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TECH TALK

Electrodialysis of produced water for optimal reuse in water flooding

BY GARY BEERS • FOR ENERGY PIPELINE

EVERY PROBLEM CONTAINS WITHIN ITSELF THE SEEDS OF ITS OWN SOLUTION

Stanley N. Arnold, American Management Consultant

The availability of water for hydraulic fracturing and for water flooding is one of the major problems faced by oilfield operations. Early solutions involved reliance on nearby municipal and agricultural suppliers of water; however, advances are being made to recycle produced water to meet these two oilfield demands. Obviously, the establishment of this water recycling loop is the basis for a sustainable solution within the oilfield operations. These two water demands are different in duration and volumes.

- Hydraulic fracturing is a short-term action needed after a new well is drilled or years later when the well is upgraded to increase production. Several million barrels of water are needed for each of these actions.

- Water flooding is a long-term action where water is injected to flush additional oil in the reservoir toward extraction by production wells. Typically, oil production is increased for decades by this secondary recovery step. Hundreds of millions of barrels of water are needed for this multi-year process.

The supply of produced water increases over time as wells continue to produce oil. Typically, this supply far exceeds the hydraulic fracturing demands as the oilfield is built-out and disposal of produced water emerges as major expense and environmental problem. Water flooding can consume a major portion of the produced water; however, this option is sensitive to the cost of treating produced water over the decades. Produced water is high in salts which must be

lowered before this water is suitable for injection to enhance oil recovery.

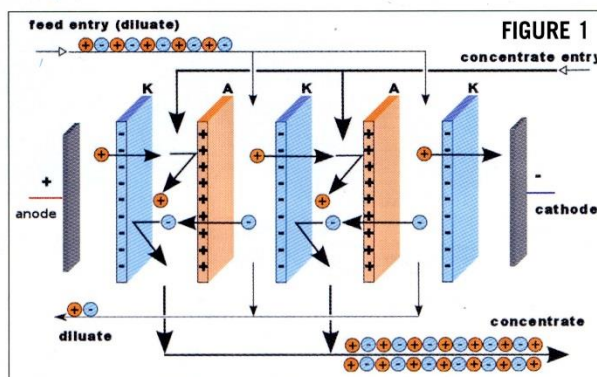
The purpose of this column is to describe a treatment process that can manage the salt levels employing a technology that economically capitalizes on the ionic properties of produced water. The resulting treated produced water is well suited for water-flooding.

SEPARATION OF IONS BASED ON ELECTRIC CHARGE (ELECTRODIALYSIS)

Electrodialysis (ED) is an electrically-driven, membrane process that is capable of separating selected ions from water (Figure 1). Two types of selectively permeable membranes are placed between an anode and cathode, which generate a direct current through the water contained in a water-tight compartment. Thus, the ions in the feed entry will migrate to the electrode of the opposite charge. For example, positively charged sodium ions will migrate towards the cathode and negatively charged chloride ions will migrate towards the



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anode. However, the membranes will control this migration process: that is, the anion transfer membrane (positive membrane, A) allows only the passage of negatively charged ions and the cation transfer membrane (negative membrane, K) allows only the passage of positively charged ions.

When produced water (feed entry) is introduced to the electrodialysis process, the salt will be removed and the exiting water will be lower in salts (total dissolved solids or TDS). The removed salts will exit the process as a concentrate stream which can be recycled through the process to control the TDS level in the exiting water.

The electrodialysis process has been used for decades with most application to water developed by General Electric. Recently, a Canadian firm (Saltworks Technologies, saltworkstech.com) has upgraded the ED process with patented additions* and successfully treated produced water to meet the optimal TDS (2,000 mg/l) for low salinity water flooding. Examples of chemical data for the inflow and outflows are provided in Table 1.

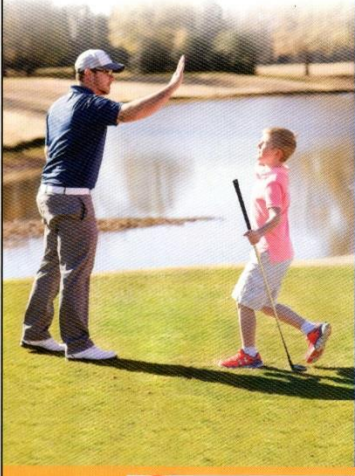
The TDS content of the two outflows can be adjusted through the extent of recirculation of the concentrate and produced water mixtures. Treated water with lower TDS would be a candidate for other beneficial uses (i.e., agricultural waters), while treated waters with high TDS, also, would be a candidate for beneficial uses (i.e., dust control on unpaved roads).

This advanced treatment technology holds substantial promise for supporting additional recycling of produced water to beneficial uses and, thus, reduce the need for final disposal options (i.e., injection wells, evaporative ponds).

*The advanced electrodialysis process (EDX) includes improvements to treat higher salinity waters, to minimize accumulations on membranes through reversal of polarity in water chamber, to provide self-cleaning capabilities, to reduce needs for pre-treatment of produced water, to minimize damage to polymers which maximizes their continued reuse in water flooding, and to minimize generation of a residual solid waste for disposal. The firm reports the total cost of ownership (CAPEX and OPEX) is site and TDS dependent and estimated in the range of 16 cents to 32 cents per barrel of produced water treated. ♦

TABLE 1. CHEMICAL DATA

Parameter (mg/l)	Inflow		
Produced Water Outflows			
	Low TDS	Water	Concentrate (Brine)
TDS	10,200	2,280	38,800
Sodium	3,960	937	13,800
Calcium	80.4	2.89	77.5
Magnesium	57.1	9.59	277
Potassium	40	6	154
Chloride	5,300	939	22,300

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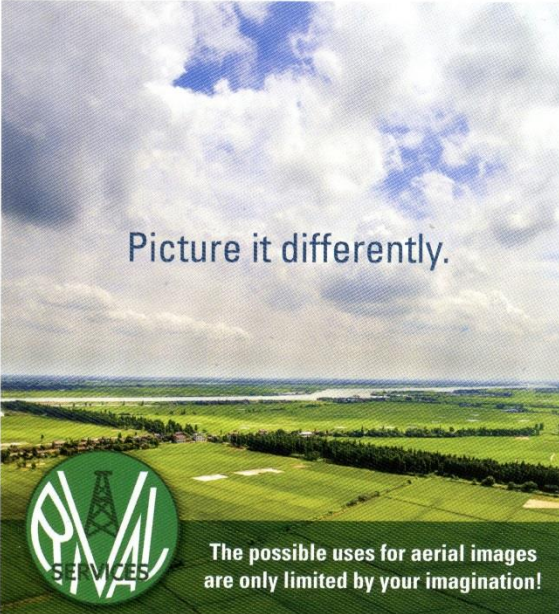
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