STRUCTURAL SYNTHESIS OF PIPELINE TRANSPORTATION OF INDUSTRIAL ENTERPRISES

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S u m m a r y. In the article the impact of the structure of pipeline transportation systems on the efficiency of their operation is examined. It is shown that, depending on the assumed structure, transport systems can be characterized by different performance characteristics. It is established that the structure of the system influences the development of the aging process and decrease system performance. Recommendations on the choice of the structure of systems that can be used at the design stage are given.

K e y м w o r d s : system, the pipeline, transportation, structure.

INTRODUCTION

Piping systems of industrial enterprises provide the ability to process flow of the technological processes and can be operated over a long period of time. Maintaining of their efficiency requires to conduct operations associated with repairing and maintenance. The need to disable the linear elements of such systems is accompanied by a reduction in their operating parameters and performance characteristics [1-5]. Therefore, the choice of rational structure of piping systems is being examined as a pressing problem, which arises at the stage of making design decisions.

ANALYSIS OF LAST RESEARCHING AND PUBLICATIONS

The possibility of reducing the efficiency of pipeline systems as a result of the gradual development of the aging process should be assessed at the design stage, and according to the results of this analysis decisions related to the choice of a particular structure should be made. A comparison of alternatives and final choice of system design is usually carried out based on the evaluation of metal consumption of the whole structure. This approach allows us to reduce the level of financial costs in the manufacture and installation of piping systems, but the expected decrease in their efficiency while in service is not taken into account [6-20].

GOAL OF RESEARCHING

The purpose of this work is a comparative analysis and the establishment of patterns of influence of restored pipe systems structures on effectiveness in operation process.

MATERIALS AND RESULRS OF RESEARCHING

In general, the problem of structural synthesis has no unique solution. This means that the final choice of structure should be based on comparative analysis of alternative options to ensure the delivery of the target product. Considered in this variants of structure may vary in the level of complexity, consumption of materials, as well as the expected values of operational parameters. Let us consider the task of structural synthesis of the pipeline system providing the delivery of the target product from the source of the seven customers, the relative position of which corresponds to the Technology section of the data presented in fig. 1. We assume that all consumers (A1, A2, ... A7) for a specified period of time should get the target product in the same volume. For example, in relation to this scheme of mutual location of the source and the seven consumers of the product, as shown in Fig.1 we can form four different variants of structure at different levels of complexity, which are presented in table 1.

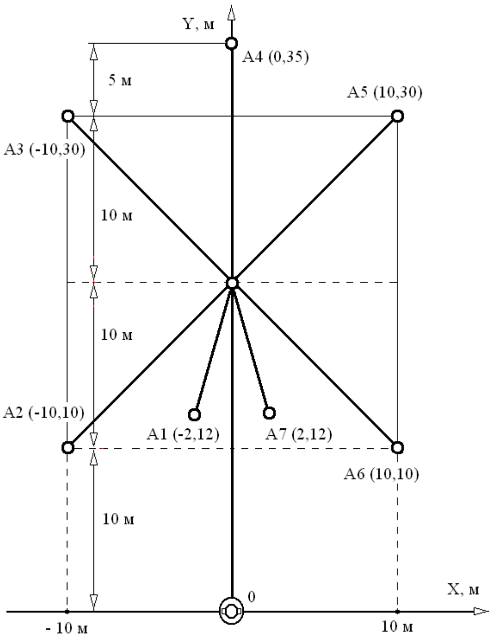


Fig. 1. The scheme of the technological area and coordinates of the consumers of the target product

To evaluate the level of a test structure should be used such characteristics as the total number of linear elements (pipes) and the number of distribution centers for the organization of traffic flow. Thus, the table. 2 shows the comparative characteristics of the analyzed structures, the structures themselves are arranged in order of increasing level of complexity. It is seen that the total length of all pipelines is minimal for the structure labeled ST4, and has a maximum value for the structure of the ST3.

The effectiveness of the renewable systems will be evaluated using the index, which is the ratio of the product volume that the system will deliver to customers within a specified period of time under the condition of reliable operation of elements of valves to the volume that the system is able to deliver over the same time, on condition of reliable operation of all structural elements [21].

In order to identify patterns of influence of renewable system structure on the efficiency of their functioning in the mode of nominal operation, it is important to consider the options presented in the table. 1.

Table 1. Alternative structures of pipeline transportation systems used in the analysis

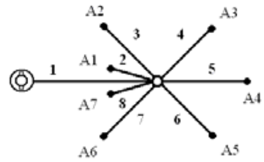
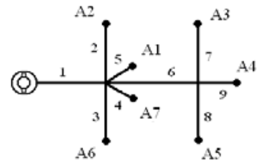
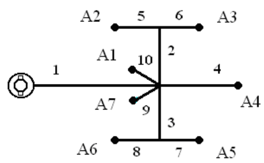
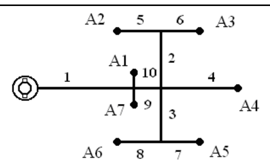
Designation of the structure	Image of the structure	Performance score of the system
ST1		$F_S = P^2$
ST2		$F_S = \frac{3P^3 + 4P^2}{7}$
ST3		$F_S = \frac{4P^3 + 3P^2}{7}$
ST4		$F_S = \frac{4P^4 + P^3 + 2P^2}{7}$

Table 2. Characteristics of the analyzed variants of structure of transport systems

Structure symbol	Characteristics of the analyzed structures		
	Number of distribution centers	Number of linear elements	Total length of the pipeline, m
ST1	1	8	108,1
ST2	2	9	80,66
ST3	3	10	111,5
ST4	4	11	99,0

1. Structure with the symbol ST1

Performance score: $F_S = P_1 \cdot \sum_{i=2}^{8} P_i \varphi_i$, where:

Pi - the coefficient of readiness of the i-th pipeline, which is the probability that the line is in working order at any moment, except for scheduled periods during which its intended use is not provided;

φi - transit potential of the i - th pipeline, which is a fraction of of the product that passes through a pipeline across the sample level in case of trouble-free operation of all structural elements.

Since in our task all consumers receive per unit of time equal volumes of the product, then: $F_S = \frac{P_1}{7} \cdot \sum_{i=2}^{8} P_i$

Let's assume that the coefficients of the readiness of all pipelines are identical and are characterized by the value of R. Then: $F_S(P) = P^2$.

2. Structure with a symbol ST2

Performance score for this case:

$$F_S = P_1 \cdot \{P_2\varphi_2 + P_3\varphi_3 + P_4\varphi_4 + P_5\varphi_5 + P_6\varphi_6(P_7\varphi_7 + P_8\varphi_8 + P_9\varphi_9)\}.$$

Transit potentials for the analyzed structures: $\varphi_2 = \varphi_3 = \varphi_4 = \varphi_5 = 0{,}143$; $\varphi_6 = 0{,}429$; $\varphi_7 = \varphi_8 = \varphi_9 = 0{,}333$. Then:

$$F_S = \frac{1}{7} P_1 \cdot \{P_2 + P_3 + P_4 + P_5 + P_6 \cdot (P_7 + P_8 + P_9)\}.$$

If the coefficients of the readiness are the same for all pipelines $P_1 = P_2 = \ldots = P_9 = P$), then:

$$F_S(P) = \frac{3P^3 + 4P^2}{7}.$$

3. Structure with the symbol ST3

Performance score for this case:

$$F_S = P_1 \cdot \{P_4\varphi_4 + P_{10}\varphi_{10} + P_9\varphi_9 + P_2\varphi_2(P_5\varphi_5 + P_6\varphi_6) + P_3\varphi_3(P_7\varphi_7 + P_8\varphi_8)\}$$

Transit potentials for the analyzed structures: $\varphi_4 = \varphi_9 = \varphi_{10} = 0{,}143$; $\varphi_2 = \varphi_3 = 0{,}286$; $\varphi_5 = \varphi_6 = \varphi_7 = \varphi_8 = 0{,}5$.

Then:

$$F_S = \frac{1}{7} P_1 \cdot \{P_4 + P_9 + P_{10} + P_2 \cdot (P_5 + P_6) + P_3 \cdot (P_7 + P_8)\}.$$

With the same value of P-availability for all linear elements: $F_S(P) = \frac{4P^3 + 3P^2}{7}$

4. Structure with the symbol ST4

Performance score for this case:

$$F_S = P_1 \cdot \{P_{10}\varphi_{10} + P_9\varphi_9 + P_{11}\varphi_{11} \cdot [P_2\varphi_2(P_6\varphi_6 + P_5\varphi_5) + P_3\varphi_3(P_7\varphi_7 + P_8\varphi_8) + P_4\varphi_4]\}.$$

Transit potentials for the analyzed structures: $\varphi_9 = \varphi_{10} = 0{,}143$; $\varphi_2 = \varphi_3 = 0{,}4$; $\varphi_5 = \varphi_6 = \varphi_7 = \varphi_8 = 0{,}5$, $\varphi_4 = 0{,}2$; $\varphi_{11} = 0{,}714$.

Then:

$$F_S = \frac{1}{7} P_1 \cdot \{P_4 + P_9 + P_{10} + P_2 \cdot (P_5 + P_6) + P_3 \cdot (P_7 + P_8)\}.$$

With the same value of P-availability for all linear elements: $F_S(P) = \frac{4P^4 + P^3 + 2P^2}{7}$.

Dependence of performance on the availability of a pipeline for all the analyzed variants of structure is shown in fig. 2. It is evident that a gradual decline in the readiness are the same associated with the development of the aging process is accompanied by a decrease in rate and efficiency of operation. For example, the declines of the readiness are the same of entry-level to a value leads to a decrease for the ST1 structure by about 14%, and for structures ST2, ST3 and ST4 at 17, 18 and 22%.This means that the best operational characteristics will have restored system with the structure of ST1, and the worst system with the structure ST4. Thus, the results of the analysis suggest that if the coefficients of the readiness of all pipelines are approximately equal, the best performance characteristics will have structures that are characterized by smaller number of linear elements, as well as distribution centers of traffic. Note that the structure of ST4, is characterized by a minimum length of pipe (table 2), is the worst among the analyzed variants of structure from an operational point of view, as evidenced by the dependencies presented in figure 2.

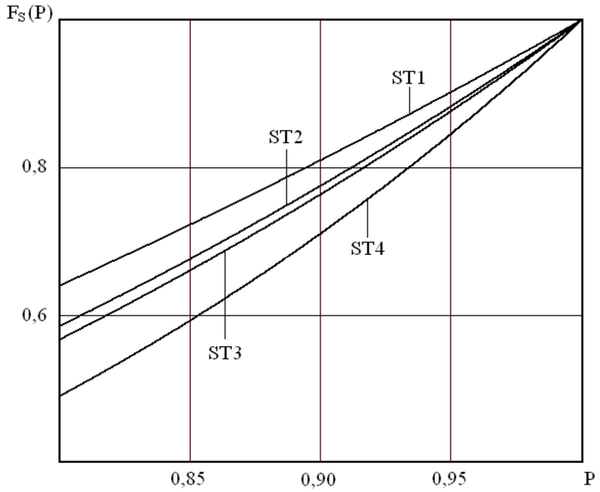


Fig. 2. The dependence of efficiency on the structure of the restored system and availability of a pipeline P

CONCLUSIONS

The regularities of the influence of the structure pipeline systems on the efficiency of their functioning are set, it allows to conclude that in the case of approximately the same values of the coefficients of the readiness of all pipelines, the best indicators are characterized by a structure with a smaller number of high-level crossings, and ensure the delivery to customers of smaller amounts of the target product at the distribution sites of higher level.

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СТРУКТУРНЫЙ СИНТЕЗ СИСТЕМ ТРУБОПРОВОДНОГО ТРАНСПОРТА ПРОМЫШЛЕННЫХ ПРЕДПРИЯТИЙ

Игорь Тарарычкин, Грегорий Нечаев, Максим Слободянюк

Аннотация. Рассмотрены вопросы влияния структуры трубопроводных транспортных систем на эффективность их функционирования. Показано, что в зависимости от принятой структуры, транспортные системы могут характеризоваться различными эксплуатационными показателями. Установлено, что структура системы оказывает влияние на развитие процессов старения и снижение эффективности функционирования систем.

Ключевые слова: системы, трубопровод, транспорт, структура.