RISK REDUCTION IN WELL FLOW LINES BASED ON EARLY DIAGNOSIS OF COMPLICATIONS

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Abstract

The reliability of the system for collecting products from oil, gas and gas condensate fields directly depends on the condition of the well flow lines. Many years of experience in the exploitation of offshore fields in the Azerbaijani sector of the Caspian Sea shows that various kinds of complications arise in the flow lines of wells associated with salt deposits, asphalt base, tarry oil and paraffin deposits, fluid accumulation, pressure pulsations, etc.

The listed complications lead to the formation of blockages in the flow lines, an increase in the mechanical load on the equipment and, ultimately, to a decrease in the productivity of lines and wells, up to the point of stopping their operation. Work to restore these lines takes quite a long time and requires significant costs.

Reducing technological risks in the operation of well flow lines is closely related to diagnosing their condition. But planned diagnostic work involving forces and equipment often in practice reveals complications at a late stage of their development and engineering decisions are made to shut down wells and restore lines.

In connection with the above, the issues of diagnosing complications at an early stage of their formation acquire current and practical importance. Timely cleaning of flow lines and regulation of operating conditions of production wells, such as the selection of an adequate wellhead pressure regime and other technological solutions, can prevent a negative scenario for the development of complications. In turn, for early diagnosis of complications it is necessary to find a diagnostic criterion. determining the beginning of their formation. Due to the fact that the main flow parameters at the metering nodes are continuously recorded in real time, it would be advisable to develop an appropriate diagnostic criterion based on the results of studying the dynamics of time series for the main indicators of flow lines.

For this purpose, in this work, flow lines of wells in the Bulla-Deniz field (Azerbaijan) were studied. The main indicators for the studied lines were length and diameter, pressure at the beginning and end of the line, gas factor and line productivity. Based on these indicators, data processing was carried out and corresponding statistical estimates were obtained.

The results of the analysis revealed a stable correlation between gas factor indicators and flow line performance. It was established that a sharp decrease in line productivity with an increase in the gas factor manifested itself in wells in which restoration work was carried out due to complications that arose. This makes it possible to use this behavior of the curves of the dependence of flow line productivity on the gas factor as a criterion for diagnosing complications at an early stage of their formation.

The results of this research can be recommended for use in the operation of a system for collecting and transporting oil and gas field products.

Keywords: flow lines, risk analysis, diagnosis of complications, gas factor, line productivity

I. Introduction

Well flow lines, as an element of the gas and oil collection network, are pipelines originating at the wellhead and ending at the entrance to group metering installations [1]. Many years of

operating experience show that various kinds of complications arise in flow lines, the elimination of which requires stopping the operation of wells and carrying out repair work, accompanied by significant downtime and, as a consequence, material and labor costs.

In work [2], using the example of Russian fields, it is shown that the accumulation of liquid, especially at the late stage of development, leads to a number of complications both in flow lines and in the operation of process equipment at the collection point. Among them, one can highlight an increase in hydraulic resistance, the observation of volley releases of liquid into separation units, pressure pulsations and the formation of hydrate plugs with a decrease in temperature in winter. The authors here also propose, in order to reduce the risk of liquid accumulation, optimal regulation of gas extraction modes, which, ultimately, should also significantly increase the operating efficiency of separation units.

The authors in another work [3] list asphalt base oil, tarry oil and paraffin deposits, the formation of emulsions, hydrates, and inorganic salts as the main factors leading to complications in field pipelines. The researchers in this work brought some clarity to the conditions and mechanism of formation of the above factors and listed existing methods for reducing the risk of their formation.

Technological risks associated with the formation of hydrate plugs and the loss of paraffin deposits in pipeline lines have been studied in detail in studies [4]. Here, the authors proposed a probabilistic model for assessing the above risks in pipelines transporting oil and gas, tested it on real field data and showed fairly good performance.

In offshore oil and gas production, flow lines are connected to a subsea pipeline that transports well production to onshore collection and treatment facilities. In this regard, the above complications in the operation of flow lines lead to potential hazards in the operation of underwater pipelines, which were analyzed in detail for the conditions of the Caspian Sea in [5].

Reducing risks in the operation of well flow lines and, in general, subsea pipelines, field process pipelines and other pipeline communications is directly related to the ability to diagnose their condition. It is important to note here that quite often, diagnostic work begins to be carried out after complications have arisen in their work and work to restore them requires significant costs. Therefore, issues of early diagnosis, that is, timely detection of the onset of complications, have always been of scientific and practical interest and remain relevant today.

For example, in article [6] the use of fractal analysis for diagnosing liquid inclusions in gas flows in field gas pipelines is justified. Based on field data, flow characteristics were constructed for the flow lines of selected wells and the corresponding values of the fractal dimension were obtained using the coating method. A stable correlation has been established between changes in fractal dimension and the presence of liquid inclusions in gas flows. The presence of such a stable connection was also confirmed by the results of studies conducted in [7].

Thus, a change in the fractal measure of flow characteristics curves seems to be a fairly effective analytical criterion for early diagnosis of complications in the operation of flow lines of wells, in particular the accumulation of the liquid phase in them.

II. Methods

As the object of research 23 flow lines of the “Bulla-Deniz” field (Azerbaijan) have been taken and dynamics of the change of average values of the following indices have been analyzed: oil consumption, gas consumption, pressure at the beginning and end of the line, gas factor, average temperature of the flow and productivity of the flow line. All these indices are presented in the Table 1.

Studied lines were divided into two groups due to their productivity on the basis of hyperbolic value of distribution to reveal the flow lines in the operation of which complications occurred [8].

Table 1: *Values of operational parameters of the flow lines*

Flow lines	Diameter D, m	Length L, m	Rate of oil, q_{oil}, t/day	Rate of gas q_{gas}, m^3/day	Pressure at the beginning P_1, MPa	Pressure at the end P_2, MPa	Gas factor q, m^3/t	Temperature t, °C	Ourput of line t/day/MPa
9	0,102	1250	253	76	5,8	2,2	300	50	70,3
60	0,102	1500	462	72	7,2	2,2	156	45	92,4
67	0,102	1700	410	30	4,5	0,8	143	57	110,8
57	0,102	1500	285	25	6,3	4,2	88	58	135,7
65	0,102	1000	200	46	9,6	4,7	230	44	40,8
62	0,102	1800	150	28	4,4	2,0	187	43	62,5
61	0,102	1250	300	44	6,8	3,0	98	40	107,1
71	0,102	1250	385	44	5,8	2,0	114	47	101,3
34	0,102	1000	450	36	6,0	2,2	120	49	118,4
48	0,102	1250	210	45	3,9	1,9	110	38	105,0
43	0,102	1750	190	21	5,0	0,8	110	37	45,2
122	0,102	1200	181	80	7,0	2,0	442	35	36,2
100	0,102	1200	310	53	4,4	2,1	170	55	134,8
84	0,102	1350	220	22	5,1	2,0	100	45	70,9
80	0,102	1250	255	65	4,0	1,8	254	53	115,3
32	0,102	1500	250	47	3,5	0,9	188	53	96,1
45	0,102	1650	225	20	4,7	1,2	88	59	64,3
85	0,102	1750	150	40	4,9	3,5	266	35	107,0
76	0,102	1750	140	38	5,9	4,5	271	29	100,0
39	0,102	1500	60	6	3,7	2,3	100	54	42,8
36	0,102	1400	180	25	4,4	2,8	140	32	112,5
105	0,102	1300	320	39	6,4	3,9	310	42	94,1
17	0,102	1300	230	57	6,0	3,5	250	40	92,0

Flow lines with output below 92 t/day/MPa refer to the first group and above 92 t/day/MPa were collected to the second group. After division into groups we proceeded with big probability that complications have occurred in the lines with small productivity. That's why flow lines have been separately taken on each group: № 9, 65, 43 and 122 — from the first group line; № 61, 57 and 48 — from the second group line. Samples on monthly indices of oil consumption; gas factor and line productivity have been prepared individually. These indices have been processed for establishing static relations between existing methods of data analysis.

III. Results and discussion

The results of data processing have revealed definite regularity in the behavior of the dependence curves of flow line productivity on the gas factor. Thus, for the flow lines of the second group where no complications were observed (lines N 61, 57 and 48) gas factor weakly influences oil consumption change at the same pressure drops. By the other words points plotted on the coordinates of flow line productivity ($q_{oil}/\Delta P$,t/day/MPa) and gas factor index (q) are located on the straight line rather accurately (Figure, a). As it is seen from the figure increase of gas factor index doesn't considerably influence flow line productivity decreases. Together with it, analysis of dependency of productivity on the gas factor index for flow lines of the group (lines 9, 62, 43 and 122), where complications were observed has revealed the following stable regularity. In these lines productivity considerably decreases by the increase of gas factor (Fig. 1). It can be explained

by that due to the complications occurred in the lines, oil consumption decreases, part of the gas dissolves in the sediments and as a result productivity of flow lines reduces.

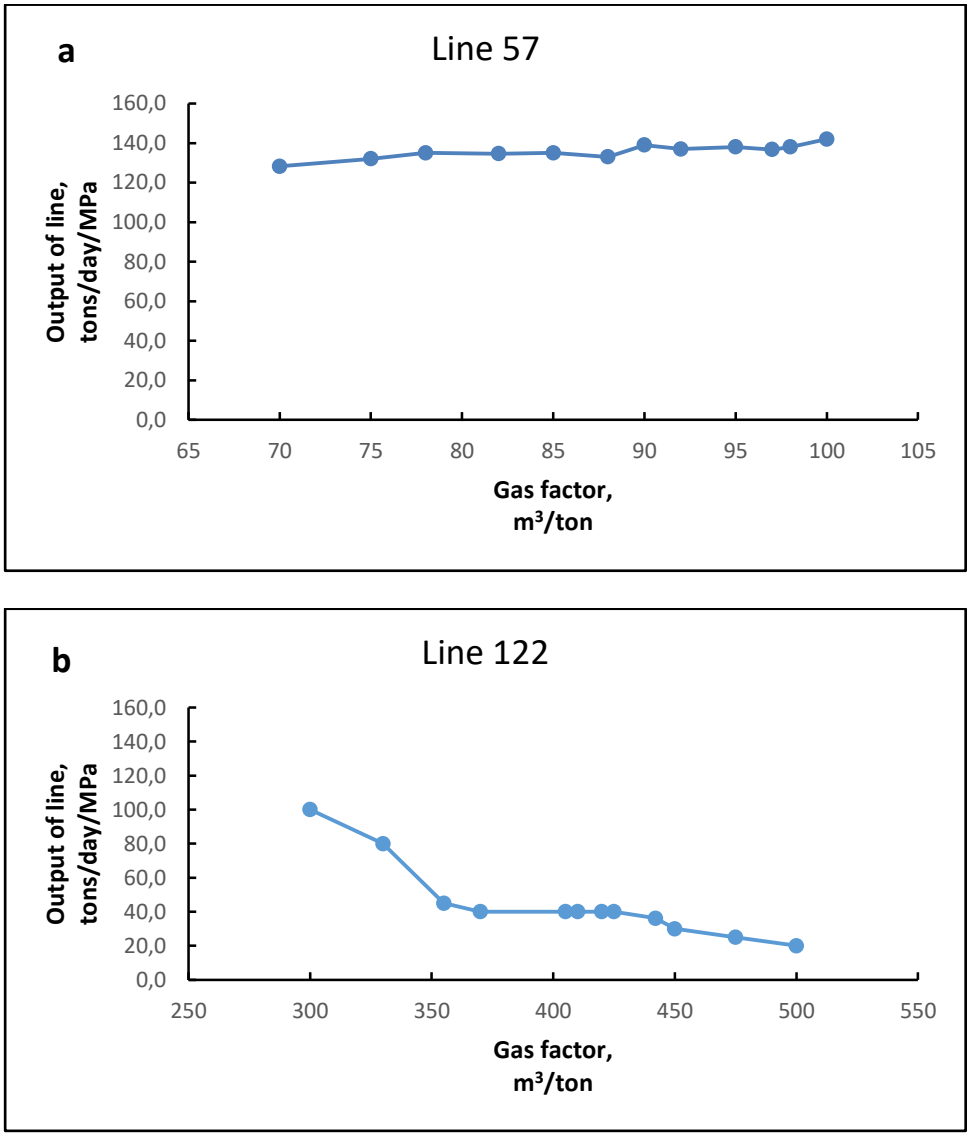

Figure 1: *The curves of the influence of the gas factor on the output of the flow lines*

The result of the carried out researches allow us to determine the following main conclusion that considerable decrease the productivity by gas factor increase is the diagnostic criterion for early revealing of the occurrence of complications in the flow lines and carrying out recovery works in time.

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