

Gripper Actuator Using Shape Memory Alloy Spring

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Abstract- This paper describes a new technique of gripper actuator using shape memory alloy spring has been fabricated .By applying electric power to the shape memory alloy spring i.e by being safely heating it has an ability to retain their original shape from fabricated shape i.e in austenite phase. When the power supply is off, Steel spring which compress the shape memory alloy spring to its fabricated shape. Thus Experimental results shows the rack and pinion to extract and retract in control motion would actuate the gripper to pick and place an object.

Index Terms- shape memory alloy spring, steel spring, gripper, rack and pinion.

I. INTRODUCTION

Most standard and available Shape memory alloy (SMA) is Ni-Ti. composition of nickel and titanium materials.SMA are in one way and two actuations. One way actuator which is used in our experiment can contract when heating(austenite phase). Two way actuator can be stretched easily when cooling (martensite phase), but contract forcibly when heating.

NOTE:

1. Based on linear-elastic deformation parallel to length of the wire
2. Activation current and Contraction time can be adjusted considerably based on environmental considerations.

The table below shows typical performance characteristics based on set parameters.

PERFORMANCE CHARACTERISTIC				
Wire diameter (inches)	Resistance (ohm/inches)	Maximum Pull force (g)	Applied current at room temperture (mA)	Contraction time (seconds)
0.015	0.2	2000	2750	1
0.020	0.16	3500	4000	1

SMA advantages include mechanical simplicity, high power to weight ratio , small size, and clean, silent, spark-free operation. And some serious disadvantages are inefficiency , hysteresis and slow speed.

Among the various types of gripper, here it involves intense use of rack and pinion gears, because it is a type of linear actuator.

Mild steel spring has low carbon content It yields high strength and compress certain weight depends on its thickness and have the capability to compress. But the superelasticity and shape memory behaviour are not normally exhibited by steels.

II. EXPERIMENTAL SET UP



[Modeled in unigraphics (NX9)]

This model shows the proposed view of gripper actuator using shape memory alloy spring. shape memory alloy used in this experiment most useful one for the mechanical simplicity and weight reduction and free spark operation. The table shown below are needed components with specified materials for the proposed model.

COMPONENT	MATERIAL
Gripper	Polypropylene(white)
Connecting rod	Aluminium
Pinion	Aluminium
Spring	Mild steel
Rubber	Hard black
Wire	Shape memory alloy

Materials which used as per the above table is because of weight reduction in this experiment. Therefore the maximum pull force of shape alloy directly applicable(pick and place) on an object.

III. CALCULATION

This experiment has a calculation for spring, rack and pinion.

Shape memory alloy spring free length and compression length are calculated as shown in figure with respected formulae.

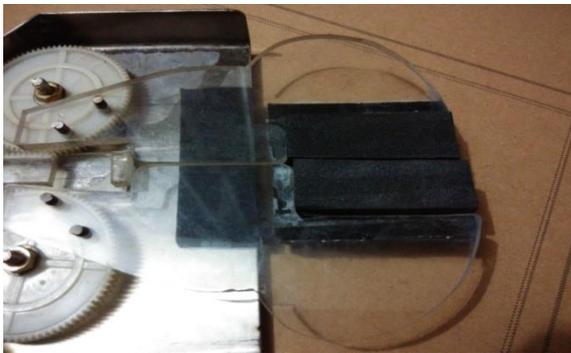
DIMENSIONAL PARAMETERS		
Parameter	Symbol	Value
Wire diameter	d	0.5mm
Free length	L_f	60mm
SPRING MATERIAL & STRESS RELATED PARAMETERS		
Parameter	Symbol	Value
Elastic modulus	E	83Gpa
Poisson's ratio	i	0.3

Also the compression of steel spring has calculated as shown in figure.

PARAMETERS	FORMULA	RESULT
pitch	$P = 3.1416/p$	6.28mm
Outer diameter	$OD = (z+2)*m$	38mm
Module	$m = p / \pi = Dp / z$	2
Number of teeth	$Z = dp/m$	17
clearance	D/d	0.33mm
addendum	$a = 1/DP$	2mm
dedendum	$d = hw - a$	2.33mm
pitch diameter	$Dp = z*m$	34mm

IV. FABRICATION OF GRIPPER

Acrylic sheet of 5×150mm is purchased and the length of 90mm is been cut with required dimensions using hack saw machining tool. Hence parts has been cut and fixed to the pinion where this is used to make the gripping section of the actuator.



Fabricated Gripper

A elastic material used at the gripping portion of the actuator where it is cut according to required dimensions and it is attached with a glue called anabond. Anabond is a glue that mostly used to fixing ceramic materials, metals etc.

V. FABRICATION OF SPRING

To achieve optimized properties, materials with 30-40% retained cold work before heat treatment should be used. Superelastic Nitinol materials are typically heat treated in the vicinity of 500°C. Lower temperatures in the range between 350°C and 450°C are also suitable for shape memory alloys.



Fabricated Spring

The purchased shape memory alloy wire(nitinol) is then fabricated to spring by using a winding tool and then heated to 500°C in a furnace then suddenly cooling it with water hence the fabricated shape becomes the original shape .By changing its shape without heating and heating the nitinol or passing the electricity at 6 to 12V the alloy changes to its original shape.

VI. CONCLUSION

A mechanical gripper has been designed and fabricated. By use of shape memory alloy spring, the mechanical gripper is able to pick an object of small size of 98mm diameter and weight less than 200g. The shape memory alloy spring is a simple design which reduces the size, cost and use of electronic equipments. This mechanical gripper can be automatically activated by supply of heat and also it can be used in high temperature environments such as robotic application, chemical industries, laboratories, nuclear power plant etc.

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