

CIM CONCEPT IN PRODUCTION ENGINEERING INSTITUTE FOR EDUCATION AND RESEARCH

Summary. The paper presents CIM concept in Production Engineering Institute (PEI). The original feature of CIM-PEI is that the part of the system is real while the other one is simulated. It allows to test different configuration of FMS and shows the way of introducing FMS by Step by Step method. The hardware consists of: DEC computer network with six VAXstations 4000, production system TOR, educational production system EMCO, Leitz 3D Measuring Machine PMM 12106. The software consists of original programs developed in PEI - MM (FMS control and simulation); programs (from different vendors installed in PEI) - EUCLID-3, QUINDOS; programs to be installed in near future- BASEstar and EDCS II.

1. Introduction

The need to match a worldwide competition imposes the use of automated production systems. These systems let us to improve productivity and product quality and allow also to lower product costs and shorten products life cycles. To achieve these goals the implementation of automation is a necessary however not sufficient condition. The key role in modern production processes plays information. The only way to get the right information to the right people at the right time is by using computer integrated manufacturing. CIM is an area of high technology that enables the inter-enterprise communication and effective cooperation in all phases of product development. Nowadays the computer integrated manufacturing is not only the subject of academic discussions but also the reality of modern industry. Up-to-date powerful computer systems equipped with high quality graphics together with modern software (CAD/CAM systems, data base systems, planning systems) allows the goals of CIM to be achieved. For polish industry CIM is prerequisite for creation working economical links and technical cooperation with highly developed countries. All plans for restructuring of polish industry, based on analysis of its current status, identify the lack of CIM infrastructure and practical knowledge of CIM based technologies. The education of the new generation of mechanical and manufacturing engineers is the most effective while long way to change this situation.

By implementing CIM a lot of misunderstanding occurs especially in polish industry. The lack of interest in this method is caused by the fact, that it is observed as to complicated and advanced one

for our current conditions. A lot of managers tend to think CIM has to be introduced in one single risky step related with tremendous investment of money. Moreover CIM would demand quite a new staff, probable from abroad, and fire old good chaps from the factory. Nothing can be more wrong. It has to be said no CIM was ever build in such a way. CIM is not a kind of goods that anyone can buy in the shop. The system has to be developed Step by Step with moderate investment carefully planed in time. This way allows the old staff not only gain a new knowledge but also perform creative work by building the system. The essential condition of the success is that the staff has to be convinced of the advantages of CIM for the factory and for the staff itself. The CIM Laboratory in Production Engineering Institute (PEI) has its goal to prepare education and research infrastructure for implementation of automation and integration of production processes, on the basis of the modern computer technology. As the education and collaboration with factories are concerned the Step by Step method has to be always presented.

2. Main parts of CIM-PEI

As it was mentioned above each CIM has to be created in Step by Step method. The same concerns CIM Laboratory in PEI (CIM-PEI). The first step is the creation of the basis stones of the whole system. These can be broken down into two groups: software and hardware.

The software of the system is the outcome of the whole concept of the production process, the hierarchy of the system, theoretical models concerning flow of information and the control subsystem. As far as software installed in PEI (and probably in other universities) is concerned it should differ from that applied in factories. The specific feature of CIM-PEI is that it is devoted for research and education. So it has to allow testing various models and computer programs. In this case software has to be more flexible then in a factory.

The hardware consists of: machine tools, quality assurance subsystem, transport and storage subsystem, control subsystems and computers. The interesting feature of CIM-PEI is that part of the system is real while the other one is simulated. It allows to test different configuration of FMS and show the way of introducing FMS by Step by Step method.

From the point of view of hardware, four main parts can be pointed out (Fig 1):

- DEC computer network,
- Production system TOR,
- Educational production system EMCO (especially devoted for students),
- Leitz 3D Measuring Machine PMM 12106.

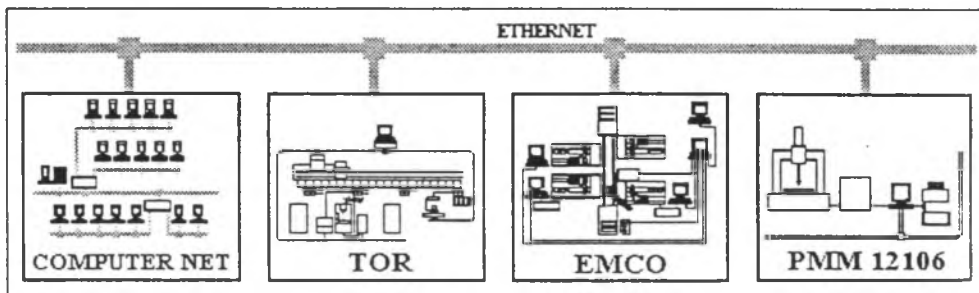


Fig. 1. Main parts of CIM-PEI

3. Software

The core of computer integration is information. Computer software allows to create, transform, store and exchange information among participants of CIM. In CIM-PEI there are three major software groups:

- *original software developed in PEI.*
 - MMFMS
- *software from different vendors installed in PEI.*
 - EUCLID-3
 - QUINDOS
- *software to be installed in near future.*
 - BASEstar
 - EDCS II

Original software developed in PEI,

The important part of CIM-PEI plays software package MMFMS for simulation and control of flexible manufacturing systems. It is based on an original FMS model, which is called matrix model (MM) because of its matrix representation of internal data. This model together with the developed software are the major achievements of PEI staff in the area of CIM. MM is based on original concept [3] [4] [5] of FMS control. In brief the idea can be described as follows. Each part of production process has its equivalent in the simulation model. When simulation model allows to start an activity, information is sent to a proper controller allowing real activity to be started. Next the program waits for information if any activity started before has just ended. After receiving the confirmation, the internal data of simulation model are converted and a new activity is selected for execution. It is important to underline here two interesting features of MM that allow the implementation of Step-by-Step method.

Firstly, the same model is used for simulation and control. It allows to test the configuration of the system and to check applied rules. The same but fully tested model is used later for control of the real system. The result of production process parameters should not differ much from real system and simulation model.

Secondly, the MMFMS software prepared on the idea of MM allows parallel control and simulation of production system components. So it is possible to build a system which consists of real part and simulated one both working together in real time. Basing on this idea it is possible to include new elements to the real system, in Step-by-Step manner. Besides when planning the extension of hardware configuration it is possible to test different possibilities and "see" how they work.

Software from different vendors installed in PEI

The essential part of CIM is integrated by a database CAD/CAM/CAE system. For many years CA technologies have been used separately. It was a source of redundant time brakes and causes the lack of coordination in data exchange. In this approach only the sequential way of design was permitted. Modern CAD/CAM/CAE system allows to use the Concurrent Engineering that means to perform many tasks simultaneously. In 1993 Matra Datavision one of the leading CAD/CAM/CAE software vendors provides PEI with EUCLID-3. EUCLID-3 [8] is the advanced mechanical CAD/CAM/CAE system that can be tailored and configured to meet user's requirements

from design to manufacturing. EUCLID-3 consists of several independent modules built around integral, object-oriented, distributed database. It combines the advantages of different modeling techniques like: solid modeling, surface modeling, parametric design, adaptive modeling, FEM analysis and provides a direct interface into all shop floor activities like: NC machining, sheet metal manufacturing, molding and more. One of the fundamental elements confirming the advantages of EUCLID-3 in CIM environment is that EUCLID-3 provides a wide variety of specialized interfaces for data exchange with other vendor software systems.

Software system QUINDOS developed by LEITZ gives all necessary tools for integrated manufacturing system in which measuring instruments are controlled by a computer or are directly connected to the industrial equipment. QUINDOS is known since its market introduction as the most powerful software for dimensional metrology. This is not only for its highly advanced system concept but also for its user friendliness, flexibility and economical performance. QUINDOS features a well defined interface between the software and the measuring instrument. This allows the connection of numerous measuring instruments and therefore offers the solution to common software in measuring laboratory as well as production environment. The well defined data communication and synchronization interface are the reason for the success in installations where systems integration is required. QUINDOS provides DMIS interface that allows to exchange the data with CAD/CAM/CAE systems.

Software to be installed in near future

As it was pointed out before the information and flow of information play the key role in computer integrated manufacturing. In CIM environment information must flow automatically from computer systems to automation equipment on the plant floor and vice versa. Developed by Digital Equipment Corporation system BASEstar will be used to provide secure exchange of information among equipment from different vendors.

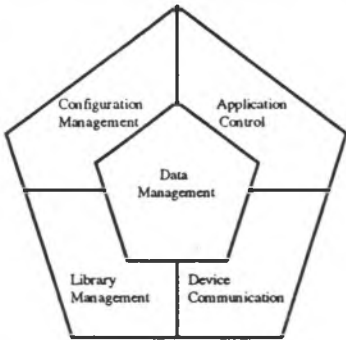


Fig. 2. BASEstar components [1]

BASEstar [1] [2] consists of five major modules (Fig. 2). BASEstar data management allows users to collect manufacturing data, distribute it, manipulate it and store in database. It provides common mechanism for defining, organizing and accessing data in integrated manufacturing environment. Data management functions allows to collect data directly from the memory of industrial control devices. BASEstar configuration management is used for logical configuration of existing equipment. Logical configuration makes users capable to prepare programs independent of devices involved in the manufacturing and quality control processes. BASEstar configuration management is responsible for security issues like: granting or denying access to the BASEstar objects, setting system protection and so on.

BASEstar Device Communication offers generic device access for plant equipment through an interface that is independent of device-specific operations and protocols. Digital offers interfaces for the majority of existing industrial control devices. BASEstar Device Communication provides tools to control and monitor device operation, starting and stopping devices, uploading and downloading device files.

BASEstar Application Control is used for starting and stopping BASEstar applications and controlling the synchronization of processes. It provides reliable interprocess data exchange.

BASEstar Library Management provides BASEstar user with a mechanism for storing and transferring files to end from plant floor devices.

A flow of information among computers and control devices is a low level communication. In production processes very important role play information interchange in CAD and CAM. The majority of this information concern technical documentation. To implement CIM in the industrial environment problems of document acquisition, storing and processing must be solved.

In CIM-PEI Digital's system EDCS II will be implemented. It gives the possibility to use DEC computers but also existing PC's. EDCS II [6][7] provides: secure storing of documents, control of documents flow, granting or denying access to documents and automatic confirmation about the changes in documents. In EDCS II client-server model of distributed computing has been implemented.

4. Hardware



Since 1993 PEI has been taking part in the project sponsored by Digital EERP. For the money from the Project PEI organizes CAD/CAM laboratory based on Digital hardware and software. The laboratory consists of six workstations, one VAXstation 4000/90 and five VAXstation 4000/VLC, integrated in a VAXcluster environment. All PEI rooms and laboratories are fully networked by ethernet LAN.

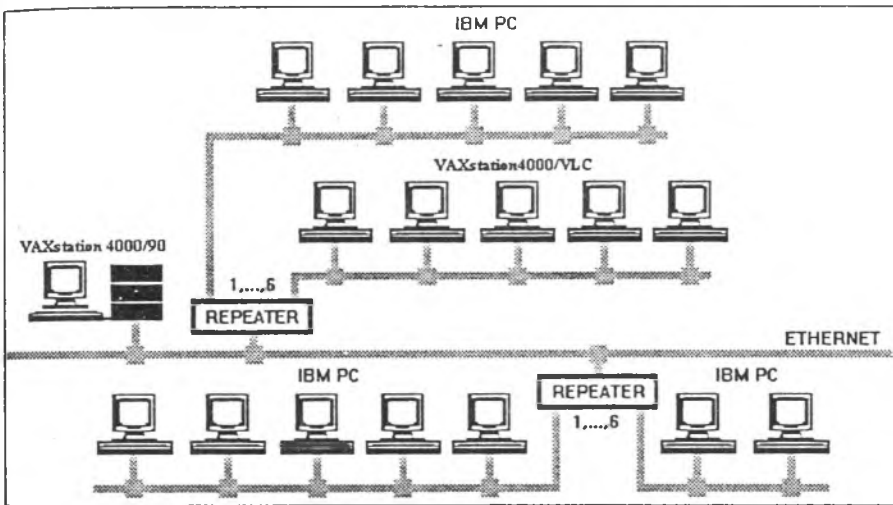


Fig. 3. Computer network in Production Engineering Institute



Machine-Tool Research and Design Center (CBKO) build the production system CP TOR1 in late seventies, but due to the lack of interest of polish industry and some trouble with the control subsystem it has not been working since then. The new control subsystem of the CP TOR1 was developed in PEI in 1992/94 as a main part of the project devoted to Step by Step method and sponsored by the Committee of Research (KBN). The system TOR is shown in Fig. 4. Pallets with workpieces are stored in the rack type store and can be transported by a track moving on a rails. The workpieces before machining are unloaded manually at the loading/unloading (L/U) station. For each machine the pallets changer and workpiece manipulator are provided. The pallet changer takes pallet from one place of the store and when all workpieces are ready gives it back to the next place. The manipulator takes the workpieces from the pallet,

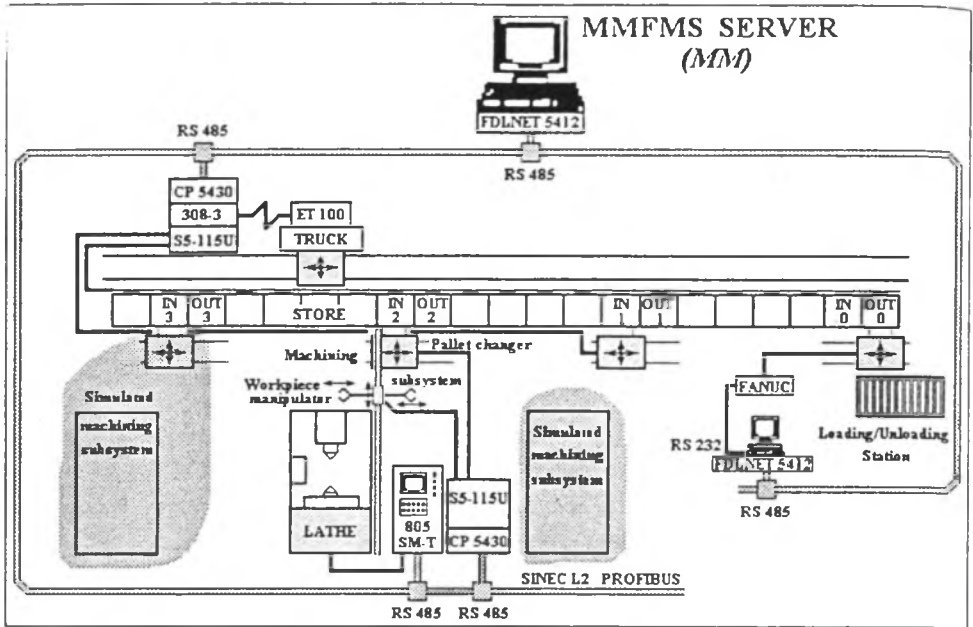


Fig. 4. Production system TOR

transports it to the machine tool and after machining in the opposite direction. In order to test matrix method (MM) of the control subsystem it was not necessary to put into action three machines. It would have been too costly. On the other hand in order to show Step by Step idea some of the objects should be simulated. In the system only the lathe TKX50SN1 works in reality while the work of two other machines are simulated. The MMFMS server, provided with the software based on MM, controls the whole system and allows the machining of three types of workpieces at the same time. For the control of the object following industrial controllers are used:

- SIMATIC S5-115U (pallet changer and manipulator),
- SIMATIC S5-115U (track and store),
- SINUMERIC 805 SM-T (lathe),
- FANUC 90-30 (loading/unloading station).

For the communication between MMFMS server and industrial controllers the net SINEC L2 is provided. SINEC L2 and the net version of SINUMERIC 805 have been put into action for the first time in Poland.



The educational production system EMCO consists of two lathes EMCO Compact 5PC, minirobot MITSUBISHI Movemaster, loading/unloading (L/U) station and pallets.

Three workpieces are transported on each pallet which is loaded on the table of the L/U station. The workpieces are machined in the centers. In order to perform the change of the workpiece in an automatic way the work of the robot and the tailstock are synchronized (project PEI). Three positions of the tool head are provided. For the control of two lathes the IBM PC is used with the original software developed in PEI. The robot has its own controllers (RV-M1 DU) made by the factory. It was also necessary to build a special interface (WUKO-PEI) between computer and steppermotors. This was needed to control the spindle rotation, feed, the tool head position and the save guard position.

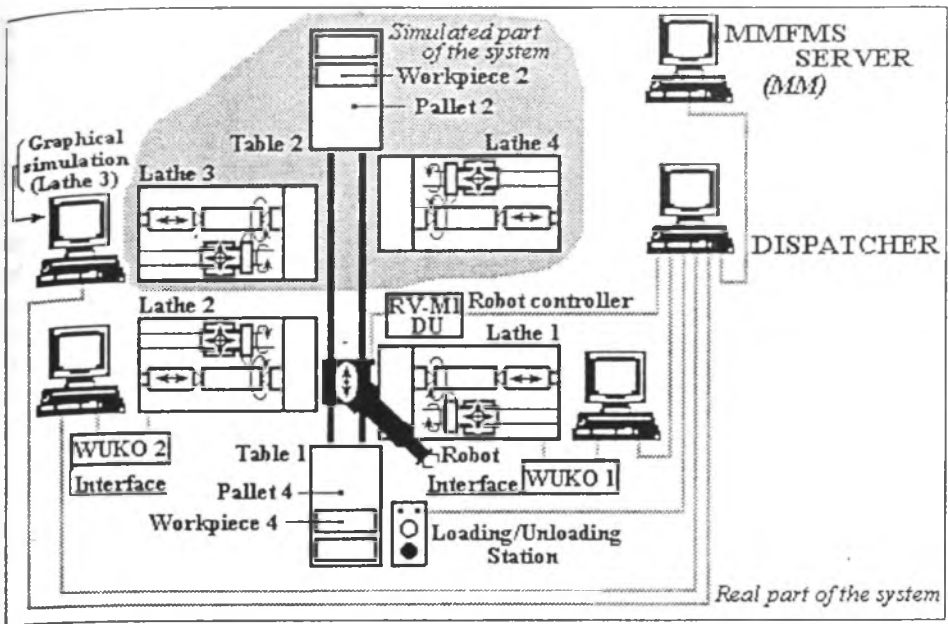


Fig. 5. Educational production system EMCO

For the students education and in order to illustrate Step by Step method an option is provided which allows to simulate bigger systems having as a part, the above described the real one. An example of such a bigger system in which two lathes are real and two lathes are simulated is shown in Fig. 5. In this case the change of the robot position is also simulated. In order to join the simulated AGV transport subsystem with the real part a simple knob is provided. After loading of the pallet on the L/U station manually (instead of simulated automatic loading) the knob is pressed and the real part of the system start work. The MMFMS server has its program based on MM of the whole system. The server sends the orders to start the activities to the control computers and receives back information that the activity has already ended. Information between computers is exchanged by RS232 and Centronics interfaces.



One of the essential part of CIM is CAQ system. The data obtained by measurement of workpieces are send to the CAM system (the so called small feedback loop) in order to improve the production process or to the CAD system (the so called big feedback loop) in order to improve the structure of the workpieces. The most effective way of the measurement offers coordinate measuring machines due to high accuracy and flexibility in use. For CIM-PEI Measuring Machine PMM 12106 of Leitz and computer VAXstation 4000/60 with QUINDOS is installed. QUINDOS is a software system for manual and computer controlled measurement for the entire industry using coordinate measuring machines, measurement microscopes, theodolites and other dimensional inspection equipment.

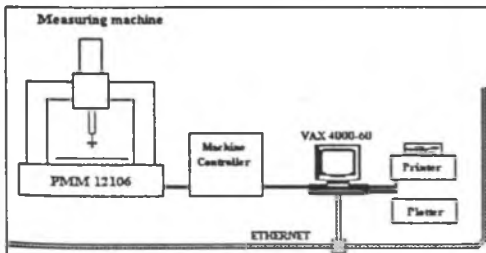


Fig. 6. Leitz 3D Measuring Machine PMM 12106

the machine more effective the pallets of White are provided for workpieces to be measured. The computer program for workpieces are prepared of line and next transmitted to the machine computer.

5. Conclusions

CIM-PEI is devoted for research and education. It has to be flexible enough for testing diverse ideas proposed in research projects. It is assumed that some parts of flexible manufacturing can be simulated. It would allow to exemplify the way how the system can be build Step by Step. The main reason of such a concept is showing managers from industry that some ideas of automation can be applied and tested without tremendous investment. For instance, it is not necessary to install robots, but simple knobs operating by the staff and informing the computer that the job has already been done and from the other side simple lights informing the staff what to do next. The essential question is how to make the production system ready for computation and automation. At the moment main parts of CIM-PEI are almost ready (but always in progress). Now is the time to let them work together.

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