Reducing Interfacial Tension in Cyclic Steam Wells

THE ISSUE

Cyclic steam stimulation is the alternating injection of steam and production of oil with condensed steam from the same well or wells and involves 3 operational steps: 1) inject steam into a reservoir, 2) allow the steam to soak and heat the reservoir to reduce the oil viscosity, and 3) produce back the now-mobile oil to the same well. The issue, however, is that the heating radius at the conclusion of several cycles of conventional saturated steam huff and puff in heavy oil reservoirs is only on the order of 10–20m. Moreover, recovery of the initial oil-in-place within the heating radius is low, limited to less than 30% and usually less than 20%. Contributing to this low recovery factor is the high proportion of remaining immobile oil trapped on the sandstone reservoir grains by ***interfacial tension*** (defined as oil-wet reservoirs).

ENERCAT POTENTIAL TO CONTRIBUTE TO THE SOLUTION

The Enercat™ Downhole Tool has been proven to substantially reduce interfacial tension in laboratory testing and has the potential to increase the wettability of oil-wet reservoirs (by reducing interfacial tensions), transforming them to water-wet reservoirs and releasing trapped immobile oil to the pore spaces where the oil can migrate to the wellbore. The Enercat™ Technology Group therefore hypothesizes that the tool may benefit cyclic steam operations in two significant ways: 1) increase recovery efficiency by unlocking the oil bound by interfacial tensions and producing more of the oil saturation S_o in the reservoir, and 2) increasing the drainage radius of the well bore, thus accessing more initial oil-in-place.

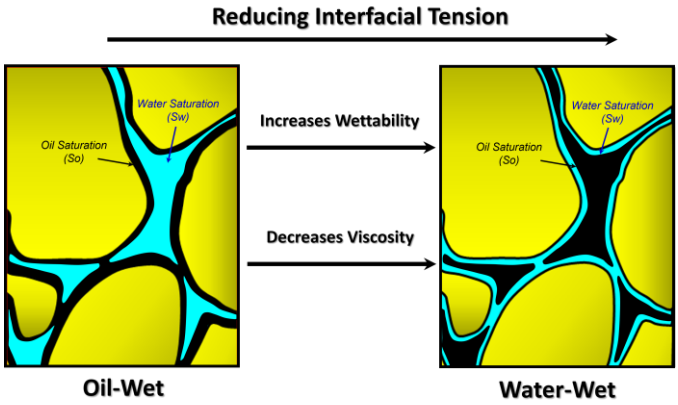
CYCLIC STEAM PRODUCTION INCREASE BY ENERCAT

The subaerial extent to which the ultra-high frequency effect of the Enercat™ tool pervades the reservoir is not established, but even a modest spatial increase will impact potential cumulative production of cyclic steam wells enormously. The volume increase in original oil-in-place (OOIP) by increasing a well's drainage radius from 10-20m and then 30m is substantial. A 10m drainage radius for a hypothetical 50m thick reservoir sandstone of 32% porosity and 65% oil saturation contains 20,552 barrels of OOIP and would produce 4,110 barrels of oil (Bo) at 20% recovery efficiency (RE) or 6,166 Bo at 30% RE. A 20m drainage radius for the same reservoir contains 82,208 barrels of OOIP (16,442 Bo at 20% RE & 24,662 Bo at 30%) and a 30m radius contains 184,968 barrels of OOIP (36,994 Bo at 20% RE & 55,490 Bo at 30%). Increasing oil RE from 20% to 30% and expanding the drainage radius of cyclic steam wells would be transformative for cyclic steam operations.

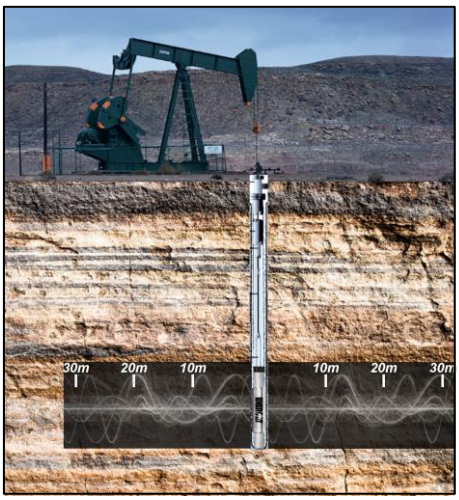
REDUCING INTERFACIAL TENSION BY ENERCAT

Interfacial Tension (dyn/cm)				% Reduction in Interfacial Tension
Pre-Tool Water & Pre-Tool Oil	11.9	Post-Tool Water & Post-Tool Oil	8.2	31
Post-Tool Water & Pre-Tool Oil	12.1	Pre-Tool Water & Post-Tool Oil	8.3	31

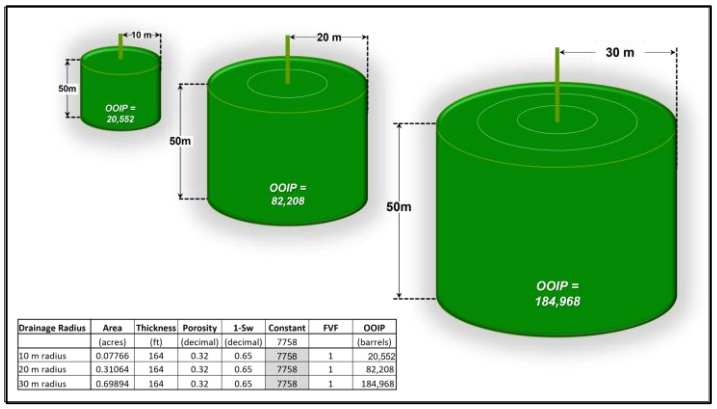
TRANSFORM OIL-WET TO WATER-WET RESERVOIRS BY ENERCAT



RADIUS OF FREQUENCY EFFECT OF ENERCAT



OOIP INCREASE BY EXTENDING DRAINAGE RADIUS OF ENERCAT



Drainage Radius	Area	Thickness	Porosity	1-Sw	Constant	FVF	OOIP
	(acres)	(ft)	(decimal)	(decimal)	7758		(barrels)
10 m radius	0.07766	164	0.32	0.65	7758	1	20,552
20 m radius	0.31064	164	0.32	0.65	7758	1	82,208
30 m radius	0.69894	164	0.32	0.65	7758	1	184,968

CUMULATIVE PRODUCTION INCREASES UTILIZING ENERCAT

Drainage Radius	Area	Thickness	Porosity	1-Sw	Constant	FVF	OOIP	RE of 20%	RE of 30%
	(acres)	(ft)	(decimal)	(decimal)	7758		(barrels)	(barrels)	(barrels)
10 m radius	0.07766	164	0.32	0.65	7758	1	20,552	4,110	6,166
20 m radius	0.31064	164	0.32	0.65	7758	1	82,208	16,442	24,662
30 m radius	0.69894	164	0.32	0.65	7758	1	184,968	36,994	55,490