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Omnidirectional State-Changing Gripper Mechanism for Various Objects

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This paper describes the morphing omnidirectional gripper which is able to grasp various objects with low melting point alloy, functional fluid, dilatancy fluid, and so on. The deformable part of the gripper changes its shape by covering all direction of objects and makes the contacting area higher. This time, we especially focus on the "Hot Ice" phenomena to realize higher grasping motion. The basic performance of fluid of CH3COONa has been observed.

***Key Words*:** Mechanism, Deformable, Hot-Ice Phenomenon, Omni-Gripper, Conformable

1. Introduction

1.1: Mechanism of the former morphing omnidirectional gripper

The former morphing omnidirectional gripper had a mechanical problem of poor response when the low melting point alloy, enclosed substance, changed its phase from liquid to solid. In this paper, we propose a method to improve gripping response making use of the phenomenon of supercooling.

As the enclosed substance, functional fluids like magneto rheological and electro rheological fluids, dilatant fluid, mixture of particulate and its solvent, and mixture/composite of all these substances, we speculate, may be possible candidates.

In our former prototype, we used a low melting point alloy which solidifies at room temperatures. Though that exhibits relatively high rigidity when it grasps objects compared to the candidates listed above, it has a problem of poor response caused by rather long time required to the phase change from liquid to solid which needs to occur after conforming to objects. Thus, in this report, we propose two alternatives for applications which impose higher importance on quick response than on high rigidity when gripping objects.

1.2: A proposal to improve response

One is a mixture of gas and particulate substance (glass beads) and another saturated water solution of sodium acetate CH3COONA which exhibits supercooling known as "Hot Ice" phenomenon.

When trihydrate of sodium acetate is cooled below 58 degree Celsius, the melting point, it solidifies suddenly in response to added nucleus or to stimulation done by metal fragment, for example. This is the Hot Ice phenomenon we refer to. The triggering for solidification may be replaced by electric stimulation, like application of voltage and we are examining this method. In addition to that, mixture of water solution of sodium acetate and other enclosed substances such as functional fluids described in Chap. 2 are being studied as well.

In this report, the two items regarding to the basic characteristics of our morphing omnidirectional gripper will be examined. One is the basic gripping performance when angle offsets are given to gripped objects and another how to use the supercooling of water solution of sodium acetate which is aimed at improvement of gripping response.

Just only the jamming phenomena have already proposed in the 1982[12]. In recently(in 2010), Cornell University, University of Chicago, and iRobot reported the jamming gripper, but the configuration is almost the same of that work by G. Bancon et al. It can grasp various kinds of object, but it needs the pushing force to deform. It means, the grasped object should take the same force from the gripper. Our proposed configuration (in 2008) can grasp soft objects effectively without any large damages, and configuration of the gripper itself is totally different from the previous any researches. And we already proposed the mixtures of the plural numbers of the particles and air or liquid as the contents of the grippers sack in that paper.

2. Morphing omnidirectional gripper

Quick response does not seem, in our experience, to be compatible with high rigidity at solid- or almost solid state.

Here, we examine the adaptability of the morphing gripper with bag-shaped structure continuously extending from inner- to external parts to longitudinal and angular offsets. High degree of tolerance to offsets may be favorable when objects to be grasped are vibrating, objects set on moving bed are vibrating and gripper itself is vibrating. In addition to the present gripper with bag-shaped structure continuously extending from inner- to external parts, we are developing a double-layered structure that may be folded.

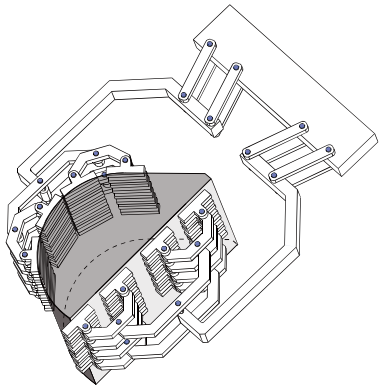

Fig. 1: Example of Previous Mechanical Gripper

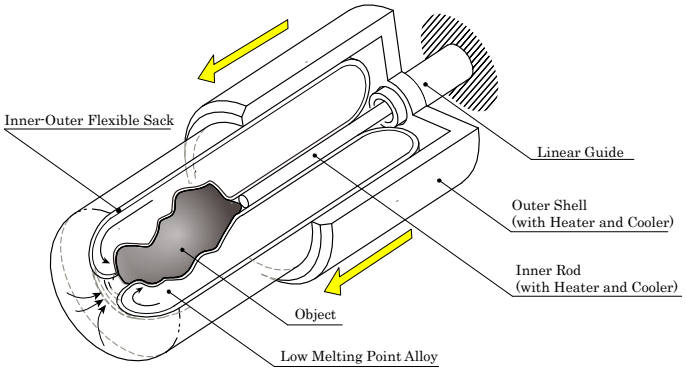

Fig. 2: Basic Concept of the Morphing Omni-Gripper

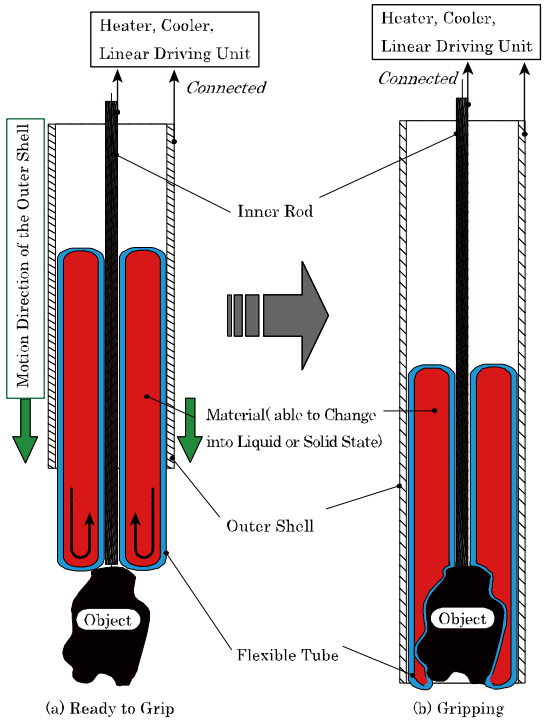

Fig. 3: Grasping Motion of the Morphing Omni-Gripper

Figure 2 depicts the basic sequence of conforming gripping. By direct displacement of only outer shell (an element of gripper) toward the grasped object, gripper may catch it eliminating the displacement of the object. It may be possible, conversely, to grasp object drawing it toward gripper.

3. Gripping characteristics when offset exists

We have measured the gripping characteristic for tilted objects. Kamakura et al. [2] coated paint on objects and observed the location of paint attached in the hand of person who grasped it. While in our experiment, we coated paint on gripper taking consideration on large contact area of grasped object.

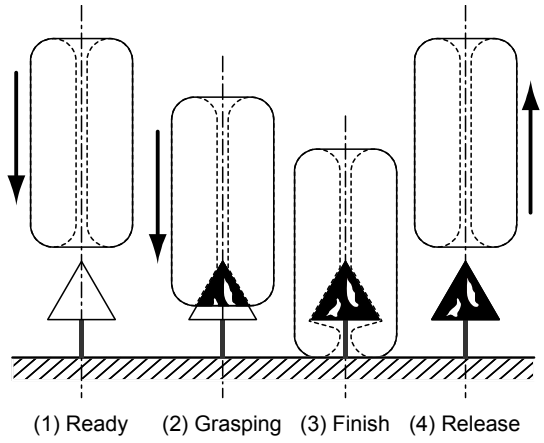

Fig. 4 Gripping Experiments

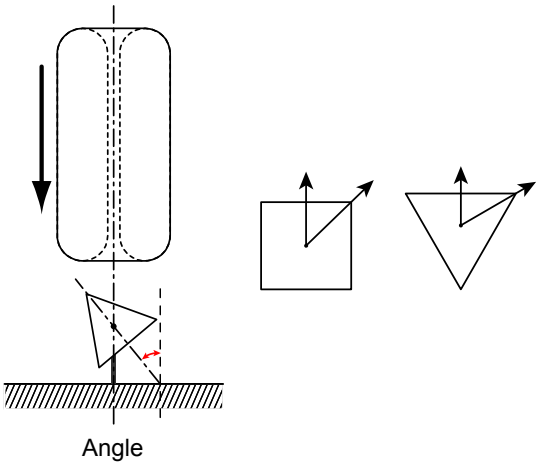

Fig. 5 Gripping Experiments with Offest

Results obtained by analyzing the amount of paint are shown in Frs. from 4 through 8. These figures demonstrate high conforming of the gripper we proposed.

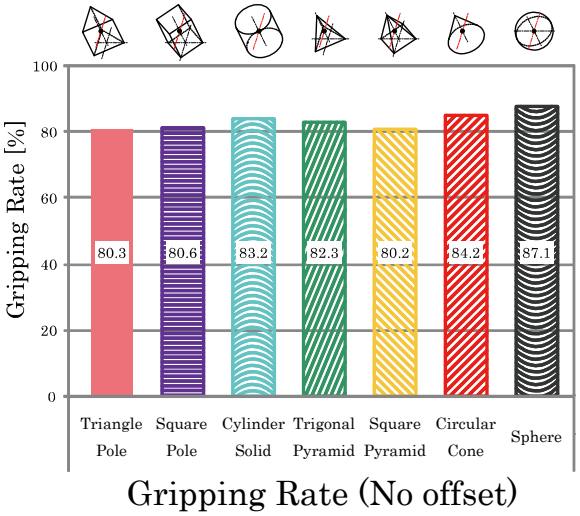

Fig. 6 Experimental Result without offset

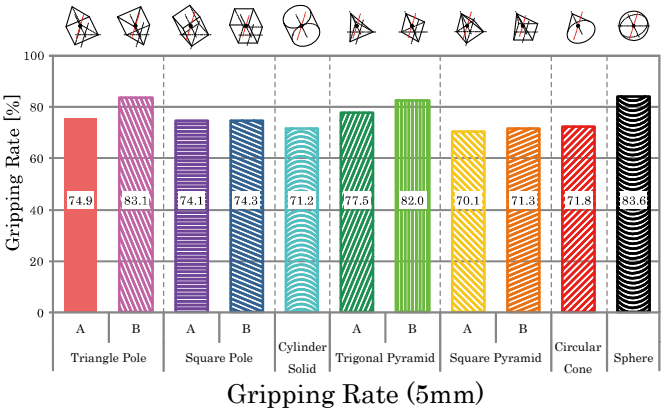

Fig. 7 Experimental Result with offset

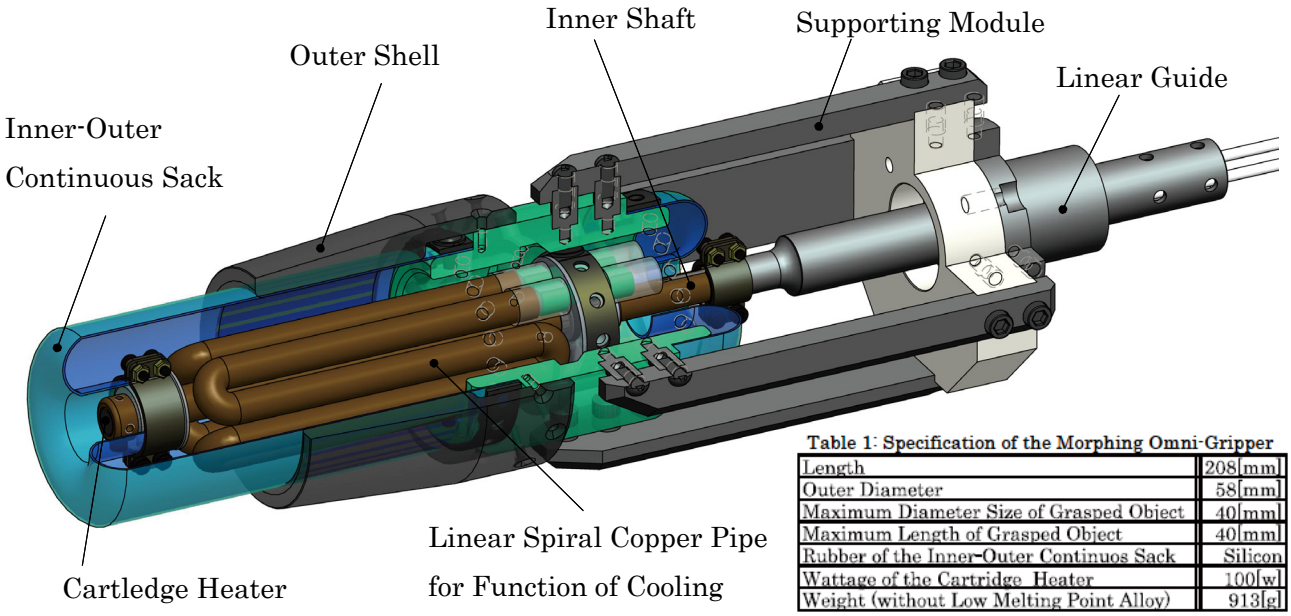

Table 1: Specification of the Morphing Omni-Gripper

Length	208[mm]
Outer Diameter	58[mm]
Maximum Diameter Size of Grasped Object	40[mm]
Maximum Length of Grasped Object	40[mm]
Rubber of the Inner-Outer Continuos Sack	Silicon
Wattage of the Cartridge Heater	100[w]
Weight (without Low Melting Point Alloy)	913[g]

Fig. 8 Prototype Mechanical Design of the Omni-Gripper

Fig. 9 Overview of the Omni-Gripper

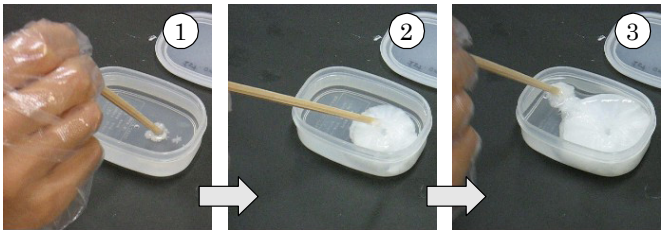

Fig. 10 Phenomenon of "Hot-Ice"

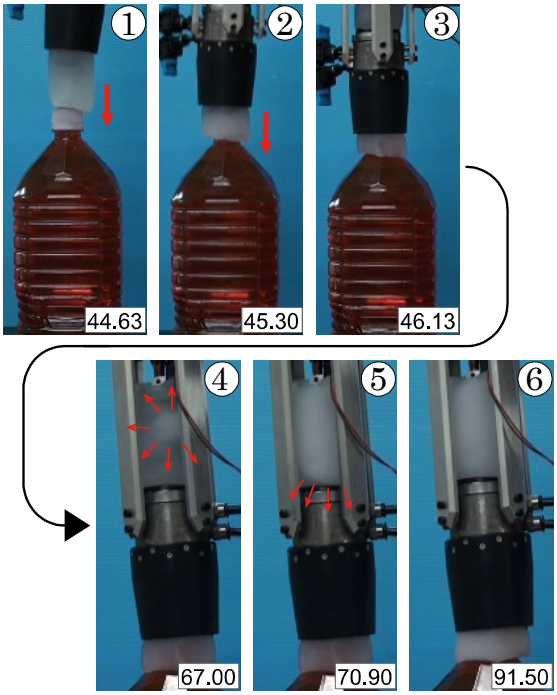

Fig. 11 Grasping Motion of the Omni-Gripper

4. Taking advantage of Hot-Ice phenomenon

Here, we discuss how to improve the response performance of solution (exhibits supercooling described above) as the enclosed substance in gripper with bag-shaped structure continuously extending from inner- to external parts. Triggering to solidification may be done by:

1) mechanical stimulation
2) introduction of nucleus
3) electric stimulation

In our experiment this time, we took the third of electric stimulation in view of simple implementation. The result of our preliminary experiment is shown in Fig. 9. Solution of 200ml volume solidified in some four seconds. This speed depends on the method of introducing electric stimulation. We are examining response performance and rigidity of solidified substance varying concentration of sodium acetate. Thus, we are working to improve the performance of enclosed substance in gripper which is conforming to grasped object and grips it firmly at the same time.

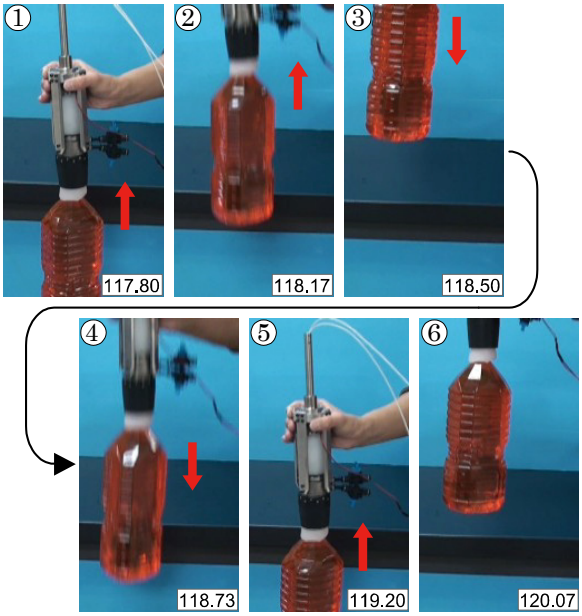

Fig. 12 Grasping Power of the Gripping in Solid State

5. Summary

We have carried out an experiment on angular offset of grasped objects to examine the basic performance of our morphing omnidirectional gripper. It proved the good conforming performance of the gripper. And some description was made on application of supercooled sodium acetate to improve the grasping performance of the gripper.

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