Journal of Achievements in Materials and Manufacturing Engineering
VOLUME 16
ISSUE 1-2
May-June
2006

Didactic model of the high storage system

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Received 15.11.2005; accepted in revised form 15.04.2006

Education and research trends

ABSTRACT

Purpose: The continuous progress in Computer Integrated Manufacturing (CIM) field with automatic storing systems is broadening the range of education process for engineers in future. This document describes the newest didactic station integrated witch a Modular Production System (MPS) model [1, 2, 3]. It is a module of high storage. This arrangement is the perfect didactic item for students.
Design/methodology/approach: The main reason, why the laboratory position, we have mentioned, has been created is brodening the students knowlegde's range. To achive this task the warehouse has been made from really industrial elements. All manipulator's axis were building from different types of transmissions.
Findings: During the work with warehouse there has been prepared the new algorithm which controlls the linear drive. Besides that there has been created brand new standards in engineers education, which are based on the described warehouse.
Research limitations/implications: The main target of the didactic activity of Institute of Engineering Processes Automation and Integrated Manufacturing Systems is broden the loboratory base. That's the reason why now there already has been building another laboratory position, which is based on Fanuc manipulator.
Practical implications: The algorithm of Pneu-Stat steering hasn't been finished yet, but when it has been done it can be used in industrial aplications
Originality/value: This paper describes the new didactic station with innovational steering algorithm [4, 5].
Keywords: Challenges of the widening labour market; Research and teaching development in the field of materials; Manufacturing and mechanical engineering; PLC controller; Proportionally controlled valves

1. The superior idea of the high storage system

Institute of Engineering Processes Automation and Integrated Manufacturing Systems tries to do all its best to develop its didactic offer which is directed to its students. MPS, which is in possession of the laboratory, is being enlarged by two new modules lately [1, 2]. One of them is high storage module. It gives possibility to demonstrate to the students the brand new world trends in automatic warehouse and high storage systems. Although this system is only a didactic model, it is built from fully industrial elements. Fig. 1 shows the photography of this model.

Fig. 2 shows the superior idea of the kinematical chain of the high storage system.

To broaden the knowledge, using only one laboratory stand, all of the warehouse's kinematical pairs were built from the various transmissions. The management of the system working was visualised by using the advanced PLC from B&R company with integrated touch panel [9, 10, 16].

2. The vertical axis transmission

The servomechanism of the B&R Company is used for moving the vertical axis of manipulator, which is integrated with warehouse [11, 16]. Thanks to this kind of motion system the manipulator can get a position with higher precision. It is necessary if we are moving objects using manipulator and when we want to change the gripper. This kind of motion system is used to develop our students skills. The servomechanisms are

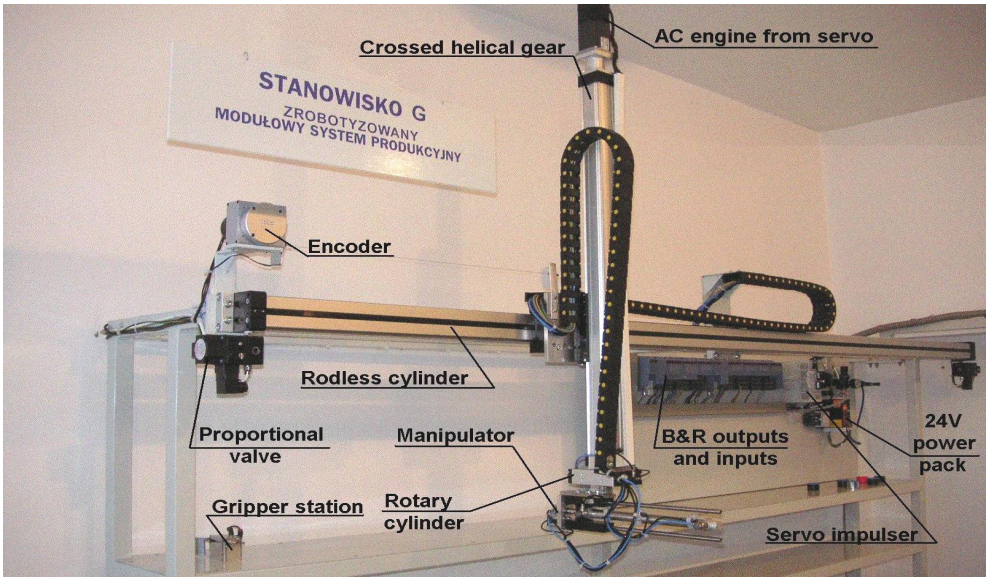

Fig. 1. Photography of the high storage system

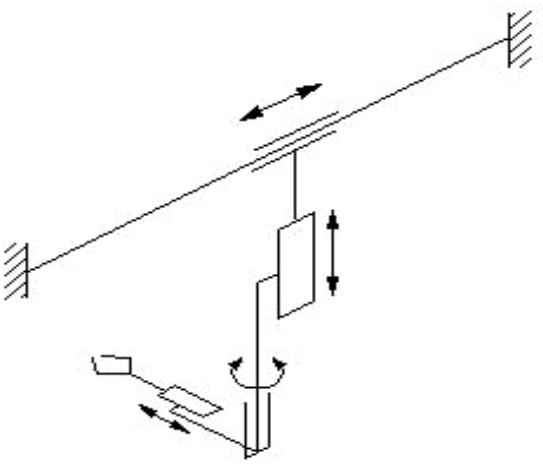

Fig. 2. The kinematical chain of the warehouse

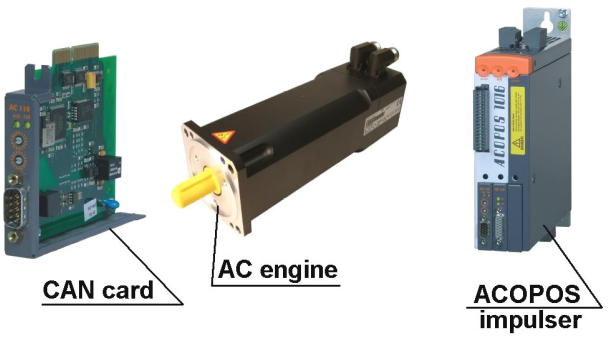

Fig. 3. The ACOPOS with AC engine and CAN card [9, 16]

tremendous example of position and speed controlled systems. During the laboratory occupations students learn how the servomechanisms are built, which problems they can solve and where they can use them. Fig. 3 shows the most important components of this servomechanism.

The frequency pulse generator (ACOPOS), which controls AC engine, is connected with PLC by CANBUS net [11]. This kind of connection shows the fully industrial solutions in inner data transfer to automatic controlling and regulating systems. In the classes the structure of transmission's protocol between PLC and another system's equipment is also described. Students also learn how to use all information about the manipulator's position and velocity. Both of them, position and velocity, are needed to work a program satisfactorily [6]. To move the manipulator the crossed helical gear is used [7, 15]. This kind of transmission permits to show the rotary motion exchange for linear motion. It can also help to improve the knowledge from constructing and operating industrial motion systems. Information about the manipulator's position and velocity is acquired continuously because the AC servo has built-in encoder [9, 16].

3. The horizontal axis transmission

To improve didactic values laboratory stand consists in many various cylinders. For horizontal axis transmission there is used rodless cylinder which is controlled in proportional technique [7, 14, 15, 18]. Using this kind of cylinders permits to get to know better the different way of industrial linear transmission. Pneu-Stat pressure regulators (valves controlled in proportional technique) use the PLC analogue outputs. It helps our student to understand the most important ideas of digital to analogue converters, e.g. their industrial applications and the methods of their programming. Fig. 4 shows this Pneu-Stat pressure regulator in intersection. The Pneu-Stat electronic pressure regulator

provides simple and accurate pressure control for many industrial applications where manually adjusted regulators have previously been used. Utilising the latest state-of-the-art electronics, it provides control up to 8 bar on air flows of up to 600 l/min. The Pneu-Stat operates simply by controlling an internal high speed pilot pressure regulator with built in electronic control valves. The system utilises two miniature solenoid valves to rapidly change the output pressure. An internal precision transducer constantly monitors pressure to provide accurate internal feedback, with an electronic control system which adjusts the pilot pressure if there is any difference between the electrical input and feedback signals [7, 15].

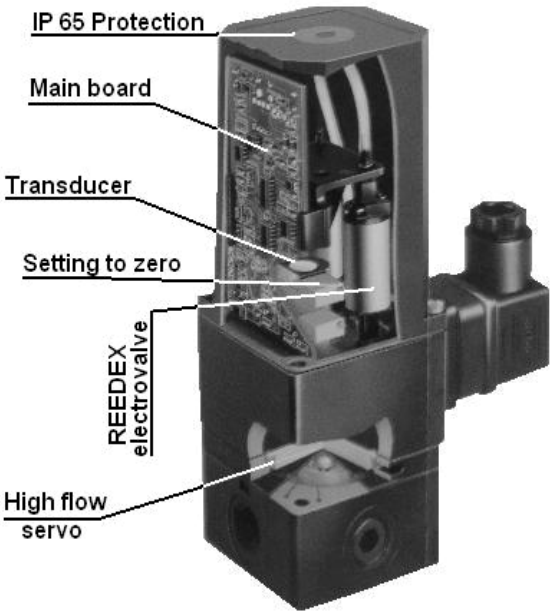

Fig. 4. Pneu-Stat pressure regulator in intersection [15]

During the classes objects with automatic pressure control are discussed. The encoder is used to measure the position. It is integrated with the reel. Showing the way of installation the rotation-to-pulse converters in industry and the way of connections these types of measuring systems with PLC were the main reason, why this kind of solution was chosen [17]. The system, which is applied in, is 1/8 mm resolution. It assures higher precision in position. Fig. 5 shows the system of measuring which is applied.

The position control system demands the connections with information about set position and the information about current position from the programmer. During the laboratory classes students can see how the steering algorithm works. This algorithm exchanges gathered information about positions (set and current) for analogue signals which controls the proportional valves. The students' task is to choose the best pressure parameters, which brings satisfactionary speed of the system. It must guarantee the fluency of acceleration and braking, and also the stability of system working. An executive element called LINTRA, which is the rodless cylinder is used [7, 15]. It is made by NORGREN HERION company, and is shown in fig. 6.

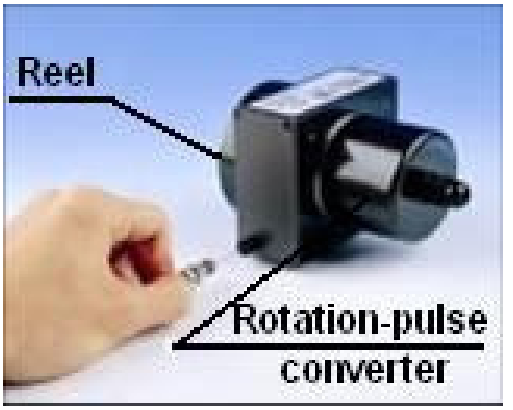

Fig. 5. Photography of encoder with integrated reel [17]

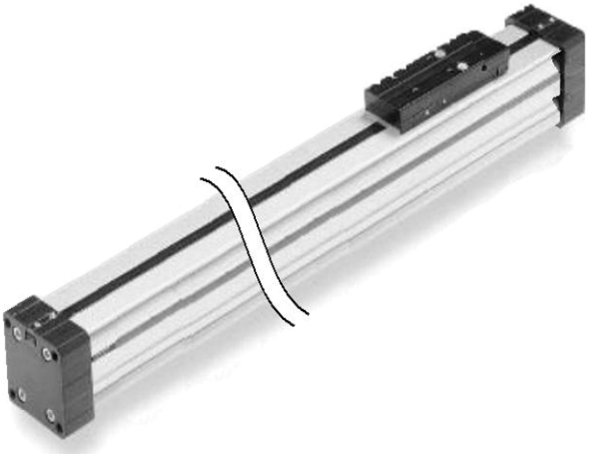

Fig. 6. LINTRA rodless cylinder [7]

It is another industrial example of automatic controlling and regulating systems. The knowledge from constructing and operating systems, based on rodless cylinder, permits students to develop their skills in that area.

4.The manipulator`s description

To assure the possibility of manipulating the objects, which are in a warehouse, the two degrees of freedom manipulator is placed. The rotation cylinder, which has 180 degree of working span, assures the rotary motion [7, 15]. Fig. 7 shows the manipulator of the high storage.

Using this type of controlled system permits students to get to know better of pneumatic cylinders with rotary motion. To assure the feedback of information, which achieved extremely position, contact sensors are used. In order to achieve proper positions inside of the warehouse piston rod cylinder [Fig. 8] which moves in linear way is applied [7, 15]. The information about achieving the extremely positions are delivered to PLC by contact sensors system.

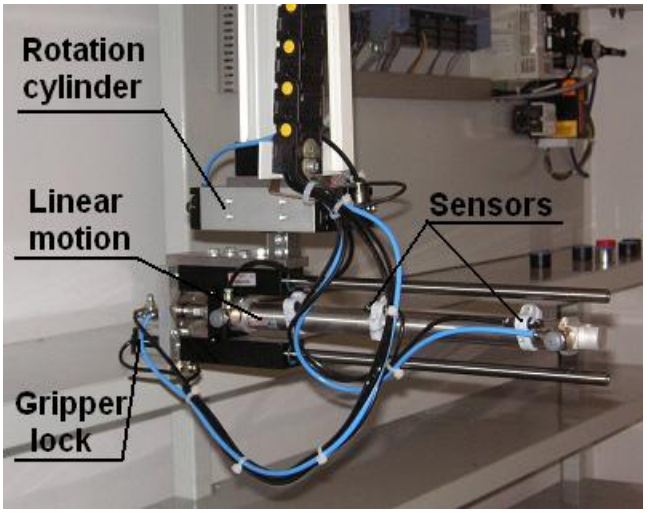

Fig. 7. Manipulator's photography

Fig. 8. Photography of the rod cylinder [15]

There is used fully industrial motion system. It has air mufflers systems and speed controlling systems of principal motion. By using the proper sensors it is possible to show how the task of gathering information about current position of the manipulator can be solved [7, 15]. What is more, students get acquainted with sensors which are often used in the industry. During the laboratory students can get to know better where sensors can be applied in, how they work and the solutions of their applications.

Manipulating of the elements, which have various shapes, is possible because the manipulator has automatically gripper exchange system with quick-release joint. This joint delivers the working medium to the gripper. This solution makes possible locking and unlocking the gripper. The proper algorithm assures the right place for gripper in a gripper's station, after that the gripper is automatically lockout. The manipulator without the gripper moves to the next, given gripper station. If it happen, the another gripper is automatically locked and the algorithm, applied to exchange the grippers, is finished. Fig. 9 shows the gripper-lock system.

5. The grippers changing stations

The reason of building the grippers changing system was to assure the correct work using every accessible gripper. The proper sensoring and constant, static gripper's position make this controlling system change the gripper, currently used, to another one, required in given operation. What is more, it can happen anywhere any time. After gripper exchanging the manipulator returns automatically to the position where the changing process has begun. Fig. 10 shows the view of individual gripper station.

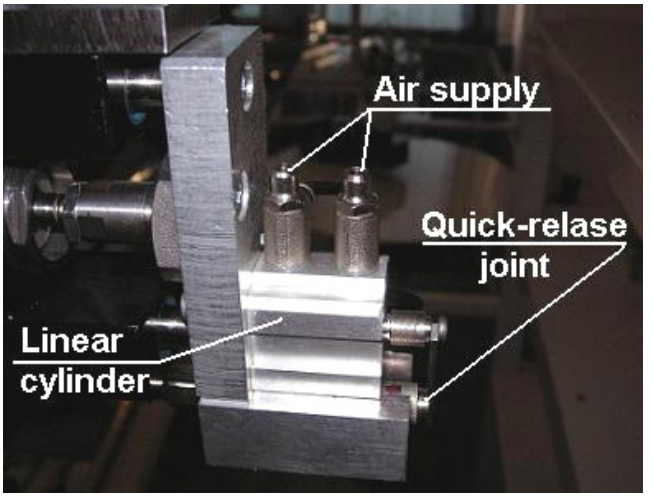

Fig. 9. Photography of the gripper-lock system

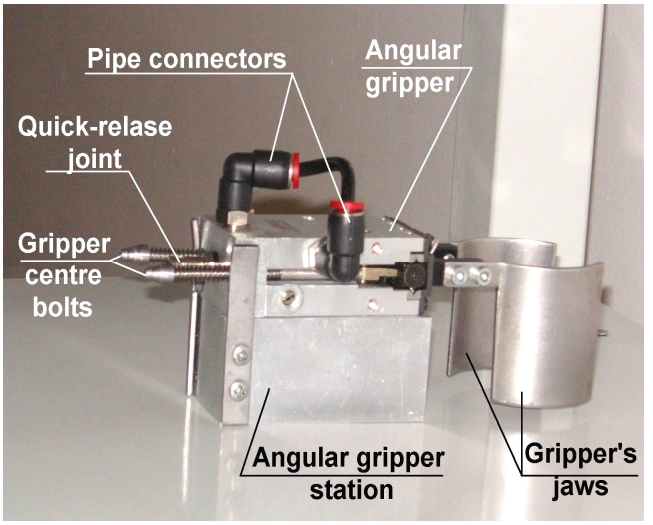

Fig. 10. Gripper station with the gripper

It shows the most characteristic elements of the gripper, which make its automatic exchange and its work possible. Manipulator makes the quick-release joint locked. When the manipulator finds the proper place for gripper in a gripper's station, the gripper is automatically lockout. Then the manipulator moves to the next gripper's station [3]. Fig. 11 shows the photography of all gripper's station systems. There are three grippers stations and three different grippers.

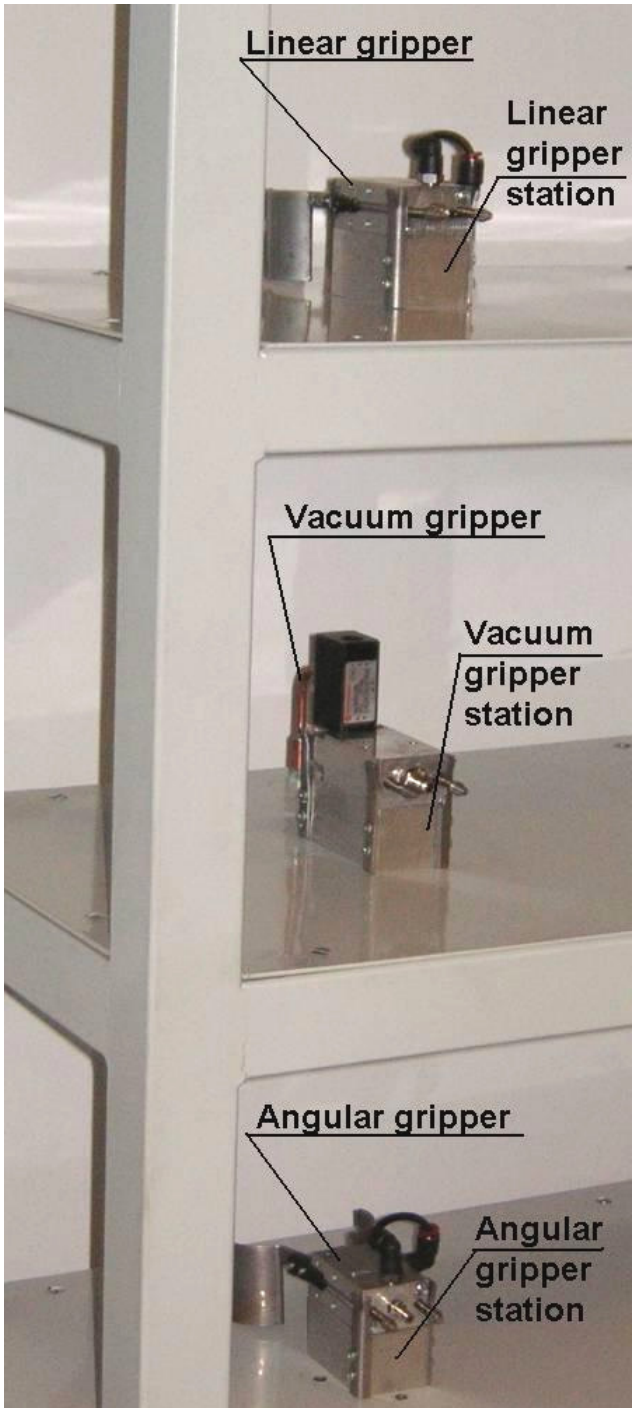

Fig. 11. Photography of all grippers' stations system

6. The controlling module

The superior controlled system, which is based on B&R, manages the working of the warehouse [9, 10, 16]. Fig. 12 shows where the outputs of the controller are. Thanks to CANBUS the outputs can communicate with the central processing unit, which is equipped in touch panel. The modules are situated in the visible place in the back of the warehouse.

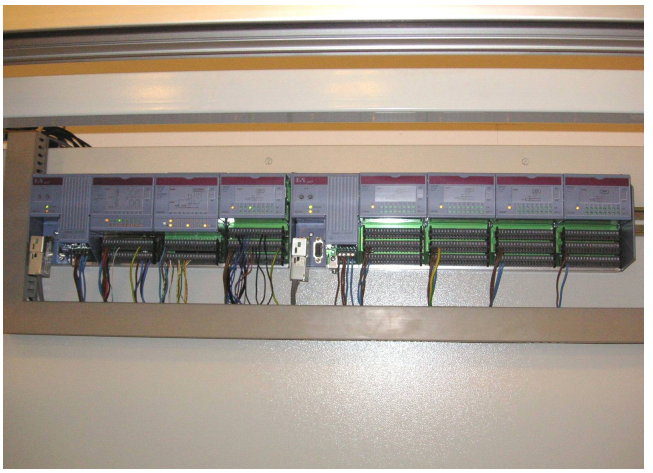

Fig. 12. B&R controller outputs and inputs

It was done to show to students the industrial solutions of controlling the pneumatic systems. To show the trends of integration and reducing the dimension of executable modules there was used a valves island by NORGREN HERION [7, 15]. During the labour students can set the logical states of the valves island by using PLC. The logical controller B&R, applied in the system, is setting by the Automation Studio software. During the labour students are taught how they should use this software. The Automation Studio makes also visualization of the whole process possible [11, 12, 16].

It is an innovatory solution of the setting PLC's software. It happens so, because Automation Studio software can use five languages of programming [12, 16]. The simplest one is very popular language which we know as the "ladder diagram" and the more advance is the implementation of C language. B&R Company made brand new programming language called AUTOMATION BASIC [13, 16]. This solution shows very interesting data exchanges between all of these languages. The Automation Basic has very interesting way of showing the variables. The data are kept as variables, which permits the programmers to forget about addressing the memory. The whole project is divided on tasks which have specified the working frequency. Thanks to this system's working has many tasks and there is possible to assign different functions to the independent tasks. Thanks to keeping the dates as the variables there is possible to create a project, which is based on these five programming languages. It can happen because the information is exchanged between these languages automatically. Automation Studio software makes possible the creation of extra task, which is basing on system data and changing paintings actually displayed on panel [12, 16]. This kind of tasks is used to create visualization of the high storage system's work [9, 12, 13, 16]. Fig. 13 shows the example of the warehouse's work visualization. The logical controller, that was applied, is useful in teaching

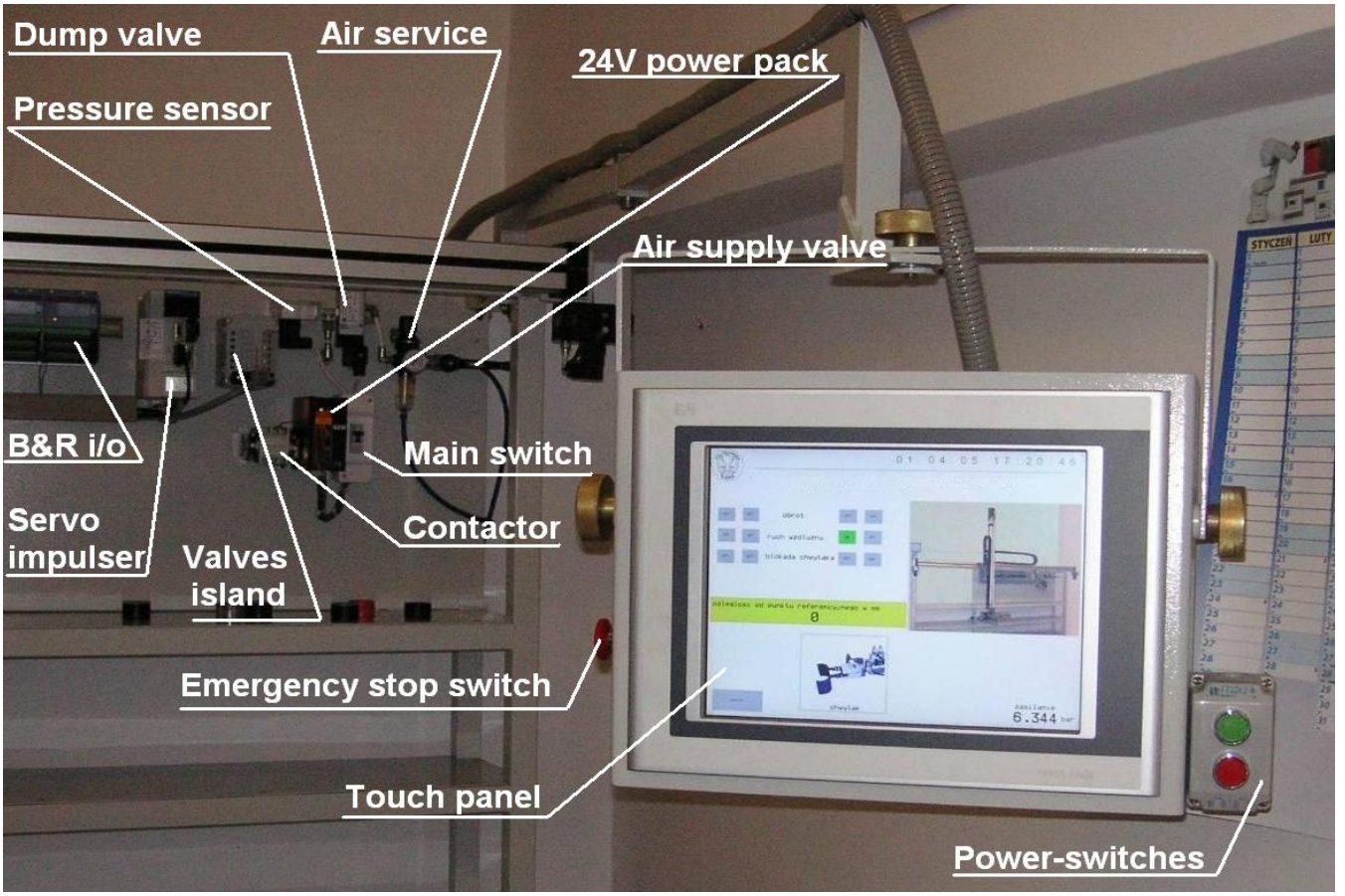

Fig. 13. Photography of touch panel working

process of programming and it shows how to connect the logical controllers with external world. It happens so because this controller can communicate with external world across ETHERNET, PROFIBUS and also across RS232 computer.

To initialize Ethernet connection the Ethernet Powerlink is used [8, 16]. It is a strict, deterministic real-time protocol based on fast Ethernet (100 MBit). Time−isochronous transfer of cyclic I/O and motion data is supported along with asynchronous communication between network nodes - a part of network bandwidth is reserved to this end. Fig. 14 and 15 show the algorithm of the high storage system's working [4, 5].

7. Summary

The high storage system owns lots of didactic values, because it is a kind of review of the newest trends in controlling and regulating systems. This system consists in elements which are used often in industrial applications. What is more, during the laboratory students develop their own skills and they gain experience.

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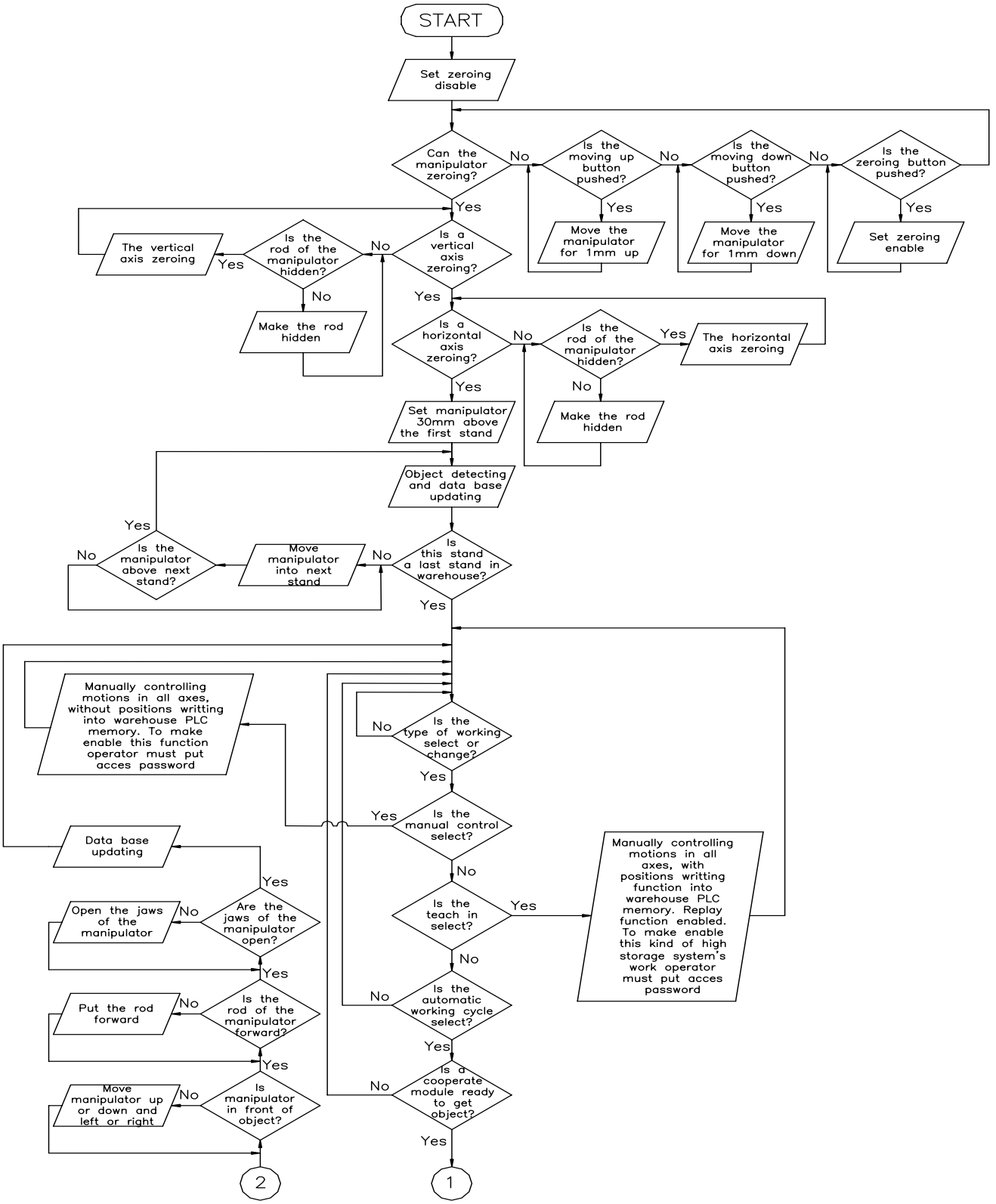

Fig. 14. Algorithm of the warehouse's working – part 1

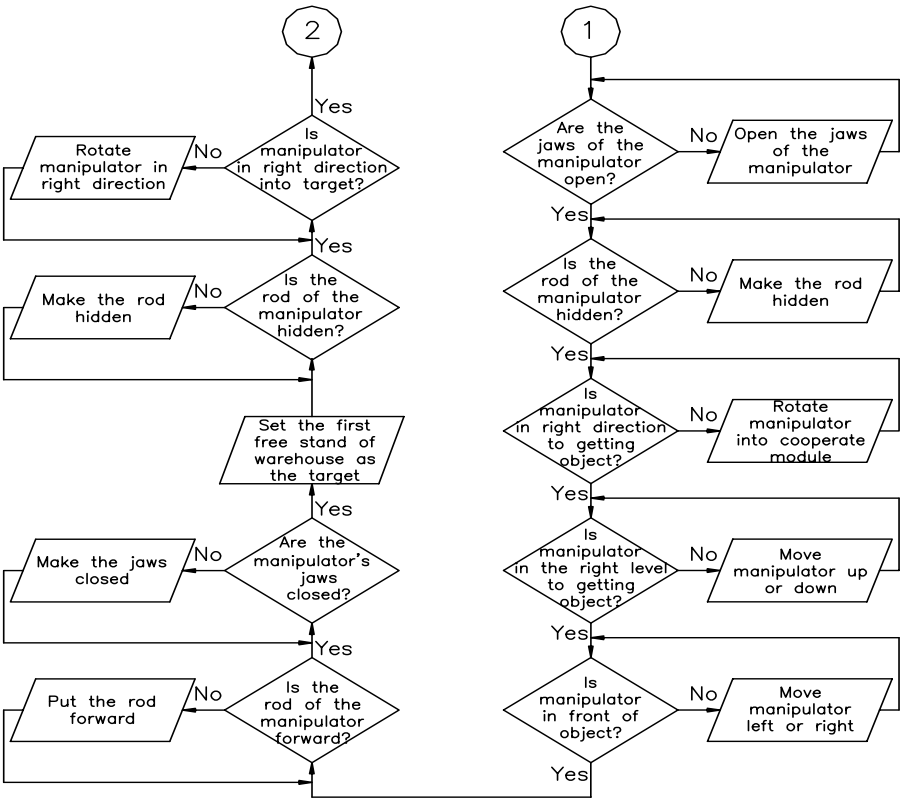

Fig. 15. Algorithm of the warehouse's working – part 2

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