SIGHTING THROUGH AS PART OF SHAFT ALIGNMENT PROCEDURE

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Summary

This paper presents chosen activities of the ships propulsion system shafting alignment procedure. The main focus in this paper was put on sighting through (bore sighting) which can be done with three different types of measurement equipment: piano were, optical instruments and laser instruments. The analysis of measurement equipment allows selection of most optimal measurement solution for company. The matter of this selection is to avoid hazard to the shaft line due to shafts misalignment. Presented in paper measuring techniques and measurement equipment which is being used for sighting trough the elements of ships propulsion system meet technological requirements requested by the client and by the ship classification society.

Keywords: shaft, alignment, ships propulsion system.

WYZNACZANIE LINII ODNIESIENIA JAKO ELEMENT PROCEDURY OSIOWANIA WAŁÓW

Streszczenie

W artykule przedstawiono zagadnienie procedury osiowania układu napędowego statku. Skoncentrowano się na ustawianiu bezpośrednim z wykorzystaniem trzech różnych przyrządów pomiarowych. Do pomiarów wykorzystano strunę stalową, urządzanie optyczne i urządzenie laserowe. Przedstawienie trzech różnych grup przyrządów pozwala na wybór najbardziej optymalnego rozwiązania dla przedsiębiorstwa. Istotą tego doboru jest uniknięcie zagrożenia dla linii wałów wynikającą z przekroczenia parametrów współosiowości. Omawiane techniki i przyrządy pomiarowe służące do bezpośredniego ustawiania elementów okrętowego układu napędowego spełniają wymagania technologiczne stawiane zarówno przez klienta jak i towarzystwa klasyfikacyjne.

Słowa kluczowe: wał, współosiowość, okrętowy układ napędowy.

1. INTRODUCTION

The alignment procedure is part of the alignment process where alignment is performed in accordance with the requirements defined by the alignment designer. It is executable part of the propulsion shaft alignment process which consists of design, analysis and measurement. Every part must be performed in accordance with the requirements defined by standard requirements of the propulsion systems, the rules of classification societies and producers elements of the ship propulsion system, shipbuilders and designers.

Activities to comply with shaft alignment procedure depends of many problems. Moreover, it must be verified by the alignment criteria and guidelines, parts of the propulsion system like bearings, shafts, couplings, depend on experiences and practices and of the production schedule in shipyards.

2. SHAFT ALINGMENT PROCEDURE

2.1. Requirement of shaft alignment

Every of shipyards must to meet the recommendations to prevent or minimize disturbances of the engine position, established bearing location, stern tube bearing inclination. The shaft alignment procedure is not expected to start before:

- temperature of the vessel's structure is stable and as even as possible (normally procedure is conducted in early morning)
- structural part like superstructure, main engine etc. shall be installed on the vessel,
- all elements of the hull structure and equipment are in place,
- vessel stern blocs are fully welded,
- leak tests have been completed.

2.2. Elements of shaft alignment

Among the activities which are carried out during the propulsion shafting alignment procedure can be summarized in the following activities [1]:

- sighting through,
- bearing slope boring and bearing inclination

- engine bedplate deflection measurements and pre-sagging,
- Sag&Gap procedure,
- reactions measurement,
- bearing-shaft misalignment evaluation,
- intermediate shaft bearing offset readjustment,
- gear-shaft bearings reaction measurements.

3. SIGHTING THROUGH

3.1 Sighting through procedure

Sighting through is a process of establishing the reference line. The another name for this process is bore sighting. When the sighting through is finished, the established shafting reference line is rectified by slope boring or inclination of stern tube bearing. By this part of the alignment process is time to put the shaft were it is positioned, connecting the engine and gearbox, propeller installation and other elements of ship propulsion.

The sighting through is normally conducted before sunrise in the early morning hours to ensure an even temperature distribution throughout the structure. Conducting this process under certain thermal condition affects on the bearing offset because reaction measurement may be significantly different in another thermal condition

Sighting through procedure is conducted by piano wire, by optical or laser instruments. The measurement equipment is positioned in front of the after stern tube bearing. Target points are defined at the location of the intermediate shaft bearings, gearbox flange or main engine flange and these are offsets for values corresponding to the prescribed bearing offsets for the dry dock condition.

When the vessel is launched the initial alignment is expected to be disturbed by hull girder deflections. Alignment of the waterborne vessel needs to be verified and adjusted. It is not possible to accurately predict the extent of hull deflections and without knowledge of offset the alignment process may not be verified with the desired accuracy.

3.1.1 Piano wire application

Figure 1 shows a piano wire application in sighting through procedure.

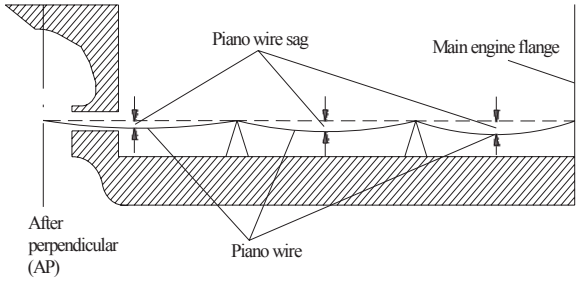

Fig. 1. Example of shafting alignment using piano wire

The application of a piano wire in sighting through procedure is used to establish a center line of the shafting. The piano wire is pulled straight from the aft stern tube bearing from the stern to the main engine flange (Fig. 1).

Fig. 2 shows screen with co-ordinate system (0÷30 mm) which is mounted on the wooden board inside the stern tube (Con-ro vessel).

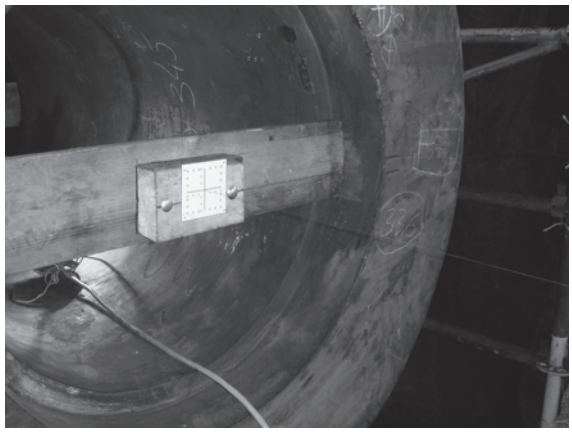

Fig. 2. View of the piano wire stretched in stern tube

The screens are mounted on brackets and wooden boards in purpose of minimize piano wire sagging. The piano wire is applied with load at least 40 kg.

Measuring the vertical distance from the piano wire to the location of the particular intermediate shaft bearing is applied to the prescribed bearing offset. When the piano method is used positions of the bearings and a slope boring angle are defined as the reference.

Using piano wire the theoretical data must be corrected for piano wire sagging which depends on the piano wire diameter (0.5, 0.6 and even 0.7 [mm] diameter wire may be applied), gravity constant, gravity of the piano wire material and distance between points of its support.

3.1.2 Optical and laser instruments application

The sighting through procedure could be conducted by optical instruments, for example like:

- telescope,
- collimator,
- autocollimator,
- theodolite.

Optical instruments can be used in two ways of measurement process: to define exact position of elements of propulsion or define their angular offset.

The optical line of reference (Fig.3) is established while the vessel is in the dry dock. After the vessel is launched this line is distorted due to the hull deflections.

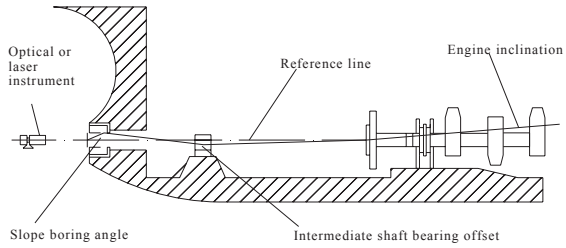

Fig. 3. Example of sighting through using optical or laser instrument

Fig. 4 presents example of using the optical instrument. It is aliniometer during concentricity measurements on the shaft bracket on the Con-ro vessel.

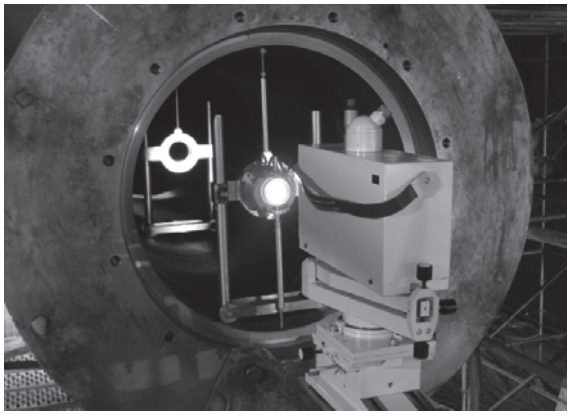

Fig. 4 Alignment using aliniometer

In the eighties, the first laser instruments were set measure the machines. This allowed to significantly increase the accuracy and simplicity of implementation of the alignment.

Laser instruments allow to receive:

- precise alignment without manual input of data and subjective interpretation,
- a graphical presentation of results of alignment,
- possibility of shaft alignment for the large distance between their flange,
- is not necessary to disassembly the couplings or the flanges,
- saving data and printing reports with the results,
- accurate and repeatability results, while ensuring their transparency to the user
- short time needed for training of the personnel,
- obtained misalignment results are projected on the screen of the instrument and compared with the tolerance limit for the coupling.

The impact of air temperature located between the laser and detector, as well as other environmental factors (dust) are affecting the stability of the measurements can be minimized by using a filter. Laser equipment made by Easy-Laser or Prüftechnik is implemented with such filters. Example of such instrument is shown on the Fig. 5. Numerous software features in the laser instruments allow to deal with different cases of measurement.

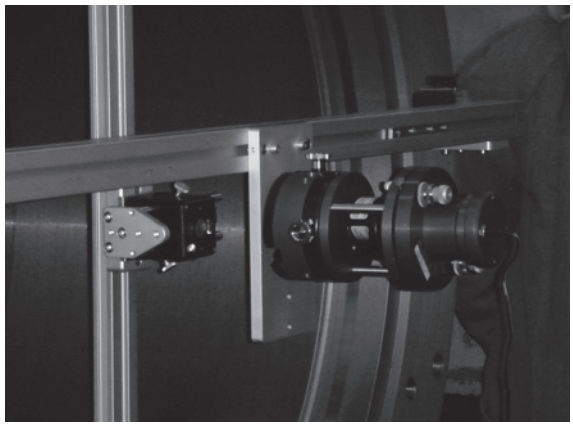

Fig. 5. Alignment using laser instrument for ex ample Easy-laser

4. DATA ANALYSIS

The problem of shafting alignment of components in propulsion system is described on the example of sighting through process on stern tube. The process of establishing the reference line has been done with three kinds of equipment: piano wire, optical instrument and laser instrument.

The figure 6 presents the scheme of stern tube alignment in order to better understanding of the problem. Measurements were performed on Con-ro vessels built the Stocznia Szczecińska "Nowa" Sp. z o.o..

Measurements on the stern tube were made in subsequent sections A, B, C in the direction from stern to fore.

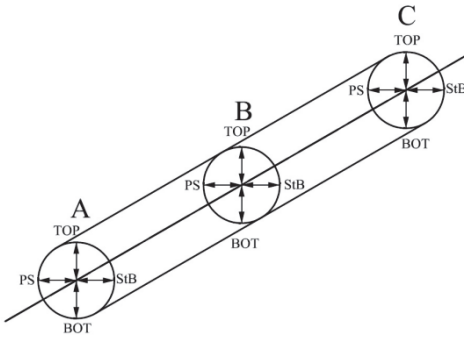

Fig. 6. Scheme of stern tube alignment

Data used for analysis allowed statistical analysis to compare the errors of measurements obtained using three equipment (piano wire, aliniometer made by Zeiss Company and laser instrument made by Easy-Laser S.L.)

The fig. 7 presents the distribution of measurements errors in successive measuring points (A, B, C). For results obtained by the optical instrument received measuring error at the order of 0,03 [mm] and for the laser instrument is at level of 0.003 [mm]. In turn measurements received by using the piano wire required further analysis due to the measuring error which is in range of 3,6÷6,6 [mm].

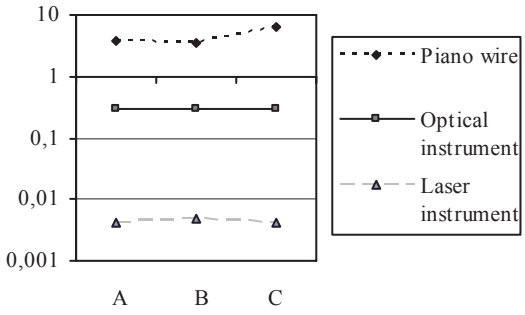

Fig. 7. Graphical presentation of the distribution of measurement errors for the selected measuring instruments

Designated error of measurement at such a high level gives a large dispersion of the value of measurand and the results obtained in measurements by this method requires further analysis.

For further analysis of measurement method using piano wire used method for evaluating the stability of measuring systems for measuring performance of specific tasks which an analysis of repeatability and reproducibility R&R (Repeatability and Reproducibility Study) was used. Results of this analysis are presented in tabele1.

Tab. 1. The results of the R&R analysis for the measurement of stern tube using piano wire

	Measurement using piano wire	
	Value	% process variability
Repeatability EV (equipment variability)	64,5708	24,6307
Reproducibility AV (operator variability)	38,3803	14,6403
Part variability PV	251,1636	95,8071
R&R	75,1161	28,6533
Total Variation TV	262,1557	100,0000

The value of % R&R below 30% [2, 3, 4] (28.65% in Tab. 1.) in the case of measurements made by piano wire allows for conditional acceptance of the measurement system.

5. CONCLUSIONS

The analysis of the results of measurements carried out on board a Con-ro vessels series B-201 produced by the Stocznia Szczecińska has demonstrated the possibility of measuring misalignment of various kinds of measurement equipment. The analysis of measurement systems shows that both a piano wire and optical and laser instruments can be used in sighting through process. However, for measurements carried out using the piano wire it is advisable to check the measurements, carried out for confirmation of quality through the application of measurement methods using optical or laser instruments.

The results obtained during measurements are satisfactory and they are within the tolerances and acquire the implementation of technical specifications related to the process of assembly of ships propulsion systems. Precise measuring instruments used in process of sighting through on stern tube (piano wire, optical instrument, laser instrument) are adequate in the existing work in the technical conditions.

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