

TOOLS AND APPLICATIONS OF COMPUTER AIDED MANUFACTURING AND ROBOT VIRTUAL MODEL DESIGNING

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***Abstract:** This article describes the possibilities of CAD/CAM/CAE system tools utilisation in the area of the engineering applications. One part of the article contains the problem of the Computer-Aided Manufacturing. The specific examples of CAD/CAM system Pro/ENGINEER applications in solving of the engineering practice tasks are presented. The possibilities of the utilisation of computer aid in the industrial robot and manipulator virtual model designing is contained in the next part of the article. The attention is aimed on the application of CAE module of system Pro/ENGINEER especially.*

***Keywords:** computer aid, CAD/CAM/CAE system, numerical control, robot, manipulator*

1. INTRODUCTION

Automation of the manufacturing support systems is aimed at reducing the amount of manual and clerical effort in product design, manufacturing planning and control, and the business functions of the firm. Nearly all-modern manufacturing support systems are implemented using computer systems. Indeed, computer technology is used to implement automation of the manufacturing systems in the factory as well. The term computer-integrated manufacturing (CIM) denotes the pervasive use of computer systems to design the products, plan the production, control the operations, and perform the various business-related functions needed in a manufacturing firm. True CIM involves integrating all of these functions in one system that operates throughout the enterprise. Other terms are used to identify specific elements of the CIM system. For example, computer-aided design (CAD) denotes the use of computer systems to support the product design function.

Computer-aided manufacturing (CAM) denotes the use of computer systems to perform functions related to manufacturing engineering, such as process planning and numerical control part programming. Some computer systems perform both CAD and CAM, and so the term CAD/CAM is used to indicate the integration of the two into one system. Computer-integrated manufacturing includes CAD/CAM, but it also includes the firm's business functions that are related to manufacturing [1].

Computer Aided Engineering (CAE) systems are very useful systems for engineering area. Integrated or independent CAE systems are used by "design – project" engineers and "specialist – calculators" too. The classic approaches to the realisation of computer analysis for the product improvement behaviours are limited in the process of concurrent designing. Therefore the classic SW analyses are namely used for the calculations of fundamental or critical components of the construction. At the present time the "old" SW equipment is not only upgraded but also extended of the new tools and new integrating approaches too.

2. COMPUTER AIDED MANUFACTURING (CAM)

Computer-aided manufacturing (CAM) is the technology concerned with the use of computer systems to plan, manage, and control manufacturing operations through either direct or indirect computer interface with the plant's production resources. One of the most mature areas of CAM is numerical control, or NC. This is the technique of using programmed instructions to control a machine tool that grinds, cuts, mills, punches, bends, or turns raw stock into a finished part. The computer can now generate a considerable amount of NC instructions based on geometric data from the CAD database plus additional information supplied by the operator. Research efforts are concentrating on minimizing operator interactions.

2.1 Characteristic of CAD/CAM system

Modern "open architecture" CNC systems, based on industrial personal computer (PC) structures prefer programming and operation in the CAD/CAM mode. CAD/CAM is concerned with the engineering functions in both design and manufacturing. The method of manufacturing a product is a direct function of its design. CAD/CAM technology, it is possible to establish a direct link between product design and manufacturing engineering.

The goal of CAD/CAM system, it is possible to take the design specification of the product as it resides in the CAD database and convert it into a process plan for making the product, this conversion being done automatically by the CAD/CAM system. A large portion of the processing might be accomplished on a numerically controlled machine tool. As part of the process plan, the NC part program is generated automatically by CAD/CAM. The CAD/CAM system downloads the NC program directly to the machine tool by means of a telecommunications network.

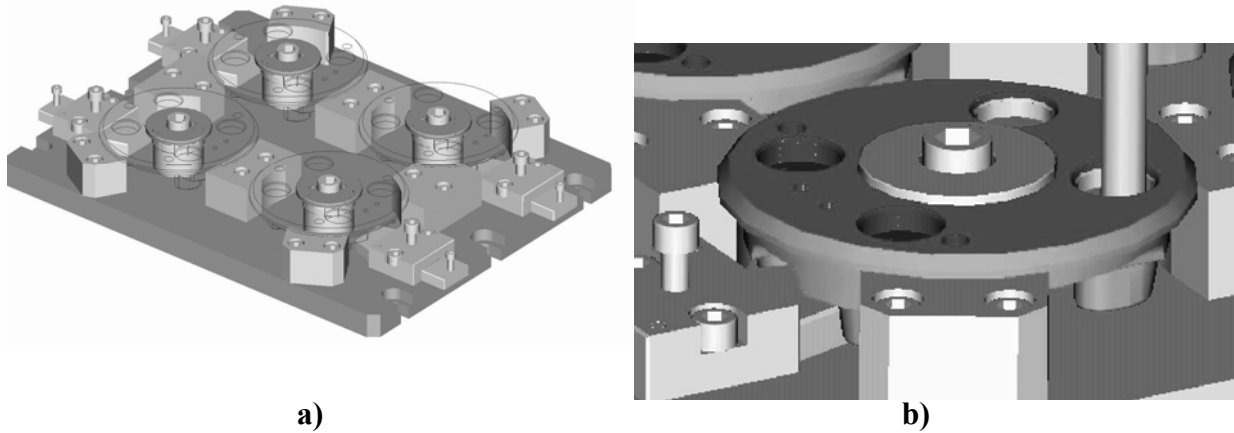
Several CAD/CAM systems from various firms are at the market nowadays. They differ from degree of integration, technical equipment and last but not least the price of the system. The main representative of present CAD/CAM system are - Pro/ENGINEER, Catia, I-DEAS, UNIGRAPHICS, and Euclid 3 etc. At present time CAD/CAM systems have a dominant position in the air, automobile and space industry primarily.

2.2 Utilization of CAD/CAM systems Pro/ENGINEER in practice

Pro/ENGINEER is full parameter 3D graphic CAD/CAM system, determined mainly for general manufacture engineering and for automation of design engineering. System covered the whole processes from preliminary design, through drawing documentation to programs for manufacturing of designed parts on numerical control machine tools. With graphical system Pro/ENGINEER is possible to create fully, unambiguous and accurately space model of solid body-simply and quickly. Pro/ENGINEER contains about 35 modules that directed for individual applications (Pro/NC, Pro/ Moldesign etc.).

Department of Measurement and Automation University of Žilina-Faculty of Mechanical Engineering has cooperation with some mechanical engineering plants that use system Pro/ENGINEER in their technological preparation of production. In frame of this cooperation the Department participate on solving some problems from the area of the CAD/CAM system utilization. For example it was the proposal of new technology for the production of mould, which are used for pneumatic tyre mould (MATADOR MACHINERY, a.s. Púchov). The other tasks solved the proposal of postprocessor verification for a milling machine DECKEL MAHO MH 700 in plant KONŠTRUKTA – Industry a.s. Trenčín or proposal of manufacturing process for flange TS 200 AZ1 (KDR, s.r.o., Žilina)-fig.1. The main problem at the solving of this task was to propose new fixtures for manufacturing of flange, suitable tool and technological parameters, decreasing of cutting time. The simulation of created

manufacturing process of flange in CAD/CAM system Pro/ENGINEER allowed us to display all critical places of the manufacturing process, the collision of the tool with the workpiece or fixtures.



a) *Fig.1a) Design of fixtures proposal*
b) *Fixture and piece for manufacturing process modelling in CAD/CAM system Pro/ENGINEER*

3. COMPUTER AIDED ENGINEERING (CAE)

The computer simulation is very significant tool for designers. The reason is – to understand to the behaviour of the technical systems before their prototype production. Therefore many analytical programmes have been created in the last thirty years for engineering area. These programmes are entitled as Computer Aided Engineering (CAE). The present – day trends show the shift from the tradition analyse based on FEM toward to CAE technologies, which are the source of today company costs economising [4].

3.1 Characteristics of system Pro/MECHANICA

System Pro/MECHANICA is very well known world CAE system, which integrates abilities to simulate and optimise the product behaviour with co-operation of the other CAD systems. *Pro/Mechanica is an independent CAE system, which has the next characteristics:*

- The own system for spatial image creation, which is taken over from the CAD system Pro/ENGINEER (part/assembly 3D model creation with aid of the parametric structural elements as logical relationship, model tree, parameters, relations and so on).
- Integration with other CAD systems as Pro/ENGINEER, Pro/DESKTOP, ICEM, CADD5, CATIA a Unigraphics (IGES, VDA, STEP, DWG, DXF and so on).
- The common user interface taken over from Pro/ENGINEER for the preparation and evaluation of all calculation types.
- Speed, quality and precision of the obtained results. The user states result precision before calculation starting. He is informed about a result quality during the solving. The used tools do not require special knowledge of numerical methods. That is why this system is suitable for designer-project engineers.
- Global Sensitive Analysis, which enables to observe how change of the model parameter influences the model behaviour automatically.
- Multidiscipline optimisation – the other parameters of CAD model have to be optimised in one study design. For example, minimisation of mass of the robot arm construction so

to do not exceed the permissible value of deformation maximum and state of stress limit too.

System Pro/MECHANICA consists of the next modulus:

- *Pro/MECHANICA Structure Simulation Package* (static, modal, dynamic analysis and optimisation of parts/assemblies behaviour, contact analyses and so on),
- *Pro/MECHANICA Thermal Simulation Package* (stationary and non-stationary thermal transmission and thermal conductance),
- *Pro/MECHANICA Motion Simulation Package* (static, kinematic and dynamic analyses of the mechanism motion),
- *Pro/MECHANICA Fatigue Advisor* (prediction of the production lifetime).

3.2 Example of CAE application in Robotics

Robots and manipulators are complex mechatronic devices that are designed for the concrete applications. Their construction (mechanical subassembly) is very different. In the first stage of the robot development, the goal of CAx systems utilisation is most of all creating of 3D complete model of robot mechanical subsystem. Such spatial model contains important information about geometric shape, mass properties and mechanism number parts. With help of tools of the suitable CAE system, designer have to watch for example an interference occurrence in assembly and to make a different analysis types that lead to mechanism functionality verifying before the prototype will be produced. The usage of the module Pro/MECHANICA Motion Simulation Package is very suitable for designer to obtain information of the 3D model of robot design correct functionality. After a preparation of the robot design assembly (define material of all components, datum points, coordinate systems, joint axis, drivers or loads and measures) the robot virtual model has to be tested. The implementation of damping, friction or spring into virtual model come it up to the real product and give assumption that the motion analysis results will be have a “high – real” information significance. The example of the motion analysis application is showed in Fig. 2. There is presented the result of the student semester work, in which have been created preliminary design of automatic workplace, equipped with two arm manipulation unit for handling with geometrically simple parts. One arm takes off the part from the position (1) and put it on the table - position (2). The second arm handles with parts from position (2) to the position (3) on the conveyor. The movement of all both arms and single shifter are synchronised to prevent some collisions.

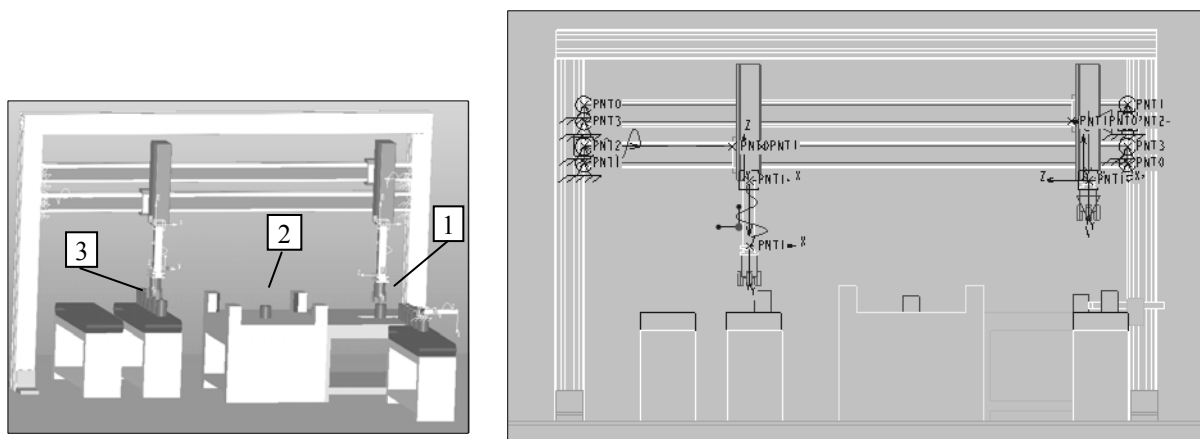


Fig.2. Virtual model of the two-arm manipulation unit, verified in Pro/MECHANICA

4. CONCLUSION

The utilization of CAD/CAM systems is highly effectiveness, because it enables to reduce the process development time and the introduction of a new product in the market heavily. They enable to realise the new product development (including its optimalization) without its physical model. The effective utilization of CAD/CAM systems expressively contributes to the product life cycle shortening. The new trend is to design of the new products by "paperless design" method - it is without any paper documentation. The next effort is to unify the exchangeable formats of data files but the use shows that the utilization of the same CAD/CAM system during the whole new product development is the best guarantee of the non-problem data transfer[1]. On the experiences with the robot virtual models or their single subassemblies designing and function verifying too, it is possible to claim that CAD and CAE systems integrated into the same CAx system are very powerful tools for effectiveness making of the designers work. Complex utilisation of all possibilities of CAx systems contributes to acceleration of the pre-production stage in process of the robot designing significantly.

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5. REFERENCES

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