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SIGNIFICANCE OF HYDRODYNAMIC MEASUREMENTS IN OIL FIELD DEVELOPMENT

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SUMMARY

The "Sopron - X" oil field is part of the "Z-1" oil field, located on the territory of Hungary. Several wildcat wells have been drilled within it so far, and their construction was preceded by numerous geological, geophysical, geochemical and hydrodynamic tests. They are used to define the stratigraphic characteristics of the deposit, tectonic relations, petrophysical characteristics of the rocks, and physical-chemical and PVT characteristics of the deposit fluids. Hydrocarbon reserves in the reservoir are also defined.

The paper presents the production characteristics of the deposit and the characteristics of the fluid inflow into the considered wells were processed. To predict the possible production of wells, an analysis system was made in the software package "PIPESIM". Data obtained by hydrodynamic measurements, as well as data on fluid characteristics, were used for the analysis.

At the "Z-1" deposit, after the hydrodynamic measurements were carried out, the production characteristics were determined, which are of great importance when making decisions about the way and methods of deposit exploitation, production intensity, economic profitability, as well as the length of commercial profitability of the "Sopron-X" oil field and Z-1 oil deposit in general.

Key words: oil, gas, oil field, hydrodynamic measurements, stocks, oil recovery factor

INTRODUCTION

In order to test the presence of hydrocarbons on the "Sopron-X" structure, the first exploratory well was located and drilled in 1980. The task of the well was to drill Tertiary sediments, drill the paleo-relief, examine the composition and development of the drilled formations and check the presence of hydrocarbons in the rock masses.

Exploratory wells revealed commercial quantities of hydrocarbons, and the drilling was repeated with the creation of well X-001. Drilling confirmed the assumed structural form and discovered the "Sopron-X" oil field.

Intensive exploratory drilling has continued, and so far, several exploratory and contour-exploratory wells have been drilled in the field. The goal of everything is to increase the utilization of established hydrocarbon reserves.

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At well X-001, during the hydrodynamic measurement, corresponding data on pressure and production were obtained, which were also interpreted. Based on them, the dependence of the fluid flow through the pore space on the dynamic pressure at the bottom was obtained, whereby the productivity index method (Well PI) was applied and the indicator curves (IPR) were determined.

1. RESULTS OF LABORATORY PVT ANALYSIS

Laboratory PVT analyzes were performed on a representative oil sample from well X-001.

On the oil sample from the interval 2279.0 - 2567.0 m, which was tested at reservoir temperature, the extraction pressure is 131.6 bar, which gives a volume factor for oil of 0.7278339 (B_{oi}). The amount of dissolved gas in oil obtained by differential degasification is 60.6 m^3.

The characteristics of oil based on PVT tests are given in table 1 and in figures 1 and 2.

It was concluded that the deposit "Z-1" belongs to the group of unsaturated deposits, with a saturation pressure of approximately 131.6 bar, which coincides with the differential degasification values.

Table 1. PVT characteristics of oil field "Z -1"

Pressure (bar)	**Rs (m^3/m^3)**	**Bo (m^3/m^3)**	**Oil viscosity (mPa*s)**	**Oil density (kg/m^3)**
344,8	60,6	1,261	-	-
310,3	60,6	1,2696	0,82061	747,29
260,6	60,6	1,2784	0,76793	740,52
206,9	60,6	1,2889	0,72175	733,41
172,4	60,6	1,2964	0,69599	729,59
137,9	60,6	1,3046	0,67076	725,79
131,6	60,6	1,3065	0,66544	725,23
103,4	49,9	1,2794	0,73558	732,74
82,8	42,01	1,2638	0,78558	738,38
62,1	33,81	1,2457	0,83324	744,55
41,4	25,17	1,2251	0,89099	751,24
20,7	15,36	1,1955	-	-
3,4	3,88	1,1607	-	-
1	0,02	1,1175	-	-

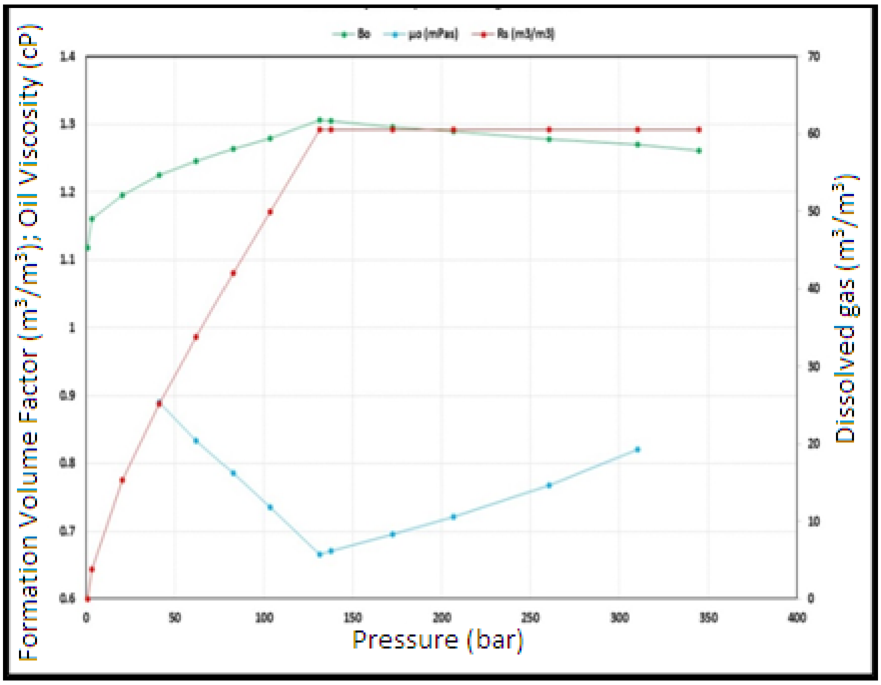

Figure 1. PVT characteristics of oil field "Z -1"

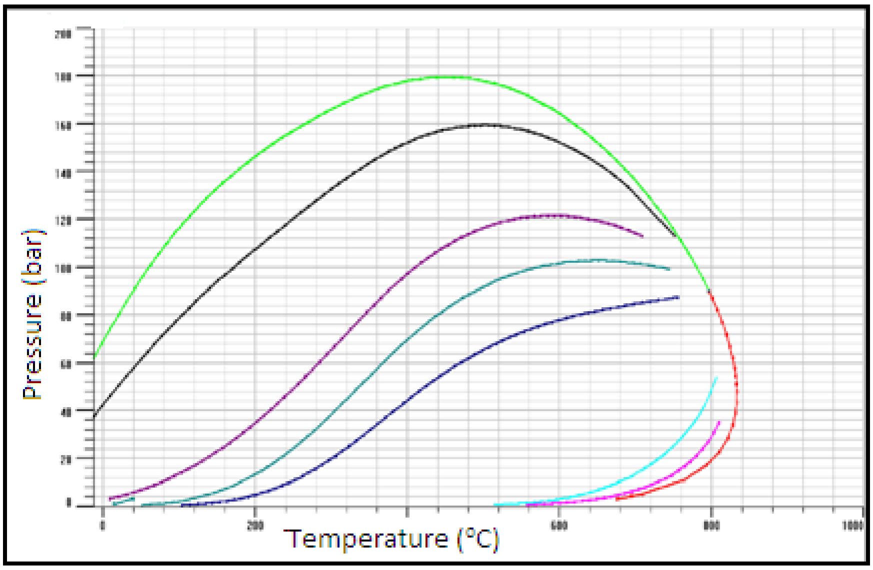

Figure 2. Phase diagram of the "Z-1" oil field

Based on the oil saturation pressure (131.6 bar), the initial reservoir temperature (133.96 °C) and the relative density of gas in relation to air (0.82), using the specialized program "Kappa PVT", the volume factor was calculated free gas formations – Bg (0.0100458), gas compressibility – Z (0.92544) and gas viscosity (0.017427 mPa s).

The values of PVT gas characteristics are shown in table 2 and in figure 3.

Table 2. PVT characteristics of dissolved gas of oil field "Z-1"

P (bar)	Bg (m^3/m^3)	Z	µg (mPas)
Pb=131,6	0,0100458	0,925446	0,017427
130	0,0101737	0,925838	0,017364
120	0,0110556	0,928702	0,016979
110	0,0121069	0,93226	0,016614
100	0,0133778	0,936474	0,016269
90	0,0149408	0,941297	0,015947
80	0,0169044	0,946673	0,015646
70	0,0194389	0,952536	0,015367
60	0,0228282	0,958813	0,015111
50	0,0275827	0,965422	0,014878
40	0,0347229	0,97227	0,014668
30	0,0466301	0,979261	0,014484
20	0,0704471	0,986288	0,014326
10	0,141887	0,99324	0,014201

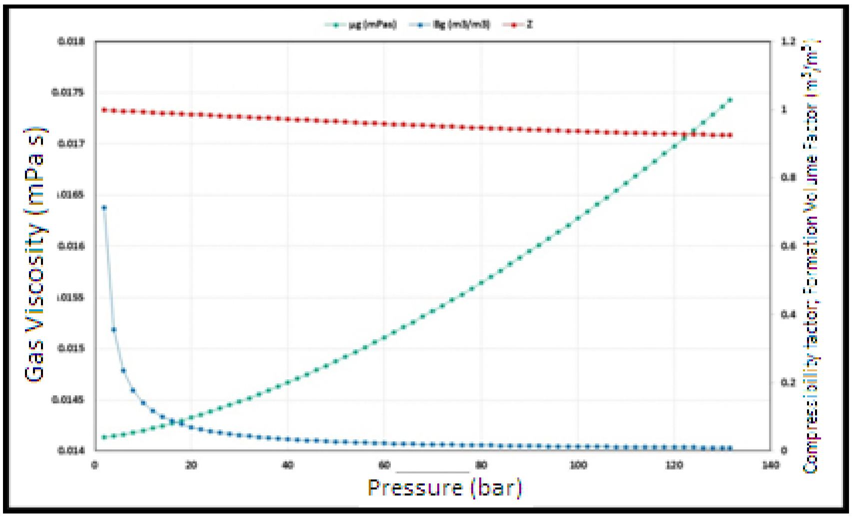

Figure 3. PVT characteristics of dissolved gas of oil field "Z-1"

2. RESULTS OF HD MEASUREMENTS CARRIED OUT ON THE WELL X -001

Well testing methods occupy a special place in oil and gas exploitation. The aim of these tests is, first of all, practical knowledge of the state of the deposit and determination of its productive possibilities.

In the period before the start of exploitation, these tests represent a necessary phase of studying the deposit, while during the exploitation of the well, hydrodynamic tests are used to control the operation of the well itself.

By processing the results of hydrodynamic tests, important physical parameters are obtained, which also serve as a parallel method to similar tests on core samples (permeability).

These tests allow us to obtain significant data about the well, but also about the deposit itself. These are data on the pressure, temperature and flow (production) of oil, gas and water, as well as the percentage of oil saturation with water (water content), and the size of the gas factor (GOR).

Knowledge and analysis of reservoir pressure, combined with oil production data and laboratory data on fluid and rock properties, provide us with the basis for determining reservoir characteristics and determining reservoir fluid reserves.

There are different HD measurement methods, such as:
- fluid level measurement,
- measurement of fluid gradient in the well,
- pressure drop measurement,
- measurement using the pressure rise method,
- testing of injection wells using the pressure drop method,
- limit test,
- interference test,
- pulse test.

During these measurements, it is necessary to collect the following surface data:
• pressure on the tubing,
• pressure on the casing,
• fluid flow at surface conditions (Qfl, Qn, Qg, Qv),
• fluid level in the well.

Measurement data, which are obtained at the bottom of the well, are:
• pressure at the measurement depth (depth of manometer installation, ESP pump depth),
• temperature at the measurement depth (manometer installation depth);
• static and dynamic fluid levels.

The production characteristics of the "Z-1" oil field were determined by hydrodynamic measurements on wells. Hydrodynamic measurements on these wells were made at several nozzle openings and the wells were closed, due to pressure increase measurements. One of those wells was well X-001.

Table 3. Productivity measurement results at the "Z-1" field

Nozzle diameter	Ps	Pd	Depression	Qo	Qg	Qfl
(mm)	(bar)	(bar)	(bar)	(m^3/dan)	(m^3/dan)	(m^3/dan)
2,3	260,89	249,6	11,3	25,4	1155,8	25,6
2,6		249,1	11,8	30	1388	30,5
3		247,8	13,1	43	2011	43,6

Ps - static pressure; P_d - dynamic pressure; Qo - oil production; Q_g - gas production;
Q_{fl} - production of fluids; GOR - gas factor; IP – I ndex of Productivity

The the pressure rise measurement, made on the well X-001, based on the interpretation of the pressure rise curves, gave values for permeability (k), layer capacity (kh) and skin factor.

The presented results of the measurement of the pressure increase in the well X-001, but also in several other wells, show that the collectors of the deposit "Z-1" belong to medium to well permeable collectors, and in the well X-001, based on the skin values obtained, it was established pollution of the near-well zone (and not only in it).

Based on the interpretation of the derivation curve, it can be clearly seen that the well is located in a reservoir with a strong active water pressure regime, which causes the derivation curve to drop sharply downwards (Figures 4, 5 and 6).

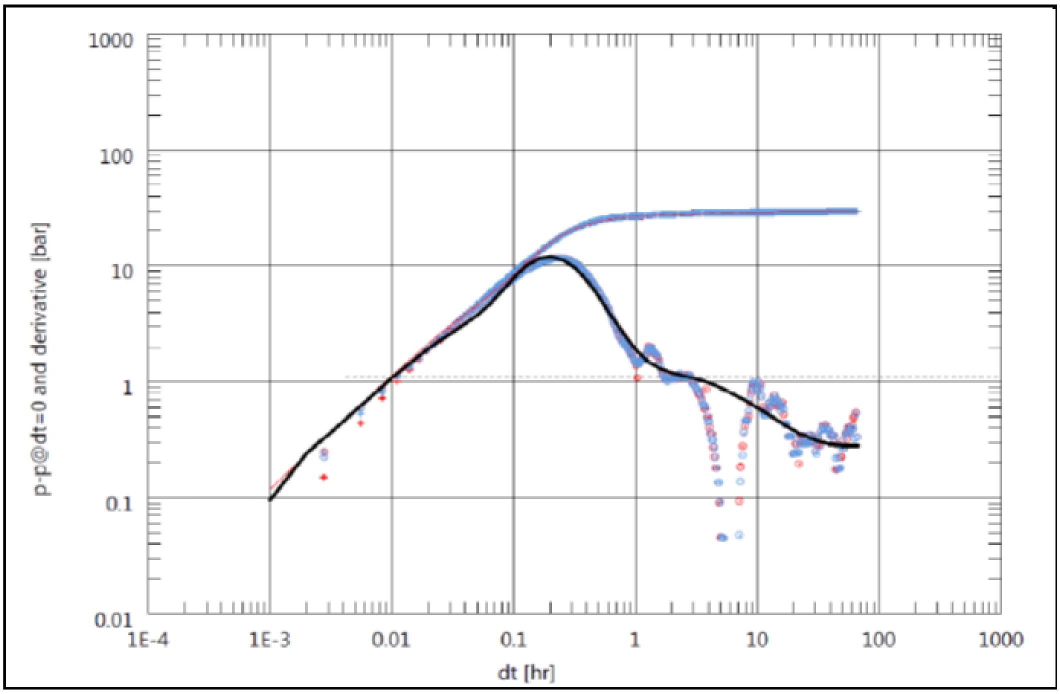

Figure 4. Derivative curve of well X-001

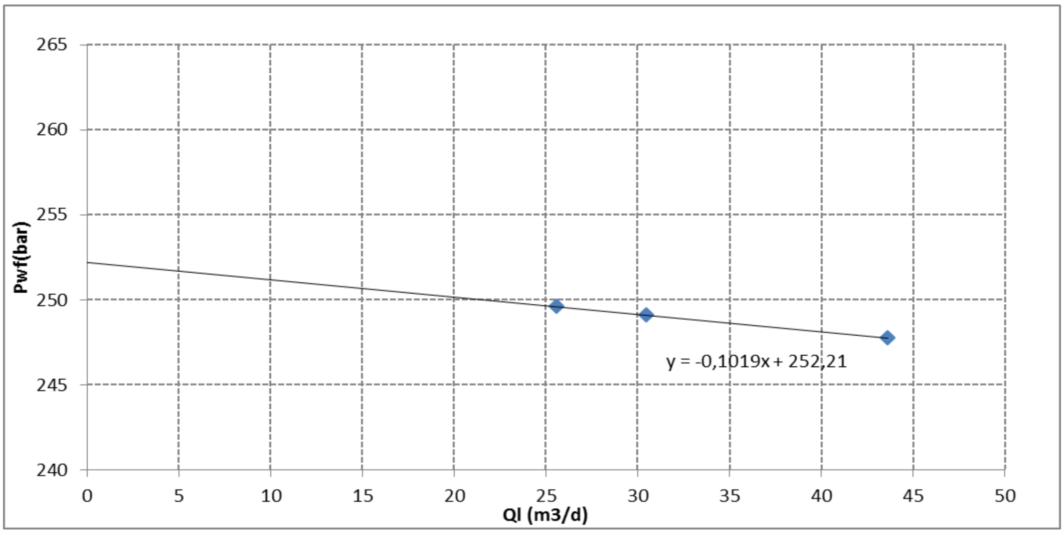

Figure 5. Results of IPR analysis for individual nozzle diamaters

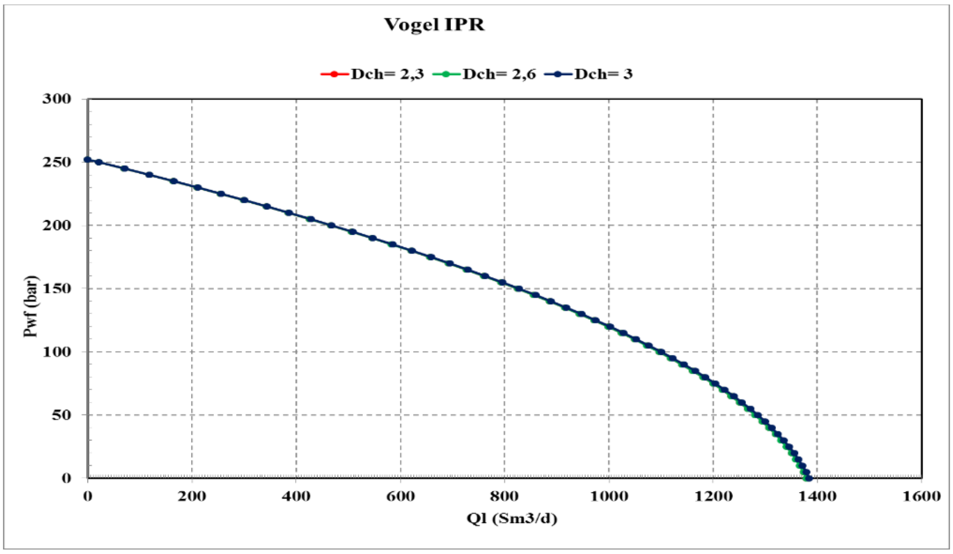

Figure 6. Results of the reservoir pressure analysis performed using the interpolation method

Taking into account the PI and the behavior of the pressure on the tubing, the optimal mode was the one achieved with a nozzle diameter 2.3 mm. Unlike the 3 mm mode, the 2.3 mm opening shows more stable operation and more stable tubing pressure.

3. TECHNOLOGY OF OIL AND GAS PRODUCTION

The production characteristics of the deposit and the characteristics of the fluid inflow into the wells can be discussed on the basis of the hydrodynamic measurements performed on the wells.

As an example, among others, well X-001 was taken.

At well X-001, during the conducted hydrodynamic measurement, corresponding data on pressure and production were obtained, which were also interpreted.

Based on them, the dependence of the fluid flow through the pore space on the dynamic pressure at the bottom was obtained, whereby the productivity index method (Well PI) was applied and the indicator curves (IPR) were determined, which is presented in Figure 7.

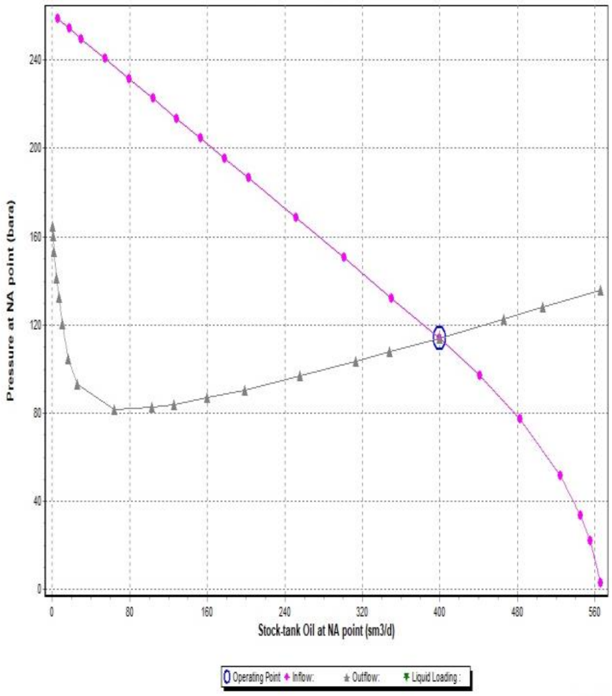

Figure 7. Indicator curve of well X-001

4. SYSTEM ANALYSIS OF WELLS PRODUCTION

To predict the possible production of wells, a system analysis was made in the "PIPESIM" software package. Data obtained by hydrodynamic measurements, as well as other, previously obtained data, were used for the analysis.

4.1. ANALYSIS OF THE INFLUENCE OF NOZZLE DIAMETER

Most eruptive oil wells, as well as a certain number of wells with a mechanical method of production, are equipped with nozzles on the surface, in order to control pressure and regulate production. The nozzles are installed at the mouth of the well or on the collection collector. When analyzing the influence of nozzle diameter, the nodal point is taken on the surface, i.e. at the mouth of the well.

At well X-001, in order to solve possible problems of lagging and collection of the liquid phase at the bottom of the well, a prediction of the behavior of the well with a drop in reservoir pressure with different nozzle openings was made, which is shown in Figure 8.

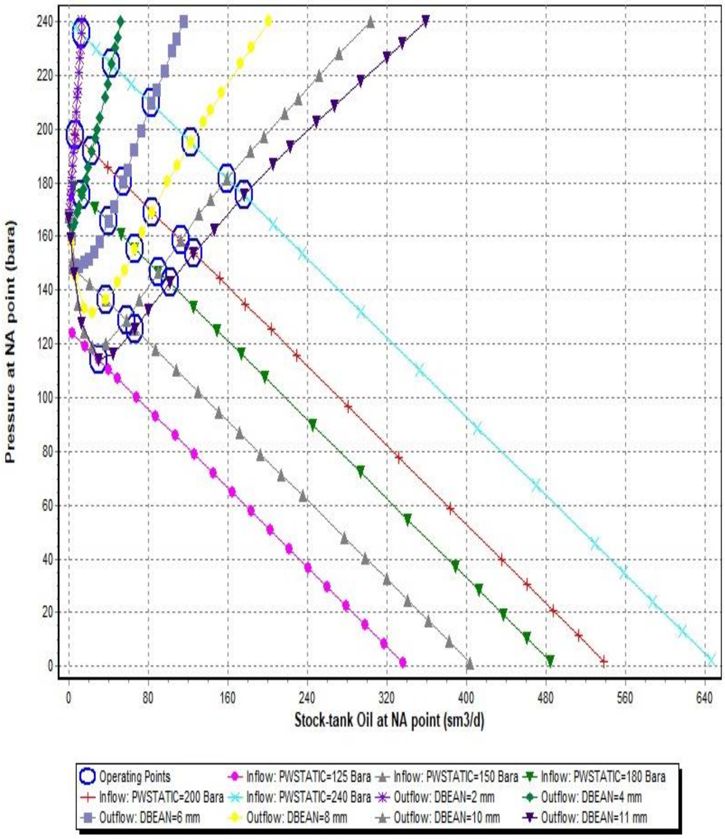

Figure 8. Graphic presentation of the analysis of the influence of reservoir pressure drop and nozzle diamaters on flows - well X-001

It can be seen on the diagram that, when the reservoir pressure drops below 180 bar, on smaller nozzle diameters, there is a problem with the release of fluid by eruptive work, and it is necessary to include some of the mechanical exploitation methods.

DISCUSSION

Hydrodynamic measurements represent the basic type of measurement that is carried out during the exploitation phase of each individual well, that is, the development of the oil reservoir as a whole. These measurements determine the production characteristics of the reservoir, obtain data on the flow and phase state of the fluid in the reservoir, pressures in individual parts of the system, and define the optimal production regime of each individual well within the reservoir.

Based on these input data and with the help of the analysis system (PIPESIM software package), we are able to effectively forecast the production of the entire field.

Based on this approach, the diameter of the nozzle opening was defined for the optimal production regime, which should lead to an increase in the degree of utilization of the deposit.

CONCLUSION

The application of hydrodynamic (HD) measurements collects the necessary data on the production characteristics of the reservoir and data on the change in pressure in the reservoir. At the "Z-1" oil deposit, after the hydrodynamic measurements were made, production characteristics were determined that are of great importance when making decisions about the way and methods of deposit exploitation, production intensity, economic profitability, as well as the length of commercial profitability, as the deposit " Z-1", as well as the entire field "Sopron-X".

On the well X-001, the pressure rise was measured and, based on the interpretation of the pressure rise curves, data were obtained on permeability (k), layer capacity (kh) and skin factor, the values of which enable more successful calculations, the results of which provide us with values that are precisely they indicate the total amount of reserves that can be exploited, the optimal mode of operation of the well and the reservoir, the optimal opening of the nozzle that we will use, as well as a better determination of the value of the reservoir pressure.

The obtained data indicate that the well X-001 is located in a part of the reservoir with a pronounced water pressure regime, which directly affects more successful exploitation and greater utilization of the reservoir.

At well X-001, production measurements were made at 3 nozzle diameters, in order to define the optimal mode of operation of the well. Based on the measurement of the productivity of the well, an analysis of the IPR curve and determination of the reservoir pressure using the interpolation method was performed. The reservoir pressure at a depth of 2200 m is 252 bar, reduced to the middle of the perforation 2277 m, with a gradient of 0.74 bar/m, it is 258.91 bar.

By reading Vogel's IPR curve and checking the IP, it is concluded that the optimal production mode will be on a nozzle diamater of 2.3 mm.

REFERENCES

1. Danilović, D.: " Razrada i eksploatacija ležišta "Z-1" naftnog polja Šopron-X“, Magistarski rad, RGGF Tuzla, Tuzla, 2023.
2. L.P.Dake.: "Fundamentals of reservoir engineering", 1st Edition, 1983. Elsevier
3. Lowell, J.M.: "Structural Styles in Petroleum Exploration", Oil&Gas Constultants International Inc., Tulsa, Oklahoma, USA, 1997.
4. Valenti, R.: "New Oil From Old Field", Oil & Gas Consultants Internacional Inc., Tulsa, Oklahoma, USA, 2003.
5. Studija izvodljivosti eksploatacije nafte i rastvorenog gasa na eksploatacionom polju "Z-1"
6. Tehnička dokumentacija NIS – Naftagas Novi Sad