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CONTROL OF FRICTION TO ADAPT GRIP FORCE BY ELECTROSTATIC CHARGE

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ABSTRACT

The present work proposes gripper design to guarantee secure grasp of the object. For the It is aimed to control the sliding of the object on the surface of the gripper and prevent the excessive increase of the gripping force. The feedback of the proposed system depends on the triboelectrification and generates positive and negative ESC at the two contact surfaces. Separation of the two contact surfaces represents the condition of slip or sliding of the object, then one of the surfaces will gain positive ESC and voltage difference will be induced. ESC generated on one of the surfaces works as feedback signals to increase the gripping force by increasing the input voltage of the copper coil, where the magnitude of the electric field increases and consequently the adhesion force between the gripper and object increases so that the object can be grasped tightly.

KEYWORDS

Control, friction, grip force, electrostatic charge.

INTRODUCTION

There is an increasing demand to securely grip objects. Human can grasp the objects with the hand that are controlled by the brain. The proper grip force is controlled by the tactile feedback from the fingers, [1], to securely handle objects, [2, 3]. In gripper, the grip force control system significantly control object manipulation, adjusting grip force to guarantee secure grip, [4]. In absence of the grip force control system, the risk of dropping or crushing the object is raising. In harvesting fruits, [5 - 8], controlled grip force is needed to handle objects. Applying excessive grip force, [9-12], can damage those objects. The grip force was controlled by force controller depends on the load force feedback, [13 - 20], where load cell was used to measure the grip and the tangential force applied on the two fingers of robotic gripper considering static friction, [21 - 26]. To achieve precise grip force control system, static coefficient of friction, grip force and weight of the object should be considered. The objective function of the control system was formulated, [18], as a combination of the gripping force for the gripper stroke and the ratio between the actuating force and the output minimum gripping force.

In the present work, a gripper design for a specific function is proposed. The objective function of the design is to guarantee secure grasp of the object. Besides, the increase of system reliability, reducing gripper cost and the capability of a gripper for grasping objects of different dimensions are aimed.

PROPOSED DESIGN OF THE GRIPPER

The proposed gripper is shown in Fig. 1, where the schematic drawings of the working mechanism is illustrated. ESC distribution on the surfaces of the gripper and object is demonstrated in the contact and separation, Figs. 2 and 3. The proposed gripper is derived by linear motor that consists of DC motor and power screw and moves the two jaws to grasp the object. The surface of the gripper is fitted by silicon rubber that has the desired softness as well as the generation of relatively high ESC when slides or being in contact and separation with different types of objects, Fig. 4. The rotation of the DC motor causes the linear motion of the two nuts leading to the contact and separation of the two jaws and the object.

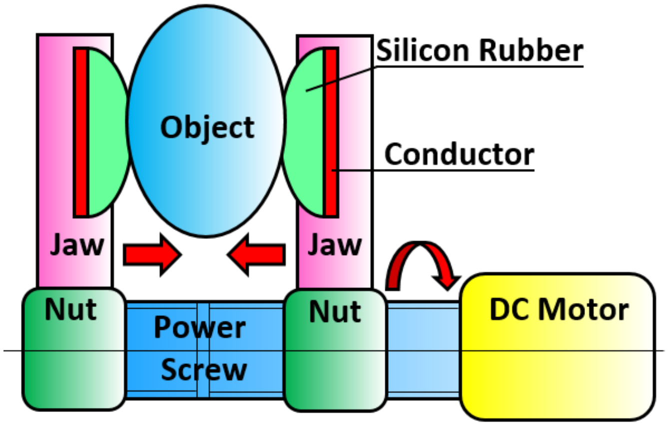

Fig. 1 The proposed gripper.

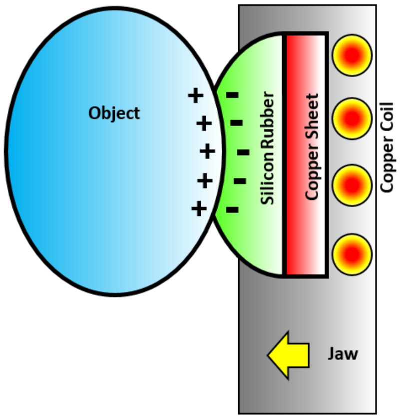

Fig. 2 Distribution of ESC on the surfaces of gripper and object during contact.

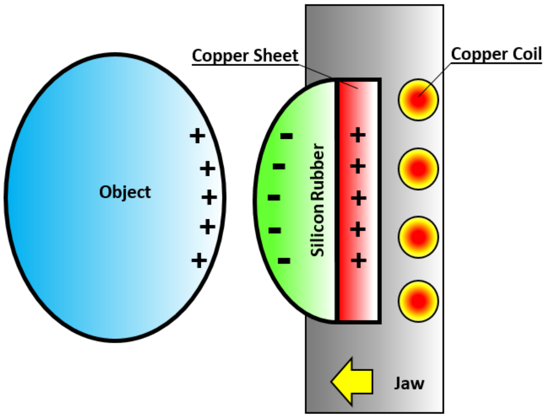

Fig. 3 Distribution of ESC on the surfaces of gripper and object after separation.


Air + ESC
Human hands
Water
Window glass
Rabbit fur
Poly methyl methacrylate
Human hair
Polyamide
Wool
Aluminum
Paper
Cellulose acetate
Cotton
Polyurethane elastomer
Wood
Styrene-butadiene
Polystyrene
Hard rubber
Polyethylene glycol terephthalate
Epoxide resin
Polyester
Natural rubber
Poly acrylonitrile
Polyvinyl chloride
Polystyrene
Polyethylene
Polypropylene
Silicon Rubber
Polytetrafluoroethylene - ESC

Fig. 4 Triboelectric series of the proposed materials, [27].

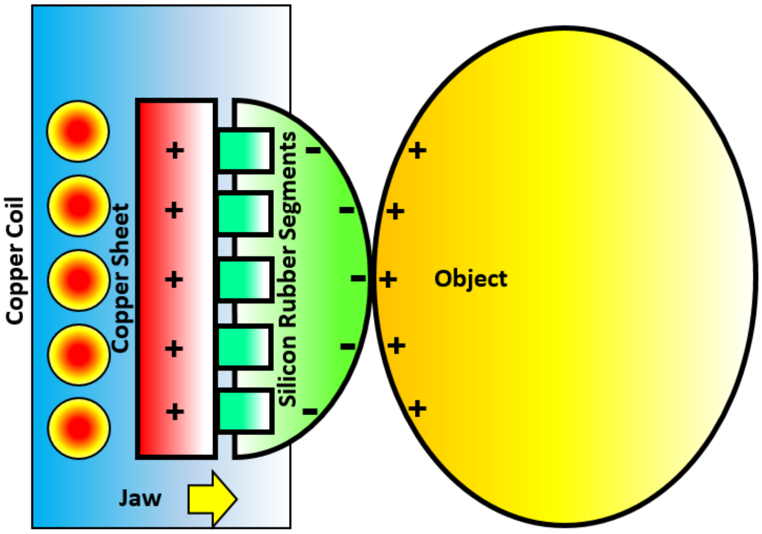

Fig. 5 Distribution of ESC on the surfaces of the left jaw of the gripper and object after separation.

For the proposed gripper, it is aimed to control the sliding of the object on the surface of the gripper and prevent the excessive increase of the gripping force. The right jaw. Figs. 2 and 3 is responsible to control the slip and sliding of the object from the gripper. The feedback action of the system depends on the triboelectric effect, where during contact there no ESC generated on the copper sheet, Fig. 2. It is expected that the contact electrification will be produced at the contact surfaces and generates positive and negative ESC. After separation of the two contact surfaces, that represents the condition of slip or sliding of the object, the copper sheet will gain positive ESC and voltage difference will be induced between the copper sheet and the ground that generate a current. ESC generated on the copper sheet works as feedback signals to increase the gripping force by increasing the input voltage of the copper coil, where the magnitude of the electric field increases and consequently the adhesion force between the jaw and object increases so that the object can be grasped grasp tightly, Fig. 3.

As discussed above, it is revealed that triboelectrification is the base of the feedback signals when the object slides and separates from the gripper. The feed back signal may increase the input voltage of the driving motor in a step of increasing the gripping force. The function of the left jaw, Fig. 5, is to control the gripping force. The jaw is fitted by segments of silicon rubber to allow their deformation due to the increase of the gripping force. It is expected that as the deformation of the segments increases, their surfaces in contact with copper sheet slide generating ESC that will be considered as the source of the induced voltage to be fed back to the comparator to decrease the input voltage to the DC motor.

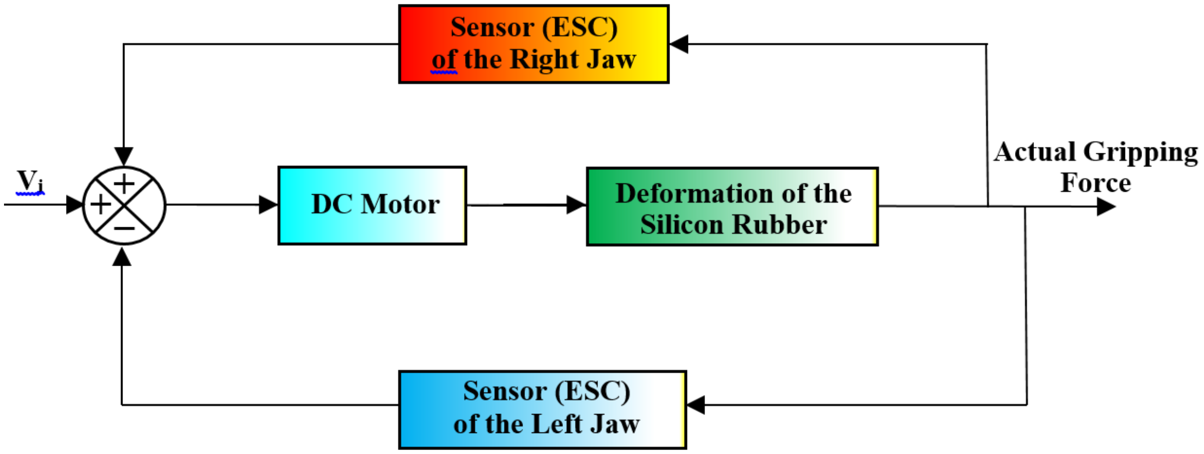

Fig. 6 Block diagram of the grip force control.

Closed-loop control system was suggested by using gripping force signals as feedback to form a closed loop to achieve reliable grasping, Fig. 6, where the block diagram of the force control system contains reference input of the voltage. The contact force feedback of the gripper should enable the system to perform fast contact detection and protect the gripper from breakdown. The slippage of the object on the jaw surface can be detected by the variation of the contact forces applied at the surface of gripping jaw that influences the magnitude of ESC generated on the sliding surfaces.

The gripping force feedback of the gripper offers secured grasping with no excessive forces. The feedback voltage induced by ESC will be integrated in the input voltage of the driving motor to control the reference input and consequently influences the force of gripping.

CONCLUSIONS

Proposed design of control system to guarantee secure grasp of the object is introduced. The base of the feedback signals depends on triboelectrification, where the feed back signal generated from the ESC may increase the input voltage of the driving motor to increase the gripping force. The gripper surface is fitted by segments of silicon rubber of high deformation to control the gripping force. Besides, silicon rubber is an active electrostatic charged material. Therefore, as the deformation of the segments increases, their surfaces in contact with copper sheet slide generating ESC that will be used as the source of the induced voltage to be fed back to the comparator to decrease the input voltage to the DC motor.

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