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Gas Pipeline System Construction Project at Black Sea Depths of up to 2140 m

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Abstract

The amount of offshore pipeline construction work in Russia, in the Black, Baltic, Barents, Kara and Okhotsk seas, will reach over 6,000 km, according to the predictions available.

On Fig.1 – The Plan of transmission of pipelines through the Black Sea, on fig.2 – The structure of transmission of pipelines through the Black Sea.

Each of the above-mentioned projects has its own specific features. There are currently various options of the gas pipeline system construction from Russia to Turkey. One of the options is to lay the gas pipeline on the Black Sea bottom.

The gas pipeline route crosses the Black Sea at depths reaching 2140 m. This option is characterized by the following specific features: large sea depth; complicated shore configuration, subject to seismic and landslide processes; a large amount of hydrogen sulfide (H_2S) in water starting with a depth of 200 m and many others.

The main problem of laying pipeline in deep sea water is to avoid pipe buckling due to bending under external pressure and its propaga-tion along the pipeline at great distances.

The paper is focussed on the problems of determining the required wall thickness of the offshore pipeline. It provides some data related to the design of pipelines and their stability under combined external pressure and bending in accordance with the methods described in the draft Russian standard for design and construction of offshore pipeline systems.

Gas Pipeline Design

In designing offshore pipelines capability of transporting larger volumes of the product, it is usual practice to elevate the internal pressure to become comparable to external hydrostatic pressure.

The hydraulic calculation on the basis of initial data (pipeline system output: 16 billion cu.m., the offshore pipeline length: 386 km, the input pressure: 25 MPa, the output pressure: 5.4 MPa) has shown that it would be desirable to construct either one line with an internal diameter of 700 mm, or two lines with an internal diameter of 534 mm.

Taking into account the pipe internal pressure only, the minimum wall thickness of offshore gas pipelines is to be found using the formula:

$$\delta = \frac{P \times D}{2 \times 0{,}72 \times \sigma_T} \qquad [1]$$

where:
D - nominal pipeline diameter, mm;
P - design internal pressure, N/mm^2;
σ_T - minimum pipe metal yield strength taken from State Standards and Specifications for steel pipes, N/mm^2;

If the external pipeline diameter, D, is equal to: D = 596 mm; P = 25 MPa and σ_T = 482 N/mm^2, then the wall thickness of the pipe should be at least 21.47 mm.

At the same time, the minimum wall thickness of the pipeline with an ideally round cross-section under uniform external hydrostatic pressure is obtained from the following formula [1]:

$$\delta \geq D \times \sqrt[3]{\frac{(1 - \nu^2) \times P}{2 \times E}} \qquad [2]$$

In our example, at ν = 0.3; E = 2.06$\times$ 10^5 Kg/cm^2; P = 21.1 MPa, the wall thickness is obtained to be equal to at least 21.45 mm.

In some previous publications the task of determining the stress and strain condition of the pipeline as a rod system was examined. Here, the ovalisation of the pipe cross-section caused by imperfect plant manufacturing of round pipes and the ovalization in the process of laying the pipeline onto the seabed were not taken into account.