DESIGN AND FABRICATION OF ROBOTIC GRIPPER FINGERS TO PICK PRISMATIC OBJECTS

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ABSTRACT

Robot Grippers are a type of end of arm tooling (EOAT) used to move parts from one location to another. They can be driven hydraulically, electrically and pneumatically. The weight of the part that the gripper experiences, both from gravity and from acceleration, is a critical factor in determining the required gripping force. This paper deals with design and fabrication of fingers of a robotic gripper which is operated pneumatically. Furthermore, the emphasis is given on grasping and picking the objects having prismatic shape. The procedure is explained by grasping a rectangular prism. Robots are being used in many applications due to the benefits they bring such as, improved production and precision. Productivity, efficiency, quality and safety have proliferated robotic technologies into almost every industry.

Keywords: *Robotics, Pneumatic gripper, Gripper finger design, Anthropomorphic finger.*

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ROBOT GRIPPER

Motion devices mimic the movements of people, in the case of the gripper, it is the fingers. A gripper is a device that holds an object so it can be manipulated. It has the ability to hold and release an object while some action is being performed. The fingers are not part of the gripper, they are specialized custom tooling used to grip the object and are referred to as *jaws*. Flexible grippers come in four categories, in order of adoption: pneumatic, vacuum, hydraulic and electric - each with its own advantages and disadvantages that make these grippers applicable to specific applications.

PNEUMATIC GRIPPER

The most widely used gripper is the pneumatically [2] powered gripper; it is basically a cylinder that operates on compressed air. Typical uses are to change orientation or to move an object as in a pick-n-place operation. Several mechanical grippers and articulated hands have been made over the past years, the description of which falls mainly in two categories i.e., *industrial* and *anthropomorphic designs* [1]. The design of *industrial manipulators* is governed by a specific manufacturing task to be executed. *Anthropomorphic manipulators* are characterized by their similarity to a human hand [5], both in appearance and potential functionality.

GRIPPER FINGER DESIGN

A good design of fingers requires taking into account those problems, whose understanding and considerations are used with a designing aim [3]. In this work, focus is on the dimensional synthesis of the mechanism of the gripper fingers. In particular, some peculiarities of the gripping mechanism have been considered with the aim to deduce a useful analytical formulation. Then, the synthesis problem has been approached and formulated by using the basic characteristics of gripping mechanism. To show the soundness of the proposed synthesis, computational results are shown using design calculations.

The force that a robotic gripper applies to a part is typically used by engineers to select grippers. While gripper force is a first order consideration, the torque that is experienced by the gripper is equally as critical and unfortunately, usually only addressed in a cursory manner. The gripper fingers/jaws are designed so that only a friction grip is provided and “squeeze” is the only thing holding in the part. Friction grip jaws rely totally on the force of the gripper to hold the part, the “squeeze” of the gripper does all of the work.

The mechanical parts of a two-finger gripper can be considered as composed by Figure 1:

- *Fingers and finger tips* (having length L), which are the elements in contact with a grasped object, so that they perform the mechanics of grasp [4] on the object itself.

- *Gripping mechanism*, which is the transmission component between the actuator and the fingers.
- *Actuator*, which is the power source for the grasping action of a gripper.

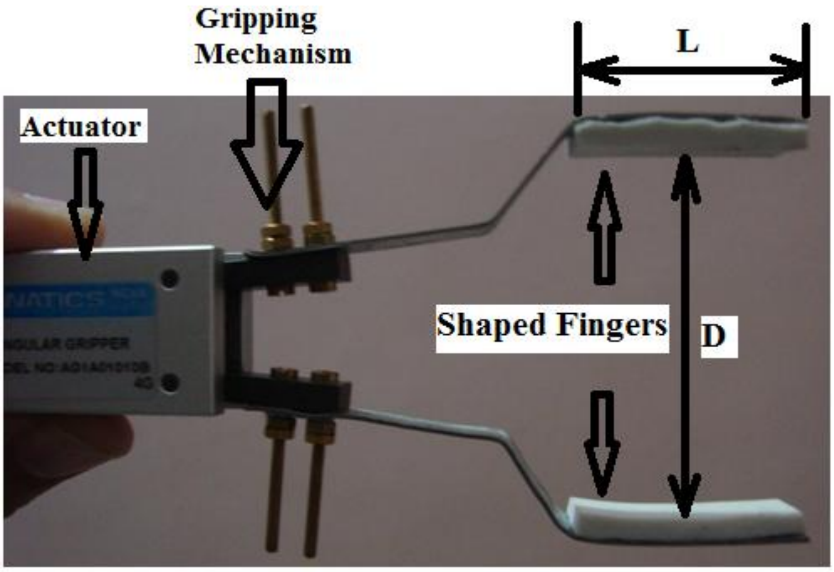

Figure 1: Mechanical components and design parameters of gripper with fingers

Referring to figure 2, a configuration of two-finger grasp can be characterized by possible elementary motions of a grasped object (rectangular prism) among the fingers as: *Slipping* down along a direction which is orthogonal to a plane of the gripping forces exerted by the fingers as couplers of mechanisms. *Squeezing* which may occur in sliding outward or inward to the gripper itself due to an effect of force components pushing the object (in this case an increase or a decrease of the gripping force by fingers may produce a squeezing motion or a release of the object). *Rolling* about the squeezing line and winding about the slipping line consisting in a motion of revolution of the object among the fingers due to an external torque or a force couple of F_1 and F_2. *Whirling* about the contact line which can be also due to a torque by the object's weight when its mass center does not lie on the contact line.

In addition, all the above mentioned elementary motions of the object may be avoided when suitable grasping force F_1 and F_2 are exerted by the fingers, so that friction forces (μ_1 F_1 and μ_2 F_2) may arise to completely balance the external action on the object.

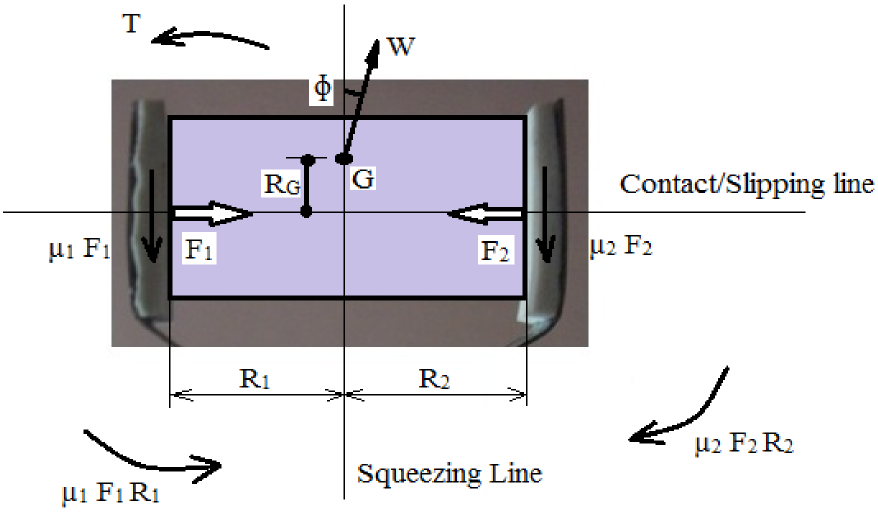

Figure 2: Mechanism holding a rectangular prism

In figure 2, a planar grasp by two fingers has been modeled by using the above-mentioned considerations.

- **W** is the weight of the object and it is oriented with an angle ϕ with respect to the squeezing line.
- **T** is an external torque acting on the object and it includes the inertial actions due to the manipulator movement, as well as **W** may include the inertial and external forces, so that the model of figure 2 can describe all the situations, which may occur to an object grasped by a two-finger gripper.

The basics of the static equilibrium of the grasped object can be expressed by using the model of figure 2 along the directions of the contact and the squeezing lines:

- In terms of *forces* as:

$$F_1 - F_2 + W \sin\phi = 0 \quad \text{and} \quad -\mu_1 F_1 - \mu_2 F_2 + W \cos\phi = 0 \qquad (1)$$

- In terms of *torque* as:

$$T - R_G W \sin\phi + \mu_1 F_1 R_1 - \mu_2 F_2 R_2 = 0 \qquad (2)$$

Indeed, the directions of the friction forces and consequently their signs in the Eqs. (1) and (2) will be determined to be contrary. $\mathbf{F_1}$, $\mathbf{F_2}$ and **T** can be determined by assuming other parameters.

Design calculations

The calculations are performed, for better understanding of the design procedure. So, let us assume: W = 250 gm = 2.452 N and ϕ = 20º

The coefficient of friction (μ) between rubber and solids in static and dry conditions vary between 1.0 and 4.0. However, because of the symmetry of a two-finger gripper in this design procedure; let us assume, $\mu_1 = \mu_2 = 2.0$.

So, to determine the forces required to grasp the object shall be obtained by substituting these assumptions in the set of equation (1), we get:

$F_1 – F_2 + (2.452 \text{ x } \sin20^o) = 0$ and $(–2 \text{ x } F_1) – (2 \text{ x } F_2) + (2.452 \text{ x } \cos20^o) = 0$

Solving the above equations, the values of F_1 and F_2 comes out to be:

- ***F_1 = 0.157 N (approx.)***
- ***F_2 = 1 N (approx.)***

Moreover, the torque required can be determined by substituting the assumption (W = 2.452 N and R_G = 8 mm), $R_1 = R_2$ = 25 mm, forces calculated above in N and keeping other parameters same, in equation (2), we get:

$T – (8 \text{ x } 2.452 \text{ x } \sin20^o) + (2 \text{ x } 0.157 \text{ x } 25) – (2 \text{ x } 1 \text{ x } 25) = 0$

Solving the above equation, the value of T comes out to be:

- ***T = 45.45 N-mm***

FABRICATION OF GRIPPER FINGERS

Material used to fabricate gripper fingers:

- Aluminium sheet having: Thickness = 0.8 mm (approx.), Width = 10 mm, Length = 82 mm
- Finger tips are accompanied by friction pads using rubber to hold/grip the object.

After fabrication of fingers, they are attached to the angular gripper with the help of nut and bolt arrangement as shown in figure 3.

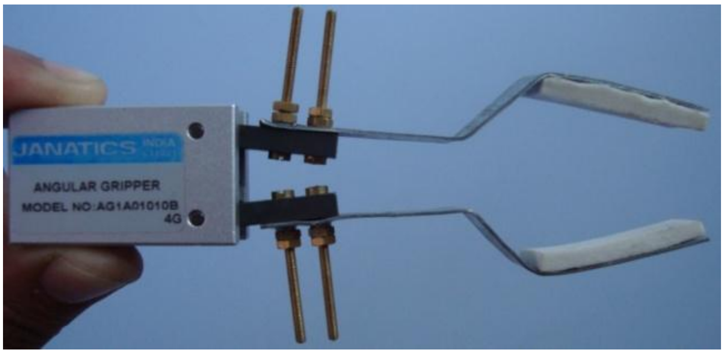

Figure 3: Gripper with fingers

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