A novel in situ device based on bionic piezoelectric actuator to study tensile and fatigue properties of bulk materials

Abstract

This study proposes a miniaturized device based on inchworm type piezoelectric actuator to investigate the static tensile and dynamic fatigue properties of bulk materials. The device mainly consists of a bionic piezoelectric actuator, a pair of grippers and a set of testing system. Tensile and fatigue examinations share one actuator and one set of testing system. The fine step size, compact structure, vacuum-compatible materials and stability enable applying the device in TEMs. The tensile and fatigue examinations on ordinary copper are carried out to verify the feasibility of the design.

Configuration, working principle, experiments and conclusions

The design shown in Fig. 1 mainly consists of an inchworm type bionic stepping piezoelectric actuator, a pair of grippers, a load sensor and a displacement sensor. The piezoelectric actuator takes advantage of 4 pairs of clamping blocks to clamp the mover and it can provide not only a linear motion with long motion range and high precision in tensile test, but also a reciprocating motion with middle and low frequencies in fatigue test.

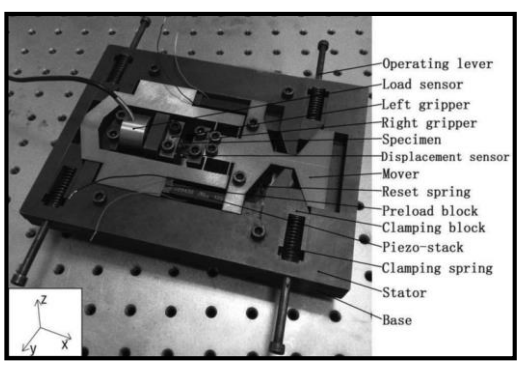

Fig. 1. Structure of the device.

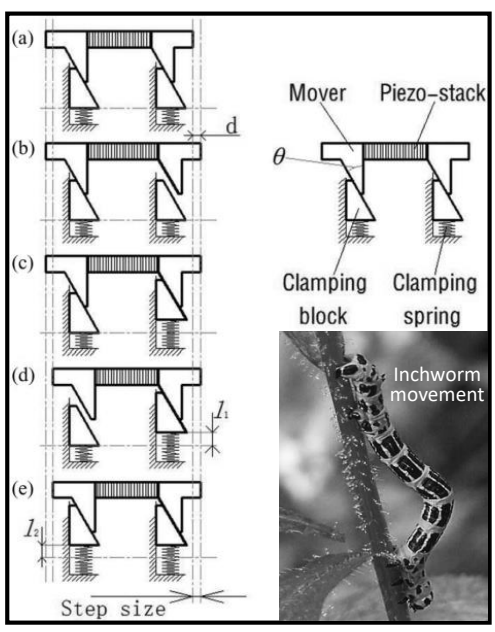

Fig. 2. Working principle.

Working principle of the inchworm type actuator:

(a) Initial state.
(b) Piezo-stack extends and the right clamping surface of the mover separates from the right clamping block.
(c) Under action of right clamping spring, right clamping block moves up until it presses the mover again.
(d) The piezo-stack contracts and left clamping surface of the mover separates from the left clamping block.
(e) Under action of left clamping spring, the left clamping block moves up until it presses the mover again.

By repeating above steps, the actuator can output long range stepping motion and tensile test can be performed.

In Step(b), if the right clamping block is fixed, the mover will reciprocate and and fatigue test can be performed.

The tensile and fatigue tests on ordinary copper are carried out and the results are shown in Fig. 3. The maximum tensile loads of specimen 1 and 2 are 271.5N and 270.4N. The result testing by a MTS machine is 268.3N, which verifies that the proposed device is credible.

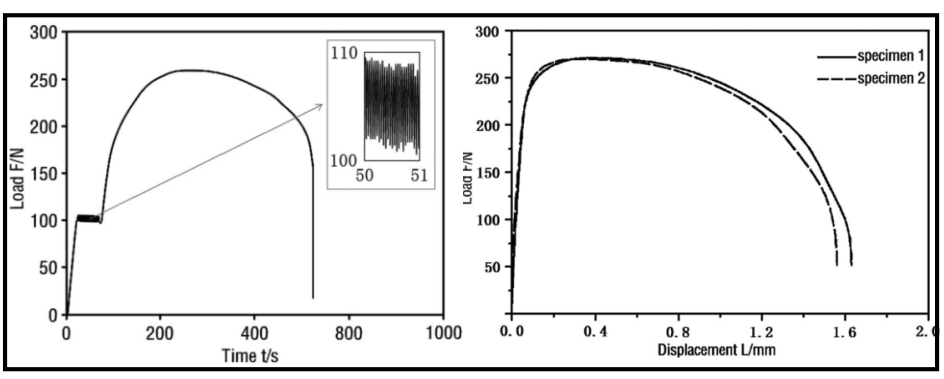

Fig. 3. Tensile and fatigue tests.

A miniaturized device with an inchworm type piezoelectric actuator is developed. The device can be used to investigate the static tensile and dynamic fatigue behaviors of bulk materials. Tensile and fatigue examinations share one driving system and one set testing system. In situ tensile and fatigue examinations under SEM or metallographic microscope can be carried out using the design. Ordinary copper samples are used to perform the tensile and fatigue examinations on the proposed device. The experiments proves that the device is accurate and easy to operate.

Publications

[1] Design and driving characteristics of a novel ‘pusher’ type piezoelectric actuator. Smart Materials and Structures 2016, 25, 015005.

[2] Design and driving characteristic researches of a novel bionic stepping piezoelectric actuator with large load capacity based on clamping blocks. Microsystem Technologies 2015, 21, 1757-1765.

[3] A novel in situ device based on a bionic piezoelectric actuator to study tensile and fatigue properties of bulk materials. Review of Scientific Instruments 2014, 85, 065013.