ULTRAFILTRATION DEVELOPMENT FOR HIGH QUALITY WATER FROM OILFIELD EMULSIONS

by

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"By-Line": Conversion of Oily Wastewater to Steam Quality with Porous Membranes

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La résumé en français sera disponible aprés la rédaction préliminaire.

Art work will be prepared after initial editing.

Large hydrocarbon resources exist in various tar sand and heavy oil deposits throughout Alberta and Saskatchewan. Since surface mining is applicable to only a small part of these reserves, in situ recovery methods must be considered. The low-grade petroleum in these reserves is of a highly viscous, asphaltic nature and most of it does not flow under reservoir conditions when subjected to driving fluid pressure. Heat is needed to reduce the high viscosities and thus overcome the resistance to flow. This heat can be supplied by either steam injection into the reservoir or by in situ combustion. Thermal recovery methods can vary and the most appropriate methods depend on the nature of the reservoir.

A difficulty encountered by these processes is that water from condensed steam or already present in the deposit is also recovered with the bitumen and heavy oil. Small amounts of naturally occurring chemicals similar to soaps or detergents (surfactants) in petroleum cause the formation of oil and water emulsions, where the oil is the bitumen or heavy oil from the reservoir. These emulsions are occasionally highly stable and refuse to break into two layers or phases. Further, the presence of clay and small solid particles also increases the stability of the emulsions. Experience has shown that these in situ generated emulsions can be very difficult and expensive to destabilize by conventional practices such as adding demulsification agents to counter the stabilizing agents, heating to increase the density difference between the water and oil so that two layers can form, using electrostatic grids to coalesce the dispersed liquid, and diluting with light oils from conventional reservoirs. These treatments increase the production cost of the heavy petroleum and can even prevent the oil producer from marketing or utilizing the product.

A second concern in Western Canada has been the anticipation of a lack of suitable water supplies for the generation of steam for injection into the reservoir. This could become the limiting factor for the recovery of bitumen and heavy oil by in situ methods unless combustion methods are used. The few large-scale recovery operations have not had problems of water supply, but this is expected to change as more producers increase the demand for high quality water. Several methods exist that generate steam from raw produced water (wastewater with most of the oil removed), but they require considerable capital investment and the corrosiveness and hardness of the produced water cause operational disruption.

Research at CANMET's Energy Research Laboratories has been directed towards the recovery of oil from emulsions and the production of suitable water to generate steam for well injection. Ultrafiltration is one technology being considered for the production of high quality water from oil-in-water emulsions. It is a separation process that uses porous membranes to simultaneously concentrate solutes on the high pressure side of the membrane and to remove water from the low pressure side as membrane permeate. This process has been used commercially for concentrating proteins from cheese whey and the recycling of cutting and lubrication oils from metal machining operations. The major factor contributing to the separation mechanism is size discrimination, where the membrane pores act as sieves and do not allow the passage of oil droplets and solid particles. However, the liquid on the high pressure side does interact with the membrane surface. This can be used to cause a repulsion of salt ions from the membrane pores to improve the hardness characteristics of the permeate. Further, the pores on the membrane surface are too small to allow the passage of fine clay particles present in the emulsion. Another effect of suitable membrane surfaces is their ability to repel the sticky oil and prevent plugging of the pores. This contributes to the lifetime of the membrane separation units and aids in maintaining high permeation rates.

Certain membrane surfaces will not only repel oil but will attract hydrophilic chemicals that have been dissolved out of the oil by the water. These components will then be passed through the membrane pores along with the water. The natural surfactants which appear to contribute to the stability of the emulsion can be removed in this manner, and the oil-in-water emulsion tends to break down into two layers, one containing mainly water and solids, and the other a water-in-oil emulsion. The exploitation of this effect along with maintaining the quality specifications for steam generation is the crux of the design of a membrane process. In order to maintain large flowrates, the pore size of the membranes must be large. This causes a reduction in the quality of the permeate water and also reduces the effectiveness of the polar organic component removal. Optimum pore sizes may have to be determined for each case.

In-house experimental results have been encouraging, and CANMET has awarded a research contract to Zenon Environmental Inc. of Burlington, Ontario, to perform further survey experiments with promising commercial and prototype membranes. Preliminary results of the research contract have confirmed CANMET's results and several membranes that resist fouling and plugging have been identified. The membrane-permeated water from the better cases meets the quality characteristics required for single pass steam generation (80 per cent quality steam) which is typical of boilers used in the oilfield. Further work will investigate the resistance of membranes to long-term fouling and thermal degradation, and identify suitable operating ranges in terms of the oil content of the water and water product specifications. Work continues on the isolation and identification of the stabilizing agents of these emulsions with the goal of improving their removal. For example, they could be recycled back into the reservoir to improve recovery. Future projects will include the evaluation of available membrane units with large surface areas and the investigation of the suitability of existing membrane unit designs for this type of high solids content emulsion.

The successful implementation of a membrane separation process will improve the economics of bitumen and heavy oil recovery as well as supply a dependable source of steam generation quality water. The reduction in water demand will increase the flexibility of in situ recovery operations and permit the establishment of oil recovery installations farther from traditional water sources. A reduction in water demand will relieve possible constraints upon oil producers, and will indirectly increase overall productivity.