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COMPUTER AIDED PRODUCTION ENGINEERING

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Abstract: *Prevalent area of exploitation of CAM (Computer Aided Manufacturing) systems is computer aided program creating for NC production equipment. However, CAM systems do not sufficiently cover all periods of production process and due to this, the necessity to define the systems of Computer Aided Production Engineering - CAPE is obvious. CAPE is a subsystem of the system CIM including the computer aided systems of all activities connected with realization of product manufacturing.*

Key words: *CA systems, CA technology, computer aided manufacturing, CAPE systems.*

1. INTRODUCTION

Computer technology equipped with suitable software is advantageously used in various branches of practice at present time. It is difficult to imagine the development and production of new products in modern enterprise without exploitation of appropriate computer aided systems. Most of present CA systems are mainly determined and used in the area of computer design and constructing of new products, but only complete application of these modern computer technologies to all periods of product design and manufacturing, can bring the maximum profit for the enterprise.

CAM (Computer Aided Manufacturing) systems are mostly used in practice in the area of production in relation to computer support. However, prevalent area of exploitation of these systems is computer aided of program creating for NC production equipment, what represents from the point-of-view of completed production process only one of its part. There are also others processes of product manufacturing process for example: automated work-in-process transport and product storing, automated handling with the products, performing the measurements in automated inspection stands, etc. Following these facts, CAM systems do not sufficiently cover all stages of production process and so it is necessary to define the systems of Computer Aided Production Engineering – CAPE.

2. HISTORY OF CAPE TECHNOLOGIES

CAPE started as an off-line programming tool for automated manufacturing equipment. Its prime purpose was [7]:

- to program robots off the shop floor.
- to provide the operators a safer working environment.
- an efficient tool to perform trial-and-error routines.
- a reduction in maintenance and troubleshooting efforts.
- better use of the production equipment for real manufacturing purposes rather than preparation work.

Soon the advantages of using CAPE tools upstream became clear. It was necessary not to use CAPE only for programming equipment, but also use it up-front, for designing the whole workcell. Enhanced CAPE tools enabled manufacturing engineers to design the complete workcell in a faster, optimized and error-free fashion. The ability to view the equipment working in a manufacturing environment allowed for much tighter designs with less error margins, as well as more accurate time and flow calculations. Thus, CAPE took a significant step forward. Computerized process design provided benefits not only in the launch phase, but also throughout the product life cycle, as optimized cell layouts and tools paths resulted in reduced capital investment and lower variable manufacturing costs. The example of computerized optimization of cutting tool path by simulation with aim of CAM system is on Fig. 1.

A typical task is to design a complete manufacturing process of a production engineer by using a CAPE tool. One creates a graphical representation of a factory workcell in his computer. Then one imports the products geometric 3-D CAD data. One selects the appropriate production tools from electronic reference libraries, where all the capabilities and features of these tools are kept together with their respective geometric data. Then,

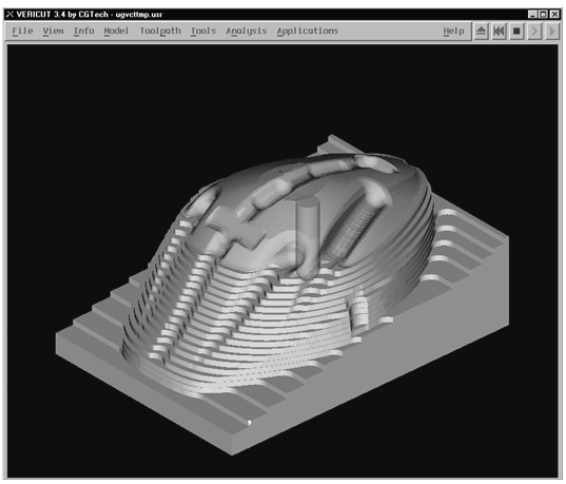

Fig. 1. Example of manufacturing simulation.

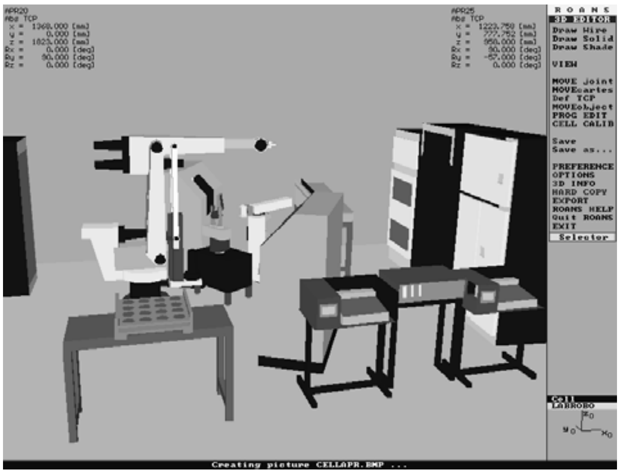

Fig. 2. Realistic simulation of robotic workcell.

one designs the process in this virtual manufacturing environment. It was beginning to several new terms in the industrial world: digital mock-up, master model, electronic prototype - all names for the same concept – refer to a single database that contains all the product data, and is consistently updated with the latest changes. This database will allow all departments involved in the same project to work on the most recent data.

CAD integration technology allows CAPE to create the production master model by directly accessing the CAD master model at the front end of the industrial process. It actually facilitates a CAPE database that both complements the CAD database and holds all production-related data. At the back end of the development process, CAPE has to provide a smooth transition to the manufacturing equipment. Following this aim, a European forum was established consisting of automated equipment vendors, CAPE and computer-aided robotics vendors, and their customers. The outcome is the RRS (Realistic Robot Simulation) standard interface, which allows a more accurate and realistic emulation of the equipment. The example of automated production workcell with two industrial robots activity viewing by simulation and programming system ROANS is on Fig. 2 [6].

CAPE technologies have evolved from a simulation and offline programming tool to a mainstream production engineering tool. It is tightly integrated with the other computerized and automated tools in the industrial development cycle. The challenge industrial concerns are facing now is to keep abreast of this evolution, and to build their organization in such a way as to fully capitalize on the benefits of CAPE. There is already a severe shortage of trained CAPE users, and turnover rate of personnel can reach 50 percent. Colleges and dedicated technical centers are falling short of demand.

3. THEORY OF COMPUTER AIDED PRODUCTION ENGINEERING

In the early 1990s, due to the economic recession, more industrial firms worldwide suffered a severe downturn in business. Most important factor for surviving was ability to reduce costs. In the mid-'90s, with a renewed and booming, customer-driven market, business success is contingent upon coming to market faster with new products and building up output to meet the increasing demand. The automotive industry was one of the first industries to respond quickly to consumers' diverse tastes and products shorter life cycles. On example the average development cycle of a vehicle was reduced from seven to five years, with three years as the current goal. But this goal cannot be achieved by compromising on quality. Quality is no longer only a selling feature but also a basic element of any product - this is one of the rules in today competitive market. Thus, manufacturers have begun to look closely at their current methods and examine how they can increase their products offering while meeting three major challenges: shorter time of product from production to market, increased quality, and lower manufacturing costs.

Shorter time of product from production to market requires more efficient and productive development tools. Increased quality means verification and analysis of the manufacturing processes to check that they comply with design intent. Cost savings can be generated through productivity gains, reduced capital investment, better allocation of manpower, efficient management of design changes and reduced overheads.

We have to study the impact of each investment on the complete development and manufacturing process when we want to make right decision where to invest. Over the past few years, manufacturers invested heavily in the two ends of the industrial process:

- the product design phase by install CAD systems (CAD – Computer Aided Design),
- the production phase by application of automated devices.

However because these automated tools become industrial standards nowadays, manufacturers have to look elsewhere to maintain improvement and competitive edge. This is the reason why many top manufacturers are increasing their use of Computer Aided Production Engineering (CAPE) tools as part of Computer Integrated Manufacturing (CIM).

Computer Integrated Manufacturing (CIM) represents the integration of traditional production and engineering technologies with the computer technology, which enable the automation all activities from product design to their expedition (design of products, creation of technological procedures, production planning, operative control, manufacturing of products, quality control, assembly, packaging, expedition, etc.), with goal to bring down of the material and energy pretension, to increase of work productivity, to bring down of supplies, to shorten of development and production time, to increase of time and power utilize of production devices and it increase of products quality [1, 2]. The strategy of complex computer integration is not only goal, but in many firms it is also reality. Slump of prices of computer components and increase of computer power in connection with modern software technologies, new methods of firm organization, new progressive technologies condition bring orientation on modern information and communication technologies communication in many firms. The CIM systems in most cases is not represented by complex wholes, or they are compile by integration of partial automated systems – CA systems (Computer Aided Systems), composition which is shown on Fig. 3.

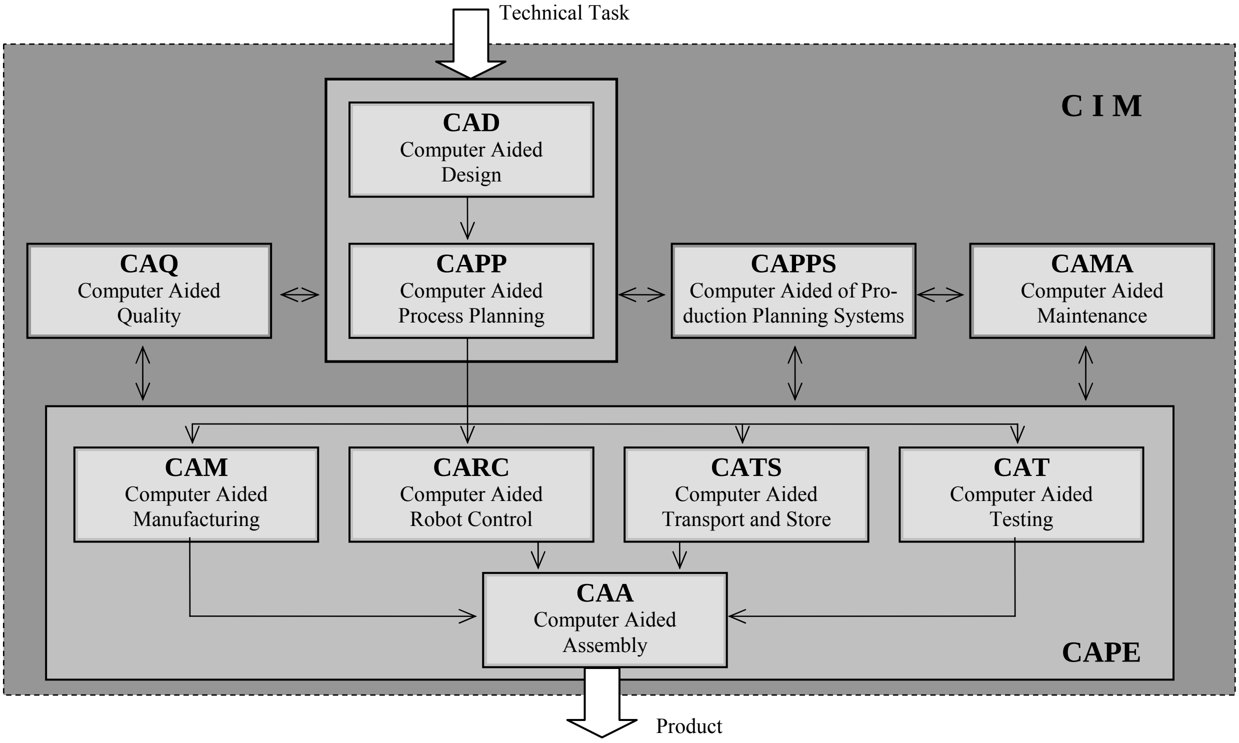

Fig. 3. Organization of partially CA systems in CIM complex.

The complex of CIM can be integrated by many partial CA systems; where familiar and more utilized are [3]:

- CAD – Computer Aided Design;
- CAPP – Computer Aided Process Planning;
- CAQ – Computer Aided Quality;
- CAPPS - Computer Aided of Production Planning System;
- CAMA – Computer Aided Maintenance;
- CAPE – Computer Aided Production Engineering;
- CAM – Computer Aided Manufacturing on NC and CNC machine tools and devices for progressive technologies (laser, water-jet etc.);
- CARC – Computer Aided Robot Control;
- CATS – Computer Aided Transport and Store;
- CAT – Computer Aided Testing;
- CAA – Computer Aided Assembly.

Computer Aided Production Engineering (CAPE) is a subsystem of the system CIM including the computer aided systems of all activities connected with realization of product manufacturing (programming of manipulation machine tools, transport and store devices, measuring, testing and diagnose of parts and assembled product). This stage of computer aided systems in complex CIM fluently establish on application of computer aided systems in technical (construction and technological) preparing of production and is inevitable for secure of concurrent engineering conditions.

Main subsystems of Computer Aided Production Engineering can be [5]:

1. *CAM - Computer Aided Manufacturing.* These are systems enabling data and program preparation for controlling of NC machines in automated production of mechanical parts, full assemblies, etc, which use geometry and other data acquired during period of CAD design.

2. *CARC - Computer Aided Robot Control.* It is a part of off-line robot and manipulator programming, when program of robot activities is prepared apart from working-place, in computer. After simulation and optimizing of activities of the model of automated working-place with robot, the system creates controlling program, which is possible to be used for concrete robot control system after post-processing.

3. *CATS - Computer Aided Transport and Store.* These systems enable computer programming of activities of automated work-in-process transport performed mainly by inductive transport, but also by portal transport systems, by cylindrical and other conveyors and also by automated way of storage using high-shelf automated systems.

4. *CAT - Computer Aided Testing.* Mainly, it is controlling and manipulating with 3-axis measurement machines by computer, programming of automated measurement stands, computer evaluation of measured data, etc.

5. *CAA - Computer Aided Assembly.* It represents last period in process of completely automated realization of the product composed from several parts and it includes such areas of computer support as, for example, programming of automated assembly machines, flexible assembly equipment, exploitation of special virtual reality systems determined for assembly technology planning, which can verify suitability and optimal composition of assembled components, suitability of manual assembling and ergonomic aspects of manual assembling (for example to ensure enough free space for hand of the worker in order to manipulate with assembled part without problems).

All of the above considerations lead to the conclusion that graphic computerized process planning holds huge potential for improvements on all fronts. This is even more so considering the fact that changing a product design is almost always less costly than changing the manufacturing process. The enabling technologies for CAPE (Computer Aided Production Engineering) emerged only in the mid-'80s. Simulation, advanced graphics, motion emulation and powerful computers to support them all matured to the extent that CAPE technology could be brought into economically justifiable use [4].

4. CONCLUSIONS

The future user must have the concrete aim and clear idea about contributions, in order to install of suitable CAPE technologies in concrete firm more effective. Implementation of large system (not only CAPE) must precede clear and concrete intention. It allows deriving criteria for selective performance and then to verify, whether it can to achieve the purpose with the product. Ability of CAPE technologies to create the environment which continues on development of virtual product and which is capable virtually to verify their production, or support creation of virtual work teams should be included among the criteria. Then will be possible extension of setting CAPE technologies in solution of future possible problems, too.

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