Lecture 16-17-18

Consideration two-phase seepage under the water-oil displacement

In all the above tasks of oil displacement water is the scheme of piston displacement. **Piston displacement** - a condition, is taken in the performance of hydrodynamic calculations displacement of oil by water, which states that the residual oil saturation behind the front displacement remains constant. This is the perfect case oil displacement when the layer between oil and water creates a clear border section, which moves ahead of oil and behind only water. And as shown by laboratory and industrial researches front displacement is a compatible flow of water and oil. Filtration resistances in the zone of oil replacement water will differ from the filtration resistances calculated at scheme homogeneous liquid piston displacement. Therefore, it can consider this fact can lead to errors in determining the flow rates and validities.

It is established that the ratio of the viscosity of oil to the viscosity of water $\mu_0=\mu_{oil}/\mu_w$, which ranges from 1 to 10 in the displacement of oil by water can be taken

$$z = \sqrt{\frac{m\mu_0 V}{150Q(t)}}, \qquad (8.1)$$

where $z=\rho_o-\rho_{ro}$; m – coefficient of porosity; V – the volume of the layer; $Q(t)$ - the total amount of water that entered in the reservoir. Equation (8.1) defines oil saturation at any point depending on its position. Oil saturation at the front oil water displacement is determined by the formula

$$z_f = 0{,}1\sqrt{\frac{\mu_0}{1{,}5\left(1-\rho_{r\,o}-\rho_{bw}\right)-z_\phi}}, \quad \text{f. u.} \qquad (8.2)$$

where $\mu_0=\mu_{oil}/\mu_w$; $\rho_{r\,o}$ - residual oil saturation, f.u.; $\rho_{b\,w}$ - saturation of bound water, f.u.

Equation (8.2) is solved the graphic-analytical method. For this first from the equation (8.2) is determined the value $1-\rho_{r\,o} - \rho_{b\,w}$.

To do this, the left and right sides of the equation (8.2) to lift the square. We obtain

$$1-\rho_{r\,o}-\rho_{bw}=\frac{1}{1{,}5}\left(\frac{0{,}01\mu_0}{z_f^2}+z_f\right). \qquad (8.3)$$

Resorting intermediate values z_f and for each value, we get the left side of equation (8.3). For ease of calculation is served at a Table 8.1.

Table 8.1 – Calculation of z_f

z_f	$1-\rho_{r\,o} - \rho_{b\,w}$
0,1	X_1
0,2	X_2
0,3	X_3
.....	.....
1,0	X_n

Then, the obtained values get the graph. The values $\rho_{r\,o}$ and $\rho_{b\,w}$ are set as defined in the laboratories of the oil and gas mechanics (Fig. 8.1).

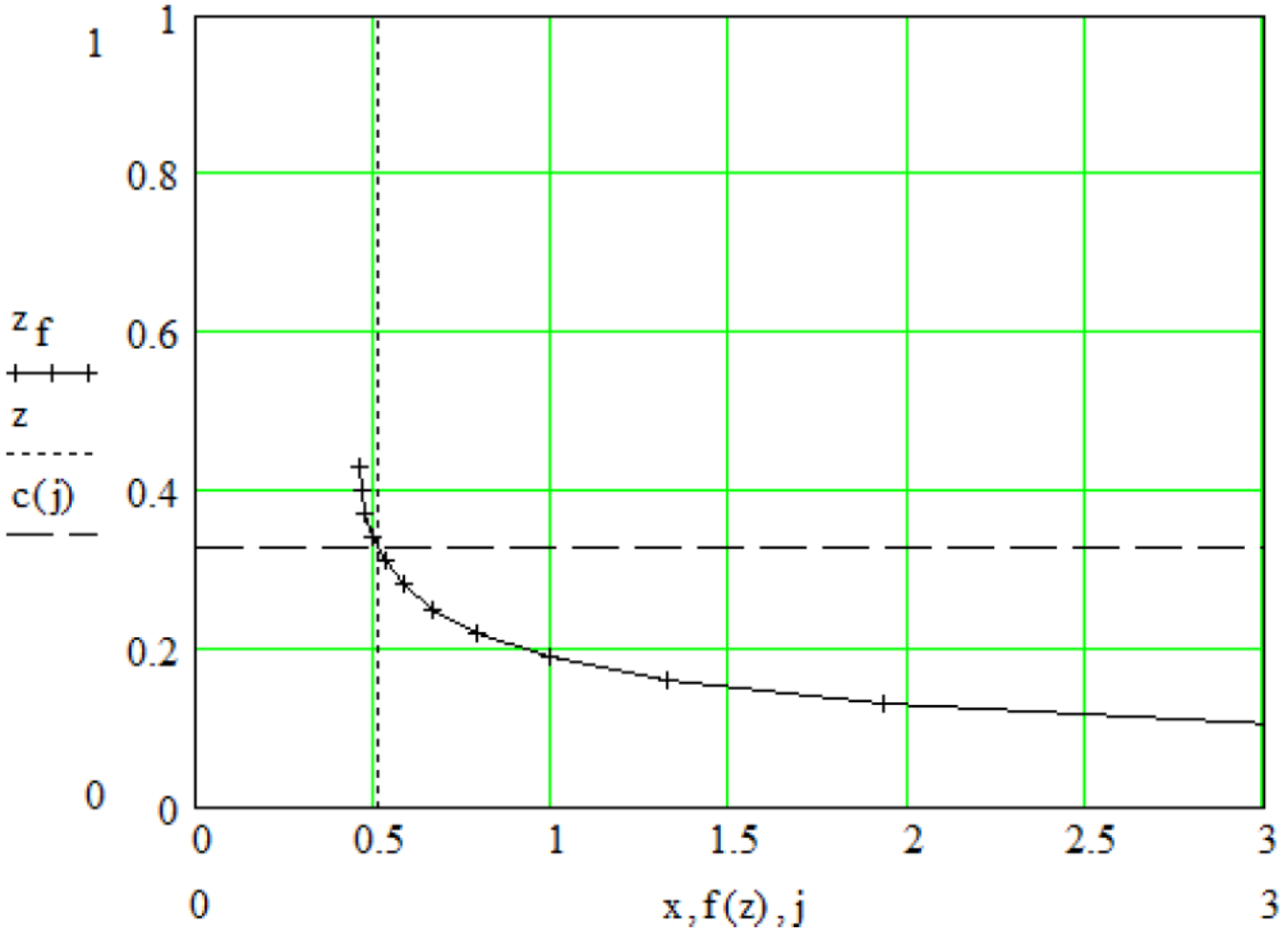

Figure 8.1 - Graph for definition oil saturation at the front water-oil displacement

The value plotted $1-\rho_{r\ o}$ - $\rho_{b\ w}$ we get on the horizontal axis and extending to the intersection with the graph, we get the desired value z_f .

Prof. Borisov showed that increased filtration resistance in the zone of replacement of oil with water can be considered the introduction of a formula filtration resistance coefficient for this zone to increase filtration resistance.

Coefficient to increase filtration resistance α shows in how many times the increased resistance in the zone of replacement of oil with water. For strip, the deposit is determined by the formula

$$\alpha = \frac{\mu_w}{\mu_{oil}}\left(1{,}7 + 8z_f + 25z_f^2\right),$$

where z_f - oil saturation at the front water-oil displacement.

For circle deposit we have two cases:

1) the displacement of oil by water from the periphery to the centre

$$\alpha_1 = \frac{\mu_w}{\mu_{oil}}\left[1{,}7 + 8z_f\varphi_1\left(\frac{r_f}{R_0}\right) + 25z_f^2\varphi_2\left(\frac{r_f}{R_0}\right)\right];$$

2) the displacement of oil by water from the centre to the periphery

$$\alpha_2 = \frac{\mu_w}{\mu_{oil}}\left[1{,}7 + 8 z_f \varphi_1`\left(\frac{R_0}{r_f}\right) + 25 z_f^2 \varphi_2`\left(\frac{R_0}{r_f}\right)\right].$$

where φ_1, φ_2, φ_1', φ_2' - auxiliary functions that are dependencies on graphs (Fig. 3.8); R_0 - the radius of the initial position WOC, m; R_f - radius of the intermediate position WOC, m.

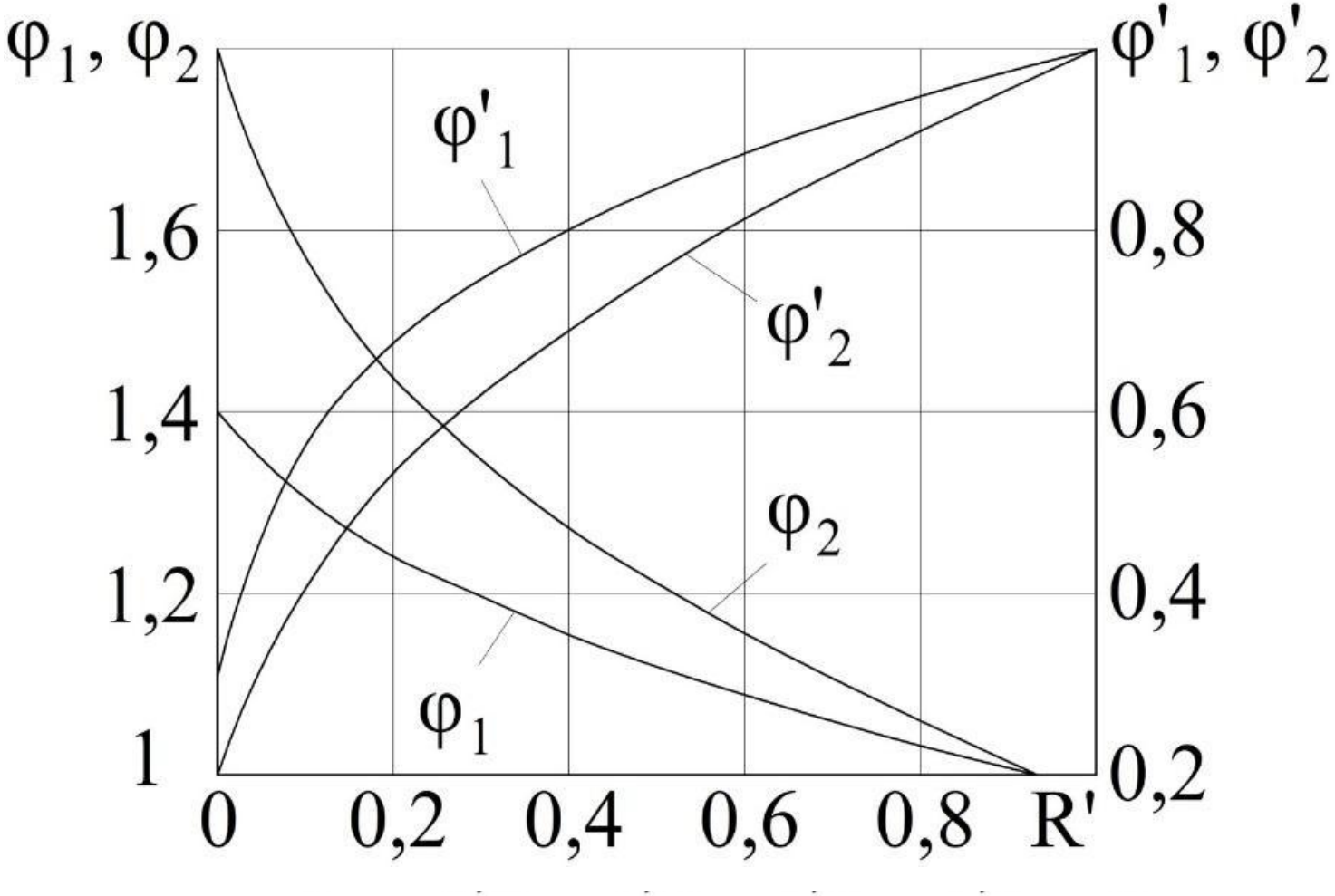

Figure 3.8 – Graphs for the definition of functions φ_1 and φ_2