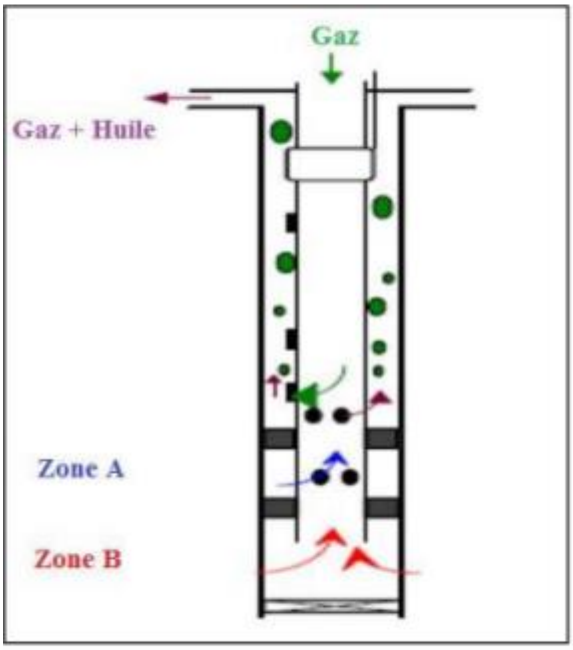


Fig II.9: Gas lift with production in the casing [8]

II-3-2-3 Dual gas lift

The design of gas lift systems for dual string completions has proven to be challenging. The total gas injection rate for both strings is measured at the surface, but accurately allocating the gas flow between each tubing string is difficult. This may result in one string receiving too much gas while the other is starved, a phenomenon known as gas robbing. Excessive or inadequate gas injection can lead to reduced well fluid production and flow instability. Therefore, it is essential to inject gas at the optimal level in each string to ensure efficient operation of the gas lift system.

Among the problems of dual completion, let us emphasize:

- Annular sub-surface safety valves are extremely complex
- The excessive load of pockets. Output from a single tube is generally impossible because the mandarin cannot overlap when the tubing is raised in the first pass.

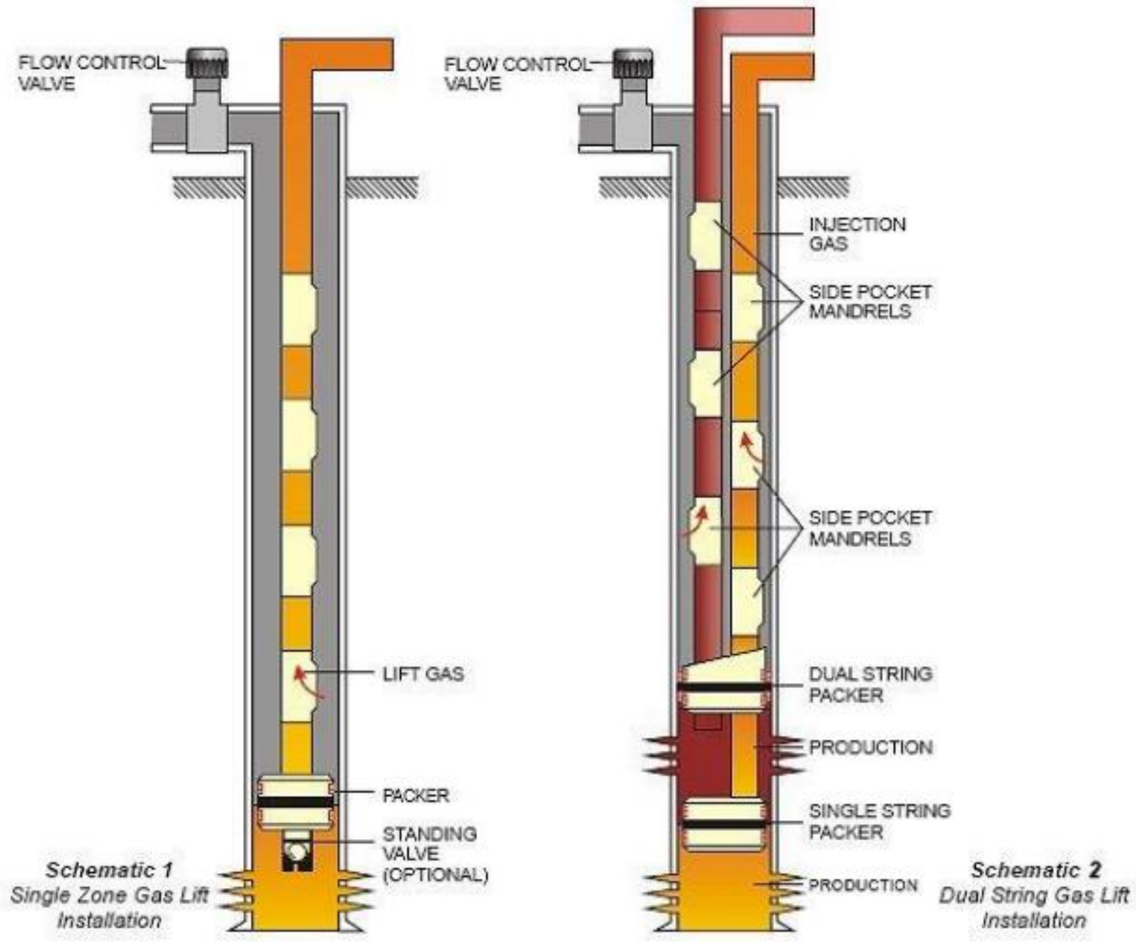


Fig II.10: Simple and dual gas lift [12]

II-3-2-4 Parallel gas lift

This mode of production has the same disadvantages as the dual gas lift in terms of the implementation of the completion.

The gas is injected into a tube while the second receives the production of the tank, this type of completion is used when the available gas is not allowed to come into contact with the case.

The parallel gas lift is often found in old wells that were initially used as multiple complement, then converted when one of the tubing has lost its use.

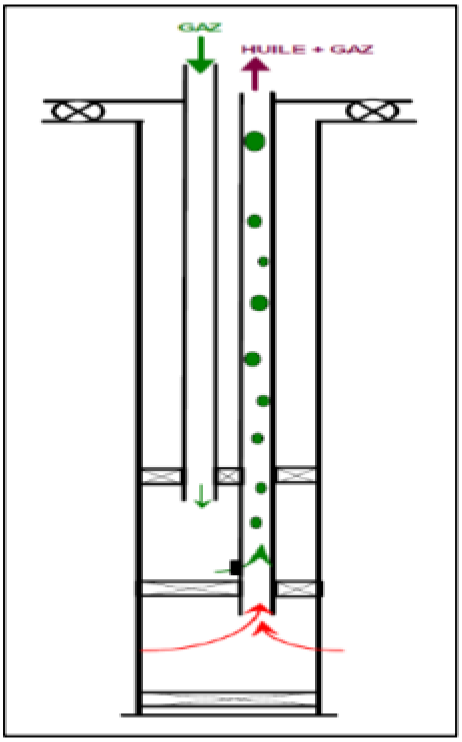


Fig II.11: parallel gas lift [8]

II -4 Gas lift applications

II -4-1 Water wells

These wells produce aquifers for various uses such as re-injection in an oil reservoir or domestic use. Gas-lift can also be used to produce seawater. There is no difference between a gas-lift design for oil wells and for water.

Thin wells often use air rather than gas (air lift).

II-4-2 Oil wells

The main objective of the use of gas lift in these wells is to increase the productivity of the fields used. It is increasingly used in non-eruptive wells and even in new wells.

II-4-3 Increased flow

For wells suffering from a pressure decline but still able to produce without activation, and which are characterized by a naturally lower GOR or GLR relative to average, the gas-lift will increase their production relative to natural production.

II.4.4. Starting wells

A well, even eruptive, is not always able to restart after neutralization. It must then be put into operation so that it can regain its eruptivity. If this well was first equipped with mandrels, it will be possible to restart it thanks to high pressure gas.

II-4-5 Injector clean up

Injector wells should be cleaned periodically to remove particles that obstruct perforations or formation.

Gas-lift is a method commonly used to perform this cleaning. It consists of injecting gas into the well, which relieves the fluid and brings it back to the surface, taking the unwanted particles with it.

If gas-lift cleaning is not sufficient, acid cleaning may be necessary. The acid dissolves mineral deposits and other obstruction that may have accumulated in the well.

II -5 Main gas lift parameters

II -5-1 Wellhead pressure

And the lower the wellhead pressure, the more effective the gas lift is. Each time the wellhead pressure is high, more gas must be injected to overcome the pressure losses and the wellhead pressure. This is why the wellhead pressure is very important, it directly influences two essential parameters of the gas lift, which are the injection pressure and the injection rate. **[2]**

II-5-2 Gas injection pressure

Discharge valves are influenced by the gas pressure to be injected, which means that a high-pressure injection can operate without discharge (single point) valves, which greatly simplifies the design, operation and maintenance of wells.

When the available pressure is low, it is extremely beneficial to be able to increase it for a few hours from 10 to 15 bars in order to kick of the well, it is also crucial to determine whether the current gas pressure will not decrease. temporarily, making it impossible to restart a well. **[2]**

II-5-3 Depth of gas injection

The deeper the injection point, the more effective the gas lift is. The determination of this point is made based on calculations of the fluid pressure gradient in the flowing well.

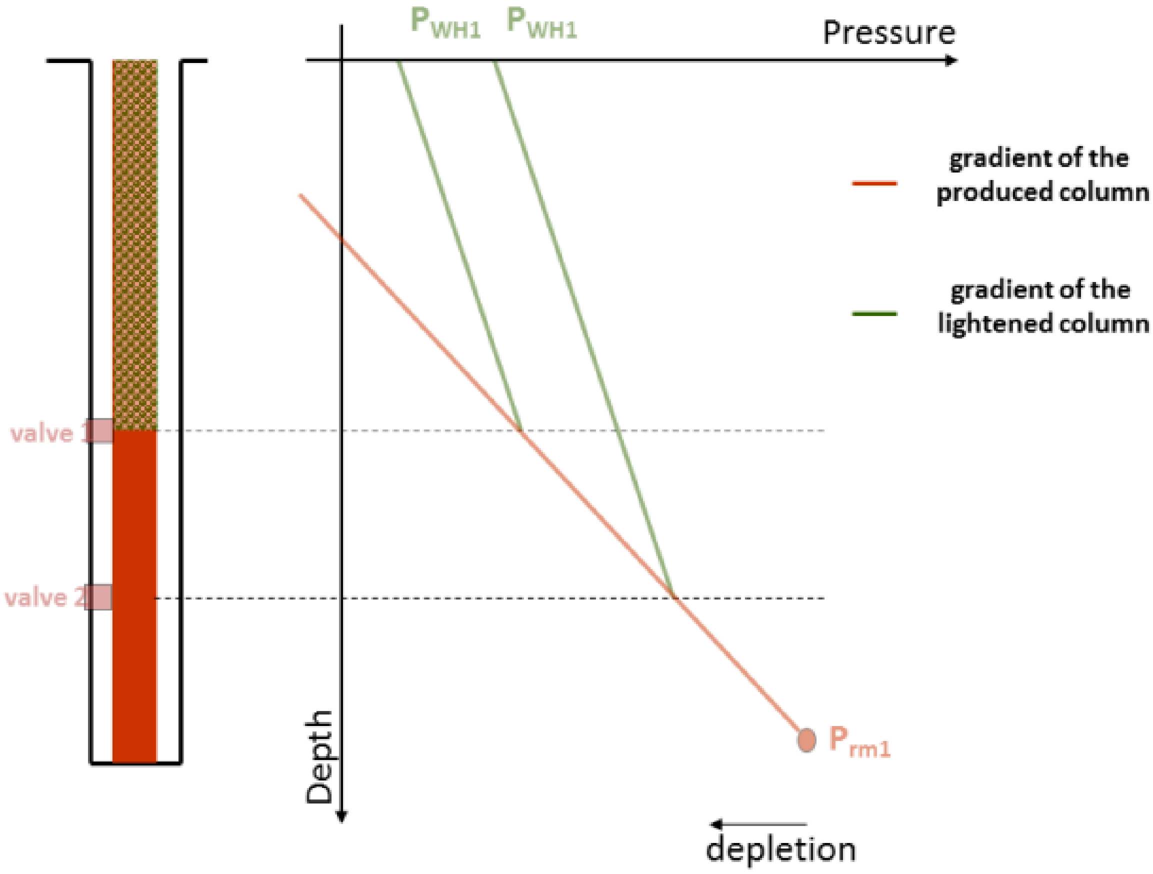


Fig II.12: The depth of gas injection [2]

II-6 Gas lift equipment

The purpose of the gas lift equipment is to allow the circulation of surface gas to the Tubing, in order to reduce it and allow the effluent to rise to the surface. It is necessary to have equipment both on the surface and on the bottom. On the surface, for example, if the pressure is inadequate. The injected gas must be compressed using a compressor.

In practice, it is necessary to have holes for gas injection, these holes are known as valves. The bottom and surface equipment are presented in (table II.1). **[2]**

Table II.1: Gas-lift equipment

<table>
<tr><th>Placement</th><th>Equipment</th></tr>
<tr><td>Surface</td><td>Compression equipment: compress the gas coming from the separation station before it is sent to the well for injection.

distribution network BP: In this network, the gas is transported in the low-pressure direction, starting from the head of the well to the separation station, then to the storage for oil and the gas compression and dehydration station.

Distribution network HP: It is a collection of the various pipelines that transport the high-pressure gas to the wells that are connected to its network.

Measurement and control equipment:
• Chocks for Manual gas flow adjustment
• Pressure measuring equipment (manometers)
• Temperature measuring equipment (thermometers)
• Flow measuring equipment (Daniel hole and Barton indicator)

Dehydration equipment: In order to remove the water from the coning from the gas, as this leads to the formation of hydrates. Dehydration is carried out using agents commonly called TEG (triethylene glycol) and DEG (diethylen glycol).
Controller Inter: suitable for intermittent gas-lift, it is for adjusting the periodicity and duration of injection</td></tr>
<tr><td></td><td>Mandrels: it's an architecture placed in the tube to allow the gas injection valve to be carried without affecting the diameter of the tube. There are three types: conventional mandrel, side pocket mandrel (SPM), and concentrated valve.</td></tr>
</table>

Bottom	**Check valve:** to prevent the fluid from returning to the formation, it is placed in the base of the tubing Tubing spool: equipped at its base with an insulating joint ensures that the pressure ring cannot create any danger to the last casing. **annular safety:** especially offshore wells. It ensures the safety of the ring where the volume of gas is large. **injection valves:** are the most important elements, its role and the injection of the gas from the ring to the tubing. Depending on the pressure sensitivity of the tubing or casing, the valves divide into two types, Casing-operated valves (COVS) and the Tubing-operated valves (TOVs)

II-7 Advantages and disadvantages of the gas lift

II-7-1 Advantages

- Well, suited to wells has a good IP and relatively high bottom pressure.
- Applicable for wells with a relatively high GLR.
- Best artificial lift mechanism, can handle sand and solid materials.
- Central gas lifting system can be used to service many wells.
- Installation of gas lift is compatible with subsurface safety valves and other surface equipment.
- Gas lift is flexible, the gas lift can be used in wide range of volume and depth.
- Adaptation to deviated wells: current reliability of gas lift equipment on wells with a deviation reaching 50°.
- Well, suited for medium or high flow rates.
- Thanks to the gas lift, large volumes of fluid can be produced: loading losses are the only limit to this production.
- Possibility of injecting an additive (corrosion inhibitor for example) at the same time than gas.
- Allows to start the well.

- It is possible to control the well remotely by telemetry.

II-7-2- Disadvantages

- Quite low yield in deep wells.
- If the gas is corrosive, it must be either treated or special steel supplements set up. What increases the cost of the investment
- Gas lift is relatively inefficient
- Relatively high backpressure may seriously restrict production in the continuous gas lift.
- High difficulty because of low gravity and friction.
- Foaming problems can be increased.
- The continuous gas lift works badly when the pressure of the outflow tank becomes very low. In such conditions, intermittent gas lifting can improve well performance.
- The gas lift is very sensitive to the pressure in the head of the well and can become very poorly performing when the counter pressure is high.
- Volumes of gases that may be excessive for wells with a high percentage of water.
- Its effectiveness is sometimes low compared to that of other activation techniques.**[6]**

II-8 Most problems related to HMD gas lift

II-8-1 Formation of hydrates

The pressure drops when gas passes through constrictions (such as chokes or valves) leads to a decrease in temperature, which can bring the system to conditions where water (gasoline) crystallization occurs. This formation of hydrates is due to the presence of water droplets in the gas. **[13]**

II-8-2 Formation of frost

The passage of gas through the gas lift valve at the wellhead causes a decrease in pressure in the pipeline (0.4 to 0.50c/bars), and this decrease is accompanied by a decrease in temperature. The presence of water in the pipeline promotes this phenomenon, which is due to poor gas treatment and also in cases where there is water injection. The formation of frost obstructs the passage of gas, resulting in well shutdown. **[13]**

II-8-3 Equipment erosion

Erosion is an undesirable phenomenon caused by the physical action of gas molecules against the walls of the flow medium. When the gas velocity is high, these actions become very active. Friction forces and impacts cause metallurgical variations in the equipment, as well as enlargement of the inner diameter of the chock used for flow regulation. Gas molecules erode the chock inner walls, and the injected gas flow rate increases with the enlargement of the passage diameter. **[13]**

Chapter III

Autoboost technology

Introduction

This chapter presents a comprehensive overview of the autoboost technology. We will review the principal of work of autoboost, the related equipment and their importance in this technology. Furthermore, the installation and process flow of it will be treated as well as its application. Finally, the different advantages and challenges of autoboost will be studied for practical purposes.

III-1 Definition and principle of Autoboost technology

To understand the concept, consider a production system with a bottomhole pressure equal to or less than the pressure of the production line, indicating no flow from the well. In such cases, an AutoBoost system is installed to circulate fluid from the well to the AutoBoost unit at a low input pressure. Subsequently, the fluid is pressurized to be injected into the production line to overcome downstream counterpressure. While this process resembles a multiphase overpressure system or multiphase pumps, AutoBoost operates differently. The fluids are separated within the system, and the gas is re-injected into the high-pressure well using gas lift technology to enhance production. This defines AutoBoost as a surface overpressure system with gas lift capability, serving as a well assistance technology utilizing its own produced gas. Essentially, the system re-injects/circulates the produced gas to improve oil production and uses it as fuel gas, making it self-fueled without external energy requirements. Moreover, the system incorporates an integrated real-time monitoring and optimization system for injection and production parameters. This provides an overview of the AutoBoost system (Fig. III.1). **[14]**

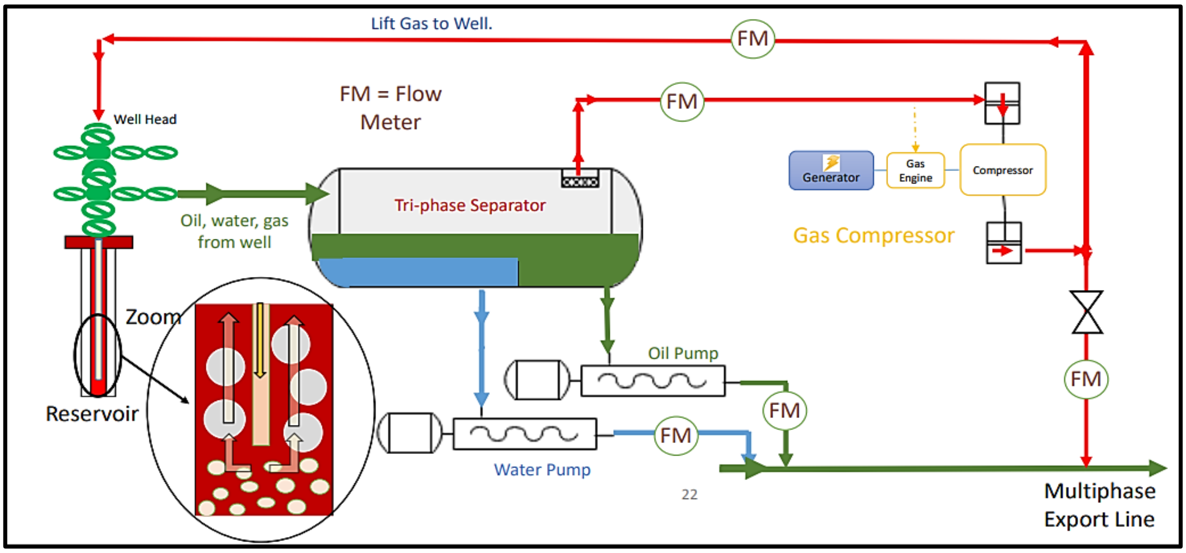


Fig III.1: Autoboost Principle

III-2 Auto-Boost Unit Surface Equipment

On the surface side, it includes two skids. The first skid is dedicated to the separation section and includes a separator and transfer pumps similar to conventional mobile well test units. The second skid is dedicated to compression and uses an alternative compressor with a gas engine. There is also a small skid for the subsequent processing of the fuel gas. In addition, there is an integrated electric generator to power all utilities of the set and make it fully autonomous.

Auto Boost Unit Surface Equipment:

Rapid Production Module (RPM):

Separation and pumping section

3 phases separator.

Oil/water transfer pumps.

WECO interconnection pipes.

Compression module:

Gas Overpressure Section.

Fuel gas skid.

Alternate compressor with gas engine.

Générateur électrique intégré.

.

III-3 Installation and process flow of Auto Boost

Auto Boost is an installation and a flow of processes designed to improve oil production in wells using surface overpressure and gas-lift techniques. Here is an overview of the Auto Boost installation and its process flow:

III-3-1 Well connection

The Auto Boost system is connected to the well head, allowing it to interact with the production system.

III-3-2 Separation section

The first component of the installation is the separation section (Fig III.2). It includes a separator and transfer pumps. The fluid from the well is directed to the separator, where it undergoes a separation in its different phases (oil, water and gas). Separated liquid components are then transferred to the production line for additional treatment and measurement.

Fig III.2: Separation section (11 May 2024)

III-3-3 Compression section

The next component is the compression section (Fig III.3). Here, the gas phase from the separator is diverted toward the compression skid includes a compressor and scrubber. An alternative compressor, driven by a gas engine, is used to over press the gas at a high pressure. This high-pressure gas is then re-injected into the well as a gas-lift which helps to improve the well's output.

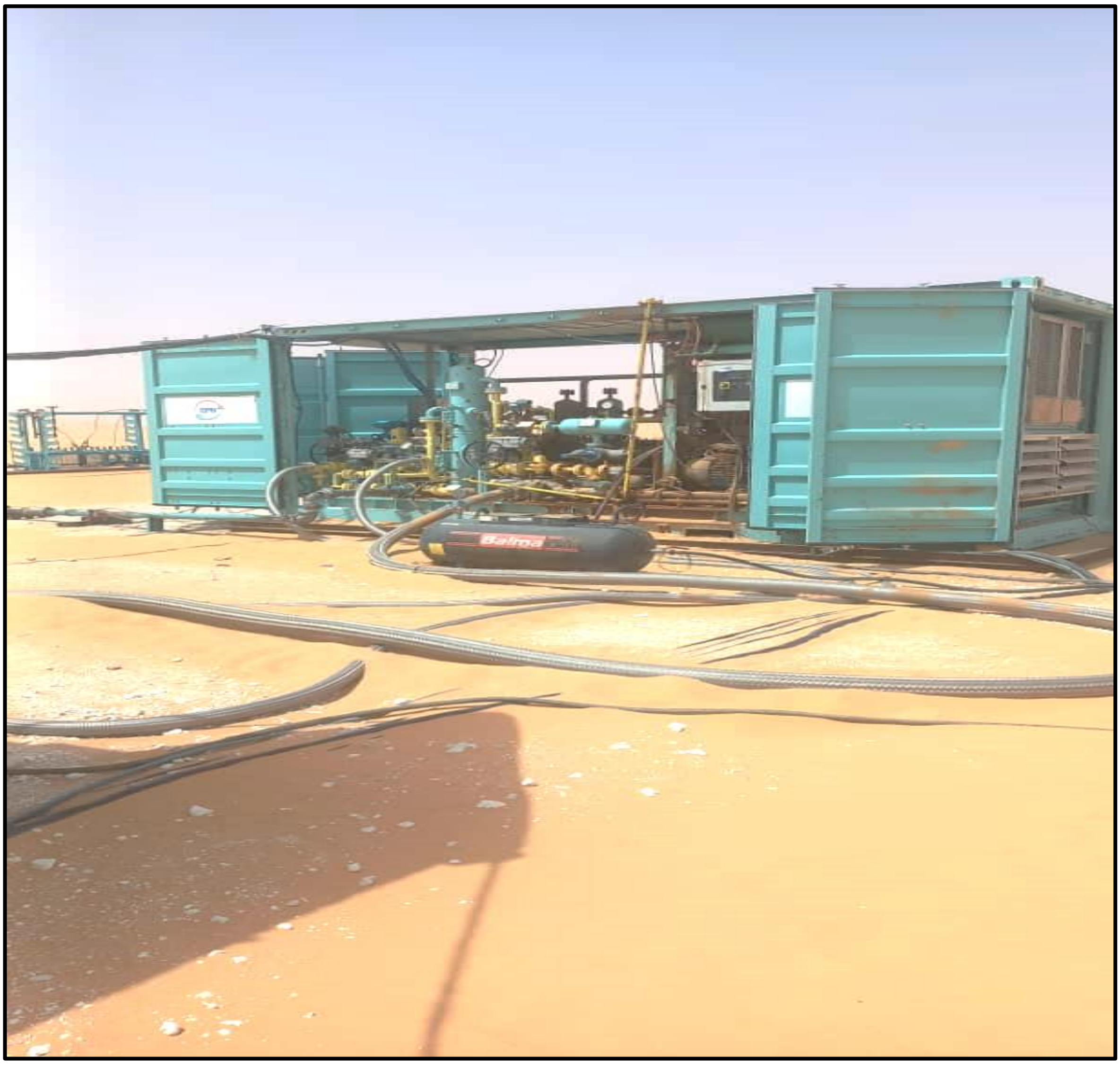


Fig III.3: Compression section (11 May 2024)

III-3-3-1 scrubber

scrubber (Fig III.4) is a dispositive used to remove impurities from the gas stream. Specifically, a scrubber in this setting typically serves to separate and remove liquid droplets, solid particles, and other contaminants from the gas before it enters the compressor. This is important to prevent damage to the compressor and ensure efficient operation. The scrubber helps maintain the quality of the gas being processed by eliminating these impurities, thereby protecting the equipment and improving the overall performance of the gas lift system.

Fig III.4: Scrubber (11 May 2024)

III-3-4 Gas recycling

The gas injected into the well returns to the separator, which completes a closed loop cycle. This recycling process allows the accumulation of gases in the system over time, ensuring that there is enough gas available for the optimization of the gas-lift.

III-3-5 Manifold

A manifold (Fig III.5) is a pipe or chamber with multiple openings, used to collect or distribute fluids or gases. In a gas lift autoboost system, the manifold distributes the compressed gas to different wells. It ensures that the gas is directed to the appropriate locations for efficient lifting of the fluids from the wells. The maximum limit for gas lift distribution to neighboring wells in this process is three wells.

Fig III.5: Manifold (11 May 2024)

III-3-5-1 Auto Valve

An auto valve (fig III.6), or automatic valve, is a valve that can operate automatically based on certain conditions, such as pressure, flow rate, or time. In the auto boost system, the auto valve is used to regulate the flow of gas within the manifold. It automatically opens or closes to control the gas injection into the wells, optimizing the gas lift process and maintaining the desired pressure and flow rates for efficient production.

Fig III.6: auto valve (11 May 2024)

III-3-6 Real-time Control and Optimization

The AutoBoost system is equipped with a real-time control system that continuously monitors and optimizes injection and production parameters. This allows quick adjustments in response to changing conditions, ensuring efficient system operation.

By combining surface overpressure and gas lifting techniques, AutoBoost maximizes well oil production, using recycled gas and real-time optimization for improved efficiency.

III-3-7 Tank

The tank (Fig. III.7) provides temporary storage for various fluids such as crude oil, water, and gas that are produced from the wells. In an AutoBoost system, it is a crucial component that supports storage, separation, measurement, conditioning, and safety management of the produced fluids, thereby enhancing the overall efficiency and effectiveness of the oil recovery process. If the pipe pressure condition is greater than what the transfer pump can provide, we change the production line to the tank instead of, as we did previously, to a manifold until the problem is solved. **[14]**

Fig III.7: Tank (11 May 2024)

III-4 Auto Boost Applications

Most low-energy wells are candidates for the Auto Boost system, and it is mainly used to improve the production of low-pressure well bottom wells as an artificial lifting solution. It can also be used to evaluate and validate a gas-lift project by conducting practical tests to confirm the project's added value before making a decision.
If the decision has already been taken, we know that the construction phase of a gas-lift project takes at least 2 years. During this period, we can use Auto Boost to obtain early production and income before the final installation is put into operation.
In terms of configuration, we have an individual installation by well, which was also the original idea, specially designed for remote wells.

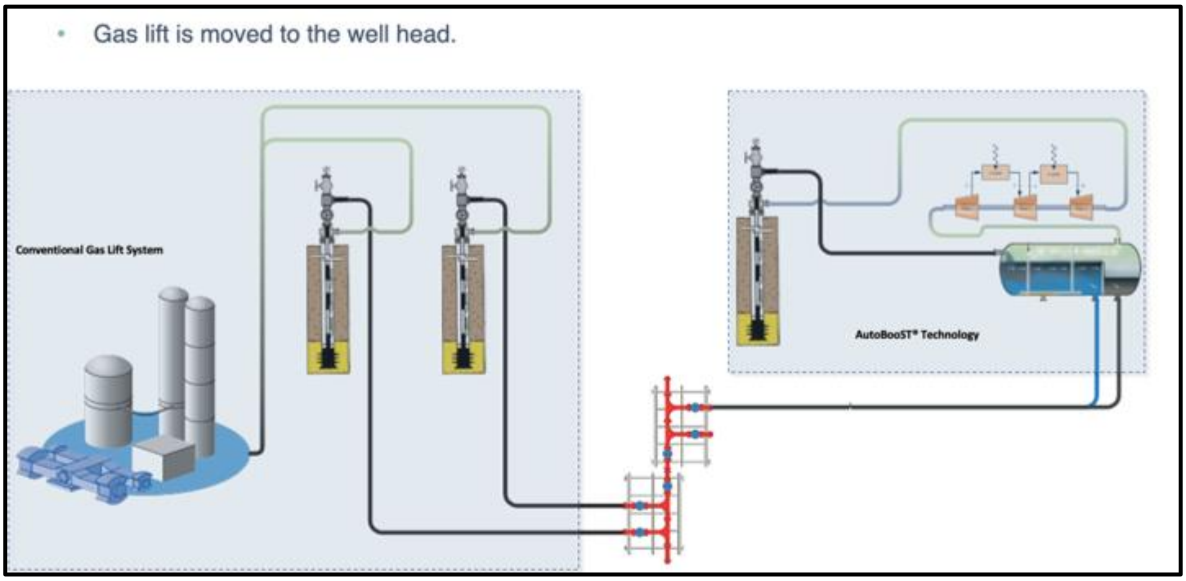


Fig III.8: Single well Boosting [14]

We have a multi-wells application with a source of gas from a high-energy well, which also feeds low energy wells. (fig III.9)

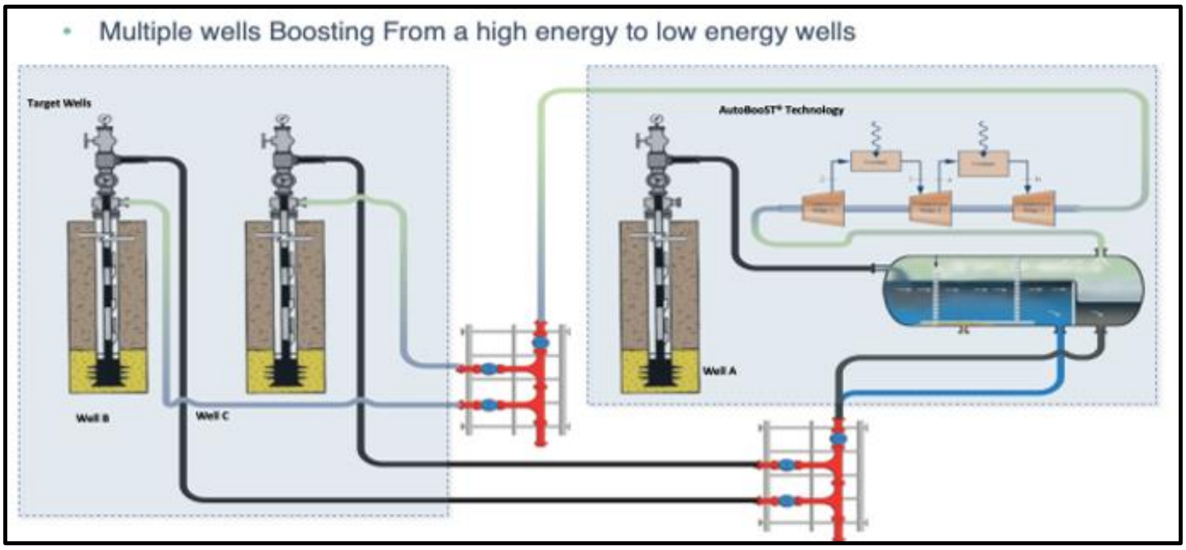


Fig III.9: Multiple wells Boosting a high energy to low energy wells [14]

We take the gas from a collector and drive it to the target wells. We have a few other possible configurations and we can design a project based on the objectives. (Fig III.10)

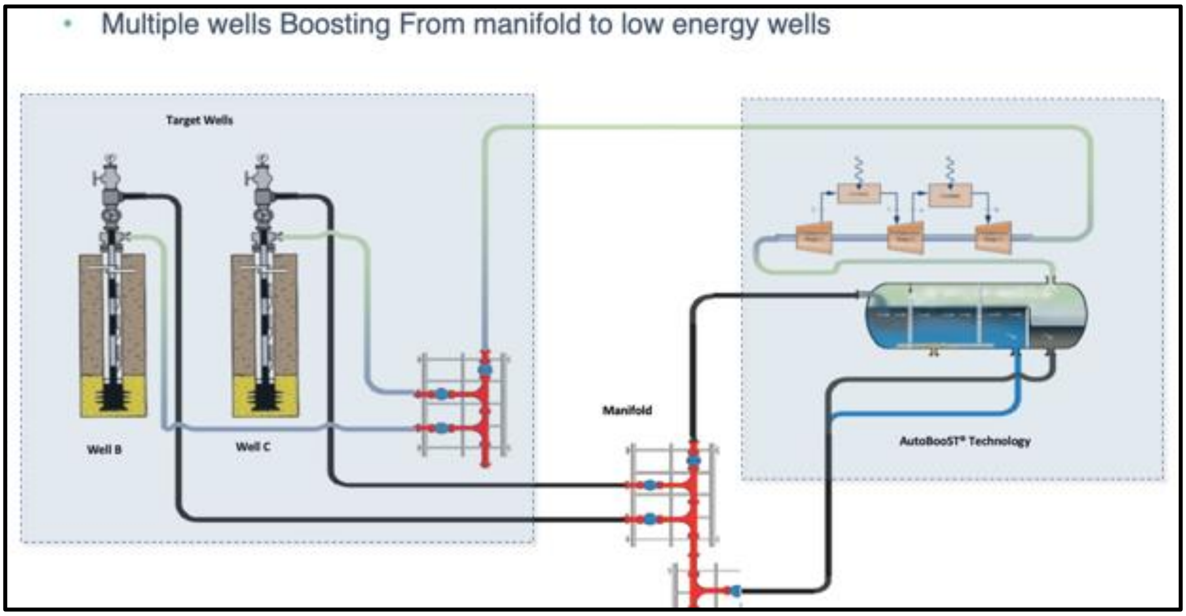


Fig III.10: Multiple wells Bosting from manifold to low energy [14]

III-5 The potential advantages and challenges of AutoBoost

III-5-1. Advantages of AutoBoost

- Easy to install mobile equipment.
- Self-powered using the gas produced, no need for external power source. Live data and real-time monitoring.
- Maintaining increased output through better control of injection parameters.
- Minimum or unmonitored operation, the system can be fully automated.
- Simple and cost-effective for the operator.

III-5-2 Potential challenges associated with AutoBoost

- Integration and adaptation: Integrating AutoBoost into an existing system can pose challenges, including compatibility with existing infrastructure. Modifications or adaptations may be necessary to ensure harmonious integration.
- Financial resources.
- Maintenance and training: Like any complex system, AutoBoost requires regular maintenance to ensure its proper operation.
- Variability of well conditions: Each well has unique characteristics, which can result in challenges when applying AutoBoost. Variations in flow rates, fluid composition and pressure conditions may require system adjustments and adaptations to the best results.
- Gas availability: AutoBoost depends on the supply of gas produced by the well. If gas production decreases or stops, this can affect system performance. Ensuring a continuous supply of gas can be a challenge, especially in situations where gas production fluctuates.
- It is essential to take into account these potential challenges and to implement appropriate mitigation strategies to maximize the benefits of AutoBoost and minimize potential problems. A thorough evaluation, adequate planning and continuous monitoring are required to ensure the successful implementation of Auto boost.

Chapter IV

Solving a gas-lift optimization problem by applying Auto-Boost technology

Introduction

This chapter focuses on how we solve a gas-lift optimization problem by auto-boost technology in our candidates wells using created model of wells in pipesim by providing wells histories and data .and show similar application of Autoboost in bbk field talking about the technical and economic success of Autoboost.

IV-1 Description of Hassi Messaoud field

The Hassi Messaoud deposit is one of the largest and most complex in the world. During its geological history, the deposit has undergone spectacular tectonic evolution. During its burial until the sediments take their current form. These events Can improve the physical parameters of the oil (natural fracturing, dissolution etc.) because they can reduce them (reduced porosity, cementation of particles, create a matrix of small particles, create a waterproof barrier, etc.).

The field covers an area of almost 2,500 square kilometers. Discovered in 1956 and put into widespread production in 1958.
Hassi Messaoud field continues after more than 50 years of intensive exploitation

For many years, it has supplied Algeria with crude oil, a natural resource. Important measures have been taken and additional measures will be taken in the future to maximize the oil impact, thereby increasing the final recovery.

IV-2 The geological location of Hassi Messaoud

Hassi Messaoud oil field is the largest oil field in Algeria and is located approximately 850 km south-east of Algiers and 280 km southeast of Hassi R'Mel gas field and 350 km west of the Tunisian border, covering an area of 2,500 squares meters.
Its coordinates are Lambert (LSA)
X = [790.000 - 840.000] Est

Y = [110.000 - 150.000] North

It is limited to :

- To the northwest by the deposits of Ouargla [Gellala, Ben Kahla and Haoud Berkaoui].
- To the southeast by the deposits ; Rhourde El Baguel and Mesdar.
- To the Southwest by the deposits of El Gassi, Zotti and El Agreb.

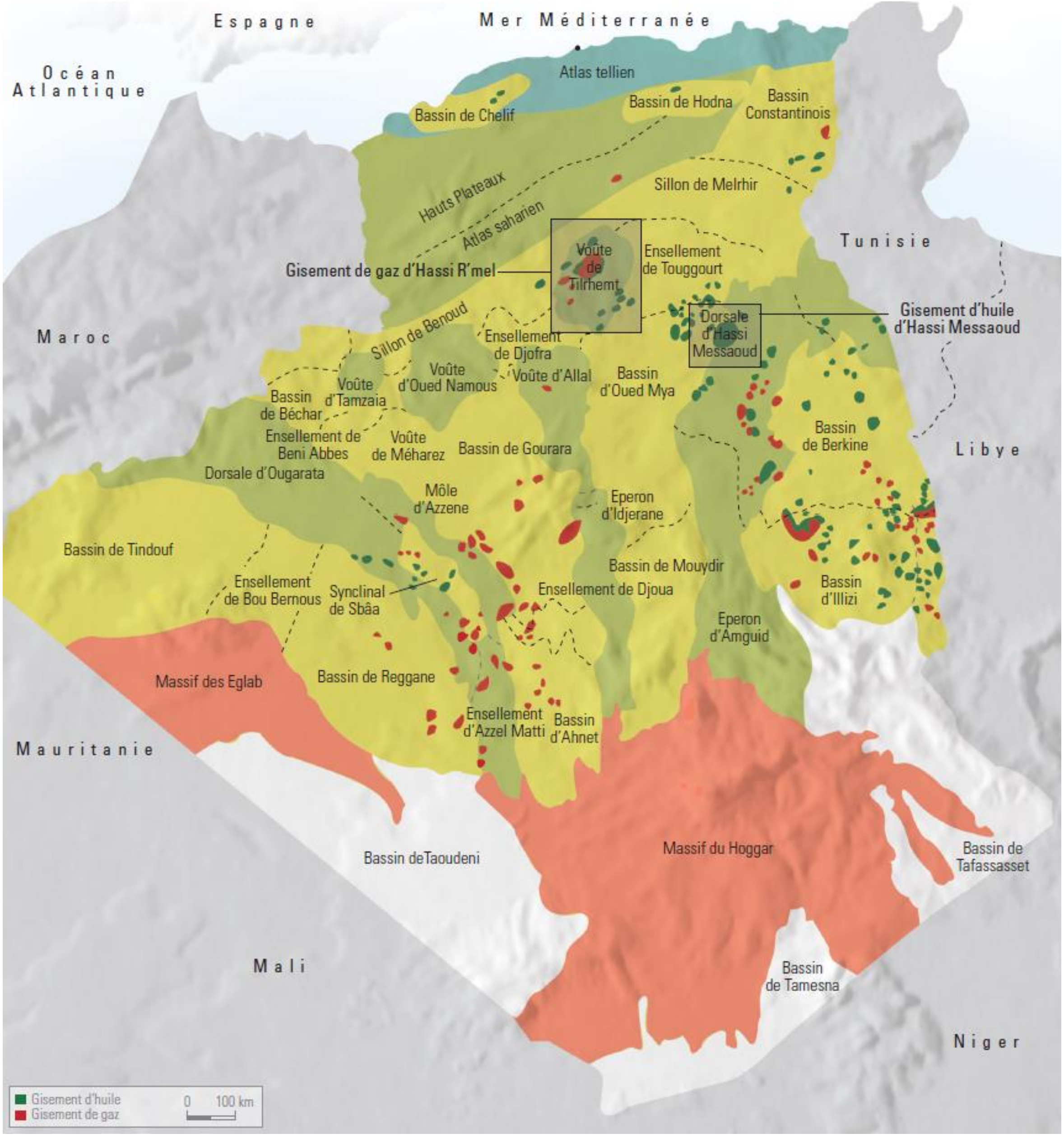


Fig IV.1: Geographical location of the Hassi Messaoud field

IV-3 Wells histories and data

- **HGANE2**: the well HGANE2 is a vertical oil-producing well drilled on 22/12/2016 (end of drilling date) to a depth of 3516 meters. the well has a completion of lpp (pre-perforated liner) with a perforated interval of 43 meters. the well has been producing from the cambro-ordovician reservoir in the northeast of the hassi guettar field, in the hzp zone of the hassi messaoud field. the production start date is 01/06/2017.the well is closed since 10/09/2022.

- **HGANE7**: the well HGANE7 is a vertical oil-producing well drilled on 09/9/202020 (end of drilling date) to a depth of 3528m meters. the well has a completion of lpp (pre-perforated liner) with a perforated interval of 53 meters. the well has been producing from the cambro-ordovician reservoir in the northeast of the hassi guettar field, in the hzp zone of the hassi messaoud field. the production start date is 01/11/202020.the well is eruptive.

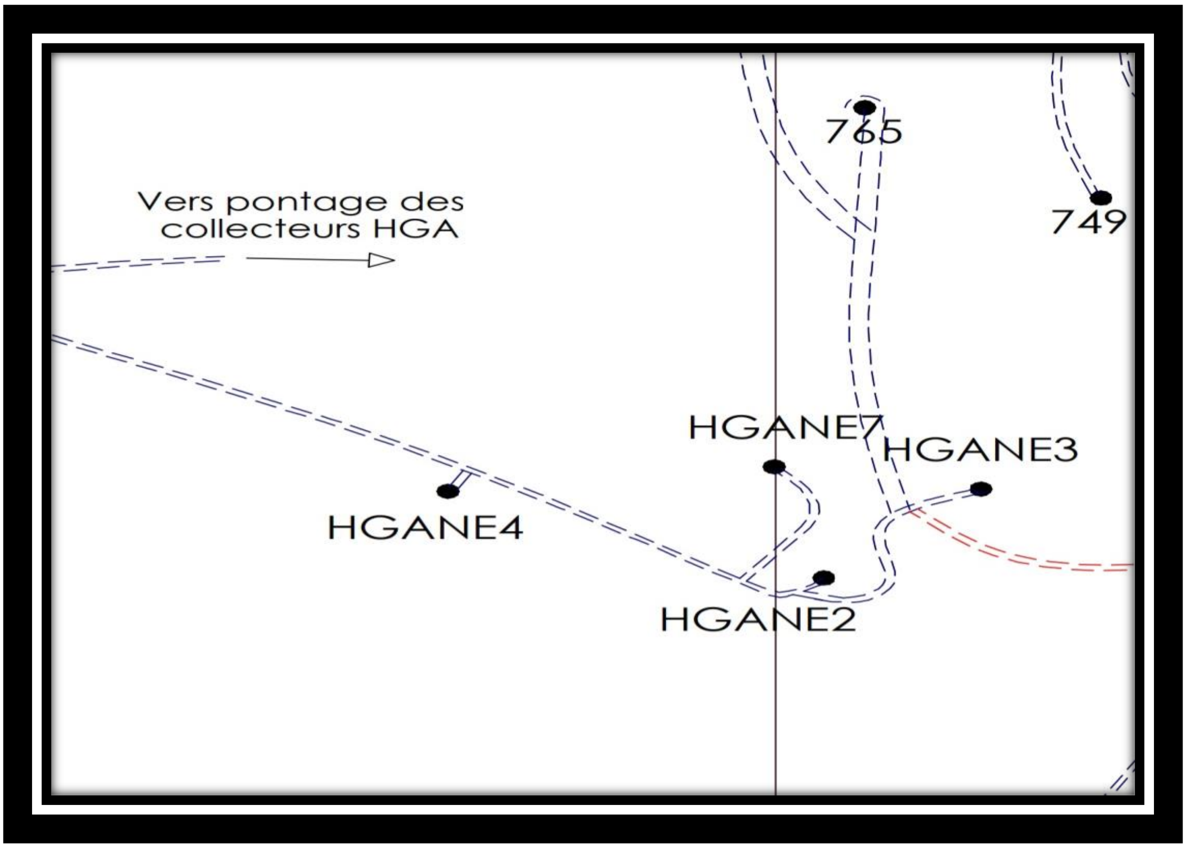


Fig IV.2: HGANE2 and HGANE7 location

This table (Table IV.1) represents the different types of tests (DST, Construction, PFS) of the HGANE2, HGANE7 wells, this test allowed us to obtain information on the reservoir and on the well.

Table IV.1: The parameters of the well test for the well

HGANE2 TESTS								
Type of Test	**Date**	**Pression (kg/cm^2)**			**Flow rate (m^3/h)**		**Prod Index**
		Gisement	**Dyn Bottom**	**Head**			
DST	**31/12/2016**	**452.83**	**403**	**173**	**Huile**	**16.25**	**.3055**
PFD	**01/11/2018**	**-**	**271**	**71.77**	**Huile**	**9.8**	**-**
PFD	**05/01/2019**	**-**	**258.76**	**64.45**	**Huile**	**8.69**	**-**
BUILD UP	**07/06/2020**	**356.39**	**254**	**62.2**	**Huile**	**6.5**	**.065**
PFS	**31/07/2022**	**283**	**-**	**25**	**Huile**	**-**	**-**

HGANE7 TESTS							
Type of Test	**Date**	**Pression (kg/cm^2)**			**Flow rate (m^3/h)**		**Prod Index**
		Gisement	**Dyn Bottom**	**Head**			
DST	**22/09/2020**	**413**	**390**	**175.81**	**Huile**	**6.88**	**.298**
PFD	**13/11/2021**	**-**	**268**	**67**	**Huile**	**4.84**	**-**
PFD	**09/02/2022**	**-**	**262.96**	**63.2**	**Huile**	**4.84**	**-**

This table (table IV.2) shows the latest operations (logging, wireline, special operations...) on the two wells. HGANE2, HGANE7.

Table IV.2: The latest well operations

HGANE2		
Start date	**End date**	**Type**
28/02/2024	**30/03/2024**	**SNUBBING**
29/03/2024	**29/03/2024**	**WIRELINE**
06/12/2023	**06/12/2023**	**SPECIAL_OPERATION**
22/06/2017		**DIAGRAPHIES PERFORATION**

HGANE7		
Start date	**End date**	**Type**
24/04/2024	**24/04/2024**	**WIRELINE**
20/09/2021	**20/09/2021**	**SPECIAL_OPERATION**
03/10/2020		**DIAGRAPHIES PP @3419 m**

Table IV.3: The latest well gaugings

HGANE2									
Measurement date	**Chock Diameter (mm)**	**Separator unit**	**Flow rate (m^3/h)**		**GOR**	**Pression (kg/cm^2)**			**Oil Temp (°C)**
			Oil	**Gas**		**Head**	**Pipe**	**Separ**	
01/06/2020	**10**	**1440**	**6.5**	**1305**	**201**	**62.2**	**12.6**	**4.38**	**31**
25/08/2021	**10**	**1440**	**4.97**	**711.67**	**143**	**44.45**	**15.31**	**15.55**	**42**
17/11/2021	**10**	**1440**	**4.31**	**534.09**	**124**	**43.81**	**14.94**	**4.87**	**36**
17/01/2022	**10**	**1440**	**1.8**	**468.54**	**261**	**20**	**14.3**	**3.95**	**17**
27/02/2022	**10**	**1440**	**2.56**	**134.08**	**52**	**21.96**	**12.29**	**11.85**	**19**

HGANE7									
Measurement date	**Chock Diameter (mm)**	**Separator unit**	**Flow rate (m^3/h)**		**GOR**	**Pression (kg/cm^2)**			**Oil Temp (°C)**
			Oil	**Gas**		**Head**	**Pipe**	**Separ**	
09/05/2023	**8**	**1440**	**5.5**	**244.41**	**44**	**48.2**	**17.34**	**17.37**	**26**
24/08/2023	**8**	-	**4.41**	**744.40**	**169**	**44.4**	**16.9**	-	**33.6**
08/12/2023	**8**	**1440**	**4.49**	**455.79**	**101**	**42.35**	**16.35**	**16.56**	**14**
29/03/2024	**8**	-	**4.49**	**626.51**	**139**	**40**	**16.9**	-	**18**

Table IV.4: Wells characteristics

The Characteristics of Wells	HGANE2	HGANE7
The Reservoir pressure	356	413
The Reservoir temperature T (°C)	120	120
Oil API Gravity	44.8	45
Gas gravity	1.023	1.023
Water density	1.2748	1.02
Pb (kg/cm2)	168	164
GOR (m3/m3)	196.68	201

IV-4 Modeling of the wells HGANE2 and HGANE7 using PIPSIM

IV-4-1 Overview of PIPESIM software

PIPESEM is a comprehensive software package developed by Schlumberger for simulating the performance of oil and gas production systems using pipesim can be used to model individual well performance and assess the impact of reservoir properties, completion designs, and production techniques on oil flow rates. by optimizing well configurations and production strategies, operators can maximize oil recovery and enhance production rates. For wells requiring artificial lift methods such as gas lift pipesim offers optimization capabilities to maximize lift efficiency and oil flow rates. by analyzing lift system performance under different operating conditions, engineers can optimize lift design and operation to enhance production.

IV-4-2 input data

• From gauging: oil flow rate, water cut, Gas-Oil Ratio (GOR), wellhead pressure, choke diameter.

• From the well test (build-up): reservoir pressure and temperature, dynamic bottom hole pressure, wellhead pressure, productivity index, skin, oil flow rate, diameter.

•From the technical specification (well completion):

1. Dimensions (tubing, casing, concentric, packer, SSSV...).
2. MD, KOP, VS, TVD, Deviation angle.
3. Inner and outer diameter of tubing and casing.
4. Roughness.
5. Mid-perforation depth.

•From PVT data: Rs (dissolved Gas-Oil Ratio), saturation pressure, oil and gas density, fluid viscosity, and compressibility factor.

• From various measurement and operation reports conducted on the wells.

IV-4-3 Architecture and Completion of HGANE2

The production casing and the tubing are detailed in the "Tubulars" tab along with their respective sizes, including dimensions (nominal diameter and internal diameter) and their mechanical characteristics (nominal weight, steel grade, thread type).

General | Deviation survey | Heat transfer | Tubulars | Downhole equipment | Artificial lift | Completions | Surface equipment

Dimension option: ○ OD ◉ Wall thickness

CASINGS/LINERS

	Section type	Name	From MD	To MD	ID	Wall thickness	Roughness
			m	m	in	in	in
1	Casing	Casing	0	3465	6,094	0,453	0,001
2	Liner	CMP	3412	3508	3,92	0,2983471	0,001

TUBINGS

	Name	To MD	ID	Wall thickness	Roughness
		m	in	in	in
1	Tubing	3411	3,92	0,254	0,001

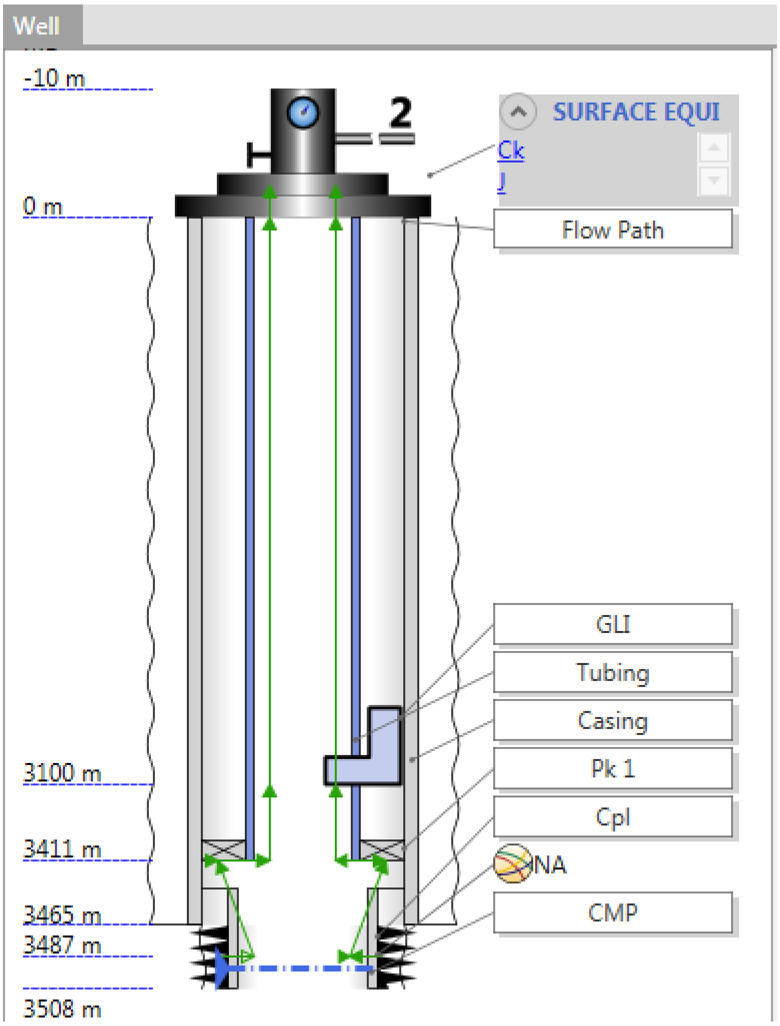


Fig IV.3: Architecture and Completion of HGANE2

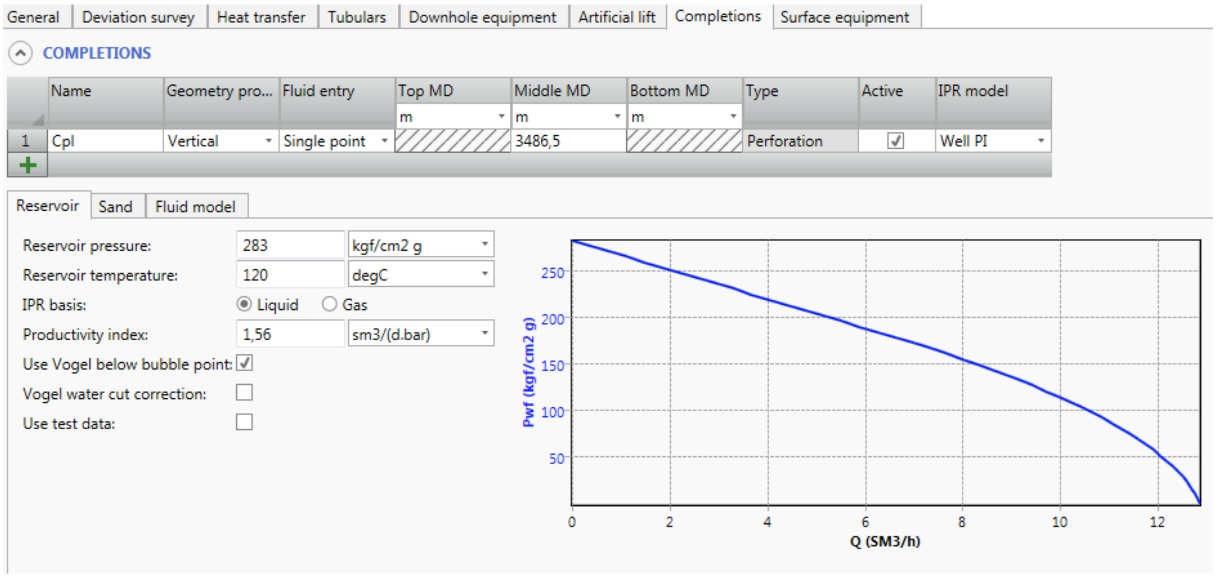
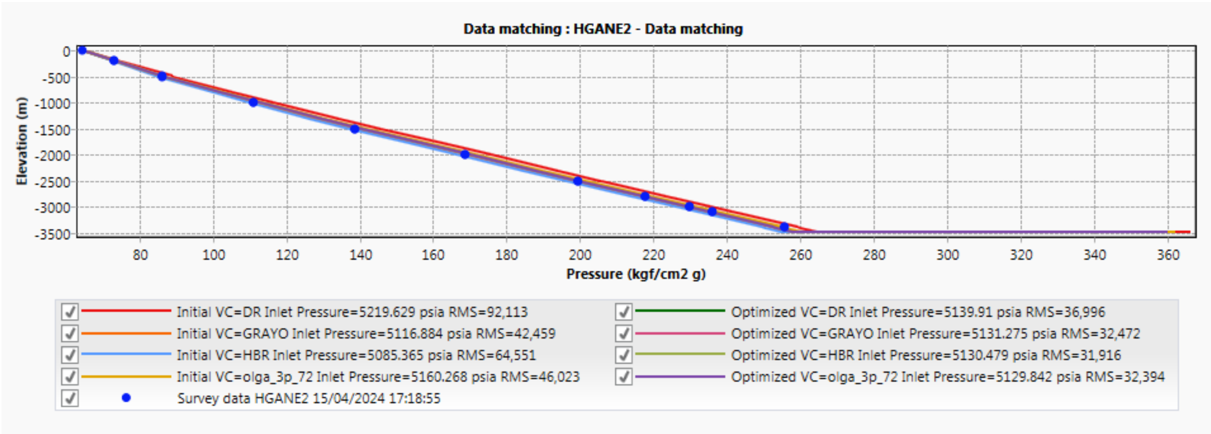


Fig IV.4: Reservoir data for well HGANE2

IV-4-4 DATA MATCHING

On 'Data matching,' we can find the correlation that best fits the input and measured data with well completion (see Figures The best correlation is selected based on the Reynolds Mean Squared (RMS) factor, which becomes lower and typically falls below a threshold value of10. The smaller the RMS, the more representative and reliable the correlation is.



	Vertical multiphase correlation	Calibrated U value multiplier	Initial pressure RMS	Calibrated pressure RMS	Initial temperature RMS	Calibrated temperature RMS	Initial holdup RMS	Calibrated holdup RMS	Initial total RMS	Calibrated total RMS	Status	Select
1	Hagedorn & Brown	0.251161	43.278779	18.437179	21.271814	13.47864	0	0	64.550593	31.915819	Optimized	☑
2	OLGAS v. 7.2 3-Phase	0.264667	24.839496	18.708159	21.183911	13.686196	0	0	46.023407	32.394355	Optimized	☐
3	Gray (original)	0.255796	21.224509	18.934809	21.234566	13.537248	0	0	42.459075	32.472058	Optimized	☐
4	Duns & Ros [Baker Jardine]	3.640831	70.882658	12.724347	21.230394	24.271673	0	0	92.113052	36.99602	Optimized	☐

Fig IV.5: Results of the data matching for well HGANE2

The HAGEDORN & BROWN correlation provides the best results for calculating pressure losses in the tubing.

IV-5 Activation by Gas lift and Optimization of gas lift parameters

The objective of this section is to select the optimal gas injection rate (optimal Q_{gasinj}), optimal CCE, optimal depth and optimal choke diameter, which allow for an increase in production and proper well operation over the long term.

IV-5-1 Optimal gas injection rate (optimal Q_{gasinj})

The most critical parameter in a gas lift operation is the optimum injection rate. Finding the optimum rate is essential because injecting an extra amount of gas not only does not improve production but can decrease it through increased slippage between liquid and gas.

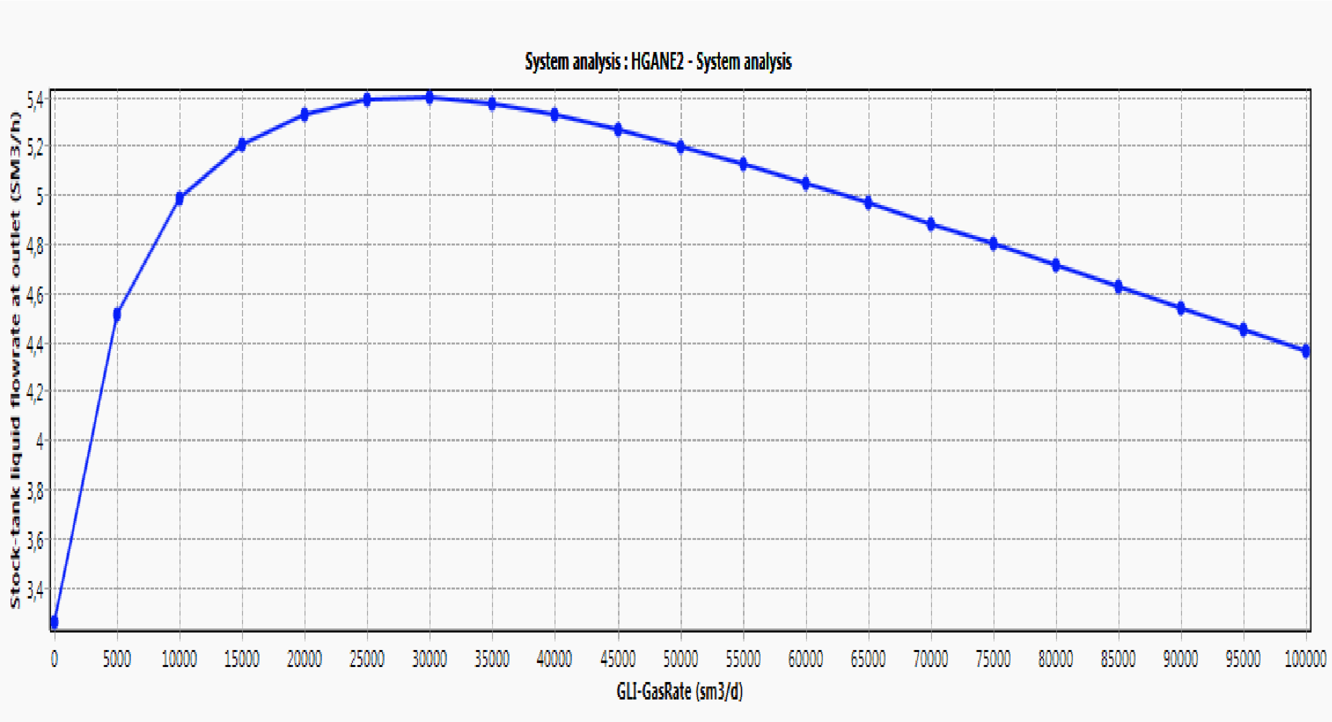


Fig IV.6: Optimal gas injection rate (optimal Q_{gasinj})

IV-5-2 A 2" 7/8 string completion

IV-5-2-1 Selection of the optimal gas injection rate (optimal Q_{gasinj}) and choke diameter for A2"7/8 string completion

The completion consists of a 4'1/2 production tubing and a 2" 7/8 string, the gas is injected in the annular space between the tubing and the 2" 7/8 srtring.and oil flow through 2" 7/8 string.

by calculating the oil flow rate based on gas injection rates ranging from 0 to 100000 Sm3/d and considering chokes of 10 mm, 12 mm, 14 mm, 16 mm, and we find the optimal Qinjgas and the optimal choke diameter (Fig IV.6).

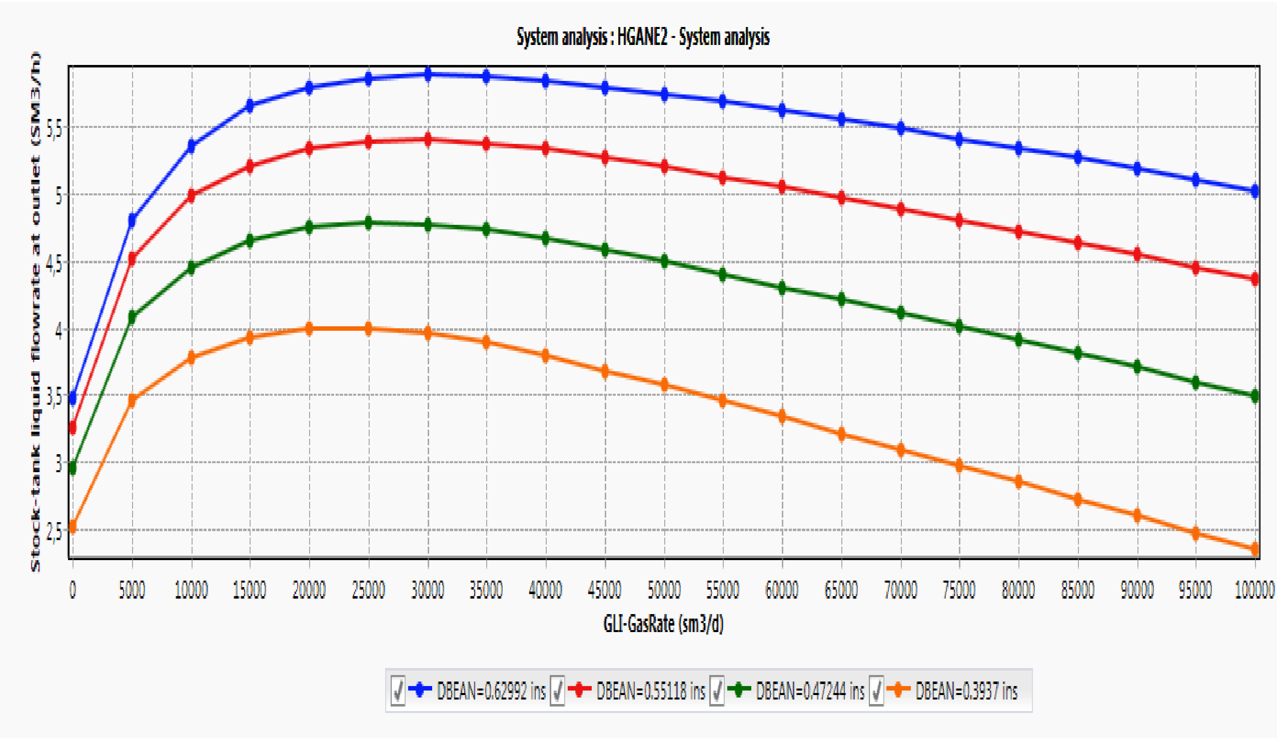


Fig IV.7: Optimization of Q_{GASINJ} and the choke for 2'' 7/8 String completion

The optimal flow rate of gas to be injected is estimated at optimal Qinjgas = 20000 Sm3/d and the choke optimal is 14 mm represented by the 4 curve in red.

IV-5-2-2 Performances of the well in GL with 2" 7/8 String completion

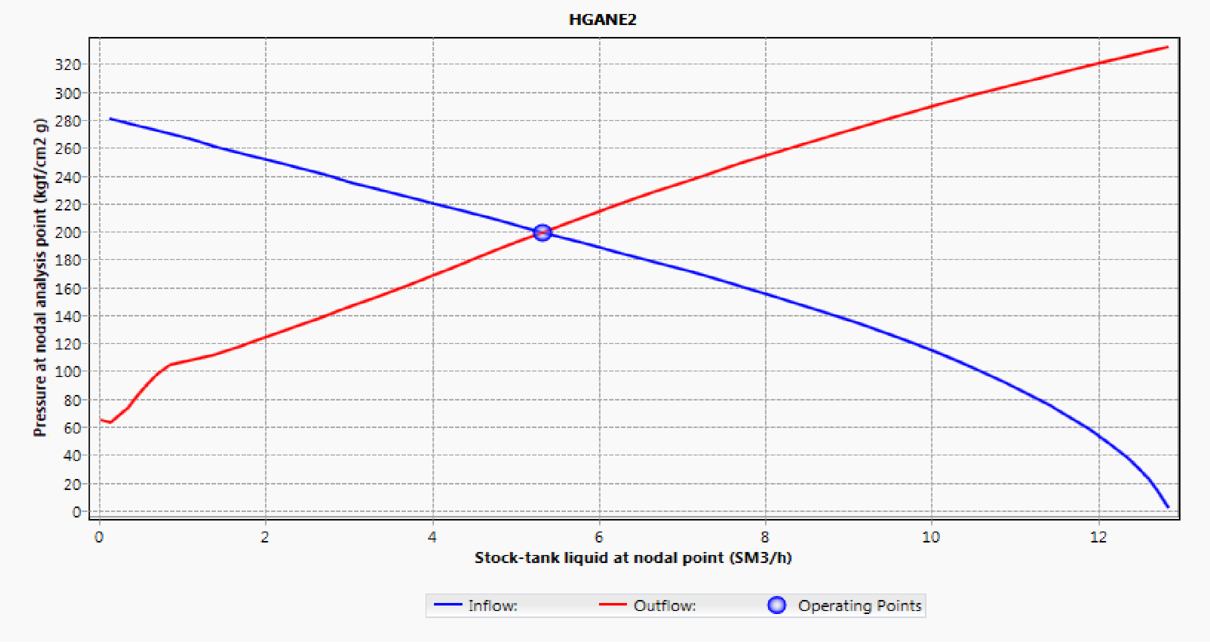


Fig IV.8: Performances of the well in GL with 2'' 7/8 String completion

The flow rate obtained with gas lift is Q_{OIL} =5,3 Sm³/h with a dynamic bottom hole pressure of BHP = 120 bar.

IV-5-3 Concentrique 1.9'

IV-5-3-1 Selection of the optimal Qinjgas and the optimal choke for the 1.9' concentric

The completion consists of a 4'1/2 production tubing and a 1.9' concentric.CCE inside the tubing for gas injection. The oil flows through the annular space between the tubing and the CCE.

By calculating the oil flow rate based on gas injection rates ranging from 0 to 100000 Sm3/d and considering chokes of 10 mm, 12 mm, 14 mm, 16 mm, and we find the optimal Qinjgas and the optimal choke diameter (Fig IV.8).

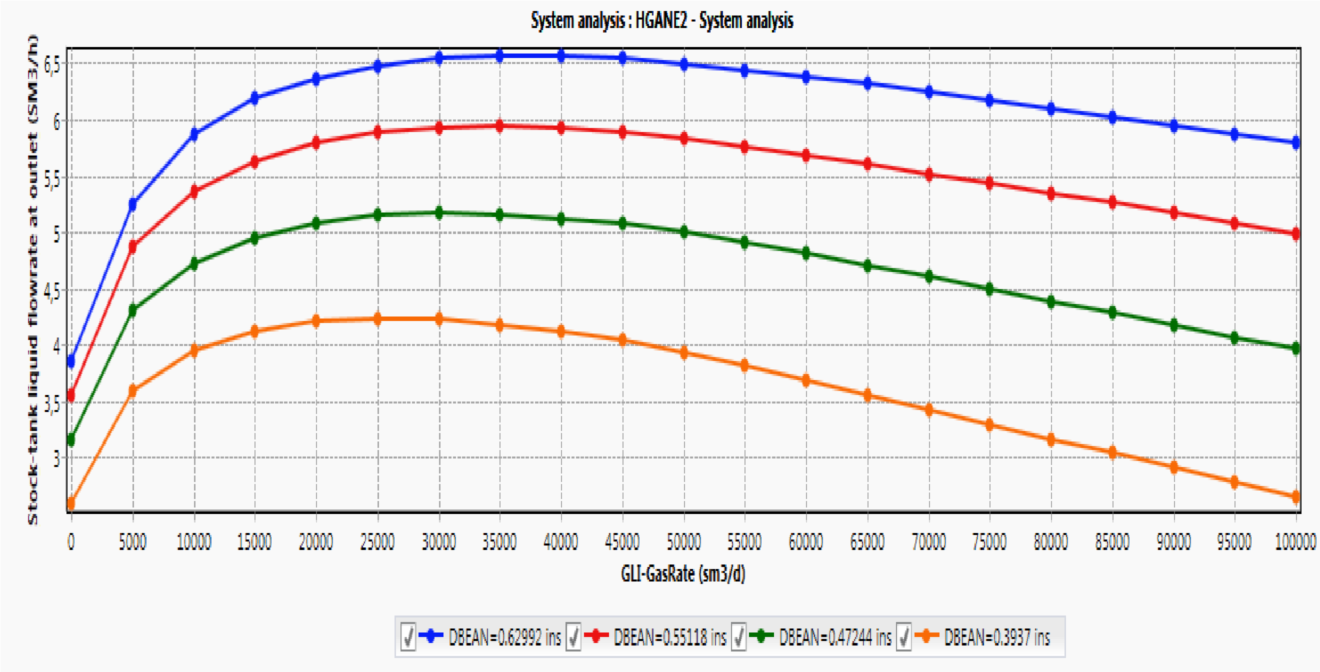


Fig IV.9: Optimization of Q_{GASINJ} and the choke for the concentric 1.900'

The optimal flow rate of gas to be injected is estimated at optimal Qinjgas = 20000 Sm3/d and the choke optimal is 14 mm represented by the 4 curves in red.

IV.5 .3.2Performances of the well in GL with 1.9' concentric

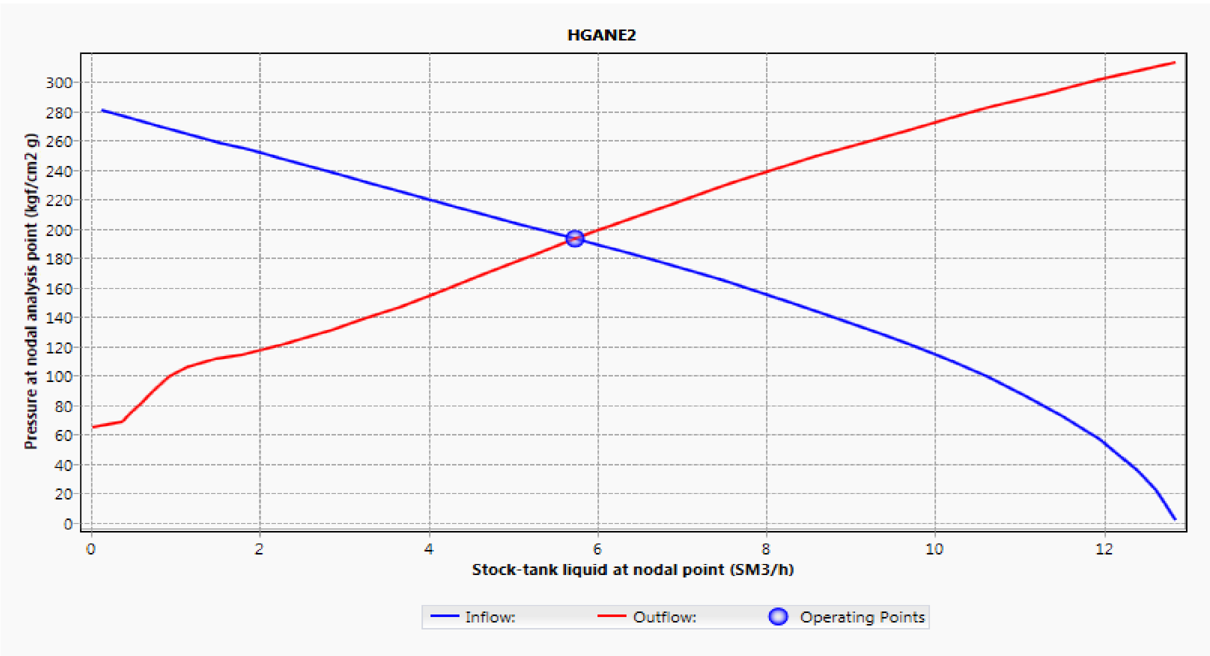


Fig IV.10: Performances of the well in GL with 1.9' concentric

The flow rate obtained with gas lift is Qh =5,7 Sm³/h with a dynamic bottom hole pressure of Pwf = 193 bar

IV-5-4 A 1.660' concentric

IV-5-4-1 Selection of the optimal Q_{GASINJ} and the optimal choke for the 1.660' concentric

By calculating the oil flow rate based on gas injection rates ranging from 0 to 100000 Sm3/d and considering chokes of 10 mm, 12 mm, 14 mm, 16 mm, and we find the optimal Qinjgas and the optimal choke diameter (Fig IV.10).

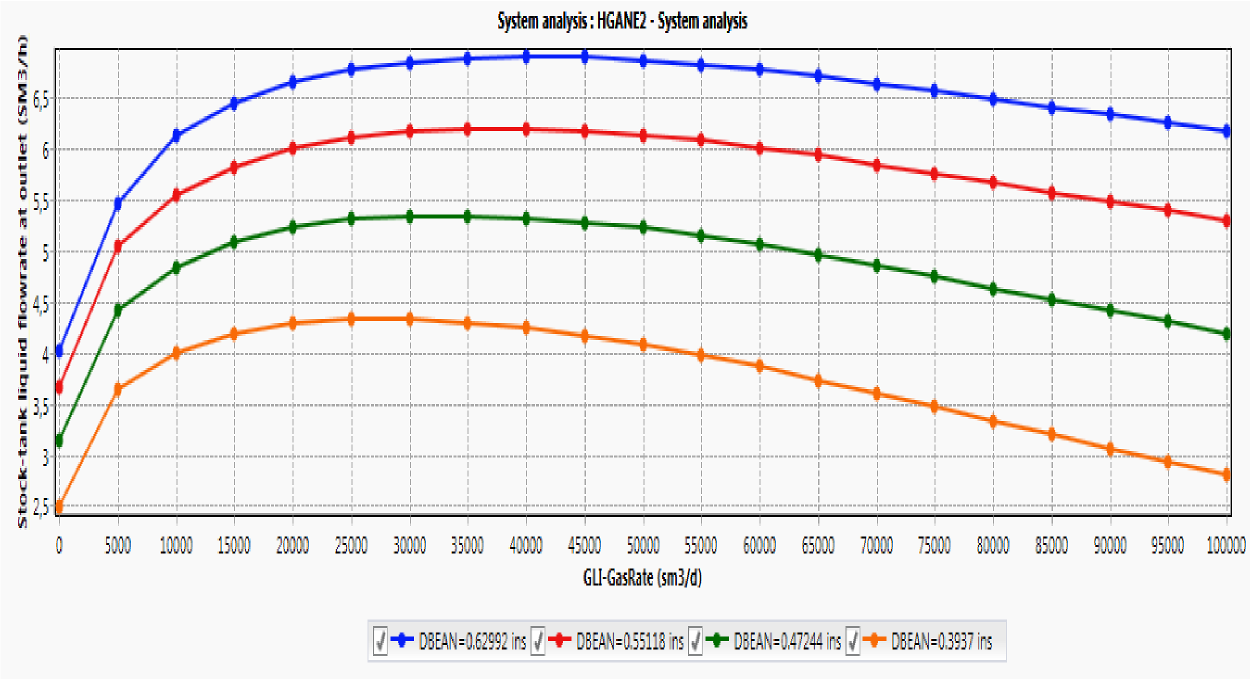


Fig IV.11: Optimization of Q_{GASINJ} and the choke for the concentric 1.660'

The optimal flow rate of gas to be injected is estimated at optimal Qinjgas = 20000 Sm3/d and the choke optimal is 14 mm represented by the 4 curves in red.

IV-5-4-2 Performances of the well in GL with 1.660' concentric

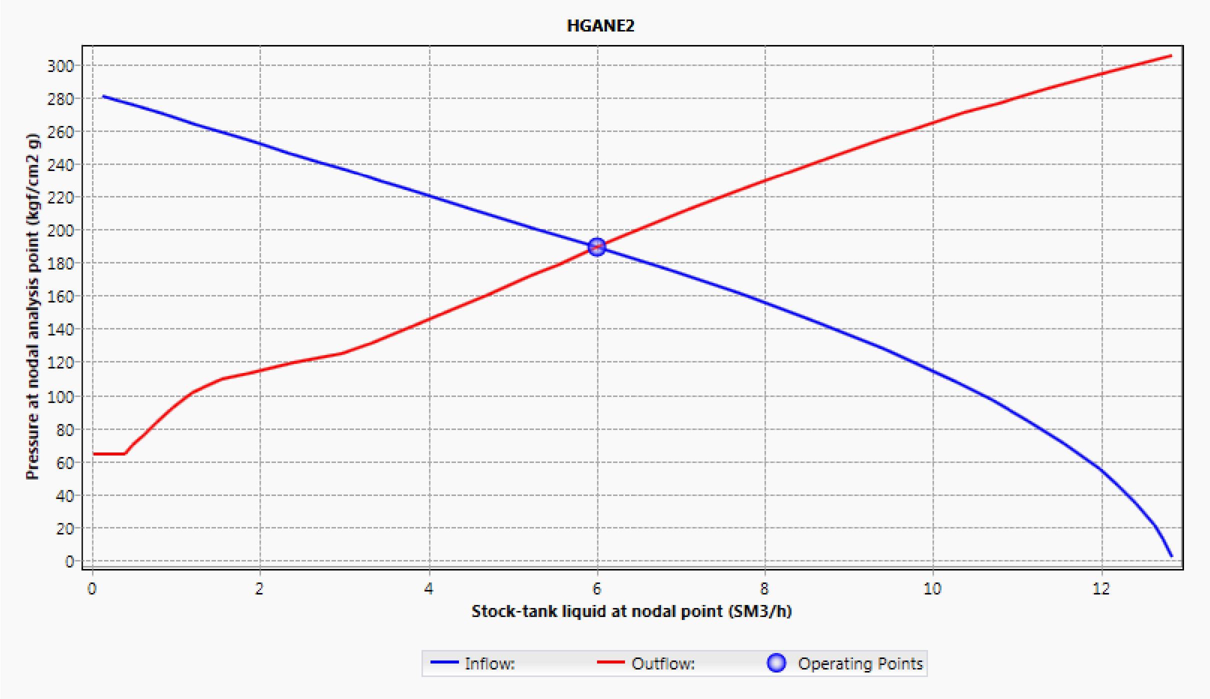


Fig IV.12: Performances of the well in GL with 1.660' concentric

The flow rate obtained with gas lift is Qh =6 Sm^3/h with a dynamic bottom hole pressure of Pwf = 188 bar.

IV-6 Results and discussions

The results obtained for the different completions are recorded in Table

Table IV.5: Summary of HGANE2 Optimization Results

Completion	Q injgas Optimal (Sm3/d)	Injection Depht (m)	Optimal Chock (mm)	QO with GL (Sm3/d)	Production Gain (sm3/h)	WHP with GL (bar)	BHP with GL (bar)
2"7/8 String	20000	3100	14	5.3	5.3	35.8	120
1,9" concentrique	20000	3100	14	5.7	5.7	37.5	193
1,660" concetrique	20000	3100	14	6	6	38	188

This table shows that the optimal gas injection rate and the optimal choke for the different concentric strings are 20000 Sm^3/d and 14 mm, respectively. The highest oil flow rate, obtained after optimizing the gas lift parameters, is for the 1.660'' concentric, with Q_{OIL} = 6 Sm^3/h and a dynamic bottom hole pressure (BHP) of 188 bar. It's wellhead pressure (WHP) of 38 bar is significantly higher than the pipe pressure (P_{PIPE}) of 12,7 bar.

Without any other considerations, 1.660'' concentric should be selected, but the operational history of this well shows that clean out operations are frequently performed to remove organic deposits (asphaltene). Considering the costs, the difficulty of the operation (namely, if it is the 1,660'' concentric, it must be pulled out to access the reservoir, whereas for the 2" 7/8 string completion, the completion does not need to be pulled out for the clean out, as it can be done with 1" 1/2 diameter coiled tubing), and the time required for the operation.

the 2" 7/8 string completion is considered the optimal choice for the HGANE2 well.With this completion, a production gain of 5.3 Sm^3/h, or 8604.4611 bbl/day, is achieved. The final choice for the HGANE2 well is presented in Table below:

Table IV.6: Final Selection of Well HGANE2

Completion	Q injgas Optimal (Sm3/d)	Injection Depht (m)	Optimal Chock (mm)	QO with GL (Sm3/d)	Production Gain (sm3/h)	WHP with GL (bar)	BHP with GL (bar)
2"7/8 String	20000	3100	14	5.3	5.3	35.8	120

IV-4-1 Using the same method, we find for HGANE7

Table IV.7: Final Selection of Well HGANE7

Completion	Q injgas Optimal (sm3/d)	Injection Depht (m)	Optimal Chock (mm)	QO with GL (sm3/d)	Production Gain (sm3/h)	WHP with GL (bar)	BHP with GL (bar)
2"7/8 String	10000	3100	14	8.63	4.14	51.6	246

IV-7 SIMILAR APPLICATION OF AUTOBOOST IN OEC1 IN BBK FIELD

IV-7-1 Technical aspect

The well OEC1 is a vertical oil-producing well drilled to a depth of 3528m meters. The well has a completion of LPP (Pre-Perforated Liner) with a perforated interval of 53 meters. The well has been producing from the Ouerdat Ech Cherguia reservoir located in the Zemoul El Kbar perimeter, in the central northern part of the Berkine Basin, in the zone BBK of the Hassi Messaoud field. The production start date is 15/1/2018.

Table IV.8: The latest well gauging

OEC1											
Measurement date	Chock Diameter (mm)	Separator unit	Flow rate (m^3/h)		GOR	Pression (kg/cm^2)			Oil Temp (°C)	
			Oil	Gas		Head	Pipe	Separ		
26/10/2018	10	3.41	3.41	297.80	87	26.4	25.5		25.2	
11/03/2019	28	2.97	2.97	292.89	99	11.26	3	1.74	19	
30/12/2019	8	1.88	1.88	147.70	78	13.1	8.6		15.4	
20/01/2020	8	3.22	3.22	358.33	111	16	5	3.57	9	
01/04/2022	12	1.18	1.18	1312.44	1109	29.3	5.35	2.78	30	
06/06/2022	12	.64	.64	23.80	37	6.1	5.27	5.11	38	
06/08/2022	11	4.09	4.09	1327.26	324	23.88	5.05	4.68	32	
06/08/2023	11	5.4	5.4	730	135	44	10	10	30	Gaugingwith lifting

The well is closed in 11/04/2024 because of Q_{OIL}=0 m^3/h

The well was out of gas lift network and it needed artificial lifting

Sonatrach with expro provided Autoboost unit and obtain of Q_{OIL}=6.1 m^3/h.

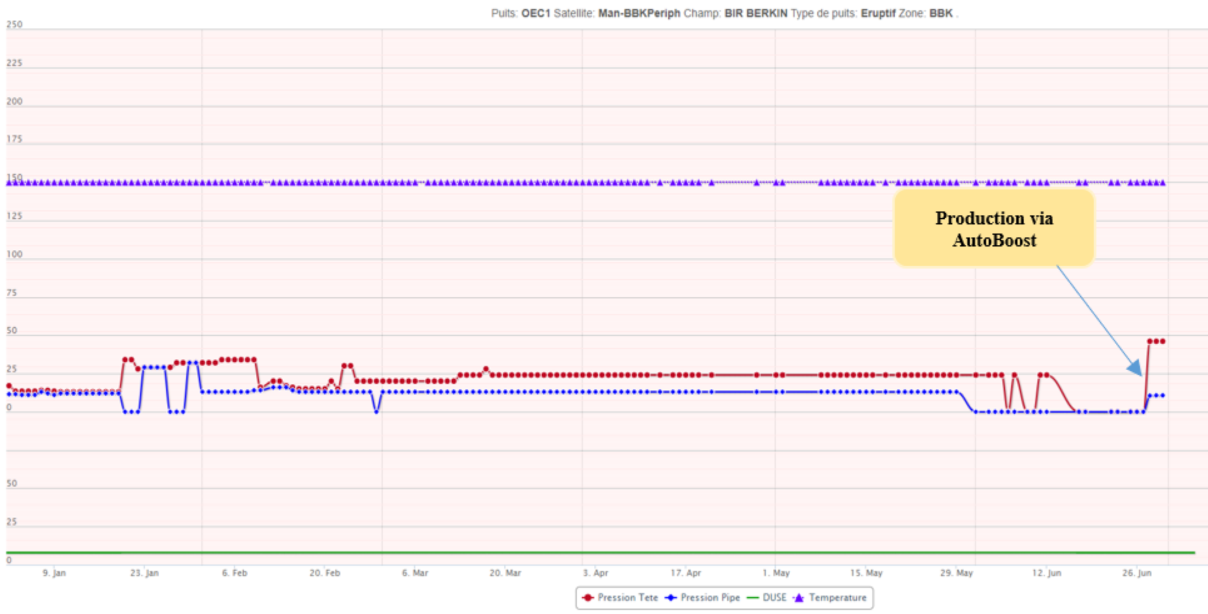


Fig IV.13: Autoboost effect in OEC 1 production

IV-7-2 Economic Aspect

After the technical success of the Autoboost unit and achieving a $6.21m^3$ increase, we began studying the economic aspect of this unit during an internship at Sonatrach Company about utilizing of this unit over a period extending from June 2023 to May 2024. Based on the following criteria:

- The daily production quantity of petroleum and the price per barrel of oil for the relevant day.
- The daily cost of using the unit. (9100$).
- The contract terms between Sonatrach and Expro stipulate that the daily usage cost is waived if the unit is used for less than 12 hours.
- Sonatrach net profit along this period of unit utilizing is 5402479.105$.

Table IV.9: Economic study

Date	Overall revenue $	EXPRO COST $	Net Profit $
May 2024	282193.0488	117000	165193.0488
April2024	464434.7361	243000	221434.7361
March2024	380766.7943	225000	155766.7943
Fev2024	627550.3128	243000	384550.3128
Jan2024	624847.5488	243000	381847.5488
Dec2023	763006.0515	261000	502006.0515
Nov2023	623530.6485	189000	434530.6485
Oct2023	445712.8985	180000	265712.8985
Sep2023	515732.8361	126000	389732.8361
Aout2023	1021153.809	243000	778153.809
July2023	1705670.799	261000	1444670.799
Juin2023	314879.6226	36000	278879.6226
Total	7769479.105	2367000	5402479.105

General conclusion

&

Recommendations

General conclusion

We conducted this study and practical work during the internship at Sonatrach Hassi messaoud in april and May 2024 to maintain and increase the production of peripheral field wells in the Hassi messaoud field HGANE2 and HGANE7 by activating them using gas lift with Autoboost by separating the quantity produced from gas of well or other nearby wells and reinjected the well-equipped on the concentric or spm and improving the parameters affecting the gas lift. this was achieved by creating a simulation model using pipesim and selecting the appropriate results. the study dedicated to optimization conducted on two wells, HGANE2, HGANE7, and allows for the conclusion of several points such as:

- HGANE7 is eruptive well and its production is the source of the separated gas in Autoboost unit which will be reinjected in HGANE2 and HGANE7 wells.
- The important of well data for simulating with pipesim the more data we provide and the more accurate it is, the more effective the model's results will be.
- Determination the operating point of the well.
- The Hagedorn & Brown correlation provides the best results for calculating pressure losses in the tubing (the well's Vertical Lift Performance (VLP) correlation).
- The determination of an optimal gas flow rate injection corresponds to a maximum oil production rate.
- The different diameters of chokes used on the gas-lift wells in the Hassi Messaoud field provide different flow rates. we take on consider the future reservoir depletion for choke selection.
- The optimization of the gas-lift (GL) system with the Autoboost unit for different concentric (CCE) diameters in HGANE2 well yielded the following results:

Optimization 2"7/8: oil flow rate of 5.3 Sm^3/h

Optimization 1"900: oil flow rate of 5.7 Sm^3/h

Optimization 1"660: oil flow rate of 6 Sm^3/h

considering future reservoir depletion, the best result obtained after optimization is with a diameter of 2"7/8, achieving an oil flow rate of 5.3 Sm^3/h.

- The production gains of wells HGANE2 and HGANE7 when utilizing Autoboost are 5.3 Sm^3/h and 4.14 Sm^3/h, respectively.

Recommendations

- Utilizing Autoboost allows for the elimination of hydrates and frost formation, which are common problems in the Hassi Messaoud field, through activation by gas lift.
- Utilizing Autoboost achieved production gains. We recommend conducting a Technical/Economic Study for Autoboost application in other peripheral fields.
- Using the Pipesim software for improving oil production.
- Ensure daily monitoring of the gas injection flow rate and pressure for the proper operation of gas-lift well.
- Ensure daily monitoring of Autoboost unit equipments (separation section, compressor section…).

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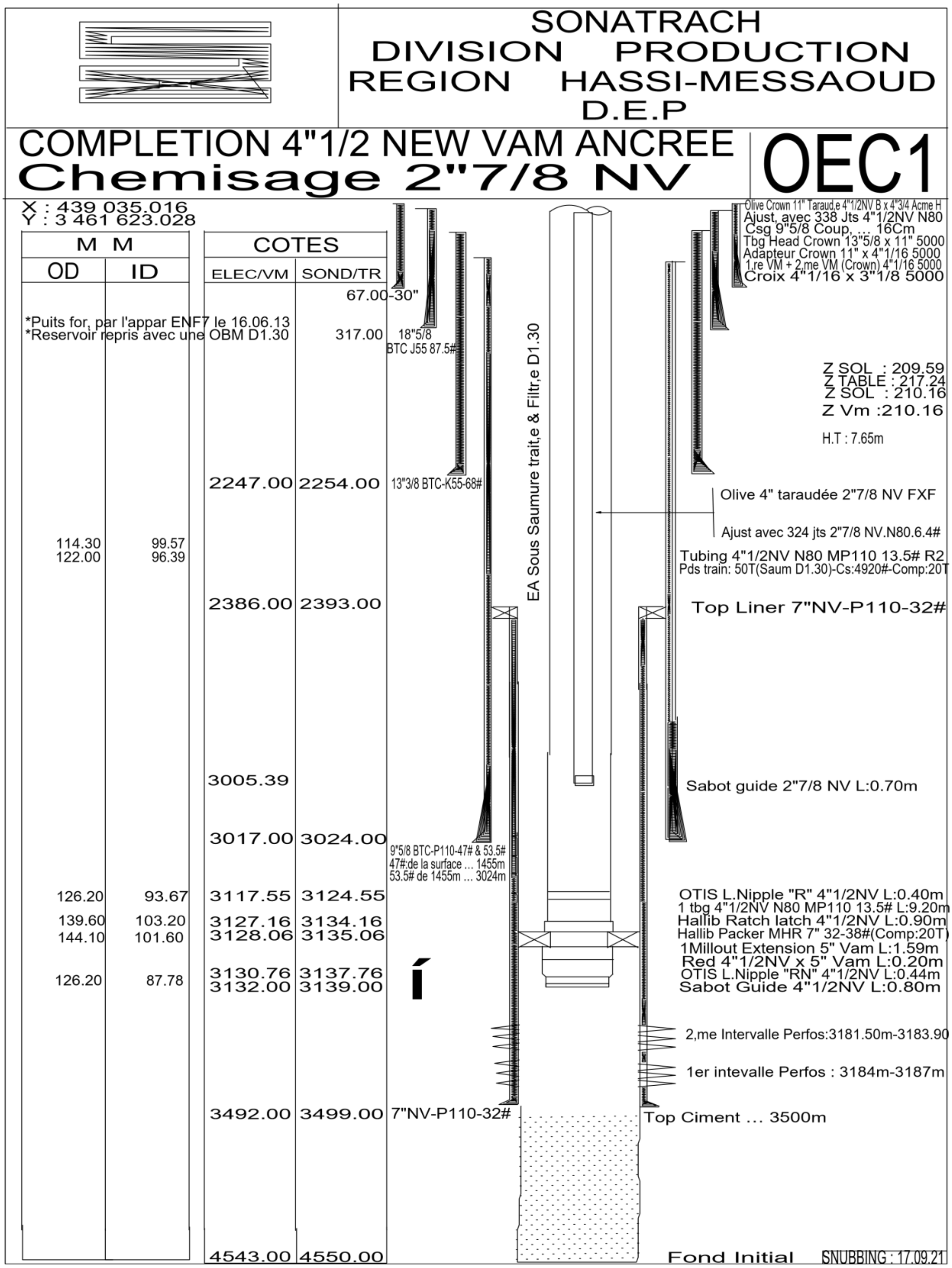
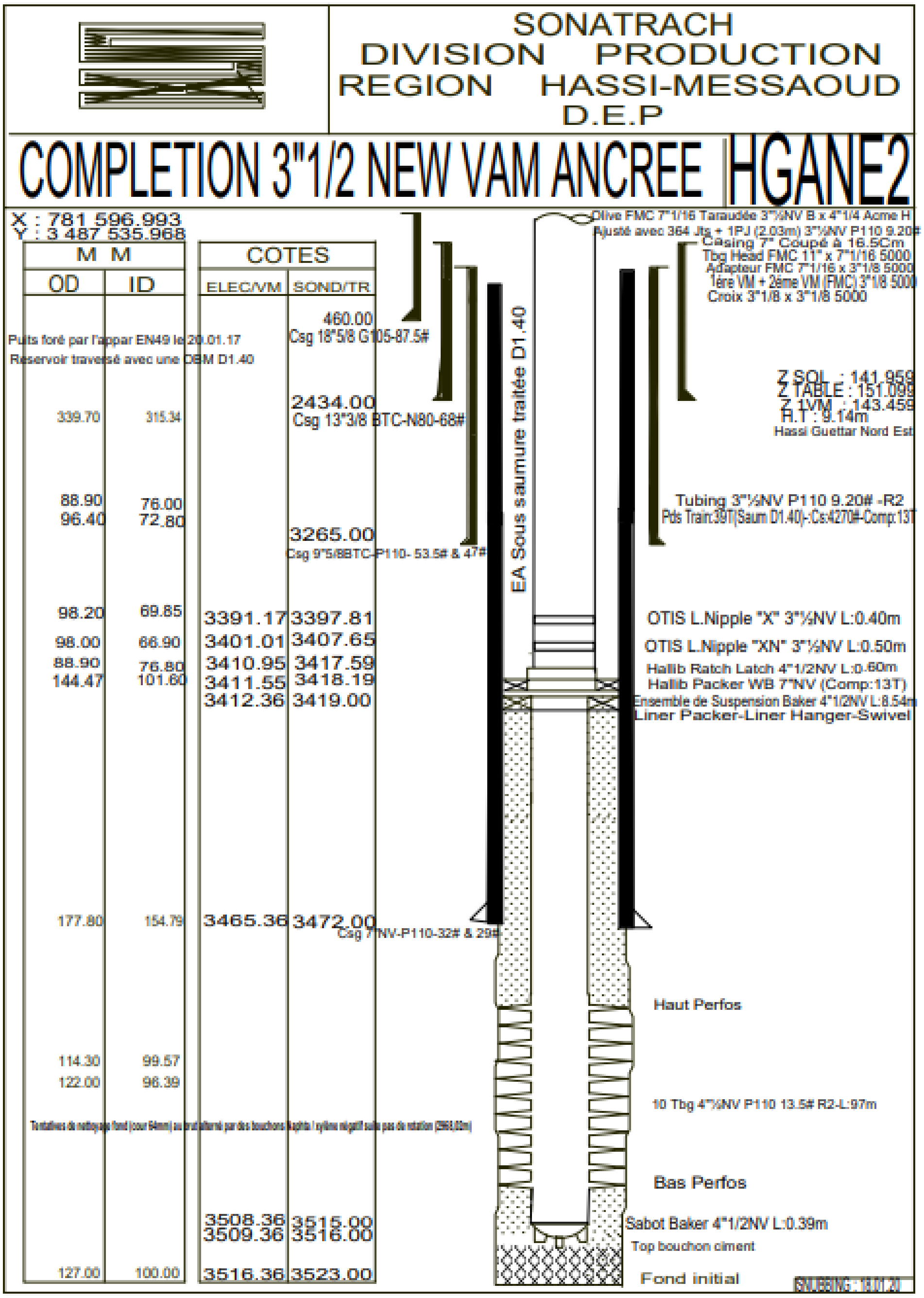
Annex

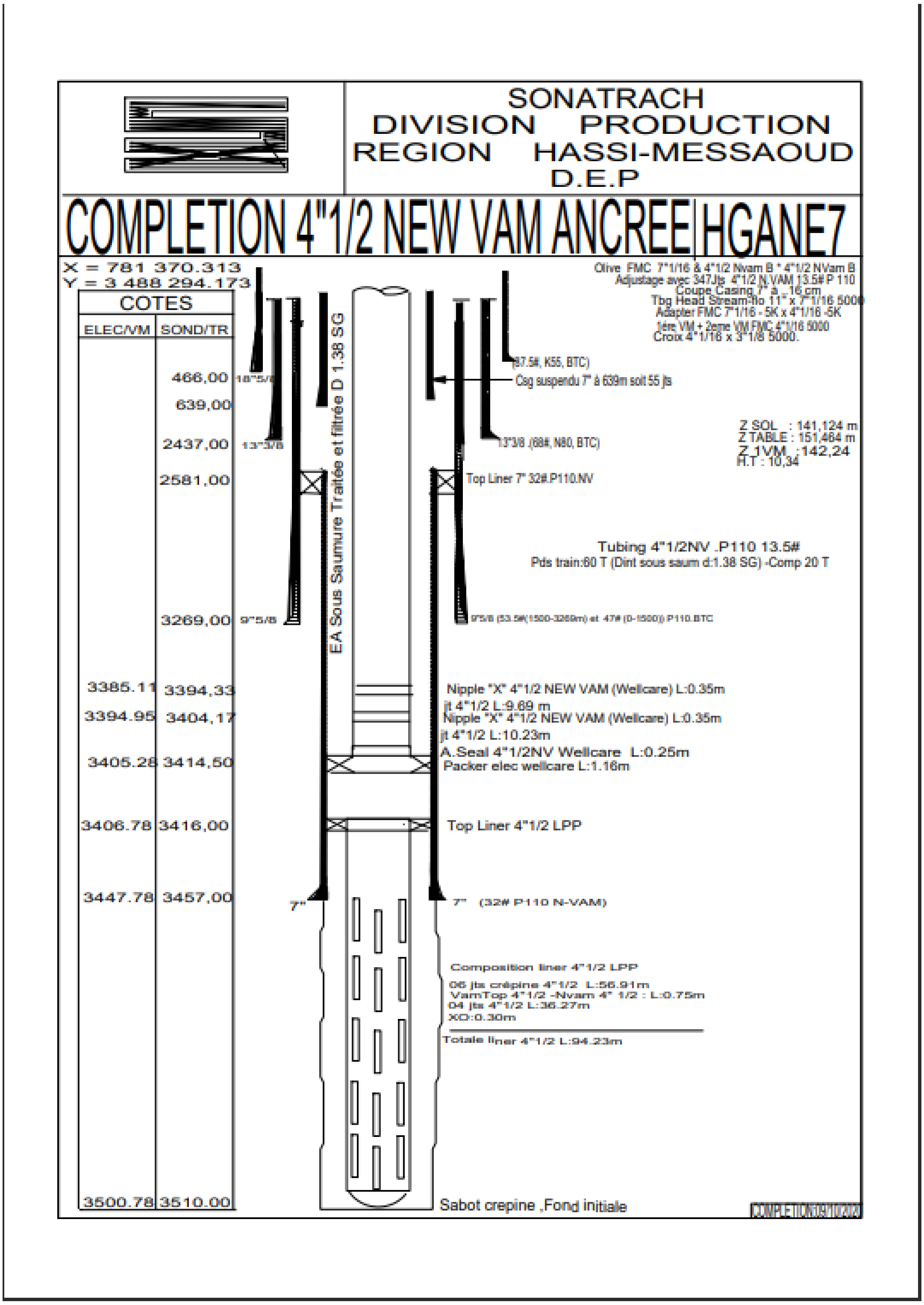
Technical Data Sheet for Well OEC1



Technical Data Sheet for Well HGANE2


SONATRACH
DIVISION PRODUCTION
REGION HASSI-MESSAOUD
D.E.P
COMPLETION 3"1/2 NEW VAM ANCREE
HGANE2
X : 781 596.993
Y : 3 487 535.968
M M
OD
ID
COTES
ELEC/VM
SOND/TR
Puits foré par l'appar EN49 le 20.01.17
Réservoir traversé avec une OBM D1.40
460.00
Csg 18"5/8 G105-87.5#
339.70
315.34
2434.00
Csg 13"3/8 BTC-N80-68#
88.90
96.40
76.00
72.80
3265.00
Csg 9"5/8BTC-P110- 53.5# & 47#
98.20
69.85
3391.17
3397.81
98.00
66.90
3401.01
3407.65
88.90
76.80
3410.95
3417.59
144.47
101.60
3411.55
3418.19
3412.36
3419.00
177.80
154.79
3465.36
3472.00
Csg 7"NV-P110-32# & 29#
114.30
99.57
122.00
96.39
3508.36
3515.00
3509.36
3516.00
127.00
100.00
3516.36
3523.00
EA Sous saumure traitée D1.40
Olive FMC 7"1/16 Taraudée 3"½NV B x 4"1/4 Acme H
Ajusté avec 364 Jts + 1PJ (2.03m) 3"½NV P110 9.20#
Casing 7" Coupé à 16.5Cm
Tbg Head FMC 11" x 7"1/16 5000
Adapteur FMC 7"1/16 x 3"1/8 5000
1ère VM + 2ème VM (FMC) 3"1/8 5000
Croix 3"1/8 x 3"1/8 5000
Z SOL : 141.959
Z TABLE : 151.099
Z 1VM : 143.459
H.T : 9.14m
Hassi Guettar Nord Est
Tubing 3"½NV P110 9.20# -R2
OTIS L.Nipple "X" 3"½NV L:0.40m
OTIS L.Nipple "XN" 3"½NV L:0.50m
Hallib Ratch Latch 4"1/2NV L:0.60m
Hallib Packer WB 7"NV (Comp:13T)
Ensemble de Suspension Baker 4"1/2NV L:8.54m
Liner Packer-Liner Hanger-Swivel
Haut Perfos
10 Tbg 4"½NV P110 13.5# R2-L:97m
Bas Perfos
Sabot Baker 4"1/2NV L:0.39m
Top bouchon ciment
Fond initial

Technical Data Sheet for Well HGANE7



Expro Production report of OEC1 well

Injection into	DATE	OEC-1 Choke size /64"	OEC-1 WHP (Barg)	Compressor total running hour (Hr)	Separator Parameters						Gas lift Parameters		Cumm Oil (Sm3/Day)
					Sep Inlet (Barg)	Separator Gas rate (SM3/H)	Separator Oil rate (SM3/H)	Separator Water rate (l/d)	Gas to Flare (Sm3/H)	GOR (SM3/SM3)	GAS LIFT (SM3/H) OEC-1	GAS LIFT Press (Barg) OEC-1	
OEC-1	05/06/2023		Mobilisation from Base to BBK - OEC 1										
	06/06/2023		Spotted ATB Equipement .										
	07/06/2023		Started rig up.										
	15/06/2023		Finished rig up.										
	17/06/2023		Equipement preflow check list and maintenance and pressure test .										
	22/06/2023		Check alignement of compressor and oil pump.										
	26/06/2023		Started separator and compressor unit with well choke size 28/64"										
	26/06/2023	28	32,63	11445,00	7,64	244,29	3,85	0,00	24,14	46,92	220,14	47,63	46,84
	27/06/2023	28	42,87	11465,00	10,77	555,80	6,07	0,00	192,93	85,90	362,87	101,19	91,20
	28/06/2023	28	46,41	11489,00	10,75	678,73	6,00	0,00	316,50	114,12	362,23	96,20	144,14
	29/06/2023	28	45,98	11513,00	10,74	679,43	6,09	0,00	316,06	112,07	363,37	93,31	147,01
	30/06/2023	28	45,50	11537,00	10,73	687,58	6,21	0,00	324,15	113,09	363,43	91,07	147,11
	01/07/2023	28	45,11	11561,00	10,73	689,09	5,99	0,00	328,15	116,34	360,94	89,40	143,14
	02/07/2023	28	44,81	11585,00	10,73	683,28	5,85	0,00	318,26	118,48	365,03	87,86	140,36
	03/07/2023	28	46,98	11609,00	10,73	759,22	5,70	0,00	371,50	128,42	387,72	85,88	137,82

HGANE2 PFD TEST

Gradient de pression et temérature HGANE2 BU 06/07/2020

Z1VM(M)	Cote WL (m)	Cote absolue (m)	Pression (kg/cm²)	Temperature C°	Gradient (kg/cm²/m)
143,45	0	-143,45	64,2981	39,69	
	200	56,55	72,6813	62,96	0,042
	500	356,55	85,9278	75,11	0,044
	1000	856,55	110,655	84,4	0,049
	1500	1356,55	138,496	92,13	0,056
	2000	1856,55	168,451	103,14	0,060
	2500	2356,55	199,133	110,91	0,061
	2800	2656,55	217,343	114,24	0,061
	3000	2856,55	229,605	116,3	0,061
	3100	2956,55	235,823	117,61	0,062
	3399	3255,55	255,297	119,95	0,065

HGANE7 PFD TEST

Gradient de pression et temératurе HGANE7 PFD 09/02/2022

Z1VM(M)	Cote WL (m)	Cote absolue (m)	Pression (kg/cm^2)	Temperature C°	Gradient ($kg/cm^2/m$)
142,24	0	-142,24	63,21	56,78	
	190	47,76	71,44	64,35	0,043
	490	347,76	85,95	73,22	0,048
	790	647,76	100,93	80,92	0,050
	1090	947,76	118,11	90,15	0,057
	1490	1347,76	141,93	99,28	0,060
	1890	1747,76	165,15	103,23	0,058
	2290	2147,76	189,91	112,63	0,062
	2690	2547,76	214,40	116,34	0,061
	2890	2747,76	226,57	118,37	0,061
	3090	2947,76	238,39	119,97	0,059
	3290	3147,76	250,74	120,6	0,062
	3390	3247,76	256,84	120,02	0,061
	3430	3287,76	259,26	121,1	0,061
	3450	3307,76	260,46	121,17	0,060
	3470	3327,76	261,68	121,23	0,061
	3480	3337,76	262,28	121,32	0,060
	3490	3347,76	262,96	121,36	0,068