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EXPERIMENTAL STAND FOR ACTUATOR TESTING

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Abstract: The paper deals with experimental stand for testing of actuators. Shape memory alloy has been one of the possible tested actuators on this stand. Experimental results gave recommendation for design of the products with tested actuators. This stand is also able to test dynamic properties of actuators.

1 Introduction

Actuator is a device for conversion of any energy to mechanical work. The main aim is to use the actuator with minimum losses and minimum size and low price.

Mechatronics applications grooving up and there is a need for actuators as base part of mechatronic systems (fig. 1, fig. 2, fig. 3).

Also smaller miniature products need also smaller actuators. Conventional actuators are sometimes not successful for using in this area, because of low efficiency and overall costs.

Figure 1 Machine with electromagnetic actuator

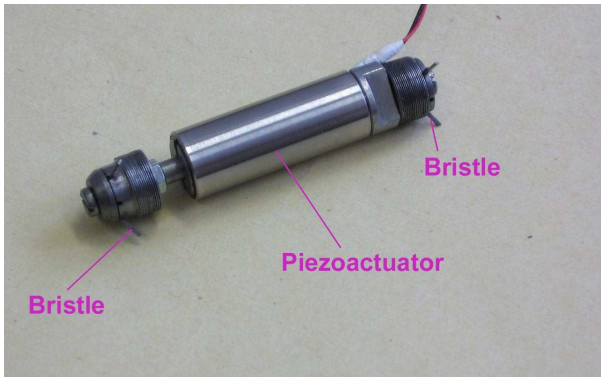

Figure 2 Machine with piezoelectric actuator

Conventional actuators is based on electromagnetic principle and on the base of theory, the efficiency in small dimensions (less than 10 mm) is lower than in bigger dimensions.

Figure 3 Machine with shape memory alloy actuator

This is the reason of using of unconventional actuators as shape memory alloys actuators, piezoelectric actuators, magnetostrictive alloy, electrostatic actuators etc. Piezoelectric actuators uses the piezoelectric phenomenon where the connected electric voltage is converted to stroke or displacement of piezoelectric material. Magnetostrictive materials need magnetic array for generation of material stroke. Magnetostrictive alloy and piezoelectric actuators have fast response time (several nanoseconds or microseconds). Obtained strokes for these actuators are low (only about 0.1 percent).

Shape memory alloy needs thermal activation for generation of displacement. Displacement is about 5 percent from dimension of shape memory alloy actuators. Main disadvantage of shape memory alloys is very slow reaction time (several seconds).

Shape memory alloy with acronym SMA is very interesting material activated with temperature change. It means that material has defined shape and after thermal heating, it is deformed, but after cooling, it returns to previous defined shape. This thermal activation is caused from internal structure transformation between martensite and austenite.

Shape memory alloy actuators are available in various forms as wire, roods, spring etc.

Shape memory alloy is available as two-way SMA, which provides pull and contract force, but with smaller displacement in comparing with one-way SMA, which provides only contract force and return to previous position

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has to be made with bias force from spring or additional force (mass gravity etc.) [1-5].

Shape memory alloy needs bias mechanism for ensuring of properly function (fig. 4). There are several ways of biasing as using of weight for generation of pull force, using of spring and antagonistic arrangement of two shape memory alloy actuators for alternate using as bias mechanism.

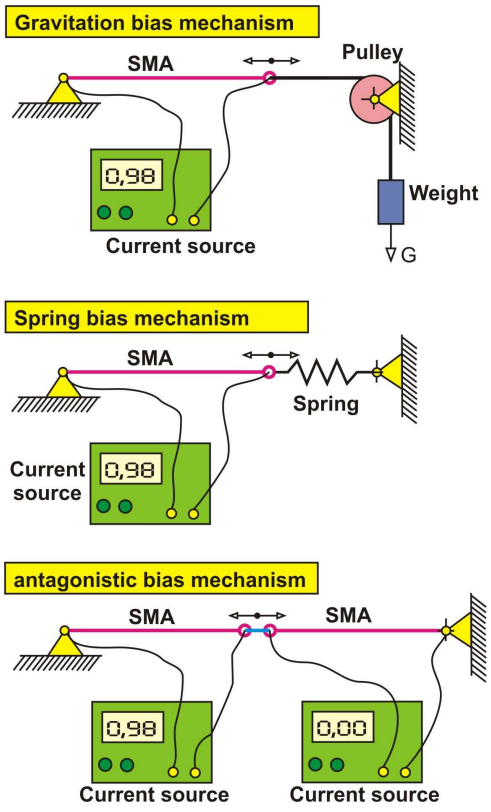

Figure 4 The SMA applying with bias force [1, 2]

There are more than twenty alloys of materials, which have shape memory effect. The most famous alloy is Nitinol, which is as alloy from Nickel and Titanium.

Thermal activation can be made with external heating and cooling system. The most frequently used is thermal activation with joule heating caused with electrical current through the material. Cooling is with passive heat exchange with surroundings or active cooling with any cooling systems.

Practical using of shape memory alloy meets with problem of attaching to mechanical parts. Actuator in wire form cannot be welded or soldering. There is a possibility of using of crimp technology of attaching to the end of actuator (fig. 6).

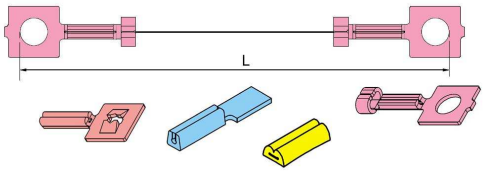

Figure 6 Crimping of the shape memory alloy actuators

Shape memory alloy can be activated using the heating caused by passing electrical current. Activation time depends on value of electrical current. Maximum value of electrical current is defined by actuator manufacturer. Activation time is also affected by way of shape memory alloy application (attaching to other parts, thermal isolation, air flow, surround temperature etc.).

Deactivation time is longer than activation, because there is only passive convection is used. But there is a forced ways of actuator cooling.

The shape memory alloy is frequently used in automotive industry, aeronautics, medicine, machinery etc.

2 Testing stand for experimental verification of shape memory alloy actuators

Activation and deactivation of wire shape memory alloy causes the change of this length - stroke. This active stroke allows to lift any weight or active force useful for any application. Useful force is decreased with required bias force or bias weight.

Experimental stand (fig. 7) has been developed for experimental testing of the shape memory alloy. Predefined bias weight is used for tested actuator. One end is fixed and connected to power supply. Second end is connected with tension rope to bias weight. Second end is also connected to power supply and control unit. Position of second movable end is measured as actuator stroke. Also additional weight can be added during the experiment. The aim is to obtain power characteristic of actuator. It means dependence of useful active force and stroke of actuator.

End position is sensed via using of permanent magnet and magnetically sensitive sensor.

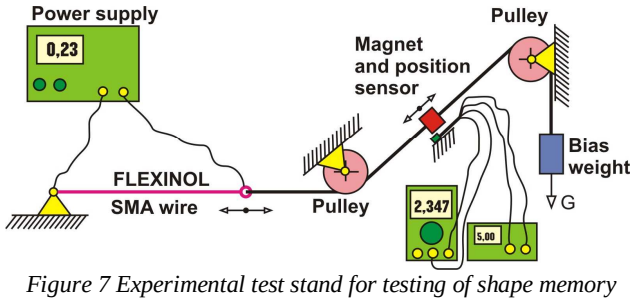

Figure 7 Experimental test stand for testing of shape memory alloy

Apparatus allows to slowly change of supply electrical current. Stroke of actuator has the significant hysteresis

also occurs during the loading of actuator. This hysteresis can be as problem in control process.

Permanent magnet is used as reference point of movable end point of shape memory alloy actuator. Hall sensor has been used for sensing of the magnet position (fig. 8).

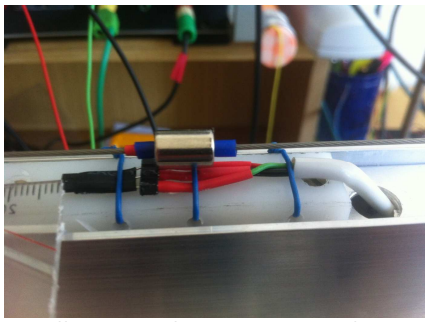

Figure 8 Hall effect sensor for measurement of position of shape memory alloy end

Calibration procedure shows dependence of output voltage on position of permanent magnet position (fig. 9). There is useful range for measurement between the values from 6 mm up to 20 mm.

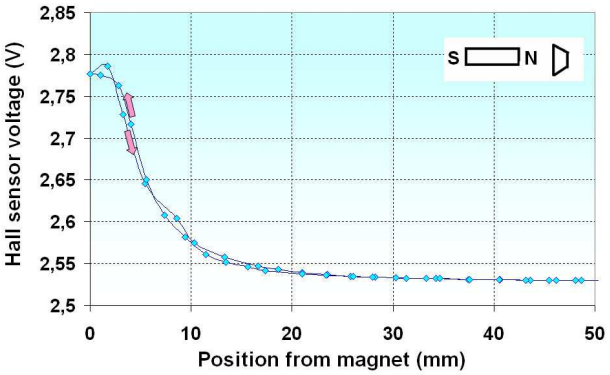

Figure 9 Hall effect sensor calibration characteristic

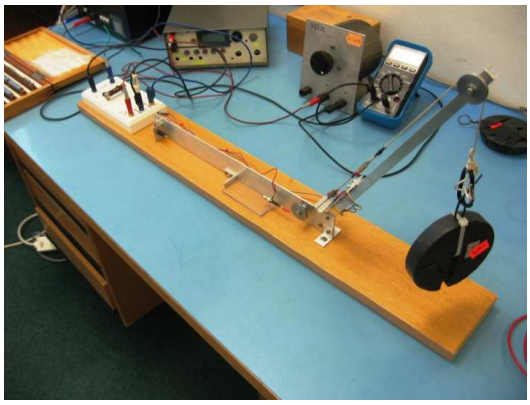

Figure 10 Experimental test stand for testing of shape memory alloy

Figure 10 shows experimental stand for testing of shape memory alloy actuators.

3 Conclusion

Shape memory alloy is actuator, which is as thin wire, and it is able to generate up to 5% stroke (from overall length) under the loading. Output mechanical work related to its dimensions is much bigger than from others conventional actuators. This type of actuator has also good corrosion resistance and biocompatibility. These actuators produces no noise, no dust and no electromagnetic array. All these properties give the great possibility for application in many various application [4-27].

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