39th Solid Mechanics Conference
Zakopane, Poland, September 1–5, 2014

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EXPERIMENTAL ASSESSMENT OF BALL JOINTS OPERATION USING SERVO-HYDRAULIC TESTING SYSTEMS

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1. Introduction

A progress in many branches of industry has spurred the elaboration and application of modern materials [2, 3]. This push is related to the current requirements concerning the lifetime extension of the responsible parts or elements of engineering constructions. For the automotive industry, ball joints are selected for modification by application of materials exhibiting better properties in comparison to the typical ones. Among these materials, the tungsten carbide (WC) is noteworthy [1]. Its melting temperature of around 2700°C, enables an operation at extreme environmental conditions. Moreover, the value of Young's modulus of this composite (around 690 GPa) is three times higher than that of typical steel. Although the ultimate tensile strength of the tungsten carbide is only equal to 530 MPa, its compressive strength is very impressive, i.e. it is almost thirteen times higher (around 6800 MPa). The producers' catalogue data [1] indicate that the WC composite is highly resistant to wear. Taking into account given advantages of the WC, one can conclude that it may be used as a thin layer to cover exploitation surfaces, and thus, protect base materials from temperature, reduce friction and non-typical loading effects.

The main aim of this paper was to check a possibility of using ball joints coated by the tungsten carbide under wear conditions.

2. Experimental procedure

All experiments were conducted using an anti-vibration platform with T slots and hydraulic servomotors. The typical ball joint (denoted as W11) and its modified version obtained by means of the tungsten carbide (WC) coating on the ball or/and cups surfaces were tested with or without application of the lubricant. The following configurations of the sliding pairs were considered, i.e.: W14 (WC-steel ball – polyamide cups with lubrication); W23 (WC-steel ball – polyamide cups) and W24 (WC-steel ball – WC-steel cups) – both without lubrication. These elements were mounted using a special gripping system, which enabled a load to be applied to the rocker arm. The loading conditions were defined based on realistic data. The amplitude reached 35 mm, and the frequency was equal to 2 Hz. Moreover, the following experimental stages were realized prior to the main test: (a) loading systems were designed and implemented; (b) software enabling identification of the effects due to the applied loading conditions was developed; (c) data acquisition system was implemented. A comparison of the experimental results obtained from the testing of modified and standard ball joints enabled an examination of the composite layer behaviour. It was evaluated on the basis of changes registered after every 500 cycles and elaborated in the form of diagrams of the force or temperature versus time, diameters, mass or roughness.

3. Results

Figure 1 illustrates some changes in the force as a function of time during the examination of the composite ball joint at the beginning (blue line) and final stage (green line) of the test. Important differences between both curves are especially visible for the compressive force. Comparison of the results achieved at the first and last cycle shows 25% reduction of the acting compressive force. Also, significant temperature variation can be observed over the entire test (Fig. 2). It increased linearly over a few initial cycles independently of the composite surface type and friction conditions. For the W14, W23 and W24 layers, an increase of temperature was equal to 60%. The smallest variations of temperature (less than 30%) were achieved for the typically lubricated surface, denoted as W11. Such a small increase of temperature reflects a stabilisation of the wear process. It was not observed for the other types of the WC composite layers.

An analysis of the weight variations of the composite coated ball exhibited its increase equal to 0.017 g, when the polyamide cups were applied. It was related to the wear product deposition. An opposite effect occurred when the WC coated steel cups were used. The weight reduction achieved a level of 0.19 g.

The results of the profilometric investigations (Fig. 3) showing irregular discontinuities in the WC layer enabled to take a conclusion that significant changes in the composite surface were observed when the WC-steel cups were used. Comparison to the roughness measured for the composite coated steel ball sliding on the polyamide cups in the received state and after cyclic loading history exhibited its reduction due to exploitation from 3.3 to 2.1 μm.

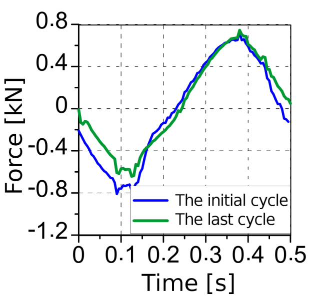

Fig. 1. Force versus time at the initial and final stage of test.

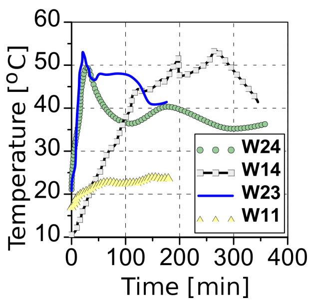

Fig. 2. Variations of temperature versus time for various sliding pairs.

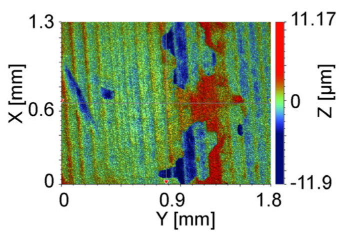

Fig. 3. A surface topography of the composite coated ball after test.

4. Conclusions

Profilometric investigations were used to examine a degree of homogeneity of the ball joint coated by the tungsten carbide layer. The composite coating on the sliding joints of the steel ball-steel cups type increased the wear coefficient. It was expressed by a reduction of the ball weight and appearance of the metallic powder. A magnitude of the ball mass reduction was dependent on the wear conditions, i.e. sliding of the joint elements with or without of the lubricant.

References

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