Adaptive Gripper Controlled with Linear Micro Actuator for Correct Fastening of Objects of Variant Forms

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***Abstract*— This study about adaptive gripper controlled with micro servo linear allows a correct fastening of objects of several forms and sizes, this facilitates at the time of picking up pieces, because the hooks are deformed according to the form of pieces that were picked. The gripper has developed for multiple applications of fastening of variable objects, driven by a linear micro actuator that provides a continuous micro-movement that allows controlling the grip, three hooks synthesize prototypes that includes force sensors not to cause damage in the selected object, due to the opening, closing and force by the linear actuator micro. Through a test of adaptability, a set of robotic hooks is developed, connected to a base and pushed by the liner micro actuator to show the effectiveness of the design with irregular objects or variants.**

***Index Terms*—Gripper, mechanics design, Forms, motors, performance simulations**

I. Introduction

Although industrial robots have been widely introduced to various production processes, it is still difficult for robots to assemble parts. For robots to assemble a product, multiple clamps will usually be prepared where each of the clamps grabs one of the parts [4].

Robotic tweezers play an important role in handling various objects in the manufacturing and production lines. Currently, most of the robotic clamps in the industry are of a degree of freedom (DOF). Although with a single DOF, the clamps are suitable for special purposes, their range of application is limited due to the lack of DOF [9].

In industrial applications with advanced technology, robots must meet certain requirements to be able to perform a controllable movement, however, the movement of the tweezers in any industrial application requires a completely adequate method to grasp an object in any of its forms, this method can be attached to an adaptive form that does not generate conflicts specifically in the subject of objects.

That is why it is necessary to unite the qualities of this type of adaptive gripper for its use in the selection and classification of pieces (pick and place), of different shapes and sizes that can be in reconfigurable trajectories. For this and using artificial vision the object is recognized first, then it is mapped for the corresponding operations of the clamp. The basic objective is that a system of reconfigurable trajectories identifies the object (triangle, square, polygon), the gripper takes the object found, and then classifies it in a specific region, thus controlling any object.

Diagrams of the hand that perform a spherical grip observed from the top view, as shown in Figure 1. When grabbing an object that has a circular cross section to the hand, it behaves similarly to a simple concentric gripper and the fingers (shown here as simple rectangles) move inward (a) until contacting the object (b) holding the object securely [13].

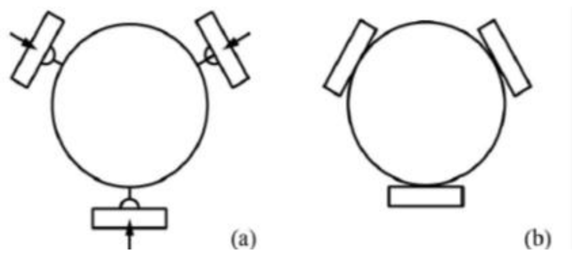

Figure 1. Diagrams of a spherical grip

II. Background

A robot designed to perform multifunctional tasks necessarily requires appropriate tools or also called end effectors that can be simple or complex. There are a variety of final effector designs, but basically, they are devices located at the end of a robotic arm and designed to interact with the environment, when developing an easy or specialized task [11].

The exact nature of this device depends on the application of the robot, so it has mechanisms that allow opening and closing with ideal characteristics to take parts.

The components of this type of adaptive gripper comply with certain characteristics that allow its optimal operation, such as the linear micro actuator, adaptive gripper design, as well as the manufacturing material.

A. Linear Micro Actuator

It is a sophisticated linear movement device with feedback and position control. Its handling is simple,

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there are several transmission ratios and voltage options to give varying speed/force configurations [1].

The selection of the PQ12 micro-actuator Fig. 2 can provide continuous micro-movement that allows grip control according to the multiple applications it is intended for, such as holding objects in a limited range on a conveyor belt.

Based on the model, it is important to consider a method of control of closing and opening of the gripper, for the solenoid valve device commanded by an Arduino UNO card through PWM.

Figure 2. Linear micro actuator PQ12.

B. Mechanical Pressure Gripper

This type of gripper is composed of mechanisms of mechanical drive that simulate fingers to grip the object, being the force of grip by contact or mechanical friction. [two]

The most common are angular and parallel, which can make external or internal grips. That's why the development of this project is based on creating an adaptive gripper that simulates the action of the fingers and allows to hold cubic, spherical and rectangular pieces easily as it adapts to the shape of the object and the size of the object, as shown in Fig. 3.

III. Gripper Design

It is important to consider the following conditions for the design of an end effector of a robotic manipulator, such as:

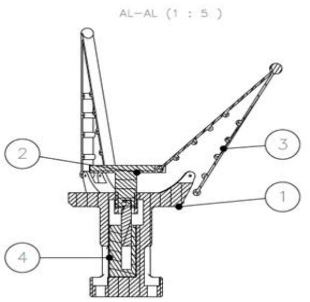
- It is necessary to be able to capture and manipulate several objects.
- The grip of heavy objects should be possible, considering the load capacity of the robotic arm and the weight of the gripper, a load of 0kg up to a maximum of 1kg.
- Maintenance must be easy [9].
- Grip the object without deformation: the objects are easily deformed, and care must be taken when gripping these flexible objects [12].
- Low weight that allows for better handling of the payload, acceleration increase and minimum processing time.
- Appropriate Dimensions to the size of the work piece.
- Maximum force required to guarantee safety and prevent damage to parts.
- Rigidity to maintain the robot's accuracy and reduce vibrations.
- The power supply must be available for the robot.
- Forms of safety so that the material is not dropped when the power supply fails.
- Make loose and flexible connections in the cables for more movement [8].

Figure 3. Mechanical adaptive gripper

IV. Mechanical Modeling of Adaptive Gripper

The mechanical design of the final effector was carried out using the computer-aided design software SOLIDWORK, in order to simulate and validate the mechanism that makes up the structure, as shown in Fig. 4.

Next, the modeling of the adaptive gripper, consisting of the body, claw and claw coupling, is presented, detailed in Fig. 5 and Fig. 6



1	Body`s gripper
2	Pusher
3	Claw
4	Linear micro actuator

Figure 4. Gripper

To test the capabilities of the clamp is performed based on object size and mass localization center [13], verifying its grip capacity with different shapes and sizes

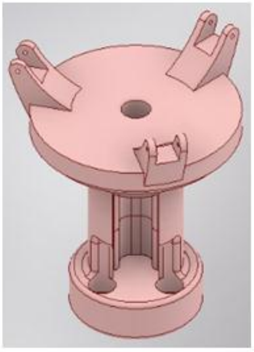


Figure 5. Adaptive gripper body

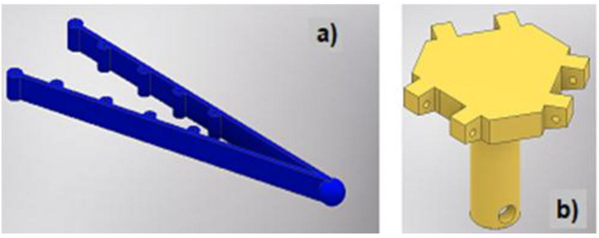


Figure 6. Parts of the gripper. A) Claw. B) Claw coupling.

An object that a human can hold stably with one hand is supposed to be less than 70 mm in diameter. According to the Manipulability Index [9].

Considering the separation distances of the clamps to grasp an object with an approximate diameter between 30 mm and 60 mm, it is based on establishing an appropriate grip without interference between the fingers and between the objects.

Likewise, these data have been verified by software that the maximum opening of the gripper is 130 mm and the closure is total, which allows having enough force to hold a piece without causing damage to it, as shown in Fig. 7.

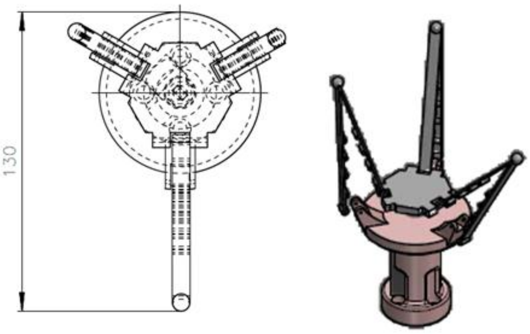


Figure 7. Maximum opening of the adaptive gripper

Additionally, in this design we considered the results obtained by software to check the maximum load, as well as the properties of this element.

A. Selection of the Motor for Opening and Closing the Gripper

To make the grip of objects automatically it is necessary to incorporate a linear micro motor given that its stroke is suitable for opening and closing the gripper.

According to the research of linear micro motors, in the market, there are no options according to the dimensions (15 x 20 x 40 mm) that are required to insert it into the gripper body and a path of its 25mm shank. Therefore, a linear micro servo called PQ12 was considered, which complies with the required dimensioning, as well as the race for the opening and closing of the gripper [8].

V. Advantages and Disadvantages of the Model

TABLE I. Comparison between Tweezers.

MODELS			
CHARACTERISTICS	Electronic	Pneumatic	Vacuum
Weight	+	+	-
Dimensions	+	+	+
Material Construction	+	+	-
Required Strength	+	-	-
Rigidity	+	-	-
Source feed	+	-	-
Security	+	-	-
Connections	+	+	+
Maintenance	+	+	-

It was analyzed based on three types of tweezers, among these we have 1. Electronics; 2. Pneumatic; 3. Vacuum; valued according to different parameters such as dimensions, material construction, required strength, rigidity, power supply, safety, connections and maintenance, depending on their performance, giving a + sign to the one that satisfactorily satisfies each parameter and a sign - when that does not meet certain parameter mentioned, in the end it is evaluated that the final effector complies with most of the parameters that will be used for this design.

Once the design alternatives have been analyzed and the evaluation has been carried out, it is concluded that the electronic adaptive gripper adequately meets the requirements, obtaining an ideal solution for the classification and manipulation of parts by their patterns [8].

It is also important to mention that the design features comply with the parameters necessary to hold any object, such as opening and closing the claws for an adequate grip, the force necessary to hold the object and be moved from one place to another, rigidity, safety and above all of easy maintenance since the implementation costs are reduced, that is to say that its design is ideal for the established application.

VI. Materials

For the manufacture of the final effectors was made by 3D printing, which allow the piece can be manufactured easy, economical and light. Intelligent materials that have been used in soft robotics or actuators for soft robotics are dielectric elastomer actuators (DEA), hydrogels, electro active polymers (EAP), SMA, shape memory polymers (SMP) and FEA [6].

When considering the different manufacturing techniques of composite products could be mentioned the following: manual stratification, spray molding, extrusion, injection, compression molding and using new technologies we could mention 3D printing or additive manufacturing, which brings many fundamental changes in the process of materials, product design, manufacturing processes since it provides many opportunities to replace the traditional manufacturing approach as a sustainable way.

The 3D impression of the gripper was made in ABS; it is a thermoplastic composed of three monomers; acrylonitrile, butadiene and styrene and the combination of these three monomers at different levels allows a wide variety of properties [5].

VII. Testing of Efforts

Once made, it was necessary to perform an analysis of stresses and deformations of each gripper element, as shown in Figure 8, to determine the strength and rigidity of the structural material, the behavior of each part subjected to an axial force was evaluated according to its maximum grip according to design. which is recorded simultaneously values of the applied force and to the enlarge produced. These values of strain and deformation analyzed in the coupling of the claw graphically originated the following results the so-called stress and deformation diagram.

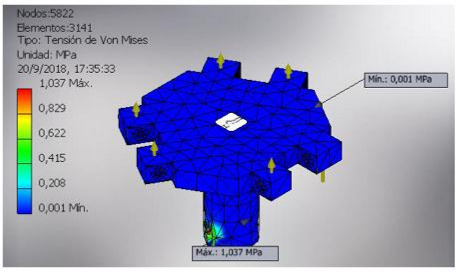


Figure 8. Von Mises Tension

TABLE II. Claw Analysis.

Name	Minimum	Maximum
Volume	10769,7 mm^3	
Mass	0,003848 kg	
Von Mises Tension	0,000949 MPa	1,03656 MPa
First main tension	-0,28625 MPa	1,16301 MPa
Third main tension	-0,50710 MPa	0,240869 MPa
Displacement	0 mm	0,00342417 mm
Safety factor	15 su	15 su
Displacement X	-0,000586 mm	0,000630701 mm
Displacement Y	-0,000578 mm	0,00055342 mm
Displacement Z	-0,000041 mm	0,00339801 mm
Equivalent deformation	0,0000003 su	0,00035106 su
First main deformation	0,0000002 su	0,000378407 su
Third main deformation	-0,000195 su	0,000000112304 su

A. Summary of Base Gripper Results

Likewise, the analysis was carried out on the body of the adaptive gripper in order to determine the force that supports or is applied to it, as shown in Fig. 9, in addition the analysis of the resistance of the material was carried out in this way the deformation in the structure of the base is controlled.

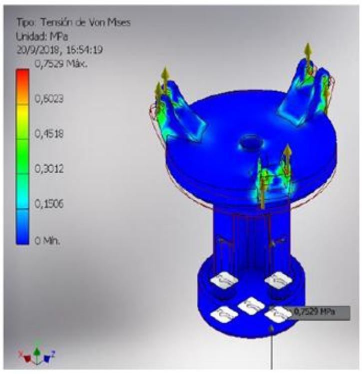


Figure 9. Von Mises Base Tension

TABLE III. Gripper Results.

Name	Minimum	Maximum
Volume	80865,4 mm^3	
Mass	0,028891 kg	
Von Mises Tension	0,0000403044 MPa	0,752903 MPa
First Main Tension	-0,274296 MPa	0,879395 MPa
Third Main Tension	-0,606362 MPa	0,250772 MPa
Displacement	0 mm	0,023264 mm
Safety factor	15 su	15 su
Displacement X	-0,005225 mm	0,01423 mm
Displacement Y	-0,000885 mm	0,01763 mm
Displacement Z	-0,006062 mm	0,01093 mm
Equivalent Deformation	0,000000014 su	0,00026 su
First equivalent deformation	0,0000000025 su	0,000273 su
Third equivalent Deformation	-0,0001514 su	0,0000000052 su

These values obtained in the base of the gripper and in the base of the claw, give the security of keeping safe the linear actuator used, since they are considerable values that allow the opening and closing of the claws.

B. Claw Results Summary

In the same way the analysis of the Claw shows that due to the fragility of the point of contact with the object, it suffers a considerable deformation, however not enough to break the claw, or generate damage on the base of the claws, this The flexibility of the claws facilitates the grip of the objects, as shown in Fig. 10, in addition the deformation produced optimizes the grip according to its shape and size.

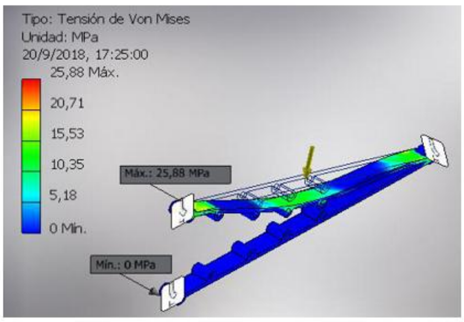


Figure 10. Von Mises Claw Tension

VIII. Prototype

The prototype of an adaptive gripper controlled with a linear micro actuator is shown to correctly fix objects of different shapes, as shown in Fig. 11.

Figure 11. Parts Fastening

IX. Conclusion

In this study, an adaptive gripper design with optimal performance results from an analysis of the grip of the object according to its shape, size and weight, which allows to adopt a mechanism driven by a linear micro actuator with an increase in payload represented by the force exerted when selecting an object. Operating through an elastic deformation in this case, facilitates the adaptation of the claw around the object, each claw fulfills the objective of enclosing the object in the center of the gripper, gradually applying a force that tightens the object without releasing it and without cause no harm on it. facilitating with a single gripper in a specific way, being able to use it for different functions, being thus dockable to different shapes and sizes, but also taking full advantage of the size, by making a light gripper that allows to continue having good grip and little load for the robotic arm.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Mogro and Lopez developed the project, designed the mechanical part and them programmed the logic secuence. The goal was to create an adaptive gripper controlled with micro servo linear. Mendoza conducted the research, analyzed the results and validated the hypothesis. All authors had approved the final version.

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- Knowledge area coordinator in computer aided design

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