Meso-scale robot assembly using
shape memory polymer rivet fastener

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Abstract— This paper describes a novel rivet fastener made with shape memory polymer (SMP). Shape recovery and modulus change are main two properties of SMPs that enable themselves to be promising base materials for fasteners. The new type of fastener was used to join two composite parts of a meso-scale robot. The fabrication procedure includes macro molding and subsequent laser machining in order to enhance manufacturability, and change size and design on demand. By pull-off experiment it was demonstrated that one single rivet can endure 8N of disengagement force. We applied this fastener to meso-scale flea robot and verified its feasibility.

I. INTRODUCTION

The recently developed manufacturing process to make meso-scale robots, so called SCM process, uses composite materials as rigid links and polymer sheets as compliant joints [1]. Because composite materials are generally thin and lightweight, it is difficult to use conventional metal-based assembly components for mechanical joining [2].

In order to develop lightweight, reliable and releasable assembly component for robots made by SCM process, shape memory polymer (SMP) was used as the base material of a new type of fastener. The most distinctive two properties of SMP [3] - shape recovery and modulus change - are suitable for a blind riveting, reliable engagement at low temperature and easy detachment at high temperature. Pull-off test was conducted to verify the reliability and reusability of this fastener.

II. SHAPE MEMORY POLYMER RIVET FASTENER

A. Design and Fabrication

Starting from the basic I-beam shape, a couple of modifications in its design were applied as shown in Fig. 1. For easy insertion, the flanges were changed into curved ones. In addition, a big notch in the middle of the flange and two small notches were placed under the flanges for stress distribution.

The rivet fastener of this design was fabricated by two steps. First, the raw SMP pellets are poured into a rectangular mold and pressed with heat to make SMP plate. Next, the SMP plate of 800μm thickness is laser machined as specific designs.

Fig 1. Assembly of legs with the body of meso-scale flea robot, using the anchor shape SMP rivet fasteners.
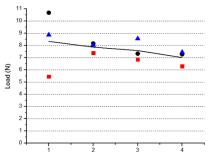

Fig 2. Measurement result of disengagement strength and reusability for an anchor shape rivet fastener

B. Applications

Fig. 1 shows that a total of 10 SMP rivet fasteners were applied to the meso-scale flea robot developed by Minkyun Noh *et al* [4]. By using these rivets instead of cyanoacrylate for attachment of legs, we could reduce the total weight of the robot and easily replace current legs to others repeatedly.

III. EXPERIMENTAL RESULTS AND DISCUSSION

The rivet used in the flea robot was tested for disengagement strength and for reusability. After testing three samples four times, the disengagement force is plotted in Fig. 2. The results show that one single rivet could endure 8N of disengagement force on average, and lost only 16% of its initial strength at the fourth trial.

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