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FUNCTIONAL MODEL AND SIMULATION OF PNEUMATIC MODEL AFFERENT TO PREHENSION VACUUM DEVICE

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ABSTRACT
This paper has presented a functional model of manipulator with pneumatic action, which has proposed to improve the technical performance of manipulator that acting of injection plastics machine. The authors had realized a 3D modeling of manipulator on which is fixed a final effector by vacuum type with four sucker grips. The manipulator has role pulling out of injected part within die and transferred this part to a conveyor which would transmitted part from a deposit container. After mathematical model is realized simulation for pulling out phase of part within die, which moving is assured by pneumatic motor of micro-moving modulus.
Keywords: manipulator, normal effector, sucker grip, vacuum.

1. INTRODUCTION
The automotive industry and advanced and automation manufacturing is imposed a quick development of industrial robots and its accessories which were improving quality parts and productivity and related human labor in hurtful work area.
The authors had proposed to improve the working performance of a manipulator with pneumatic action which is operating an injection machine of plastic materials. In this aim is realized a 3D modeling of manipulator [1,2] on which is clamped a final effector by vacuum type with four sucker grips. The manipulator has task of pulling out of injected part from die and transferred this parts to a conveyor which continuing transfer the parts from a deposit container. For that it’s done a mathematical model of the pulling out phase of part within die by a pneumatic motor, being following by simulation.

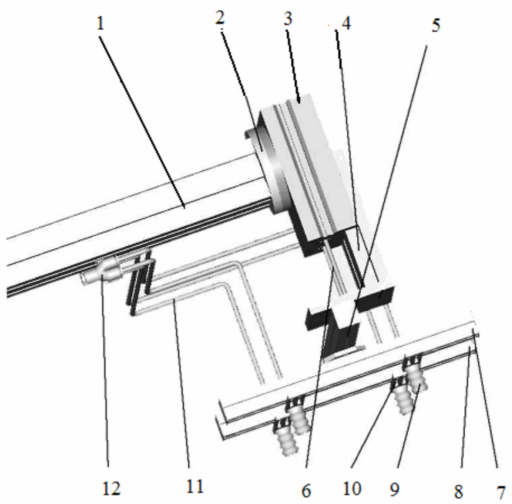


Figure 1. Vacuum prehension device of manipulator.

The detail of vacuum prehension device is presented in fig.1, being compound from: *1*-mechanism of orientation, *2*-coupling element, 3-modul of micro-moving, *4*-mobile support plate, *5*-central support, *6*-pneumatic motor with two piston, *7,8*-side way supports, *9*-sucker grips, *10*-supports sucker grips, *11*-pipe of link void, *12*-energetic interface.

2. MATHEMATICAL MODEL

Mathematical model [1] is get in from mobile element moving of pneumatic motor from prehension device structure, which is connected at pipes necessary vacuum realizing in port-sucker grips supports at sucker grips level, going to particularization of this equation for ever sequences resulting following:

- Sequence 1: because motor pistons displacement is done without resistance forces and didn't touch the sucker grips the surface of handling object the equation becomes:

$$m\frac{d^2x}{dt^2} = P_1S_1 - P_2S_2 - P_0S_t - c_0\frac{dx}{dt} - \sum F_{fi} \quad (1)$$

In which reducer mass-*m* [kg] of pneumatic motor rod is given by:

$$m = 2\cdot(m_p + m_t) + m_g + m_{bp} + 2\cdot m_{bpc} + 4\cdot(m_{sv} + m_v) \quad (2)$$

, where: m_p-is piston mass, m_t-rod mass, m_g-sliding mass, m_{bp}-catching arm mass, m_{bpc}-central catching arm mass, m_{sv}-mass of sucker grip support, m_v-sucker grip mass. If it's considered that pressures within chamber-2 of pneumatic motor are equal with atmospheric pressure-$P_{o,}$ equation (1) becomes:

$$\left(2\cdot(m_p + m_t) + m_g + m_{bp} + 2\cdot m_{bpc} + 4\cdot(m_{sv} + m_v)\right)\frac{d^2x}{dt^2} = P_1S_1 - P_0(S_2 - S_t) - c_0\frac{dx}{dt} - \sum F_{fi} \quad (3)$$

- Sequence-2: it's characteristic coming out a elastic force in moving equation due to occurring forces in sucker grips during them distortion, resulting:

$$m\frac{d^2x}{dt^2} = P_1S_1 - P_0(S_2 + S_t) - 4\cdot k\cdot x - c_0\frac{dx}{dt} - \sum F_{fi} \quad (4)$$

, where: *k*-is elastic constant of sucker grip. By substitution mass-*m* (from eq-2) in eq (4) is obtained:

$$\left(2\cdot(m_p + m_t) + m_g + m_{bp} + 2\cdot m_{bpc} + 4\cdot(m_{sv} + m_v)\right)\frac{d^2x}{dt^2} = (P_1 - P_0)\cdot S_1 - 4\cdot k\cdot x - c_0\frac{dx}{dt} - \sum F_{fi} \quad (5)$$

- Sequence-3: it's prehension of injected part being realized with these four sucker grips.
- Sequence-4: it's pulling out of injected part doing by come back of manipulator arm, in this case can be written:

$$m'\frac{d^2x}{dt^2} = P_1S_1 - P_2S_2 - P_0S_t - 4\cdot k\cdot x - c_0\frac{dx}{dt} - F_a + F_e - \sum F_{fi} \quad (6)$$

, where: *m'*-is reducer mass of motor rod with m_{0L}-mass of injected part, F_a-adession force of object at die; F_e-extraction force. Also, eq.(6) can be written:

$$\left(2\cdot(m_p + m_t) + m_g + m_{bp} + 2\cdot m_{bpc} + 4\cdot(m_{sv} + m_v) + m_{OL}\right)\frac{d^2x}{dt^2} = P_1S_1 - P_2S_2 - P_0S_t - 4\cdot k\cdot x - c_0\frac{dx}{dt} - F_a + F_e - \sum F_{fi} \quad (7)$$

- <u>Sequence-5:</u> it's withdraw of arm manipulator after detachment of injected part within die, can be written the motion equations:

$$m'\frac{d^2x}{dt^2} = P_1S_1 - P_2S_2 - P_0S_t - c_0\frac{dx}{dt} - \sum F_{fi} \qquad (8)$$

$$\left(2\cdot\left(m_p + m_t\right) + m_g + m_{bp} + 2\cdot m_{bpc} + 4\cdot\left(m_{sv} + m_v\right) + m_{OL}\right)\frac{d^2x}{dt^2} = P_1S_1 - P_2S_2 - P_0S_t - c_0\frac{dx}{dt} - \sum F_{fi} \qquad (9)$$

3. SIMULATION

The mathematical model was an important step in realizing functional simulation of prehension device for pulling out phase of object within die, the moving is assured by a pneumatic motor of micro-moving modulus. The goal of modeling and functional simulation of prehension device of manipulator is that to foreseeing its working in such away as injected plastic items undetached from vacuum prehension device during pulling out, before its physical building up.

This simulation is realized by using Symulink Program from MATLAB R14.v.7.01 System. The functional model of prehension device [1] by using Symulink Program is presented in fig.2, being compound from: enter signal block, command system of final effector, and exit block. The step signal is get in command system of final effector which has proposed of position device monitoring and approaching speed of sucker grips from prehension workpiece. The results of tests are plotted by the display block of diagrams for displacement and speed.

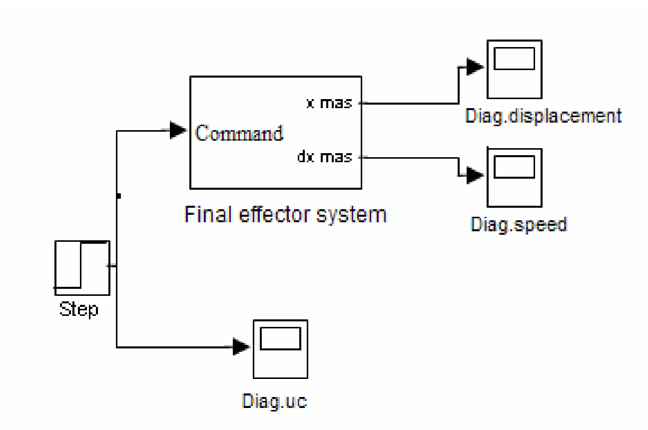
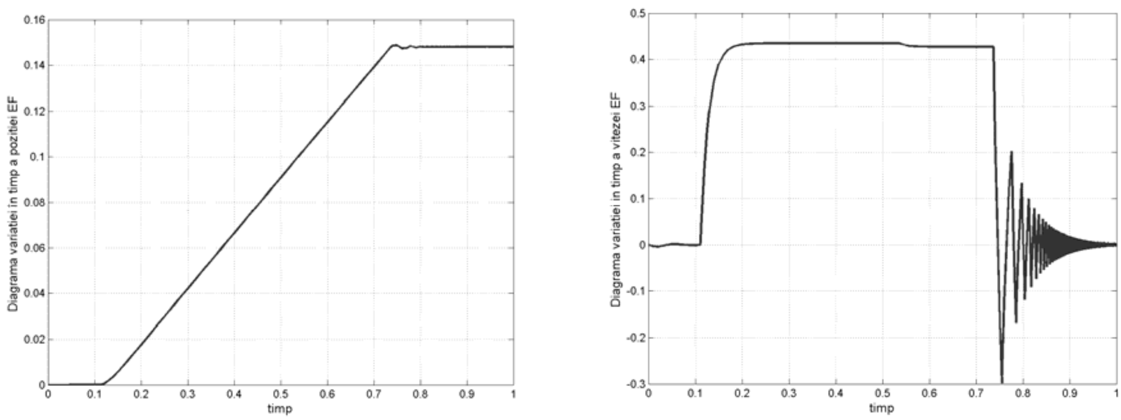


Figure 2. Functional model of prehension device of manipulator.



a. displacement b. speed

Figure 3. Diagrams of position variation in time for prehension device.

The simulation tests [1] were realized for many tensions voltage of command at servo-valve system. In dependence with these values were plotted prehension device diagrams of variation in time for displacement, respectively for speed. An example of result tests for values: U_c=5.1V, k=737N/m is depicted in fig.3.

4. CONCLUSIONS

The results of tests functional simulation of prehension device system of manipulation are confirmed mathematical model thinking out by authors. By analyzing of diagrams of position device by functional simulation they are corresponding with a normal working of manipulator, which is endowed with an execution element with pneumatic action, necessary for optimal working of translation moving modulus.

The response system simulation and sequence of sucker grips compression which following to be pulling out within injected die of plastic material.

5. REFERENCES

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