The assembly line model at Department of Cybernetics and Artificial Intelligence

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***Abstract*— The main objective of this article is a basic description of the assembly line located at the Department of Cybernetics and Artificial Intelligence. It is a practical educational model designed to improve the quality of the teaching process and also for research purposes. The description is focused on essential division of assembly line to functional blocks - posts. The assembly line has its global aim, and every post has its well defined role, so that the resulting aim is achieved.**

***Keywords*—Assembly line, technological communication networks, PLC (Programmable Logic Controller), educational model.**

I. Introduction

In the framework of projects supported by EU Structural Funds are at the Technical University in Košice built research centers of excellence [4]. Under the leadership of Doc. Ing. Ján Jadlovský CSc. the Department of Cybernetics and Artificial Intelligence has completed assembly line named Flexible Assembly Company (FAC). FAC model also with the another assembly line [3] are located in laboratory V147 at Vysokoškolská 4. Its location in this room is also shown in Fig.1.

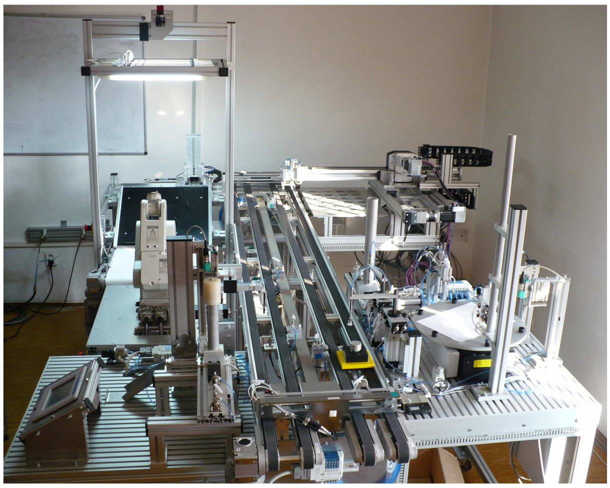

Fig. 1. The assembly line located in the premises of the department.

FAC model will serve as support for research and diagnosis of of industrial communication networks, the modelling of production lines, but the main task of this model is to improve the quality of the teaching process. Therefore, the model was specifically designed and this fact explains the details and selected technologies, which in practice would be better to choose alternatively to optimize the reliability and simplify the assembly process. The purpose of the model, however, was not to optimize proposal and a subsequent programming of the model, but summarize in one place as much possible technological elements as it possible. At this case students have the opportunity to become acquainted with multiple technologies and solutions, which are used in practice, and all in the one place. The FAP model obviously does not contain all the technologies used in practice, but the designers decided to use just those which they themselves frequently use in practice, and with which would be able to meet also graduates of our department in practice in the future. Some information about the technologies and design of this model are described in the following parts of the article.

II. Assembly line output

The aim of the assembly process FAC is to assemble a product that is shown in Fig.2 (B). The resultant product consists of four intermediate products (Fig.2 (A)) that are assembled together by the assembly line in such way that product on pallette comes through the process posts and the intermediate products are progressively mounted together until a resultant product is completed. After its completion on output of assembly line is saved to serviser and awaiting to order allocation. The entire assembly process can be divided into five positions – posts (Fig.3). The entire assembly operations are divided between these five posts till to store the finished product warehouse. Each post has a well defined action, and these are directly linked to each other, i.e. that each post is waiting to close on the previous post, except the post number 1 (Fig.4), where the entire assembly operation

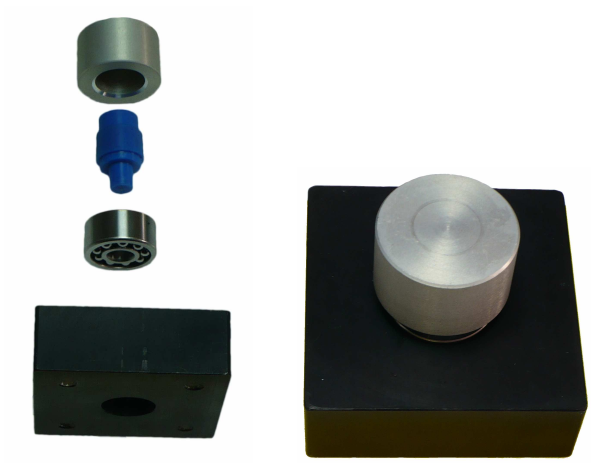

Fig. 2. Individual parts of the product in the order they are assembled (A). The resulting product (B).

begins. In the fully operation of assembly line it should not happen, when would any post was in work and others should be idle because the design and hardware assembly line enables production of multiple products simultaneously. Matter of course is the synchronization of individual activities so that there is a collision in the production process. Consecutive posts have the ability to arrest the intermediate product on belt conveyor until then, when the next post released, although the previous post has already finish its activity. Assembly line work will be cyclically repeated, up to the fulfilment final product store. Products are transferred between the various posts by using a special palette (in the middle part of Fig.1 we can see palette with already finished products situated on the belt conveyor). Palette itself is therefore not part of the finished product and hence will not be placed in serviser. All pallets are situated on a belt conveyor and either they are waiting in the queue at the beginning of the assembly process, or move product between the posts assembly line.

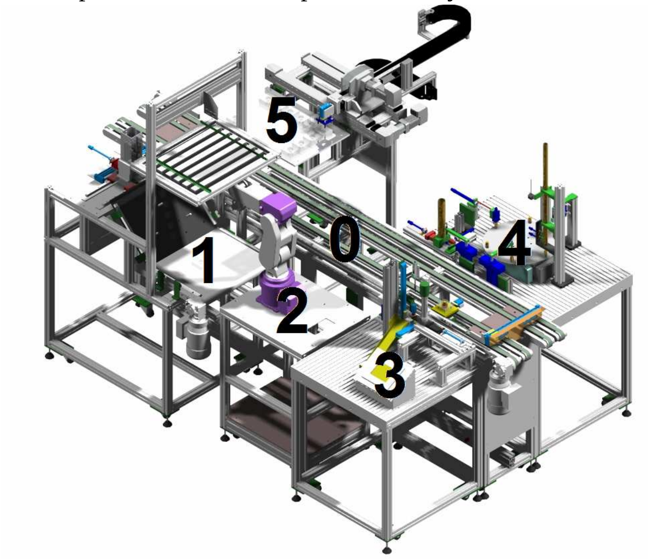

Fig. 3. Graphic design of the assembly line with the numbered posts.

III. DESCRIBED POST FUNCTIONS OF THE FLEXIBLE ASSEMBLY COMPANY

A. *Post 0 – Belt conveyors*

Belt conveyors are situated in the middle of the assembly line, as can be seen in Fig.3 (also in the Fig.1) and serve to transfer the product at each assembly line posts. Belt conveyors are powered by three-phase motors with a gearbox to drive the belt conveyors at a constant speed and constant direction. The conveyors are triggered in software and should move during the whole operation without stopping the assembly line. Stopping the pallets with products in the required position is indicated by the presence sensors and is done by using of pneumatic up-tongues that stop the palette at the required position on the belt conveyor, although it still runs. In this way is resolved the independence of assembly tasks (post) among each other, although they are located on the same belt conveyor (on the belt conveyor can move independently at the same time multiple pallets). If there is palette with products at the end of belt conveyor is necessary to move it to another belt conveyor. And because the belt conveyors are moving against each other, so the begin of the second belt conveyor is now near the end of the first one. At both ends of these conveyors is therefore simple pneumatic device, which ensures pallets movement from the end of the first, the belt on beginning of second one.

B. *Post 1 – Ejecting the blocks and camera system*

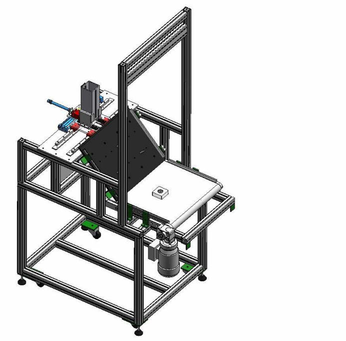

Fig. 4. Graphic design of the Post 1 – Ejecting the blocks and camera system.

On the Post 1 (Fig.4) starts the assembly process. This post contains a serviser for black plastic blocks into which will be inserted other parts of the product (bearing, plastic shaft and metal cap). Blocks are pneumatically removed from a special serviser on sloping surface that contains pins, which has randomly rotated the blocks. Subsequently, randomly rotated block gets on a wide white belt conveyor located behind mentioned sloping surface. Above the belt conveyor is color industrial camera with artificial lighting, which is connected to desktop computers, whose task is to process data from the camera and on the basis of these data to calculate the exact position and rotation of the block on a belt conveyor. Data from the camera system are forwarded to the central control computer PLC (Programmable Logic Controller), which uses the data for coordinate movements of industrial robot arm. To facilitate the image recognition has the belt conveyor a white color and it is powered by three-phase motor with gearbox, whose speed is controlled from a PLC via a frequency converter.

C. *Post 2 – Robotic arm*

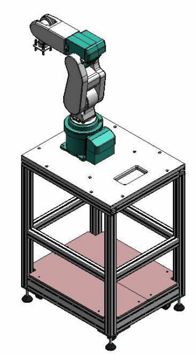

Fig. 5. Graphic design of the Post 2 – Industrial robotic arm Mitsubishi RV-2SDB with the rack for placing of its control system.

From the first post and from the belt conveyor is the block grabbed by the the arm of robot (Fig.5) and thanks to the information from the camera system about the position and the rotation of blocks is the arm able to grab a block from anywhere on the conveyor and move it to an empty palette placed on a belt conveyor (Post 0). It is a dimensionally small industrial robot Mitsubishi RV-2SDB that has on the end of the arm positioned pneumatic suction, by using which is able to manipulate with the blocks. The arm design gives it a very good movement abilities, by using which it can also move in a limited workspace. [2] Kinematic structure of the robot arm has six degrees of freedom powered by six servomotors, which give it very good dynamics and precision of movement. The arm is attached on a special control computer supplied by the manufacturer, which is an essential part of an industrial robot and directly manages and monitors the activities of arm. This control computer is physically located below the arm worktop and directly supplies the arm actuators. Mitsubishi robot by using its control computer can communicate with other control systems or devices the surrounding technological communication network. Even in the FAC application is robot connected to the control PLC by technological Profibus network, via which it receives control commands and information about the location and rotation of the product on a belt conveyor (Post 1) from the master PLC, which led it operates.

D. Post 3 – Inserting bearings and PanelView

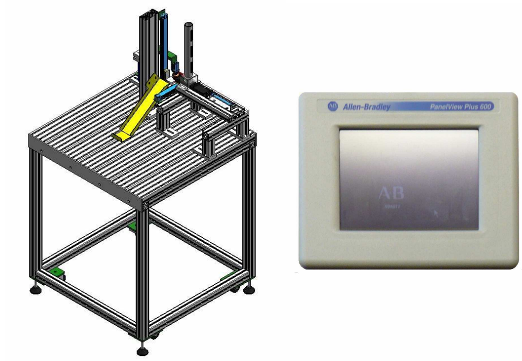

Fig. 6. Graphic design of the Post 3 – Inserting bearings rack (A). PanelView Plus 600 (B).

After the previous activities of the posts the block is loaded on a pallet belt conveyor and in it is necessary to insert the bearing. Bearing, however, must have the correct height. Maximum outer dimension of the bearing is limited by serviser size. So bearing is necessary to pick from a serviser, to measure and insert it into the block. And these activities are carried out in the post 3 (Fig.6). Bearings are situated in the serviser similar to that on the Post 1, but this is in the shape of a hollow circular cylinder. At the bottom part of serviser are by the pneumatic piston removed new bearings. In the serviser of our application are bearing of two dimensions. Therefore, after ejecting the bearing from the serviser is always measured his height. If the dimension of the bearing is unsuitable then it is discarded and from the serviser is ejected the new bearing. This operation is repeated until from the serviser is obtained bearing with the correct dimensions and then by using a rotary pneumatic manipulator is inserted into a prepared block, which is already waiting on the conveyor. When the correct bearing is embedded into the block, then the palette with the product proceeds by the conveyor to the next post.

Post 3 include also a small touch screen PanelView Plus 600, which is connected to the controller PLC.

E. Post 4 – Inserting plastic shaft and metal hats.

Final assembly work is carried out at the Post 4 (Fig.7). Into the imbedded bearings in the plastic block is still imperative to insert a plastic shafts, on which is ultimately put metal cap. On Fig. 2 (A) are both parts are displayed in the upper part of the picture.

This post consists of 6-position rotary table - rotary conveyor, which is the central facility of the post. At each of its six positions can either insert plastic shaft or metal cap. Rotary conveyor thus serves the fast and accurate transfer of hats and shafts between the devices, which are located in this post. Under the title devices, it is necessary to understand the sensors, servisers and pneumatic handlers, whose job is to choose caps and shafts with the right parameters and then use those to complete the final product.

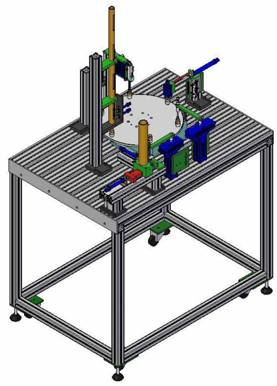

Fig. 7. Graphic design of the Post 4 – Inserting plastic shaft and metal hats.

Caps and shafts have its own serviser above the rotary table, and at each one there are two types of stored products. Operator must manually fills the serviser. From the serviser to the rotary table positions are these semi-product situated by pneumatic devices. Plastic shaft dimensions are the same, but are distinguished by the colour to green and blue. The application is operator fault-tolerant, because he could insert shaft into the reservoir rotated incorrectly. Metal caps are also dimensionally identical and also are together in the same serviser, but they differ in material from which they are made (metal and aluminium). Each tray is located above the one of the positions of the rotary conveyor, what makes together two used positions. Over the other two positions of the rotary conveyor are situated special sensors, videlicet sensor colour and sensor for measuring the height of product. Using the colour sensor, we find the colour of shafts and the other one sensor is used to determine whether the shaft is rotated in the correctly position, i.e. whether the operator inserted shafts into the serviser correctly. In the case of incorrect product embedding to the rotary conveyor, the product is discarded from the used positions using a pneumatic manipulator, which is located above another position of the rotary conveyor. The last available position uses a simple pneumatic manipulator with pneumatic suction providing moving shaft and hats from form the rotary conveyor to the waiting pallet on a belt conveyor (post 0). After the inserting of both components in the correct order on the block with bearing the product is finished and proceed to the final post 5.

F. Post 5 – Warehouse

Palette with the finished products stops at the last post and triaxial manipulator moves product from the pallet to its position in the warehouse (post 5 in the Fig.8). The triaxial manipulator is powered in two axes by stepper motors and the third axis is controlled pneumatically. The manipulator handles the products using suction cups. This manipulator was selected after the positive experience in its use in a similar project before [3]. Warehouse is implemented as a metal table, where milled positions for products are marked with letters of the alphabet from A to Y. Together there are 24 positions. Final position for each product will be stored in the information system of the FAC.

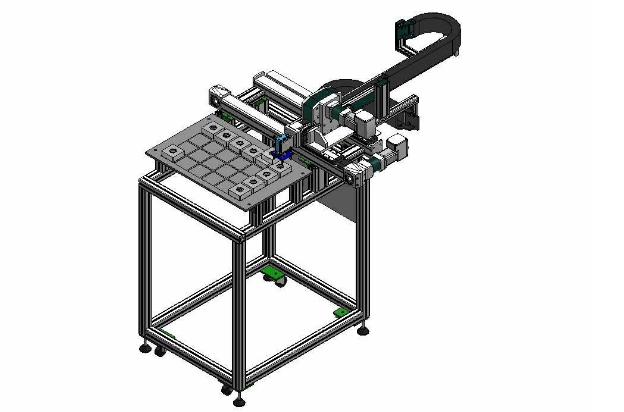

Fig. 8. Graphic design of the Post 5 – Warehouse of the resulting products.

Delivering finished product from warehouse carries line operator by hands, despite the fact that triaxial manipulator can moved it too, but only on to the belt conveyor Post 0.

IV. Network Control System

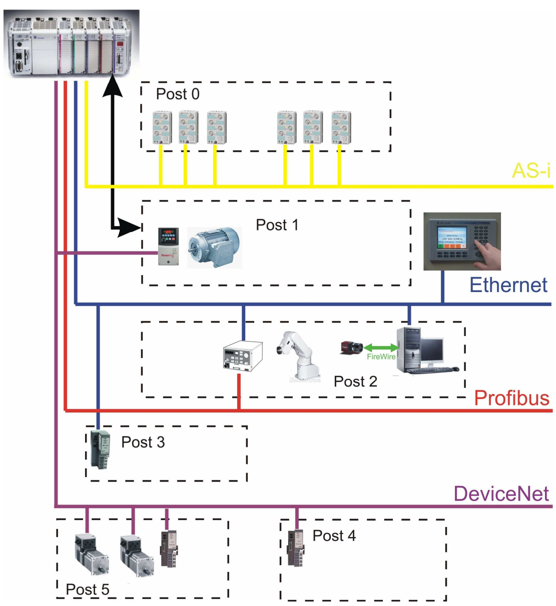

Fig. 9. FAC network control system.

The FAC is controlled by PLC which is equipped with network adapters. The most sensors, actuators and electrical devices of FAC control system are connected to the control unit via the technological networks. All technological posts except the posts two and one use remote inputs and outputs. There are together four types of technological networks used in this technological system (Fig.9): AS-i, Ethernet, Profibus, DeviceNet. This special system configuration of use the various types of technological networks is not common way of control system design, because is not easy to correctly configure the industrial network to work correctly. What more difficult task for a programmer is to configure up four networks in one control system. It is more easily to work only with direct PLC I/O. But it is caused by the use of this system. This system is mainly designed especially for industry network research and also for learning at scholar process at scholastic environment.

V. Conclusion

The FAC model is now already a second assembly line at our department that was built by the EU financial support.

This model was to school supplied completely assembled but without the control programs, that are being developed at this time and there are also resolved basic model electrical and the construction problems and its debugging. In parallel are also developed other applications, namely: an application to image recognition, the control program of the industrial robot Mitsubishi, the visualization applications, the information system application and course it is solved communication and synchronization of all these applications.

Another important objective is to support research at our department and especially in the field of modelling and diagnosis of discrete systems. The authors of the article are also dealing with this issue in its doctoral dissertation [1].

For the FAC model design was used standard automation software and hardware technologies. Control system, sensors and actuators were also selected from the standard used industrial elements. Some of the technical and engineering solutions should be designed easier in practice, but this is special application.

All these and other solutions related to the fact that it is a educational model where a student has the opportunity to try out several technology equipment on a small model. As mentioned in the article introduction, the main objective is to improve the educational process and improve the adequacy skills and competencies of graduates of our department. Furthermore, solution is complicated so that all technologies have to be interconnected to one system and it have to be synchronized to work together to do the defined tasks. Using the more types of technologies in one system is for the programmer more complicated than using only one technology type. But if a student handles this task, thereafter in practice it will be more easily to him manage the complex tasks that it will be given to him. Based on the gained experience he will not be narrowly focused and so he will be more competitive at the labour market. And that's also an important task of the University.

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