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Test Device for Hip Joint Endoprosthesis Cups Abrasion Tests and Experimental Evaluation of the Polyethylene Abrasion

M. Houfek(1)*, V. Fuis(1), L. Houfek(1)

(1) Institute of Solid Mechanics, Mechatronics and Biomechanics, Faculty of Mechanical Engineering, Brno University of Technology, Czech Republic, houfek.m@fme.vutbr.cz

* Corresponding author.

Abstract – Problems of artificial joints are actual problems in orthopedics today, occurring in both older and productive age people. The problems of joint cup abrasion are actual for patients after the surgery due to hip joint attrition or injury and for oncology patients. Therefore nowadays the medical system is interested in reliability of bioimplants, that is based apart from stress/strain analysis also on determination of abrasion properties and loss of material caused by common life style of a patient. The hip joint abrasion tests are currently actual and therefore we designed and implemented experimental device for experimental testing of hip joint prosthesis abrasion.

Test device is equipped with two MAXON RE36 DC drives and planetary gearboxes MAXON GB42. Upper tray is connected with actuator through flexible joint. Upper actuator simulates one part of combined motion (walking), that is inclination. The main step is simulated by lower actuator (step forward). Lower actuator is connected with clevis containing the head of hip joint. The tray with cast-in joint cup is connected through flexible joint with upper element. Actuators of the test device are controlled by EPOS unit by MAXON (Fig. 1).

The test element is mounted rigidly with high precision due to consecutive evaluation of abrasion using optics method. For mounting we used cup cast-in to DENTACRYL. This mounting method seems to be the most suitable for our requirements (Fig. 2). The test element mounted this way is put into the test device and tested.

To evaluate the abrasion we used single hologram optical method [1]. This method is based on the interference of reconstructed hologram wave with the wave coming from the object. So first a hologram is made for the test element. This hologram is put into its original location and test element is lit through the hologram. The light coming through the hologram is unchanged, but whenever there are changes in the test element the light is reflected in different direction and interference fringes occur (Fig. 3) [2]. The creation and position of the fringes quantitatively is obtained by reconstructed wave description according to:

$$u_1 = \bar{u}_1 + \chi u_c u_R^* u_s + \chi u_c u_R u_s^*$$

After performing the test on the sample of hip joint cup with no wear we verified that we are able to perform real measurement of abrasion using single hologram method. During the initial test stage we verified the method on hip joint cup with no wear where no interference occurred, which matches reality. The experiment can be concluded with the statement that the method of mounting the cup in the bed and in optical channel enables the measurement of material wear with holographic method.

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Figure 1: Experimental device.

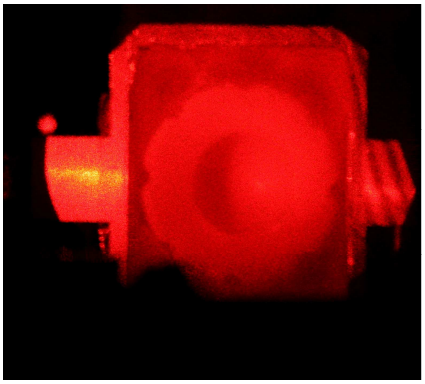

Figure 2: Cast-in hip joint cup.

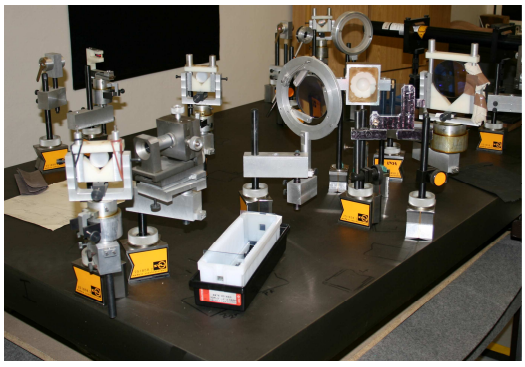

Figure 3: Interferometric method.

[1] P. Janicek, Experimental modeling, Brno, 1999.
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