— University of Mosul —
College of Petroleum & Mining Engineering

Enhanced Oil Recovery Processes

Fourth Year

Lecture 5

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Optimum time to water flood

The following factors are an important when determine the reservoir pressure (or time) to initiate a secondary recovery project:

- Reservoir oil viscosity: Water-injection should be initiated when the reservoir pressure reaches its bubble-point pressure since the oil viscosity reaches its maximum value at this pressure. The mobility of the oil will increase with decreasing oil viscosity, which in turns improves the sweeping efficiency.
- Free gas saturation: (1) In water-injection projects, it is desirable to have initial gas saturation, possibly as much as 10%. This will occur at a pressure that is below the bubble-point pressure. (2) In gas injection projects, zero gas saturation in the oil zone is desired. This occurs while reservoir pressure is at or above bubble-point pressure.
- Cost of injection equipment: This is related to reservoir pressure, and at higher pressures, the cost of injection equipment increases. Therefore, a low reservoir pressure at initiation of injection is desirable.
- Productivity of producing wells: A high reservoir pressure is desirable to increase the productivity of producing wells, which prolongs the flowing period of the wells, decreases lifting costs, and may shorten the overall life of the project.

2- Practical considerations in water injection projects:

In order to put water injection into operation in a reservoir the following points must be considered:

a- Injection well completions.

b- Quantity, quality and reliability of the water supply.

c- Water treatment and pumping equipment.

d- Maintenance and operation of the water injection installations and possibly the monitoring of areal sweep using traces.

2.1 Injection well completions:

The completion of injection wells involves:

a- The initial completion.

b- The selective plugging of thief zones.

2.1.1 Initial completion:

There are two possibilities:

a- Completion of new injection wells.

b- Conversion of existing production wells.

2.1.2 Detection and selective plugging of thief zones:

It is often advisable to locate and then plug off the most permeable zones (“thief zones”).

a- Detection of thief zones

Thief zones may be detected either by the use of a continuous flow meter or by adding a radioactive tracer to the water and recording radioactivity profile. The first method is applicable in cased hole and the second in open hole completions.

b- Plugging agents

Among plugging agents in current use, many are dispersed solids or semisolids in suspension (powders such as talc, zinc oxide, cement soluble in caustic soda). The technique used is a follows: the solids are injected in the form of particles whose size is such that they will only enter the pores of the most permeable parts of the formation.

2.2 Sources and treatment of injected water:

The first investment required in a water injection project is for the drilling and completion of the injection wells. The second involves the range of installations required for the water supply, and for its treatment to enable it to pass through the reservoir without corroding the surface installations and well completions.

2.2.1 Sources of injected water:

After injection has been in progress for a certain time, injected water appears at the production wells by way of the most permeable beds. The water is separated from the oil at surface and becomes available for re-injection into the reservoir. The volume of water available for recycling increases with time, since the oil production rates decrease as the water production rates increase.

It is of course always necessary to have an independent source of water, firstly to get injection underway and fill up the reservoir, and secondly to replace the volume of oil produced.

a- Fresh water sources

b- Salt water sources

2.2.2 Water treatment

A. Treatment objectives:

The objectives of water treatment are:

a- To avoid plugging the reservoir.

b- To avoid the corrosion of the injection system (surface and down-hole).

c- To avoid the swelling of shales.

1- Plugging:

This may be due to:

a- Suspended solids

b- Corrosion

c- Bacteria (the most damaging being sulphate reducing bacteria)

d- The incompatibility of the waters

2- Corrosion:

This must be avoided both for the protection of metallic equipment and in order to avoid the plugging referred to above. Corrosion is principally due to the presence of gas dissolved in the water: H_2S, CO_2 and oxygen, and to bacterial action.

3- Swelling of shales:

The introduction of foreign water into an argillaceous reservoir may cause bentonitic shales to swell due to exchange of ions between the water and the shale; this results in a reduction of the rock permeability.

B. Treatment methods

Three method of treatment are available: physical, chemical and biological.

Physical treatments include filtration, oil-water separation, settling and degassing, the last two being especially common in installations open to the atmosphere.

Chemical treatments include the addition of surface tension reducers and corrosion inhibitors.

Biological treatment involves the use of bactericides, bacteriostats and algicides.