THREE DIMENSIONAL SHAPE RECOVERY RATIO FOR A SHAPE MEMORY POLYMER COMPOSITE HINGE

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ABSTRACT

In this study, the concept of three dimensional shape recovery ratio (3DSRR) has been introduced to explain the shape recovery phenomenon more accurately. The 3DSRR can be defined as the difference between the recovered shape and original shape in a three dimensional sense. To define 3DSRR, three dimensional shape change must be recorded and a three dimensional scanner was used for the purpose. The concept of 3DSRR was applied to a shape memory polymer composite hinge. The results revealed that 3DSRR is necessary for better explanation of shape recovery phenomenon.

1 INTRODUCTION

In the near future, small spacecraft will need lightweight, flexible, and cost-effective mechanisms for deploying of antennas, solar arrays, and other devices. This paper aims to fabricate a controllable hinge for deploying antenna's arms in the spacecraft when reaching the desire orbit.

The merit of shape memory polymer are high recovery strain, low density, ease for fabrication and low cost. However, low modulus and strength are their essential drawback. To overcome these disadvantages but still maintain the merits of SMP, a combination between carbon fiber reinforced and SMP, shape memory polymer composite (SMPC), will be a good solution, which is studied in this paper.

Three dimensional shape recovery ratio (3DSSR) is revealed during the test using an optical measuring techniques system (ATOS system). The definition of shape memory polymer in previous paper (Lan et al., 2009) hard to define exactly the full deployment moment because a SMPC laminate with a larger storage angle will result a larger residual angle. It means that when we fold a SMPC laminate with a larger storage angle, the recovered hinge is more different with original one. Therefore, we offer a new definition about three dimensional shape recovery ratio in order to define the full deployment moment of a SMPC hinge more accurate and time-consuming.

2 EXPERIMENTAL SET-UPS FOR DEPLOYING A SHAPE MEMORY POLYMER COMPOSITE HINGE

2.1 Deploying a shape memory polymer composite hinge

The SMPC hinge will be deployed by using the chosen heating elements. ATOS system will be utilized to capture movement of the hinge and then extract displacement, velocity, and accelerometer of moving point attaching on the tape's surface. With this system, the shape recovery ratio of the SMPC hinge in three dimensional ways can be defined easily and accurately.

Figure 1 shows a real SMPC hinge with 4 layers. For fabrication of the SMPC tapes, a SMP resin (MP5510, SMP Technologies Company, Japan) and a carbon/epoxy resin (SK WSN 1K, SK Company, Korea) were used. Total length and radius of the SMPC hinge are 130 mm and 32 mm, respectively. A hand lay-up method was used to make the SMPC tapes.

Figure 1: A SMPC hinge with heating elements.

2.2 Shape recovery ratio and three dimensional shape recovery ratio

In this application, the recovered hinge will be divided into 5 sections, and then deviations of the points on the section's surface can be defined using ATOS software after scanned all of the original SMPC hinge and recovered SMPC hinge successful. The first section was 8mm (6 % of the length of the hinge) along the z-axis from the origin of the coordinate and the final one was 122 mm (94 % of the length of the hinge).

3 CONCLUSIONS

In this study, the heating element was designed and double checked using an experiment set-up, and then a SMPC hinge which can be deployed using heating elements had been fabricated and successfully tested in about 6 minutes. Consequently, a new 3-dimentional shape recovery ratio (3DSRR) definition was developed in order to define the full deploying time of the SMPC hinge.

The results show that the SMPC hinge has a good recoverability.

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