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CAD/CAM SYSTEMS INTEGRATION

Summary. The paper presents a short introduction to the Computer Aided Manufacturing Cutting Edge system and possibilities of integration of the Cutting Edge and Emco systems. Data formats in these systems, especially DXF and IGES, as well as differences in NC program structure generated by both packages are presented. A solution to the problem of implementing the Cutting Edge in Emco system is given. A sequence of stages in the Cutting Edge and Emco systems integration process is discussed along with the role played by the converting programme.

1. INTRODUCTION

The use of CAD/CAM (Computer Aided Design and Manufacturing) has rapidly spread into the world of design/drafting. In a very short time, CAD/CAM has grown from only a handful of workstations to literally scores of different workstations, software, peripheral devices, and applications. CAD is not limited to simply creating graphics. Creating graphics is only one part of the total design and manufacturing of product. It is possible to merge the two major phases of manufactured product: design and manufacturing. The automation of product design is accomplished using CAD. The automation of the manufacturing process is accomplished with CAM. CAM is the automation of the manufacturing process using computer-controlled machines and robots for fabrication, assembly, material handling, measuring, and inspecting. Some of these operations are created by using the geometric data base created with the CAD software. For example, the NC (Numerical Control) program for a milling machine can be produced from the geometric data base from the CAD system if the part geometry data is output in a format that can be interpreted by the NC machine. This merging of CAD and CAM is the key to the factory of the future which will automate the entire design and manufacturing process. The merging of design and manufacturing process is called CAD/CAM. It is an umbrella process that combines the design and manufacture of a product into one integrated approach through the use of computers and the sharing of data. Alone, micro-based CAD systems are not capable of generating the data necessary for CAD/CAM. Most systems provide only some of the data but not all. However, a few micro-based CAD systems provide the link to other computers that can produce the data necessary for CAD/CAM. CAD/CAM systems connected and integrated with another computer aided solutions is called CIM. CIM is the total automation and computerisation of the manufacturing process from receipt of the order to

shipment of the product. For CIM to work effectively, a common data base pool must be available to all phases of the manufacturing operation. CIM conveys the concept of a semi- or totally automated factory in which all processes leading to the manufacture of a product are integrated and controlled by computer. It includes computer aided: process and production planning, quality control and especially design and manufacturing.

2. CUTTING EDGE. COMPUTER AIDED MANUFACTURING SYSTEM

Cutting Edge is a three-axis CAD/CAM software system that is integrated with CADKEY. It has all the capabilities of CADKEY combined with its own CAM machining features. The common user interface allows engineering, design, drafting, and manufacturing departments to communicate better with each other. Cutting Edge decreases CNC programming time and increases productive machine time. With Cutting Edge it is possible to edit a tool path graphically while creating it. One of the major benefits of working with the Cutting Edge system is that it is possible to see each machining operation reflected in the manufacturing process. Cutting Edge integrates the CAD and CAM elements of design and manufacturing within a single database, as well as provide an open architectural framework for continued development. Another true benefit of the Cutting Edge system is the ability to create one file, a job file, which contains all the elements needed to machine the part. This makes the exchange process of files easier, and of course more efficient. Geometry can be created from within the Cutting Edge system, read in from the CADKEY program, translated from another systems via DXF, IGES, or through the CADKEY Advance Design Language (CADL) program. Cutting Edge offers a number of output formats including standard text, APT, NCI, and CE APT (designed for use by the Post Configuration Module). There is a generic post processor included with the Cutting Edge system designed to work with all FANUC based controllers.

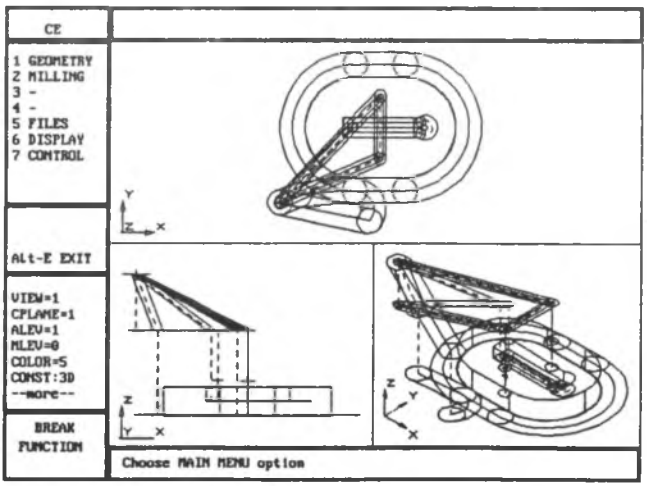

Fig. 1. Milling simulation and tool path in Cutting Edge system

The system allows to machine every element, using four main milling options:
1) **contour** functions generate motion for machining along a set of entities (drive surfaces), and methods to approach and exit the contour.
2) **pocket** automatically machines a cavity within a closed contour using single or multiple passes in the z direction.
3) **cycles** offers options for defining and executing drilling cycles.
4) **letters** generates tool path moves to engrave lines of text on the work surface.
Fig.1 shows milling simulation and tool path in Cutting Edge system.

3. INTERFACES AND DATA FORMATS FOR CUTTING EDGE SYSTEM

Since the introduction of the computer as an automation tool for planning and control of manufacturing operations, the problem of interconnecting various software and hardware systems has become a major issue. The adaptation of protocols, data formats, and data transmission rates is done by the interface. The interface must provide electrical and physical compatibility and it must ensure that the semantics of the exchanged information is maintained. Data conversion may be done directly in the interface with pre-processors and post processors. With the help of such an interface it becomes possible to use existing software and hardware modules for various applications in a factory. There are also interfaces problem among CAD/CAM software, because different applications use different outputs and data format. Currently there are efforts to standardise the output of CAD/CAM software.

One of these standards is called IGES (Initial Graphics Exchange Specification). This standard will allow the bi-directional exchange of data between different CAD/CAM systems. As this standard improves and as more software companies adopt IGES, the possibility of CIM becoming a reality will increase. CADKEY and Cutting Edge packages contain IGES translator. The IGES translator program is flexible and lets exchange data between CADKEY or Cutting Edge and another CAD or CAM system. The IGES translator converts CADKEY or Cutting Edge part files to IGES files, or translates IGES files to CADKEY or Cutting Edge part files. The data transfers through an IGES ASCII format file. Figure 2 is a model of the IGES communications link used by CADKEY or Cutting Edge packages.

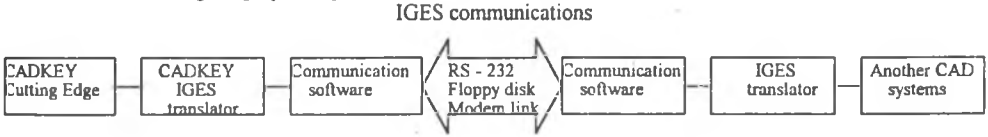

Fig.2. IGES communications model used by CADKEY and Cutting Edge

Another popular data format used by CAD/CAM software is DXF (Drafting Exchange Program). CADKEY and Cutting Edge packages can not directly read files of DXF format so the bi-directional translator program was created. The ALCADMY utility is a CADL-DXF bi-directional translator providing an easy method of moving data between dissimilar CAD/CAM systems. Most PC CAD/CAM systems are capable of storing and retrieving data in one of these ASCII formats. Few, however, are able to handle files in both formats and still preserve enough of the original drawing to be considered a transparent conversation between the CAD/CAM systems.

ALCADMY provides this transparent conversation. It is a self-contained, executable package

requiring no support files or system overlays. Alcadmy is currently based on the CADL and DXF definitions as specified in CADKEY version 3.5 and AutoCAD Release 10, respectively.

4. INTEGRATION OF CADKEY, CUTTING EDGE AND EMCO SYSTEMS

The interconnection of CAD and NC programming systems is an important step towards CIM. Until now, batch and dialogue-oriented generation of part programs has been highlighted, in which both the technical drawing and the language description are basic ingredients. The drawing may be generated conventionally or by CAD. The term CAD/NC programming is used to describe the generation of workpiece data for NC using the CAD database implemented by the designer. In CAD/NC integration, the conception and design of the proper facilities and procedures are an important task of software engineering.

Here we distinguish between:

- The program building blocks for the integration itself and for man-machine communication.
- The description model.
- The data interfaces, for example, part-program and IGES interfaces.

It follows that description and interpretation rules together with interface specifications are particularly important. When integrating CAD into CAM, two tasks should be considered:

- modification of the geometry,
- extension of the technology.

Both of these tasks are usually carried out via an interface building block involving interactive graphics. The modification of the geometry results from the fact that a CAD geometry is not suitable for manufacturing. Neither is it directly suitable for computation or for quality assurance. Thus, a product model suitable for CIM requires a number of slightly different views of a workpiece. Integration may be expected to lead to the following advantages:

- increase in quality in the product development,
- guaranteed data and model consistency,
- minimisation of foults,
- reduction of costs associated with the acquisition and generation of data,
- faster job throughput,
- time savings in planning tasks,
- improved quality of NC programs and work plans.[2]

There is a problem of integration of two different CAM systems (Cutting Edge and EMCO) at the Institute of Mechanical Engineering and Automation. EMCO system connected with two machine tools: milling machine and lathe is much more limited in the area of graphics possibility, tool path simulation and implementation to another programmable individual machine than Cutting Edge system. So it was decided to implement CADKEY software in EMCO system. It was necessary to fix the Cutting Edge system to the controller requirements of the milling machine in the EMCO system.

Program translator was created which changes and adopts the NC program generated by Cutting Edge into NC program compatible with controller requirements and the EMCO milling machine specifications.

The examples of differences in the NC program structure generated by both systems are illustrated in Figure 3.

FEATURES	CUTTING EDGE	EMCO
Programming system	Absolute	Incremental
Definition of the first motion of tool in programe structure	G00 (default) -rapid motion	Set in program
Begining of the program	'%'	-
End of the program	'%'	M30
The way the controller interprets I,J,K parameters for defining circular moves	Signed incremental distance from start of circle to center	Signed incremental distance from center to start of circle

Fig. 3. Examples of differences in NC programme structure generated by Cutting Edge and Emco systems

At the beginning of the NC program created by the program translator it was necessary to change the programming motion system from absolute in Cutting Edge to incremental in EMCO. An important action was also to change the way the controller interprets I,J,K parameters for defining circular moves. In the case of NC program structure generated by Cutting Edge, program was written for controller which interprets I,J,K parameters as signed incremental distance from start of circle to centre and in EMCO is opposite situation.

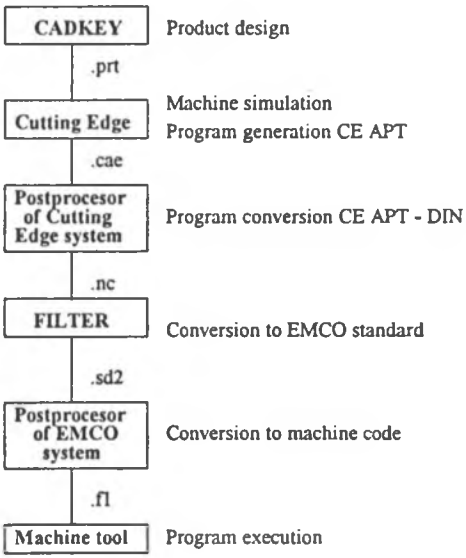

Fig. 4. Sequence of stages in the integration process of Cutting Edge and Emco systems

EMCO two axis milling machine could not work with the NC program generated for three axis machine tool and it was an additional problem in the integrating area of both systems which should have been solved.

The EMCO controller interprets simultaneous motion in three axes as an error so the programme translator divides motion in three axes as motion in the XY axes and in the Z axis. All differences between Cutting Edge and EMCO system were changed and placed in program translator. A sequence of stages in the integration process of Cutting Edge and EMCO systems is illustrated in Figure 4. A program translator called 'filter' was written in C++ language. The program reads a file of the NC program with extension .nc and writes a new NC program file with extension .sd2 which is compatible with EMCO controller.

In general the main problems and difficulties of implementing computer aided manufacturing arise because of the lack of standard programming methods and algorithms of machine tool controllers. A very important point of integration of CAM systems is adoption of NC program structures generated by CAM packages to the different generations of control systems.

There is often the same problem in the industry. Production engineers are essentially the link between the CAD system and the computer controlled machine tools on the floor. Each manufacturer's machine tools require slightly different dialects to be produced to allow for their different physical designs and controllers. The programs which translate the code into the right dialect are called post-processors. Fortunately if for CNC machine tools post-processor software is available, if there is not such a software, the main task of integration is creating post-processor software needed for available machine tools.

The new generation machine tools understand the different dialects of programming language and there is no problem of adoption of CAM systems on the shop floor, if there is such a problem with older controllers it is necessary to create program filter or just post-processor software.

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