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INCREASING OF EFFECTIVENESS OF MANUFACTURING AND DIRECTING TECHNICAL LEVEL

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Abstract: *Continuous developing technologies dwell on the focus to requirement of manufacture effectiveness, her directing and of shortening process time, etc. Through the application of various simulations software is possible to verify and optimize the running of material flow in manufacturing process. By this philosophy is planning solution of European Union project in our Institute of Manufacturing Systems and Applied Mechanics. Project aim is researching increasing of manufacturing efficiency and of directing in the frame of plastics punched parts to achieve increasing of competitiveness through the knowledges and technologies transfer and by cooperation with researching and develop activities in academic sphere and praxis.*

Key words: *manufacturing, effectiveness, material flow, designing methods, directing.*

1. INTRODUCTION

Aim of this paper is to advance the current trend in the production, control and interface these components with the materials flow. This philosophy we apply to solve the problem rise from intelligent assembly cell by building on our institute of manufacturing systems and applied mechanics. The intention is to use the knowledge gained from increasing levels of technical efficiency of production and control we have acquired and applied to solve the task.

Developing an integrated model of flexible assembly system designed for piece production, small-lot production represents a new philosophy in building a complex production.

2. FLEXIBLE ASSEMBLY SYSTEM

Assembly process is made up of elements expressing the main aim of the technological cycle. It is decisive for the establishment of the flowcharts, which together with an analysis of mounting boards are a tool for creating assembly procedure and determine the resources for the implementation of the assembly.

Analysis of the assembly cycle consists of the following parts:

- Classification of components, defining their shape and dimensions as well as its handling characteristics,
- Structural analysis of assembly complex, which describes the assembly product structure and determines the assembly process.
- Application assembly process − the logical, mathematical modelling.
- Application of assembly operations, the elected assembly services and generation of movements necessary to ensure a perfect assembly service.

Shining modernization in flexible assembly is representation of robotic assembly systems. Industrial robots have to replace manual work in production especially in the automotive industry. The application of such assembly systems in practice is now the exception rather. This is particularly suited of price follows a robot, especially in connection with the complexity and availability of sensor technology necessary for recognition and evaluation of robot part of technology.

The general structure of the robotic assembly systems are divided into three main groups:

- assembly systems where the robots perform only manipulation functions,
- assembly systems constituting the assembly centre, where they are carried out in one place, manipulation, assembly and auxiliary functions,
- assembly systems, where the advanced generation assembly robot performs assembly and handling operations.

For any assembly work is necessary to ensure maximum integration of material and information flows both in the assembly as well as storage, supply and control. A separate group in structuring a flexible assembly systems representative of assembly centres. It is a system meeting the following criterions:

- realization out some kind of assembly and manipulation operations,
- is equipped with digital control system,
- feeding system components is automated,
- secure mounting system of automatic exchange of tools.

For manipulation and assembly are using changeable grippers positioned at the last element. System using of

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effectors change increases productivity and universality of complete system.

Manufacturing process of workpiece consists of five periods:

- Storage of semifinished products and its transport to manufacturing device.
- Semifinished product machining to final workpiece.
- Manipulation with particular elements.
- Assembly of particular elements to final product.
- Manipulation with final product and its storage before expedition.

Acquired knowledge and experienced in solution project Vega 1487 Intelligent assembly cell improve by solution with the project company Hanil E-HWA Automotive Slovakia. The aim is to develop accurate in-depth analysis of the current state of the material flow in manufacturing and production planning as a whole. In solution the members of project team particularly want to focus on the quantity and movement of container traffic in the production, movement of individual products during the manufacturing process and storage planning. Of course there is also the focus of the current volume capacity of production and the amount of detail not fully loaded containers in production. Another aim is to create a lay-out material flow for each product. Course is to analyze ways of marking the input materials, intermediate products and finished products, production tools, carried packs and other components entering the manufacturing process. Then optimize the design of reusable shipping containers in order to eliminate the deformation effects of the products, economics and ecology. Optimum use of containers to ensure commonality of standardized and orientation of components in a container with the impact on handling and automation Specified trend of unification political of returnable containers. The basis for production effectiveness the and controlling of the obtaining of input parameters and material flow of manufacturing planning is preparing documents for subsequent modelling and simulation of material flow and production planning with their subsequent optimization. For the assistance provided relevant documents and data obtained directly in the manufacturing process, we can establish the temporal and spatial map the current state of the material flow with a focus on the movements and the amount of material in the production, traffic congestion on roads and the time needed for manipulation materials in the production hall and the .mathematical material flow model, including production planning.

3. INTELLIGENT ASSEMBLY SYSTEM

The industrial manufacture is still forwarding. Today we are not talking only about using of IT, classical automated instruments. But when we are talking about flexible manufacturing systems it is effective to talk also about possible using of new generation manufacturing systems. These new generation manufacturing systems are also called intelligent manufacturing systems. All IMS subsystems are including parts of so called machine intelligence (sensor equipment). Using of given systems with combination of machine intelligence will lead to the complete labour remove from the manufacturing system. Basics which are needed for realization of machine intelligence in manufacturing systems is so called monitoring, which is able to monitor internal stay of the system and also changing conditions coming from environment. Monitoring systems are using sensors which are located at some proper place of the system, usually such place is tool, machine or some manipulating device. Sensors are identifying parameters (Fig. 1), which are then used as input data of control system. Following to this data is realized some, technological, manipulating or other helping process.

Fig. 1 Optical sensor.

Basic functions of sensors applied to monitoring systems are specified in the following groups:

- Monitoring of handling devices status - monitoring of handling devices status deals mostly to monitoring of assembly robot status. Monitoring of information of robot arm motions, velocities, accelerations, temperatures, pressures, status of electronics etc.
- Monitoring of external environment − for monitoring is used from simple sensors of object presence to systems of visual recognizing of environment status.
- Monitoring of the status of assembly machines, assembly units, supply units and other active elements of assembly system - there is necessary to identify status of program steps and status, which can affect reliability and safety of units and devices running. Deals about information: turn on and off of working units, status of important surfaces etc.
- Monitoring of interactions - deals about information file of operations, at which participates minimum of two elements of function system (e.g. removal of parts out of moving conveyor). Purpose of interaction information scanning is in evaluating of system connections, which are determining for proper function. Among the most important interaction information fall the geometric reading (mutuality of position), temporal reading (present and temporal shift) and non-regular function reading (breakdowns).

An intelligent assembly system is situated at the department of technological devices and systems. This intelligent assembly system is created of some bearing subsystems such as:

- industrial robot with Cartesian kinematics structure,
- shelf storage system,
- feeding device [1].

Flexible automation represents the evolution of programmable automation. Its goal is to allow manufacturing of variable batches of different products of minimizing the time lost for reprogramming the sequence of operation and the machines employed to pass from one batch to the next. The realization of a flexible manufacturing system demands a strong integration of computer technology whit industrial technology.

Our intelligent assembly cell is Cartesian robot with 3 axes from SMC. This robot is portal construction with serial kinematics, which consists of 3 linear electrical drives. Next parts of assembly cell are:

- a mechanical structure or manipulator that consist of a sequence of rigid bodies connected by means of articulations (joints), a manipulator is characterized by an arm that ensure mobility, a wrist that confers dexterity and the end effector that performs the task required of the Cartesian robot,
- actuators that set the manipulator in motion through actuation of the joint, motors employed are typically electric and hydraulic, and occasionally pneumatic,
- sensors that measure the status of the manipulator (proprioceptive sensors) and if necessary, the status of the environment,
- a control system (computer) that enables control and supervision of manipulator motion.

The control system of this robot is realized by PLC from Mitsubishi. In this time we can control 6 axes. Number of controlled axis is sufficient for industrial robot, but we want use this control system to control of all devices (shelf storage, storage manipulator, feeding device, fixture and etc.). That means we must extend this control system. Because the Mitsubishi PLCs can connect to cascade, expansion of this control system is no problem.

Computers can realize programming of these PLCs. The program we can simulate on PC before we loading it to PLC. We are planning to use the workstations to educations and research in assembly process.

In the concrete, we want built:

- Automated exchange effectors.
- Inspections by sensors.
- Electro – pneumatic regulators control air pressure for proper clamping of the workpiece.
- Storage jaws for automatic exchange of jaws fixture.

Flexible manufacturing devices are in these days created mostly for piece production area or less series production area. The word “flexible” can be in automated productions interpreted as “simply” and “rapid” changeable. So this kind of systems is able to produce various kinds of objects without any time slip during the change of productions schedule [2].

Main mission of designed feeding device is manipulating with objects between flexible manufacturing cell and shelf storage system. This device is more teaching instrument, which aim is not reaching of maximal performances, but to show basic principles of objects manipulating operations.

To these devices belong for example positioning platform, conveyors and accessories for manipulation. They are often used for intermediate operation transport and also as reservoirs [8 and 9].

At the intelligent manufacturing cell construction project and shelf storage system was in final consequences applied the sequential method of description. By this method is created very good description of individual communication in cell during the production process. The sensorial elements was projected for the shelf storage system and then for the all parts of intelligent manufacturing cell. The main aim of this research project was the sequential diagram method application for intelligent cell by the sensors and its practical usage for education process and laboratory purposes. The flexible manufacturing systems are indivisible part of manufacturing industrial process. The systems of new generations are the trends (intelligent manufacturing systems) in production process. It is necessary to say that intelligent production systems area is still in research phase.

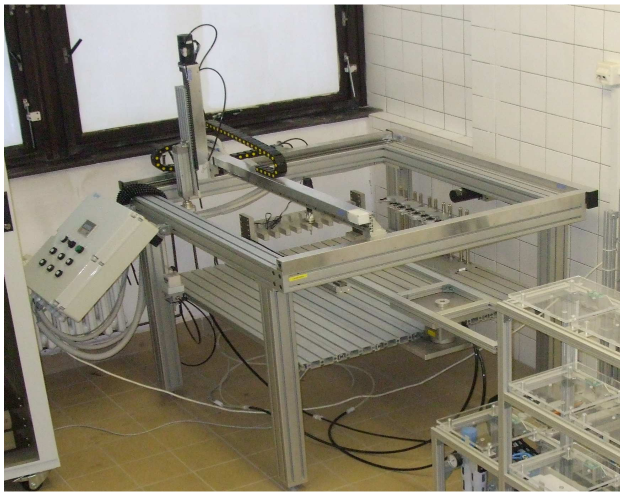

Fig. 2. Flexible manufacturing cell.

Feeding device Feeding device (Fig. 3) is located on the side frame of the robot construction. Workspace of the feeding device will reach in to the workspaces of shelf storage and multifunctional industrial robot. Very important requirement to the feeding device design is fixation of feeding device that is located on the bottom part of flexible manufacturing cell frame (Fig. 2). The design of the feeding device (Fig. 4) is based on main requirements, which were given to the device:

- using of pneumatic actuator, which influences to the final design,
- the material of the construction is normalized aluminium sheet,
- feeding device body fixed on the bottom part of flexible cell frame,
- individual designed parts must have the lowest possible weight,
- rotary platform have to be tough enough and must be able to rotate in scale 180°,
- locking and clamping of the feeding device have to be tough enough.

Feeding device has two working positions, on which are located the pallets. The main task of the device is to manipulate with objects that are located on the pallets. Pallets are transmitted between workspaces of the shelf storage and flexible manufacturing cell. One position hits the workspace of the flexible manipulating cell and another one position is accessible for shelf storage.

Feeding device has to be designed for maximal load of 10 kg. It is very important to regard whole load of designed feeding device construction, because big load can lead to the overcharge.

Fig. 3 Feeding device in Institute of Manufacturing Systems and Applied Mechanics

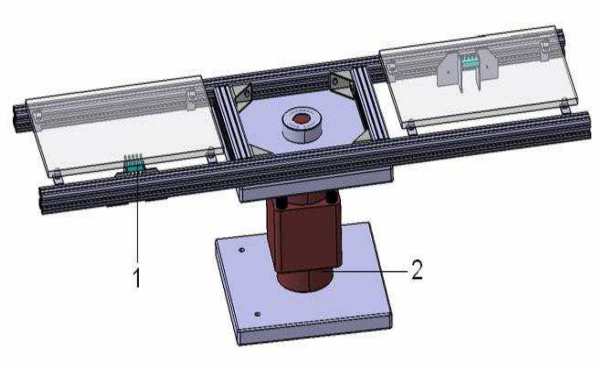

Fig. 4. Feeding device designed by CATIA V5R16:
1 − mechanic switch, 2 − rotary motor [6].

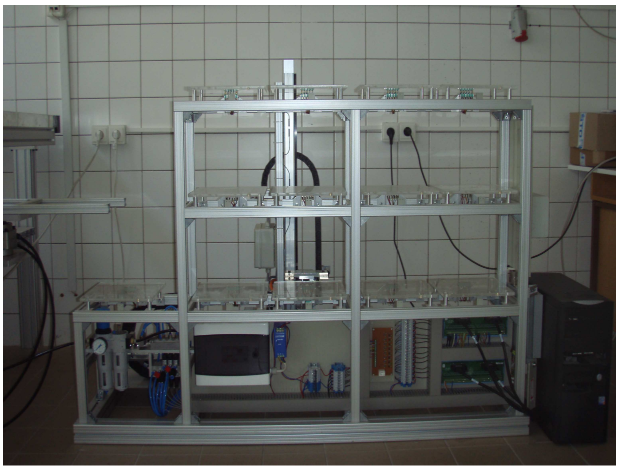

Fig. 6. Shelf storage manipulator in real.

Shelf - storages manipulator. Shelf-storage manipulator (Figs. 5, 6 and 7) has Cartesian workspace and tree DOF. The manipulated workpiece together with system palette has less than 3 kg. The manipulator takes these pallets (together with workpiece) to rotational feeding device (interface device between assembly cell and shelf storage) and giving it to shelf storage cells. Movement along *X* and *Y* axis are realized by pneumatic cylinders. Movement along *Z* axis is realized by electrical stepper motor with possibility of usage reprogrammed positions addressed by 4 bits.

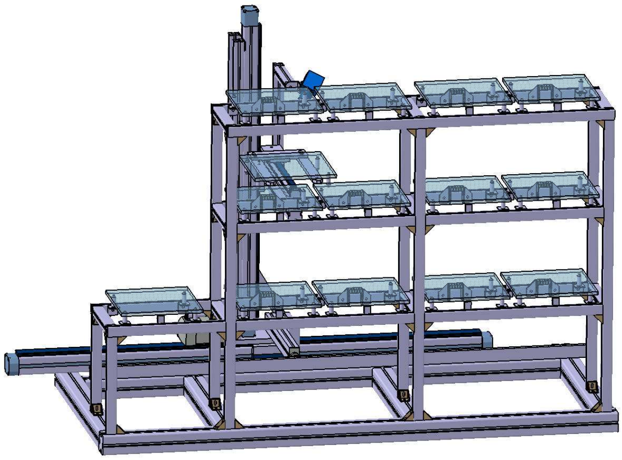

Fig. 5. Shelf – storage manipulator.

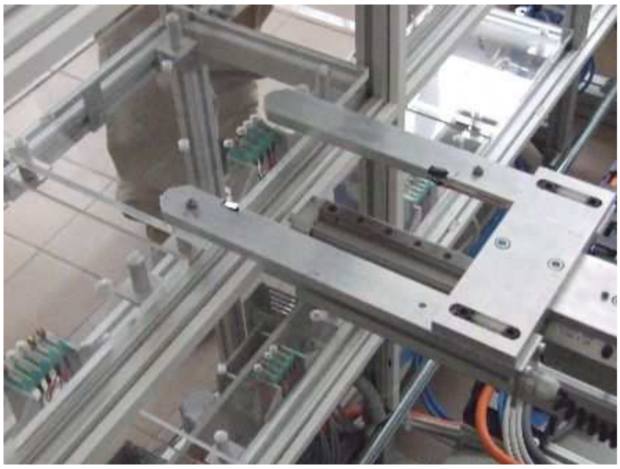

Fig. 7. Manipulation device for pallet system.

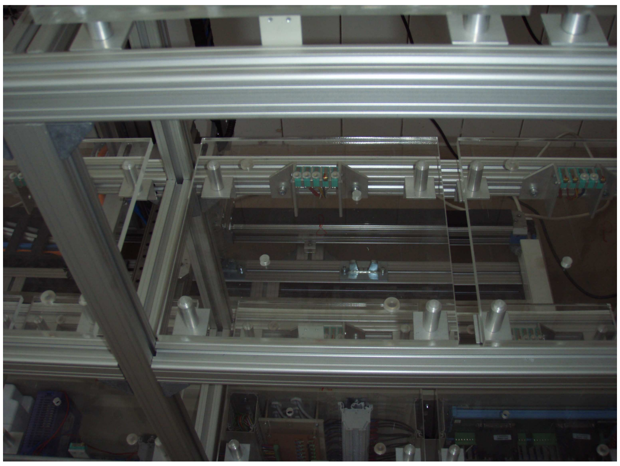

Fig. 8. Detail of shelf - storage pallet.

In the shelf storage design time we must accept give conditions, which determine its structure.

Manipulator operates with pallets (number of them is 12 and next one is for manipulation) situated in the 3 rows of shelf – storage (Fig. 8).

4. INCREASING OF DIRECTING EFFECTIVENESS

One way of increasing effectiveness is usage of the tool for streamlining means possible to use sequence

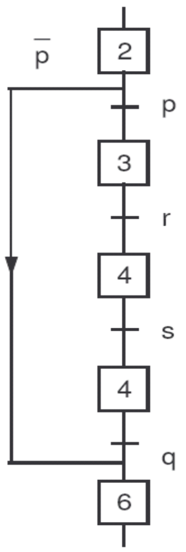

Fig. 9. Simple sequence with possibility to miss the steps 3, 4, and 5.

diagrams - GRAFCET. Sequence diagram (GRAFCET) - is a special flow chart with their own graphics and rules established for the purpose of describing sequential operations of automated systems.

GRAFCET is suitable for the design of algorithms for directing using programmable logic controllers (PLC). Grafcet advantage over other programming language is better simplicity and readability, and in most cases has less periods than other languages.

Grafcet comprises: steps (stages) that are associated with intended actions (periods), transitions that are associated with conditions for transition and oriented connection, established by lines. In developing control programs using Grafcet must follow strict rules set out in International Standard CEI IEC 848 [4, 5].

In developing the structure of the graph has a respect to the input conditions or to control the production system are implemented in successive steps or in the sequence where the steps move about and they are limited by the exact conditions.

The structures of graphs according to this are:

- simple sequence,
- simple sequence with possibility to miss the steps (in Fig. 9 it is steps 3, 4, 5) in depending of concrete request,
- simple sequence with re-run steps,
- sequence selection – branch “OR”,
- Simultaneous sequences – branch „AND“ (Fig. 10) [3, 7].

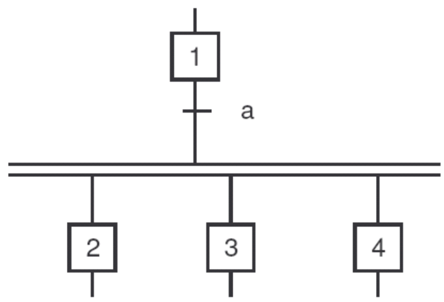

Fig. 10. Grafcet type with simultaneous sequences – branch „AND“.

5. CONCLUSIONS

Failure – free, effectively and synoptically operations of material flow are provided for information flow. Information flow is depended on rationalization of material flow. It is in central position in logistics. Before all kinds of material movement could be and follows information. Every this steps are necessary to information flow attend and brings that information on that is possible to adopt a decisions. Majority of problem resolution is in the optimisation of material and information flow and their application into highest level of automation and mechanisation into manipulation and transport processes. In the material flow projecting, here is necessary to know that aim of the project is not transporting and storage material because the price of these operations is high and the material rate is not higher by them.

Present development of automation leads to useful organisation of manufacturing machines with automated material flow and information when the controlling is realised by computer. To functionality of these systems, there is the necessity of material and information flow integrity; it means automation transport and automatic tool changing. For uniform assuring of transport, tool changing, of material manipulation was defined three areas positioned in the flexible manufacturing systems, concrete in flexible manufacturing – assembly cells. Three areas are storage, utility and operation area. According to described advantages and characteristics of areas is constructed and designed flexible – assembly cell in Institute of Manufacturing Systems and Applied Mechanics too. Her priority is continual connecting through the palette feeder next the shelf – storage and the end of the material manipulation is the shelf – storage, it means storage system. Although there is one of disadvantages and it means in flexibility of manufacturing – assembly cell. It means that flexibility of manufacturing – assembly cell is given only for particular facility ranges of workpieces but the suitable organisation design leads to full automation of manipulation and storage actions. By this designing the manufacturing effectiveness, turnover of storage system, safety of storage material and advantage is possibility of full time processing.

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