

Oil/Water Flow

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The attention was focused on two subjects: (i) the determination of the permeability decrease as a result of water injection and (ii) the break-up of oil droplets in the choke. Concerning the injection of produced water the activities were concentrated on matrix injection experiments, use of the CT scanning technique and testing of a new, dynamic, set-up. For break-up of oil droplets the attention was directed to methods to minimize this break-up.

Introduction

When oil is produced under high water-cut conditions, the amount of water to be handled at the surface is large. In many cases this results in separation problems, not only caused by the large amounts of water, but also by the presence of small oil droplets, which are difficult to remove. Investigation into different aspects of this type of oil production is ongoing. A PhD project on water injection is carried out. In this project the phenomena related to injection of produced water, both under non-fracturing and fracturing conditions, are investigated. For the produced water it is assumed that this water contains small solid particles, but no oil. Furthermore attention is given to the break-up of oil droplets in and near the choke, as a continuation of a PhD project on this subject and an MSc project which was focused on an important aspect of droplet break-up, viz. the influence of the choke geometry.

Results in 2003

Water injection

Concerning injection of produced water, a PhD project is ongoing. The original aim of this project was to arrive at a description of the process of subsurface injection of produced water under fracturing conditions. However, while the project was under way, this aim was somewhat modified. Under fracturing conditions quite a number of processes take place, of which some are influencing each other. Specifically the development of the fracture growth as a function of time cannot be predicted unless the injection into the formation (resulting in formation damage) and the flow processes in the fracture are thoroughly understood. Therefore the main activities were related to experimental work on matrix injection, i.e. injection under non-fracturing conditions. Very well-controlled core-flow experiments were performed, in which the permeability decline as a function of position and time was determined. Furthermore the cores and sections thereof were analyzed in detail, making use of image analysis and of the results of chemical analysis for determining the amount of trapped solids. A new development is that successful experiments were carried out in which the formation damage was not determined by image/chemical analysis but by on-line measuring with the CT scanning technique. In this way not only the end result of an experiment can be determined and analyzed, but also – in a direct way – the development of this damage while the experiment is in progress.

Information on matrix injection alone is not sufficient for gathering knowledge on the processes taking place under fracturing conditions. Therefore a new set-up was designed to mimic the situation in the fracture. In this dynamic set-up two processes are taking place simultaneously: matrix injection and flow of the water parallel to the surface. This is also what is happening in a fracture: part of the water (containing small particles) invades the formation, the rest flows in the direction of the fracture tip, causing shear forces to occur at the surface of the porous medium. Successful preliminary experiments with the dynamic set-up have already been done. The next stage is carrying out a measuring program (in the framework of a MSc thesis), in which a number of parameters will be varied. These parameters are flow-rate through the porous medium, flow-rate parallel to the surface of the porous medium (in fact the crucial parameter is not the flow-rate but the velocity, because this velocity determines the shear force at the surface), and particle concentration.

For further information: see the contribution of PhD student F.A.H. Al-Abduwani.

Oil-droplet break-up

Concerning oil-droplet break-up minimization of this break-up may be realized in two ways. The first one is lowering the pressure gradient in the choke while the pressure drop remains constant. In the MSc thesis of Beckers (2002) it was demonstrated that this is a sensible approach. Secondly, it can be tried to influence the radial composition of the

upstream fluid in the sense that relatively much oil is present in the center of the fluid. Because the energy dissipation rate varies strongly with radial position, this can be very advantageous. Both ideas will be worked out further.

Research plan for 2004

The research plan for 2004 is:

- On *produced water injection*: carrying out the measuring program with the dynamic set-up, evaluate the data, compare these data with the matrix injection data, and use the results as input for the available simulation models for formation damage.
- On *oil-droplet break-up*: working out theoretically the mentioned ideas on minimization of droplet break-up and investigate whether practical solutions can be formulated.

Contributed papers/articles

- *F.A.H. Al-Abduwani, A. Shirzadi, W.M.G.T. van den Broek and P.K. Currie*, Formation Damage vs. Solid Particles Deposition Profile During Laboratory Simulated PWRI, SPE paper 82235 presented at the SPE European Formation Damage Conference, The Hague, 13-14 May, 2003 (10 p.).
- *P. Bedrikovetsky, T.K. Tran, W.M.G.T. van den Broek, D. Marchesin, E. Rezende, A. Siqueira, A.L. Souza and F. Shecaira*, Damage Characterization of Deep Bed Filtration from Pressure Measurements, SPE Production & Facilities, May 2003, pp. 119-128.