DEVELOPMENT OF ULTRA-LIGHT ULTRA-FLAT ROBOT APPLYING MONOLITHIC SPIRAL JOINT MECHANISM

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INTRODUCTION

We propose a new method to make the robot thin and light; we try to process the joint and the link together in one thin board as a robot, and we use the elastic deformation of spring

MONOLITHIC TWO SPIRAL SPRING JOINT

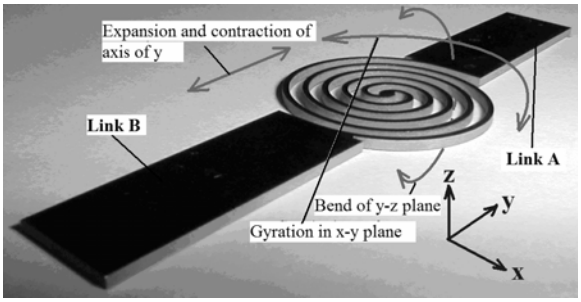

FIGURE 1. Monolithic two spiral spring joint

In Fig.1 we present new type monolithic joint consisting of two spiral springs, and one end of each springs is combined together in the center of each joints. The other end of each springs is connected with the link A and the link B. Main behavior of this joint is an elastic circular movement: the gyration in x-y plane by the link A's bending in the x-y plane, however additional behaviors, that is small amount of expansion on construction in the y direction, and big bending in the y-z direction will happen. We will try to solve this problem later using Fig.4 or Fig.5. We try to analysis the monolithic spiral joint's stress and strain when driving forces are added.

In Fig.2, both stress and strain diagram are shown, when the link A over the joint is fixed and the link B under the joint is rotated elastically by the driving force. We can understand that the stress around the joint center is almost zero and the more the spring's outside is far from the joint center, the more the stress is strong. We apply the MSC/NASTRAN for the joint stress and strain analysis.

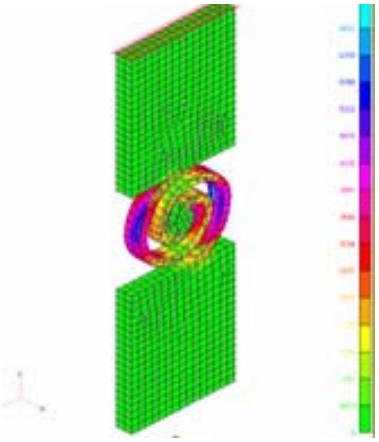

FIGURE 2. The joint stress and strain analysis by MSC/NASTSTRAN

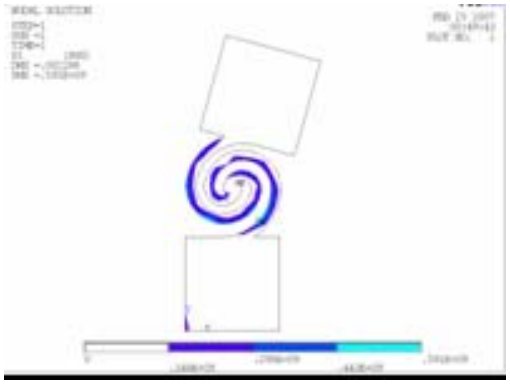

FIGURE 3. The joint expansion and constriction analysis by MSC/ANSYS

In Fig.3 we show both the monolithic spiral joint consisting of two spirals and its stresses arisen by the driving force by ANSYS. It proves that the dynamic ranges of this two spiral joint is much bigger than just one spiral form and any stresses occurred in the monolithic spiral joints is much more homogeneous; not so much sharp changed.

APPLICATIONS USING THIS MONOLITHIC TWO SPIRALS JOINT

Fig.4 shows a human robot with three monolithic joint together. The first one of this joint is used as a hip joint, the second one is done as a knee joint and the third one is done as an ankle joint. The three joints are sandwiched by two metal sheets for preventing bending in the y-z planes. This robot mechanical part's materials are made by Copper-phosphate alloys, manufactured using the wire cutting dischange machine. This robot's weight is 150g, height: 216mm, and its thickness: 3mm.

FIGURE 4. Human two leg's robot

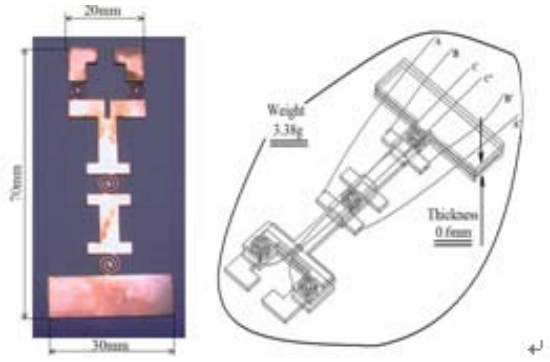

FIGURE 5. Manipulator robot

Fig.5 shows a manipulator that functions is griping something in the plane. This has 4 monolithic spiral joints, 5 links and 6 wires for making each links' move. Its weight is 3.38g; its thickness is 0.6mm.

In Fig.6 spaces between two fingers is first going to be closed, to be opened and finally opened again for catching up something, when 2 wires are driven by 6 servomotors which are controlled

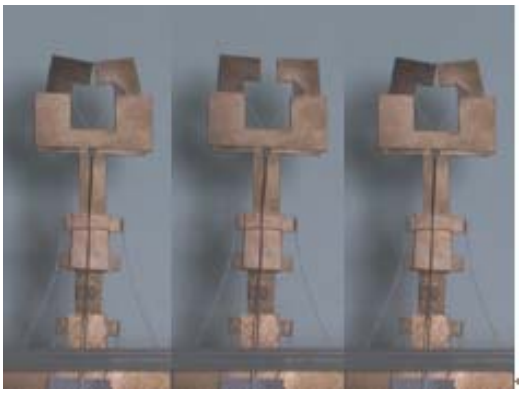

FIGURE 6. Behavior of gripping manipulator

FIGURE 7. Behavior of arm manipulator

by microcomputers. In Fig.7 two monolithic spirals joint which are located under the fingers inclines by upper mentioned servomotors clockwise or unticlockwise, when 4 wires are driving 2 those joints again.

In Fig.8 we present a small car which consists of 1 monolithic spiral joint and 2 BMX which will be able to extend on constrict applying a voltage. The length of this car is 60mm, width is 30mm, and body part thickness is just 0.6mm

This is also made of copper-phosphate and manufactured by the wire discharge.

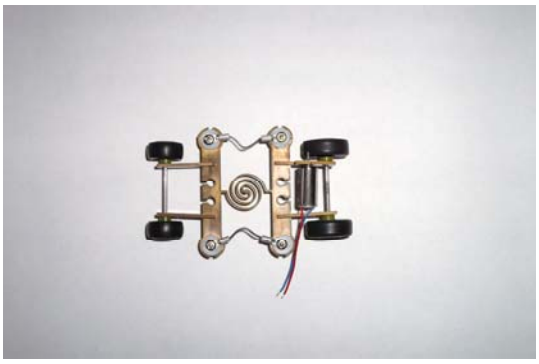

FIGURE 8. A small car applying 1 monolithic spiral joint driving by BMX

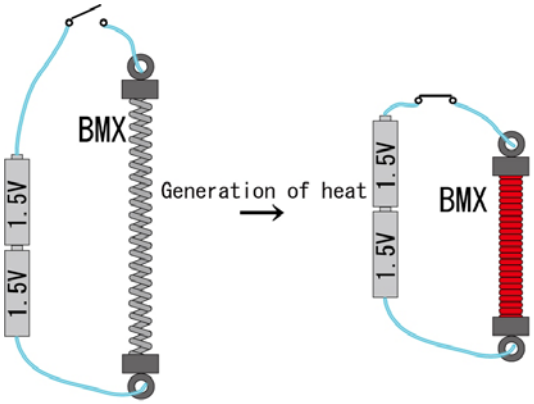

FIGURE 9. BioMetal Helix (BMX)

The exact function of BMX is shown in Fig.9.

BMX's is a spiral spring form and made from the shape memory alloy, which is possible to be constricted as small as 200% compared with normal no implied voltages condition. Two BMX makes this car drive in the left hand direction or sometimes in the right hand direction.

We manufactured the new type manipulator; we call this snake robot which has 4 monolithic spiral joints, as many as 9 BMX, and two fingers as shown in Fig.10

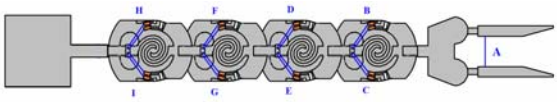

FIGURE 10. Thin and light snake robot

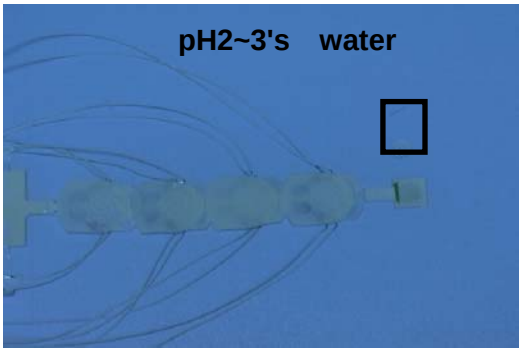

FIGURE 11. Thin and light snake robot trajectory on the desk

Fig.11 shows this robot is going to inspect whether a water drop on the desk is acid or alkali. Two fingers in this robot grips a litmus paper and carry this paper as far as the place the water drop is located. We can judge now that the water drop is acid drop because the paper is changed into pink color which means PH values are 2 or 3.

This experiment shows that this snake robot can pass through even the very narrow clearances between the floor and locked door's bottom frames and this also will be able to inspect the PH values of some liquids outside of the door which are something very dangerous.

Fig. 12 shows an insect which has 4 legs with 4 monolithic spiral springs, a human model, a water strider which floats on water and will jump up on the water surface.

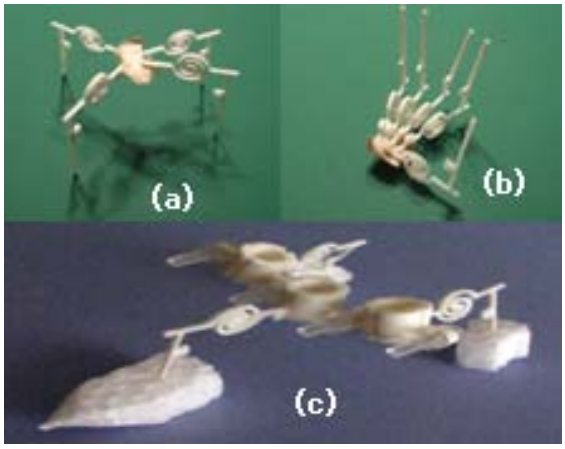

FIGURE 12. (a),(b),(c) 3 kinds of trial

CONSTRUCTION

1. We propose very thin very light monolithic spiral joint which rotates elastically around the center point combined with two spiral springs. We analysis this joint behavior using FEM, then it proves that these are almost no stresses around the spiral spring combined center point, which means this joint center is almost steady and does not rotate.

2. The monolithic spiral joints are applied for hip, knee and ankle's mechanical parts for gyration. We also manufacture very thin manipulator, a small car, PH value inspecting snake robot which passes through very narrow spaces like a locked door and floor clearance, is developed.

3. 4 leg's insect, a human hand and a floating insect are also very light since they are manufactured using a two component polyurethane resin.

REFERENCES

[1] FEM software, 2005 Riko-Gaku-sha Co.ltd.