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DESIGNING A FLEXIBLE GRIPPING SYSTEM FOR AN INDUSTRIAL ROBOTIC ARM

BY

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Abstract. The paper summarizes the researches on specialized literature and designing a gripping system capable of meeting the current requirements of flexible manufacturing systems and industrial robots, namely handling a variety of parts with different shapes, sizes and weights. The first part of the paper contains general information about current state of researches in gripping system application field and gripping forces analysis and methods of calculation. The second part of the paper contains my own contribution. From studies I choose gripping system that is capable to configure for achieving several tasks. It is designed with four parallel fingers and two pneumatic cylinders. The primary cylinder drives the fingers to grab objects like an ordinary gripper. My main contribution is by introducing the second cylinder who changes the position of the fingers, transforming the system from a four finger gripper to a two finger gripper, through this, expanding the range of seized objects.

Keywords: gripper; gripping system; gripper design; prehension; finite element analysis.

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1. Introduction

The gripping mechanisms are complex mechatronic structures used by industrial robots, which are aimed to realize gripping operations of parts in order to handling, transfer or assembly in a robotised technological process (Khoo, 2008).

Gripping mechanism are designed to replace the human hand because they are very effective in repetitive cycles, can handle heavy objects and can operate in extreme ambient conditions and temperatures (Monkman and Hesse, 2008).

There are numerous of parts with different shapes and sizes that must be handled, that is why it is impossible to design a gripper suitable for all parts. Most gripper researches utilize electric motors or pneumatic cylinders and two fingers, because those are designed for one specific job. However, new technological developments have given the opportunity to develop universal gripping systems (Burak, 2010).

A gripping system must meet the following properties (Rajput, 2008):

• 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.

In Table 1 are presented comparison criteria between electrical, pneumatic and hydraulic operating (Deaconescu, 2008).

Table 1

Comparison Between Electrical, Pneumatic and Hydraulic Operating

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 to transform a simple gripper, who can accomplish a single task, to a multipurpose gripper. These can handle a variety of object, but are to complex with a large number of components and linkages. Some of these adaptive gripper designs are presented as follows: 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 is based both adaptive and flexible gripper. Not only the position of fingers are changing, but the fingers are flexible and can mold around the objects (Fig. 3).

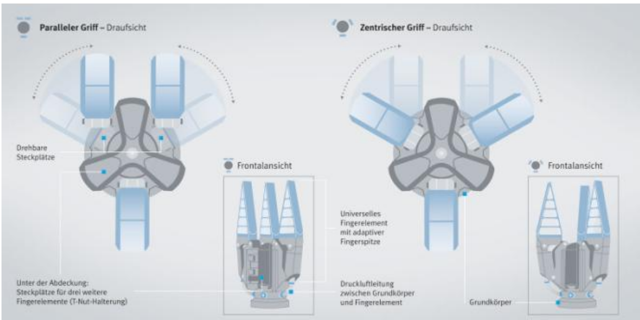

Fig. 3 – Multi choice gripper
(https://www.festo.com/group/en/cms/10221.htm).

Researches are made in order to drive way of fingers. In Fig. 4 is represented the drive mode of fingers where “tendons” are used to operate them.

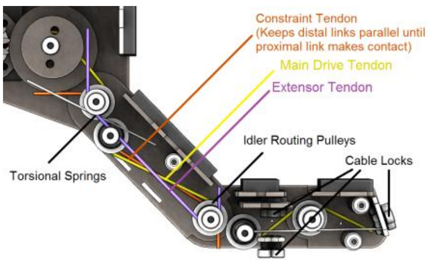

Fig. 4 – Tendons operating finger
(http://yameb.blogspot.ro/2014/04/mit-meche-deflorez-competition-entry.html).

2. Personal Contributions

Following the researches in the first part of the paper and considering the current trends in gripping systems development, I designed a gripping mechanism with four fingers, opening/closing parallel and pneumatic drive. This acts like a normal gripper with concentric clamp (Fig. 5). Because the necessity of a flexible gripper who can grab various types of parts, I added a second cylinder connected to a flange (Poz. “b” in Fig. 6) and a linkage system connected between the flange and fingers (Poz. “a” in Fig. 6) that can change the fingers configuration, transforming the mechanism from four finger grippe to a two fingers gripper with parallel clamp. The operating principle of the second cylinder and the way it changes the fingers position is represented in Fig. 7.

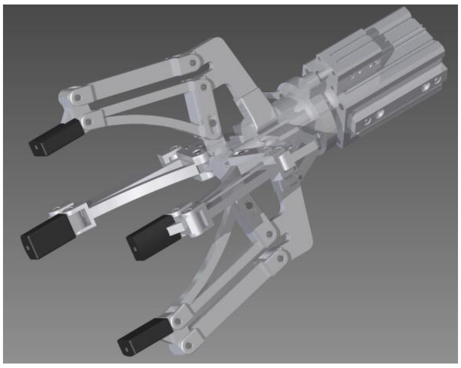

Fig. 5 – Design of four fingers gripper.

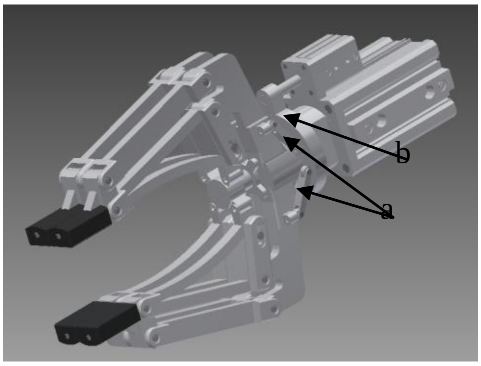

Fig. 6 – Design of two finger gripper.

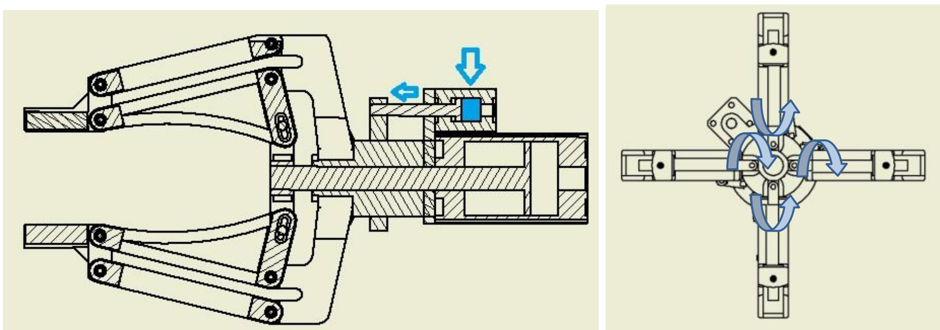

Fig. 7 – The gripping system changing mode from four fingers to two fingers.

As we can observe, this solution bring many benefits regarding the variety of shapes and dimensions of parts that can be handled, but increase the complexity of the system, making it unstable and expensive to produce. The main future objective is to reduce the number of components making it more rigid and with lower production costs.

3. Conclusions

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

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

My experimental gripper designs extend only the range of shapes and dimensions of the objects.

The future directions of my researches is to 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 I am looking for is to test different materials for gripper component parts, to reduce the weight and to increase the strength, such as fiber glass, aluminium alloys or other materials.

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CONCEPEREA UNUI SISTEM DE PREHENSIUNE FLEXIBIL PENTRU UN BRAŢ ROBOTIC INDUSTRIAL

(Rezumat)

În această lucrare se prezintă o sinteză a literaturii de specialitate în domeniul sistemelor de prehensiune. Plecând de la cerinţe, a fost creat un sistem de prehensiune nou capabil a îndeplini criteriile domeniilor de prelucrare flexibile şi a roboţilor industriali. Prima parte a lucrării conţine informaţii generale referitoare la stadiul actual al dezvoltării în domeniul sistemelor de prehensiune, a analizei forţelor şi a metodelor de calcul a lor. În partea a doua se prezintă contribuţia proprie. Analiza sintetică a literaturii de specialitate a condus la definirea unui sistem care să îndeplinească mai multe sarcini. În construcţia lui au fost utilizaţi doi cilindri pneumatici şi patru degete paralele. Primul cilindru asigură deplasarea degetelor ca într-un sistem clasic. Al doilea cilindru asigură schimbarea poziţiei degetelor transformând astfel sistemul dintr-un sistem prehensibil cu 4 degete într-unul cu două degete, asigurându-se astfel extinderea gamei de utilizare.