DEFORMATION AND RECOVERY PROPERTIES OF SHAPE MEMORY POLYMER COMPOSITES TUBE

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1 INTRODUCTION

As a typical smart material, shape memory polymers (SMPs) and their composites have the capability of variable stiffness in response to external stimuli, such as heat, electricity, magnetism and solvents. Shape memory polymers (SMPs) are stiff like plastic in their glassy state. However, when they are heated above the transition temperature (Tg), they become soft and have large strain capability. Further following a cooling process, they become stiff again. Compared with other smart materials such as shape memory alloy, SMP possesses the advantages of large deformation capacity, low density and low cost.

2 ANALYTICAL MODEL OF SMPC TUBE

In our work, both simulation and experimental verification were demonstrated to study the properties of the shape memory polymer composites tube.

It is necessary to predict the distribution of stress and deformation to verify the feasibility of the tube. A finite element model was created using the commercial software ABAQUS. Multiple models were created to simulate the different tests that were examined. Varying boundary conditions can be matched to constraints on the physical systems. The modal analysis is utilized in several working conditions to make a comparation of different natural frequencies. The results show that the composite shell sectional moment of inertia and the materials of the tube play the major role of influencing the natural frequency. And layer thickness of shape memory polymer composite tube and laying angle of carbon fiber have little impact on the natural frequency of the structure.

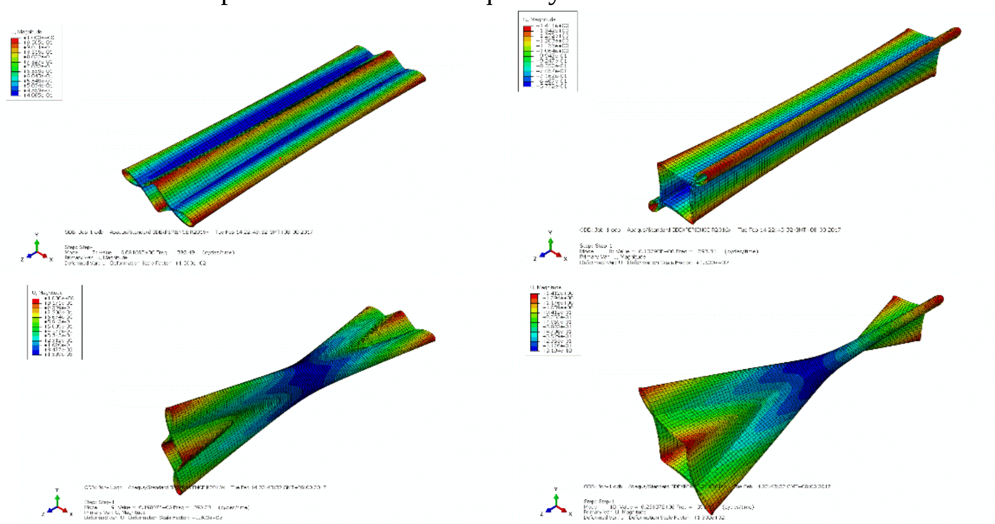

Figure 1: the first four order vibration mode of the SMPC tube

3 SMPC TUBE FABRICATION AND EXPERIMENT TEST

For the physical tests, a new kind of shape memory polymer composites (SMPC) tube is developed, which possesses considerable flexibility under high temperature and rigidity under low temperature. In this paper, the elastic modulus and glass transition temperature of an epoxy-based SMPC material reinforced with carbon fiber are obtained under different temperature by tensile tests and dynamic mechanical analysis (DMA). Then, the SMPC tube is fabricated by filament winding technology. Resistor heater is applied to heat the device and actuate the shape recovery process. Finally, compression tests and recovery process are performed under different temperature, during which the depth and recovery time are recorded. In addition, the packaging efficiency of tube is investigated through a series of stowage and redeployment tests.

Figure 2: SMPC tube fabricated by filament winding technology

Figure 3: SMPC tube and their three points bending experiments

Figure 4: The recovery process of SMPC tube

4 CONCLUSIONS

The physical test data and the simulation results are compared. There exist some problems with the manufacturing technique, which leads to a few differences between the experiment and simulation, but they can show some validity. Development of a computational model for the tube requires accurate and precise experimental determination of the material properties. Further work will focus on continuing to improve material properties definition for the model in order to obtain correlation between experiment and model. Due to the flexible and expandable properties, the SMPC tube has great potential in future aerospace field, such as satellite and space station.