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PRESENTATION OF THE PROPERTIES OF THE SUPERVISED MEASURING SYSTEM WITH FLEXIBLE SUPPORT OF CRANKSHAFTS IN APPLICATION TERMS

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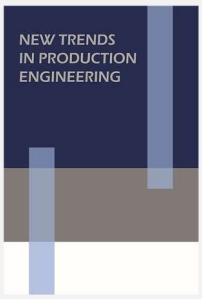

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dr hab. inż. Krzysztof Nozdrzykowski, prof. AM
dr inż. Waldemar Kostrzewa
mgr inż. Elwira Kałkowska
Maritime University of Szczecin, **Poland**

Abstract. The article presents an original, innovative solution for an universal system for measurements of geometric deviations of large crankshafts with so-called flexible support of the measured object. The principles of selection of reaction forces realized by flexible supports enabling elimination of elastic deflections and elastic deformations of the shaft under the influence of own weight are discussed. Also presented are the properties of the Automation Studio programming environment and a visualization application for the control and management program of the measurement system developed on the basis of this programming environment.

Keywords: measuring system, elastic deflections, elastic support, crankshafts, computer-aided design

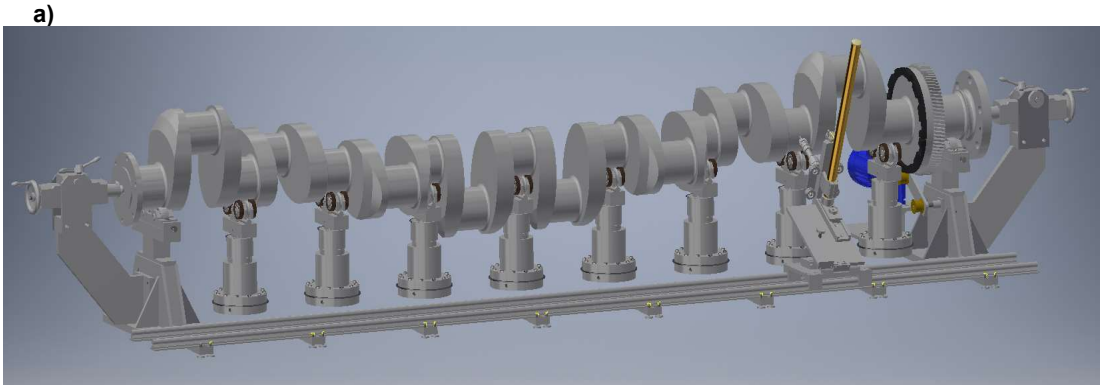
INTRODUCTION

The correct assessment of the geometrical state of the machine elements depends to a large extent on the measurement conditions. Due to the characteristics of the large crankshafts of ship engines, these conditions should guarantee the elimination of elastic deformations of the shaft under the influence of its own weight. Therefore, an important issue at the stage of dimensional and shape control of the manufactured crankshafts is their proper support ensuring the elimination of deflections and elastic deformations. The necessity to make turns during the implementation of measurements causes that the possibilities of supporting the shafts are significantly limited, and they result from their construction and depend on the number and arrangement of the main journals. Supporting the shaft on the main journals with a set of several rigid supports does not guarantee the elimination of elastic deformations (Adamczak, 1998, Adamczak and Makieła, 2007). The areas in subsequent cross-sections to the main axis of the shaft have different surfaces and their centers of gravity are situated in different directions and at different distances relative to the axis of the shaft (Nozdrzykowski and Bejger, 2013, Nozdrzykowski and Grządziel, 2015). For this reason, deflections due to the weight of the own crankshafts supported on the main journals change not only on the length of the shaft, but also depending on the rotation angle of the shaft on the supports. Due to the variable stiffness of the shaft and flexibility, there are not only deformations in the vertical direction but also in the horizontal direction (Sun et al., 2010).

A SUPERVISED SYSTEM OF FLEXIBLE CRANKSHAFT SUPPORT

In the Department of Basics of Machine Construction and Operation of the Maritime University of Szczecin, for several years, research has been conducted covering the issues of measurements of large-size machine elements with particular emphasis on the problem of their deformability. A measurable effect of this research is the universal measuring system developed with the so-called elastic support of the crankshaft Fig. 1.

a)



b)

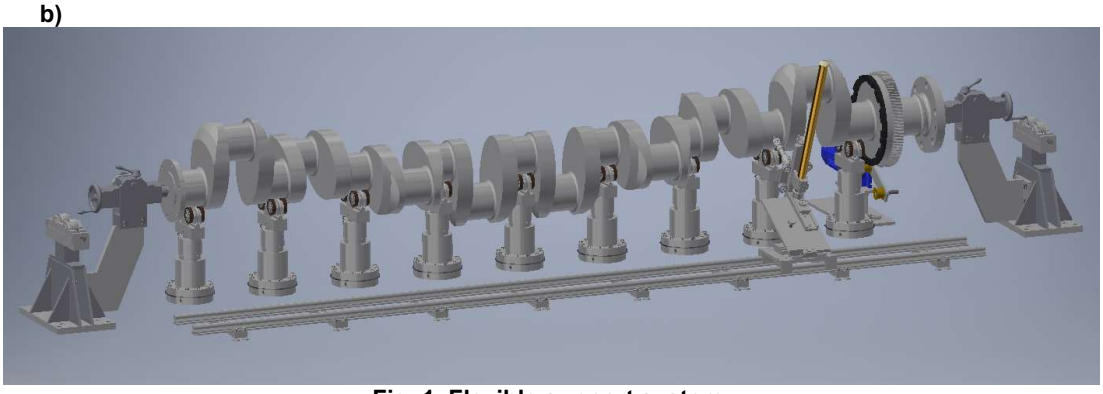


Fig. 1. Flexible support system:
a) for the case of setting the shaft with the outermost pivots in the V-blocks,
b) for the case of setting the shaft with external frontal surfaces' centers.

Regardless of whether the shaft is fixed by the outermost main journals in the V-blocks, or the outer surface in the centers, the elastic supports supporting its main pivots located in the central shaft are a part of exerting specific, variable and continuously controlled forces of action, carried out in order to eliminate deflections on the journals and elastic deformation of the shaft (Fronte et al., 2015, Zhao and Cao, 2013). The change of the set values of forces guaranteeing the elimination of the elastic deformation of the shaft is carried out by means of precise controlled valves cooperating in the feedback loop system with force sensors, which are equipped with flexible relieving supports (Quan et al., 2011). The set values of forces are determined earlier by means of specialist strength calculation programs. Supervision of forces is carried out on a computer.

For the research needs, the Automation Studio programming environment was adapted (Wimmer, 2017). Automation Studio is an integrated environment programming that allows to combine selected stages of a project within one application, including: selection and configuration of controllers, drives, communication with executive systems, and control and visualization of the measurement and control cycle. The main advantages of the program include efficient and flexible communication with spreadsheets, the universality of formats implemented to the designed interface, the ability to interact by feedback with executive elements in real-time, a wide range of sampling frequencies during measurements, rich database of library items with a large range of parameters selected and transparent signaling of nominal states during measurements (Walczyk el al., 2011). The application is also characterized by an intuitive way of creating individual components during the development of the interface, and the openness of the program's code allows for easy and intuitive modification of selected elements at any stage of the project.

The application based on continuous interaction between the displayed diagram and processing on the controller, developed on the basis of Automation Studio, enables management of the flexible support system and active tracking of the supervised values of reaction forces guaranteed to eliminate deflections and elastic deformations of the shaft in the feedback loop system. During the planning and designing of the application, a wide range of

visualizations of the supervised implementation of forces eliminating shaft deflections was taken into account. After the specifications were fully defined, the needs included in it were subsequently implemented in the software design phase (Al-Azirijawi, 2018, Dai et al., 2006).
The application interface consists of two main parts: data entry and visualization. Entering data can be done by importing from an external file or manually, directly from the keyboard via three text windows, containing information about:

- angular position of the shaft,
- the main journal number,
- the required value of the reaction force guaranteeing zero deflection value on the journal.

The required set values of reaction forces are calculated in advance using a strength calculation program (in the case under consideration, the Nastran FX 2010 program is used), and then replaced by a mathematical record expressed in the trigonometric form of the approximation function (Nozdrzykowski and Grządziel, 2015). This kind of record enables continuous computer monitoring of the work of precise controlled valves through which the flow of the medium supplying the elastic relieving supports is regulated.
The developed visualization enables (Figure 2):

- tracking or selection of the actual and set image of the force on the individual main journals for the subsequent selected angular positions of the shaft,
- presentation in the polar or Cartesian coordinate system of the image of real and set force changes on the selected main journal, in the range of the full rotation angle of the shaft 0°÷360°,
- tracking the current angular position of the shaft,
- signaling non-compliance of real and set force after exceeding the accepted tolerance for differences between the compared values of forces.

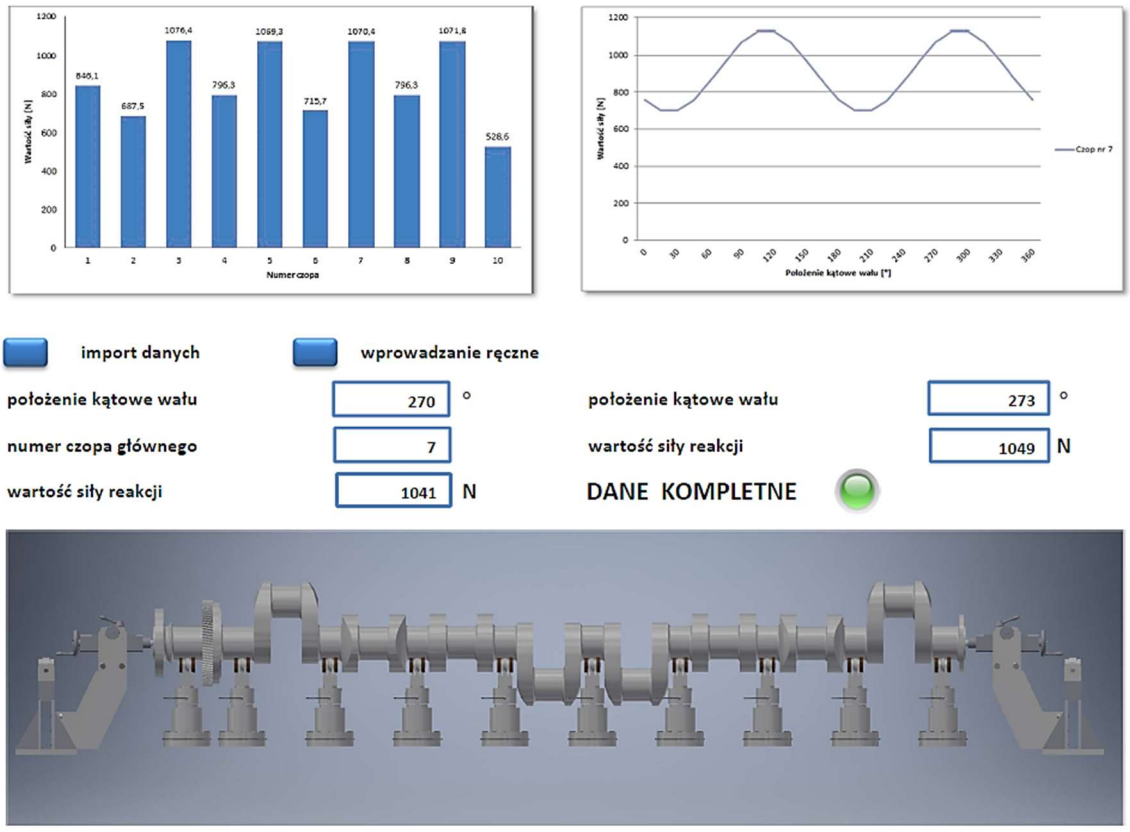


Fig. 2. Picture of the visualization of the supervised system of reaction forces eliminating deflections and elastic deformations of crankshafts.

The application additionally has a blockade that allows to generate result graphs only in case of entering complete data for the entire main journal assembly.

SUMMARY

The presented measuring system with flexible support of the measured object finds practical application in the measurement of large crankshafts, and the developed measurement system and supervising-visualization application makes it possible to correctly assess their geometrical state in the V-blocks and in the centers, which makes the system extremely versatile. The application is clear and legible, easy to use, and the selection of available options is intuitive for the user. An additional advantage of the developed system is the ability to interpret the measurement results in real time. The support method proposed in the developed system may have practical applications to eliminate elastic deflections of other deformable parts of large-size machines, such as: bodies, camshafts, stepped and straight shafts, or plates and flimsy large-size constructions.

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