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POČÍTAČOM INTEGROVANÁ PRUŽNÁ VÝROBNÁ BUNKA

COMPUTER INTEGRATED FLEXIBLE MANUFACTURING CELL

Článok opisuje pružnú výrobnú bunku (FMC) vytvorenú v rámci projektu INCO-Copernicus: „Modelovanie výrobku a procesných dát pre FMC-PPDM-MC“ (CP-960052). FMC je integrovaná pomocou počítačom podporovaných systémov ako: CAD, CAD/CAM, PPC a SFC, čím je umožnený informačný tok medzi nimi a realizáciu celého výrobného cyklu vo FMC. V pružnej výrobnej bunke je možné obrábať rotačné a prizmatické súčiastky. Použitie simulačných systémov FACTOR AIM a Roans umožňuje uskutočniť simulačné experimenty, ktoré poskytnú dáta pre optimalizáciu návrhu výrobku a výrobných dát pre FMC.

The paper describes the flexible manufacturing cell (FMC) created in INCO-Copernicus Project. „Product and Process Data Modelling for FMC - PPDM-MC“ (CP-960052). The FMC is integrated with computer systems as: CAD, CAD/CAM, PPC and SFC, which makes the flow of information possible between them and the demonstration of the full manufacturing cycle in the FMC. In the flexible manufacturing cell rotating and prismatic parts can be manufactured. Using simulation devices FACTOR AIM and Roans enables to make simulation experiments, which provide the data for optimisation of product and process data design in FMC.

1. Introduction

In a market economy, the survival of the organisation depends on its ability to react to changes in production. Specific factors such as quality, state of the art technology and low cost in relation to production are crucial to the success of the organisation. It is for the reasons that the organisation must do all it can to foster these specific circumstances. Flexible Manufacturing Systems (FMS) enable high quality production, short production cycles, quick implementation of new products and low level of production in progress reserves, which can all assist in improving the competitiveness of the organisation.

The project resulted in design and implementation of a model FMC consisting of a number of CNC machines, material handling devices and transfer devices, together with the necessary tooling, planning and control software. The software includes Production Planning and Control and CAD/CAM software. The fully operational cell enables demonstration, modelling and investigation of the flow of parts, materials and information in the FMS and is useful for small and medium sized enterprises equipped with CNC machine tools and devices.

The model FMC is created in the European research project “Product and Process Data Modelling for FMC - PPDM-MC” (CP-960052). It focuses on the issues of modern manufacturing: production planning and control (PPC) for flexible manufacturing systems (FMS), CAD/CAM systems, and simulation.

The PPDM-MC project resulted in the construction of flexible manufacturing cell, with the purpose of modelling the flow of information, materials and products. By designing and implementing this model FMC, the project achieved the following goals:

- to provide example a showcase of FMS technology and its applications for Central Eastern European industry,
- to intensify co-operation between industry and academia,
- to develop appropriate courses for students.

The implementation of FMS was accomplished in three main stages, namely:

- Planning,
- Design,
- Implementation.

A computer simulation technique was also used to model the FMC at the design and implementation stages.

2. The design of model flexible manufacturing cell

The model FMC was planned for rotary and prismatic parts. The parts to be machined were selected. The treatment technology, technical requirements, terms of production, quantity of series, and other relevant factors were also defined. The planning chart of FMC is shown in Fig. 1.

The design of FMC included the detailed design of all subsystems. This was provided in two stages. The first stage

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defines the type of systems (single DNC, DNC lines, FMC, FMS). The second stage outlines the layout of the cell (number of machine tools, transport devices, placement of machines, the methods of storage, manipulators, tools, controlling systems etc.).

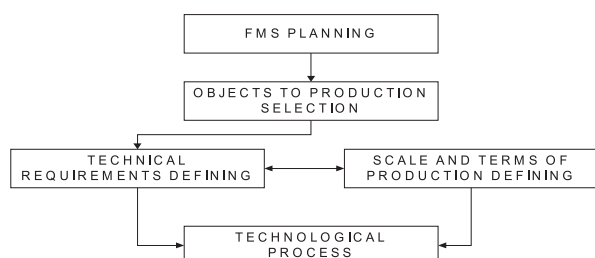


Fig. 1. FMS planning

The FMS implementation was undertaken as two tasks (Fig. 2.). The first task is that of software implementation, which is connected with the controlling system implementation (DNC system, production schedule, production controlling, process monitoring, process inspection, tools monitoring etc.). The second task was that of the implementation of production system (designing of tooling, manipulators specification, treated materials and object transport system, tools system, inspection system, machine tools).

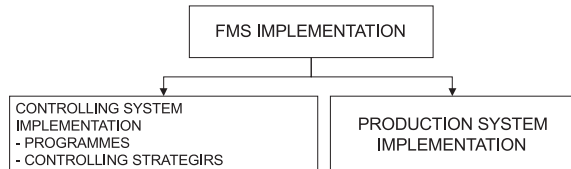


Fig. 2. FMS implementation

3. Structure of model FMC

The computer integrated flexible manufacturing cell consists of two numerically controlled machine tools (CNC lathe and CNC milling machine), control and measurement position and group of semi-products and finished parts stores. The workpieces are passed to processing by a robot, installed in a conveyor system, which is programmed in five axes (Fig. 3).

Robot is on-line programmed using TeachBox or special operational software. Controlling programmes are divided into two parts. The first one contains robot positions in the workspace, second one contains the orders for robot positions and additional orders like: interval of time, opening and closing the robot jaws, etc.

Communication between the HOST computer and robot is through RS-232 connection. In each programme for robot the safety robot arm position is included. That position is also the starting and finishing position for each programme. It is selected in such a way that if there is any collision the arm would not have any collision with the machines, or with any of the storages. At the end of each controlling programme there is an order added, which

causes the sending of the signal to in/out card. The signal on the card is returnable and it is informing the Manager FMS programme that the programme is finished. The Manager programme can indicate the next programme, which is controlling, for example, milling machine. Starting on the next programme is connected with sending the programme with positions and orders from the HOST computer to the robot.



Fig. 3. FMS Laboratory at PUT

The robot in FMS station is moved among all manufacturing stations and storage units. The crossing system contains: a special table with all the FMS stations placed on, a linear guide with the table for robot and controlling system mounting.

The crossing system is on-line programmed, or using the special operational software, which uses MRP2 inner regulator language. Thus, it is possible to programme unrestricted numbers of start and stop robot positions.

Palettes are used as stores for semi-finished products and treated objects. One store is added as an inter-operation store. Each palette has several positions for placing the objects. Palettes can be modified, allowing different objects to be placed on them. The machines co-operate with the robot which is placed on the linear slide. The parts ready for machining are taken from a pallet by the robot to the machine where they are processed according to their process plans.

The model FMC contains the following devices:

machines: - CNC MIRAC lathe and CNC TRIAC milling machine,
industrial robot: - MITSUBISHI - model RV - M2,
material transport unit: - pallets, linear slide for the robot and
auxiliary devices: - manual measurement tools, cutting tools, clamping devices and other devices necessary for the FMS.

The flexible manufacturing cell enables data preparation, which is essential for production and enables their modelling. The cell is integrated with such computer systems as: CAD, CAD/CAM, PPC and SFC, which makes the flow of information possible between them and the demonstration of the full manufacturing cycle in the FMC. The structure of the cell, its integration and the flow of information are shown in Fig. 4.

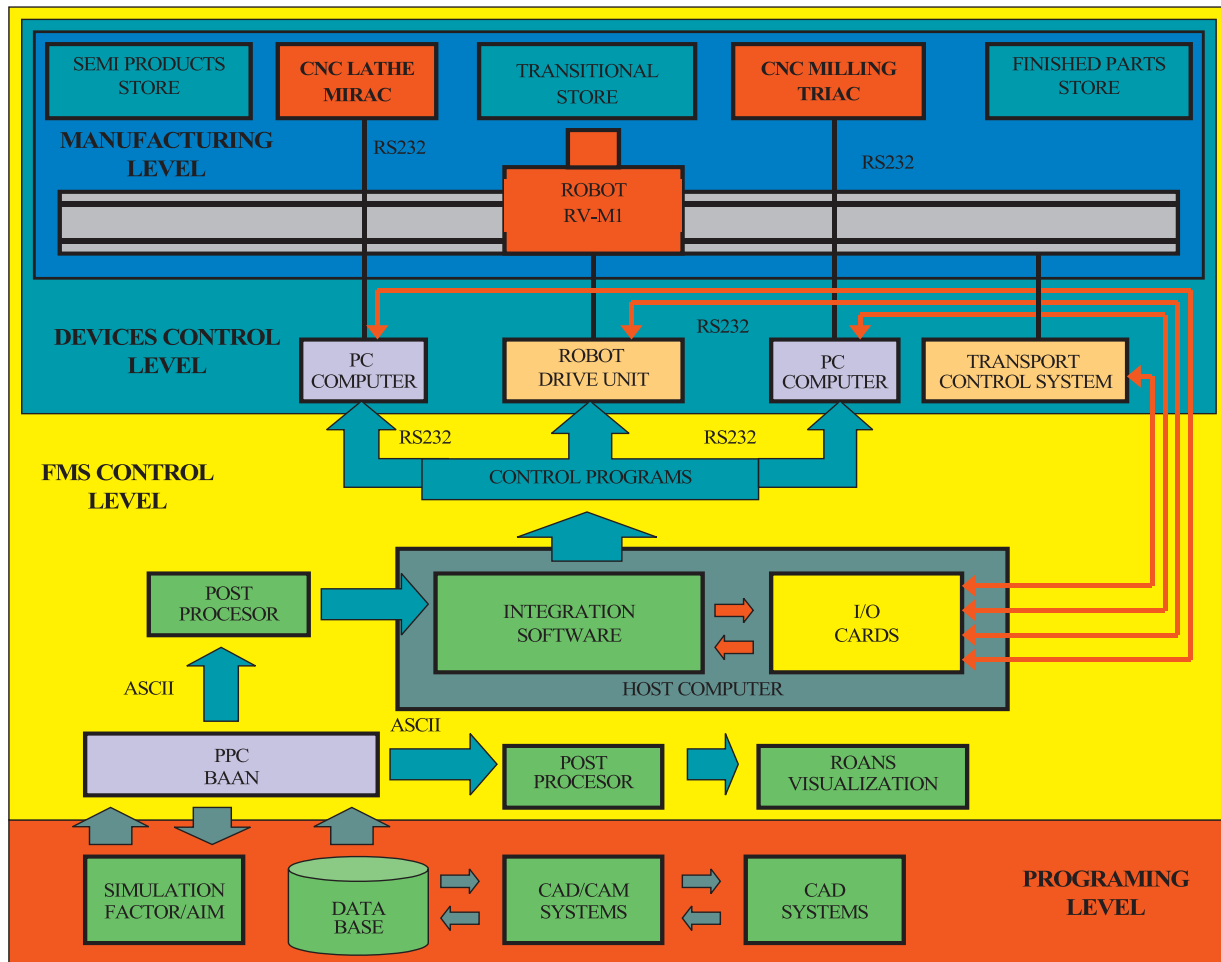


Fig. 4. Connections scheme of hardware and software within the FMC

The model FMC functions in the integrated computer environment. Three levels can be distinguished and controlled with the help of various computer systems. The manufacturing level is served by controlling computers and technological devices that supervise work. The superior level which controls the manufacturing process in the cell is operated by a host computer with the help of a Manager programme which uses information generated in a PPC system. The manager software integrates all technical components in a model FMC. The software is open and it means the possibility of adding another device, e.g. a measuring machine robot and CNC machine. The programming level includes the computer systems: CAD, CAD/CAM, databases and a simulation program.

Rotating and prismatic parts can be manufactured in the flexible manufacturing cell.

4. Data flow in FMC

The system works on the basis of algorithms and models of the flow of information and scheduling of manufacturing tasks as well

as algorithms of digital signal processing (DSP), drawn up by the research team. Planning of orders in FMC is based on methods MPS (Master Production Scheduling) and MRP (Material Requirements Planning) methods and for small batch production, manually.

For planning and controlling the order the integrated PPC system BaaN IV is used. System BaaN is based on Dynamic Enterprise Modelling (DEM) rule.

The schedule of data flows between planning and controlling system and simulator placing the orders based on the time of their starting up are shown in Fig. 5.

BAAN IV was selected as the PPC system for designed demonstration FMC. The level of integration between PPC system and simulation devices depends on a specific situation. Simulation running is performed by realising the orders entering the FMC, each order determines a part, number of parts, process plans, priority and other data which are to be processed in simulation running. This data are used in the environment of simulator by more detailed definition. The following simple procedure is used

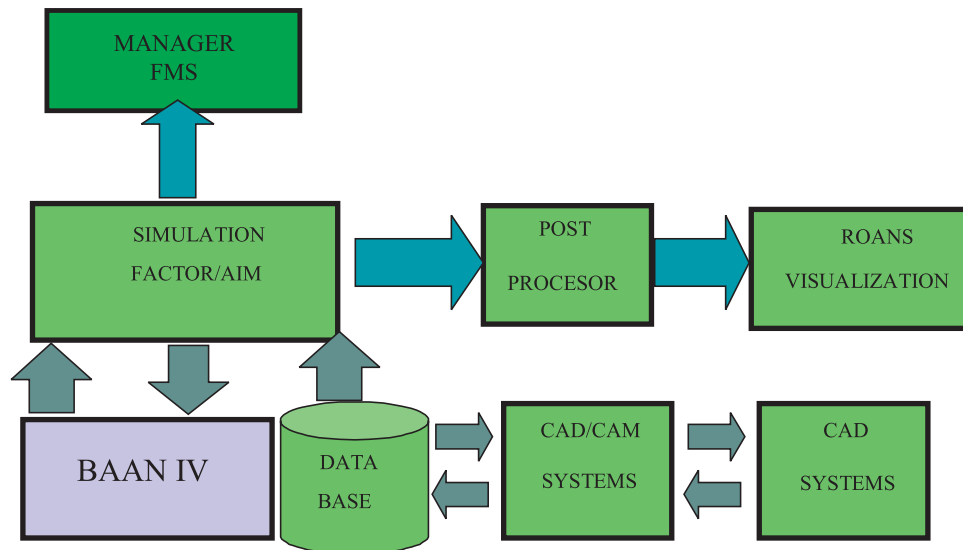


Fig. 5. Data flow between planning and controlling system and simulator

for importing orders to AIM 8.0. The orders which have to be simulated in AIM 8.0 are exported from BAAN IV in ASCII file format. ASCII file exported from BAAN IV is imported to the AIM 8.0 databases directly (using user insert programmed in C++) or by using MS Access 7 (AIM 8.0 databases standard).

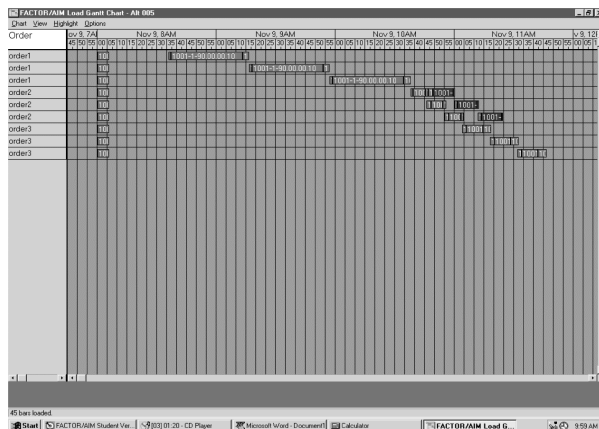


Fig. 6. Example of AIM simulation output - order Gantt chart

AIM 8.0 allows the user to build simulation models very effectively in a user friendly environment. It enables to perform most of the studies required in industrial simulation and also provides high calculating performance and power utilities for evaluation of simulation running results. AIM 8.0 provides a lot of possibilities for evaluation of the data acquired from simulation experiments. This section does not show all of them. AIM 8.0 simulator will be able to perform most of studies required by end users of FMS technology. The type of study and required results will be defined in discussion between the end user and AIM 8.0 simulation expert. The results shown in this section were taken from the simulator as a demonstration. The simulation model is

able to provide more detailed results in relation to the requirements of the end user.

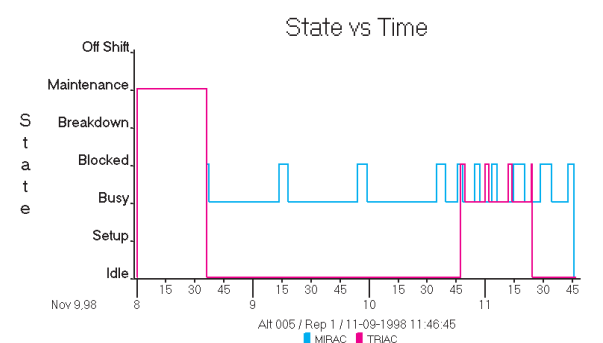


Fig. 7. AIM simulation output - time graph

5. Integration of CAD/CAM systems

Technological equipment used in FMS is numerically controlled. For objects treatment it was necessary to prepare controlling programmes. For CAD/CAM adaptation to FMS, postprocessors were made, which enable to generate NC programmes for the used CNC machine tools. The database of NC programmes has been also prepared (Fig. 8).

Three groups of objects have been proposed: rotating objects treated on a lathe, prismatic objects treated on a milling machine, and rotating objects treated on a lathe and milling machine. For each group of objects the technological process programming method has been chosen for numerically controlled machine tools. That programming method choice is closely connected with programming tools used by the Poznan University of Technology, and with those used in industrial companies from partner countries.

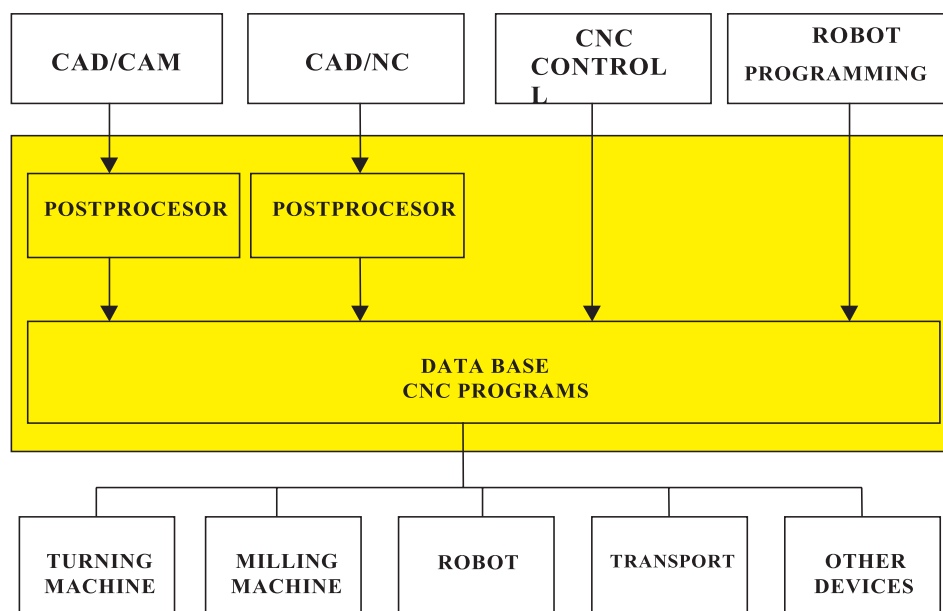


Fig. 8. CAD/CAM systems connections with FMC devices

6. Conclusion

Flexible Manufacturing Systems (FMS) are systems that have already found applications in manufacturing enterprises. These systems are large and designed for big and rich companies. Flexible manufacturing cell (FMC), realised within the confines of INCO-COPERNICUS/ESPRIT Programme, together with other scientific centres and industrial partners takes into consideration the specificity of the market and the situation of small and medium-size companies.

The simulation devices FACTOR AIM and system Roans enable to make simulation experiments. The modelled processes can be shown in a graphic form, using a network to the centres of technology exchange situated near SMEs. The system will be used to run project works regarding products design, to draw up manufacturing processes and production planning numerically to controlled machine tools work in the cell of the FMS type (but not only), and also to train students and the technical staff of a particular enterprise.

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