Tikrit University

College of Petroleum Processes Engineering

Department of Petroleum Refining Engineering

Specialized Petroleum Processes

Fourth Class

Lecture 5

By

Jasim I. Humadi

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Crude Oil Processing from Oilfield to Refinery

3. Desalting of Crude Oil

Salt in crude oil is in most cases found dissolved in the remnant water within the oil. It is evident that the amount of salt found in crude oil is attributed to two factors:

- The quantity of remnant water that is left in oil after normal dehydration
- The salinity or the initial concentration of salt in the source of this water.

The removal of salts found in the form of what we may call remnant brine is carried out in the desalting process. This will reduce the salt content in the crude oil to the acceptable limits of 15 to 20 PTB (pounds of salt, expressed as equivalent sodium chloride, per thousand barrels of oil). Desalting takes places at the refinery or in the field. Average values for the PTB for some typical crude oils are observed in Table 1.

Table 1: Average values for the PTB for some typical crude oils

Source of Oil	Average Salt Content (PTB)
Middle East	8
Venezuela	11
Pennsylvania	1
Wyoming	5
East Texas	28
Gulf Coast	35
Oklahoma and Kansas	78
West Texas	261
Canada	200

Salt Content of Crude Oil

Figure 1 is explained of the basic concept in the desalting operation of crude oil.

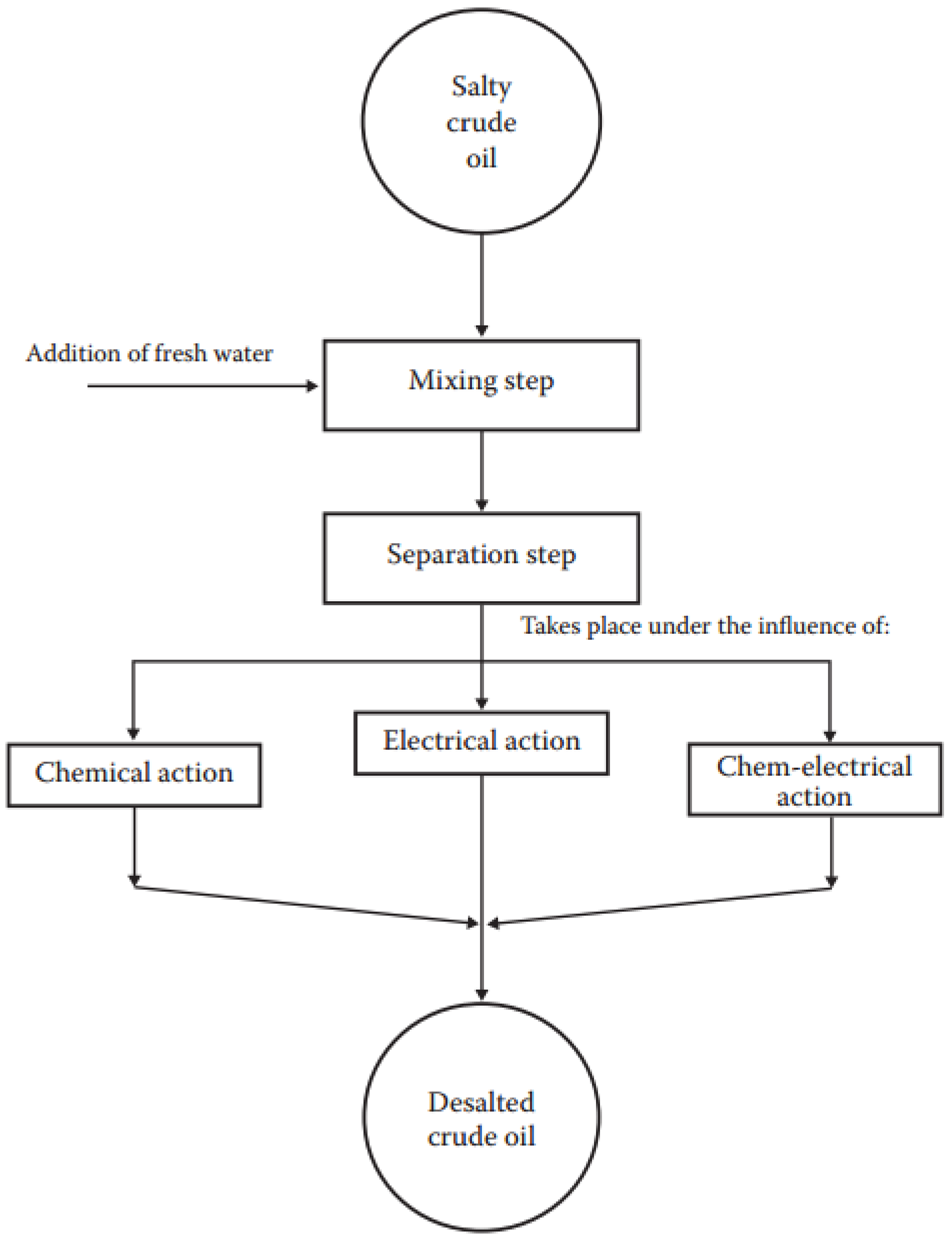

Figure 1: Illustration of the basic concept in the desalting operation of crude oil.

Example 1

Find the PTB of a crude oil having 10% by volume remnant water if its concentration is estimated to be 40,000 ppm at 25°C.

Solution

The example is solved using two approaches: One is based on Figure 1 and the other approach utilizes basic calculations.

1. Using Figure 1, the PTB of crude oil having 0.1% remnant water with 40,000 ppm salinity is found to be 14 PTB. For crude oil containing 10% remnant water, the value of PTB obtained from the figure should be multiplied by 100; therefore, the given crude contains 1400 PTB.
2. Take a basis of 1000 bbl of wet oil; the B.S.&W. = 10%, and the saline water concentration = 40,000 ppm = 4%. Then,

$$\text{Quantity of water in oil} = (1000)0.1$$

$$= (100\ \text{bbl})(5.6\text{ft}^3/\text{bbl}) = 560\ \text{ft}^3$$

Now, the density of the saline water is estimated using Table 3. For 4% concentration and at 25°C, the density is 1.0253 g/cm^3, or 63.3787 lb/ft^3. Hence,

$$\text{Mass of water} = (560\ \text{ft}^3)63.3787\ \text{lb/ft}^3$$

$$= 35{,}828\ \text{lb}$$

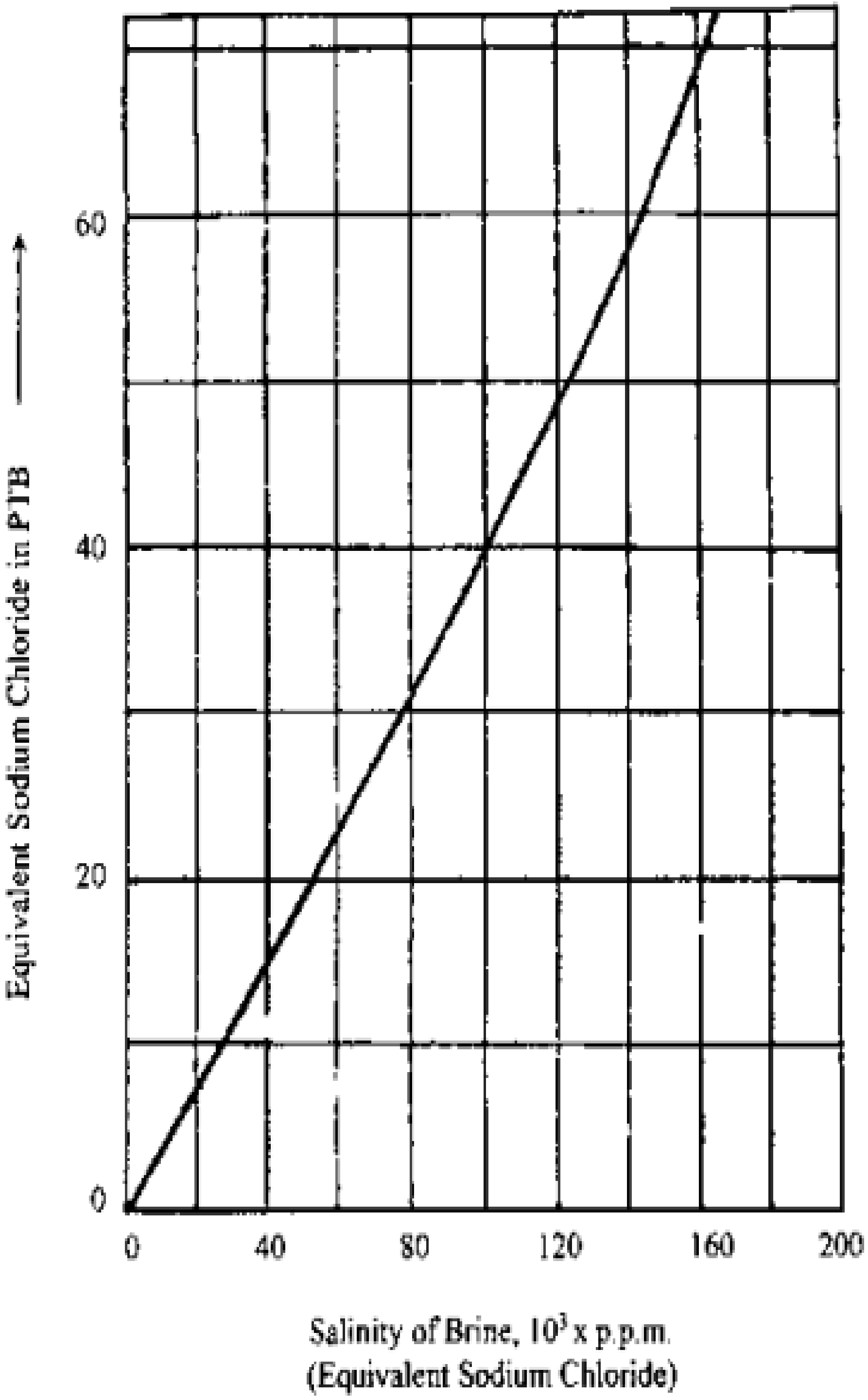

Figure 2: Salt content of crude oil (PTB) as a function of salinity of its remnant water 0.1% (1/1000) by volume remnant water.

Table 3 Densities of Aqueous Inorganic Solutions [Sodium Chloride (NaCl)]

%	0°C	10°C	25°C	40°C	60°C	80°C	100°C
1	1.00747	1.00707	1.00409	0.99908	0.9900	0.9785	0.9651
2	1.01509	1.01442	1.01112	1.00593	0.9967	0.9852	0.9719
4	1.03038	1.02920	1.02530	1.01977	1.0103	0.9988	0.9855
8	1.06121	1.05907	1.05412	1.04798	1.0381	1.0264	1.0134
12	1.09244	1.08946	1.08365	1.07699	1.0667	1.0549	1.0420
16	1.12419	1.12056	1.11401	1.10688	1.0962	1.0842	1.0713
20	1.15663	1.15254	1.14533	1.13774	1.1268	1.1146	1.1017
24	1.18999	1.18557	1.17776	1.16971	1.1584	1.1463	1.1331
26	1.20709	1.20254	1.19443	1.18614	1.1747	1.1626	1.1492

The quantity of NaCl salt found in this mass of water is $(35{,}828)(40{,}000)/10^6 = 1433$ lb. Since our basis is 1000 bbl of oil, the salt content is 1433 PTB.

3. Using Eq. (1) we get

$$\text{PTB} = 350\gamma_{\text{Brine}} \frac{1000 W_R}{100 - W_R}\left(\frac{S_R}{10^6}\right)$$

$$\text{PTB} = (350)\,(1.0253)\frac{1000(10)}{100-10}\left(\frac{40000}{10^6}\right)$$

$$\text{PTB} = 1595$$

Description of the Desalting Process

If the salinity of the water produced with oil is much greater than 20,000 ppm (formation water has a concentration of 50,000–250,000 mg/L). Accordingly, a two-stage system (a dehydration stage and a desalting stage) as shown in Figure 3a is used. Under certain conditions, however, a three stage system may be used that consists of a dehydration stage and two consecutive desalting units as shown in Figure 3b.

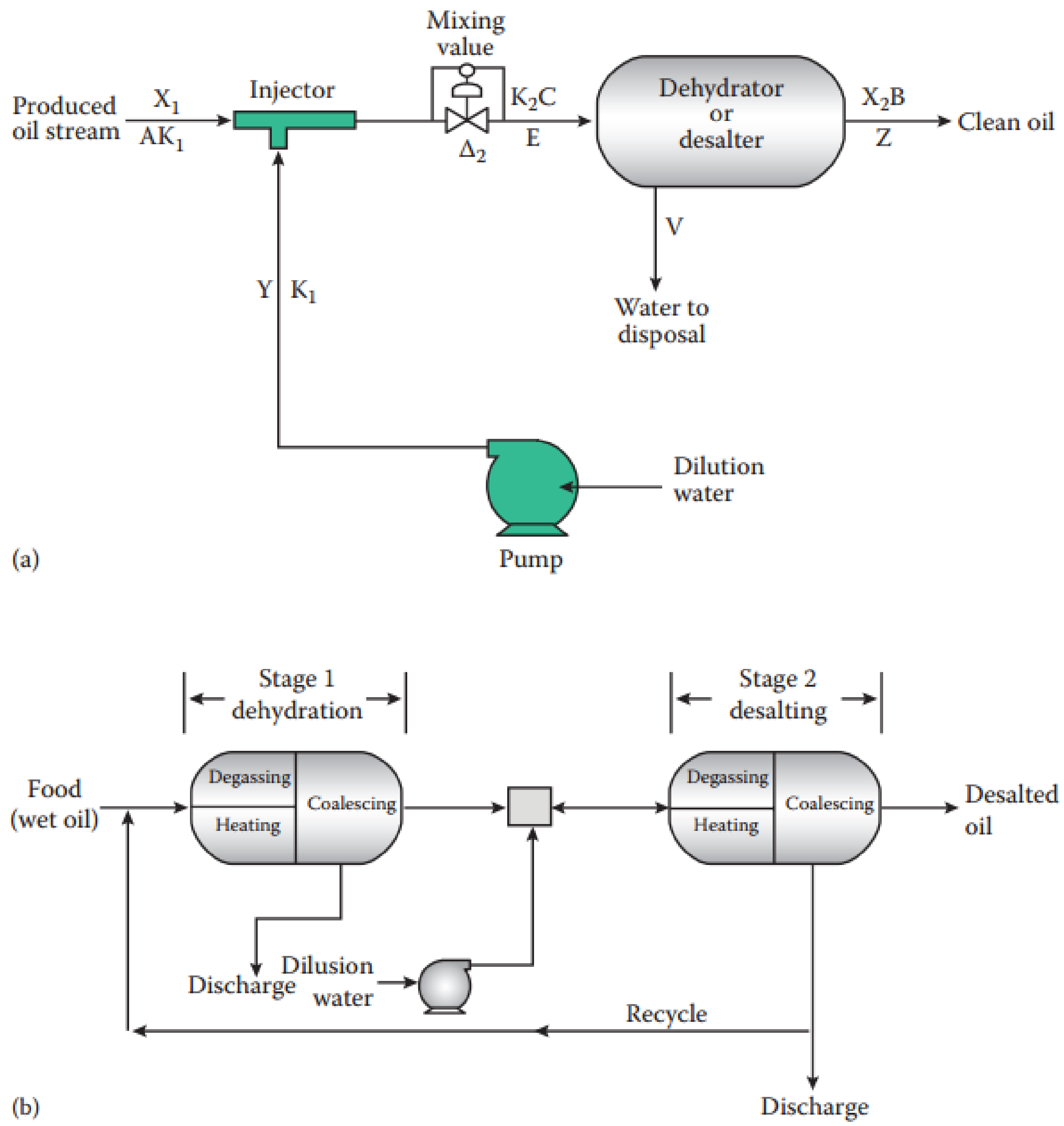

Figure 3: (a) Single-stage desalting. (b) Two-stage desalting

Electrostatic Desalting

In this case, an external electric field (Figure 4) is applied to coalesce the small water droplets and thus promote settling of the water droplets out of the oil.

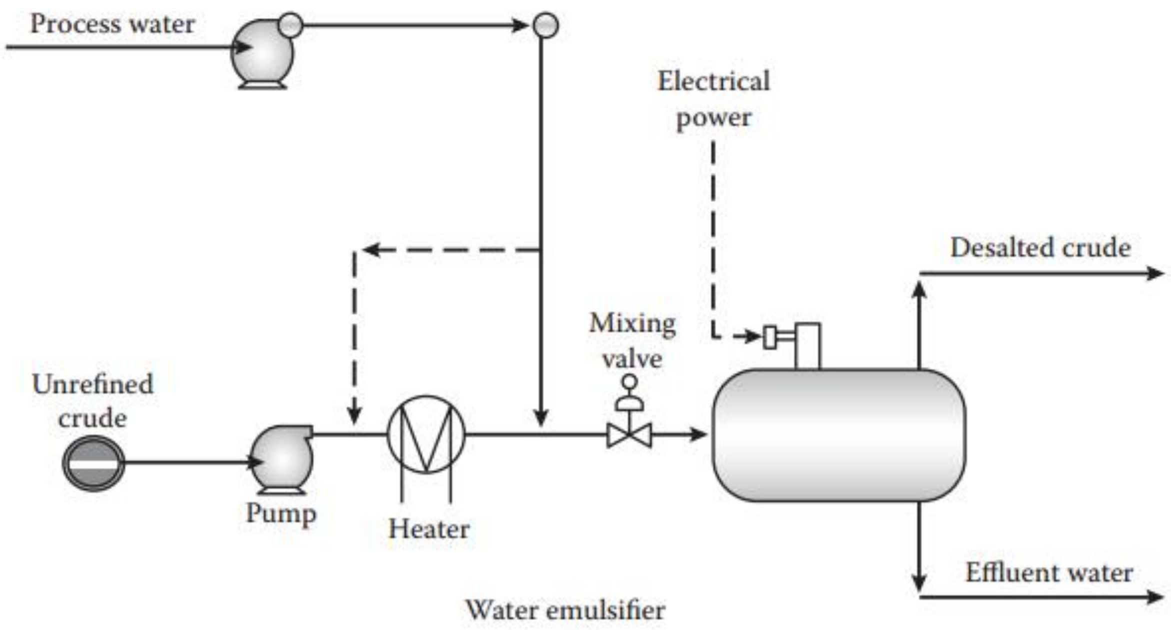

Figure 4: Electrical desalting.

Effect of Operating Parameters

Efficiency of desalting of crude oil is normally dependent on the following parameters:

- Water–crude interface level
- Desalting temperature
- Wash water ratio
- Pressure drop in the mixing valve
- Type of demulsifirs: demulsifirs are added to aid in complete electrostatic coalescence and desalting.

Troubleshooting

Table 2 lists some tips that are helpful in solving some of the operating problems or troubles that are of significance to the desalting process.

Table 2: Problems, Causes, and Solutions

Problems	Causes	Solutions
A high salt content in the desalted crude oil	• Feed salt content high • Wash water injection low • Crude oil flow rate exceeds the design flow rate • Insufficient mixing of the crude oil and wash water	• Increase the wash water rate • Reduce the crude oil flow rate • Increase the mix value pressure drop
Oil in the desalter effluent water	• *Interface* level too low • Wide emulsion band at the *interface* • Excessive crude oil wash water mixing • Poor wash water quality • Crude temperature too low	• Increase the interface level • Inject a chemical or dump the emulsion • Reduce the mix valve pressure drop • Check for any waste in the wash water source
High water carry over in desalted crude oil	• Wash water flow rate too high • Excessive formation water in the crude oil	• Reduce the wash water flow rate and commence or increase chemical injection • Reduce the interface level and check the effluent water valve