Analysis of the Communication Methods of an iCIM 3000 System within the Frame of Research Purpose

Radovan Holubek, Daynier Rolando Delgado Sobrino, and Roman Ruzarovsky

Abstract—Current trends in manufacturing are characterized by production broadening, innovation cycle shortening, and the products having a new shape, material and functions. The production strategy focused on time needed change from the traditional functional production structure to flexible manufacturing cells and lines. Production by automated manufacturing system (AMS) is one of the most important manufacturing philosophies in the last years. The main goals of the project we are involved in lies on building 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 to a transport system and they will be served by industrial robots. Within this flexible manufacturing system a station for the quality control consisting of a camera system and rack warehouse will be also located. The design, analysis and improvement of this manufacturing system, specially with a special focus on the communication among devices constitute the main aims of this paper. The key 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.

Keywords—Paperless manufacturing, flexible manufacturing, robotized manufacturing, material flow, iCIM.

I. INTRODUCTION

AT the end of 2008 our institute – Institute of Production Systems and Applied Mechanics responded to the call No. OPVaV-2008/2.2/01-SORO of the ASFEU Agency of the Ministry of Education and prepared a project named Laboratory of flexible manufacturing systems with robotized operation for environment of drawing-free production. The main target of the project is to build up a laboratory with a flexible manufacturing system consisting of minimum two NC controlled machines (milling, lathe). 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.

MSc. Eng. Radovan Holubek, PhD. Author is with the Slovak University of Technology, Faculty of Material Science and Technology, Paulinska 16, 91724 Trnava, Slovakia (e-mail: radovan.holubek@ stuba.sk).

MSc. Eng. Daynier Rolando Delgado Sobrino. Author is with the Slovak University of Technology, Faculty of Material Science and Technology, Paulinska 16, 91724 Trnava, Slovakia (e-mail: daynier_sobrino@ stuba.sk).

MSc. Eng. Roman Ružarovský, PhD. Author is with the Slovak University of Technology, Faculty of Material Science and Technology, Paulinska 16, 91724 Trnava, Slovakia (e-mail: roman.ruzarovsky@ stuba.sk).

In the final phase of the project in 2013 this flexible manufacturing system will be linked to the CAD laboratory in our Institute creating thus the "Laboratory of flexible manufacturing systems with the robotized operation for environment of drawing-free production." After the project completion, our Institute will have available a fully functional flexible manufacturing system prototype with robotized operation of individual production machines, integrated with CAx laboratories. However, the final goal is to build up an intelligent manufacturing system. This prototype will enable further exploration of relations and properties of the manufacturing process itself but also in its relation to process of production preparation and planning.

We expect several other consecutive projects (incl. international ones) which should further extend possibilities of the laboratory [1].

II. MANUFACTURING SYSTEM DESIGN

The design of manufacturing system is a part of production 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.

The manufacturing systems design is a fine prepared project which includes the several kinds of calculations (capacity, space, manpower, etc.), material and information flow and others. In manufacturing system design time the realization of following tasks is very important:
- data collection and analyze methods for manufacturing system analyze,
- methods for measuring and analyzing of tasks,
- manufacturing systems design methodology,
- methodology of manufacturing system controlling,
- computer simulation of designed manufacturing system,
- methodology for a continuously improving of a design team work.

In base of manufacturing systems organization we can design these systems by following profiles:
- technological – machines are fully interchangeable,
- subjective – its characteristic is sequence of the material flow,
- combined – enables variability of material flow,
- virtual – the same machine is associated into several cells on base of actual needs [2].

The control system of a manufacturing system is usually connected to the input side of a manufacturing management system of a company. This system provides the planning and managing of manufacturing requests and provides the information and material flow integration in the higher level in the connection to control systems of a several manufacturing processes. This means that this management system provide the managing the whole material and information flow on all manufacturing phase.

III. MATERIAL FLOW PLANNING

In the process of material flow planning, it is necessary to consider the fact that the aim is not the transport and storage of material since 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 reduce mentioned activities to a minimum [3].

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 talking 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 [9]. The type, quantity, volume, mass and dimensions of manipulated material have strong influence to possibilities of manipulation, storage, packaging and transport. In time of material flow analysis we observe the important material movements between material incoming and outgoing stations. The methods used for analysis are similar for production processes and for material flow processes too (Sankey diagrams, CRAFT, coordinate methods, networking methods, linear programming, value analysis …) [3].

The general sequence of material flow planning is the following:
- material flow analyze, volume of transport operations determination,
- layout,
- analyze of existing devices,
- design of transport systems variants,
- computer simulations and dynamical dimensioning of material transport and handling devices.

In this time we solve the equations of material flow (Fig. 1).
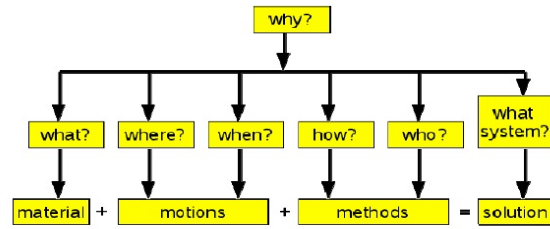

Fig. 1 Material flow equation

At material flow analysis we usually analyze the transport stream too, this is an analysis of the 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. In base of this analysis we will have view of the transport device quality and quantity too. The other useful information from this analysis is the needed structure of operators (number, qualification, geographical position).

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 got the optimal production process (minimal cost, minimal time) and we can see the crucial activities of production.

One of most usual methods for material flow representation is the triangle net method. The triangle net of relations (Fig. 2) described the factors and relations among workplaces the material flow passes through [4].

These factors and relations must be classified and evaluated.

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

Assigning the classification character usually correspond to specific solve in project layout. For better visualization are suggested using the several colors for classification.
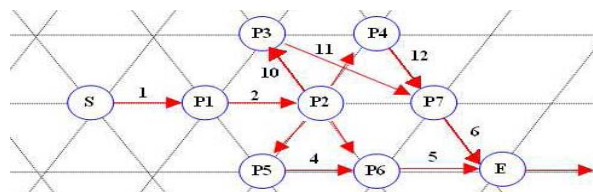

Fig. 2 Example of a triangular material flow description

Objectives for the development and control of an 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.

IV. FLEXIBILITY OF MANUFACTURING SYSTEMS

There are various approaches to the term flexibility of manufacturing systems- FMS. The most frequent meaning of this term are described as follows:

- possibility of production program change without any significant alteration of machinery (new NC program, eventual tool change),
- speed of production program change from previous product line to new products,
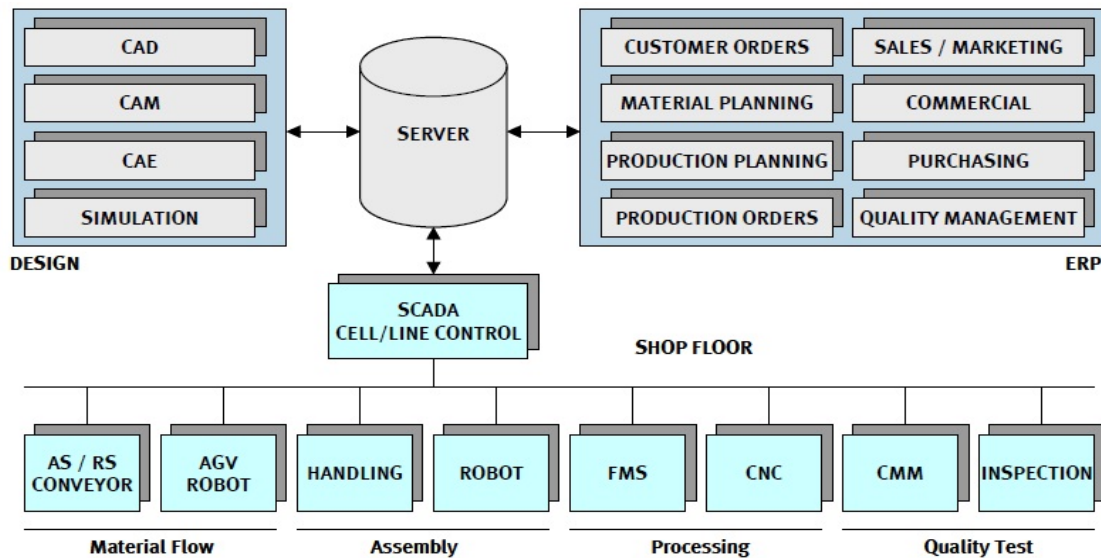- Possibility to change production program at level of individual products [5], [8].

Fig. 3 Modular flexible manufacturing system block diagram

The reasons why iCIM solutions are much more modular, flexible and open compared to other CIM/FMS training systems are:

A. Distributed Intelligence

The design of iCIM is based on the technology of distributed control. All the iCIM Stations have their own industrial controllers and can be operated stand alone as well as in the iCIM network.

B. Standard Interfaces and Communication

In iCIM exclusively Standard Communication Protocols are used. Due to this fact most industrial level components and subsystems like CNC, Robots, Vision Systems, PLCs are compatible to iCIM.

C. World Class CELL/LINE Control Concept

iCIM utilizes one of the most powerful Factory Integration Software available in the market, Cosimir Control.

Including all SCADA features, it is much more than a SCADA system. The high level Process Plan Language makes it easy to define the various processes in the environment of a real multitasking operating system. The powerful set of communication drivers makes it an easy task to integrate mostly all brands of automation equipment [7].

Flexible Manufacturing Systems (FMS) are defined as a number of CNC-machines together with robots for automated feeding, local material buffers and a material input/output point. FMS are able to produce a range of similar products in mixed sequence down to lot-size 1. For this, the robots, CNC machines and storage are managed by a FMS controller.

All FMS in iCIM can be equipped with local raw material feeders as well as local pallet buffers. The dual machine FMS have a linear slide to feed both machines with one robot. Material flow to and from the FMS takes place either by means of conveyor system [7]. For FMS the communication method is very good used standard communication method (Fig. 4). But, an additional communication channel is established from CELL/LINE Controller to the CNC Controllers. This is to select the CNC-Program – Number in real-time according to the production planning.
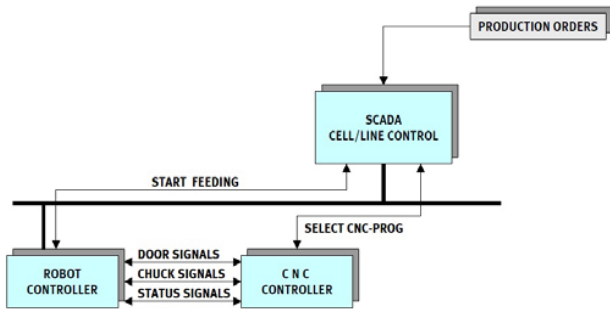
Fig. 4 Standard communication method in FMS system

In iCIM is possible too (networked) operation, all the available single robot programs to perform a complete assembly job are triggered by the CELL/LINE Controller via the iCIM task tool and handshake procedure on TCP/IP. Both, program name and parameters are send to the robot controller. Creation of new robot tasks is easy – write a new program in the multitasking environment of the robot (e.g. TEST77), define the parameters, teach the positions – that's all. Now, by means of the CELL/LINE Controller, you can start the task TEST77 in single task operation or you can integrate this new task in a process Fig. 5.
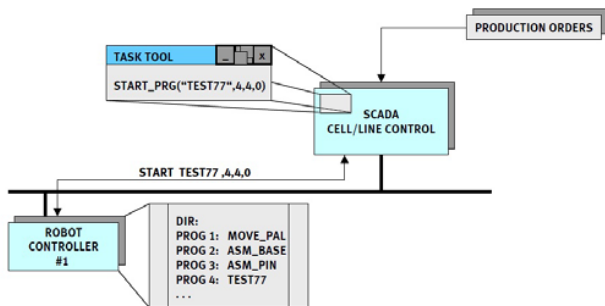

Fig. 5 Possibility of the multitasking communication

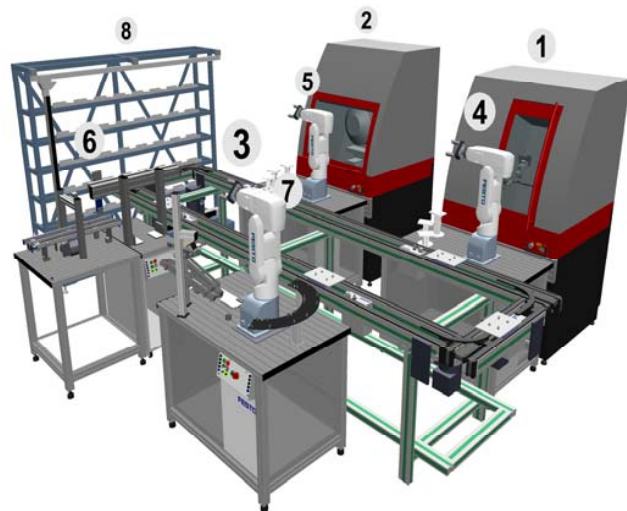In the Fig. 6 is shown comprehensive of a flexible manufacturing system with an individual device.

Fig. 6 Flexible manufacturing system
1) Concept turning 105,
2) Concept milling 105,
3) FAC - Flexible Robot Assembly Cells,
4) FRF - The Flexible Robot Feeder,
5) FRF - The Flexible Robot Feeder,
6) Quality and Handling station QH 200,
7) Conveyor system FMF - Pallet Transfer System,
8) AS/RS Automatic Storage / Retrieval System.

These are complex devices that must communicate with each other and need to cooperate along at every moment of the manufacturing and assembly processes.

V. CONCLUSION

Our main aim of project is building of laboratory, in which will be located flexible manufacturing system consisting of at two production machines with NC control (milling machines - Concept milling 105, lathe machines Concept turning 105). These machines will be linked with transport system - (Conveyor system FMF - Pallet Transfer System) and they will be served by industrial robots (FRF - The Flexible Robot Feeder). Within this flexible manufacturing system will be also station for quality control (Quality and Handling station QH 200) with camera systems and rack warehouse (AS/RS Automatic Storage / Retrieval System) [6].

In the final phase of this project in year 2013, the flexible production system will be linked with the CAD laboratory of our institute and it will arise as "laboratory flexible manufacturing systems with robotic handling for environment of without drawing production.

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 and will be interconnected with each other.

REFERENCES

[1]   Košťál, Peter - Velíšek, Karol: *Flexible manufacturing system - registrovaný*: Scopus. In: World Academy of Science, Engineering and Technology. - ISSN 2010-376X. - Vol. 77 (2011), s. 825-829.
[2]   M. Hajduk, *Pružné výrobné bunky*. Technická univerzita Košice, 1998.
[3]   P. Košťál, A. Mudriková, and D. R. Delgado Sobrino, "*Material Flow in Flexible Production Systems*," Proceedings in Manufacturing Systems, vol. 5, no. 4 (2010).
[4]   Košťál, Peter - Mudriková, Andrea - Delgado Sobrino, Daynier Rolando: *Material flow in flexible production systems*. In: Proceedings in Manufacturing Systems. - ISSN 2067-9238. - Vol. 5, No 4 (2010), s. 213-216.
[5]   http://www.referenceforbusiness.com/management/Ex-Gov/Flexible-Manufacturing.html.
[6]   P. Košťál, K. Krajčová, R. RUŽAROVSKÝ, "*Material flow description in flexible manufacturing,*" Advanced logistic systems, vol. 4, pp. 104-108, 2010.
[7]   http://www.festo-didactic.com/ov3/media/customers/1100/u_teciam_30_production_opti misation_web.pdf.
[8]   Javorová, Angela - Oravcová, Jarmila - Velíšek, Karol: *Assembly system design with modularity and CA support using*. - Online available since 2011/Oct/24 at www.scientific.net. - registrovaný: Scopus, Web of Science. In: Applied Mechanics and Materials. - ISSN 1660 9336(PRINT). - ISSN 1662-7482(ONLINE). - Vol. 120 : International Conference on Applied Mechanics, Materials and Manufacturing (ICAMMM 2011), China, 18-20 November 2011 (2012), s. 114-118.
[9]   Kusá, Martina - Matúšová, Miriam - Charbulová, Marcela: *Optimalisation method of material flow at manufacturing process*. In: International symposium on Advanced Engineering & Applied Management - 40th Anniversary in Higher Education: Romania /Hunedoara/ 4-5 November, 2010. - Hunedoara : Faculty of Engineering Hunedoara, 2010. - ISBN 978-973-0-09340-7. - I-77 - I-80.