Proceedings of the International Conference on Manufacturing Systems – ICMaS
Vol. 4, 2009, ISSN 1842-3183

University POLITEHNICA of Bucharest, Machine and Manufacturing Systems Department
Bucharest, Romania

DESIGN OF NETWORK MODEL FOR HOT BILLETS AUTOMATIC-LOADING SYSTEM FOR PRODUCTION OF ALUMINIUM PROFILES

Ivo MALAKOV, Georgi GEORGIEV, Roman ZAHARIEV

Abstract *This paper presents the results from development of multitude structures variants for network model for hot billets automatic-loading system for production of aluminum profiles. For this purpose on the base of the system approach was built functional model of the system and were designed elementary executer devices which execute the partial function of the system. Compatibility between them is defined, this is, the possibility for collaboration in joint structure. The multitude of structure variants is present through network model.*

Key words: *network model, extrusion, automatic loading and elementary executer device*.

1. INTRODUCTION

The first task in the design process of the systems for automation on technologicals processes was created of the multitude structures variants. These systems contain collectivity from executer device, called conditional elementary, which serve different operation in technological process.

In this case, an automatic system for loading hot billets into presses for production of aluminum profiles was built. Additionally, it must work synchronically with the remaining executer devices and mechanisms. We will use this system to transport the hot aluminum billets with 500^0 C temperatures from oven into presses for extrusion of aluminum profiles (Fig.1) and loading the billets into the presses. This system is a part of flow line for production of aluminum profiles.

In the process of creating of the possible structures variants of elementary executer devices, which are executing the particle function of the system, were taken into consideration the specific of the extrusion process [4] and the following technical characteristics of the system:

- Parameters of the billet:
  - weigh maximum – 20 kg.
  - size – Ø130 × 240÷ 400 mm.
  - temperature – 480 C ° ÷ 500 C °.
  - positioning precision – ± 2 mm.
- Occupied area of the system, considered with the free area of 3.78 m^2 between the oven and the extruder.
- Transport distance of the billet – ~2 600 mm with adjusment possibility.
- Operating range from 30 to 80 sec depending on profile's type and billet's size.

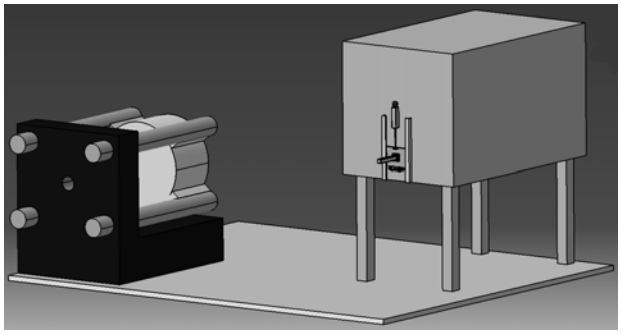

Fig. 1. Relation between the oven and extruder.

2. NETWORK MODEL OF THE STRUCTURES VARIANTS MULTITUDE

In the solution process of choosing the optimal structure variant of the system, we used network model of the structures variants multitude, shown on Fig. 2. The network models comprise 18 elementary executer devices, which are arranged in five columns depending on the functions that they execute and the relations between them. From this multitude, using the methods for multicriteria optimization, the optimal one is defined [1].

The three main partial functions of the system are, as follows:

- Taking out the billet from the oven and its axial transportation.
- Transportation of the billet and its positioning with the axis's matrix.

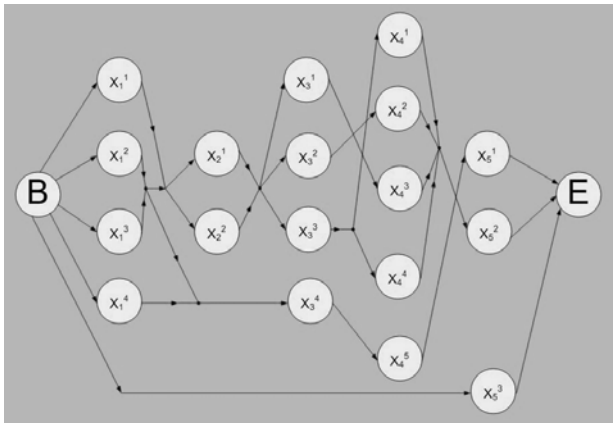

Fig. 2. Network model of the structures variants multitude.

- Axial transportation of the billet until it contacts the matrix and the contact is supported until a defined closing stage of the container.

The columns number is larger than the number of the partial functions, because additional manipulations with the billet are necessary.

The elementary executer devices in the network model are registered with x_n^l, where n is the number of the column and l is the consecutive number of the device in the column.

3. DESCRIPTION OF ELEMENTARY EXECUTER DIVICES

Because the multitude of structure variants is very wide and capacity of the paper is limited, only portion of the elementary executer devices will be shown. Different variants for system for automatic system loading hot billets into presses for production of aluminum profiles are created, taking into consideration the specifics of the extrusion process [4] and the peculiarity of the automation and robotization of specific technological processes [2, 3, 5].

The elementary executer device x_1^3 shown on Fig.3 is located in front of the oven. In this case, the griper takes the billet from the face site. The system is insured by supporting rollers, because of the high billet's mass and small contact surface with the griper.

The process begins when oven door is opened and the hot billet comes out. Then the device takes the billet and extracts it from the oven. The device is built from two round guide bars and it is driven by pneumatic cylinder.

The elementary device x_1^4 is shown on Fig.4. This device is gravity roller transportation. When the hot billet comes out of the oven, it is carried out by the billet extractor conveyor and it is stopped by the stopper at the end of the conveyor. Once the billet is stopped, it can be transported by gravity transportation or manipulator. The specific in this case is that oven's billet-extractor must have stroke length as much as the billet length. In previous case x_1^1, x_1^2, x_1^3 the extractor stroke length is independent from the billet length.

x_1^2 is elementary executer device serving for translocation in lower level in vertical direction, as shown on Fig. 5. This operation is necessary for easier transmission of the billet to next devices. This device is built by column and round guide bars and is driven by pneumatic cylinder. The elementary executer devices x_1^1, x_1^2 and x_1^3 can be easily fastened to the x_2^1.

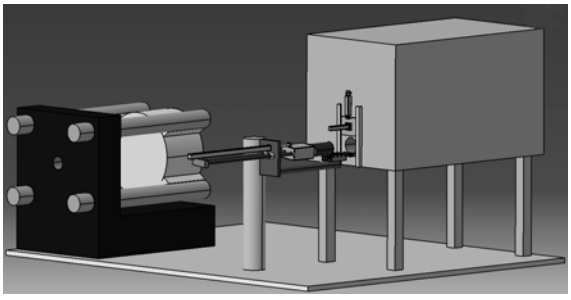

Fig. 3. Elementary device x_1^3.

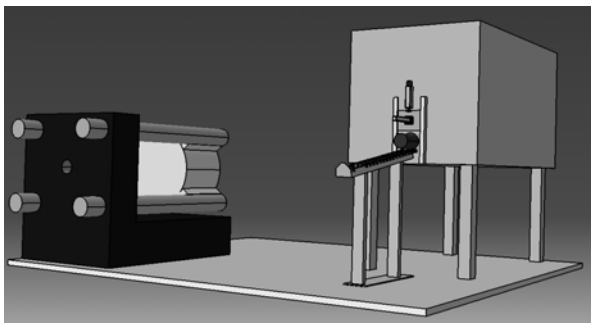

Fig. 4. Elementary device x_1^2.

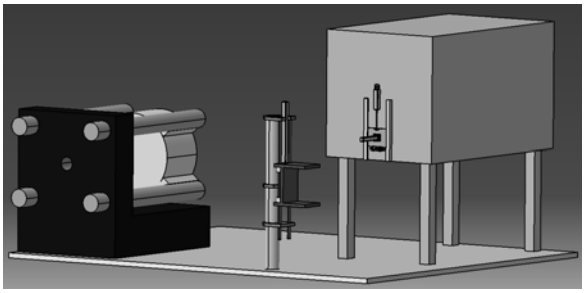

Fig. 5. Elementary device x_2^1.

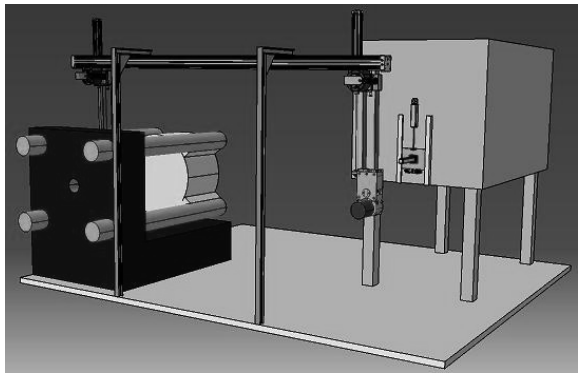

Fig. 6. Elementary device x_3^1.

The elementary device x_3^1, shown on Fig.6, carries out the main operation of the mechanical arm from the oven door's axis to the matrix axis in the press. In this task, the distance between these axes is 2 600 mm with adjusment possibilities.

The device is built on the base of DGPL-63-2800 of the firm FESTO with the following features: stroke length 2800 mm, piston diameter 63 mm, position sensing, without piston pin, mechanical coupling between the piston and the slide, adjustable end-position cushioning systems and plain bearing guide.

We have chosen this element, because it fulfills the requirements of the system.

The main operation of the billet is combination from the oscillation motion of the arm direct-coupled of the output shaft of the gear-motor, which rotates on 180 degrees toward the inception position and the translational arm end. The gear-motor is made by firm SEW-Eurodrive SDFT90L8 / RM67_Fl300.

The motor has a built in electromagnet break, feedback system in position, frequency inverter for ease speed control. The gear is with extended output bearing

hub, which is a special type of helical gear-motor. The hub was designed especially for agitating applications and allows high overhung, axial loading and bending moments. The gear motor is mounted to the frame of the manipulator through flange. The translational arm end is driven by pneumatic. This elementary executer device x_3^2 is shown Fig.7.

The elementary device x_3^3, shown Fig.8, consists of big rotate arm, which is mounted through bearing to the flange on the gear motor DFTE90C/R87F and is direct-coupled on output shaft. The small rotate arm is mounted through elementary executer device x_5^2 (Fig. 12) to the big rotate arm and it can operate in radially and axle directions.

The kinematic relation between the big rotate arm and small rotate arm is realized through passively roller chain with selected suitable gear ratio for optimal transport trajectory. This decision allows both rotate arms to operate with one gear motor, located in the manipulator bottom which relieves the dynamic processes during manipulator motions and simplifies the control.

The elementary executer device x_3^4, shown on Fig.9, is gravity transportation. The device is installed on elementary executer device x_4^5 considered below. It can work with x_1^2, x_1^3, x_1^4 devices. It is chute-conveyor built of two semi-chutes as one of them is mounted on the x_4^5 device while the second one is installed on the first one by two round guide bars and is driven by pneumatic cylinder.

This allows adjustments of the chute-conveyor adjustment to different billets size. The transport is simple – the billet rolls out itself and is stopped by the stopper at the end of the conveyor.

The task of elementary device x_4^5, shown Fig.10, is to transport the hot billet in conjunction with executer device x_3^4 to press's center for future manipulation with the billet.

The elementary executer device is driven by linear drive DGPL–63–530 made by firm FESTO with stroke length 530 mm, piston diameter 63 mm, position sensing, without piston pin mechanical coupling between the piston and the slide, adjustable end-position cushioning systems and plain bearing guide.

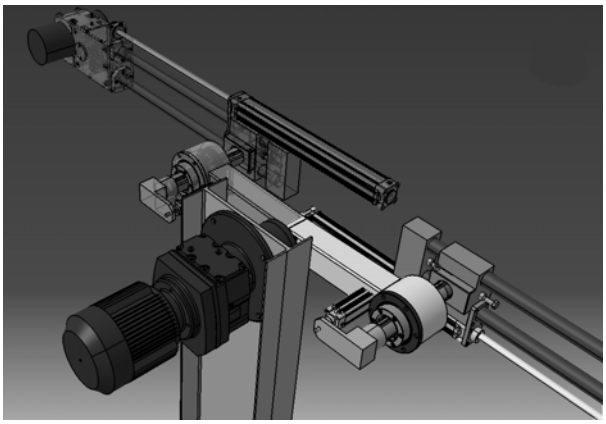

Fig. 7. Elementary device x_3^2.

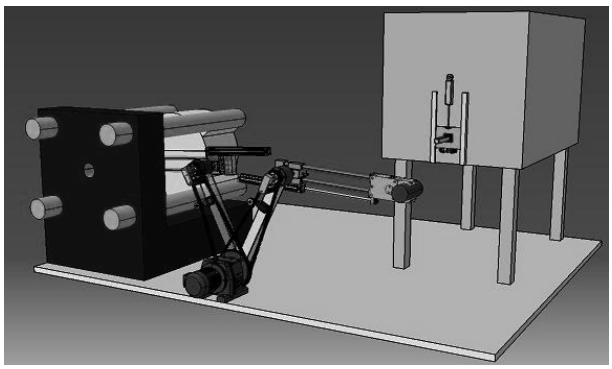

Fig. 8. Elementary device x_3^3.

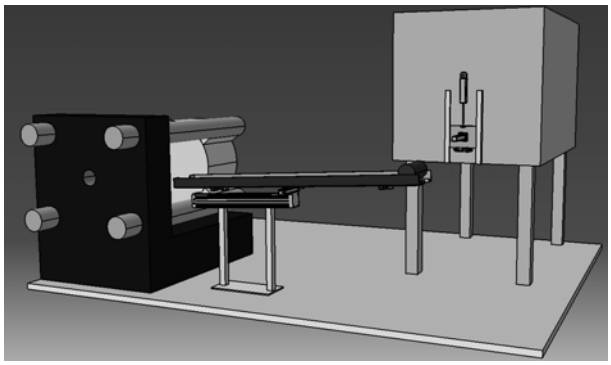

Fig. 9. Elementary device x_3^4.

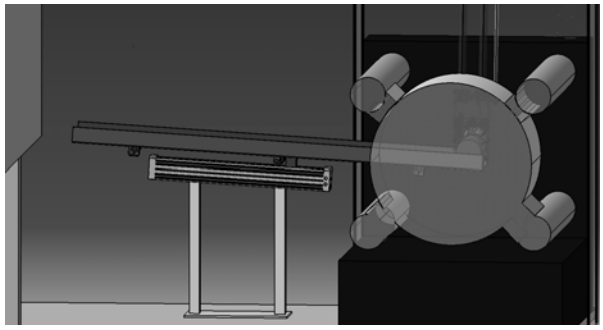

Fig. 10. Elementary device x_4^5.

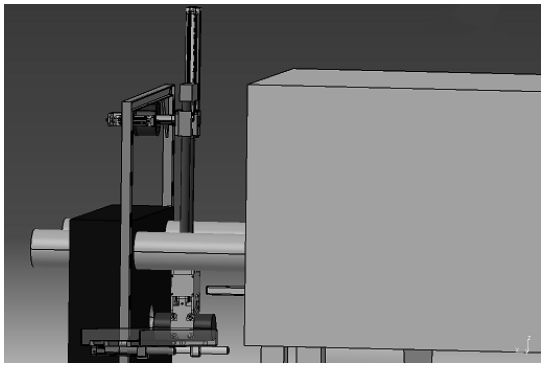

Fig. 11. Elementary device x_5^1.

The executer device x_5^1 (Fig. 11) is mechanical arm with griper. The contact between the billet and the griper is in four points only, in order not to deprive of billet's temperature. The device executes the axial transportation of the billet until it contacts the matrix and the contact is supported until a defined closing stage of the container.

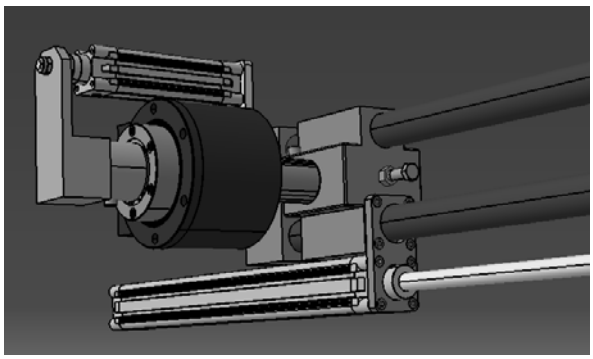

Fig. 12. Elementary device x_5^2.

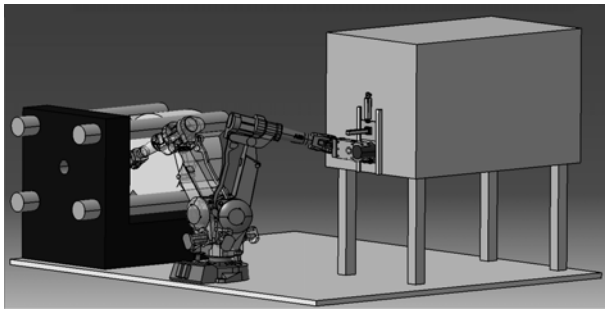

Fig. 13. Elementary device x_5^3.

Device x_5^2 (Fig.12) has the same functions as device x_5^1. When the container is partially closed, it grasps the billet. Then the device releases the billet and takes start position.

The device x_5^2 (Fig.13) is a robot IRB 2400–10 made by firm ABB with six axes of freedom and handling capacity of up to 20 kg. On the arm is mounted hot-hard griper. Lever mechanism in the griper ensures the blocking of the cheek in the maximum effort zone.

4. CONCLUSIONS

The created variants for hot billets automatic-loading system for production of aluminum profiles, presented in this paper, contribute wide possibility for solutions of one complicated problem like automation transport of the hot billets into presses for production of aluminum profiles.

The usage of network model has priority over the remaining presenting methods of possible structures variants like description, table form, etc. The priorities are: high compactness, which every device executing defined partial function to be written only once; its inserting in different variants carried out through the model arcs; create good visualization of the connections between the elements of the system and the compatibility between them; facilitate the formalization on the process of optimal variant search; easily supplement and/or reduction on the partial function and elementary executer devices.

For the concrete example are created following elements of the design process:

- System variants variants for hot billets automatic-loading system for production of aluminum profiles, are created, taking into consideration the extrusion process specifics and peculiarity with automation and robotization of specific technological processes.
- A network model of multitude structures variants for hot billets automatic-loading system for production of aluminum profiles, is created, which comprises elementary devices for executing the particle function and the connections between them.

REFERENCES

[1] Collette, Y., Siarry, P. (2003). *Multiobjective Optimization*, Springer, 3–540–40182–2, Berlin.

[2] Pavlov, V. (1993). *Проектиране на промишлени роботи* (Design of Industrial Robots), TU Sofia Publishing Office, Sofia.

[3] Tchakarsky, D., Vakarelska, T., Stankov, Vl., Raikov, A. (2004). *Промишлени роботи, роботизирани технологични модули и системи* (Industrial Robots, Robotized Technological Modules and Systems), Books 1 and 2. TU Sofia Publishing Office, Sofia.

[4] Sheppard. T. (1999). *Extrusion of Aluminum Alloys*. Springer, 0412590700, NY.

[5] Staib, G., Dörrhöfer, A., Rosenthal, M. (2008). *Components and Systems: Modular Construction - Design, Structure, New Technologies*, Birkhäuser, 376–386568, Basel.

Authors:

PhD, Ivo MALAKOV, Assoc. Professor, Technical University of Sofia, Mechanical Engineering Faculty, Dept. Automation of Discrete Production Engineering,
E-mail: ikm@tu-sofia.bg

Eng, Georgi GEORGIEV, PhD Student, Technical University of Sofia, Mechanical Engineering Faculty, Dept. Automation of Discrete Production Engineering,
E-mail: georgi6@abv.bg

PhD, Roman ZAHARIEV, Assoc. Professor, Bulgarian Academy of Sciences, Central Laboratory of Mechatronics and Instrumentation, Dept. Mechatronics Handling Mechanisms and Systems,
E-mail: roman@clmi.bas.bg