Waterflood Breakthrough by Buckley–Leverett and Welge

Front saturation, water cut at the front, average saturation and pore volumes injected at breakthrough, time to breakthrough and oil recovered (Welge tangent).

Input parameters

Unit system: SI

Parameter	Value	Unit
Coefficient a in k_ro/k_rw = a·e^{bS_w}	5,000.0	
Exponent b (negative)	-15.000	
Oil viscosity	4.0000	cP
Water viscosity	0.60000	cP
Initial water saturation	25.000	%
Residual oil saturation	25.000	%
Water injection rate (reservoir)	900.00	bbl/d
Porosity	25.000	%
Cross-sectional area	26,400	ft²
Distance from injector to producer	660.00	ft
Oil formation volume factor	1.2500	

Calculated results

Parameter	Value	Unit
Water saturation at the flood front	51.352	%
Water cut at the front (at breakthrough)	74.702	%
Slope of the fractional flow curve at the front	2.8347	
Average water saturation at breakthrough	60.277	%
Pore volumes injected at breakthrough	0.35277	
Time to breakthrough	304.10	d
Displacement efficiency at breakthrough	47.036	%
Oil produced at breakthrough (stock tank)	218,951	bbl

Notes for this case

- Linear, horizontal, piston-like Buckley–Leverett displacement with capillary pressure neglected, and complete areal and vertical sweep; multiply by the sweep efficiencies for a pattern flood. Fit a and b to k_ro/k_rw on a semilog plot over the mid-range of saturation.

Formula and method

$$f_w = \frac{1}{1+\frac{\mu_w}{\mu_o} a e^{bS_w}}, \quad \left(\frac{df_w}{dS_w}\right)_{S_{wf}} = \frac{f_{wf}}{S_{wf}-S_{wi}}, \quad Q_{iBT} = \bar{S}_{wBT} - S_{wi} = \frac{1}{(df_w/dS_w)_{S_{wf}}}, \quad t_{BT} = \frac{V_p Q_{iBT}}{i_w}$$

Variables

a	Coefficient a in k_ro/k_rw = a·e^{bS_w}	-
b	Exponent b (negative)	-
μ_o	Oil viscosity	Pa·s
μ_w	Water viscosity	Pa·s
S_{wi}	Initial water saturation	-

S_{or}	Residual oil saturation	-
i_w	Water injection rate (reservoir)	m³/s
ϕ	Porosity	-
A	Cross-sectional area	m²
L	Distance from injector to producer	m
B_o	Oil formation volume factor	-
S_{wf}	Water saturation at the flood front	-
f_{wf}	Water cut at the front (at breakthrough)	-
$(df_w/dS_w)_{S_{wf}}$	Slope of the fractional flow curve at the front	-
$\bar{S}_{wBT}$	Average water saturation at breakthrough	-
Q_{iBT}	Pore volumes injected at breakthrough	-
t_{BT}	Time to breakthrough	s
E_D	Displacement efficiency at breakthrough	-
N_{pBT}	Oil produced at breakthrough (stock tank)	m³

Method and standards

Buckley–Leverett frontal advance with Welge's construction.

Assumptions and limits

- Linear, homogeneous, incompressible; capillary pressure neglected.

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/chemical/reservoir-engineering/buckley-leverett-welge-breakthrough

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Reopens the calculator with the inputs of this report.