Methodology for determining the spatial position of the ship's shaft line

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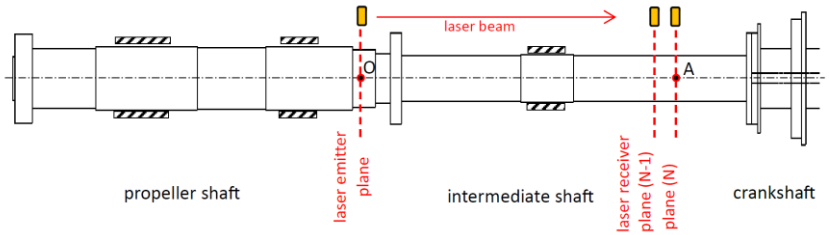
The aim of the article is to achieve a reliable assessment of the spatial position of the shaft line without the need to dock the ship and dismantle the shaft line.

The task is related to the development of a methodology for measuring the spatial position (vertical and horizontal) of the shaft line using an optical laser system.

Task

The figure shows the general arrangement of the ship shaft line and bearings. In the fore part of the propeller shaft, in the plane "laser emitter plane", the laser emitter is positioned. This plane is assumed to be the base, i.e. it is assumed that the zero line (reference line) passes through the intersection of this section with the shaft axis (point O). The spatial position of any section of the intermediate shaft is determined relative to it. In this case, two sections are indicated: plane (N-1) and plane (N). In the considered setting, the plane (N-1) is auxiliary. The measurement data in the two planes plane (N-1) and plane (N) will determine the spatial position of point A.

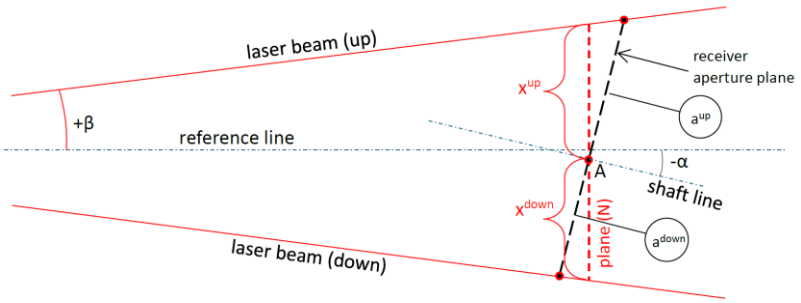


Implementation methodology

The measurement is carried out in the following sequence:

- the position of the emitter is determined, choosing it as close as possible to the fore stern tube seal of the propeller shaft;
- a section of the intermediate shaft, which will be selected experimentally (plane N);
- an auxiliary plane (plane N-1) is selected at a distance of 0.5 D_{shaft} from (plane N);
- the radial runout in the sections is measured. It is recommended that measurements be carried out at a runout < 0.15 mm;
- the angular position of the shaft corresponds to the T.D.C. of the piston of the aftmost cylinder. This recommendation is optional.
- the emitter and receiver are mounted securely using magnets or a chain brackets. During installation, the receiver is strictly perpendicular to the shaft (deviation <1°)
- the shaft is rotated with a turning gear, clockwise, looking at the engine. For each measurement, the pinion teeth are checked to ensure that they do not touch the flywheel teeth.
- the measurements are carried out in the vertical (UP-DOWN) and horizontal (PS-SB) planes.

After the input table is filled in a software application (Mathcad, Matlab, Excell or others), in order to determine the spatial position of point A, the data is transformed according to the proposed geometric scheme and formulas.



The angles α and β are calculated as the difference in readings between plane (N-1) and plane (N):

$$\alpha = \frac{1}{2}\left(\tan^{-1}\left(\frac{a_{n-1}^{down} - a_{n}^{down}}{d}\right) - \tan^{-1}\left(\frac{a_{n-1}^{up} - a_{n}^{up}}{d}\right)\right)$$

$$\beta = \frac{1}{2}\left(\tan^{-1}\left(\frac{a_{n-1}^{down} - a_{n}^{down}}{d}\right) + \tan^{-1}\left(\frac{a_{n-1}^{up} - a_{n}^{up}}{d}\right)\right)$$

The values for x^{up} and x^{down} are calculated according to formulas:

$$x^{up} = a^{up}\left(\frac{\sin(90 - \alpha - \beta)}{\sin(90 + \beta)}\right)$$

$$x^{down} = a^{down}\left(\frac{\sin(90 - \alpha - \beta)}{\sin(90 + \beta)}\right)$$

The position of point A relative to the zero line is determined by formula:

$$A = \frac{x^{down} - x^{up}}{2}$$

If the obtained value for point A is positive, the point is located above the zero line.

A similar approach is used to determine the position of point A in a horizontal plane.

Conclusion

The method can be used in the absence of information about the set alignment of the shaft line by the manufacturer, i.e. for identification of the current alignment parameters of the shaft line.
The proposed methodology is sensitive if the shaft line has residual deformation (bending).
The method can be used to determine the deformed line of ship shaft lines, if applied in n-number of sections.
The proposed method does not provide information about the contact of the shaft journal with the bearing shell in the measurement plane. It is recommended that the proposed methodology be accompanied by the jack-test method for full disclosure of the technical condition of the shaft line.