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THE SIMULATION AND THE INTERFACE OF THE MECHANISMS USED IN MICROFACTORIES

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Abstract: *In this paper the design and simulation control issues for the development of mechanism which are aimed to be used in microfactory is presented. The developed five bar mechanism is miniaturized size adapted for microfactories, miniaturized version of conventional mechanism based on well-known kinematic structures. The CAD model is parameterized, the lengths of the elements can modified to determine the optimal workspace. The control of model parameters is achieved in an application developed with C#.*
Key words: *Micromanipulation, mechanism, microfactory, interface.*

1. INTRODUCTION

The researches in the twenty first century have the aim to reduce costs for manufacturing products. In this context, the miniaturization of products and small-size parts are need of an adaptive sustainable production.

In the context of the obvious trend of miniaturization, which is manifested in all the components of a mechatronic system, the commercial potential of miniaturized production systems, designed to achieve generally small benchmarks in terms of high accuracy, has grown, and carrying out research leading to the development of new microfactory systems or the improvement of existing ones [1].

The micromanipulation in microfactories is the key to increase the competitiveness of world industry and hence that of the Romanian one, and is one of the most important opportunities to reduce manufacturing time, energy consumption, production costs and to increase product quality.

The main tasks in the process of developing microrobotics and microfactories are: precise manipulation of micrometric components, reduction of the costs and the delay, reduction of the energy consumption, saving materials, insertion in controlled environment, portability, etc. The pick-and-place tasks are the base level for manipulation systems with micrometric accuracy. A micro production system is characterized by the precision, modularity, flexibility and re-configurability to make the assembly of small (micro) products which have a more variability [2].

The development of a new generation of the mini and micromanipulator satisfy the continuing need to perform various operations needed in factories and small factory and investigate the world at micro level. This is made possible by recent advances in the field of computers and programming, on the one hand, and those in the modeling of physical phenomena, chemical, biological, etc., on the other hand [3].

Consistent with this emphasis, the paper aims to combine theoretical research activities with the design, modeling and simulation of a five bar mechanism for miniaturization used in microfactories.

2. THE MICROMANIPULATION SYSTEMS

Production is required to have a good flexibility with the possibility of frequent changes in short time to plan operations carried out by these devices, so it was appropriate to introduce the possibility of reprogramming their default have developed computational techniques that led to simplicity in use and low cost of production. The block diagram of such a complex technical manipulating system is shown in figure 1.

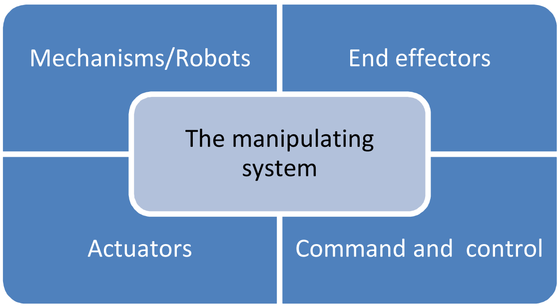

Fig.1 The block diagram for a manipulating system

The structure of mechanisms by robots of the manipulating task have two subsystems based on serial and parallel chain. The characteristics of these structures, such as modularity and reconfigurability, responding to requests from applications in various fields such as: manufacturing, electronics, medical in surgery, pharmaceuticals, etc.

The serial manipulator mechanisms have a simple structure and are obtained by serial coupling cinematic rank of two, from the fixed element by kinematic couplings of rotation and/or translation. The serials mechanisms have a large work space but low rigidity.

The parallel manipulators mechanisms have more complex structure obtained by coupling elements in parallel kinematic second or higher rank, from the fixed element by kinematic couplings of rotation and/or translation. The mechanical subsystems with parallel mechanisms have advantages over the series such as improved stiffness, increased accuracy and better ratio between payload and weight so that they can be used in microassembly applications, microinjection, surgery, etc.

3. THE PROPOSED ROBOT FOR SI2M

In the previous work the team has developed the structure for manipulating systems (SI2M) with a parallel robot with five bar mechanism and a compliant mini-gripper with piezoelectric actuation [4].

For a five bar mechanism we propose a structure based on parametrization geometry which is presented in figure 2. The mechanism is symmetrical to the Oy axis, so we consider *AB=DE=l* and *BC=EC=L.* The driving elements are AB and DE.

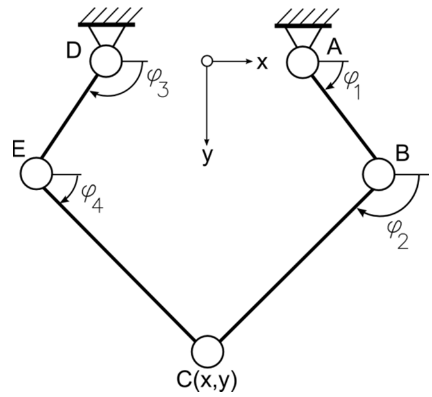

Fig. 2. The geometry of the five bar mechanism

By analyzing the direct kinematic equations one can determine the respective positions velocities and accelerations for expressions follower or a point on it, depending on the laws of motion of the motor elements. The coordinates of point C are known the values of the angles and after simulation it will obtained on the basis of the analytical relations. Based on the inverse kinematic analysis determined the laws of motion of the motor elements depending on kinematic parameters of point C. angle values, (i = 1 ... 4) knowing the coordinates x, y of point C can be calculated with the analytical equations [5].

For this mechanism the workspace is defined as the area determined by the x and y values for which the determinant of the matrix J_B is zero:

$$\det(J_B) = 0 \Rightarrow lL\sin(\varphi_1 - \varphi_2)\sin(\varphi_3 - \varphi_4) = 0 \quad (1)$$

where:

$$J_B = \begin{bmatrix} l \cdot L\sin(\varphi_1 - \varphi_2) & 0 \\ 0 & l \cdot L\sin(\varphi_3 - \varphi_4) \end{bmatrix} \quad (2)$$

There are several methods to determine the workspace most of them based on offline calculations done with numerical computing software (ex. Matlab, Maple etc.)

The classical methods of analytical calculation do not reflect the true functioning of the microsystems, so it is necessary to implement new methodologies involving virtual models to follow the actual behavior as closely as possible.

Following it is realized the 3D model for the five bar mechanism which is used in the CATIA v5. Our previous approach enabled us to develop a parametric CAD model where the variables are lengths of the kinematic elements and the angles by the actuators (Fig. 3).

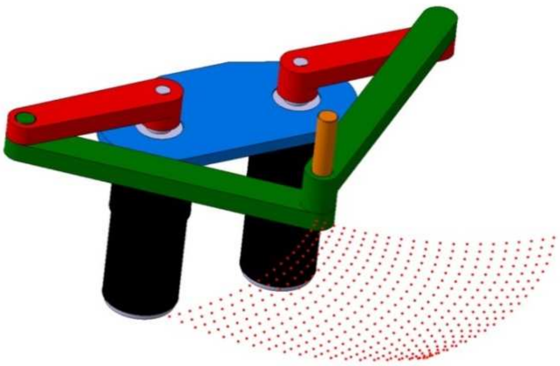

Fig. 3. The CAD model of SI2M and the workspace

The lengths of the elements can be modified to determine the optimal workspace for various applications. The mesh for workspace can be generated by the one set of the lengths.

The control of model parameters is achieved in an application developed with C#.

4. THE INTERFACE FOR FIVE BAR MECHANISM SIMULATIONS

The interface of the developed application is presented in figure 4. The application allows changing of the geometric parameters of the mechanism while still maintaining the imposed kinematic constraints.

This can be achieved using the textboxes (1). The position of the elements is modified with sliders (2) and the workspace generation is accomplished using the buttons (3). The interface also allows the manual update of CATIA model parameters (4). The application can be closed with the button (6) and the name of the opened assembly document appears in the text field (5).

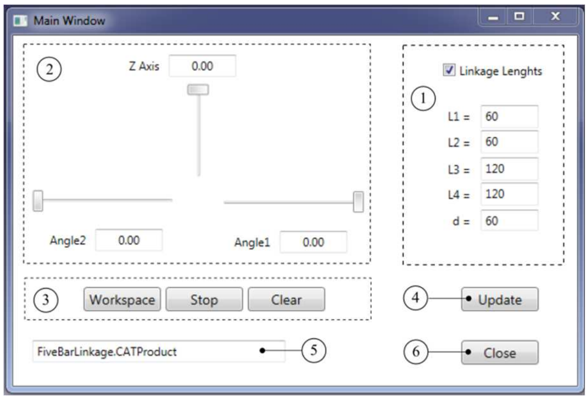

Fig.4. The interface of developed application

After results of the simulation it can be realized the prototype of the five bar mechanism.

5. TEST BENCH

The experimental study was focused on the workspace for different parameters. In the next figure a constructive variant of a five bar mechanism in the structure of the studied mini-system is presented.

The design of manipulating systems as well as the interactions at the system level between the mechanical structure, the actuators, the sensors, the electronics and the control algorithms, allows, in fact, benefiting from the proposed five mechanisms approach in the design of mechatronic equipment.

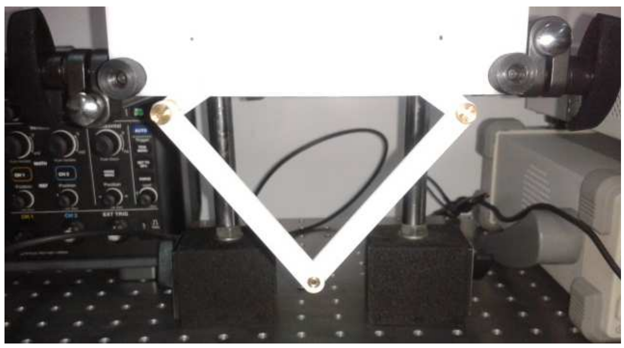

Fig.5. The test bench for experimental data

The structure of the test bench for measurements contains a Laser displacement sensor LC-2420 with resolution 0.01 µm and response time 100 µs [6].

6. CONCLUSION

The paper points out some specific problems in simulation of mini-mechanical systems built on various mechanisms. In order to simulate the performance of the five bars mechanism with workspace and present the experimental test bench was developed.

The mini-system can be successfully applied to the fields that need high precision in small workspace, such as: optics, precision machine tools and mini/micro component fabrication.

In the future the control will be realized in closed loop, with a reaction by position; it is necessary to measure the actuators displacements using suitable position sensors that needed to obtain the exact position required by the mechanism action.

The tests and the characterization of this mini-system are still in progress.

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Simularea si interfatarea mecanismelor utilizate in microfabrici

În această lucrare se prezintă proiectarea și simularea mecanismelor din structura manipulatoarelor destinate microfabricilor. Se propune o versiune miniaturizata a unui mecanism pentalater cu cuple cinematice clasice. Modelul CAD este parametrizat, lungimile elementelor putandu-se modifica, in vederea determinării spațiul de lucru optim. Controlul parametrilor modelului se face printr-o interfață dezvoltată în C #.

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