A kind of two-way smart actuator device based on shape memory polymer and rubber

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Introduction

A kind of smart actuator was proposed by integrating shape memory polymer (SMP) and rubber materials, in which the rubber material was placed at the middle position between two piece of SMP plates. some pre-tension deforming was carried out on the SMP/rubber composite actuator and the two-way shape memory effect (SME) was demonstrated during the shape recovery step.

Methods

Simulation: The Generalized Maxwell model and WLF equation shown in reference [1, 2] was applied to simulate the two-way SME during the shape recovery step with heating rate 5℃/min.

Experiment: A rubber strip (length 100mm * width 10mm * thickness 10mm) was integrating with SMP plate (length 100mm * width 10mm * thickness 1mm) to form the composite actuator.

Critical load F_{cr} for three cases : The compression load for SMP plates would be produced when temperature was cooled to 30℃ for composite actuator with some pre-tension deforming. When the compression load was lower than critical load, the case 1 (full fixity) would produce.

$$F_{cr} = \frac{\pi_2 EI}{(\mu L)^2}$$

Discussion/Results

Step 1: Pre-tension 3mm at 90 ℃;

Step 2: Cooling to 30 ℃ with 5℃/min;

Step 3: Removing external tensile load; （ Three temporary shapes would produce based on the modulus of rubber materials）

Step 4: Heating to 90 ℃ with 5℃/min to realize the two-way SME of case 1 and 2.

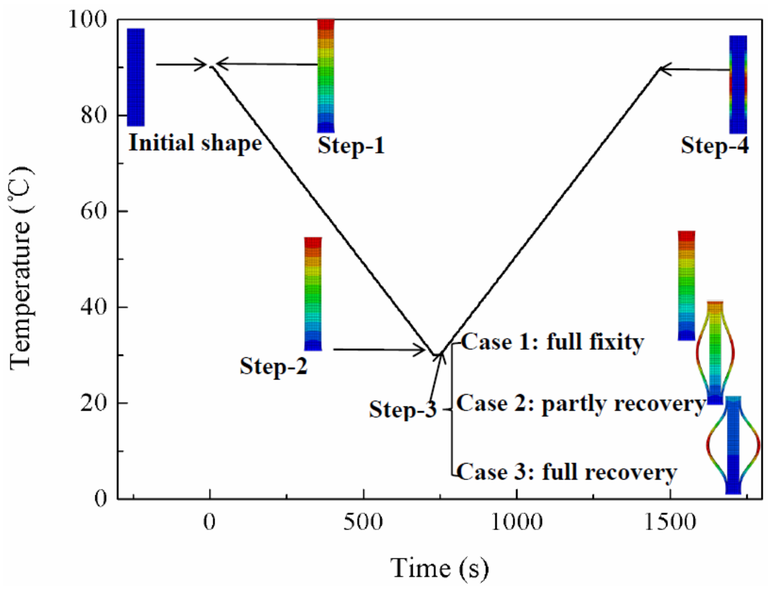

Fig 1. A thermo-mechanical process of SMP/rubber composite actuator

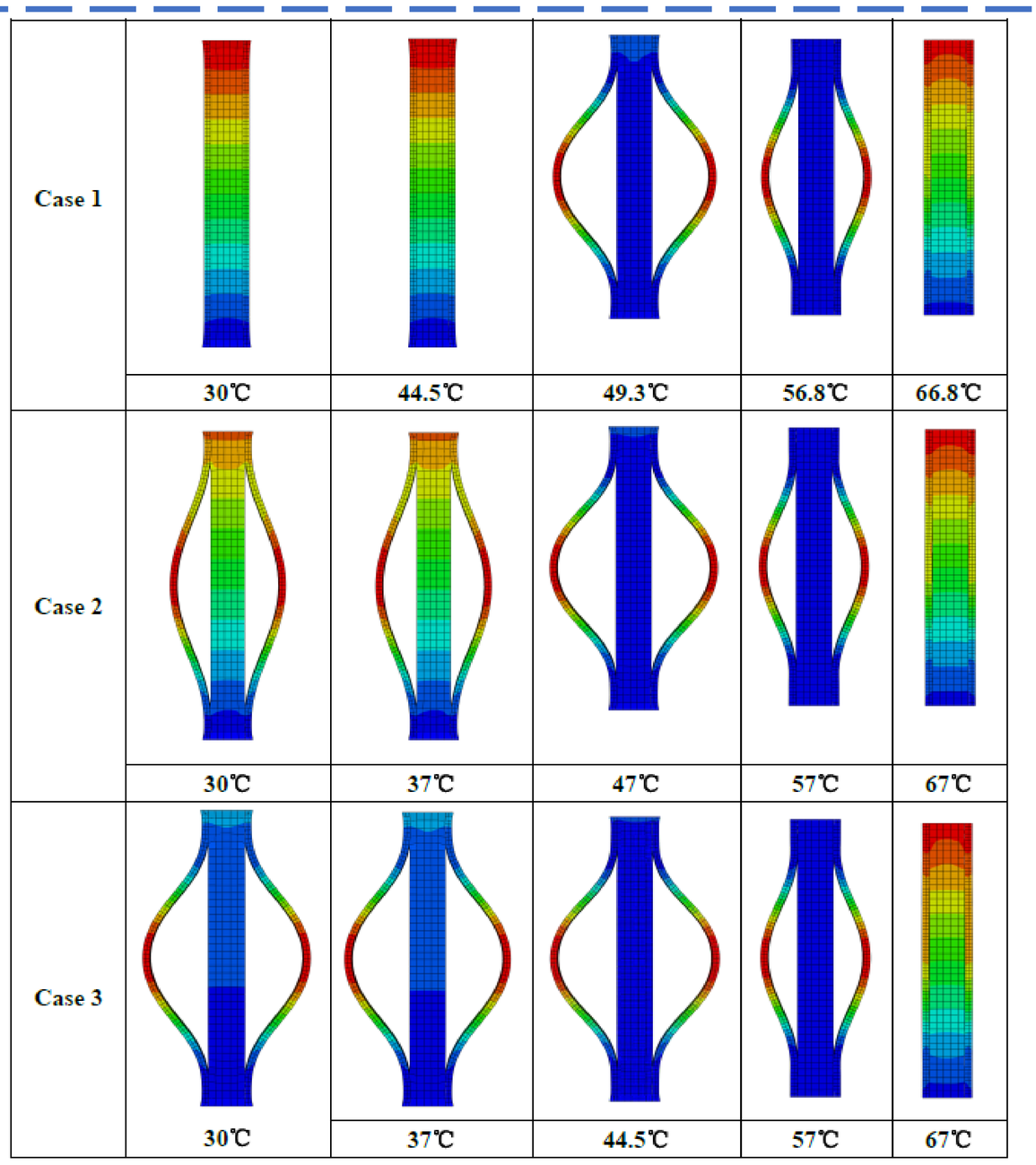

Fig 2. Shape recovery process simulation of SMP /rubber composite actuator for case1, case 2 and case 3

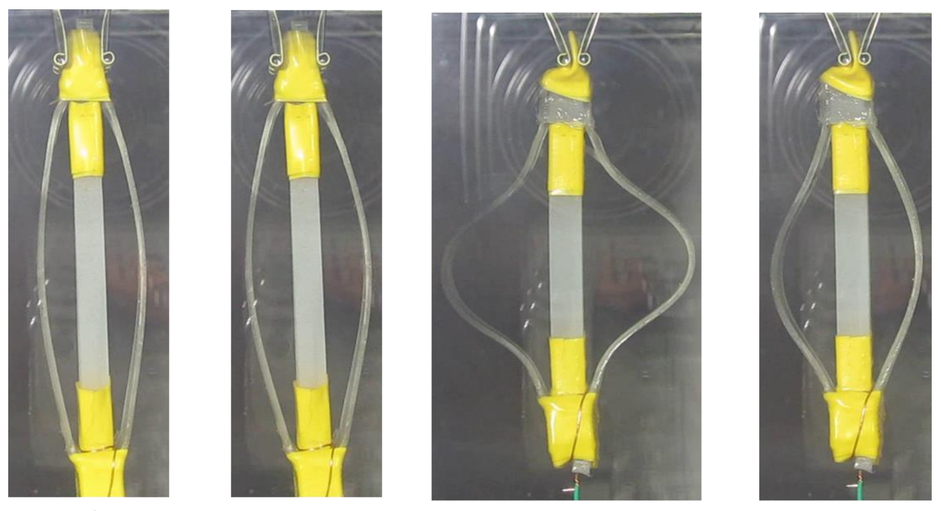

Fig 3. Shape recovery process demonstration of SMP/rubber composite actuator for case 2

Conclusions

The two-way SME was demonstrated during the shape recovery step for the case 1 and case 2. The work mechanism for two-way SME was a dynamic balance between the elastic recovery force of rubber material and the shape recovery force of SMP plates.

[1] Diani J, Gilormini P, Fredy C and Rousseau I. International Journal of Solid and Structures, 2012, 49: 793-799.

[2] HY Du, LW Liu, FH Zhang, JS Leng and YJ Liu. Composites Part B: 2019, 172: 106905.