Introduction to Petroleum Engineering

An Online Continuing Education Course for Engineers

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Introduction To Petroleum Engineering

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Petroleum Engineering

Petroleum engineering is the field of engineering concerned with production of hydrocarbons, which can be either crude oil or natural gas. Exploration and Production are deemed to fall within the upstream sector of the oil and gas industry. Exploration, by earth scientists, and petroleum engineering are the oil and gas industry's two main subsurface disciplines, which focus on maximizing economic recovery of hydrocarbons from subsurface reservoirs. Petroleum geology and geophysics focus on provision of a static description of the hydrocarbon reservoir rock, while petroleum engineering focuses on estimation of the recoverable volume of this resource using a detailed understanding of the physical behavior of oil, water and gas within porous rock at very high pressure.

The combined efforts of geologists and petroleum engineers throughout the life of a hydrocarbon accumulation determine the way in which a reservoir is developed and depleted, and usually they have the highest impact on field economics.

Petroleum engineering is divided into several groups:

- Petroleum geologists find hydrocarbons by analyzing subsurface structures with geological and geophysical methods.
- Petrophysicists analyze log data after drilling to check the hydrocarbon availability and the rock types.
- Reservoir engineers work to optimize production of oil and gas via proper well placement, production levels, and enhanced oil recovery techniques.
- Drilling engineers manage the technical aspects of drilling exploratory, production and injection wells. It also include mud engineer who manage the quality of drilling fluid.
- Production engineers, including subsurface engineers, manage the interface between the reservoir and the well, including perforations, sand control, downhole flow control, and downhole monitoring equipment; evaluate artificial lift methods; and also select surface equipment that separates the produced fluids (oil, gas, and water).

History of Petroleum

Petroleum belongs to the minerals that have been used by humanity since the earliest ages, earlier than metals and coal, and for numerous different purposes. The people and tribes who found and used these useful but unusual materials gave them many different names in their languages like “sweat of the devil”, “oil from rocks”, “shining water” and many others. Some of these names have survived thousands of years. For example: “naptha” which is coming from the “Babylonians” and “Assyrians” and petros derived from the Greek word “petros” for rock, and the Roman word petroleum for oil. Reports on petroleum and especially on the use and production of petroleum have been found in esopotamian libraries about 4000 years BC. For thousands of years, the only source of petroleum had been surface springs or tar pits. However most of these finds were not very productive. Therefore people began to look for oil under the earth. In Pennsylvania, Colonel Edwin Drake drilled 69 feet and struck oil in 1859. That day, August 27, 1859 is dated as the birthday of oil industry in USA. Even though, James Williams had completed the first commercially producing oil well one year earlier and oil seekers in Azerbaijan did the same few years earlier. Drake went one step further and he proved that oil could be obtained in sufficient quantities to meet the increasing demand by drilling through rock.

Definition of Petroleum

Petroleum is a mixture of naturally occurring hydrocarbons that may exist in the solid, liquid or gaseous states, depending upon the conditions of pressure and temperature to which it is subjected. Virtually all petroleum is produced from the reservoir in either liquid or gaseous form, and commonly, these materials are referred to as either crude oil or natural gas, depending upon the state of the hydrocarbon mixture. Petroleum consists of approximately 11-13 wt % hydrogen and 84-87 wt % of carbon. Traces of oxygen, sulphur, nitrogen and helium may be found as impurities in crude oil. Crude oils obtained from different oil reservoirs have widely different characteristics. Some are black, heavy, and thick like tar, and others are brown or nearly clear with low viscosity and low specific gravity. However, nearly all crude oils have elemental analyses within the limits given below.

Table 1. Elemental Analysis of Typical Crude Oils

Element	**% by wt**
Carbon	84-87
Hydrogen	11-14
Sulphur	0.06-2.0
Nitrogen	0.1-2.0
Oxygen	0.1-2.0

Table 2. Typical crude oil fractions

Crude Fractions	Boiling Point, °F	Chemical Composition	Use
Hydrocarbon gas		C_1-C_4	Natural gas, bottled fuel gas
Petroleum ether	To 160	C_5-C_6	Solvent, paint thinner, cleaner
Gasoline	160-400	C_7-C_8	Motor fule, solvent
Kerosene	400-575	C_{10}-C_{16}	Illuminating oil, diesel fuel, jet fuel
Light gas oil	575-850	C_{16}-C_{30}	Lubricating oil, mineral oil, cracking stock
Heavy gas oil	850-1100	C_{30}-C_{50}	Lubricating oil, bunker fuel
Residue	1200+	C_{80+}	Tars, asphalts, wood preservatives, roofing compounds

Exploration and Production Process

The oil and gas extraction industry can be classified into four major processes:

(1) exploration,
(2) well development,
(3) production, and
(4) site abandonment.

Exploration involves the search for rock formations associated with oil or natural gas deposits, and involves geophysical prospecting and/or exploratory drilling.

Well development occurs after exploration has located an economically recoverable field, and involves the construction of one or more wells from the beginning (called spudding) to either abandonment if no hydrocarbons are found, or to well completion if hydrocarbons are found in sufficient quantities

Production is the process of extracting the hydrocarbons and separating the mixture of liquid hydrocarbons, gas, water, and solids, removing the constituents that are non-saleable, and selling the liquid hydrocarbons and gas. Production sites often handle crude oil from more than one well. Oil is nearly always processed at a refinery; natural gas may be processed to remove impurities either in the field or at a natural gas processing plant.

Oil and Gas Exploration, and Production Life Cycle

Before making an acquisition or investment, applying for an exploration license or farming-in to an existing project, an extensive risk-screening process need to be carried out which includes assessing whether there are potential health and safety, social, human rights, political, corruption, security or environmental impacts. This is used in decision-making on whether or not to proceed, and if investment goes ahead, it informs approaches to risk management going forward.

When an exploration license is applied, the necessary documents are submitted to the relevant authorities. Typically this includes information about our legal status, financial capability, technical competence and plans to manage health, safety and environmental risks, and contributions to local economic development.

Once it has been awarded the right to explore in a certain area, seismic surveys may be carried out to develop a picture of geological structures below the surface. This helps identify the likelihood of an area containing hydrocarbons. Seismic surveys are usually preceded by an assessment of environmental, social and human rights impacts, which are managed through the Project Delivery Process (PDP).

Before commencing any drilling activity, site surveys are carried out to gain more detailed information on the area where an exploration well may be drilled, and to confirm that the selected drilling location is safe and that any sensitive environments can be avoided.

The process normally involves taking geological samples from the seabed and carrying out shallow seismic surveys. These activities have low social and environmental impacts and, therefore, usually do not require a separate Environmental Impact Assessment (EIA) or Social Impact Assessment (SIA).

Exploration wells are drilled to determine whether oil or gas is present. This phase can be accompanied by a step-change in activity and visibility to local people, as offshore exploration can involve a drilling rig, supply vessels and helicopters for transporting personnel.

Exploration drilling is preceded by an assessment to understand potential health, safety, environmental, social, security and human rights impacts. This identifies appropriate steps to reduce impacts and operate responsibly. Limited community development programs may also be put into place at this time depending on the nature of the programs.

If promising amounts of oil and gas are confirmed during the exploration phase, field appraisal is used to establish the size and characteristics of the discovery and to provide technical information to determine the optimum method for recovery of the oil and gas. The potential

social and environmental impacts associated with appraisal drilling are comparable to exploration drilling, and similar assessments are carried out in advance.

If appraisal wells show technically and commercially viable quantities of oil and gas, a development plan is prepared and submitted to the relevant authorities for approval. This includes a rigorous assessment of all the potential risks and a long-term assessment of environmental and social impacts covering a timeframe of between 10 and 30 years. The plan will also detail projected benefits to local communities, for example employment and supplier opportunities, as well as proposing how to manage potential impacts such as an influx of workers from outside the local community.

A variety of options are available for the production of oil and gas. During this phase, which can last many decades, regular reviews are made of social and environmental performance to ensure that impacts identified in the assessments are mitigated. Changes in the risks associated with activities are assessed throughout the production period.

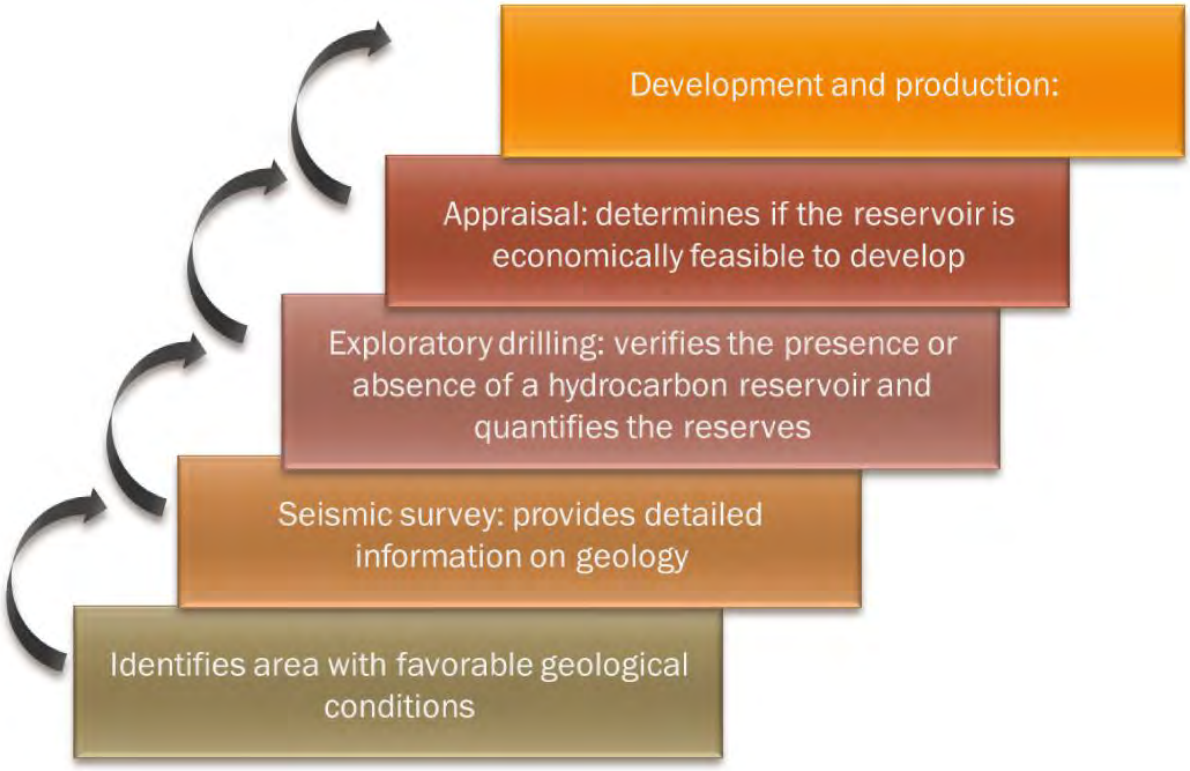

Figure 1

BASIC PETROLEUM GEOLOGY

Introduction

The oil and natural gas that are produced from oil and gas fields reside in porous and permeable rocks (reservoirs) in which these liquids have collected and accumulated throughout the vast expanse of geologic time. Oil and gas fields are geological features that result from the coincident occurrence of four types of geologic features: (1) oil and gas source rocks, (2) reservoir rocks, (3) seals, and (4) traps. Each of these features is discussed and illustrated below and the role of each type of feature in our natural oil and gas system is emphasized.

Role of the Geologist

Why Geoscience is important in Petroleum Engineering

- Sources of hydrocarbons are in rocks – most of them in sedimentary rocks.
- The hydrocarbon is contained within a pore (void space) or fracture system (or both) within the rocks
- Depositional processes, and the changes that subsequently occur during burial, control the geometry of the hydrocarbon-bearing layers in the subsurface
- Geological maps and cross sections define where the oil
- Rock properties define how much hydrocarbon there can be in the ground and how much of it can be economically recovered.
- Wells are drilled through rocks to recover hydrocarb
- The minerals that make up the r ce the distribution of oil and water in a

The production geolog es production for a field and looks for ways of g a specific role. The production geologist is e work of the reservoir and creating a represent object of this model is to help understand how t ducing reservoir and creates dead ends that co l-end pockets may be worth targeting with new will then take a leading role in planning t

Petroleum geologists assig ing as part of a multi disciplinary team. In nager, geologists, geophysicists, petro physic nists, and technical assistants. Some teams ma ologists.