MATERIAL FLOW IN FLEXIBLE PRODUCTION SYSTEMS

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Abstract *The main aim of this paper is to resolve material flows in systems, by describing the situation of flexible manufacturing systems laboratory and to make the designs of arrangement of these flows, to make design variants of spatial arrangement of this laboratory. We planned to create at Institute of manufacturing systems and applied mechanics the laboratory of flexible manufacturing systems. This laboratory is planned to equip with a turning and milling machine centers, conveyors, automated storage systems and industrial robots. This laboratory will enable more qualitative class works for students and do easier the start to praxis*

Key words: *material flow, laboratory, class works, manufacturing system, flexible manufacturing.*

1. INTRODUCTION

The production strategy in the second half of the 20th centuries was characterized by effective using of dedicated machines and automated lines. The goal was to achieve a maximal volume of production − the small shortening if production cycle has significant effect to production volume in mass production.

Today, the market is characterized by strategy of consumer's individualization. This strategy is oriented to consumer's requests. Consumers want new products and time becomes fundamental task to their satisfaction. The productionas broadening, innovation cycle is shortened, and the products have new shape, material and functions. At this strategy time is the most important parameter and the improvement is its shortening. The production strategy focused to time need change from traditional functional production structure to production by flexible manufacturing cells and lines. Production by flexible cells (FMC) is the most important manufacturing philosophy in the last years. This philosophy is based on similarity:

- similarity of manufactured parts,
- similarity of process plans.

Recognizing the similarity of manufactured parts allows grouping them to groups by machines required to their manufacturing. By manufacturing of this group of parts we achieve economical effect besides the mass production.

By some study the existing manufacturing capability of machines used is only of 30 to 40%. The other resources say that technological processes spend only 5% of time needed to manufacturing. The rest of time is spending by manipulation, transport and storage.

The flexible manufacturing system contains some CNC machine tools supported by industrial robot for material handling. This system is designed to manufacturing a group of similar workpieces. The system is characterized by its internal material and information flow. The manufacturing process represents a complex dynamical process included technological, manipulation and control operations.

In frame of our national grant we build a new robotized laboratory of production systems. This laboratory will be connected directly to our CAD laboratory by internet. One of the main target of this project is building the paperless production environment.

The production process will be planed and simulated at CAD laboratory and after a successful simulation will be sending the production data to production system by internet connection.

The production planning and simulation process will be realized in virtual production space at computer. The advantage of this approach is the very easy and fast possibilities of any change. This means also changes in the whole product design, part design and production process design. This possibility is so interesting for industry, because any changes in product design or production process design is very expensive and this approach enables applying time shortening, cost saving and production process tuning up.

2. MATERIAL FLOW

The material flow is one of the most expensive systems into production because it employs the most workers. For high efficiency of production, it is necessary to consider the high-usage of transport ways on base of transported material and the exploitation of single production system devices in the time of the project proposal.

In the next paragraph, the particular factors affecting the logistic flow proposal for manufacturing system will be described.

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Transport and handling subsystem is generally one of the most important subsystems of the manufacturing system. It is intended for the transport and manipulation with main and supply material, manufacturing tools (tools and tool holders, fixturing, equipment, scales, carriers and others) and with the waste. Used features of inter-operational transport and handling are dependent on geometrical shape and weight of transported material, parts and tools. Automation of handling in manufacturing system is enabled by technological pallets (holders or another element with this function, e.g. fixtures). The part is clamped outside a machine workspace onto technological pallet and transported. The part is positioned and clamped into position for machining. Technological pallet serves at the same time as a transport pallet.

The other objects for transport and handling are production devices representing the needed technological equipment of workstation and they are required for realization of specific operations using a correspondent machine. These objects are transported to workstation in sets or in parts in case when some of them create undetachable part of standard workstation equipment.

The waste is removed from workstation by transport system specifically designed for this purpose. The transport system for supply material (cooling fluid, lubricant substances and other) is built similarly.

Devices for operational handling are solved modularly. That means that to one machine more types of operational handling devices can be connected according to the type of machined part. Operational handling is controlled by machine control system because it is related to the technological devices performing a technological process. Manufacturing system control is connected to the inter-operational transport and handling.

Storage system is an important part of the flexible manufacturing system. It provides effective entry and storage (holding) of a number of raw products, semi-products, parts, tools and others. To this type of automated storage belongs for example the shelf storage too. The storage capacity and parameters depend on necessary material reserve for fluent production and continuous manufacturing system. Automatic shelf storage contains the following main elements:

- shelf construction,
- automatic rear or stacker devices,
- device for palette relocation in container,
- device for palette transport from container to transport system,
- technical resources of automatic control system.

Necessary condition for operation of integrated system is integration of materials and information flow; that means for example automated transport and automatic tools exchange.

Production system is characterized by the possibility of processing the arbitrary part from defined groups by given manufacturing procedure while the rebuilt time for a new production task is very short. Primary feature is the flexibility.

2.1 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 material 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 elaboration of detailed system solution is to minimize the mentioned activities.

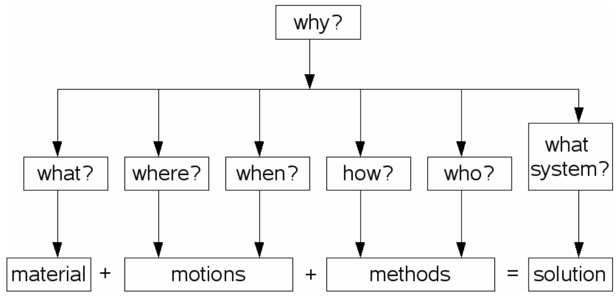

Fig. 1. Material flow formula.

It is necessary to take into account a great importance of the dependence of material flow and following elements of manufacturing system:

- Workstation and its capacity, incorrectly designed capacities induce unbalance materials flow, resources cumulating, and necessity of buffer stocks, containers and addition handling operations.
- Informational flow and the system controls, proper regulation of manufacturing tasks entering the system, synchronization of purchase, manufacturing and expedition, coordination of manufacturing system control by transport system, while all of them have a significant effect to material flow plan (Fig. 1).

All features of manufacturing system must be planned considering mutual interactions and verified by a simulation model before the system realization.

From the point of view of manufacturing and material flow, it is about mutual connections and formation of material chain. 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.

Material flow analysis is one of the main parts of production process analysis. The type, quantity, volume, mass and dimensions of manipulated material have strong influence to possibilities of manipulation, storage, packaging and transport. During material flow analysis, we observe the important material movements between a materiel incoming and outgoing stations. The methods used for analysis are similar for both production processes and material flow processes (Sankey diagrams, CRAFT, coordinate methods, networking methods, linear programming, value analysis, etc.).

At material flow analysis also we usually analyze the transport stream, this being an analysis of transport devices organized movements. Observed information is characterizing the communications loadings. We can see the crossings of material flows, communications, loading and unloading stations and transport device capacity using and other. On the base of this analysis we will have view to transport device quality and quantity too. The other useful information from this analysis is the needed structure of operators (number, qualification, geographical position).

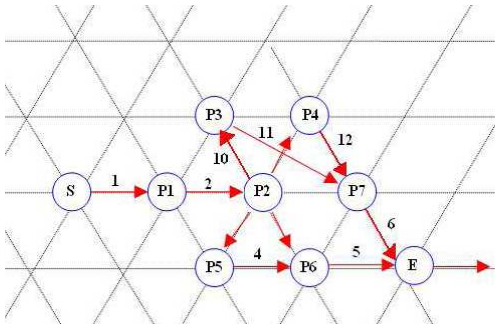

Fig. 2. Example of triangular material flow description.

The networking analysis methods are very usable for flexible production analysis. They allow the timing and coordinating a lot of operations participle in production process. The base idea of these methods is that a whole production process is transformed to oriented graph. By processing of oriented graph (time, cost, capacity analysis), we can get the optimal production process (minimal cost, minimal time) and we can see the crucial activities of production.

One of the most usual method to material flow representation is a triangle net method. The triangle net of relations (Fig. 2) describes the factors and relations between a workplaces which acting to material flow. These factors and relations must be classified and evaluated.

This classification and evaluation is the analytical activity what need the exact knowledge of given situation from the several specialized aspects.

Assigning the classification character usually corresponds to specific solvingin project layout. For better visualization are suggesting using the several colors for classification.

Objectives for the development and control of optimal material flow chain are:

- cost saving,
- powerful capacity along with the minimal resources,
- short passing through times and minimization of storing times,
- quick and simple holder motions,
- high flexibility of forwarding and articles quality,
- high level of work and failure minimization,
- high transport and storage quality,
- humanization of workplaces.

3. MANUFACTURING SYSTEM

In flexible production system is included one to tree technological devices that can work in automated working cycle. This system can have flexible reaction to manufacturing change in some limits.

After a program changing it is possible to manufacture other type of product. The manufacturing and supporting devices are not specialized. These kind of flexible manufacturing systems are dedicated for batch production, where the produced parts changing are realized by data change in machines control system.

Effective using area for flexible production systems is a medium batch production. In this area it is possible using the high manufacturing capacity and high flexibility of production systems. The production costs approximate comparisons between flexible and nonflexible systems shows that the production costs in flexible systems are somewhere about one half of cost as in nonflexible systems.

The higher efficiency of production is a result of better using of flexible production systems devices (automated 24 hour working) and reducing the supplementary time.

Disadvantages of flexible production systems are usually the higher investment cost, control system complexity and possible break outs of non standard devices.

The existing principles of machine plant design become to be improper and a completely new concept of manufacture and control design is gained ground.

The requirements for the new manufacturing system design are as follows:

- flexibility,
- productivity,
- quality.

Requirements set by product to manufacturing space result from product size, mass, type of construction, from its position in manufacturing program structure and production volume. Size and mass of the product determine the needed manufacturing, operating and storage places. Product constructions assign the process of manufacture and the further technologically constraint task sequences which form the base for general plant design i.e. the manufacturing device arrangement and space structure formation. Entire plan comprises material, information, power and personal flows.

Signification of particular flows of manufacturing system composition is dependent to the manufacturing process of a given product. In case of transport demanding production, the arrangement of manufacturing centers focused on the materials flows is critical.

Size and mass impose requirements to spaces from the aspect of necessary place. Production space must provide workpiece input and output, supply materials and allows transport device locomotion.

The flexible manufacturing system contains two CNC machines (lathe and milling center) for technological operation (machining) realization. These machines are served by one industrial robot on rail (Fig. 3).

The material moving is realized by conveyor. This conveyor integrates the whole manufacturing system.

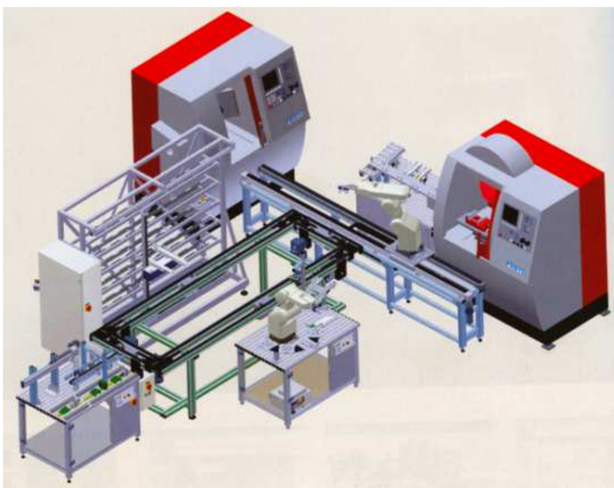

Fig. 3. Flexible manufacturing system.

The next device of this flexible system is the shelf storage for raw material and finished parts storage.

The second industrial robot serves the check station. In this station the dimension and shape controlling operations by camera system are realized.

4. CONCLUSIONS

In the last years, the cell manufacturing becomes one of the most important manufacturing types. This conception is based on the relation between manufacturing cell and workpiece. Flexible manufacturing cells allow to manufacture the small number of parts from the huge range of types and to achieve good economical effects besides to large batch or mass production. The manufacturing cells structure enables to connect machines and to save the production time, space and production costs as well. Functions of machines are coordinated and the material flow can be fast.

Manufacturing process of components, parts or final products is usually not realized in single workplace. The manufacturing logistics solves the tasks concerning organization of material and information flow in manufacturing. The importance of manipulating and transport devices is underlined by the fact that more than 50% of time needed for manufacturing is spent by manipulation and transport. Automation level of these processes is generally smaller than automation level of technological processes.

ACKNOWLEDGMENTS: This article was created thanks to the national grant OPVaV-2008/2.2/01-SORO – 26220220055 – *Robotized flexible production systems laboratory for paperless environment***.**

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