PRODUCTION SYSTEMS SAFETY, MODELLING, SIMULATION AND THE POSSIBILITY OF AUTOMATION OF A PRODUCTION WAREHOUSE AS A KEY COMPONENT IN CIM SYSTEMS

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Abstract: *this paper deals with the safety, modeling, simulation and the possibility of automation of a production warehouse as a key component on CIM systems. The manufacturing has been changed significantly by using information systems. Using electronic data processing in the production systems and beyond, automatic protocols are derived and flow both on confirmation of the order and in economic aspect of the raw material. Also, information systems are used in planning and controlling the production, including machines, equipments and entire production process, as well as a lot more opportunities have been provided for the operator. But, security of the production systems is one of the concerns which are elaborated in this paper. Production systems play an important role in industrial and economic development of a country. Recent years, there was a tremendous change in the technology of production systems. Such changes happened as a result of advances in the field of hardware and software technology, which are directly or indirectly related to modeling and simulation of production systems. In this paper, we will investigate the possibility of automation of a production warehouse as one of the key components of CIM technology. Simulations are new and very attractive area. Nowadays they have become indispensable engineering tools for solving engineering tasks, leaving behind the traditional analytical methods. They include design, analytical and optimisation tasks of complex production systems, computer architecture, biological and military systems etc. This is made possible, because of failure to gain good results by the analytical methods, which is the case also for simple systems too. In the group of traditional methods are distinguished: arrays method (querying theory), different heuristic mathematical methods etc.This paper also deals with modelling and simulation of flexible system for electrical machine assembling by ARENA software.*

Keywords: *PRODUCTION SYSTEM, SAFETY, CRYPTOGRAPHIC, SIMULATION, CIM, WAREHOUSING.*

1. Introduction

Manufacturing systems are very complex systems. Calculation, optimization and management of such systems require lot efforts, which are followed by very large volumes for the transfer and processing of data. So these systems are complex and created by man, so they are artificial and are systems with other systems in the world, communicating and exchanging information with the other systems. Within them there is always flow of goods, energy and informations, and therefore they are part of dynamic systems.

In order to place a product in the market, financial resources, human resources and technological resources are needed, and then we must start with design, production and finally marketing and selling the product. With the recent technological developments these market demands can only be satisfied by the manufacturers who are ready to make their products better in terms of quality, faster in terms of time and cheaper in terms of cost.

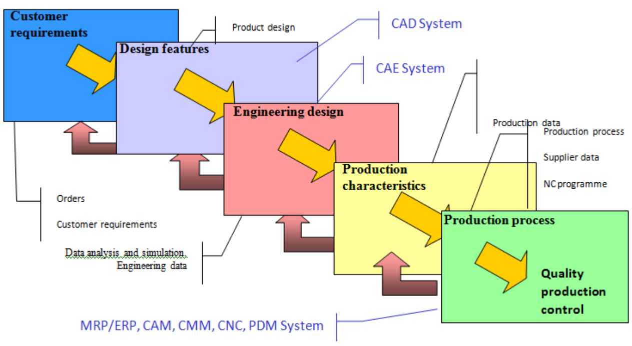

Fig. 1*. From customer needs to production process*

The flexible mounting system of electric motors is a rather complex system. In order for it to be explained and understood more easily it should be divided into several subsystems. This system consists of the following main subsystems:

Technical subsystem
Computer subsystem
Human subsystem
Other subsystems.

Manufacturing systems are very complex systems. Their calculation, optimization and management require very large calculations, followed by a very large volume in the transfer and processing of data. They are open systems there is always movement of goods, energy and information, and therefore they are part of dynamic systems.

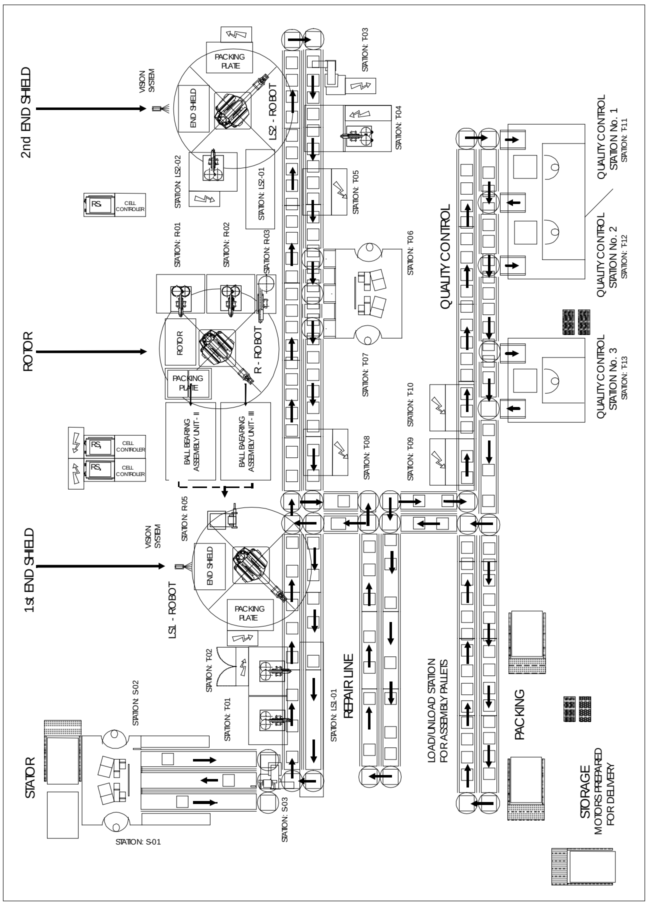

Fig. 2*. Flexible assembly system of electromotors at ATB in Austria*

In most cases we are dealing with output products in a form of numerable units, one by one or in groups, thus discrete and very rarely in continuous or combined form. Therefore, they are not linear systems but a various functions which are often very complex, and can not be solved by any analytical method. They are stochastic and open systems, and a lot of random variables act on them. These systems are known as flexible systems, where after each type is produced with a very small action, they can easily adapt to the new type of production.

2. *Information sub system of flexible system for electromotor assembling*

In the context of the programming interfaces will are referring to the so-called protocols. Protocols represent the "language" of components. Protocols depend on the operating systems which are installed in the computers, but in this paper is mentioned well known and the most compatible protocol: TCP / IP (Transmission Control Protocol / Internet Protocol). This protocol provides the rules of exchange of information through various system components in the networks with different operating systems and with different hardware components. Currently this protocol is the most used and is very suitable for the design of networks with different topologies in both small and large enterprises. This protocol will be used for the case of the flexible system for electrical machine assembling.

In Fig. 3 is shown the information subsystem of flexible system of electrical machine assembling. As is shown on the top of the hierarchy lies the internet network. For each customer is given the opportunity to communicate on the enterprise server via TCP / IP protocol. This means that nowadays is not necessary to go physically to the enterprise or faxing a document and in order to order the products, but this is done automatically by the computer system on-line within 24 hours. So, every day we will have the list of the orders which are processed in the appropriate planning unit of the enterprise.

On the top level is the production planning system. Each order has an external priority as a scale of order urgency. The priority scale has 10 points, from 0 to 9. Priority 0 is given to orders which are not to be processed yet. The normal urgency is priority 5, a very good order is priority 9 and a not urgent order is priority 1.

The first level of contact with the outer world is a WAN (Wide Area Network) and constitutes the wide network of computers. Large enterprises such as Ford, BMW etc have this kind of wide networks, while small enterprises are connected to the internet with LAN-Local Area Networks.

The second level is therefore LAN, which in the practice represents a part of the enterprise (eg sections of planning, design, finance, etc.), each of them collects a number of computers. Production planning of flexible system for electrical machine assembling is followed by building of so-called "Queue of awaiting messages." This range has a trapezoidal shape, giving us the means that such messages are not treated equally, but each of these has a certain priority. The messages at bottom of trapeze are urgent messages. In contrast to those which lie at the beginning and represent the messages that can wait for a while to be executed?

Ordering of these messages by following such a hierarchy is based on the strategic interests of the enterprise. For practical purposes, it should be known accurately which are messages that should begin the installation process and what it look like the order of products assembly process. This is so-called off-line simulation and is assigned a rank of optimal one dimensional Queue of messages, by taking into account the preliminary phase. The designed Queue in this way is called FIFO (First In First Out), which is afterwards broken down, starting from the first and finishing with the last.

The third level of network is called DPCS (Distributed Process Control Systems). This level represents directly some smaller subsystems in the production process. This level role is to inform the central system for the failure / performance of processes and activities in the assembly process. At this level it is performed so called On-Line simulation for the purpose of division of work to the assembling system resources. At this stage is performed so-called resource reservation which results in the construction of Queues of parts, pallets, workers etc. Word On-line means that we are dealing directly with the processes, in the literature this is known the Scheduling activity. Scheduling is the final level where depending on the reaction of the system me must take decision for production process.

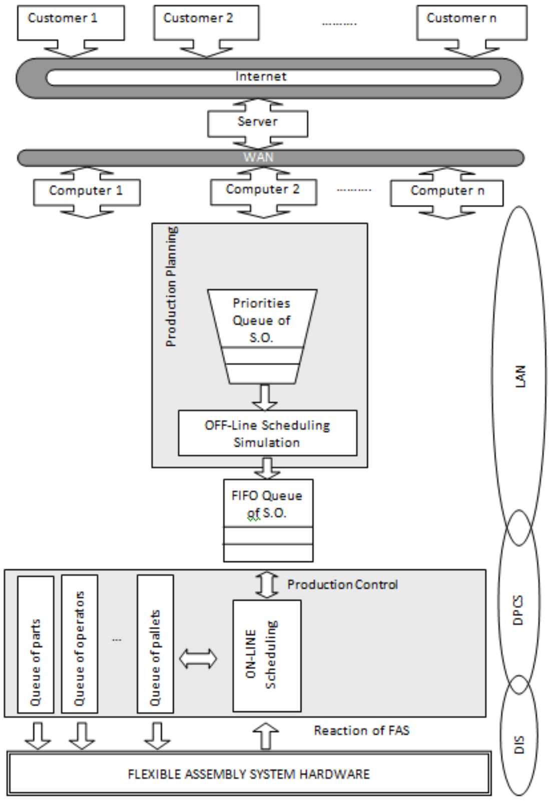

Fig. 3*. Information subsystem of flexible system for electrical machine assembling*

Fourth level of the information subsystem, of the flexible assembling system is called DIS (Distributed Systems Interface). This is the final level of information subsystem which has a very important task to transfer the information through devices and sensors. These are components that have direct physical contact with system components, with their feedback links showing whether the goal is achieved or not. In the most cases in the literature this is known as peripheral subsystem, where the operator through various keyboards provides technological instructions.

System Inventory Manager which is shown in Fig. 4, is used for registration, maintenance and the classification of stocks, warehouses, inventory, etc. Inventory Manager System is an autonomous fast and efficient system and consumes a limited system and human resources. Its administration is very simple and quick. All what a manager should do is: to assign users and their rights and to make backup of database in regular intervals.

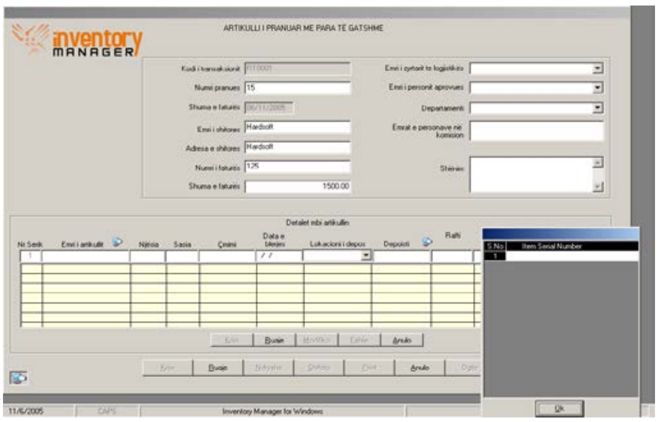

Fig.4*. Inventory Manager Interface*

3.System Analysis, Goal Definition and Simulation

Activities at the flexible system of the electrical machines assembling are very complex, and needs to be described in detail. For purpose of modelling, only main points of them will be subject of analysis.

The system which is considered for analysis from the entry at the first conveyor as a resource point up to the exit from conveyor as an absorbing point for the parts, and is built by following resources:

- Human resources,
- Industrial robots,
- Pallets with ID chips,
- Rolling conveyors.

In Fig.5 is shown graphically the path of all entities that circulate in the flexible assembling system. The path of material flux through working stations contains following elements:

- Input / Output points of the system given by rectangle,
- Stations given by small circle denoted by R (Resource),
- Logic points or system nodes given as parallelepiped (N-Node),
- Straight lines represent the conveyors,
- Arrows show the direction of the material flux.

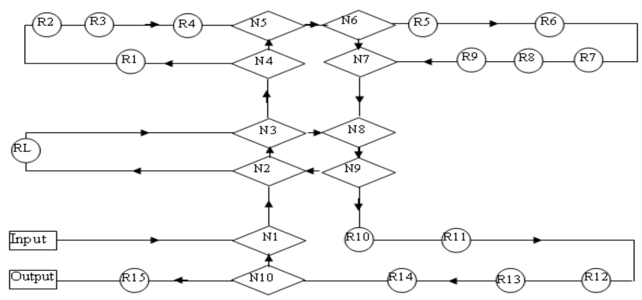

Fig 5. *Scheme of material flow through the assembling flexible system*

System input represents the source of entities, indicating the input boundary of the system, while output or so-called disappearance point of entities is output boundary of the system. But, the subject of study is analysis of the inner part of the system by considering that all external activities are reduced in two points, input and output. Such approximation brings to the definition the system boundaries.

System allows change the number of resources at working station and also change of material flux depending on overfeed of the system with pallets and to change the frequency of material flux. Therefore, the system input and number of the engaged resources are considered as variables. In the other side, the system is influenced by different demands of the consumers which are made in different timing and in various quantities. These are representing stochastic effects that interfere and put condition to the system itself. The aim of the simulation is to achieve a maximum level of rent ability based on these demands, conditions, schedule and resources.

It is adopted that:

C_{Ri} - are the costs for *i* resources for the simulation period, *i=1,..,n,*

C_{Mi}- are the material costs of specified product *i*, for *i=1 to n (Euro)*

C_{Ti} - are the costs for waiting time of product-Entity Flow Time *i* of the system, for *i*=1 *to n (Euro)*

Ψ - is the objective function.

By the simulation process we are trying to minimise the objective function. This means that if decrease of the costs is achieved the main goal of optimisation is met, meaning that "with minimum utilisation of resources the maximum production volume is obtained, satisfying technical and organization conditions of the system".

Mathematical model is expressed by:

$$min(\Psi) = min\left[\sum_{i=1}^{n} C_{Ri} + \sum_{i=1}^{n} C_{Mi} + \sum_{i=1}^{n} C_{Ti}\right] \quad (1)$$

If *k*- simulations are executed then function (1) has form as given in (2):

$$min\left(\sum_{j=1}^{k} \Psi_j\right) = min\left\{\sum_{j=1}^{k}\left[\sum_{i=1}^{n} C_{Rij} + \sum_{i=1}^{n} C_{Mij} + \sum_{i=1}^{n} C_{Tij}\right]\right\} \quad (2)$$

So, the simulation that in the best way fulfils the criteria is adopted. This operation is realized with **OptQuest** package which will be described later.

At **OptQuest** is chosen the option:

$$min\left(\sum_{j=1}^{k} \Psi_j\right) \approx = \text{minimize}\{\text{Entity.Flow.Time}\} \quad (3)$$

In this case, the only goal was the definition of the objective for our experiments in the assembling flexible system.

4.Entering Samples for assembling at flexible system

Another important point of the simulation is to generate data for the working stations known as samples, which is made in manual and automatic way. Once the system is equipped by a device for identification of pallets and because the system has the possibility of communication with central computer, in this way there is possibility for automatic tracking of data. The data that must be entered in this case are listed in the following:

- Time of arrival of piece at the x station and type,
- Time of piece processing at the station,
- The time between the fall of assembling system and the duration of the fall,
- Schedule of the system, short and long breaks, changes and other organisational restrictions

5. System Simulation

System simulation and the animation ascheme is shown in the Fig 6.

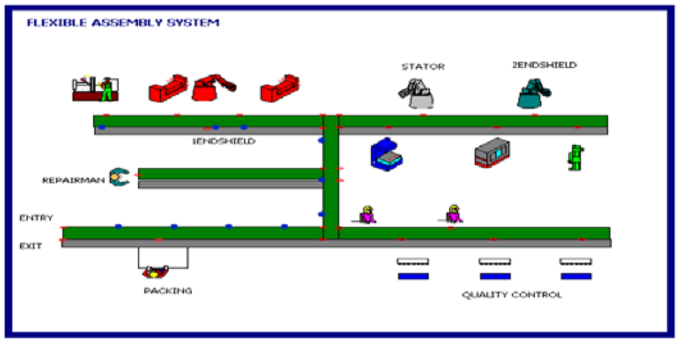

Fig 6. *Animation scheme of system simulation*

In Table 1 is presented the exploitation of the resources at respective assembling stations for the flexible system. Simulation was carried out during 5760 seconds, with material flux of one part per second. The **Arena** program in its **Reports** windows shows: **Replica 1,** Start Time=250,00 [sec], Stop Time= 5760,00 [sec], Time Unit=sec, Resources Utilization.

If **a** simulations are made and we want all of our results to lie somewhere in the 95% of the confidence interval, then we need to look whether the required number of simulations has been made.

$$a^* = [a\,(h/h^*)] \quad (4)$$

If a^* is larger than 1, than additional simulations needs to be carried out in Arena Software, while simulation methods of flexible assembly system are given at Fig.7.

Table 1. *Resources utilisation in the simulation process*

	System Resources	Instantaneously Utilisation	Number Busy	Number Scheduled	Number Seized	Schedule Utilisation
1	Resource 01	1	1	1	1.102,00	1
2	Resource 02	1	1	1	552	1
3	Resource 03	1	1	1	394	1
4	Resource 04	1	1	1	365	1
5	Resource 05	0,93	0,93	1	366	0,93
6	Resource 06	0,79	0,79	1	364	0,79
7	Resource 07	0,98	0,98	1	362	0,98
8	Resource 08	0,92	0,92	1	361	0,92
9	Resource 09	0,78	0,78	1	359	0,78
10	Resource 10	0,9	0,9	1	356	0,9
11	Resource 11	0,98	0,98	1	337	0,98
12	Resource 12	0,85	0,85	1	336	0,85
13	Resource 13	0,73	0,73	1	334	0,73
14	Resource 14	0,66	0,66	1	333	0,66
15	Resource 15	0,6	0,6	1	331	0,6
16	Resource 16	0,79	0,79	1	215	0,79

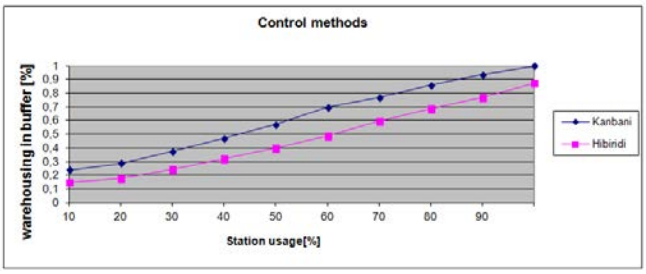

Fig 7. *Simulation Methods at flexible assembly system in ATB*

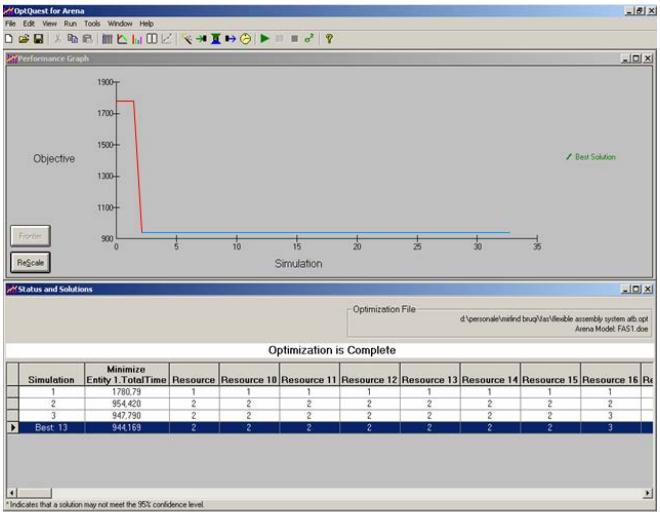

Fig 8. *Simulation results*

5. Conclusions

The demand for storage systems with high degree of automation have been decreased over the last years, this happened for two reasons: (1) a trend toward the reduction of the amount of stored inventory and (2) trend toward ' Just-in -Time ' systems, which reduce the work in process.

The purpose of the management of purchase and materials units is the existence of two or more suppliers. The idea has been that through the competition to have price reduction and to reduce the risk of supply shortage.

For a given company in order to successfully compete in the global market the supplier of high quality and with acceptable price and delivery time is needed.

Inventory Manager will compile a list of suppliers and then develop a program to improve technical capacity of suppliers, quality, delivery and prices.

Inventory Program Manager, is used for the management of warehouses, starting from the registration and distribution of items throughout the process, then placing the supplier and customer, time, type, quantity of purchase and supplies, reporting about the warehouse state related to each item separately, reports on the status of each supplier and buyer and so on.

Flexible systems for assembling are part of the most sotisficated systems of the time. As such they have the possibility to pas from an assembly programme to another in a very short period of time. The flexibility of such systems is the main property. In this way the pas from one assembling system to another is made in automatic or semi-automatic way or manually, by the replacement of the auxiliary devices of robots and machines.

But besides the positive side these systems also have their negative side. Very often in such systems are mounted also different products, and the managerial point of view this is heavy duty because of prior planning and preparations. These preparations include tasks of choosing an optimal or suboptimal scenario of material, energy and information flow, including human resource organisation. The selection of such scenarios is made through different optimisation algorithms such are: finite, limited and random enumeration.

Module varies from one system to another, thus this module must be built for each and specific system.

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