DESIGN AND APPLICABILITY OF A NEW ARCHITECTURE OF A DOUBLE SCARA ROBOT

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Abstract: SCARA robot mechanisms can be divided into two categories namely : mechanisms consisting of open kinematic chains and mechanisms consisting of closed kinematic chains. The second category includes Double SCARA robot, which comprises a five bar mechanism. The paper will propose several variants of mechanisms for Double SCARA robots, modeled by CATIA software.

Keywords: SCARA robot, five-bar mechanism, modelling, CATIA software

1. Introduction

The SCARA is acronym for Selective Compliant Assembly Robot Arm or Selective Compliance Articulated Robot Arm [1]. It was first developed in Yamanashi University of Kofu, Japan by Hiroshi Makino. Today this configuration is adopted by companies all over the world like AIBO, COBRA, EPSON, KUKA, STÄUBLI, YAMAHA, for industrial tasks and also in the medical field [2].

This type of robot has been first used as an industrial robot for pick and place tasks, assembly tasks, painting etc. after, entering into the medical field as well. As the name describes, the main function is to simulate an articulated arm, having in its structure an open, articulated kinematic chain, placed in the horizontal plane of the robot [2]. The described mechanism is the serial SCARA Robot.

Further in this paper the design of a Double SCARA Robot is detailed. The configuration is obtained by linking two serial kinematic chains into a closed five-bar-mechanism. This new configuration has the advantage of a wider workspace and a higher capability to carry loads.

2. Modelling of different configurations of planar five-bar mechanism

Planar five-bar mechanism is included in the category of parallel mechanisms [3, 4]. They may present two versions: the general case (Fig. 1a, $d \neq 0$) and the particular case (Fig. 1b, $d = 0$).

To model the five-bar mechanism, kinematic joints and the all system, we utilised CATIA V5, because of advantages offered by this software [5, 6].

3

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Editura "Academica Brâncuşi" , Târgu Jiu, ISSN 1844 – 640X

For the 3D modelling of the elements, we used CATIA-Part Design product, and for the execution design CATIA-Drafting. The assembling conditions required that the elements must be having different forms. The definition of kinematic joints we achieved with CATIA-DMU Kinematics product, obtaining the mechanism with Assembly Design.

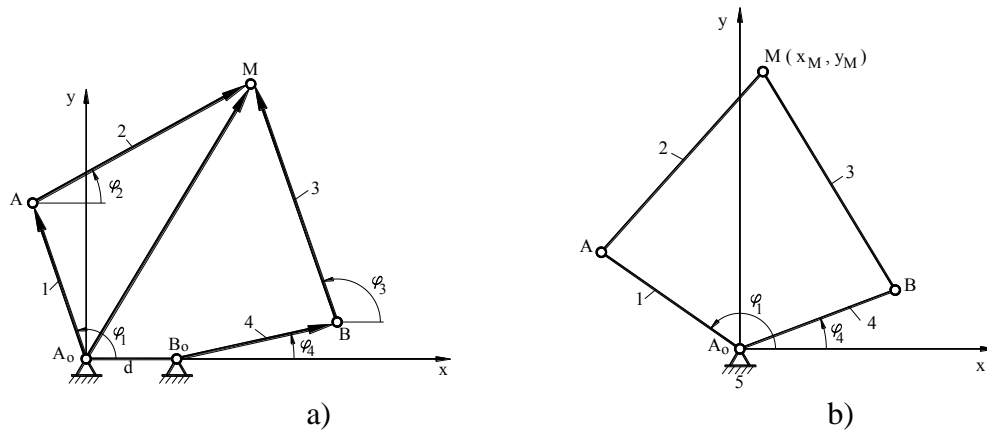a)   b)

Fig. 1 Five-bar mechanisms

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The lengths of the elements 1-4, respectively 2-3 are equal (Fig. 1a, b), but the assembling conditions required that the elements must be having different forms. Also, for the 1 and 4 elements we achieved the constructive solution (see Fig. 2a) and the execution design is shown in the Fig. 2 b.
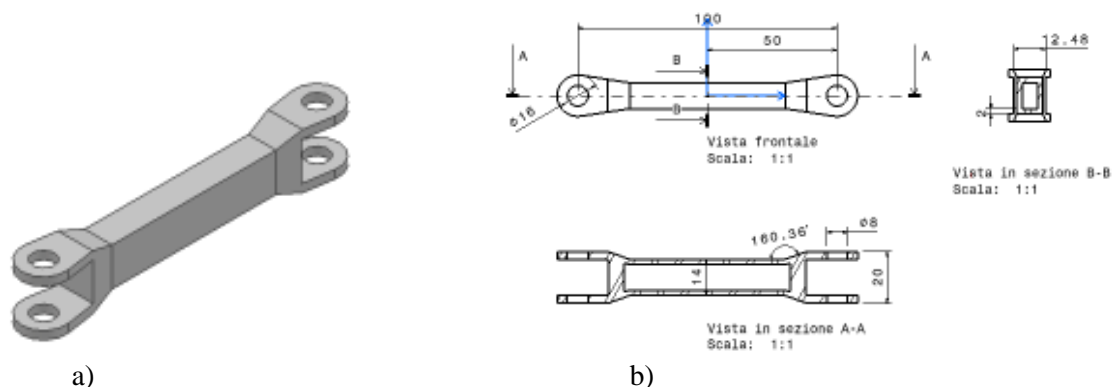

a)   b)

Fig. 2 Constructive solution (a) and execution design for 2 and 3 elements (b)

4

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Editura "Academica Brâncuşi" , Târgu Jiu, ISSN 1844 – 640X

For 2 and 3 elements, the constructive solution is represented in fig. 3a, and the execution design in fig. 3b.

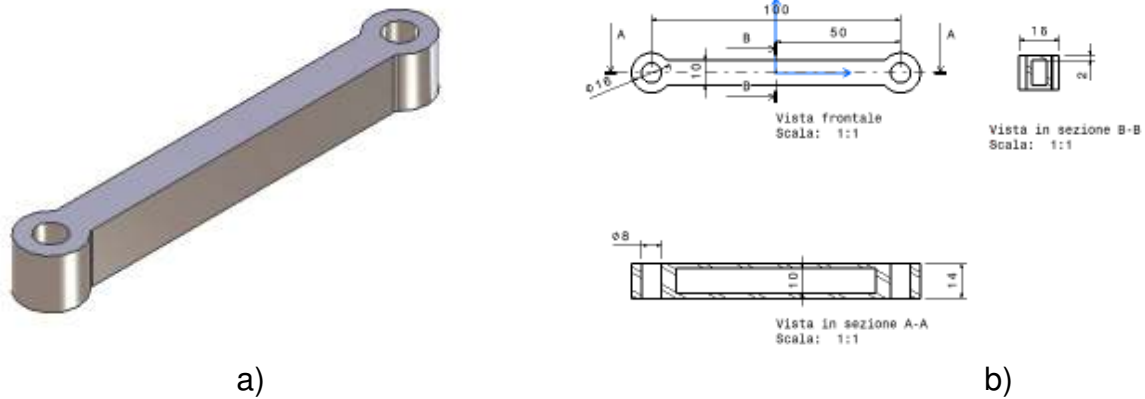a)   b)

Fig. 3 Constructive solution (a) and execution design for 2 and 3 elements (b)

With CATIA Assembly Design we have obtained the models of kinematic chains of five-bar mechanisms from Fig. 1 (a, b).

a)   b)

Fig. 4 Kinematic chains generators of five-bar mechanisms

By mounting of kinematic chains on a support we have obtained five-bar appropriate mechanisms (Fig. 5a, b).
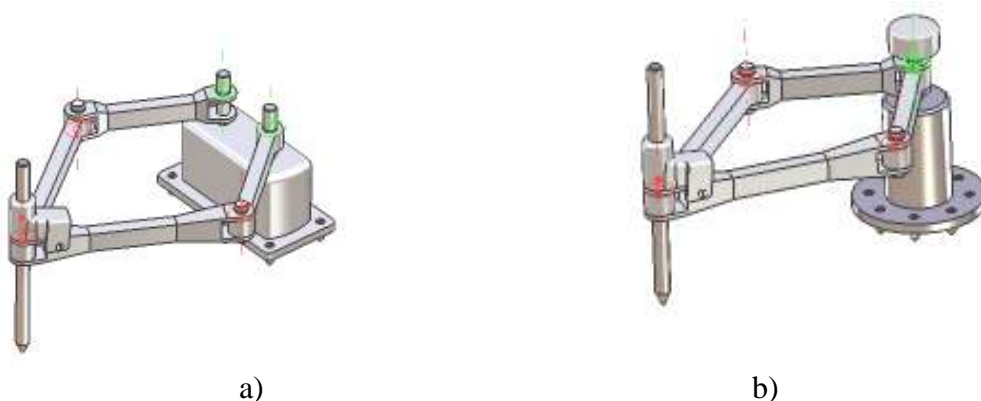

a)   b)

Fig. 5 Five-bar modelled mechanisms

5

Fiabilitate si Durabilitate - Fiability & Durability   No 1/ 2016
Editura "Academica Brâncuşi" , Târgu Jiu, ISSN 1844 – 640X

The second version of the mechanism (Fig. 5b, d=0) has the advantage of compact building, but comparing it to the first version (Fig. 3a, d≠0), the workspace is reduced.

To double the number of operations that this kind of mechanism can perform, starting from the previous configuration, a double five-bar linkage can be built as shown in the Fig. 4.

Fig. 6 Double five-bar mechanism
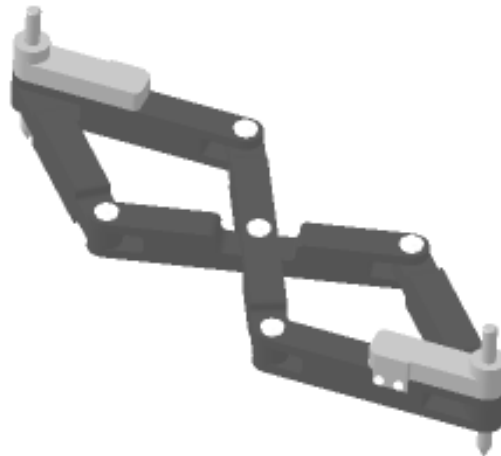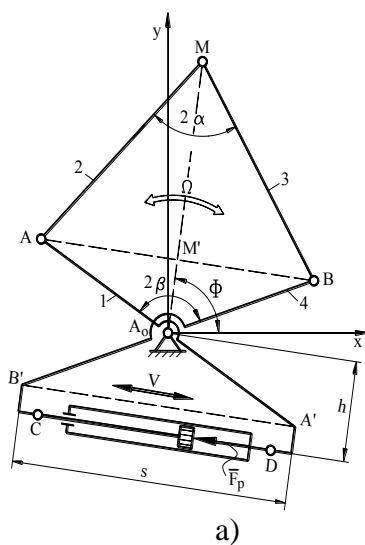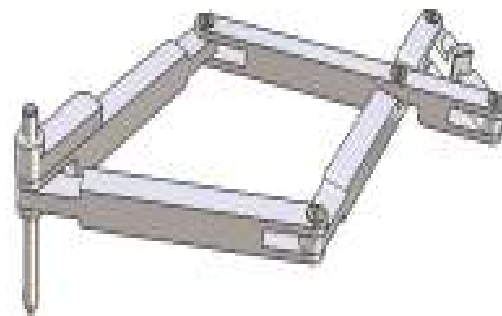

a)   b)

Fig. 7 A new acting solution of the mechanism from Fig. 5b and CATIA's design of the five-bar mechanism with translation actuator

6

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Editura "Academica Brâncuşi" , Târgu Jiu, ISSN 1844 – 640X

For the particular five-bar SCARA mechanism (Fig. 5b) the actuators are located in fix joints, in which case there are some constructive complications. For these reasons, we propose a new acting solution of a five-bar mechanism presented in Fig. 7a.

The design of this mechanism is represented in Fig. 7b.

The mechanism act is performed in this manner:

- - the distance between the joints A-B modifies thanks to the linear motor action, located between joints C-D;
- the mechanism can rotate around the joint A_0, by acting one of element 1, 4.

In this way, the motors overlap from A_0 joint can be eliminated. The command parameters are s and $\emptyset$.

3. Double SCARA robot models with three degrees of freedom

To obtain three-dimensional workspace of the SCARA robot on attaches of five-bar linkages's base a translational joint, to control the vertical translation of the end-effector. This way a 3D workspace is defined [7]. This configuration can be also presented as two design solutions that can be seen in Fig. 8a (general case d≠0) and in Fig. 8b (particular case $d = 0$).

a)   b)
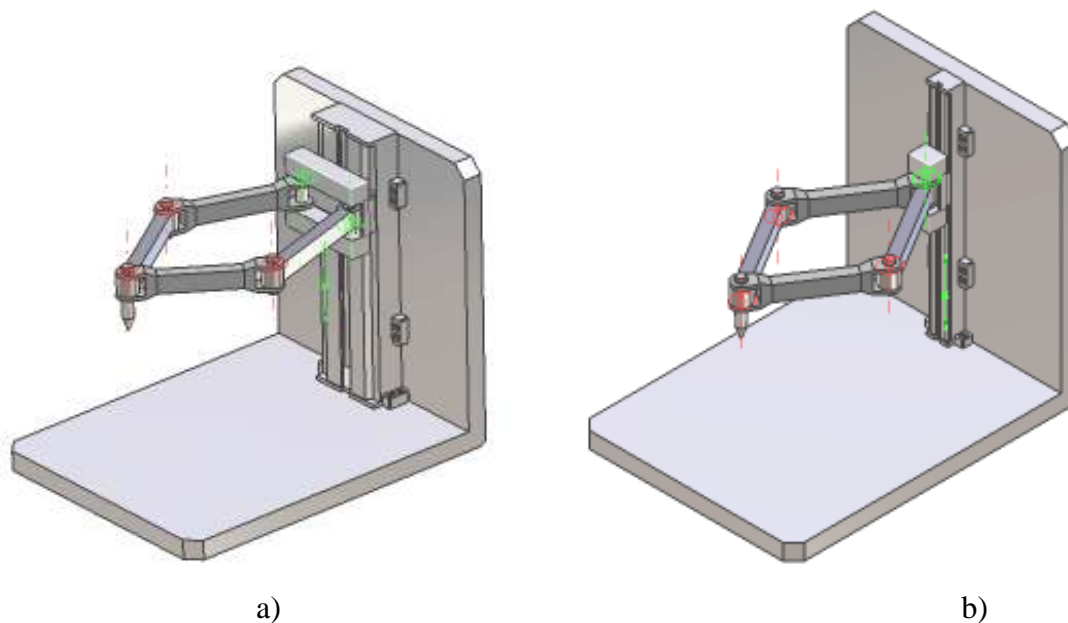
Fig. 8 SCARA robots

An application of this type of design is a pick and place robot. In the pictures 5 and 6, various positions of the end-effector's trajectory are presented. The mechanism's trajectory is simulated with the DMU Kinematics Module of the CATIA V5 software [6].
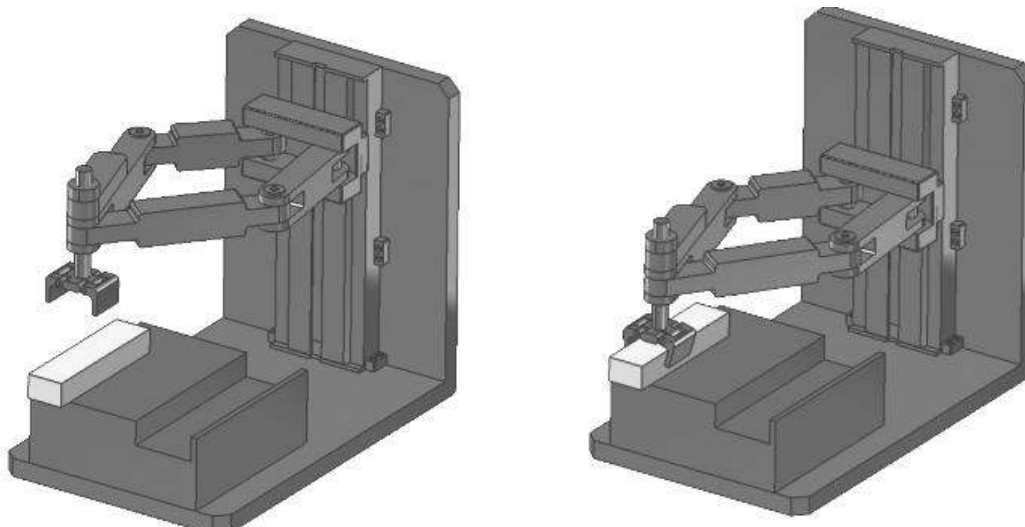
7

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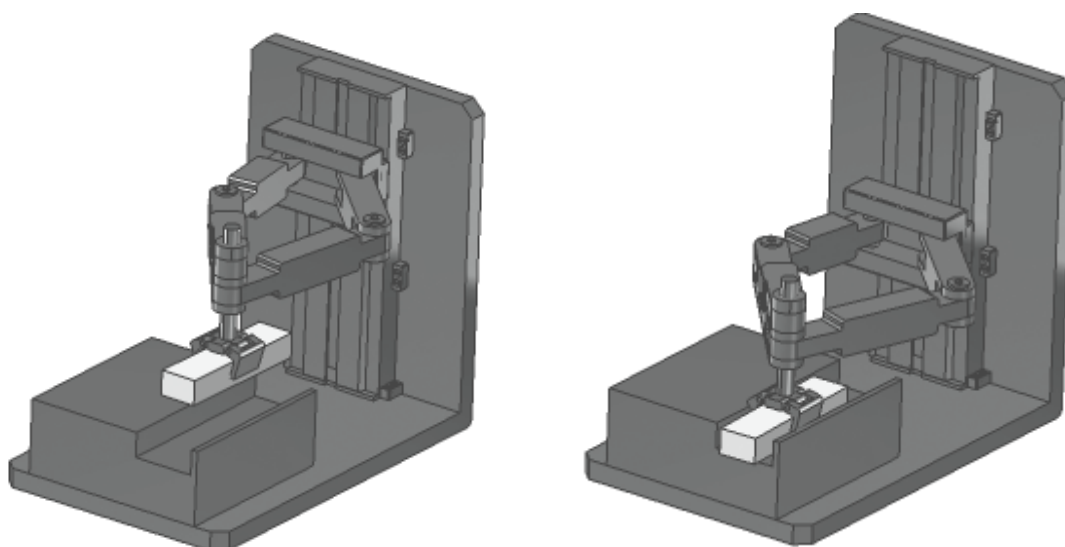Fig. 9 Positions 1 and 2 of the "pick and place" Double SCARA Robot

Fig. 10 Positions 3 and 4 of the "pick and place" Double SCARA Robot

4. Conclusions

Double SCARA robots mechanisms can be modularized through two sub-assemblies: a five-bar kinematic chain (five-bar linkage) and a support by which it is linked on a translational joint. The paper presents several variants of five-bar mechanisms, modeled using CATIA software. These constructive solutions differ one from another by configuration and actuation mode. Finally, it shows the constructive model of a SCARA robot for pick-and-place applications. The models were validated, their operation can be watched by an animation program.

8

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REFERENCES

[1**]** https://en.wikipedia.org/wiki/SCARA

[2] **Tempea, I., Livadariu A. M., Dugaesescu, I.,** Laser Engraving Double Scara Robot Modeling, Proceedings of The third edition of the International Conference "Optimization of the Robots and Manipulators", OPTIROB 2008-Predeal, Romania, May 30th-June 1st, pp 53-58.

[3] **Merlet, J-P**., Les robots parallèles,Hermès, Paris, 2007.

[4] **Tempea, I., Livadariu, A.-M.**, New solutions regarding planar bi-mobile mono-contour parallel mechanisms, Proceedings of the 18th International Workshop on Robotics in Alpe-Adria-Danube Region, May 25-27, 2009, Brasov, Romania, p 41-47.

[5] **STÄUBLI** RX brochure GB.pdf.

[6] **Dassault Systèmes**, CATIA Version 5 User's Documentation.

9

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