LECTURE №8-9
FORECASTING DEVELOPMENT INDICATORS

Plan of lecture:

1. Forecasting oil production using the results of previous development.
2. Forecasting oil production under characteristics water-oil displacement.

Technological indicators of development at the stage of design determine the results of hydrodynamic calculations. To obtain these results need to have a large number of factors (the oil drives, parameters of the reservoir, parameters of the fluids, operating conditions of wells, etc.). Accurate knowledge of these data, especially in the early development unlikely. Therefore, to do the forecasting.

Forecasting – it is a prediction installation of further development, i.e. the course of the process of development in the future. There are forecasting oil production worked well-day and forecasting oil production under characteristics water-oil displacement.

1. Forecasting oil production worked well-day

Forecasting oil production worked well-day – it is forecasting oil production using the results of previous development. It is performed in the following order.

The study evidence of oil set basic patterns in the changes of oil in recent years. The dynamics of oil production in time trace using charting. In constructing graphs on the vertical axis – oil production, and the horizontal axis - time. Since the operation field is constantly changing number of wells, the construction schedules when oil production is set to worked well-day. After plotting selected analytical expression curve of production over time. With regard to the prediction of oil wells worked on day widely used in oilfield practice were formulas:

$$q_{oil}(t) = a \cdot t^{-b}, \qquad (1)$$

where a, b - coefficients are determined using actual processing results.

The input data for the calculation of prediction for oil production flow rate for the worked well-day are:

Years of development	Flow rate for the worked well-day

The coefficient *a* and *b* are determined by a system of equations:

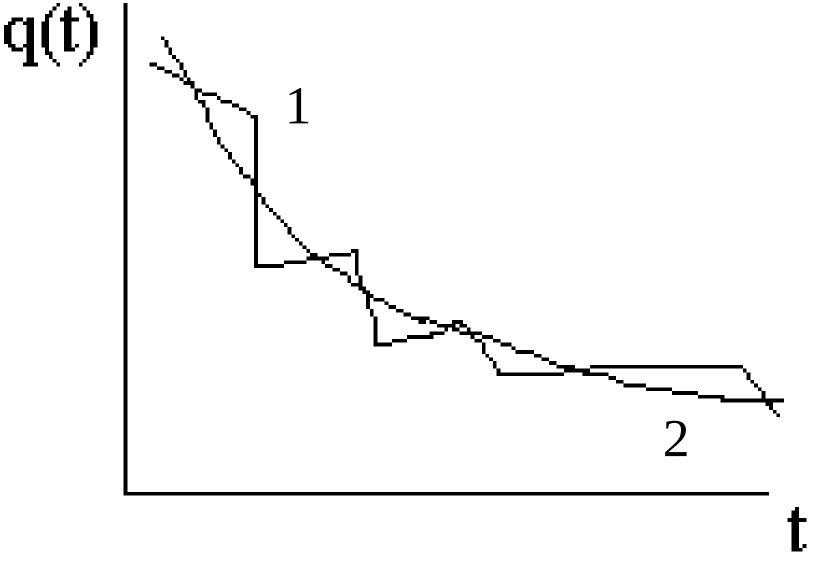
$$\begin{cases} \Sigma \log q_{oil}(t) = n \log a - b \Sigma \log t, \\ \Sigma \log q_{oil}(t) \log t = \log a \Sigma \log t - b \Sigma (\log t)^2; \end{cases} \quad (2)$$

where *n* – amount of years.

For solving the system of equations (2) the actual flow rate data changes over time more convenient to file as a table.

t, years	Flow rate, $q_{oil}(t)$	$\log q_{oil}(t)$	logt	$\log t \times \log q_{oil}(t)$	$(\log t)^2$
1 2 3 . . n		$\sum \log q_{oil}(t)$	$\sum \log t$	$\sum \log t \times \log q_{oil}(t)$	$\sum (\log t)^2$

Determining coefficients *a*, *b* for the formula (1) can calculate the theoretical value of oil and comparing the theoretical and actual production is set convergence results.



1 - actual results;
2 - theoretical curve.

The degree of precision composite equation is judged by a correlation coefficient, which is determined by the formula

$$r = \frac{\Sigma\left(\log t \cdot \log q(t)\right)/n - \log t_{aver} \cdot \log q(t)_{aver}}{\sigma_t \cdot \sigma_{q(t)}}, \tag{3}$$

where σ_t *and* $\sigma_{q(t)}$ - mean-square deviation

$$\sigma_t = \sqrt{\frac{\Sigma\left(\log t - \log t_{aver}\right)^2}{n}}, \tag{4}$$

$$\sigma_{q_{oil}(t)} = \sqrt{\frac{\Sigma\left(\log q(t) - \log q(t)_{aver}\right)^2}{n}}, \tag{5}$$

where $\log t_{aver}$ and $\log q(t)_{aver}$ - the arithmetic mean of all values of logarithms t and q(t).

The correlation coefficient ranges from -1 to +1. The closer the correlation coefficient to the unit, the more accurate theoretical formula corresponds to the actual flow rate change over time.

For downward curves correlation coefficient is (0 - -1), for upward curves - (0 - +1).

If *r* = 1, the correlation is converted to exact a relationship and if *r* = 0, the correlation between the studied parameters do not exist. It is believed that by convergence *r* = 0,5 results are satisfactory, with r = 0,7 - good for *r* > 0,7 - excellent.

From the formula (3) that the larger *n*, the greater the correlation coefficient.

To carry out the forecast for the worked well-day can be no more than 1/3 of the years under consideration (years of development).

2. Forecasting oil production under characteristics water-oil displacement

Characteristic water-oil displacement is called the relationship between the accumulated oil production and accumulated fluid production. Characteristics displacement reflects the actual process of extracting oil from the depths and the associated flooding dynamics of production or development mode heterogeneity of strata displacement of oil by water. Displacement characteristics allow determining the efficiency of extraction of oil in the flooding. In practice, the displacement characteristics are used to assess the effectiveness of measures designed to improve the system design. Displacement characteristics can be divided into two types: *integral and differential*.

There are many different characteristics water-oil displacement:

- $Q_{fl}/Q_{oil} = a + bQ_w$; (6)
- $Q_{oil}=a+bq_{oil}/q_w$; (7)
- $Q_{oil} = a + b \cdot lnQ_{fl}$; (8)
- $Q_{oil} = a + b \cdot lnQ_w$; (9)
- $Q_w=a+bln(q_w/q_{oil})$; (10)

where Q_{oil} , Q_{fl} , Q_w - accumulated oil, fluid and water production; q_{oil} , q_w - year production oil and water; *a*, *b* - statistical coefficients.

Integral characteristics water-oil displacement (6), (7) are the most simple and convenient, those in the processing of data to determine the effectiveness of hydrodynamic action. Characteristics of water-oil displacement (8), and (10) are differential. They include the following values: current production, water cut.

The coefficients *a* and *b* are determined by statistical data processing from the system of equations.

$$\begin{cases} \sum y = na + b\sum x, \\ \sum xy = a\sum x + b\sum x^2. \end{cases} \tag{11}$$

$$b = \frac{\sum y \sum x - n\sum xy}{\left(\sum x\right)^2 - n\sum y^2}; \qquad a = \frac{\sum xy - b\sum x^2}{\sum x}.$$

In this case, the prediction of the expected oil production will hold through arithmetical selection dependence, corresponding to actual dependence accumulated oil production from an accumulated fluid. The initial input data are:

Years	Accumulated oil production, ths. tons	Accumulated liquid production, ths. tons

Prediction for extracting characteristics repression carried out as follows. Pick formula by which we carry out forecasting (this is a formula in which the highest correlation coefficient in absolute value). Determine the amount of extracted liquids annually in recent years (for example, ten). Determine the average fluid production over the years. Then add the final production accumulated fluid (produced last year) and the average fluid production in the coming years. And according to the established formula determines the estimated accumulated oil.

In determining the accumulated oil and liquids can be found accumulated water production, years production of oil, fluid and water, and the water cut to determine the growth of production for years.

Thus, forecasting production is carried out in three stages:

1) pre-processing statistical series;

2) the choice of form curve that describes the change in flowrate over time;

3) the calculation of the unknown coefficients *a* and *b* in the equation of the curve and the actual prediction.