POSITIONING AND MICROPOSITIONING SYSTEM ON TWO AXIS

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Abstract. *The paper presents aspects regarding the achievement of the virtual model and the experimental model of a mechatronic system for positioning and micro-positioning, designed to be integrated into applications of precision positioning for measurement, characterization of surfaces in complex vector space and temperature, inductive displacement sensors calibration, etc.*

Keywords: *micropositioning, mechatronics, linear axis, microgripper*

1. INTRODUCTION

Considered at first as a prerequisite, now mechatronics is a single solution for achieving competitive high-tech products, which key indicators of quality are accuracy and reliability of both the new subfields as micro-electro-mechanical systems and advanced industrial fields at macro and medium scale.

Micro-positioning is needed in research and production applications for investigating surfaces: atomic force microscopy (AFM), scanning electron microscopy (SEM), focalized electron beam (FIB) and in micro-manipulation, in micro-assembly and micro-production [1]. Micro-positioning equipments development is directly influenced by the development of measurement technologies, manufacturing technologies of semiconductor materials as well as manufacturing technologies of electromechanical micro-systems [2].

2. VIRTUAL MODEL OF MECHATRONIC MICRO-POSITIONING SYSTEM

The main part of the micro-mechatronics flexible positioning system consists of two electric linear axis [3]. The design of the two electric linear axis was performed individually for each axis for horizontal or vertical mounting. In order to achieve the specified accuracy for guiding (see technical data), the axles are mounted on a controlled, plane surface, in order to avoid twisting the guides.

The gripper, mounted on the vertical sled, must ensure piece gripping for micro-positioning and supporting a piece with a mass of up to 0.5 kg. Gripper fingers are individualized by the shape of parts to be positioned.

Since positioning accuracy is of sub-micron size, is used a temperature sensor mounted in the structure of the system.

Linear axis drive is provided by DC motors, transmission of screw-nut type assures safety and positioning accuracy.

The electric drive is used as the unique solution to the product; it may be structured in various combinations with other types of drive systems.

For micro-positioning flexible system design was used aided design software Solid Works.

Figure 1 schematically shows the micro-mechatronics system, highlighting its components.

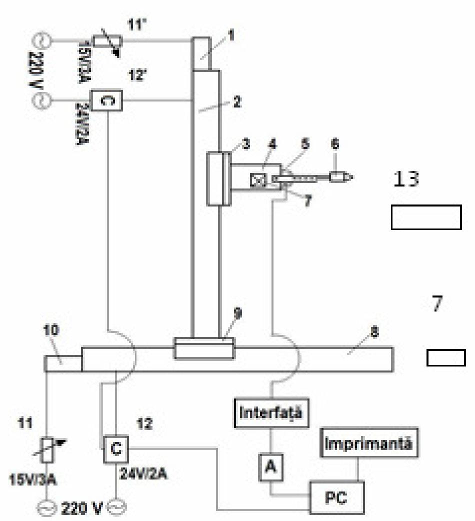

Figure 1. Scheme of the mechatronic system experimental model

In Figure 1, the notations correspond to the following components of the mechatronic system: 1 and 10 - DC motors, 2 and 8 - linear axis, 3 and 9 - linear axis sled, 4 - electric gripper, 5 – shaped fingers, 6 – piece, 7 - temperature sensor, 11:11 '- supplying, 12 and 12'- controllers, 13 – sensor for piece presence.

Figure 2 represents the kinematic scheme of mechatronic micro-positioning system.

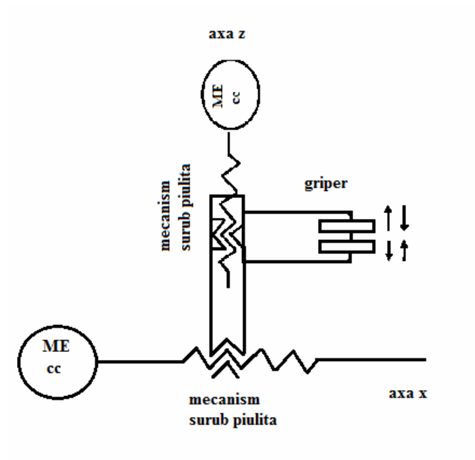

Figure 2. Kinematic scheme of mechatronic micro-positioning system

Figures 3 and 4 shows the ways to assemble linear xz axis, vertical and horizontal respectively, to illustrate how the forces and moments act on the mechatronic axis [XZ].

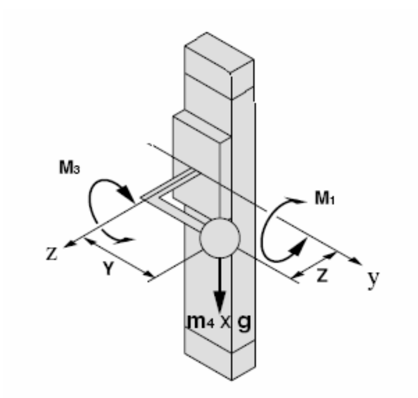

Figure 3. Mechatronic axis z vertical assembly

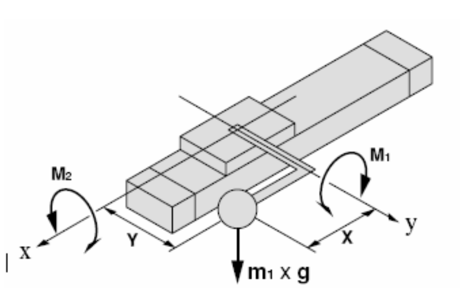

Figure 4. Mechatronic axis x horizontal assembly

Figure 5 shows virtually the placement on the aluminum workbench, of the linear positioning axis together with the gripping system, of the optical barrier and the parts warehouse.

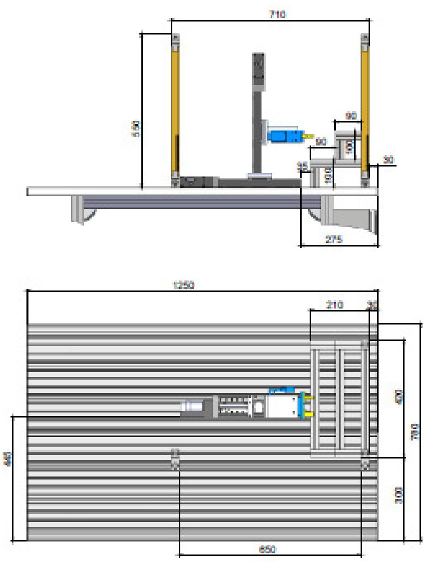

Figure 5. Representation of the placement of the linear axes and pieces magazine

Figure 6 shows a detail of the mechatronic system virtual system, highlighting the x and z axes and location of microgripper bracket.

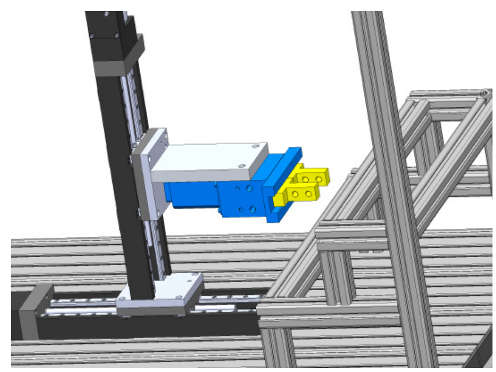

Figure 6. Highlighting the x and z axes and location of the microgripper bracket

In Figure 7 is shown the micro-gripper of micro-mechatronics flexible positioning system [3].

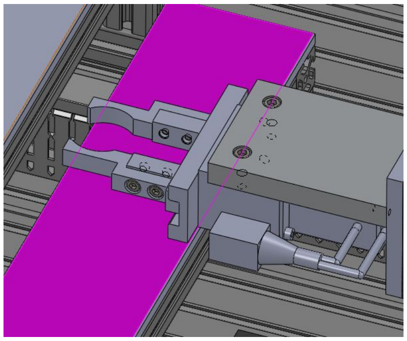

Figure 7. Representation of the gripper from micro-mechatronic flexible positioning system

In Figure 8 are the linear axes x and z and the gripper.

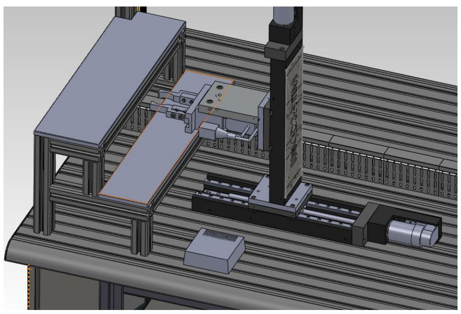

Figure 8. Representation of linear axes x and z and gripper

In Figure 9 is shown the virtual model of the whole mechatronic positioning/ micro-positioning system.

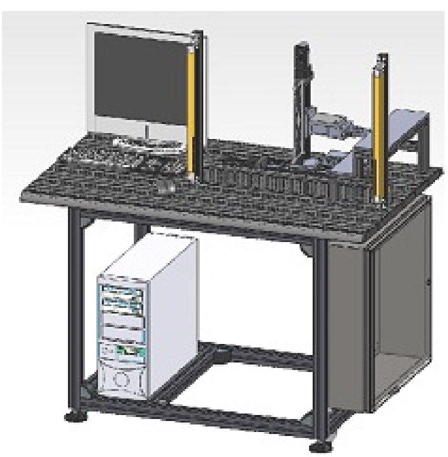

Figure 9. Representation of the whole micro-mechatronics flexible positioning system

3. REALIZATION OF THE MICRO-POSITIONING EQUIPMENT

The product, being a micro-mechatronic system that borders nano-mechatronic products, its main part is the positioning system, consisting of two linear axes electrically operated.

The two linear axes of the micro-positioning system shown in Figure 10 are connected to the two controllers, for each positioning axis the linear lifting being 200 mm.

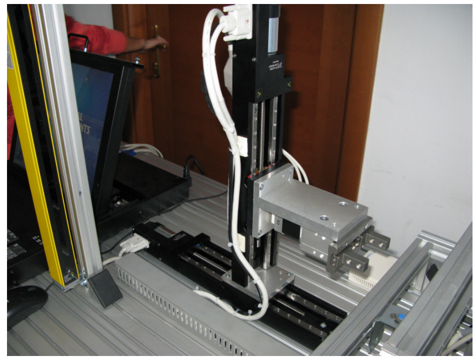

Figure 10. Positioning system, consisting of two vertically-mounted linear axis

The electrical linear axes transforms rotation of DC motor, supplied by 24V, in translational motion by the screw- nut type mechanism, displacement increment is 0.2 µm.

In Figure 11 there is shown the linear axis and its components.

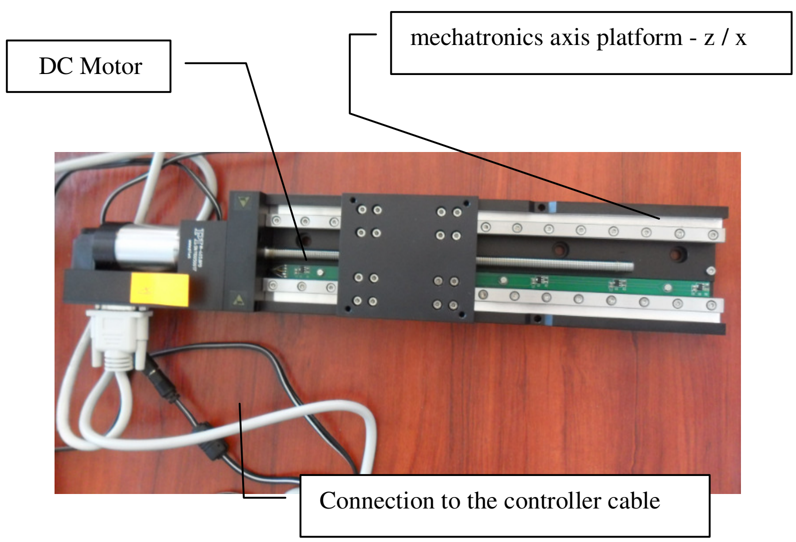

Figure 11. Electric linear axis

Electric gripper is mounted on the carriage vertically ensuring catching piece to micro-positioning [5] and permitting sustaining a piece with a mass of up to 0.5 kg. Gripper fingers are individualized by the shape of parts to be positioned.

Electric control system is positioned in a panel-accessibly mounted. The computer ensures the hardware part of the system, and is materialized by a laptop or desktop computer.

Since positioning accuracy is of sub-micron size, a temperature sensor mounted in the structure of the system is used.

The temperature sensor is included in the control circuit in order to warn or turn the system off if exceeding the ambient temperature which may compromise the accuracy.

Linear axis drive is provided by DC motors, transmission of screw-nut type assures the safety and positioning accuracy.

The electric drive system is used as the unique solution to the product; it may be structured in various combinations with other types of drive systems.

The electric gripper with two fingers which equips flexible micro-positioning system[4] with electric linear axis is controlled by the output controller and provides a constant force of about 50N, applied at a certain distance from the point of application to the base of the fingers.

4. MEASUREMENT OF THE CLAMPING FORCE FOR TWO FINGERS MICRO-GRIPPER

Clamping forces developed by electric micro-gripper fingers, included in the gripping system of the mechatronic micro-positioning system were measured using a force transducer compact C9B type, supplied by HBM (Hottinger Baldwin Messtechnick) Germany.

Compact force transducer, type C9B, whose image is reflected in Figure 12, can measure static and dynamic compressive forces up to 50kN. This force transducer is suitable for micromanipulation, pharmaceutical applications, processes of press connection, etc.

Figure 12 Compact force transducer, C9B type

The force transducer was chosen to determine the values of the clamping force because the material from which it is made (stainless steel) as well as robust and compact design provide high stability, in particular in the micro-measurement, enabling reliable measurements. Force transducer was used in connection with digital measurement unit type DK 38, manufactured by HBM Germany (Figure 13).

Figure13. Digital measurement unit, type DK 38

Measurements of the clamping forces developed by the micro-gripper were performed in static regime. Nine tests were performed, consisting in measuring the clamping force developed by micro-gripper fingers to grip the workpiece. The workpiece is considered to be the load cell, together with gauges used to vary the size of the workpiece.

In the closed position between electric gripper jaws remain a distance of 29.5 mm. Maximum jaw opening of electric gripper is 49.25 mm. Compact force transducer, type C9B has a height of 27.9 mm. In order to achieve measurements gauges were used ranging in size from 2 to 6.6 mm.

For each value of the thickness of the workpiece, there were three measurements of preload. In Table 1 are summarized the values for the tightening torque (both values obtained for each test, and average values), depending on the size of gauges used to vary the size of the workpiece.

Table 1

Thick feeler gauge[mm]	Workpiece thickness[mm]	Medium value of clamping force [N]
2,0	29,9	52,43333
2,1	30,0	51,94667
2,2	30,1	49,92333
3,0	30,9	51,30333
3,5	31,4	52,41667
4,0	31,9	41,50333
4,5	32,4	43,46667
6,0	33,9	47,08333
6,2	34,1	44,70000

In Figure 14 are shown developments of clamping force values obtained for tests performed.

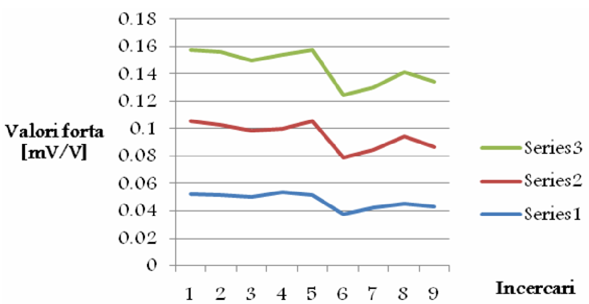

Figure 14. The force for each test

Figure 15 is showing the trend of variation of average clamping force depending on the size of the workpiece.

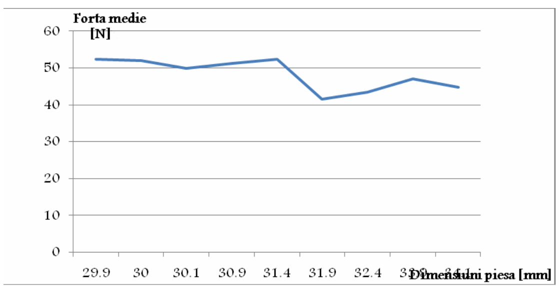

Figure 15. Trend of variation of average clamping force depending on the size of the workpiece

Although the first three tests seemed uniform clamping force will decrease as the size of the piece increases, at the end of nine tests it was found that the variation cannot be considered uniform for clamping force.

The linear evolution of the clamping force depending on the size of the workpiece is shown in Figure 16.

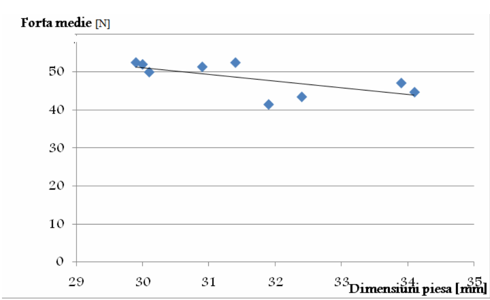

Figura 16. The linear evolution of the clamping force depending on the size of the workpiece

From the graph is shown that the trend of the clamping force is to decrease as you increase the size of the workpiece but cannot be considered a uniform decrease.

5. CONCLUSIONS

The experimental model of mechatronic/micro-mechatronic system of micropositioning and measurement was conceived, designed and built in modular manner and is in INCDMTM Bucharest laboratory, consisting of: horizontal linear positioning axis, vertical positioning linear axis; gripper with two fingers, electric drive system, controller, beam sensor, temperature sensor, position sensor, computer process, software process, mass support.

After testing and experimentation to determine the values of the clamping force of the gripper with two fingers, depending on the size of the workpiece, there are the following conclusions: although the first three tests seemed uniform clamping force will decrease as the size increases, it was noticed that at the end of nine trials the size variation cannot be considered uniform for clamping force. Preload trend is to decrease with increasing size of the workpiece. Clamping force is the average value in the range 41.50333÷ 52.43333 N, which is a difference of 10.93 N, for the size of the workpiece within the range of 29.9 ÷ 34.1 mm (that is a variation of 4.2 mm).

6. REFERENCES

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