MATERIAL FLOW DESCRIPTION IN FLEXIBLE MANUFACTURING

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Abstract: This paper shows a project about building a laboratory that will include the flexible production system consisting of at least two processing machines using NC control (milling machine, lathe). These machines will be interconnected with the transport system and operated by industrial robots. In this system, material flow will have to be planned and visualised in an optimal way – using the triangular method.

Keywords: flexible production system, transport system, triangular method.

1. Introduction

At the end of 2008, our workplace – Institute of Production Systems and Applied Mechanics – responded to the challenge No.: OPVaV-2008/2.2/01-SORO coming from the ASFEU agency within the Ministry of Education and developed a project named Laboratory of flexible production systems with robotized handling for a non-drawing manufacturing environment.

Main goal of this project is building the laboratory where it would be possible to place the flexible production system consisting of at least two processing machines with NC control (milling machine, lathe). These machines will be connected by a transport system and operated by industrial robots. Station for quality checking using the camera system and a rack warehouse will be included within this flexible production system.

In the final planning stage of the project, in 2012, this flexible production system will be connected with CAD laboratory at our institute and this all will enable the creation of „Laboratory of flexible production systems with robotized handling for a non-drawing manufacturing environment".

After the project terminates, our institute will be able to utilise a fully functional prototype of flexible production system with robotized handling of individual manufacturing equipments that will be integrated with CAD laboratories.

This prototype will allow the additional research of relations and characteristics not only within the production system itself but also in the connection of production system with the preparation process and production planning.

We assume the realisation of several following (also international) projects that will extend the possibilities of the laboratory.

At present, we are working on the layout of space assignment concerning the individual devices and the selection of suitable processing machines. Very important part of this layout is the design of transport and handling tracks, selection of the transporter and planning of material flow within the whole system. Concerning the expected wide production assortment

(very different produced components), it is necessary to pay attention to the problem of material flow planning in this production system.

Therefore, the material flow is the integral part of every production system. Many different procedures and methods are used for description and visualization of material flow. Some of these methods will be described in this article. To describe or illustrate the material flow, we can use a lot of different symbols and tables.

2. Ways of material flow description in the flexible production system

Material flow tells about moving of passive elements (material, raw materials, semi finished goods, products) that is secured by means of active elements (transport, handling, storage systems). It also characterises the dynamics of production course in the space. Its most important part is the flow of working objects. Material flow is influenced by more factors, e.g.:

- production volume and assortment,
- level of technological complexity and segmentation of assembling units,
- number of operations on individual parts,
- shape of the given space,
- way of interoperation transport,
- placing of auxiliary plants and services (tool issuance, maintenance location, placing of the co-operating production subdivisions etc.).

To illustrate and describe the material flow, the following methods are usually used:
1. flow diagrams:
   a. flow chart – contains the sequence of technological and non-technological operations within the individual parts during their transition through the production process with the recording of individual operations time factors,
   b. flow graph – graph that schematically traces the material flow by means of production process or its part. In these graphs, it is possible to draw in not only all the data concerning the technological process (figures of operations and their duration), but also other information that may be significant for the material flow analysis, e.g. warehouse location, distance between the work places and so on,
   c. manufacturing process scheme – is a joint visualisation of the technologically similar parts group process and it presents the possible differences that arise on certain parts during this process, e.g. skipping of some operations,
2. material flow schemes:
   a. simplified scheme of material flow – figures the volume of material transported between individual workplaces without reference to its real arrangement. It considers only the sequence of material flow and meeting the conditions of certain selected scale regarding the transported amount,
   b. material flow sequence scheme – with the help of reciprocally different lines, it figures the flow of individual parts, tools, waste between individual workplaces – these are drawn in ground plans in a certain scale,
   c. Sankey's material flow diagram – originates by making a simplified material flow scheme into the ground plan of dislocated workplaces. It is a matter of complex material flow image that shows, by a visual demonstration, its length, direction, intensity, crossing and returning,
3. transfer relations matrix (matrix table) – shows the volume of material that was supplied or purchased by individual workplaces within certain production

4. subdivision in a certain time period. It is necessary to differ between the workplaces that supply exclusively, purchase exclusively and the workplaces that supply and purchase at the same time,
   4. triangular table of mutual relations – it presents a method that is used to design the spatial arrangement of workplaces (or more precisely machines, devices). Its subject matter presents the carrying-out of material flow intensity analysis in the individual workplaces. Those which have the highest intensity of material flow are placed as close to each other as possible. Other workplace that has the highest intensity in connection with them is placed in the triangular position to them.

Triangular table of mutual relations, also called the triangular method, is the most exact and most effective from all mentioned methods. Therefore, we will use it during the material flow planning in the laboratory of flexible production system and the next chapter will be dedicated to it in more detail.

Nowadays, more programmes for material flow graphic visualisation and simulation are being utilised. One of the most popular is Witness, which is used in our workplace too. Example of material flow graphic visualisation and simulation using this programme can be seen in the Figure 1.
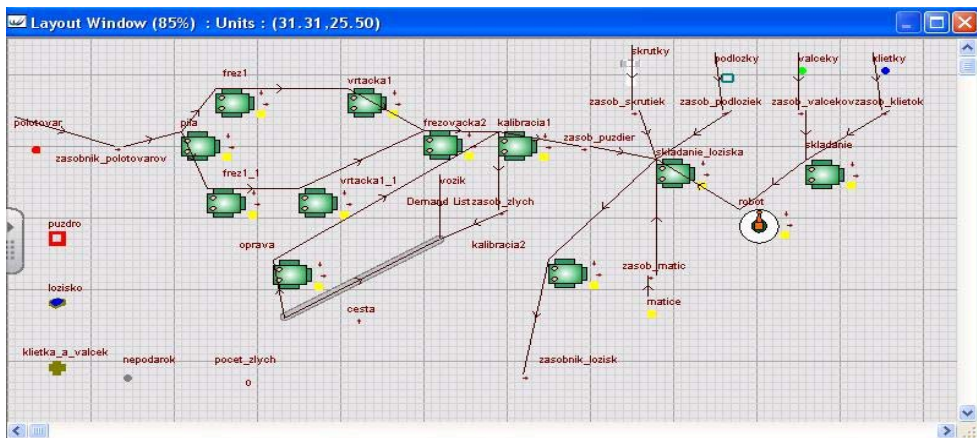

Figure 1. Example of material flow visualisation in Witness [1.]

3. Triangular table of mutual relations

It depicts the relations of all, or more precisely the most important factors affecting the material flow. The relations among the relocated or permanent workplaces and factors, which influence them, as well as among the workplaces and factors reciprocally, are classified in some way.

Classification of the relations is an analytic activity demanding detailed knowledge of the particular situation from many different scientific points of view. Binding a particular classification symbol generally corresponds to a certain solution within the arrangement project. For better visualisation, it is highly recommended to code the individual classifications using different colours.

For practical utilisation of this method, we assume the following procedure:
   1. to work out the matrix table of transport relations between those objects whose spatial situation we want to solve,

2. to set the order of transported material volume size and write the serial number in the upper corner of each allocated box in the matrix table,
3. to design a secondary table of transport relations between the objects. It consists of as many columns as cross-freights and it has 4 lines. The first line includes the order. The second line includes recording of suppliers' selected symbols, the third line contains the purchasers. The last line consists of transport volume.
4. to draw (in an appropriate module) a triangular system by the help of which the whole task will be solved,
5. to solve the spatial arrangement so that using the table we will find the supplier and the purchaser assigned to the serial number 1. Symbols will be drawn into two consecutive arbitrary vertices of an arbitrary triangle in the system. Volume of their mutual transport from the fourth line can be marked above the directed line segment by which the two points are connected. Giving the serial number is considered to be enough. The next step is presented by searching. To the points given, we will search the fourth one and the other points that have the most intensive material flow to some of the given pairs. This process continues until the arrangement of all, or at least the main objects in the examined space.

Example of this method procedure output is presented in the Figure 2.
Drawing the triangular table of mutual relations, a production designer obtains an important base for economically purposeful arrangement of certain production subdivision workplaces.
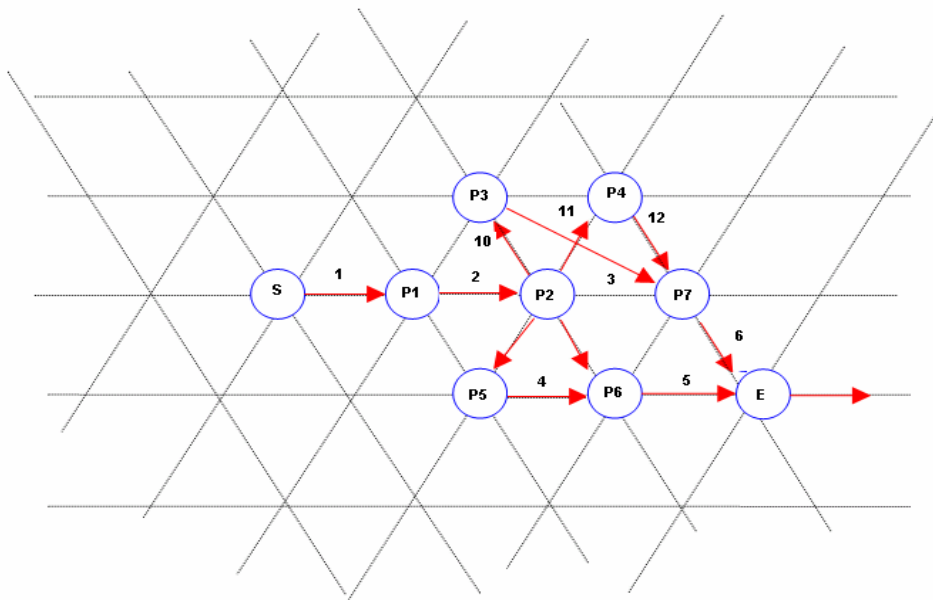

Figure 2. Triangular method output [2.]

4. Conclusion

Main goal of this project is to build a laboratory that will include the flexible production system consisting of at least two processing machines using NC control (milling machine, lathe). These machines will be interconnected with the transport system and operated by industrial robots.

In this system, material flow will have to be planned and visualised in an optimal way – using the triangular method.

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