Artificial Muscle Actuator Based on the Synthetic Elastomer

Nguyen Huu Chuc, Ja Choon Koo, Young Kwan Lee, Jae Do Nam and Hyouk Ryeol Choi*

Abstract: In this paper, we present an artificial muscle actuator producing rectilinear motion, called the Tube–Spring–Actuator (TSA). The TSA is supposed to be a prospective substitute in areas requiring macro forces such as robotics. It is simply configured from a synthetic elastomer tube with an inserted spring. The design of the TSA is described in detail and its analysis is conducted to investigate the characteristics of the actuator based on the derived model. In addition, the performance of the proposed actuator is tested via experiments.

Keywords: Artificial muscle actuator, EAP, synthetic elastomer.

1. INTRODUCTION

Recently, polymers have been emerging as substitutes for existing actuators such as electromagnetic motors, piezo actuators, etc. Up until now, there have been a wide variety of polymeric materials applicable to actuation as well as sensing. The most promising ones among them are the ElectroActive Polymer (EAP), Ionic Polymer Metal Composites (IPMC), conducting polymer, polymer gel, dielectric elastomer (DE) and piezo electric polymer [1]. In general, EAPs are classified into two groups, including ionic and non-ionic EAPs, depending on the physics of actuation. Presently, actuator technologies employing non-ionic EAPs such as the dielectric elastomer or piezo electric polymer have matured up to practical applications, though the other polymers also have a good potential of being implemented for practical use in the near future. Dielectric elastomers, which are one of the most feasible actuation materials because of their large deformation and force, are easily found at a moderate cost. There are numerous dielectric elastomers commercially available such as silicone, polyurethane, acrylic elastomer, etc. [2,3].

Actuators made from the dielectric elastomer have broad applications in robots, micro/milli devices, etc. So far, many configurations of actuators have been proposed such as the planar, tube, roll extender, diaphragm and bender actuator [4-10]. Among them the roll actuator was demonstrated to provide large strain as well as macro force [4,9]. Carpi et. al. presented a new contractile linear actuator called the helical dielectric elastomer for actuating a Martian jumping rover, the eyeballs of an android robotic face and the anthropomorphic skeleton of an upper limb [5]. Wingert et. al. proposed the design of a binary actuator with the dielectric elastomer [10].

Recently, we have developed a new material called synthetic elastomer whose properties, such as the mechanical properties, electrical properties as well as electromechanical properties, can be adjusted according to the requirements of the applications [11]. In this paper, we present an artificial muscle actuator based on the synthetic elastomer, which is able to provide rectilinear motion and is known as the tube-spring-actuator (TSA). The TSA is configured with a spring and a tube that is fabricated from the synthetic elastomer. The spring is inserted inside the cylindrical actuator after being compressed and it generates rectilinear motion according to the input voltage. A comprehensive description on the design, analysis, and fabrication are given, and the synthetic elastomer’s performances are experimentally evaluated in this paper.

The present article is organized as follows: the next section describes fundamentals on the proposed actuator. Also, the details on the TSA are outlined in Section 3 and the equations for calculating the relation between the displacement and applied voltage of the TSA are derived in Section 4. The simulation and experimental results are illustrated in Section 5.