Shape memory alloy hybrid composite plate for vibration control

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Abstract

1. Introduction

Shape memory alloys (SMAs) are widely used as the sensor, actuator and damping instruments. The hybrid composites that embedded with SMAs show some unique properties or functions such as self strengthening, active modal modification, high damping, damage resistance, control and self healing so they can provide tremendous potential in many engineering applications. Since that vibration control is one of the most important and common applications of the shape memory alloys, the study of vibration characteristic of SMAs become important. Past researcher like Jae-Sang Park *et al.* [1] had studied on the vibration of thermally post-buckled composite plates embedded with shape memory alloy fibers. Although the shape memory alloys had been manufactured and used in the modern smart structure, but the major internal problem of shape memory alloy still occur as a result of the characteristic of shape memory effect only limited to motion along the fibers' longitudinal axes [2]. The inter-relationship between the angle of SMAs embedded into the composite and the effect of different angle of SMAs embedded into the composite to the vibration characteristic had not been studied and determined by previous researchers.

In this paper, there were four specimens with different angle orientation of the arrangement of SMAs in the composite to be fabricated. These four specimens are the composite plate that without SMAs was fabricated as a reference for analysis, and for the sample which embedded with Muscle Wire type Flexinol 375 HT were oriented at 0^0, 45^0 and 90^0 to the epoxy/fiber glass reinforcement composite plate. The specimens were tested for the boundary conditions of clamped-free. The amplitude of the wave form received from the vibrometer for the composite plate was studied.

2. Specimen preparation

The specimen with the dimension of 200 mm x 150 mm x 2 mm was made from the epoxy resin and reinforced with the glass fiber. The SMAs that used in the testing are the Flexinol wire from Mondo Tronics, Inc. Detail parameter of Flexinol wire can refer to www.Mondo.com. The mold was made from ply wood which cut to the required shape and then jointed together to form the shape. Since the Flexinol wire which will be embedded into the composite sample having the diameter of 0.375mm, the hole of size 0.4mm was punched to the mold at the required locations. The volume faction of the Flexinol wire had been designed to be 0.05% so the distance from center to center for the hole is 20.0mm. The samples are shown in the Figure 1 below.

The flat area should be chosen to place the mold. The hand lay-up technique was used to manufacture the samples. Before adding the epoxy resin, the mold should be applied with wax so that the sample can be easily removed from the mold at the final stage. Each upper layer and the lower layer of the samples will be reinforced with a layer of tissue mat fiber glass. At first, the bottom layer filled up with the mixed epoxy resin and then uses the roller to move the resin to form a thin layer before adding the tissue mat fiber glass. After the tissue mat fiber glass had been added, the roller was used to remove the bubble which trapped within the epoxy resin with the fiber glass. Before continue with next step, the Flexinol wire is then fix to the mold and force is applied at both end of the Flexinol wire so that the Flexinol wire can form a straight line before embedded into the composite. The applied force should not be too high to avoid the Flexinol wire been stressed. Then fill the mold with the epoxy and the tissue mat glass fiber and placed a flat surface sheet at the top of the mold which already been filled up to made sure that the sample will be having the required thickness.

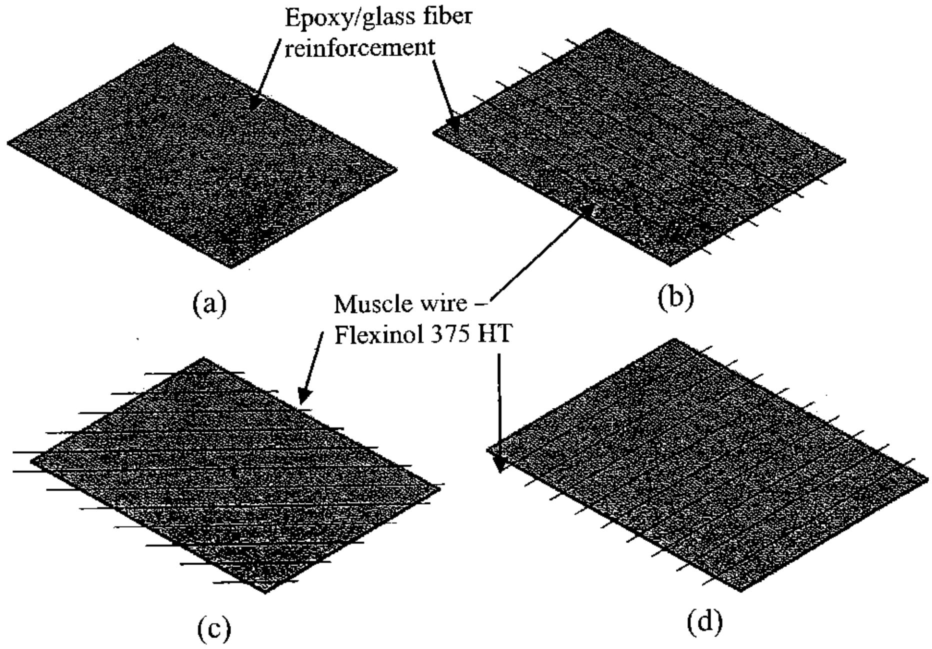

Fig. 1. Samples of the composite plate embedded with Flexinol wire (a) without Flexinol wire, (b) 0^0, (c) 45^0, and (d) 90^0.

When the sample is ready to be removed from the mold, the Flexinol wire which located outside the mold will be cut. Then the sample was careful remove from the mold. Due to the limitation of the DC power supply current range, the Flexinol wires will then connected again at the areas which have been cut during the process to remove the sample from the mold. The connector will allow the current flow from Flexinol wire through it and to another Flexino wire to behave like a series system. The electrical current needed to flow through the sample should not over the range of the DC power supply.

3. Experiment setup

Two types of testing conditions were done, that is the inactivated condition and the activated condition. The term of activated refer to the Flexinol wire in which the current will flow through the wire and heated up until the phase transformation occur. For this testing, the shaker will excite from the frequency range of 0 ~ 500 Hz, but the laser vibrometer capture the vibration of the plate at the frequency of 250 Hz. The temperature of the surface of the Flexinol wire is allowed to stabilize for few minutes before the measurement is recorded with a thermocouple. The layout of experiment is shown in Figure 2.

For the experiment setup, the electrical heating must be done very careful so that the temperature for the Flexinol wire will not exceed the temperature that can damage the properties of the Flexinol wire. The jig to hold the specimen must be careful design and check so that the jig does not vibrate with the specimen during testing.

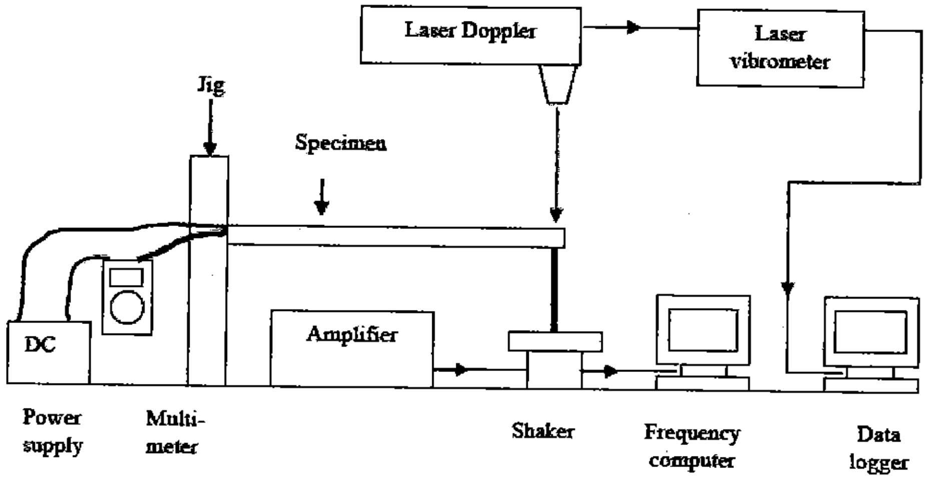

Fig 2. Experiment setup for the vibration test.

4. Data and analysis

As discussed in previous chapter, the vibration test was conducted for the clamped-free for all four samples. The numbering of samples is as in Table 1.

Table 1: Description of samples

No Sample	Description
1	Without Flexinol wire
2	0^0 of Flexinol wire
3	90^0 of Flexinol wire
4	45^0 of Flexinol wire

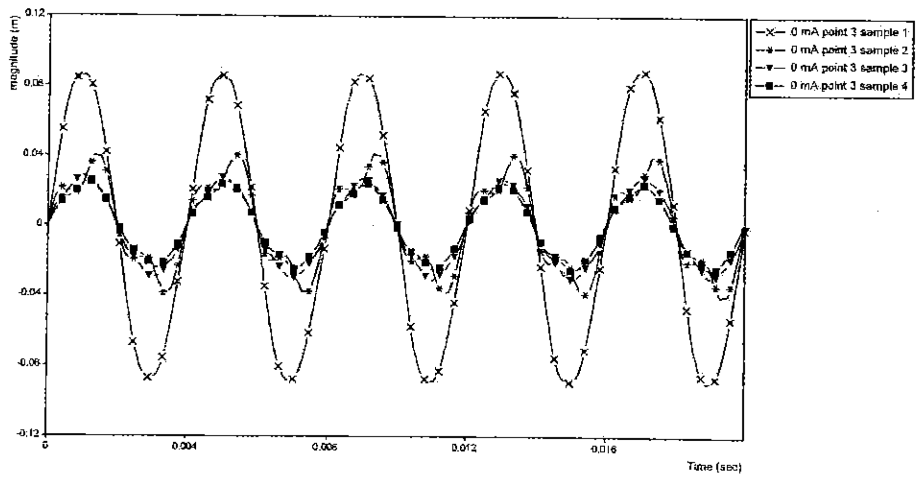

Fig 3. Vibration at point 3 where Flexinol wire is inactivated.

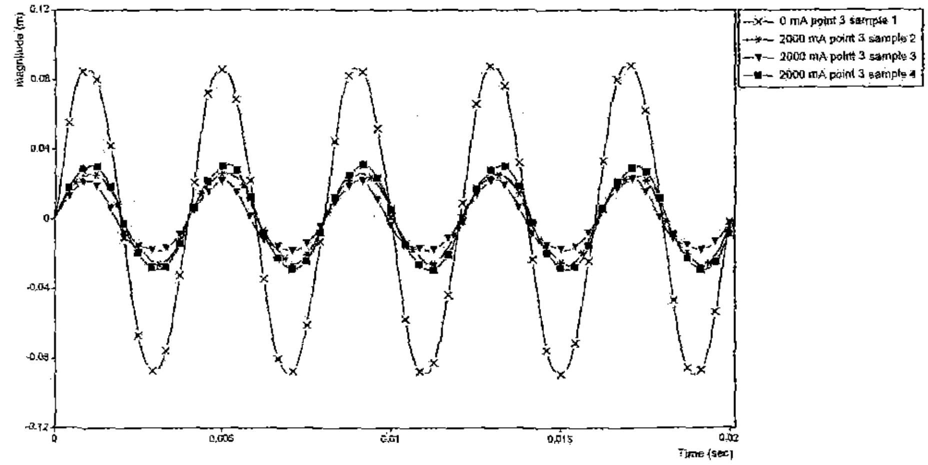

Fig 4. Vibration at point 3 where Flexinol wire is activated.

5. Conclusions

The different angle of orientation for the Flexinol wire on the composite plate showed to be important to control the amplitude of vibration for the composite plate in both activated and inactivated condition. During inactivated condition, the Flexinol wire behave like a normal reinforcement agent to reduce the amplitude of the vibration and when current flows through Flexinol wire and heated up to the phase transformation temperature, the wire was activated. Thus the shape memory effect of the Flexinol wire will cause the composite plate having inner stress and reduce the vibration amplitude. Beside that, it is found that there was reduction amplitude also change with the location whereas the maximum of amplitude reduction occur at the center point of the center axis of the composite plate. About 76.59% of amplitude had been reduced for the 90^0 angle orientation during activation and 69.51% and 65.08% amplitude reduction on the sample with 0^0 and 45^0 angle orientation of the Flexinol wire at the center point of the composite plate.

References

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