Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Measurement system based on virtual reference axis for evaluation form and location of surfaces and axes of rotary details

To cite this article: D Diakov *et al* 2019 *J. Phys.: Conf. Ser.* **1379** 012074

Measurement system based on virtual reference axis for evaluation form and location of surfaces and axes of rotary details

D Diakov, Hr Radev, V Vassilev and H Nikolova

Technical University of Sofia, Bulgaria

E-mail: hnikolova@tu-sofia.bg

Abstract: The system for measurement and control of the form and location of the surfaces and axes of large scaled rotational parts by means of a virtual reference base is used, by using a self-orientation multistage gauge allowing exclusion of the radial run-out of axis of rotation when access to the face surfaces of the workpiece is difficult or impossible.

1. Introduction

Deviation of the form and location of the surfaces and the axis of the rotational parts can be determined by measuring the radial run-out of a certain number of cross sections and subsequent processing of this primary measurement information by certain algorithms [1-4].

A basic requirement is the stability of the axis of rotation when measuring the radial run-out. Large scaled details due to their large mass and dimensions, the fulfillment of this requirement is very difficult, and in some cases practically impossible.

This problem is solved by bringing the run-out results to a virtual output base, a virtual base axis representing the straight line passing through the centroid of the points of the instantaneous axes of rotation, in the sections of two rings attached to the end faces of the workpiece approximately coaxially to its geometric axis [5]. The deviation from circularity of the two rings is previously known or negligible.

The processing of the results of the radial run-out measurement to the virtual output base is done by introducing corresponding corrections into these results, excluding the influence of the so-called run-out of axis of rotation (axis of rotation error motion) reflecting on the rotational axis inconsistency [6-8].

At measurement process the detail is based on prisms, its own bearing seats or centers, and the radial run-out is determined using universal length measurement tools.

Due to the specificity of the measured parts, usually and especially in repair and test operations, the measurements are made based on their own bearing seats, where the access to their end faces is difficult or impossible, respectively, the establishment of the reference rings is very difficult or impossible. This limits the application of the method described above [5].

The subject of this paper is a system for measuring variations in the form and location of the surfaces and axes of rotational large-scaled parts relative to a virtual output base with no reference rings attached to the end faces of the measured parts.

Journal of Physics: Conference Series **1379** (2019) 012074 doi:10.1088/1742-6596/1379/1/012074

2. Measurement schemes

The basic measurement scheme is shown in figure 1. The part is based on prisms, centers, or its own bearing seats representing a base 5 on which radial run-out is measured.

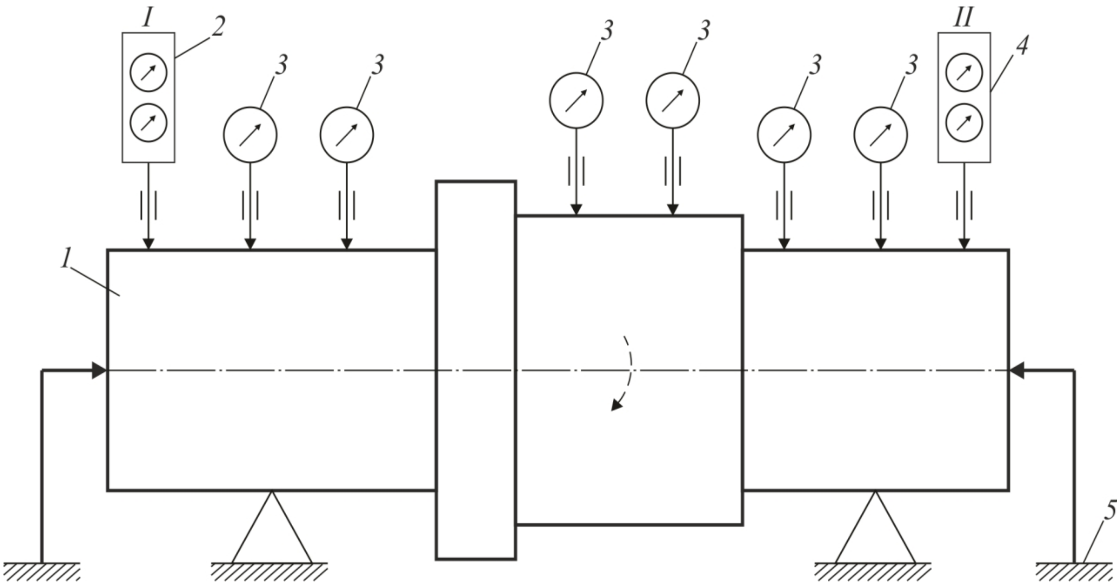

Figure 1. Measurement scheme.

With the measuring heads 3, the radial run-out in the respective cross sections is measured. This run-out includes within itself the deviation from the circularity of the measured profile, the eccentricity and the run-out of axis of rotation (axis of rotation error motion).

With the measuring devices 2 and 4 located in two pre-marked cross-sections I-I and II-II of the measured surface of the workpiece, the run-out of axis of rotation is determined. For the established run-out of axis of rotation, analogous to the method described in [5], corrections are made to the readings of all measuring heads, and so the corrected values of the radial run-out in the respective programs determine the deviations of form and location.

The main element of these measuring devices is a multistage self-orientating gauge (Figure 2) based on the measured surface in the respective cross-section. With a relative rotation of the gage relative to the shaft, each point in its body describes a circle equidistant to the median circle of the profile in the given cross section [9, 10]. This makes possible to define the run-out of axis of rotation as a deviation from circularity of the circular trajectory of a given point in the gauge body.

Journal of Physics: Conference Series **1379** (2019) 012074 doi:10.1088/1742-6596/1379/1/012074

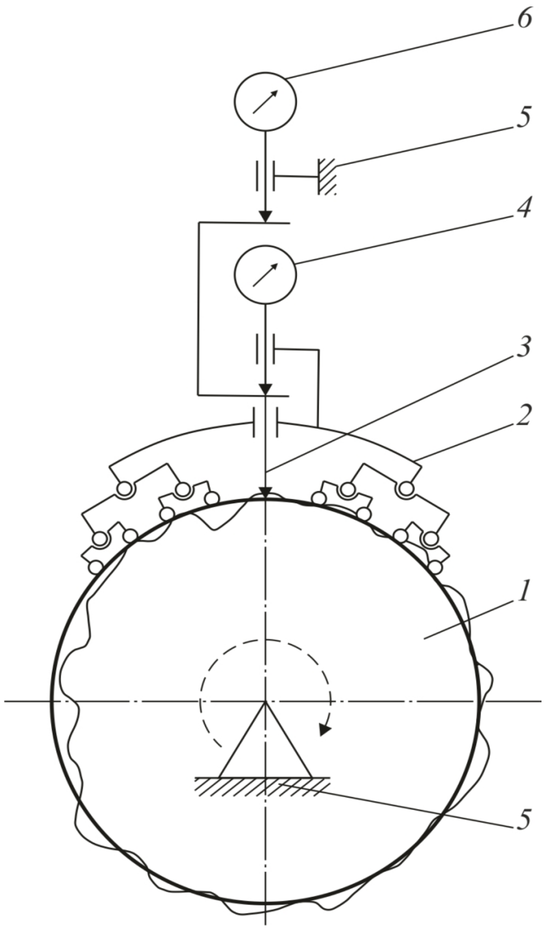

Figure 2. Measurement device based on multistage self-orientating gauge.

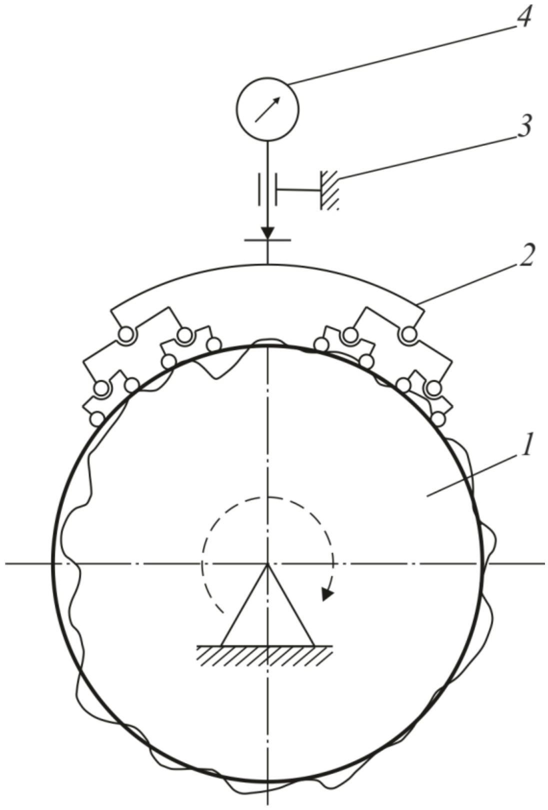

Figure 3. Measurement device based on multistage self-orientating gauge with one measuring head.

In the housing of the multistage self-orientating gauge 2 a measuring rod 3 is mounted whose measuring tip contacts the profile of the part 1 at the measured cross-section. Measuring heads 4 and 6, which are positioned along the measurement line simultaneously measure the run-out relative to the housing 2 of the gauge and the base 5. The readings A4 of the measurement head 4 represent the deviation from the circularity with respect to the median circle of the measured profile and the readings A6 of the measuring head 6 - deviations from circularity, eccentricity and run-out of axis of rotation. The difference between the two readings represent the eccentricity and the run-out of axis of rotation.

It is also possible to realize the measuring device (Figure 3), in which only the eccentricity and the run-out of axis of rotation of the average circle of the measured profile are determined by only one measuring head.

The choice of the particular realization of the measuring devices is determined by constructive, metrological and operational considerations, depending on the object and the measurement conditions.

3. System approbation
System approbation made in real environmental conditions at scheduled NPP Kozloduy turbine repairs confirmed its workability and good metrological characteristics.

4. Conclusion
The multistage self-orientating gauge measurement system allows the measurement of the deviations of the form and location of the surfaces and axes of large-scaled rotational parts at difficult or impossible access to their face surfaces.

References
[1] ISO 2017 *ISO 1101:2017 Geometrical Product Specifications (GPS) - Geometrical Tolerancing - Tolerances of Form, Orientation, Location and Run-out* (International Organisation for Standardization)
[2] Graham T Smith 2002 *Industrial Metrology: Surfaces and Roundness* ISBN-13: 978-1852335076, ISBN-10: 1852335076
[3] Whitehouse David J, *Handbook of Surface and Nanometrology* 2nd Edition, ISBN-13: 978-1420082012, ISBN-10: 9781420082012
[4] Zhelezarov I 2010 Analysis of measuring devices and measurement systems. *Mechanical Engineering in XXI Century* (Nis, Serbia) pp 199 –0. ISBN 978-86-6055-008-0
[5] Radev H 2008 Metod za izmervane na otklonenieto na formata i razpredelenie na ploshtta na rotatsionnite detaĭli na virtualna izkhodna baza, *Patent № 65461 V1 / 27.10.2008* (in Bulgarian).
[6] BDS 1976 *BDS 13872:1976 Mashini Metalorezheshti. Metodi za Proverka na Radialnoto Biene na Osta na Vŭrtene* (in Bulgarian)
[7] ISO 2012 *ISO 230-1:2012 Test Code for Machine Tools - Part 1: Geometric Accuracy of Machines Operating under No-load or Quasi-static Conditions* (International Organisation for Standardization)
[8] Dichev D, Koev H, Bakalova T and Louda P 2016 An algorithm for improving the accuracy of systems measuring parameters of moving objects *Metrol. Meas. Syst.* **23**(4) pp 555-65 DOI: 10.1515/mms-2016-0041
[9] Gebel I D 1973 *Meas.Tech.* 3 pp 347-53
[10] Dyakov D 2000 Optimizirane na parametrite na sistemata za izmervane na otklonenieto ot krŭga na bazata na mnogostepenna samozavisimost. *Sbornik dokladi ot 10-ti Natsionalen Nauchen Simpozium s mezhdunarodno uchastie* "*Metrologiya i metrologichno osiguryavane* 2000" pp 87-9, ISBN 954-438-229-3 (in Bulgarian)