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CAD/CAM SYSTEMS IN TEACHING PROCESS FOR EXAMPLE FMS - EMCO MAIER

Summary. The paper gives a description of FMS EMCO-Maier elements, their functions and didactical application possibilities. The study was prepared on the grounds of experience of the work with the system and the documentation supplied with the system.

1. Introduction

The dynamic development of technology and engineering requires means of production to be flexible. That is why traditional machine tools are replaced by numerically controlled machines and frequently by flexible machine systems (FMS) as well. Consequently, a demand arises for preparation of high qualified personnel for engineering and technical servicing of machines and flexible systems. According to the plot in Fig.1 this requires increasing of the cost of labour and workers training time.
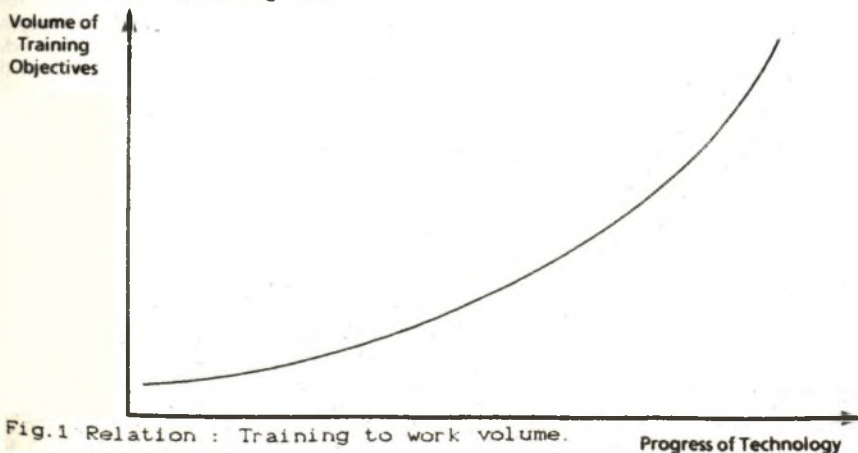

Fig.1 Relation : Training to work volume.

2. FMS-components

The didactical equipment of the Mechanical Engineering Institute
of Warsaw University of Technology enriched itself recently
with FMS by Austrian EMCO-Maier.
The system is designed for machining of rotary parts as shafts,
sleeves or disks of maximal dimensions 10-50x20-130 mm.
It is composed of the following modules:

1.   - Main computer of the type IBM PC/AT
2.   - Control panel PCI
3.   - Interface RS - 232
4.   - Pallet 1
5.   - NC lathe: COMPACT 5 CNC (2 axles)
6a   - Industrial robot: Mitsubishi Move Master RV-1
6b   - Drive Unit
7.   - Electric cabinet
8a   - ⎫ NC milling machine: F1 CNC (2.5 axles)
8b   - ⎬
9.   - Pallet 2
10   - Base of robot
11   - tailstock   ⎫ electrically controlled
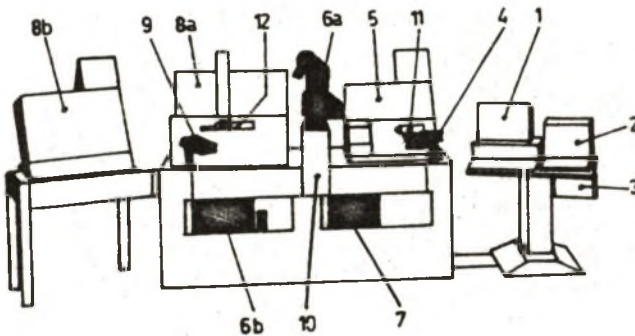12   - machine vice ⎭

Fig.2 FMS modules

The system is designed for application in teaching process and
contains special software that enables cooperation on different
levels of a student with the system or its elements.
The structure of the system is designed so as to let any of its
elements be usable independently. Thanks to this one can conduct
lessons on programming and servicing NC machines, industrial robots
programming or the whole system programming and servicing.

2.1. CNC machines

The NC machine tools are typical training machines manufactured
and supplied as independent units by EMCO. Since they are low
powered, it is recommended to use easy machinable materials
such as aluminium or plastics.
The machines can work in two modes:
    - manual control
    - Numerical Control mode.

The manual control mode is used mainly to instruct students how the parts of the machine tool move, how to measure the tool correction and how to make initial arrangement of the tool for a program execution. The position coordinates of the machine tool elements are visible on the display. The displacement values can be zeroed at any time and then they can be calculated relatively to such a position. The spindle rotation speed and the feed values are continuously variable in their ranges.
The milling machine can work in horizontal and vertical arrangement. The lathe has a rotary 6-position toolhead.

In NC mode the monitor screen displays a program sheet that contains fields to be filled with a machining program data. The control code is in accordance with DIN 66025 norm. The data can be input directly from the keyboard of machine tool control panel or from a computer. The correctness of the input data can be checked without program execution (syntactic and semantic errors) or executing it unit by unit. The executed program can be stopped at any time, and then one can make measurements of the workpiece, introduce corrections to the tool position, and then continue the program execution. The actually executed line of the program is marked by a highlighted unit number. These functions are extremely valuable in a teaching process because they enable a precise analysis of a program structure as well as of its technologic cuts correctness

2.2. Industrial micro-robot system

In the system the robot transports workpieces between machine tools and pallets for semi-finished and finished products and accurately positions workpieces on machine tool.
It is a typical industrial robot adopted by EMCO to the needs of the system. It constitutes an integral unit with its control system which is the kernel of the whole system.
The robot is programmable by PTP method from the remote control system. It can be rotated in 5 axles or moved in cartesian space coordinate system. The positions of successive points are input into battery supported RAM memory in the control system. The robot control system maintains not only the set of points, but also the program for the whole system control.
The Drive Unit has two 8 bit registers: output and input. Every register bit is assigned to a definite system element or corresponds to a system state. For example: when 0 bit is assigned to the first machine, then state 1 in input register means that the machine tool is working, and state 0 in output register means start instruction of machining program for this machine.

2.3. PCI (PC Interface)

In order to facilitate introduction to the mode of operating the FMS, and to provide greater clarity, a separate intelligent control console has been provided. The PCI is fitted with 5 permanent functions (assigned keys: Emergency Off, FMS Start, FMS Feedhold, DNC Check, Menu Selection) and 8 softkeys. The softkeys are assigned to the corresponding new points of the PCI to influence and control the system. The control console allows 3 major menus to be selected to operate the FMS:

* FMS Test: machines, robot programs and other programs can be tested individually. The system is decoupled.

* FMS DEMO-EDIT: Operation of the FMS can be controlled from the PCI.
* FMS HOST: The host computer takes over control of the entire system.

2.4. Host computer

The computer serves as a system supervisor. The bidirectional communication is provided between the computer and the machine tools and the robot control system.
The computer software enables a user to work on different levels of advancement. The computer programs are easy operable and 'user friendly'. At any moment there are available help screens.
There are two ways of programming the system. The first one is programming in the language of robot instructions (the robot program is also for system). The second one is programming in a high level language (of structure similar to Pascal) supporting possibilities to create user's own macrodefinitions and macroinstructions.
The working system run and the state of its elements can be observed on the monitor screen.
Machine tools programs can be written directly in the machine programming code or prepared with a CAD/CAM program that on the base of introduced graphical information generates an adequate machine tool program.

2.5. CAD/CAM program

CAD/CAM is the 2D-drawing set up system provided with all common characteristic features, designed mainly for applications in mechanical engineering. Its main feature consists in the complete integration of the CAM part so that drawings set up with CAD can be further executed directly in CAM.

Characteristic features CAD:
- all geometry components (from point to ellipse)
- color support
- system library is to be defined by the user
- automatic dimensioning and cross-hatch
- geometry manipulations (rotation,mirror etc.)
- measuring and computing
- splines
- full integration of CAM part

Characteristics features CAM:
- turning and milling
- tool library
- blank actualization
- graphic simulation with collision control
- manual or automatic toolpath generation
- subprograms, cycles, macros
- automatic cutting plan distribution
- full integration of CAD part

3. Work with the system

At any stage of programming there is a possibility of computer simulation. In the case of teaching the simulation is an extension to theory. It enables a safe combination of theory and practice. When faults occur (which is quite often in learning) during the pass from theory to practice it can be costly. A collision of tool with workpiece or machine tool element is even dangerous and always brings material losses. A computer simulation enables revealing of errors (a collision can be safely observed on monitor screen), correction of errors and then machine tool program execution. FMS servicing and programming by students should be the last stage of training. Students should begin machine engineering course from acquaintance with traditional machine tools. Then they should attain good introduction to NC machine tool servicing and programming.

This purpose can be perfectly supported with small training machine tools, which students do not fear. After this training stage the listner is excellently prepared and has makings of a specialist in the NC machine tools discipline. The next teaching step is to instruct students how to control and program industrial robots. The last step is FMS control and service, where a number of modules must cooperate. The purpose of such a step training is instruction of good theoretical foundations, their establishment and verification in practice.

Very important element in the teaching process is composed by good written handbooks and teaching supporting materials. The laboratory, in which the system is installed, possesses a rich training documentation. Among others there are handbooks for NC machine tools programming with slide sets illustrating machine tool programming issues (lathe, milling machine), a set of service manuals with examples for a CAD/CAM program devoted to robot control and servicing, programming and servicing of the system as a whole of cooperating elements. The manuals and handbooks are written very intelligibly and conduct a trained person from beginnings to next steps of advancement. A teacher can use sets of slides and large-scale illustrations about NC machine tools programming. He has also handbooks similar to students', but with solutions to problems. The configuration of the system affords possibilities for realization of a whole CAD/CAM training program, though for a limited number of students. Our experience indicates that the optimal number of a group is 4 to 5 students. However employment of a few students' computers connected by a net with teacher's host computer considerably increases training efficiency and makes training groups enlargement possible.

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SYSTEME CAD/CAM IM DIDAKTISCHEN PROZEß AM BEISPIEL FMS-EMCO

Zusammenfassung

   In dieser Bearbeitung wurden die FMS - EMCO Maier Elemente,
ihre Funktionen und Moglichkeiten der didaktischen Verwendungen
beschrieben. Der Vortag wurde vorbereitet auf Grund der eigenen
Erfahrungen der Arbeit mit dem System und der Dokumentation,
die zusammen mit dem System geliefer wurde.

SYSTEMY CAD/CAM W PROCESIE DYDAKTYCZNYM NA PRZYKŁADZIE FMS-EMCO

Streszczenie

   W opracowaniu opisano elementy FMS - EMCO Maier, ich funkcje
i możliwości zastosowań dydaktycznych. Referat przygotowano na
podstawie własnych doświadczeń pracy z systemem oraz dokumentacji
dostarczonej wraz z systemem.