The method of compensation for deviations of ship pipeline routes

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Abstract. In the article, the authors examine the problem of enhancing the technological features of ship's pipeline systems at the designing stage. Moreover, it introduces the solutions for questions of ship pipeline's manufacturing and assembling without measuring the actual size of the ship. The possibility of using the rotating method for paralleling pipe sections simultaneously with technical operation of removing the technical allowances of the pipelines is taken into consideration to fully compensate the total deviations of pipelines routes, which was arisen not only in process of pipes' manufacturing but also in hull, mechanisms, and equipment's assembling. An algorithm for determining the compensation level of the pipeline route is established. Based on the results of the researching process, the method to determine the compensation possibilities of pipeline routes and values of technical allowances is established, which was appointed on fitting pipes for expansion in the compensation field in possible directions. The author presents the method of pipeline displacement by using the rotation method to rotate the parallel sections of the pipelines for compensating total deviations, and the technology of assembling the pipeline systems from prepared pipes, which was produced by designing information without measuring the actual size of the ship.

1. Introduction

In the works [1-2] theoretical studies of the compensatory possibilities of the pipelines of the ship systems were carried out and a mathematical description of the area of compensation was developed. It was established that to compensate for total deviations and successfully install the pipelines with "fitting pipes", it is necessary to have pairs of parallel pipe sections with free connections in the route, which during installation make it possible to move the route, compensating for the resulting deviations of both pipes and adjacent structures, that cannot be compensated by allowances on the "fitting pipe".

Based on the results of the researching process, we developed the methodological foundations for improving the technological effectiveness of pipelines in carrying out shipbuilding orders:

- a method for determining the compensatory possibilities of the pipeline routes and the values of the necessary allowances assigned to the ends of "fitting pipes";
- method of compensation for deviations of pipeline routes by rotating pairs of parallel sections using the necessary allowances for installation of ship systems.

2. Methodology for determining the compensatory possibilities of pipeline route

The results of researches conducted in [1-16], confirm the possibility of installing pipelines without using the pipes, the configuration of which is required to specify at the ship (measuring pipes). Instead

of measuring pipes, fitting pipes are used with the appointment of technical allowances if necessary. At the same time, all pipes of the route are made beforehand in the workshop according to design dimensions.

In this methodology, we use parallel sections of pipes with free connections of pipelines to compensate for deviations arising in the process of pipe manufacturing and installation of systems. Parallel sections are an element of the pipeline route configuration, the turns of which allow to compensate for the total deviations by moving the pipeline route.

In many cases, the use of pairs of parallel pipes sections cannot fully compensate for deviations arising in the process of assembling pipelines of ship systems from prefabricated pipes, which are manufactured according to design dimensions. For full compensation, the total deviations are compensated by rotating pairs of parallel pipe sections together with performing a technical operation - cutting the technical allowances when fitting the connections on the “fitting pipe”. This operation changes only the design dimensions of the “fitting pipe” and does not affect its design configuration.

Pairs of parallel sections and the above technical operation are used to fully compensate for deviations of ship systems pipelines in the following combinations:

- parallel sections, at least three pairs;
- parallel sections, at least two pairs and an allowance at the end portion of the fitting pipe;
- parallel sections and two allowances at the end sections of the fitting pipe.

Let us consider in more detail at the use of the proposed combinations:

- There are three or more pairs of parallel sections in the route that have the ability to fully compensate for deviations in three directions. In this case, the deviations are compensated by using only the turns of the parallel sections, it is not necessary to designate the fitting pipe with allowances, i.e. there is no technical operation.
- In the route, there are two or more pairs of parallel sections, the rotation of which allows compensation of deviations in two directions. In this case, to fully compensate for deviations, it is necessary to designate an additional allowance, which is assigned at the end section of the fitting pipe in the remaining direction.
- In the route, there is one or more pairs of parallel sections, the rotation of which makes it possible to compensate for deviations only in one direction. In this case, to fully compensate for deviations in three directions, it is necessary to assign two allowances on the fitting pipe, the end sections of which are located in the two remaining directions.

In these cases, to fully compensate for deviations in three directions, the rotation of pairs of parallel sections with additional allowances is used. At the same time, in addition to the compensation element - parallel sections - technical operation was used to cut allowances.

If there is no possibility of compensation (there are no parallel sections and a sufficient number of end sections in the necessary compensation directions), it is necessary to correct the pipeline route.

To implement this technique in the pipeline industry, we have developed an algorithm for determining the compensatory possibilities of pipeline routes:

- analysis of pipeline routes and the preparation of baseline data. The source data refers to the coordinate dimensions of the route and the positions of free connections in the local coordinate system, the starting point of which coincides with the starting point of the route;
- search the parallel sections with free connections in the route, which are necessary for building the compensatory possibilities area;

- determinate the compensatory possibilities area of the route. Based on the search result of parallel sections with free connections. The compensation area is represented as the maximum and minimum values of compensation possibilities in three coordinate directions;
- comparative analysis of the parameters of the compensation area and the parallelepiped of deviations in three coordinate directions;
- determination of the level of compensation of the route and the proposed method of expanding the compensation area to fully compensate for the total deviations;
- determinate the value of assigned allowances, if necessary;
- make changes in the sizes of the fitting pipes with allowances in the design drawings to prepare for production.

3. Method of compensation for deviations of pipeline routes during the installation process

3.1. Method of moving the route using turns of pairs of parallel pipe sections

To move the route by turning pairs of parallel sections, it is necessary to produce the documentation after processing the calculation results of the compensation area. In this documentation indicate the pairs of parallel sections and directions in which the movement of the route can be carried out. Each pair of parallel sections allows moving the route in only one direction. Therefore, to fully compensate for deviations, it is necessary to have three or more pairs of parallel sections in the route.

The order of movement of the route by rotating pairs of parallel sections:

- To measure the deviations of the end point of the route after preliminary installation in three coordinate directions.
- Assess the effect of the rotation of one pair's parallel sections in one coordinate direction to the deviations of the route in other directions and rotate the route at the first connection of the pair of parallel sections.
- Rotate the route at the second connection in the opposite direction by the rotation angle of the first section to maintain the parallelism of the pipes sections of the route located behind the second parallel section.

3.2. Installation of the routes, which are not having the fitting pipes

The route is mounted from prefabricated pipes, the change of any constructive dimensions of which is not supposed:

- Familiarize with the technical drawings and documentation of the route concerning the installation process.
- Start the installation process from the starting pipe of the route, i.e., from one of the pipes connected to the rigidly fixed connection.
- Pre-mount all other pipe tracks.
- Measure the deviations between the end of the last pipe of the route and the position of the second rigidly fixed joint.
- To find in the produced documentation and technical instructions of the route drawing the supposed methods for compensating deviations in different directions.
- To carry out movement of the route using turns of the specified pairs of parallel sections for combining the end of the route with the second rigidly fixed connection.
- Fix the position of the route and collect all the connections of the route completely.

3.3. Installation of tracks with fitted pipes with allowances

- Familiarize with the technical drawings and documentation of the route concerning the installation of pipes.

- Start the installation of the route from the supposed pipe. If there is only one fitting pipe in the route, located on the edge of the route, directly attached to a rigidly fixed connection, the installation starts from the side of the pipe that is attached to the rigid connection in the opposite direction. If the fitting pipe is located between two rigidly fixed connections, or there are two fitting pipes in the route, the installation starts from the two ends directions of the route.
- Pre-mount all other pipe route.
- Measure the deviations between the end of the last pipe of the route and the position of the second rigidly fixed joint.
- Find in the produced documentation and technical instructions of the route drawing the supposed ways to move the route with using turns of the specified pairs of parallel sections in different directions.
- Carry out the movement of the route using the turns of the specified pairs of parallel sections to partially compensate for deviations in possible directions.
- Fix the position of the route after its movement
- Measure the value of deviation (deviations) remaining in the direction to which the allowance is assigned (allowances) and mark the position of the alignment of the connections on the fitting pipe.
- To carry out the technical operation of cutting off excess allowances on the fitting pipe.
- After machining the fitting pipe, carry out a route fit.
- Fix the position of the route and collect all the connections of the route completely.

Consider the procedure for installing the pipeline route, the scheme of which is shown in figure 1.

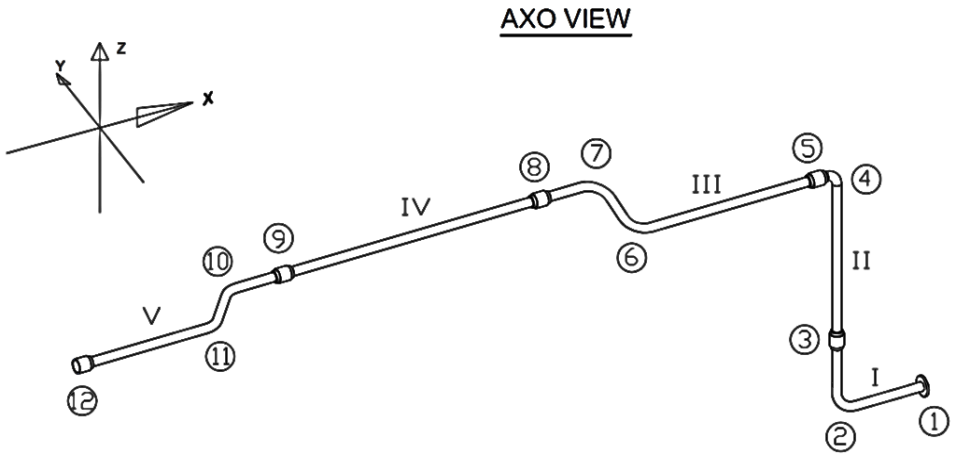

Figure 1. The scheme of the mounted route.

The route consists of five pipes connected by free-flanged connections. Both ends of the route are attached to rigidly fixed connections.

In the route there are three pairs of parallel sections (1-2 and 4-5; 5-6 and 7-8; 9-10 and 11-12) with the ability to compensate for deviations in two directions Y and Z. To fully compensate for all possible deviations in three coordinate directions, it is necessary to assign a technical allowance at the end section of the fitting pipe in the X direction. Pipe 5 is used as the fitting pipe.

The installation of the route starts from the side of the non-fitting pipe, i.e. pipes 1. After mounting pipe 1 to the first rigidly fixed joint, we preliminary mount all the remaining pipes of the route and measure the deviations between the end of the last pipe of the route and the position of the second rigidly fixed connection.

Rotate a pair of parallel sections 1-2 and 4-5 to compensate for the deviation in the direction of the

Y axis. In case of incomplete compensation, we additionally use the rotation of a pair of sections 9-10 and 11-12. Next, rotate a pair of parallel sections 5-6 and 7-8 to compensate for the deviations in the direction of the Z axis.

After that, we measure the amount of deviation remaining in the direction of the X axis and mark the position of the alignment of the connections on the fitting pipe. The fitting pipe is removed from the route and the superfluous allowance in the workshop is cut off. After that we carry out a fit of the route and collect all the connections finally. Installation of the route is completed.

Figure 2 shows an example of the installation of the pipeline route with compensation for total deviations on a vessel of the type “Damen Platform Supply Vessel 3300 CD” [2].

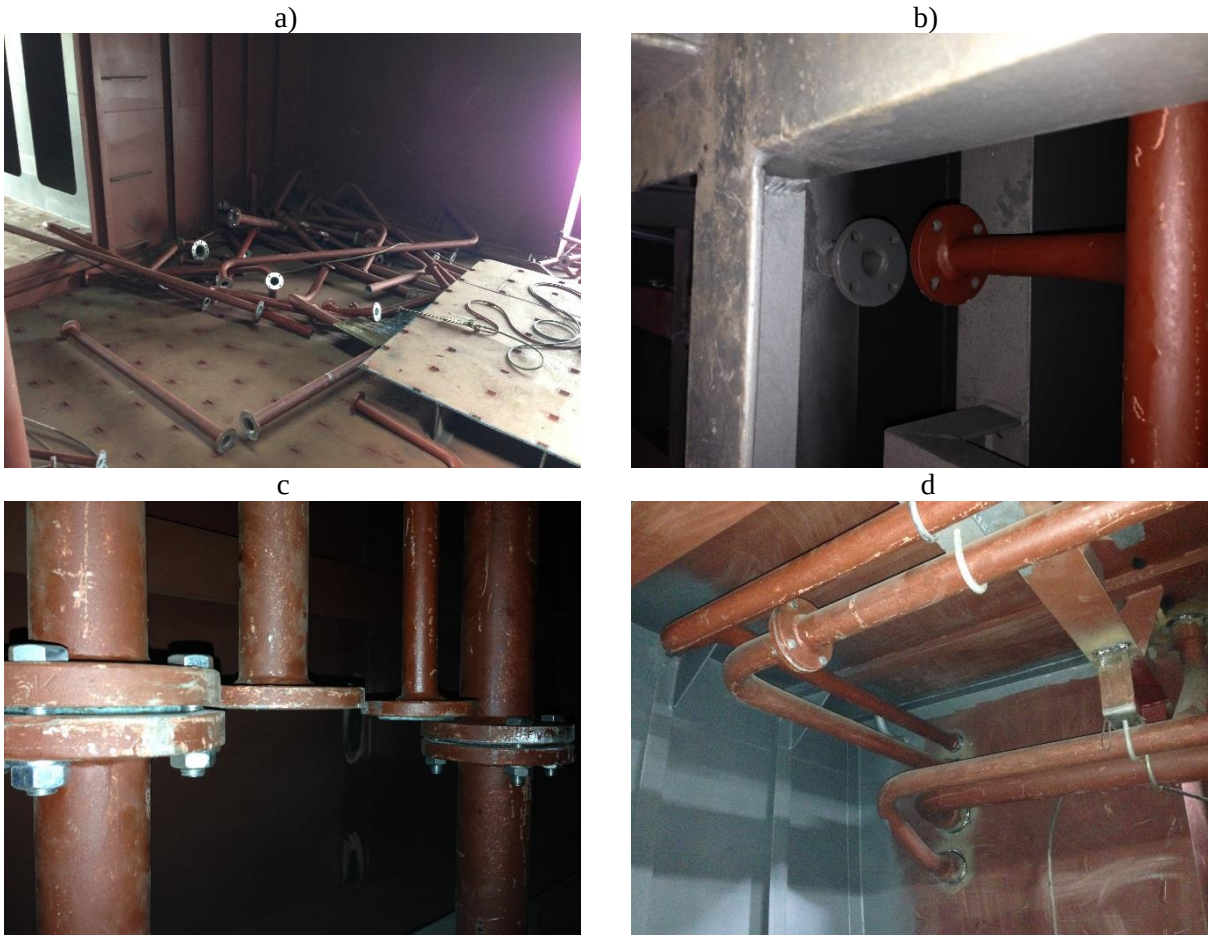

Figure 2. Installation of the pipeline route from prefabricated pipes.
a – pipes manufactured according to project information that are sent for installation on the vessel;
b - the actual deviations of the end of the path in three coordinate directions;
c, d – the alignment positions of the route connections after the compensation of deviations.

4. Conclusion

In the presented work, the possibility of using the rotation of pairs of parallel pipe sections together with the technical operation of cutting off the allowances to fully compensate for the total deviations of ship systems pipelines is considered. It was established that to compensate for total deviations and successful installation of pipelines with fitting pipes, it is necessary to have pairs of parallel pipe sections with free connections in the route, which make it possible to move the route, compensating for deviations in directions that cannot be compensated by allowances on fitting pipe.

In this paper, we developed an algorithm for determining the compensation level of the routes and the method for determining the compensation capabilities of the pipeline routes and the values of the necessary allowances assigned to the fitting pipes.

A method of moving the route using turns of pairs parallel sections of pipes to compensate for total deviations and the technology of pipelines installation from prefabricated pipes, which was made according to design information without specifying the size of the place at the ship.

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