Tikrit University

College of Petroleum Processes Engineering

Department of Petroleum Refining Engineering

Specialized Petroleum Processes

Fourth Class

Lecture 3

By

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Crude Oil Processing from Oilfield to Refinery

Well Fluid Compositions

Fluid flow from a well can include gas, free water, condensable vapors (water or hydrocarbon), crude oil, and solid debris (basic sediment). The proportion of each component varies in different well streams. When water is produced with crude oil, it is mixed in either or both of the following forms:

- **Free Water/Produced Water**: Water mixed with the oil but will separate easily into a clear layer when the mixture is allowed enough time to settle.
- **Emulsion**: Water can also be mixed with the oil in the form of very small droplets of water coated with oil. A mixture like this is called emulsion. Water in this case cannot be easily separated from oil and need to undergo **demulsifications process** in order to remove the water content in crude.

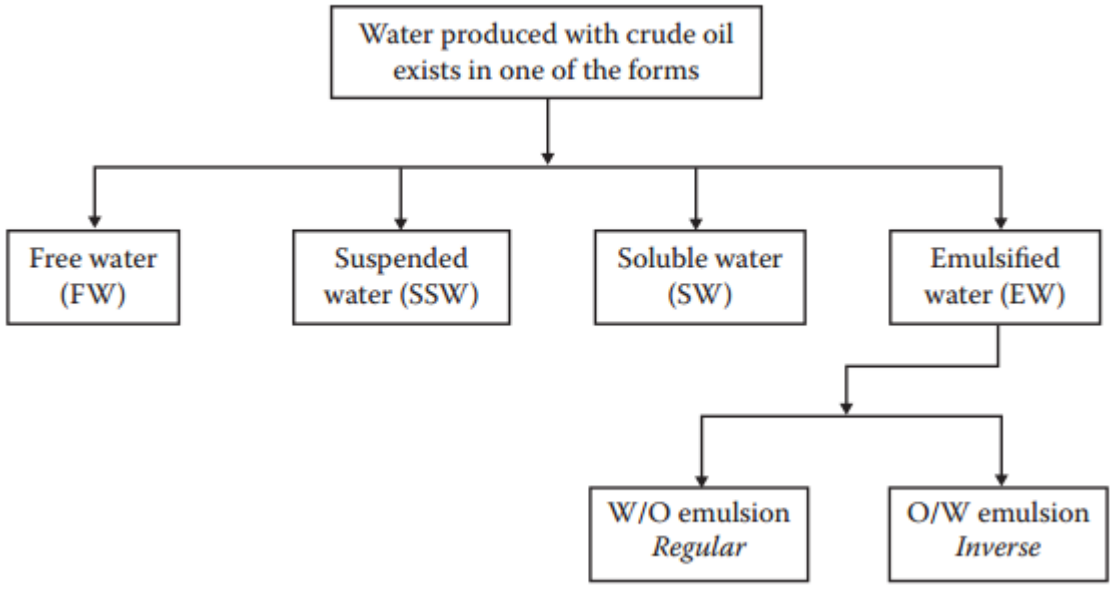

Figure 1: Forms of saline water produced with crude oil.

2. Oil Dehydration and Emulsion Treatment

Introduction

Once crude oil is separated, it undergoes further treatment steps. An important aspect during oil field development is the design and operation of wet crude handling facilities. One has to be aware that not all the water is removed from crude oil by gravity during the first stage of gas–oil separation. Separated crude may contain up to 15% water, which may exist in an emulsified form. The objective of the dehydration step is a dual function:

- To ensure that the remaining free water is totally removed from the bulk of oil
- To apply whatever tools necessary to break the oil emulsion.

In general, free water removed in the separator is limited to water droplets of 500 μm and larger. Oil stream leaving the separator would normally contain free water droplets that are smaller in size, in addition to the water emulsified in oil. Produced crude oil contains sediment and produced water (BS&W), salt, and other impurities. These are readily removed from the crude oil through this stage. The waste water may be used as utility or discharged as water effluents to the sea. In either case, the water must be treated for solid particles removal, de-oxygenation, bacteria and hydrocarbon recovery at skimmer pit. Clean, dehydrated oil flows from the top of the vessel. Depending on the salt specifications, a combination dehydrator followed by a desalter may be required.

The treatment process and facilities should be carefully selected and designed to meet the contract requirement for BS&W. The basic principles for the treating process are as follows:

- Breaking the emulsion, which could be achieved by either any or a combination of the addition of heat, the addition of chemicals, and the application of electrostatic field
- Coalescence of smaller water droplets into larger droplets
- Settling, by gravity, and removal of free water

Oil Emulsions

Oil emulsions are mixtures of oil and water. In general, an emulsion can be defied as a mixture of two immiscible liquids, one of which is dispersed as droplets in the other (the continuous phase) and is stabilized by an emulsifying agent. The normally form water-in-oil emulsion (W/O emulsion), in which water is dispersed as fie droplets in the bulk of oil. This is identified as part (c) in Figure 2. However, as the water cut increases, the possibility of forming reverse emulsions (oil-in-water, or O/W emulsion) increases, as shown by part (b) in Figure 2.

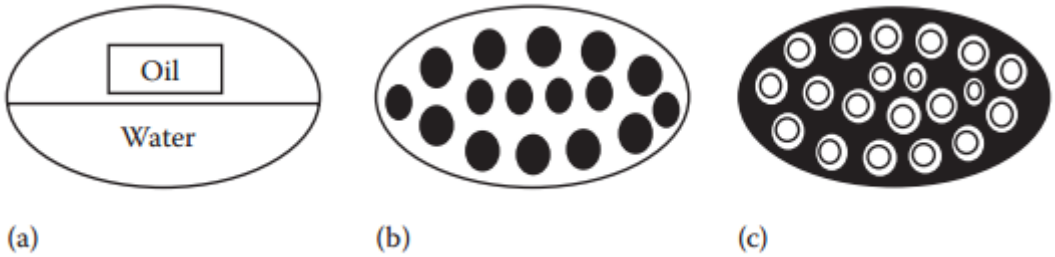

Figure 2: Schematic representations of different forms of emulsions. (a) Two immiscible fluids, (b) O/W inverse emulsion, and (c) W/O normal emulsion

For two liquids to form a stable emulsion, three conditions are to be fulfilled:

- The two liquids must be immiscible.
- There must be sufficient energy of agitation to disperse one phase into the other.
- An emulsifying agent must be present.

Emulsifying Agents

If an oil emulsion is viewed through a microscope, many tiny spheres or droplets of water will be seen dispersed through the bulk of oil, as depicted in Figure 3. A tough film surrounds these droplets; this is called a stabilizing film. Emulsifying agents, which are commonly found in crude oil or water in the natural state or introduced in the system as contaminants during drilling and maintenance operations, create this type of film. Some of the common emulsifiers are as follows:

- Asphaltic materials
- Resinous substances
- Oil-soluble organic acids
- Finely dispersed solid materials such as sand, carbon, calcium, silica, iron, zinc, aluminum sulfate, and iron sulfide

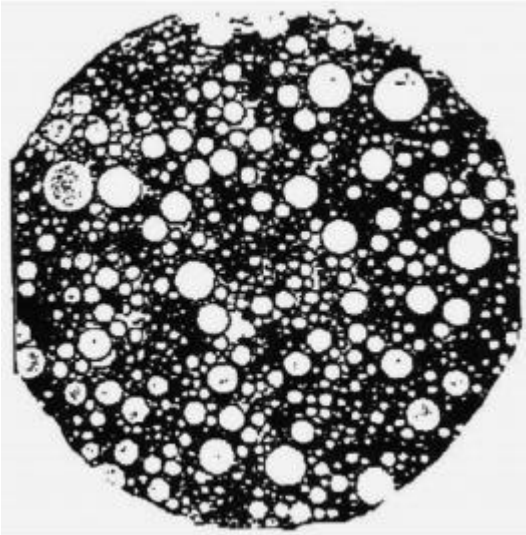

Figure 3: Photomicrograph of loose emulsion containing about 30% emulsified water in the form of droplets ranging in diameter from about 60 μm downward.

The relative difficulty of separating an emulsion into two phases is a measure of its stability. A very stable emulsion is known as a tight emulsion and its degree of stability is influenced by following factors:

- Viscosity of oil (separation is easier for a less viscous oil phase).
- Density or gravity difference between oil and water phases (larger difference is better).
- Interfacial tension between the two phases (lower force is better).
- Size of dispersed water droplets (the larger the size of water drops, the faster is the separation).
- Percentage of dispersed water (the presence of a small percentage of water in oil under turbulence conditions could lead to a highly emulsified mixture).
- Salinity of emulsified water (highly saline water will lead to a faster separation because of a higher density difference between the oil and the water phases).

Dehydration/Treating Processes

The method of treating wet crude oil for the separation of water associated with it varies according to the form(s) in which water is found with the crude. Free-water removal comes fist in the treating process, followed by the separation of *combined* or emulsifid water along with any foreign matter such as sand and other sediments. The basic approaches of handling wet crude oils are illustrated in Figure 4.

A dehydration system in general comprises various types of equipment. Most common are the following:

- Free-water knockout vessel
- Wash tank
- Gun barrel
- Flow treater (heater-treater)
- Chemical injector
- Electrostatic dehydrator

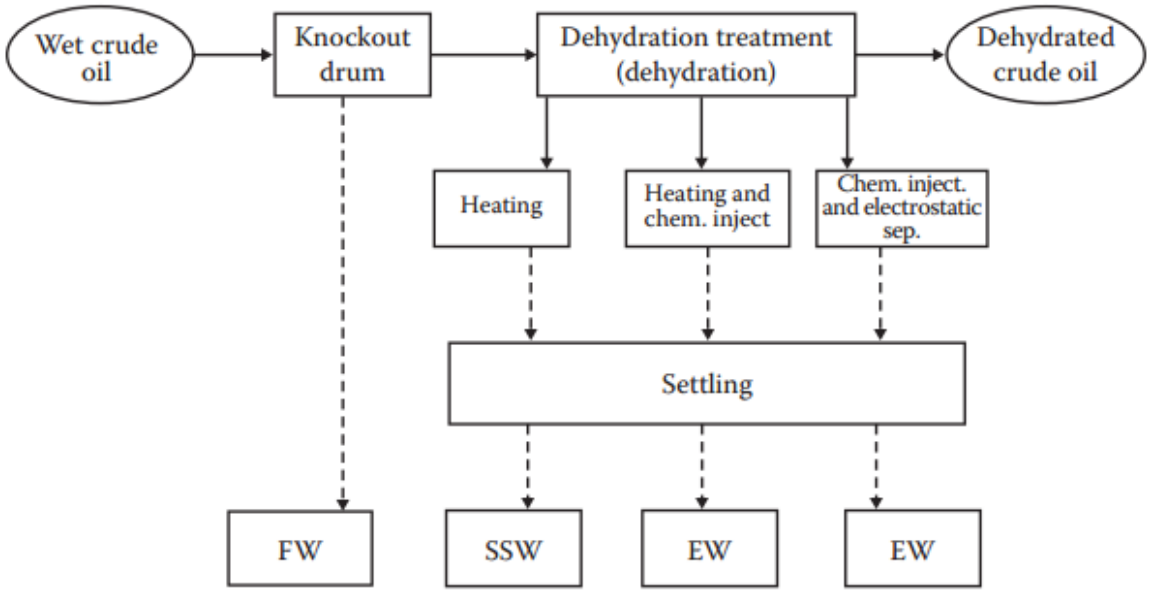

Figure 4: Basic approach of handling wet crude oil. (EW, emulsifid water; FW, free water; SSW, suspended water)

Removal of Free Water

Free water is simply defied as that water produced with crude oil and will settle out of the oil phase if given little time. There are several good reasons for separating the free water first:

- Reduction of the size of flow pipes and treating equipment
- Reduction of heat input when heating the emulsion (water takes about twice as much heat as oil)
- Minimization of corrosion, because free water comes into direct contact with the metal surface, whereas emulsified water does not.

Further, free water contributes to what is called water wash, which is the action of the salt water to break the oil emulsions. Free water removal takes place using a knockout vessel, which could be an individual piece of equipment or incorporated in a flow treater.

Resolution of Emulsified Oil

Resolution of emulsified oil is the heart of the dehydration process, which consists of three consecutive steps:

- Breaking the emulsion: This requires weakening and rupturing the stabilizing film surrounding the dispersed water droplets. This is a destabilization process and is affected by using what is called an aid, such as chemicals and heat.
- Coalescence: This involves the combination of water particles that became free after breaking the emulsion, forming larger drops. Coalescence is a strong function of time and is enhanced by applying an electrostatic field, impingement on a solid surface area, and water washing.
- Gravitational settling and separation of water drops: The larger water droplets resulting from the coalescence step will settle out of the oil by gravity and be collected and removed.