A Method for Calculating KGD Fracturing Model through Excel Tables

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Abstract: ***When the geological conditions of the reservoir are relatively simple, two - dimensional models (PKN, KGD) can be used to calculate the length of fractures generated by hydraulic fracturing technology. This article mainly introduces the method of using Excel tables to calculate the KGD fracturing model. The independent variables of Excel spreadsheet functions have high adjustability, and the assumption of independent variables is not interrupted. Therefore, the calculation formula of the crack model can be repeated, and the results can be easily and accurately calculated.***

Keywords: hydraulic fracturing technology, KGD model, Two dimensional fracturing model, Excel sheet, Calculation method

1. Using Excel sheets to calculate the KGD model

1.1 Information on reservoir strata

The average porosity of the reservoir formation is 17.6%, the average permeability is 12.63mD, and the average carbonate content is 15.3%, belonging to a medium porosity and low permeability reservoir.

The clay content in the reservoir rocks is too high, and the reservoir rocks have characteristics of moderate salt sensitivity, strong stress sensitivity, and weak water sensitivity. The burial depth of the reservoir in this area is between 2500 - 4700m, and the burial depth in the middle is 3600m. The geothermal gradient is 2.3 ℃/100m, and the reservoir temperature is 118.6 ℃. The temperature and pressure system is within the normal range.

In summary, fracturing and stimulation measures can be taken for the reservoir formation.

The known length of the fracturing well pipeline is 3595m, with an outer diameter of 101.6mm and an inner diameter of 93mm. The oil reservoir temperature is 118.6 ℃, the average ground temperature is 2 ℃, and the formation fracture pressure gradient is 0.0156MPa/m;

1.2 Estimation of relevant crack parameters using Excel tables

The KGD model is used to calculate crack parameters, assuming the following conditions:

- The formation is homogeneous and isotropic;
- Linear elastic stress - strain;
- Laminar flow within the crack, considering filtration loss;
- The width of the seam is rectangular in cross - section and elliptical in lateral direction;

Obtained from the depth integration formula for calculating crack width based on England and Green;

$$W_{\max} = \left[\frac{84(1\text{-}\nu)}{\pi} \left(\frac{1}{60} \right) \frac{\mu_f Q L_f^2 D}{G h_f P_w} \right]^{\frac{1}{4}} \tag{2.12}$$

$$L_f = \frac{Q}{32\pi h_f c^2} \left(\pi W_{\max} + 8S_p \right) \left[\frac{2\alpha_L}{\sqrt{\pi}} - 1 + e^{\alpha_L^2} \operatorname{erfc}(a_L) \right] \tag{2.13}$$

$$a_L = \frac{8c\sqrt{\pi t}}{\pi W_{\max} + 8S_p} \tag{2.14}$$

Calculation principle: First, assume the half length "L_{f1}" of a fractured fracture, and use formula (2.12) in the Excel table to calculate the maximum bottom hole crack width Wmax. Substitute Wmax into formula (2.14) and use an Excel table to calculate "a_L", Substitute the calculated Wmax and "a_L" into formula (2.13), and use an Excel table to calculate the half length of the crack "L_{f2}". Finally, use an Excel table to subtract the calculated half length of the crack "L_{f2}" from the assumed half length of the fracture $_{Lf1}$ to obtain the result "Z". By repeatedly assuming the half length Lf1 of the fractured fracture, when the result "Z" approaches zero, the assumed half length "L_{f1}" of the fracture is the desired half length "L_f".

Firstly, assume that the half length of the crack is 275m, and the calculation results obtained using an Excel table are as follows:

C1	C2	C3	C	Injection volume of fracturing fluid	shear modulus		
0.035216266	0.132755505	0.07724	0.024759	5.333333333	1639.344262		
			Lf1	Wmax	aL	Lf2	Z
			275	0.068696088	10.71386228	105.6221039	169.3778961
					E		
					e	y	
					0.055070546	0.221740998	
				J0	J1	P	0.00074424
				0.696811436	5.907680372	14.703	

Afterwards, it was repeatedly assumed that the half length "L_{f1}" of the fracturing crack was regulated, and the result "Z" gradually approached zero by subtracting the half length "L_{f2}" from the half length "L_{f1}" of the crack. The final calculation result is as follows:

C1	C2	C3	C	Injection volume of fracturing fluid	shear modulus		
0.035216266	0.132755505	0.07724	0.024759	5.333333333	1639.344262		
			Lf1	Wmax	aL	Lf2	Z
			146.6138	0.050159487	14.57518962	146.6137714	2.8597E-05
					E		
					e	y	
					0.041836863	0.173169097	
				J0	J1	P	0.00074424
				0.696811436	5.907680372	14.703	

It can be seen that when the half length "Lf" of the crack is about 146.6138m and the maximum crack width "W_{max}" at the bottom of the well is 0.0502m, the depth integration formula for calculating the crack width by England and Green is met. So according to the KGD model, the half length of the crack is about 146.6138m, and the maximum crack width "W_{max}" at the bottom of the well is about 0.0502m.

1.3 Compare the calculation results with the fracturing simulation results of fracporPT software

The crustal stress parameter table of the reservoir stratum, the reservoir, temperature and pressure system table, and the length, outer diameter, inner diameter, reservoir temperature, average ground temperature of the fracturing well pipeline are substituted into fracporPT software for fracturing simulation, and the comprehensive profile of the fracture model obtained is as follows:

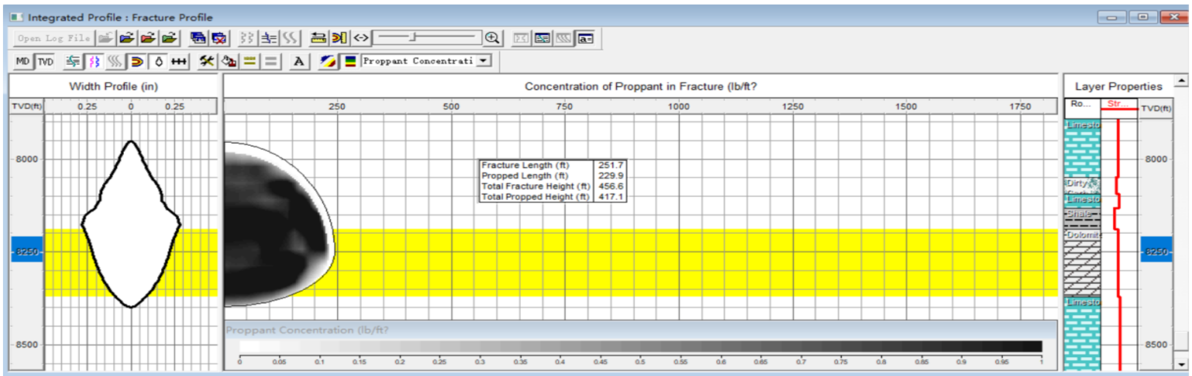

Figure 2.1: Comprehensive cross - section of the crack model

The fracture model length obtained by fracporPT software for fracturing simulation is 456.6 feet (ft), which is converted into international units of 139.17m. It can be seen that the half length of the crack calculated using Excel table is 146.6138, and the results obtained from fracturing simulation using fracporPT software are not significantly different.

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