Exploration and Production LTD

INTERN REPORT

DURATION - 1 JULY 2023 - 31st JULY 2023

Prepared by -
NIKHIL NEMNANI
Branch - B. Tech, Petroleum Engineering
Indian Institute of Technology (Indian School of Mines), Dhanbad

UNDERTAKING

I, **Nikhil Nemnani** , a 3rd year student at the Indian Institute of Technology (Indian School of Mines), Dhanbad, am doing a Summer Internship at Essar Oil and Gas Exploration and Production Limited, Durgapur, West Bengal, from **1st June 2023** to **31st July 2023** in the **Sub- Surface Department**.

I undertake the following:

That I will not disclose any confidential information (proprietary information) received from EOGEPL to any other person, company, organisation, or firm, as I know that confidential information cannot be sold, exchanged, published, or disclosed to anybody in anyway, including photocopies or reproduced materials, etc. without the prior written consent of EOGEPL.

That I will keep confidentiality to the highest extent in order to avoid the disclosure or use of information received during the internship.

That I will not publish/ use data provided by EOGEPL anywhere in India or outside India.

That if I am proven to be guilty of the disclosure of confidential or proprietary information, EOGEPL has the right to reimbursement of damages borne due to the disclosure.

DATE - 1st July 2023 **NIKHIL NEMNANI**

PLACE - Durgapur, West Bengal

ACKNOWLEDGEMENT

I would like to take this opportunity to express my heartfelt gratitude to everyone who has played a pivotal role in making my summer internship at **Essar Oil and Gas Exploration and Production Ltd.** a truly enriching and valuable experience. The knowledge and skills I acquired during this internship will undoubtedly shape my future oil and gas industry career.

First and foremost, I would like to extend my deepest appreciation to **Mr. V. Magesh Iyer** and **Mr. Anand More** for their exceptional mentorship in the Reservoir domain. Their extensive expertise and guidance have been instrumental in expanding my understanding of reservoir engineering concepts and techniques. I am immensely grateful for their patience, support, and insightful inputs that have greatly enhanced my learning experience.

Special thanks to **Mr. Ram Niwas, Mr. Karan Raj , Mr. Kriti Raj** for their guidance in Hydraulic Fracturing. Their expertise and support have been invaluable in helping me grasp the intricacies of hydraulic fracturing techniques and their role in optimising oil and gas production. I am thankful for their valuable input and guidance throughout my internship

I also extend my gratitude to **Ms. Troyee Dasgupta** for her invaluable guidance in the field of well-logging analysis. Her expertise and willingness to share her knowledge have been instrumental in helping me comprehend the intricacies of well-logging techniques and their applications. I am truly thankful for her continuous support and valuable feedback throughout my internship.

Furthermore, I would like to acknowledge the contributions of **Mr. Joydeep Mandal** and **Mr. Saransh Maheshwari** in providing me with valuable insights into PCP pumps. Their expertise and guidance have significantly deepened my understanding of the functioning and applications of PCP pumps in the oil and gas industry. I am grateful for their patience, support, and willingness to share their knowledge.

I would also like to extend my gratitude to **Ms. Bhoomika Bakshi** for her assistance in ensuring a smooth onboarding process and making me feel welcome at Essar Oil and Gas Exploration and Production Ltd. Her warm support and cooperation have contributed to a positive and conducive work environment, allowing me to focus on my internship objectives.

Finally, I want to express my appreciation to the entire team at Essar Oil and Gas Exploration and Production Ltd. for their cooperation, encouragement, and willingness to share their knowledge and experiences. The collaborative atmosphere and the opportunities provided for hands-on learning have been instrumental in my professional growth.

In conclusion, I would like to extend my sincere appreciation to all those mentioned above and anyone else who has contributed to my growth during this summer internship. Your mentorship, guidance, and support have been invaluable, and I am deeply grateful for the opportunity to learn from each one of you.

Thank you.

Sincerely,

Nikhil Nemnani

TABLE OF CONTENTS

HEALTH AND SAFETY TRANING

Health and safety in the oil and gas industry are of paramount importance due to the inherent risks associated with the exploration, extraction, refining, and distribution of petroleum products. The industry operates in challenging onshore and offshore environments and involves complex processes and equipment.

Effective health and safety practices are crucial to protect workers, the environment, and surrounding communities. Here are some key aspects of health and safety in the oil and gas industry:

Risk Assessment: Companies conduct comprehensive risk assessments to identify and evaluate potential hazards and risks associated with their operations. This includes analysing equipment, processes, and work environments to determine potential sources of accidents or injuries.

Regulatory Compliance: Oil and gas companies are subject to strict regulations and standards set by government agencies and industry bodies. These regulations cover various aspects such as workplace safety, environmental protection, emergency response, and occupational health. Companies must adhere to these regulations to ensure the safety of their workers and minimise environmental impact.

Personal Protective Equipment (PPE): Workers in the oil and gas industry are required to use appropriate personal protective equipment, including hard hats, safety glasses, gloves, flame-resistant clothing, and respiratory protection. PPE helps protect against hazards such as falling objects, chemical exposure, and fire.

Process Safety Management: Process safety management focuses on preventing major incidents, such as explosions, fires, or toxic releases, that can cause significant harm to workers and the environment. It involves implementing safety procedures, conducting regular inspections, and maintaining critical equipment to ensure safe operation.

Emergency Preparedness and Response: Oil and gas companies develop comprehensive emergency response plans to address potential accidents, natural disasters, or other incidents. These plans include evacuation procedures, communication protocols, medical response, and coordination with local emergency services.

Training and Education: Proper training and education are essential for workers to understand potential hazards and safety procedures. Employees receive training on topics such as equipment operation, emergency response, hazard communication, and the proper use of safety equipment. Ongoing training and refresher courses are conducted to keep workers updated on best practices.

Environmental Protection: The oil and gas industry is increasingly focused on minimising its environmental impact. Companies implement measures to prevent spills, manage waste, reduce emissions, and conserve resources. Environmental monitoring and regular audits ensure compliance with regulations and identify areas for improvement.

Contractor Management: Many oil and gas companies engage contractors for specialised tasks. Effective contractor management systems are essential to ensure that contractors adhere to the same health and safety standards as the company's employees.

Incident Investigation and Lessons Learned: When incidents occur, thorough investigations are conducted to determine the root causes and prevent future occurrences. Lessons learned from incidents are shared across the industry to improve safety practices collectively.

Safety Culture: Establishing a strong safety culture is vital to promote a proactive approach to health and safety. This involves fostering a mindset of continuous improvement, empowering employees to identify and report hazards, and promoting open communication between workers and management.

It is important to note that health and safety practices in the oil and gas industry can vary between companies and regions, depending on local regulations and specific operational conditions. However, the overarching goal is to ensure the well- being of workers, protect the environment, and maintain the integrity of operations.

Reservoir Estimation And production forecasting-

Production system-1. Source rock

2. Reservoir rock

Basically in CBM both reservoir rock and source rock are the same.
But in conventional reservoirs source rocks are below the reservoir rock so by some means or methods we bring our oil or any fluid to the reservoir rock.

Now for estimation of the reserves we do this by 3 methods-

1. Material Balance Equations
2. DCA(Decline curves)
3. Reservoir simulation(Above two methods are used in reservoir simulation)

After these 3 methods we do the history match of those.

These reserves are economically and technically recoverable by some methods and means.

Now there are different means in both conventional and unconventional reservoirs-

To understand the above part the basic difference between conventional reservoirs and unconventional reservoirs have to understand -

Conventional-

Here we do oil production. So to increase production we increase the pressure inside the wellbore so tha oil can travel from high pressure to low pressure easily and come to the subsurface easily.To increase production here economically and technically there are three methods-

1.Primary-

2.Secondary-In this we do water injection inside the well to increase the pressure.

3.Tertiary-

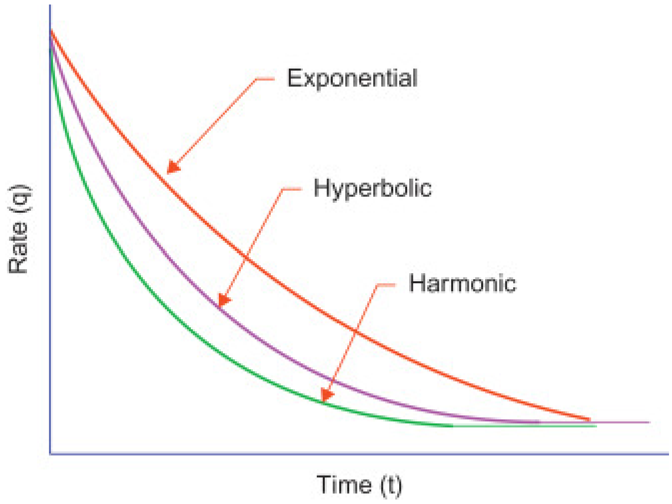
Then there are some drive mechanisms also to increase production .

Non-Conventional-

In this we pump out the water to lower the pressure inside because the gas is adsorbed in the inside structure of the coal so after reducing the pressure the gas can come outside and we can extract it. In this HF is also important for making conductive paths and making the well producible.In this there is also a **gas isotherm concept.**These wells have low permeability also.

So all these are used to make reserves economically and technically recoverable.

Decline Curves Analysis(DCA)-



Golden rule of decline curve analysis-

The basic assumption in this procedure is that whatever causes controlled the trend of a curve in the past will continue to govern its trend in the future in a uniform manner

What are Decline curves?

Decline curves are graphical representations that show how the production rate of a well or a group of wells decreases, or declines, over the life of the reservoir.

Why are they used?

In reserve estimation for oil and gas fields, decline curves are a crucial tool used to forecast the future production decline of a well or a group of wells over time.

Why is there a decline in production?

The decline is a result of various factors, including the natural depletion of reservoir pressure, increased water or gas influx, and the changing properties of the reservoir rock and fluids.Oil and gas production rates decline as a function of time; loss of reservoir pressure, or changing relative volumes of the produced fluids, are usually the cause

How decline curves are generated?

Decline curves are generated by plotting historical production data, usually monthly or yearly production rates, against time.

How are its data points analysed?

These data points are then analysed to identify a trend or pattern that describes the rate of production decline over time. Different mathematical models can be used to fit the decline curve to the data, and the choice of model depends on the characteristics of the reservoir and the production history.

Common types of decline curves-

1.Exponential decline-

This model assumes that the production rate declines at a constant percentage over time. It is suitable for some naturally flowing wells.

2.Hyperbolic decline-

This model is often used for wells that experience a more gradual decline after the initial high production period. The decline rate decreases over time.

3.Harmonic decline-

This model represents a smooth decline with decreasing production rate over time.

Uses of declining curves-

Decline curves are valuable tools for estimating future production rates and predicting the remaining recoverable reserves of a well or a field. By extrapolating the decline curve into the future, reservoir engineers and production analysts can make informed decisions about field development, well performance, and economic viability. These predictions help in optimising production strategies, planning well workovers, and managing overall field development plans. However, it's important to note that decline curves are based on historical data and certain assumptions, and actual production rates may vary due to various uncertainties and unexpected events in the reservoir's behaviour.

Nominal and Effective decline

- There are two types of decline factors (often called the decline rate).
- The nominal decline factor d is defined as the negative slope of the curve representing the natural logarithm of the production rate q vs. time t or :

$$d = -\frac{d(\ln q)}{dt} = -\frac{1}{q}\frac{dq}{dt}$$

- Nominal decline is a continuous function and it is the decline factor that is used in the various mathematical equations relating to decline curve analysis. For exponential decline it is a constant with time.
- The effective decline factor D is a stepwise function that is in better agreement with data recording practices. It is the drop in production rate from qi to q1 over a specific time period.
- It is defined as

$$D = \frac{q_i - q_1}{q_i}$$

- D is the effective decline rate = the decline rate over a time period.
    - This is the decline often quoted in e.g. commercial software decline graphs. Such software may, at user's discretion, report nominal decline.
    - It is the proportion by which the production rate reduces over a given time period.
    - D is a constant only for constant percentage or exponential decline.
    - D decreases with time for hyperbolic and harmonic decline
    - (1> b > 0)
- It is easy to convert from a nominal decline factor to an effective decline factor and vice versa.

$$D = 1 - e^{-d}$$

Exponential declining-

An exponential curve is a type of mathematical model that exhibits exponential growth or decay. It is characterised by a constant percentage change over equal intervals of time. In other words, the rate of change of the variable being measured (e.g., production rate) is proportional to its current value.

The general form of an exponential curve can be represented as:

$$y = a * e^{(bx)}$$

where:

- y is the value of the variable at time x.
- a and b are constants.
- e is the base of the natural logarithm, approximately equal to 2.71828.

In the context of reserve estimation for oil and gas fields, the exponential curve is often used as one of the decline curve models to forecast future production rates of wells or reservoirs. The exponential decline model assumes that the production rate of a well will decline at a constant percentage over time.

To use the exponential curve for reserve estimation, historical production data for the well or reservoir is analysed. The decline curve is fitted to this historical data using mathematical techniques to determine the values of the constants 'a' and 'b' in the exponential equation.

Once the decline curve is fitted, it can be extrapolated into the future to estimate the future production rates of the well or reservoir. This projection helps in predicting the remaining recoverable reserves and the economic viability of the field.

However, it's important to note that the exponential decline model is based on certain assumptions, and its accuracy may depend on the specific characteristics of the reservoir and the production history. In some cases, the exponential decline model may not accurately capture the decline behaviour, especially if the reservoir experiences complex production mechanisms or has other factors affecting the production rate.

As a result, other decline curve models like hyperbolic or harmonic decline curves are also commonly used in reserve estimation to provide more flexibility and accuracy in capturing different production decline patterns observed in oil and gas fields. The choice of the decline curve model depends on the specific reservoir characteristics, production history, and the objectives of the reserve estimation study.

Reservoir types with exponential decline-

- Oil reservoirs
  - Above the bubble point
  - Down dip wells with gravity drainage
  - Solution gas drive with unfavourable kg/ko
- Gas reservoirs
  - High reservoir pressure (liquid-like compressibilities)
  - Wells with liquid-loading problems
- Both oil and gas reservoirs
  - Produced with small drawdown relative to reservoir pressure
  - Tubing limited wells.

Cumulative production being analysed-

$$Np = \int_{t1}^{t2} q\,dt = \int_{t1}^{t2} q_i e^{-dt}$$

$$= \frac{q_1 - q_2}{d}$$

- q = current production rate
- qi = initial production rate (start of production)
- di = d = dt = nominal decline rate (a constant)
- t = cumulative time since start of production

Hyperbolic Declining-

A hyperbolic curve is a mathematical model that describes a type of production decline behaviour commonly observed in oil and gas reservoirs. Unlike the exponential curve, which assumes a constant percentage decline over time, the hyperbolic decline curve accounts for a more gradual and variable decline rate.

The general form of a hyperbolic decline curve can be represented as:

q(t) = q(i) / (1 + b *di* t)^1/b

where:

- q(t) is the production rate at time t.
- q(i) is the initial production rate.
- b constants.
- di=initial nominal decline rate at t = 0

Cumulative production-

$$N_p = \left[\frac{q_i^b}{(b-1)d_i}\right] * \left[q^{(1-b)} - q_i^{(1-b)}\right]$$

- q = current production rate
- qi = initial production rate (start of production)
- di = initial nominal decline rate at t = 0
- t = cumulative time since start of production
- Np = cumulative production being analysed
- b= hyperbolic decline constant (0 < b < 1)
- This is the most general formulation for decline curve analysis. Exponential (b=0) and harmonic (b=1) decline are special cases of this formula.

The hyperbolic decline model suggests that as the production time (t) increases, the decline rate becomes slower due to the reservoir's natural depletion mechanisms. The value of the constant 'n' determines the rate at which the decline rate slows down over time. Smaller values of 'n' indicate a slower decline, while larger values indicate a faster decline.

To use the hyperbolic curve for reserve estimation, historical production data for the well or reservoir is analysed. The decline curve is fitted to this historical data using mathematical techniques to determine the values of the constants 'q(i)', 'b', and 'n' in the hyperbolic equation.

Once the decline curve is fitted, it can be extrapolated into the future to estimate the future production rates of the well or reservoir. This projection helps in predicting the remaining recoverable reserves and the economic viability of the field.

The hyperbolic decline curve is widely used in the oil and gas industry for reserve estimation and production forecasting. It is particularly useful for reservoirs that exhibit a gradual decline after the initial high production period. Many oil and gas reservoirs tend to show hyperbolic decline behaviour due to factors like pressure depletion, water or gas influx, and changing reservoir characteristics.

The accuracy of reserve estimates and production forecasts depends on the quality of the data, the choice of the appropriate decline model, and the reservoir's complex behaviour. Therefore, reservoir engineers and analysts often use multiple decline curve models and apply judgement based on their understanding of the reservoir's dynamics for more reliable reserve estimates.

Comparison between hyperbolic and exponential declining-

When compared to the exponential decline curve, the hyperbolic decline curve offers a more flexible and realistic representation of the actual production decline observed in many reservoirs. However, it's essential to recognize that the hyperbolic decline curve, like any other decline curve model, is based on certain assumptions and simplifications.

Harmonic decline

- **Flow Rate**

$$q = \frac{q_i}{(1 + d_i t)}$$

- **Cumulative production**

$$N_p = \left[\frac{q_i}{d_i}\right] * \ln\left[\frac{q_i}{q}\right]$$

- Variables
  - q = current production rate
  - qi = initial production rate (start of production)
  - di = initial nominal decline rate at t = 0
  - t = cumulative time since start of production
  - Np = cumulative production being analysed
  - A simple formula – often the most optimistic case
- Plot of log rate vs. cumulative production is a straight line on a semi-log plot.

Decline curves for reserve estimates

A major use of decline curve analysis is made in estimation of reserves. Even for the assets where history matched simulation models are available, a cross check with DCA is normally made to give increased confidence in numbers.

References-

1.GRI(Gas Research Institute)
2.Wikipedia