Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 176 (2017) 96 – 106

Procedia Engineering

www.elsevier.com/locate/procedia

Dynamics and Vibroacoustics of Machines (DVM2016)

Effect of the method for treatment of the functional surface of a piezoelectric vibration sensor on its sensitivity

Y.S. Andreev*, N.A. Demkovich, R.M. Isaev, A.A. Tselischev, S.D. Vasilkov

ITMO University, 49 Kronverksky pr.,St. Petersburg, 197101, Russia

Abstract

The investigation has been performed for the possibilities to improve the operating characteristics of aviation vibration sensors without increasing the cost price of their manufacture due to optimization of the microgeometry of functional surfaces. The goal of investigation is to develop a set of procedures for modernisation of the process of manufacture of parts for the vibration sensor providing the optimum microgeometry of their functional surfaces. The investigation has been carried out with the use of computer simulation method and experimentally. The microgeometry of functional surfaces has been described by means of graphical criteria. The Taguchi method has been used for planning full-scale experiments on machining of functional surfaces. The computer model of the vibration sensor design has been developed allowing to evaluate the effect of deviation of the relative position of functional surfaces of the sensor on its functional characteristics, the experimental and design data have been compared. As a result of investigation, the relationship between process factors and sensitivity of the vibration sensor has been identified and described, the optimum process parameters of treatment at manufacturing the functional surface, which provide its best sensitivity, have been determined.

Peer-review under responsibility of the organizing committee of the international conference on Dynamics and Vibroacoustics of Machines

Keywords: Surface microgeometry; machining; piezoelectric vibration sensor; computer simulation; functional properties of the surface.

Nomenclature

S	Conversion coefficient of the sensor (the vibration load is appliedparallel to the sensor sensitive axis)
S_T	Conversion coefficient of the sensor(the vibration load is appliedorthogonally to the sensor sensitive axis)
S_T^*	Relative coefficient of transverse conversion.

* Corresponding author. Tel.: +7-921-897-77-76.
E-mail: ysandreev@corp.ifmo.ru

Peer-review under responsibility of the organizing committee of the international conference on Dynamics and Vibroacoustics of Machines
doi:10.1016/j.proeng.2017.02.277

1. Introduction

The vibration sensor is a precision device for measuring external vibrations levelwith small tolerances on functional characteristics. These characteristics depend upon many factors, in particular, upon the manufacturing process, tolerance on geometrical dimensions, equipment and tools being used as well as means andmethods of control. The report determines the dependence betweengeometrical characteristics of the functional surface of the sensor and its sensitivity. The boundaries of variation of the geometrical characteristics are determined according to cutting parameters variation bythe Taguchi method. The use of this method allows to significantly reduce the number of experiments being performed withoutsignificant loss of the reliability of results.

The scientific significance of the investigation consists of studying the effect of accuracy of manufacture of the working surfaces of parts on the sensitivity of the vibration sensor with the use of graphical criteria for evaluating the microgeometry of functional surfaces and simulation of the vibration sensor operating process in the engineering analysis computer system. The practical significance of the study consists of the enhancement of operating reliability of the vibration sensor and improvement of its characteristics without increasing the cost of manufacture.

Among scientists dealing with problems of studying the effect of surface microgeometry on the operating properties of parts, it is important to note the works by I.V. Kragelskiy, N.B. Demkin, Yu.G. Shneider, E.V. Ryzhov, A.G. Suslov, J.A. Greenwood, Ya.A. Rudzit, V.M. Musalimov, V.A. Valetov and others. Among those dealing with piezoelectric sensors, it is important to mark Yu.V. Kiselyov, M.V. Bogush, A.A. Simchuk, V.Yu. Vusker and others.

The following tasks are solved within the framework of the research:

- Investigation of the effect of deviation of the shape, relative position of the surfaces and cleanness of the working surface on functional characteristics of the sensor;
- Development of the procedure of calculation of the limit tolerance on the relative position of functional surfaces with the use of numerical simulation (finite element analysis);
- Development of the procedure of election of the cutting modes and cutting tools providing achievement of the required cleanness of the surface;
- Identification of dependencies of the effect of process factors on functional characteristics of the vibration sensor;
- Optimization of the existing technology of manufacturing parts of the aviation vibration sensor with the use of procedures proposed.

This work was supported by grant № 16-38-00847 from RFBR.

2. Bibliographic review

The first piezoceramic electro- acoustic transducers differing by strongly expressed piezoelectric properties, simple configuration and relatively low cost of initial materials have been developed on the basis of barium titanate (BaTiO3) obtained by the synthesis method in 1944 [17].

The development of theory and practice of piezoelectric devices is related to the names of W. Cady, R. Thurston, W. Mason, L. Bergman, G.V. Katz, M. Onoe, H. Tiersten and others. Among domestic researches, one can mark N.N. Andreyev, A.A. Kharkevich, V. Domarkas and R. Kazhis, V.V. Malov, A.N. Kutsenko, L.Ya. Gutin, A.M. Bolkisev, V.V. Lavrinenko, I.A. Glozman, S.I. Pugachev, O.P. Kramarov, I.G. Minayev, A.I. Trofimov, A.E. Kolesnikov, M.V. Korolyov, I.N. Yermolov, R.G. Jagupov, V.M. Pluzhnikov, P.O. Gribovskiy, P.G. Pozdnyakov, V.M. Sharapov, M.V. Bogush and others.

Dozens of companies abroad manufacture piezoelectric transducers on a commercial basis and the leaders in this sphere of engineering and technology are as follows: PCB Piezotronik JNG, Endevco Corporation, DYTRAN, Sanstard Date control – (USA), Erich Broza, Rheometron - (Germany), Flopetron, C.F.V. LTD - (France), Mullard Ltd, Merles, Motoroia JNG, AVL - (Great Britain), Kistler Instrument AG, Vibro-meter - (Switzerland), Hans List – (Austia), Bruel & Kjaer (Denmark), ONO Sokki (Japan) and others. [3]

The leading enterprises in Russia in development and manufacture of piezoelectric transducers and sensors are Physcial measurement research institute, TsNIIMASh (Central research institute of mechanical engineering),