Technology of suspended structures creation of the electro-hydraulic system in the design of a prototype underwater manifold and its elements

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Abstract. The article discusses the urgent problem associated with the creation of technology for designing the supports of the electro-hydraulic system of the Russian model of an underwater manifold under conditions of import substitution in the country's oil and gas sector. Trends and prospects for the development of mechanical engineering for underwater hydrocarbon production are shown. Based on the initial data for the design for the calculated and simulated pipelines of small diameter, which are part of the electro-hydraulic circuit of the manifold, the corresponding supports have been developed. After developing the technologies on the prototype, it is planned to further use the developed supports as part of the serial delivery of components of the subsea production system for deep-sea oil and gas condensate fields in the Arctic region of the Russian Federation.

1. Introduction

Engineering is an industry that is part of the heavy industry. In total, it includes more than two hundred subindustries. According to the 2015 data, about 3.6 million people are working in this field in Russia.

The structure of this industry is as follows:

• Production of various machinery and equipment;
• Development and creation of vehicles;
• Development and creation of electrical equipment.

Currently, the development and implementation of new advanced technologies for the production of machinery and equipment for all mechanical engineering sub-sectors, including oil and gas, is relevant [1–15].

It is known that hydrocarbon production is a very complicated process. Many monographs and scientific articles devoted to the issue of development hydrocarbon production [16–19]. The list of machines and equipment for performing such work is quite extensive.

Currently, concerning the Russian oil and gas equipment market, the following trends can be observed:

1) an increase in demand for drilling and oil-producing equipment in connection with the development of new deposits in Eastern Siberia and on the sea shelf;
2) increased requirements for the reliability and operational characteristics of oil and gas equipment in connection with the severe conditions for the development of new fields.

2. Trends and prospects for the development of engineering for subsea hydrocarbon production

Thousands of specialists are working on the development and design of equipment, machines, auxiliary mechanisms for the extraction and processing of hydrocarbons. Every year, the requirements for the necessary equipment increase, and therefore engineering is also being improved and developed.

Reducing the level of energy consumption, as well as improving the safety of the created mechanisms for people and the environment, are the goals of development engineers.

Currently, deposits in the Sea of Okhotsk regions, such as the Kirinskoye and South Kirinskoye fields, require the use of new technologies with the use of subsea production systems, as well as the prospective future use of subsea plants to compress and separate the extracted hydrocarbon resources without building any surface structures. For the first time, a subsea production system was installed at the Kirinsky field in 2013. In 2017, the Ministry of Industry and Trade of the Russian Federation and the Public Joint Stock Company Gazprom agreed on bilateral cooperation in the development and localization of subsea production systems. Fourteen engineering developments related to marine engineering are approved. After creating prototypes, integration tests are planned for subsequent production for a series, or development in terms of making any improvements to the design. According to forecasts, by 2022, it is planned to install a domestic subsea production system at the Yuzhno-Kirinskoye field [1]. The results presented in the course of designing suspended structures of an electrohydraulic system for pipelines of a small diameter of a prototype of an underwater manifold are presented below.

3. The main provisions for the implementation of work related to the design of suspended structures of components of the subsea production system

Figure 1 shows an underwater manifold, which is a system of intake/distribution manifolds and branch pipelines used to collect reservoir products from wells, to distribute reagents / injected gas to maintain reservoir pressure, and also gas lift gas to wells.

![Figure 1. General view of the underwater manifold assembly](image_url)

The electro-hydraulic system of the manifold is a set of equipment connected to pipelines of large and small diameters. According to the statement of work, it is small-diameter pipelines (3/8" and 3/4") that must be fixed with suspension structures in the electro-hydraulic system of the manifold with clamps. For fixing the pipelines, clamps (purchased items) following DIN 3015 from polypropylene together with fasteners in the amount of 66 pieces for pipes with a diameter of 3/8 ", as well as 336 pieces for pipes with a diameter of 3/4" were selected.

Depending on the location of the equipment, according to the electro-hydraulic scheme, three options for fastening clamps for small-diameter pipelines are designed:

1. Figure 2 (a) shows the first variant of mounting the clamps on the brackets located on the interface control panels using a remote-controlled uninhabited underwater vehicle.
2. Figure 2 (b) shows the second option for attaching the clamps with welded plates to the support (frame) of the manifold.

3. Figure 2 (c) shows the third option for attaching the clamps to specially designed struts and strips welded to the structural members of the manifold.

The clamps, consisting of two halves, are bolted to the welded plates. The plates are welded to the corners located on the racks and other body structures. The clamps in the project are spaced at least 0.6 meters apart for 3/8” pipes, and at least 0.8 meters apart for 3/4” pipes.

Figure 2. Variants of placement of suspended structures in the electro-hydraulic system of the prototype manifold: a – 1; b – 2; c – 3

As a result, suspension structures with pipeline fastening were worked out under the electro-hydraulic scheme by installing clamps on the corresponding supporting structures (strips, racks, kerchiefs, brackets), drawings of individual support elements were developed, 3d models of small-diameter pipelines were created together with a system of suspended elements of the electro-hydraulic manifold system with a detailed description of the installation sites by issuing an assembly drawing for the supports, partially presented in Figure 3-5.

4. Conclusion

In the course of the study, the suspended structures of the electro-hydraulic system with the appropriate supports were developed and confirmed by calculations and mathematical modeling. The design was based on international experience in underwater field development, as well as relevant Russian industry standards and rules of the Maritime Register of Shipping. The justification of the design decisions made regarding the design of the suspension structures of small diameter pipelines of the electro-hydraulic manifold system allowed us to optimize the prototype and substantiate the nomenclature of purchased products (clamps, metal, pipes). It is assumed that the implementation of all the above-mentioned works in a complex, as well as the successful completion of integration tests of all components of the subsea production system developed during development work, will allow for the import substitution of subsea production systems on the shelf of the Russian Federation and create worthy competition for international companies in this area.
Figure 3. Supports of the electro-hydraulic system: assembly drawing sheet 1.

Figure 4. Supports of the electro-hydraulic system: assembly drawing sheet 4.
Figure 5. Supports of the electro-hydraulic system: assembly drawing sheet 5.

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