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OPTIMIZATION OF A GRIPPER MADE BY COMPOSITE MATERIAL

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Rezumat. *În această lucrare se prezintă o sinteză a literaturii de specialitate în domeniul mecanismelor de prehensiune, dar și o soluție constructivă. În prima parte a lucrării s-au luat în considerare aspecte generale ale roboților industriali, stadiul actual in domeniu mecanismelor de prehensiune, analiza forțelor, metodele de calcul, precum și un studiu al materialelor compozite. A doua parte reprezintă contribuția proprie. În urma analizei literaturii de specialitate a fost conceput un mecanism de prehensiune capabil să îndeplinească necesitățile actuale domeniilor de prelucrare flexibile și a roboților industriali. Acesta constă în doi cilindri pneumatici, unul pentru acționarea principală, iar al doilea pentru gruparea degetelor două câte două. Tot în a doua parte au fost efectuate și încercări experimentale de diferite tipuri de materiale compozite, rezultatele fiind utilizate pentru analiza cu elemente finite.*

Abstract. *This paper presents a synthesis of the literature for gripping mechanisms and also a gripper solution. In the first part of the paper were taken into account general aspects of industrial robots, the current state of the art for grippers, force analysis, calculation methods and composite materials. The second part of the paper contains my own contribution. Following the analysis of current requirements, a gripping mechanism capable of meeting the criteria of flexible manufacturing systems and industrial robots was designed. This contains two pneumatic cylinders, one for the main movement and the second for grouping the fingers two by two. Also, in the second part, experimental tests of different types of composite materials were performed, the results being used for finite element analysis.*

Keywords: gripper, gripping system, gripper design, prehension, finite element analysis

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1. Introduction

Gripping mechanisms are complex mechatronics systems that are used by industrial robots, which are designed to realize gripping operations of parts in order to handle, transfer or assembly in robotized technological process [1].

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Gripping systems are designed to replace or to ease the human operations because they are very effective in repetitive cycles, can handle big and heavy objects and they can operate in extreme ambient conditions and temperatures [2].

There are numerous parts with different sizes and shapes that need to be handled, that is why it is impossible to design a gripper suitable for all tasks. Most gripper researches utilize electric motors or pneumatic cylinders and two fingers, those designs being suitable for one specific job. However, new technological developments have given the opportunity do design universal gripping systems [3].

A gripping system must meet the following properties [4]:

- Optimal adjustments of gripper structure at performed operations;
- Adjustments to a wide range of openings and prehension options of different shapes and sizes parts;
- Safety in handling parts;
- Stability in positioning and orientation of the parts;
- Optimum characteristics in terms of clamping force;
- Systems with small weight and size;
- Avoiding damage and deformation of parts during prehension;
- Position on objects precisely;
- Variation in gripping possibilities based on weight, size and shape;
- The possibility to grip an object, when this is near to another object;
- Fast change/adapt of gripping system according to the next part to be manipulated;
- Changes in clamping force according to the part weight.

Table 1) Comparison between electrical, pneumatic and hydraulic operating [5]

Comparison criteria	Type of acting		
	Pneumatic	Hydraulic	Electrical
Availability	**	*	***
Long distance transport possibility	**	*	***
Storage cost of the working environment	***	**	*
Level of environmental pollution	***	*	**
Components cost	***	*	***
Speed of movement in execution element	**	*	***
The size of obtained forces	**	***	*
Lifetime	***	**	**
Working parameters adjustments	***	**	*

Where: *** = very good; ** = good; * = satisfactorily

Nowadays, there are researches which try to transform a simple gripper who can do one single job to a multipurpose gripper. These can handle and manipulate a large variety of objects but they are to complex with a large number of components and linkages. Further are presented few solutions: in Fig. 1 is a two finger adaptive gripper, in Fig. 2 is a three finger adaptive gripper.

Fig. 1. Two finger adaptive gripper (http://robotiq.com/products)

Fig. 2. Three finger adaptive gripper (http://robotiq.com/products)

Another research covers up two gripper designs: adaptive and flexible. Not only that the fingers are flexible and can mold around the objects but they can change the position of fingers (Fig. 3).

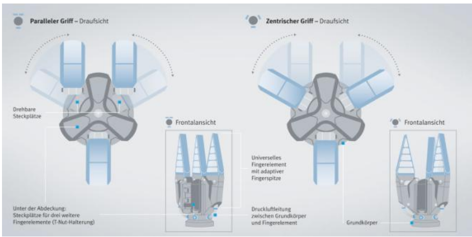

Fig. 3. Multi choice gripper
(https://www.festo.com/group/en/cms/10221.htm)

In Fig. 4 is represented a research where the drive mode of fingers where “tendons” are used to operate them.

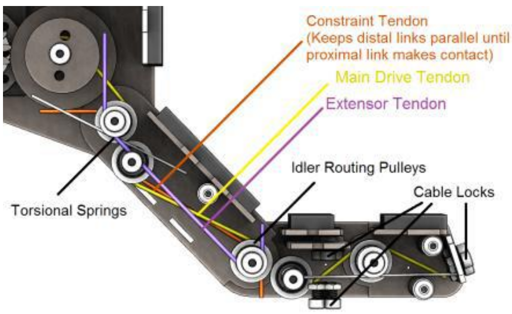

Fig. 4. Tendons operating finger
(http://yameb.blogspot.ro/2014/04/mit-meche-deflorez-competition-entry.html)

2. Innovative Solution of the Gripper

Analyzing the researches from the first part of the paper and considering the current trends in gripping mechanisms development, we designed a gripping mechanism with four fingers, opening-closing parallel and drive by a pneumatic cylinder. At the beginning, the gripping mechanism act like a normal gripper (Fig. 5). Because the necessity of a flexible gripper who can handle various types of parts, a second pneumatic cylinder was added (Poz. “b” in Fig. 6) and a linkage system who connect this cylinder with the fingers (Poz. “a” in Fig. 6) that can change fingers configuration, transforming the mechanism from a four finger gripper to a two finger gripper. The operating principle of the second pneumatic cylinder and the way the transformation is made is represented in Fig. 7.

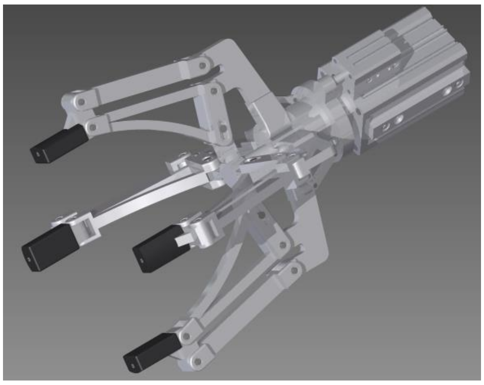

Fig. 5. Design of four fingers gripper

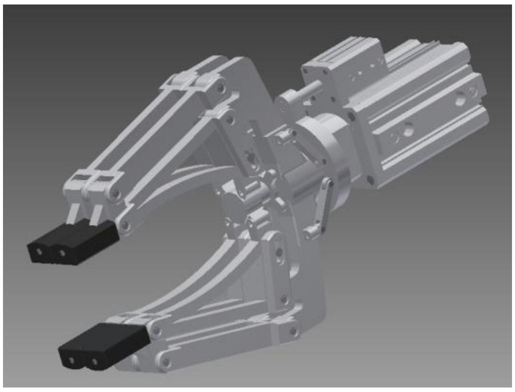

Fig. 6. Design of two finger gripper

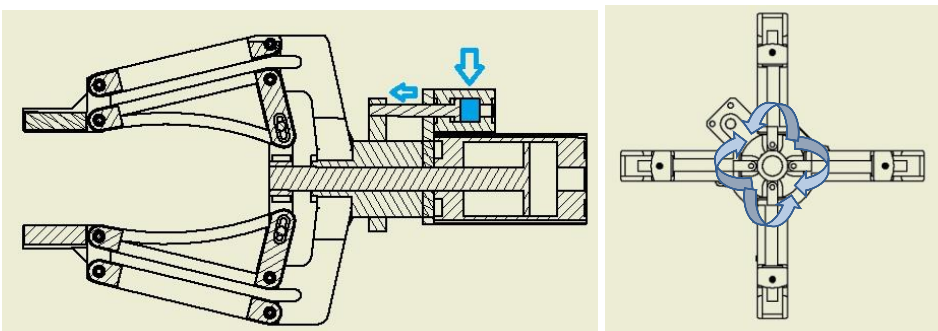

Fig.7. The gripping system changing mode from four fingers to two fingers

3. Gripper Composite Material Test

The tests of the probes were done on an existing test bench for traction and compression. Each composite material was fixed on the test bench.

Each material plate was pressed with a force transducer and the deformation of the material was recorded with two linear travel transducer (Fig. 8) and also with a GOM stereo-camera system (Fig. 9).

Fig. 8. Aragement for force and travel transducer and the acquisition system

Fig. 9. Aragement for GOM stereo-camera and acquisition system

4. Finite Element Analysis

The data obtained from the test bench acquisition systems were introduced to a finite element analysis software.

From the entire model (Fig. 10), only one finger was used to analyses (Fig. 11).

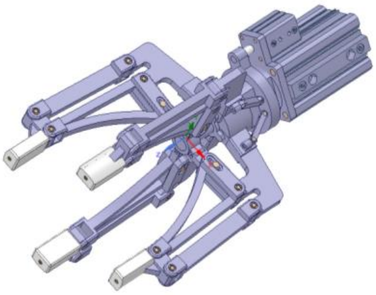

Fig. 10. Entire model

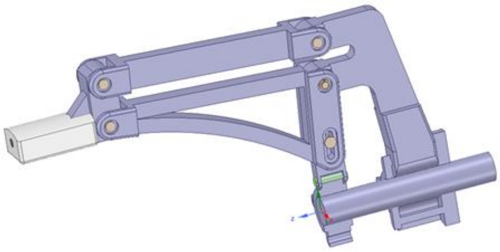

Fig. 11. Simplified model

Part of results are presented below, such as total deformation (Fig. 12) and equivalent stress (Fig. 13).

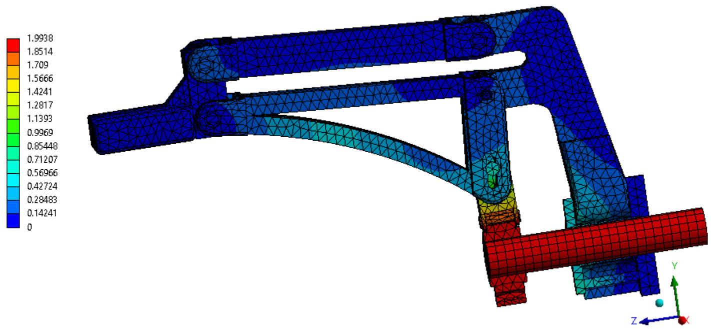

Fig. 12. Total deformation (in mm)

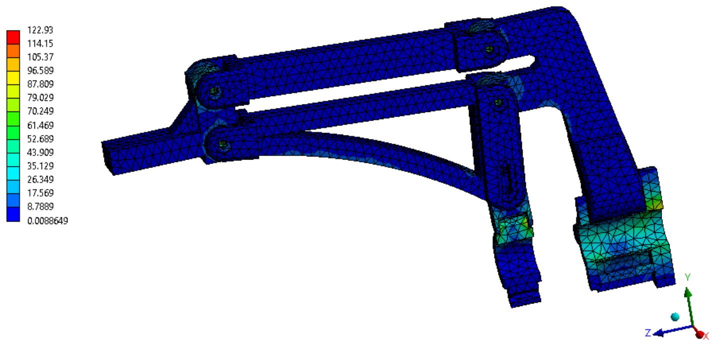

Fig. 13. Equivalent stress (in MPa)

Conclusions

After researches I concluded that the technology is in an ascending progress of development for more flexible industrial robot which requires designing more flexible grippers to handle a large variety of parts.

Another trend in robotic development is to create a gripper that is capable to send numerous information from the object like weight, temperature, the grabbing pressure and automatic positioning the robot arm on the parts.

My experimental gripper design increase only the range of shapes and dimensions of the objects that can be handled.

The future directions of my researches are to improve the design and reduce the component parts of the gripper, to be less expensive to produce, to try different types of fingers configurations to extend the range of objects shape.

Another direction is to test different types of materials for component parts, to reduce the weight and to increase the strength of the gripping mechanism, such as fibre glass, aluminium alloys or other materials.

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