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Low cost high sensitivity dynamometer

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ABSTRACT

This paper concerns the dynamometer with magnetoelectric actuator. Its construction and functionality were described. The conducted tests allow to estimate a number of metrological parameters of the dynamometer. Several practical applications together with their results were shown.

1. Introduction

One of the basic quantities measured in the laboratory and the engineering practice is force [1–3]. The authors present dynamometer with magnetoelectric actuator [4] which was designed and built in the Laboratory of Micrometrics, The Strata Mechanics Research Institute of The Polish Academy of Sciences. Dynamometers of this type are designed to measure force in the range up to 5 N. Due to metrological properties and low cost of the production of this particular device as well as moderate technological requirements needed in production, it is an interesting alternative to commercial offers.

Dynamometer diagram with magnetoelectric actuator is shown in Fig. 1. Outer force put on measuring rod results in its displacement. It causes dislocation sensor reaction, which controls the position of the measuring rod. After processing in the PID controller, the signal generated in the dislocation sensor is used for steering the actuator. As a result the measuring rod returns to the initial position and the steering signal of the actuator is the quantity of measured force. Dynamometer properties depend on the parameters of its individual elements, which will be described further on in this paper.

2. Structural elements of dynamometer

All of the described below construction elements of the dynamometer cooperate with each other. Therefore, individual points of this paragraph describes the situation wherein the discussed element is treated as a part of a working instrument.

2.1. Dynamometer suspension

The most important mechanical element of the described dynamometer construction is its suspension. It was assumed that dynamometer should work while situated in whichever direction. That precludes the usage of prisms and bearings typical for mechanical scales. Fulfilling of this condition is possible while using suspension with two parallel rocker arms. Rocker arms of 50 mm length and 100–200 mm distant from each other are usually used in our constructions. The endings of rocker arms are connected with dynamometer body and its measurement rod by flat springs (Fig. 2). This configuration enables the movement of the measurement rod relative to

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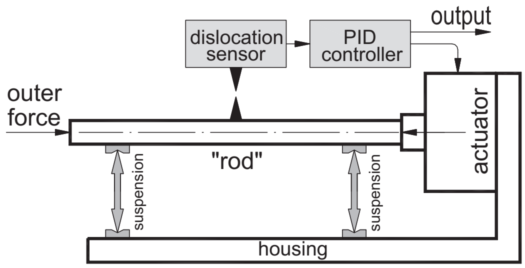

Fig. 1. Dynamometer diagram with magnetoelectric actuator.

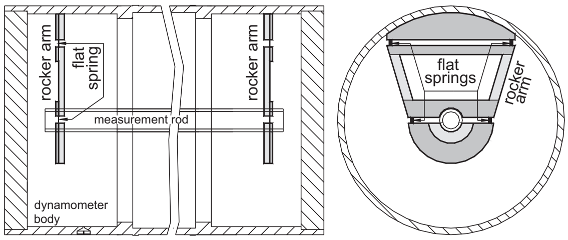

Fig. 2. Construction of the suspension.

inflexible dynamometer body only in axial direction. Stiffness of the used flat springs should result from the compromise between minimization process of springy reaction, which accompanies rod displacement, and the necessity of ensuring sufficient mechanical strength of the dynamometer suspension.

The authors constructed suspension rocker arms as shown in the Fig. 2. Flat springs of suspension are made of 0.1 mm thick phosphor bronze sheets. Kinematic block diagram of the dynamometer with springy suspensions is presented in the Fig. 3. The usage of springy elements makes acting force generate rod displacement. Such displacement is proportional to acting force. The authors created the characteristics of suspension (Fig. 4). Coefficient of elasticity of the used springy suspensions equals approximately 36 N/m.

The dynamometer reacts to the change of the measured force when rod displacement resulting from this change was greater than peak resolution of the dislocation sensor. In the face of this, if stiffness of the suspension is increased, the requirements for dislocation sensor have to also be increased.

2.2. Dislocation sensor

Dislocation sensor with differential capacitor [5,6] was used in dynamometer (Fig. 5). The analysis of several of

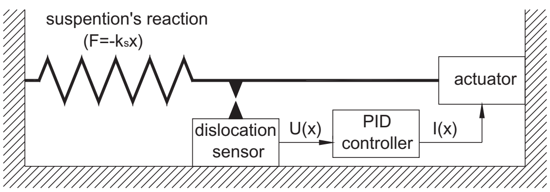

Fig. 3. Kinematic block diagram of the dynamometer with springy suspensions.

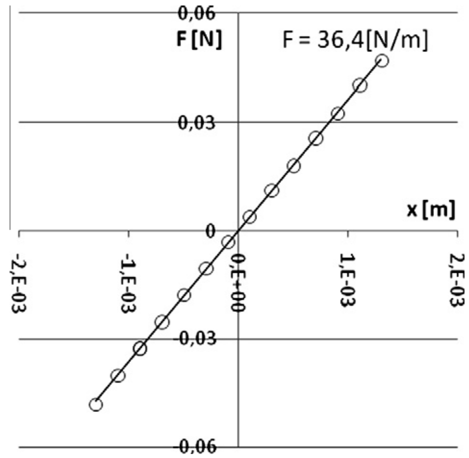

Fig. 4. Force generated by suspension.

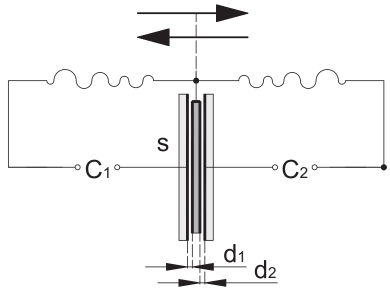

Fig. 5. Differential capacitor.

its properties can be found in the article [7]. Fig. 6 presents the dislocation sensor reaction to forced cyclic displacements at the level of 3.3×10^{-9} m. It enables to estimate the peak resolution of this sensor at about 10^{-9} m.

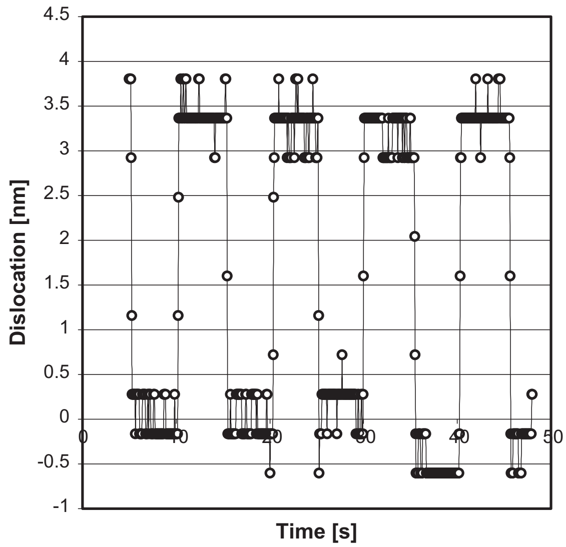

Fig. 6. Sensor's reaction to cyclic weighing down and lightening the one gram load from the bow dynamometer (3.33 nm) [7].