Piping assembly with regard to the design trace of ship systems

Konstantin Sakhno[1], *Tat Manh* Do[2], *Vladimir* Tsaloev[3], and *Artem* Butsanets[4,*]

[1]Astrakhan State Technical University, Astrakhan, Russia
[2]Vietnam Maritime University, Vietnam
[3] Sevastopol State University, Sevastopol, Russia
[4]Admiral Makarov State University of Maritime and Inland Shipping, Saint-Petersburg, Russia

Abstract. The influence of design routing on the possibility of assembling pipelines of ship systems is considered. As a result, it is planned to manufacture pipes for the backlog, ensuring successful installation to reduce the labor intensity of pipeline work and shorten the construction time of the vessel as a whole. To exclude deviations during the installation of ship pipelines systems, it is proposed to use direct pipes made with an admissible mixing and connection. According to the proposed approach, in which the joints are not installed perpendicular to the pipe axis, but mutually parallel, a line consisting only of straight pipes (or having straight sections in its composition) can be moved to eliminate possible deviations of rigidly fixed joints by the actually required value. The process of excluding pipeline deviations when using straight pipes made with an allowable offset of mutual arrangement of joints and pipe turning is simulated.

1 Introduction

One of the important areas of modern shipbuilding is to increase the efficiency of shipbuilding production through the introduction of new technologies for the manufacture of pipes, for example, according to design information without taking measurements in place [1]. In this regard, there is a need for scientific research aimed at the development of mathematical models to study possible compensations for deviations of pipelines, taking into account the features of their design routing [2-5]. This led to the need to create various methods and software based on them to determine the possibility of assembling pipelines [6-10]. This is caused by the fact that today the labor intensity of pipeline work has increased from 5 to 15 -20% of the total labor intensity of the ship's construction. The task of the work is to simulate the process of elimination of deviations of pipeline routes when using straight pipes made with an allowable displacement of the relative position of connections and turning.

* Corresponding author: butsanetsaa@gumrf.ru

2 Materials and Methods

2.1 Straight pipe made with allowable misalignment of connections

In the process of manufacturing pipeline routes using the stand (SGT-160, SGT-160M, according to RD 5R.0005-93), straight pipes can be manufactured with an allowable displacement of the joints. According to this principle, the plane of the initial joint and the plane of the final joint of the pipe are always parallel to each other, but may not be perpendicular to the axis of the pipe (Fig. 1, Fig. 2). The angular deviation from non-perpendicularity (θ) is within the limits allowed by the regulatory documents. By rotating such pipes, it is possible to eliminate actual deviations during the installation of pipelines.

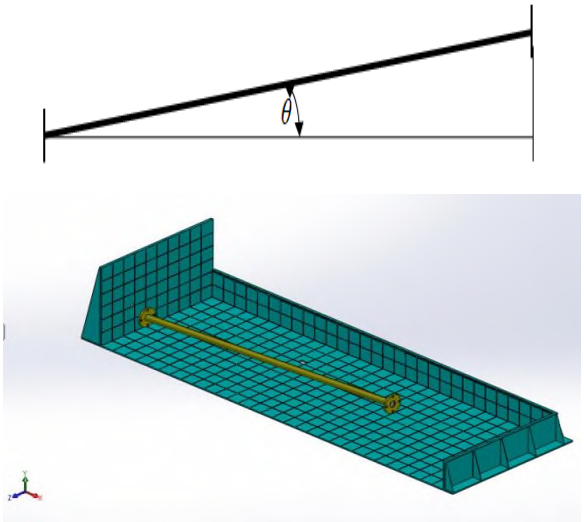


Fig. 1. A pipe made with an allowable displacement of the joints on the stand according to RD 5R.0005-93.

Fig. 2. Stand SGT-160.

In this case, both connections will be installed not perpendicular to the pipe axis. The permissible non-perpendicularity is regulated by the relevant regulatory documents. The industry standard OST 5.95057-90 defines the permissible values of deviation of flanges

(rings) from perpendicularity to the pipe axis based on the diameter of the sealing surface (Table 1).

Table 1. Deviation of flanges (rings) from perpendicularity to the pipe axis, mm.

Pipe size	The amount of deviation from perpendicularity, no more than
Up to 100	2.0
100 to 200	4.0
200 to 400	6.0

The use of loose flanges greatly facilitates the manufacture and installation of pipes: there is no need to precisely match the holes of the flanges to the holes for the fastening bolts, since the loose flanges can be turned to any angle. For example - a loose flange on a welded steel ring (Fig. 3) and all connections that can turn the pipe around the axis of the end section of the pipe (couplings, fittings ...).

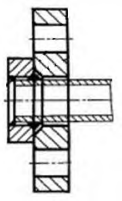


Fig. 3. Loose flange on welded steel ring.

The manufacturing process for the piping of ship systems is characterized by a variety of operations and checks. In ship pipelines and systems, pipes made of steel, copper and alloys based on copper, aluminum and titanium, as well as plastic and plastic-clad pipes are used, but this production requires significant and complex preparation.

2.2 Modeling the process of elimination of deviations when using straight pipes made with an allowable joint displacement

In accordance with the proposed approach, taking into account [10-13], to eliminate deviations of pipeline routes using turns of straight pipes, the connections of which are not installed perpendicular to the pipe axis, but mutually parallel, a route consisting only of straight pipes (or having in its composition straight sections) can be moved to eliminate possible deviations of rigid connections by the actually required value.

If, after installation with the displacement of the joints and pipe bends, deviations in some directions have not yet been compensated for, allowances should be use. Thus, from all pipes of the route, we select a pipe on which an allowance can be assigned in the required direction, and this pipe will become fitted. The fitted pipe can be the last pipe in the route, or intermediate.

To simulate the process of eliminating deviations when using straight pipes made with an allowable displacement of the joints, routes consisting of straight pipes and pipes with bends are considered. All such routes can be divided into two categories:

1. The route has only straight pipes;
2. The route has straight sections and turnings.

It is clear that, in fact, the routes of the second category are more common than routs of the first category.

We will simulate the installation process with the displacement of joints and pipe turns for routes of the above two categories. In each case, the main steps will be shown:

actual position and deviation of the route;

in the process of fitting, installation with the displacement of joints;

turning pipes to eliminate deviations.
The route has only four straight pipes.

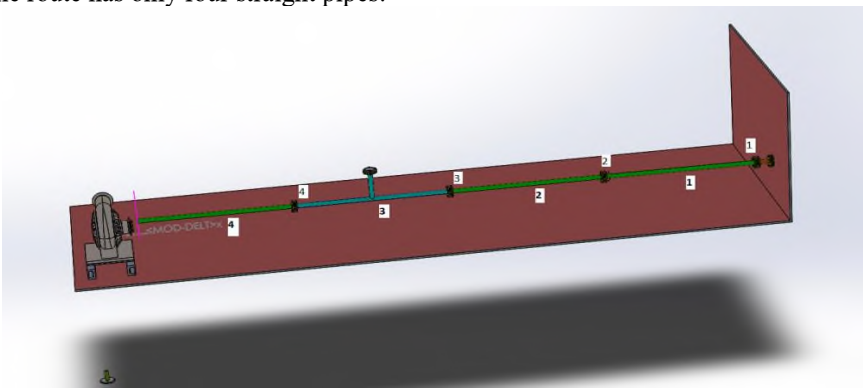


Fig. 4. Theoretical position of route 1.

This route 1 connects the bottle on the bulkhead to another rigidly fixed connection (for example, a horizontal centrifugal pump) (Fig. 4). In this case, due to deviations, the final flange of the route and the pump flange are not aligned (Fig. 5). This route contains four straight pipes with loose flanges.

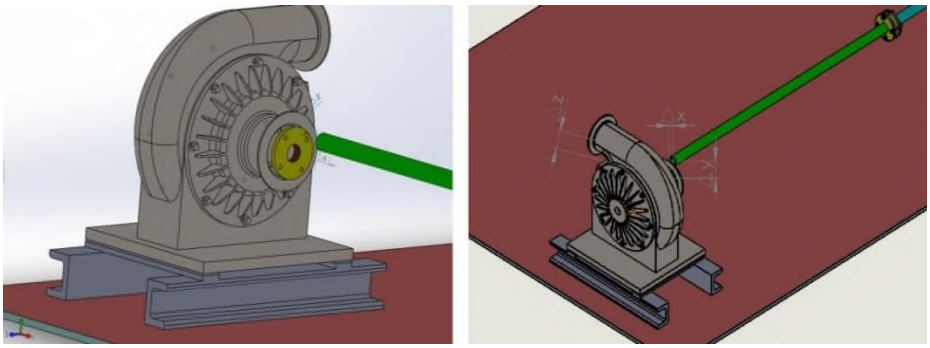
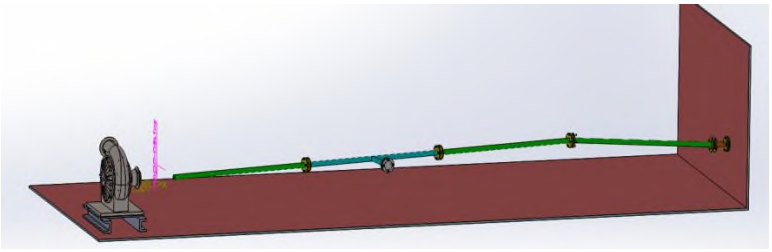
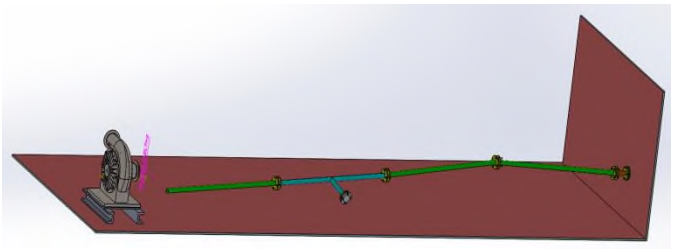


Fig. 5. Actual route deviation.

After the pipe manufacturing process, straight pipes are obtained with an allowable joint displacement. Installation on the ship has been completed (fig. 6, fig. 7).



a)



b)

Fig. 6. Turning the pipes of the route at joints 1 and 2: a). Turning the pipes of the route at joints 1; b). Turning the pipes of the route at joints 2.

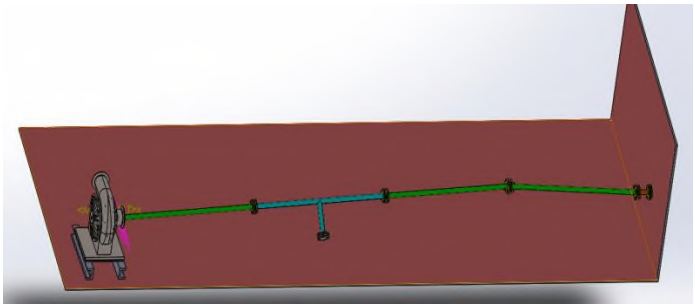


Fig. 7. The installation was carried out successfully due to the turns of straight pipes.

After installation with a bending until the position of the pump flange is aligned, we rotate pipe 3 by 180º to maintain the direction of the branch (Fig. 8):

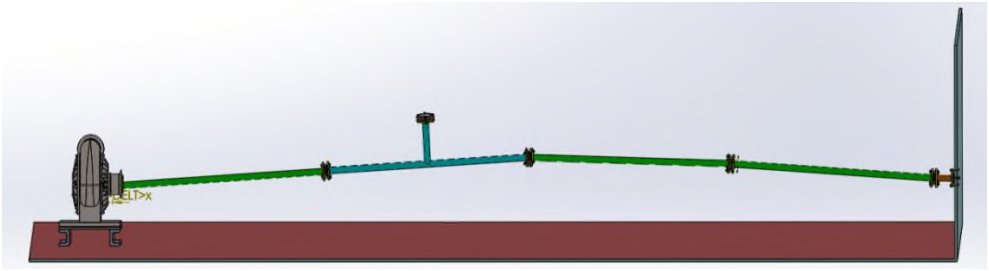


Fig. 8. Turning the pipes of the route at joint 3.

In the process of modeling the installation of pipeline route 1, all displacement deviations of the welded bottles are compensated.

The route has two straight pipes 1,3 and two pipes with bends 2,4.

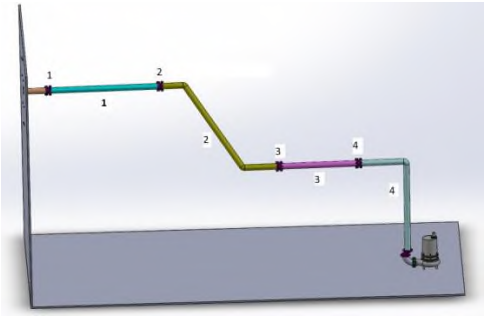


Fig. 9. Theoretical position of rout 2.

This route 2 connects the bottle on the bulkhead with a vertical centrifugal pump (Fig. 9). In this case, due to deviations, the final flange of the route and the pump flange are not aligned. This route has two straight pipes 1,3 and two pipes with bends 2, 4 with loose flanges.

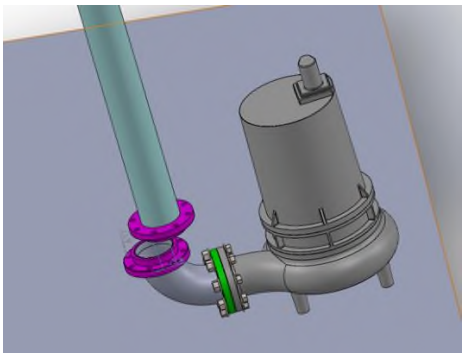


Fig. 10. Actual track deviation.

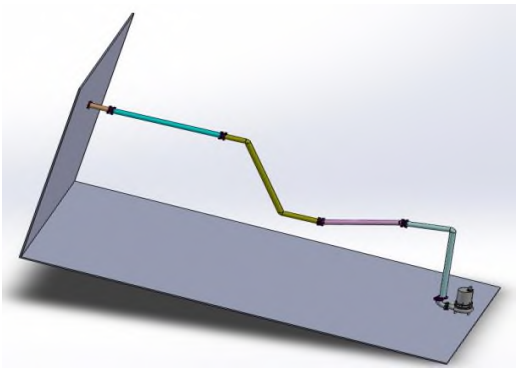
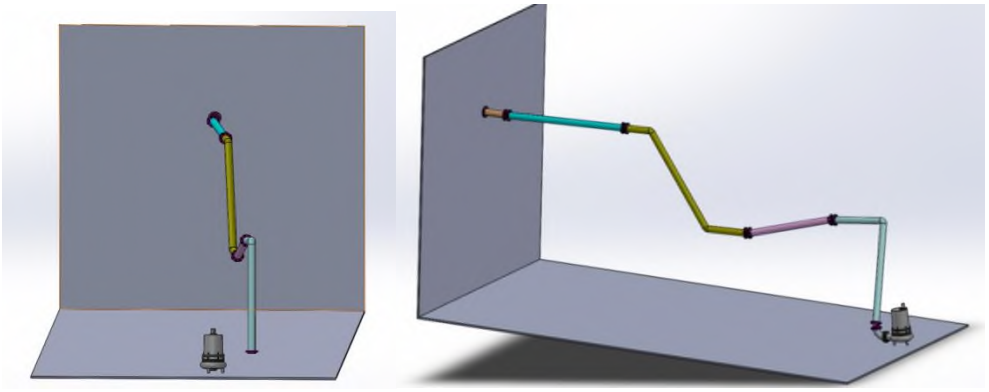


Fig. 11. Position of route 2 after installation with allowable displacement of joints 1 and 2 during pipe manufacturing.

In the process of modeling the installation of pipeline route 2, all deviations in the displacement of the welded bottles are compensated (see Fig. 10-13).



a). b).

Fig. 12. Rotation of route pipes at joints 1 and 2: a). Turning the pipes of route 2 at joint 1 counterclockwise; b). Turning the pipes of route 2 at joint 3 clockwise.

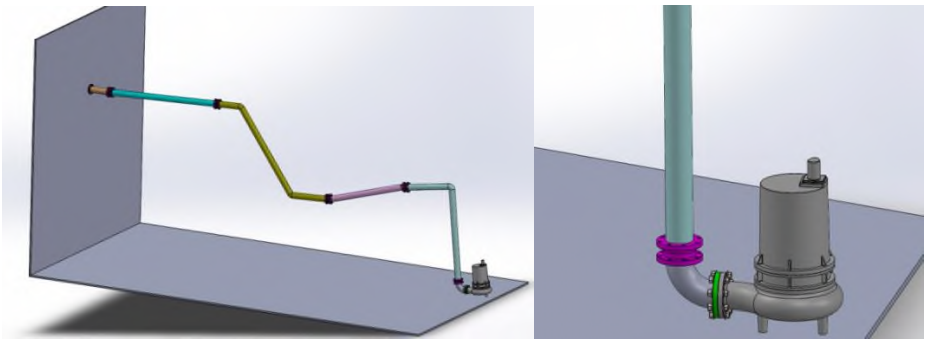


Fig. 13. Turning pipe 4 at joint 4 to align the position of the pump flange.

3 Results

As a result of the studies carried out, the following was established:

1. To exclude deviations in the installation of ship piping systems, it is possible to use straight pipes made with an allowable displacement of the joints and pipe turning.

2. The process of elimination of deviations of pipelines' routes when using straight pipes made with an allowable displacement of the relative position of the joints and pipe turning was simulated.

The reliability of the results obtained is ensured by the use of proven methods of theoretical and experimental research and does not contradict the works [13-19]. The reliability is confirmed by comparing the experimental data obtained by field measurements during the production of 88 pipeline routes for the Azimuth Rotor Tug 85-32W tugboats of the YN-512546 project, built according to the requirements of Bureau Veritas Register (France) and VR Register (Vietnam).

4 Discussion

During the construction of a ship, the actual dimensions differ from the theoretical ones due to many factors, such as errors in the operations of hull construction, measurements, welding, equipment installation, pipe manufacturing, etc. [10-15]. Therefore, during the installation of piping systems, the dimensions and configuration of the pipes may differ from those drawn up in the drawings, and the location of the equipment may also be in the wrong coordinates compared to the theoretical position.

5 Conclusion

The developed method of ensuring the assembly of pipelines is applicable in the pipe processing industry, increases the productivity of pipeline operations, and reduces the labor intensity and lead time for shipbuilding orders.

Preconditions for the formation of regional centers operating in an automated mode of pipe production are being created.

As a result of the studies carried out, it becomes possible to create a new automated program for determining the possibilities of assembling pipeline routes without taking measurements in place and an algorithm for its application, as well as to develop a method for ensuring the assembly of pipelines, taking into account the peculiarities of the design routing of ship systems with a minimum number of inserting pipes

References

1. K.N. Sakhno, Ch.K. Vo, Marine Intellectual Technologies **1(39).1**, 50-56 (2018)
2. K.N. Sakhno, Zh.V. Ngo, T.M. Do, Marine Intellectual Technologies **1(39).1**, 43-49 (2018)
3. K.N. Sakhno, Zh.V. Ngo, Marine Intellectual Technologies **1(39).1**, 63-70 (2018)
4. K.N. Sakhno, Ch.K. Vo, Marine Intellectual Technologies **2(40).2**, 47-51 (2018)
5. K.N. Sakhno, G.V. Ngo, Journal of Physics: Conference Series. United Kingdom, Mathematical simulation and data processing **1015** (2018) http://iopscience.iop.org/article/10.1088/1742-6596/1015/3/032099
6. K.N. Sakhno, T.M. Do, P.A. Saadati, M.M. Sabbir, Marine Intellectual Technologies **4(42).4**, 50-56 (2018)

7. K.N. Sakhno, T.M. Do, R.V. Guseinov, V.M. Tsaloev, V.P. Bulgakov, Marine Intelligent Technologies **1(43).4**, 50–55 (2019)
8. K.N. Sakhno, T.M. Do, R.V. Guseinov, V.M. Tsaloev, V.P. Bulgakov, Marine Intellectual Technologies **1(43).4**, 56-60 (2019) DOI: 10.26160/2474-5901-2020-20-40-46
9. K.N. Sakhno, T.M. Do, IOP Conference Series: Materials Science and Engineering. United Kingdom **510(4)** (2019) https://iopscience.iop.org/article/10.1088/1757-899X/510/1/012010
10. G.V. Ngo, Marine Intelligent Technologies **2-2(40)-2**, 34–39 (2018)
11. M.C. Amann, T. Bosch, M. Lescure, R. Myllyla, M. Rioux, Optical engineering **40(1)**, 10-19 (2001)
12. Z. Dong, Y. Lin, Journal of Ship Production and Design **33(N2)**, 122 – 134(13) (2017) DOI: https://doi.org/10.5957/JSPD.33.2.150005.
13. N. Fafandjel, Urednistvo Casopisa Strojartvo **50(3)**, 141-150 (2008)
14. S. Haiteng, N. Wentie, Frontiers of Mechanical Engineering **11(3)**, 214-223 (2016) DOI: 10.1007/s11465-016-0384-z.
15. S.H. Kim, W.S. Ruy, B.S. Jang, Int J. Naval Archit. Ocean Eng., Korea **5**, 468-477 (2013) DOI: 10.2478/IJNAOE-2013-0146.
16. Q. Liu, G. Jiao, IEEE Access **11(3)** (2018) DOI: 10.1109/ACCESS.2018.2789361
17. Q. Liu, International Journal of Computer Integrated Manufacturing **29(2)**, 1-10 (2016) DOI: 10.1080/0951192X.2015.1033019
18. J.H. Park, R.L. Storch, Expert Systems with Application **23(3)**, 299–309 (2002) DOI: 10.1016/S0957-4174(02)00049-0
19. M. Safa, A. Shahi, M. Nahangi, C. Haas, H. Noori, Structures **3**, 71–80 (2015) DOI: 10.1016/j.istruc.2015.03.003