Fractional Flow of Water (Water Cut) in a Waterflood

Reservoir water cut from relative permeabilities and viscosities, with the gravity term for dipping beds, and the matching reservoir and surface water-oil ratios.

Input parameters

Unit system: SI

Parameter	Value	Unit
Oil relative permeability at the saturation	0.30000	
Water relative permeability at the saturation	0.12000	
Oil viscosity	3.0000	cP
Water viscosity	0.50000	cP
Absolute permeability	50.000	mD
Cross-sectional area of the flood	25,000	ft²
Water injection rate (reservoir)	1,000.0	bbl/d
Water density	64.000	lb/ft³
Oil density	45.000	lb/ft³
Dip angle (positive: injector down-dip, flood moving up-dip)	5.0000	°
Oil formation volume factor	1.2000	
Water formation volume factor	1.0500	

Calculated results

Parameter	Value	Unit
Water cut, horizontal (no gravity)	70.588	%
Water cut with gravity (reservoir)	70.474	%
Oil cut (reservoir)	29.526	%
Water-oil ratio (reservoir)	2.3868	
Water-oil ratio (surface)	2.7278	
Surface water cut	73.175	%

Notes for this case

- Capillary pressure gradient neglected. Injecting down-dip so that water moves up-dip lowers the water cut; injecting up-dip raises it. Repeat at several saturations to draw the fractional flow curve.

Formula and method

$$f_w = \frac{1 - \frac{k k_{ro} A}{\mu_o i_w}(\rho_w - \rho_o) g \sin\alpha}{1 + \frac{k_{ro}}{k_{rw}}\frac{\mu_w}{\mu_o}}, \quad WOR_s = \frac{B_o f_w}{B_w(1 - f_w)}$$

Variables

k_{ro}	Oil relative permeability at the saturation	-
k_{rw}	Water relative permeability at the saturation	-
μ_o	Oil viscosity	Pa·s
μ_w	Water viscosity	Pa·s
k	Absolute permeability	m²
A	Cross-sectional area of the flood	m²

i_w	Water injection rate (reservoir)	m³/s
ρ_w	Water density	kg/m³
ρ_o	Oil density	kg/m³
α	Dip angle (positive: injector down-dip, flood moving up-dip)	rad
B_o	Oil formation volume factor	-
B_w	Water formation volume factor	-
$f_{w,0}$	Water cut, horizontal (no gravity)	-
f_w	Water cut with gravity (reservoir)	-
f_o	Oil cut (reservoir)	-
WOR_r	Water-oil ratio (reservoir)	-
WOR_s	Water-oil ratio (surface)	-
f_{ws}	Surface water cut	-

Method and standards

Fractional flow equation (Leverett).

Assumptions and limits

- Linear displacement; 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/fractional-flow-water-cut

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.