Computer Aided Production Engineering (CAPE) as Subsystem of CIM

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Abstract: ***The enabling technologies for CAPE (Computer Aided of Production Engineering) emerged in the mid-'80s. Simulation, off-line programming, advanced graphics, motion emulation and powerful computers to support them all matured to the extend that CAPE technology could be brought into economically justifiable use.***

Introduction

In the start of this millenium was changed old products by new, especially in mechanical engineering, thus slow that one product could be produced some decades with little changes. During this long time the new product might be in quiet prepared. Although in this time are in centre of attention efforts to produce a quality products with a long lifetime, especially with regards to environmental problematics, a big mechanical products are out of date and insaleable after 6 to 8 years. In consumer goods it is much fomerly, after 2 to 3 years.

Effort to abbreviate the cycles of change productions and to increase value and sophistication of product enforce the change in technical preparation of manufacture and in realisation of manufacture. Number of new designed and inovated products in present industry is big and it is obvious that with complication and improving of technical solutions, it will magnify.

The important rationalization method in stage of production preparing and production realization is using of computer techniques with suitable software. It is interested in products design, in design of machine tools and systems, where it is possible to use computers devices as basic work tool.

The computers quickly penetrate to all areas of technical production preparing and to production activities. The using of computers, which was firstly aimed to scientific and technical calculations in isolated problems, was increased to other areas by graphical outskirts devices. There was created the base of new disciplines of automatized construction and technological works, where the familiar are Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) [1].

History of Computer Aided of Production Engineering

In the early 1990s, due to the economic recession, more industrial firmss worldwide suffered a severe downturn in bussines. 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: in todays competitive market, quality is no longer a selling feature but a basic element of any product. 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 to market, increased quality and lower manufacturing costs.

a) *Shorter time to market.*

Shorter time to market requires more efficient and productive development tools. The same work needs to be done, not only quicker, but also with fewer errors. Design have to be "first time right" and efforts should be made towards catching errors up front and eliminating rework. Moreover, manufacturers can no longer afford to walk consecutively through the development phases, to make significant progress, they must make large strides towards concurrent engineering. These changes involve greater development risk, and tools to minimize these risks must be readily available. Standardizing the manufacturing tools will also reduce time to market, as it will eliminate lengthy redesigns, speed up production ramp-up time and reduce downtime through better maintenance.

b) *Increased quality.*
Increased quality requires verification and analysis of the manufacturing processes to check that they comply with design intent.
In addition, an optimized design of the manufacturing process delivers savings in process cycle time. This time may be used to enhance the manufacturing process in order to increase the products quality.

c) *Cost savings.*
Cost savings can be generated through productivity gains, reduced capital investment, better allocation of manpower, efficient management of design changes and reduced overheads.

To decide where to invest to gain competitive edge, we have to study the impact of each investment on the complete development and manufacturing process. Over the past few years, manufaturers invested heavily in the two ends of the industrial process:

- the product design phase by install CAD systems
- the production phase by application of automated devices.

But as these automated tools become industrial standards, 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) represent 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 ti increase of products quality [1, 3].

The complex computer integration is not only goal or in many firms it is reality. bring down of computer components prices and increase of computer power in unite with modern software technologies, new methods of firm organisation, new progresive technologies condition orientation on modern information and communication technologies in many firms. The CIM systems in most cases is not represented by complex wholes, or they are compile by integration of partial automatized systems - CA systems (Computer Aided Systems), composition which is shown on Fig. 1 [5].

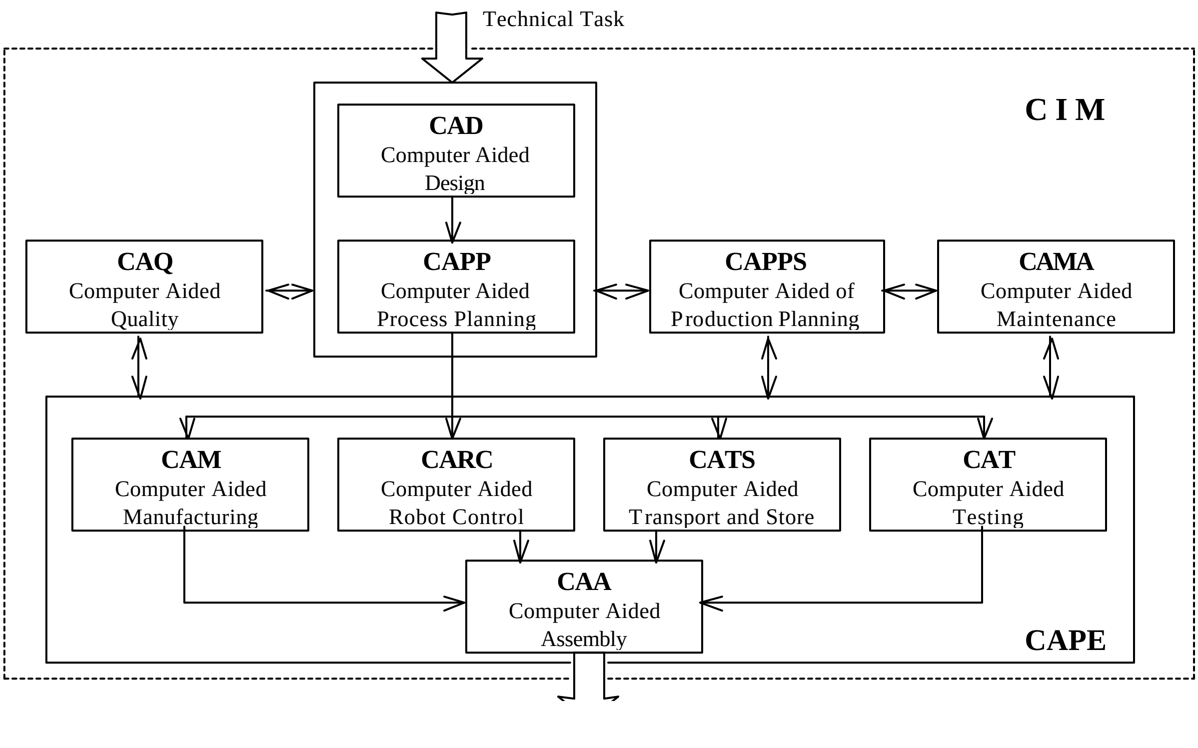

Fig. 1 Organization of partially CA systems in CIM complex

The complex of CIM can be integrated by many partial CA systems, where familiar and more utilized are [2]:

- 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 macchine tools and devices for progresive technologies (laser, waterjet 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 machine tools, manipulation, 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 applicaton of computer aided systems in technical (construction and technological) preparing of production and is inevitable for secure of concurrent engineering conditions.

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].

The present time and future of CAPE technologies

CAPE started as an off-line programming tool for automated manufacturing equipment [8]. Its prime purpose was:

- 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 benefits of using CAPE tools upstream became clear. Why use CAPE only for programming equipment, why not 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 enironment 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. Although savings resulting from off-line programming were significant, they were only in the initial phase of production. Computerized process design provided benefits not only in the launch phase, but 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 optimalisation of cutting tool path by simulation with aim of CAM system is on Fig. 2.
A typical task of a production engineer is to design a complete manufacturing process. Using a CAPE tool, he creates a graphical representation of a factory workcell in his computer. Then he imports the products geometric 3-D CAD data. He 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. In this virtual manufacturing environment, he designs the process.
The drive for concurrent engineering has given birth to some 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.

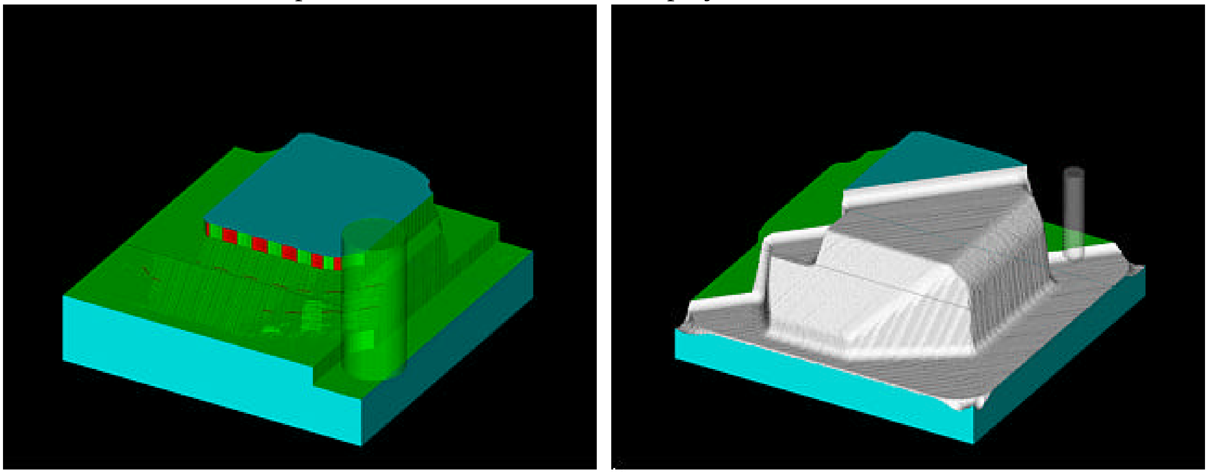

Fig. 2 Example of module CIMULATOR utilize in CAD/CAM system Cimatron IT

At the front end of the industrial process, CAD integration technology allows CAPE to create the production master model by directly accessing the CAD master model. This assures that the production engineers work on the most recent product data and that they can progress with their production design alongside the product designers. 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. With 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 automatized production workcell with two industrial robots activity viewing by simulation and programming system ROANS is on Fig. 3 [7].
Based on instalation of CAPE technologies we can production firms divide to two groups:
- firms where has a longer time installed CAPE technologies as important tools of production engineering in industrial processes,
- firms where managers are rapidly closing the gap, migrating to CAPE as they did to CAD in the 80s.

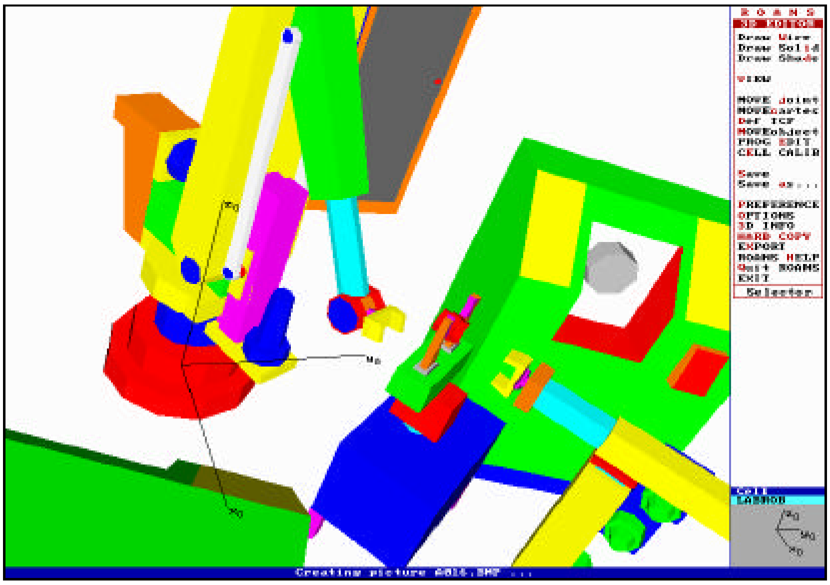

Fig. 3 Realistic simulation of robotized workcell function by system ROANS

CAPE technologies has evolved from a simulation and offline programming tool to a mainstream production engineering tool which 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.

At this time exists real shortage on demanded level educated specialists for instaling CAPE technologies, their education in comparison with CAD specialists is only in start. Higher educational institutions and universities in this area are late after real claims of industrial praxis.

Product designers can now view how the parts they are designing will be manufactured while they are actually designing the product. This is true concurrent engineering, which allows product designers to design for manufacturing based on viewing the exact manufacturing process. Designs are no longer thrown „ower the wall" to the production engineers, but the manufacturing difficulties they generate can be viewed and corrected.

Conclusion

In order to install of suitable CAPE technologies in concrete firm more effective, the future user must have the concrete aim and clear idea about contributions. Implementation of large system (not only CAPE) must precede clear and concrete intention. It allows to derive criterias for selective performance and then to verify, whether it can to achieve the purpose with the product. Among this criterias should be included 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. Then will be possible extension of setting CAPE technologies in solution of future possible problems, too.

Acknowledgements

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