THE LABORATORY OF FLEXIBLE DRAWINGLESS MANUFACTURING SYSTEM

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Abstract

A trend today in manufacturing is characterized by production broadening, innovation cycle shortening, and products with new shapes, material and functions. The production strategy focuses on the time needed to change from a traditional functional production structure to production by flexible manufacturing cells and lines. Production by automated manufacturing system (AMS) is one of the most important manufacturing trend in recent years. Nowadays, the modern manufacturing philosophy trend is called Industry 4.0. (1).
This approach increases the value of the product and simultaneously decreases the produced waste (2) and saves the energy.

At the end of 2008 our institute - Institute of Production Systems and Applied Mechanics responded to the call: OPVaV-2008/2.2/01-SORO. ASFEU Agency and the Ministry of Education developed a project called "Laboratory of flexible manufacturing systems with robotic handling for drawing – less environment".

The main aim of this project was to build a laboratory equipped with a flexible manufacturing cell and directly connected to our CAD laboratory. The direct connection between these two laboratories enabled the completion of a joint design and manufacturing system. The main advance of this system is the possibility to react quickly to manufacturing design changes without manufacturing documentation in paper form. This is a model of a new form of 'digital' manufacturing.

In the final phase of this project in 2012, the flexible production system was linked with the CAD laboratory of our institute

Key words

drawing less production, flexible production, robotized production, material flow

INTRODUCTION

Flexible cellular manufacturing is now an established international practice to integrate: equipment, people, and systems into `focused factories', `mini-businesses' or `cells' with clear customers, responsibilities and boundaries. The major elements in exploiting the benefits of CM is efficient layout designs (3). The main advance of this system is a possibility of manufacturing fast reaction to design changes without manufacturing documentation in paper form. This is a model of a new ‘digital’ manufacturing.

The flexible manufacturing system will contain the two CNC controlled machines (milling and lathe machines). These machines will be interconnected by a transport system and operated by industrial robots. This flexible manufacturing system will also include a quality control station including the camera system and shelf storage.

The supplementary devices are used mainly to manipulation with workpieces and tools:

- workpiece storage and device for workpiece changing,
- storage, controlling and changing of tools,
- quality control.

A part of the complex automated manufacturing process is the automation of technological process control, automated transportation, handling, feeding, and interchange of workpieces, tools and an automated waste cleaner. There are many technological sites existing, which match the given requirements. Besides obvious computer techniques for controlling the manufacturing machines, automatically working bins, loaders, conveyors, manipulators and industrial robots are implemented step by step. As industrial production is growing constantly, besides implementing of the classical automated means, which were mentioned above, manufacturing systems with intelligent control are being installed.

Material flow is an integral part of every production system. In this paper we will focus on material flow possibilities in the flexible manufacturing system. The material flow is determined by several variants of system layout (4).

MANUFACTURING SYSTEM DESIGN

An FMS is a production system where a discrete number of raw parts are processed and assembled by controlled machines, computers and/or robots. It generally consists of a number of machine tools, robots, material handling, storage systems and computers. A typical FMS can fully process the members of one or more part families on a continuing basis without human intervention and is flexible enough to suit changing market conditions and product types without buying other equipment (the concept "flexible" can refer to machines, processes, products, routings, volume or productions) (5).

The design of a manufacturing system is a part of manufacturing process planning. The main determining factors for the manufacturing system design are: the product, the production volume, the used machines, the disposable manpower, the disposable infrastructure and the legislative frame for the specific cases.

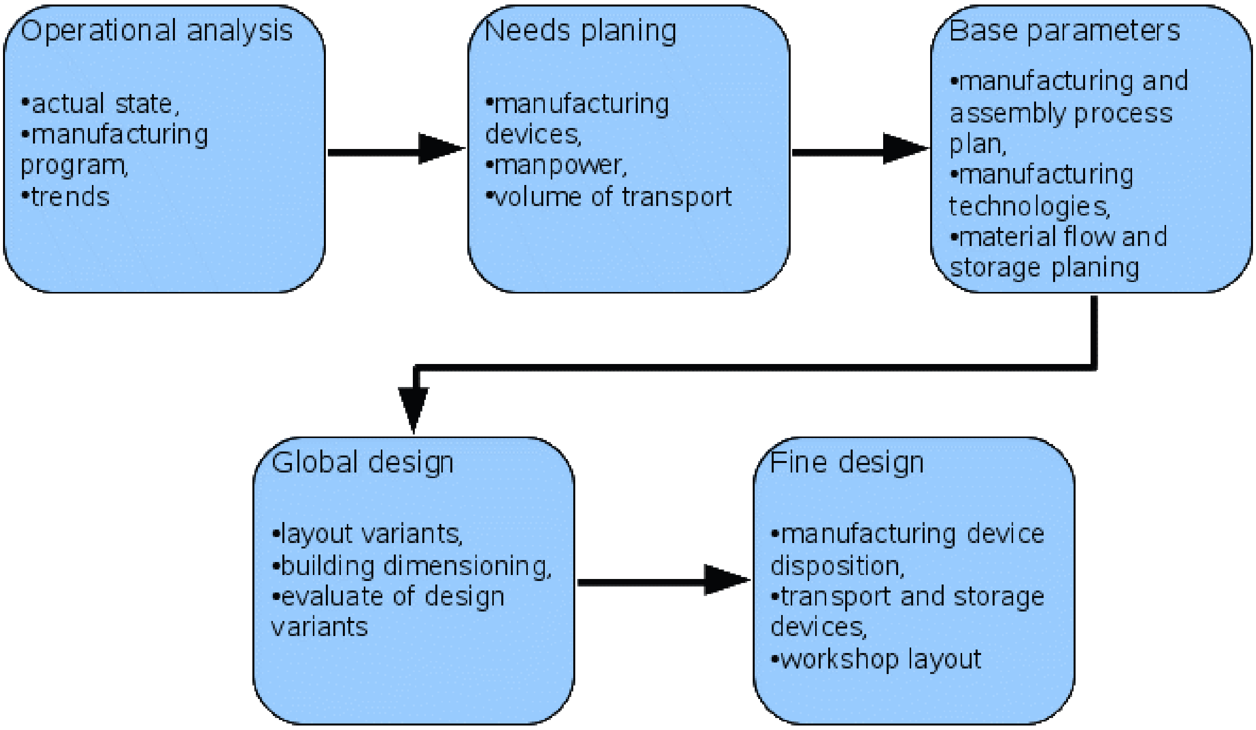

Fig. 1. *The general sequence of manufacturing system design*

The automation of the manufacturing and assembly process can be run in terms of the manufacturing profile, material flow or information flow. These basic elements of the manufacturing process are usually automated together in practice, but it is not a required condition. The task of manufacturing and assembly process control is to provide a running status of the dynamic stability, and to provide a replacement in the equilibrium status to the same or acceptable standard. Process control is characterized as the organizational process, which achieves the required final state; the assembly or manufacturing process. This information can be then only used if the model of system behavior is known, in order to create the control algorithm and technical system for its completion.

During detailed inspection, it seems advisable to analyze the technological workplaces that are functional and spatial areas:

- Technological areas are spaces where technological operations are performed on workpieces;
- Manipulation areas are spaces where manipulations (operational and intermediate operational) are performed with workpieces, tools and waste;
- Directing areas are spaces where controlling operations are performed;
- The area of maintenance is a space in which set up, maintenance, and servicing is completed.

MATERIAL FLOW PLANNING

In the process of material flow planning, it is necessary to consider the fact that the aim of the plan is not the transport and storage of materials as these activities are expensive and do not improve the material value. Current systems for handling, transport and storage provide a great number of possibilities for the application of expensive and complex systems. The optimal design should contain minimum storages, transport and handling. Hence, the suitable way before the development of a detailed system solution is to reduce the mentioned activities to a minimum.

All features of a manufacturing system must be planned considering mutual interactions and verified by a simulation model before the system is completed (6).

From the point of view of manufacturing and material flow, mutual connections and the formation of the material chain are important considerations. The main aim is the mutual coordination of all material flows and assurance of the efficiency of material flow between individual segments of a chain.

We want to produce (simulate production) various components of the shaft, flange, bracket and box shape in this system. Each component made will represent piece production that means only one piece of this component will be made. Variability (dimensions and shape of each component) will be relatively wide. Planning and management of the production process in FMS must be adapted accordingly (7).

The whole process starting with design up to storage of the final component must run automatically without human intervention. That means, materials in the FMS storage system will be automatically taken out of store, transported to individual machines according to the program, and put in the operating area by a handling device (industrial robot). The machine will execute individual technological operations to reach final properties (shape and dimension) of the component. Simple components can be worked by one machine only but in case of more complicated parts, the component will have to be handled in the machine (e.g. turned to another position) or relocated to another machine so that other necessary technological operations can be completed (sometimes this relocation between individual machines needs to be repeated several times) (8, 9).

After completion of all necessary technological operations, the component will be moved to a checking station for quality control and if quality control is successful, the finished and checked component will be automatically transferred to the FMS storage system. If the quality control is not successful, the component is also transferred to the storage system, however to the section where faulty products are stored.

A function graph of the whole flexible manufacturing system is showed in Fig. 2.

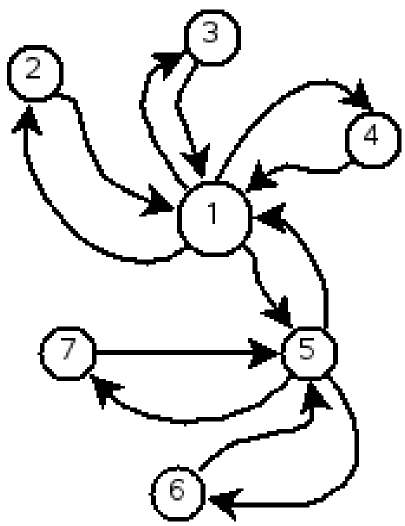

Fig. 2. *Flexible manufacturing system function graph*
1 – conveyor, 2 – storage, 3 – pallet handling and quality station, 4 – robot vision and assembly station, 5 – robot feeder of machine tools, 6 – CNC lathe, 7 – CNC milling machine

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Fig. 3 shows the final variant of a flexible manufacturing system layout. This system contains two machining centers (milling and turning), an assembly station, shelf storage with the manipulator and industrial robot on the rail. This final variant of a flexible manufacturing system is extended by a transport system in a closed loop, quality control station and by a robotized assembly station.

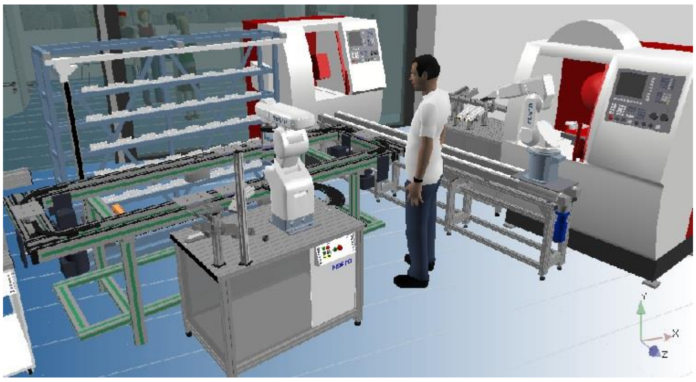

***Fig. 3.** The flexible manufacturing system visualization*

CONCLUSION

Flexible manufacturing cells allow manufacturing of a small number of parts from the huge range of types to achieve economic effects similar to large batch or mass production. The manufacturing cells structure has connected the machines and saves the production time, space and production costs too.

The functions of machines are coordinated and the material flow can be fast. The manufacturing process of components, parts or final products usually are not completed at one workplace. Manufacturing logistics carry out tasks regarding the organization of materials and information flow in manufacturing. The importance of manipulating and transport devices are underlined by the fact that more than 50% of manufacturing time is spent by manipulation. The transport and automation level of these processes are smaller than the automation level of technological processes.

Our main aim of the project is to build a laboratory, in which will be located a flexible manufacturing system consisting of at least two production machines with NC control (milling machines, lathe). These machines will be linked with a transport system and they will be served by industrial robots. Within this flexible manufacturing system will also be a station for quality control with a camera systems and rack warehouse.

After termination of the project, our Institute will have a fully functional prototype of a flexible manufacturing system with robotic operation of individual production facilities, which will be integrated with CAx laboratories.

Acknowledgement

This article was created with the support of the
OP Research and development for the project
Laboratory of flexible manufacturing systems with robotized manipulation supported by no drawing production
ITMS 26220220055,
co-financing from the resources of European Regional Development Fund.

Operačný program VÝSKUM a VÝVOJ

Support research activities in Slovakia/
Project is co-financing from resources EU

Európska únia
Európsky fond regionálneho rozvoja

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