***Korobiichuk Igor**, Ph.D, associate professor,*
Industrial Research Institute for Automation and Measurements PIAP, Warsaw, Poland
Bezvesilna Olena, Doctor of engineering, professor,
National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine

EXPERIMENTAL INVESTIGATIONS OF A PRECISION SENSOR FOR AN AUTOMATIC WEAPONS STABILIZER SYSTEM

Weapons stabilizer is an automatic control system that provides combat vehicles with weapon targeting and stabilization in the target fire direction during oscillation of a moving armoured vehicle (AV). To increase the effectiveness of fire during movement in all modern tanks and other combat vehicles, the main armament is stabilized by a special device referred to as a weapons stabilizer. AV oscillations are random and never dampen in motion. The amplitude of angular oscillations and oscillation frequencies are quite high. The accuracy of shooting is mostly influenced by AV oscillations in the longitudinal plane, changing the angle of gun elevation, and angular oscillations in the horizontal plane, changing the traverse. This leads to a significant displacement of the aiming mark towards the target and does not allow the gunner to keep it on target even with the most advanced power drives.

First of all, these causes increase vectoring errors by 10–30 times due to firing on the move, as compared with firing from a halt. Dispersion of projectiles increases by about 10–12 times. Precision of fire on the move also decreases due to continuous changes in the target range. AV oscillations in motion significantly worsen firing conditions.

To increase the effectiveness of fire on the move, all modern combat vehicles are equipped with a special automatic device referred to as a weapons stabilizer system (WSS). WSS effectiveness is mostly dependent on the accuracy and performance of the sensitive stabilizer elements and accelerometers. Therefore, the urgent scientific and technical challenge is to improve the accuracy and speed of response when measuring the acceleration values by experimental investigations of a piezoelectric sensor (PS) for the automatic weapons stabilization system.

The task given by the Ministry of Education and Science of Ukraine grant No. 0115U000210 was to improve the accuracy and error characteristics of the precision accelerometer sensor for WSS. The WSS under consideration was the SVU-500, produced by the G. Petrovsky Kyiv Automatics Plant (Kyiv, Ukraine).

The WSS of this type are used in the fire control systems of the "Shkval", on BTR 3E, on infantry fighting vehicles BMP IM (SVU-500-3TS), and in "Shturm" and "Parus" systems for APCs BTR1 3E and BMP 4 (SVU-500-4TS). The modernized version of SVU-500 is intended to be mounted on the AVs, such as the BMP-2 (BMP-2, BTR, BMP, BMD), to stabilize targeting and improve fire control during motion on land and on water. The existing WSS was using obsolete vibrating string accelerometers; therefore, a new approach was chosen, based on piezoelectric elements. The new sensor had to be compatible with existing WSS systems, which gave initial assumptions for the development process.

Experimental device was created for experimental investigations of the sensing element (SE). The test stand includes the following devices: a mechanical vibration generator GMK-1 (vibration table) with two on-board induction transducers converting electrical signals into mechanical displacement; an SE placed directly on the vibration table; an input/output module; an SE output signal amplifier unit; a personal computer (PC); an AC generator and voltmeters for logging voltage levels of the generator and of the induction transducers.

As a result of experimental investigations we have obtained dependencies of amplitudes of the SE output voltage and the induction transducer on the vibration table oscillation frequency. It has been established that the maximum amplitude of the output voltage SE USE takes place when values of the vibration table oscillation frequency are equal to the values of the SE natural oscillation frequency. This is a case of the so-called "main resonance". Additionally, voltage USE decreases with increasing vibration table oscillation frequency. We have investigated the calibration characteristics of the SE WSS and found that the rotation angle of the SE WSS measurement axis relative to the reference vertical directly impacts on its output values and the value of its error.

The main sources of the sensor's error are the temperature coefficient of piezoelectric modulus for given material, mass and dimension variations between individual sensors, and supply voltage stabilization errors. The identification and compensation of hysteresis effects should be included in future developments of the sensor, if greater accuracy is required. The new sensor is implemented in the SVU-500 WSS, and produced by the G. Petrovsky Kyiv Automatics Plant for a modernised version of the BMP-2 APC. Newly-produced units are currently (late-2016) being investigated in military trials. Preliminary results indicate an order of magnitude improvement of the modernised system accuracy.