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COMPUTER SUPPORT – TOOL FOR INCREASING THE PRODUCTIVITY AND EFFECTS OF ENGINEERING ACTIVITIES

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Abstract: *The paper deals with aspect of computer support in engineering activities. Computer support and Computer Aided systems present tools for improving of productivity and efficiency in engineering enterprises. It is necessary to know methods and approaches leading to an implantation of the modern CA systems and technologies. Special attention is given to design and process planning activities.*

Key words: *CA systems and technologies, CAPP, productivity.*

1. INTRODUCTION

Economic pressures urge manufacturers to make more customised products of high quality, in smaller series, with shorter lead time and of course, without increased costs. Time is becoming rapidly the most strategic topic of companies. Costs are also important, more important are competitive price and the most significant are marketability of manufactured products. Resource cost and job cost have essential influence on direct product cost. The outline strategic business goals can be achieved by increased flexibility and well organised information flows.

Engineering activities realised before manufacturing are very important in term of influencing of total production cost. The engineering drawing and the process planning such as the main engineering activities are critical production cost factors.

2. NEW TOOLS FOR CA SYSTEMS

New conditions on global market, globalization of market, globalization of competition and globalization of trade urge that enterprises look for new methods and approaches which increase productivity and efficiency of all factory processes. The following items are very important reserve areas for increasing economic factory indicators:

- new constructional and tool material,
- new progressive production technologies,
- automation of production,
- rationalization and computer support of engineering activities,
- implementation of modern information technologies,
- new methods of planning, production control and factory organization.

The following methods seem to be very good candidates for increasing efficiency and productivity of engineering activities in the production enterprises:

- Concurrent Engineering /Simultaneous Engineering/ - this method enables parallelism of several processes during design process. The main advantage consists in possible problem prediction for production and assembly just during design process. The method is especially based on DFx /DFM, DFA, DFMA, DFE, DFC, etc../ technique.
- DFC /Design For Cost/ – methods belonging to CE/SE however has special meaning in the enterprise. It is design method taking care of connection between design process and cost;
- PDM /Product Data Management/, PDMII /Product Development Management/, PLM /Product Lifecycle Management/ – systems and methods for managing the enterprise documentation, processes and business activities;
- DOE /Design of Experiments/ – set of methods and recommendation for design process;
- FMEA /Failure mode and effects analysis / – prediction of potential product errors;
- VA-VE /Value Analysis-Value Engineering/,
- QFD /Quality function deployment / – determination of critical location in the production processes; CAE /Computer Aided Engineering/ – set of methods for simulation and analysis. It is possible to meet with them especially in CAD/CAM systems or as individual special CA systems;
- Integration STEP – Powerful tool for integration of CA systems in framework of product life cycle. It is standardized by ISO norm 10303;
- Cross Enterprise Engineering – horizontal and vertical enterprise integration. It is view on integration solving in framework of the whole factory;
- Dynamic process planning – dynamic process planning according actual capacity and conditions in the factory workshop;
- Non-linear process plans – creation of process plan variants /in tree structure/ corresponding with various situation in the factory workshop;
- JIT in process planning – process planning according actual state in the factory workshop;
- Expert process planning – expert support for creation of process plan;
- Parametrisation in CAPP – methods of parametrisation and association known in CAD/CAM systems implemented in CAPP systems;
- Evolution and genetic algorithms – utilised especially for solving of optimisation tasks;
- Utilisation of complex CA system such as DELMIA Fig. 1. and Fig. 2. The SW is enables solve all impor-

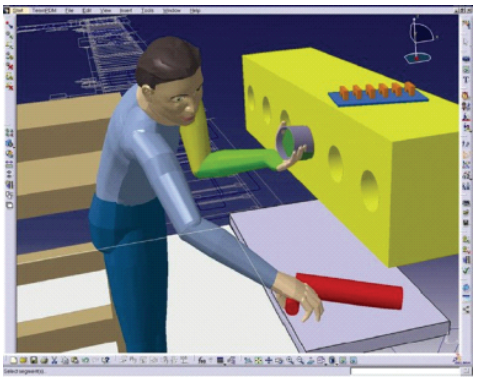

Fig. 1. Ergonimics solving in SW DELMIA.

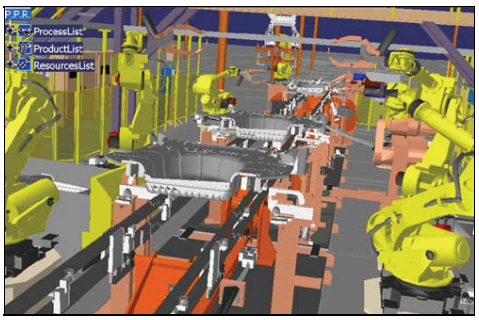

Fig. 2. Robotics solving in SW DELMIA.

tant activities /development, design, process planning, ergonomics, quality, layout, robotics, etc./ in framework of enterprise.

However these methods are not panacea for problem enterprise solving. It is necessary to realise very serious analyse the factory conditions before their implementation. An inexpert implementation could have opposite effects. It happens oftentimes.

3. REVIEW OF COMPUTER AIDED PROCESS PLANNING

The process planning activities are significant means for flexibility, time to market and competitive advantage of enterprise. The process planning systems are therefore important tools for increasing of efficiency and profit. One question is very relevant – is possible to achieve by current methods and means of the process planning the flexibility and time performance? Accordingly it is needful to find new tools and advanced methods for solving of the process planning task in the modern enterprise.

Computer support can markedly help to solve some planning activities. Computer aided process planning (CAPP) is a tool for the automated design of route sheet. The CAPP represents the implemented methodology of process planning in the software package. The CAPP includes all process planning activities needful to realise of the design of the process plan. The CAPP system has to solve the planning activities such as selection of machining operations, selection of machine and cutting tools etc.

There are two basic approaches for creation and processing of process plan based on computer support and advanced planning methods:

- variant process planning based on Group Technology utilizing,
- generative process planning based on exact mathematical principle utilised modelling of part, manufacturing knowledge and process planning.

There is necessary to elaborate methodology for variant and generative process planning. Concrete CAPP system will be designed and made according process planning methodology. As the two planning approaches are different, as well the CAPP methodology for variant and generative methods will be unequal.

The methodology for generative approach consists of the following main activities and tasks:

- modelling of engineering parts (feature modelling, B-REP, CSG method, etc.),
- modelling of process planning (selection of machine tools, cutting tools, fixturing, sequence of manufacturing operations, etc.),
- modelling of manufacturing operations (feature modelling),
- modelling of manufacturing operation parameters (selection and optimisation of cutting conditions),
- modelling of engineering knowledge (manufacturing knowledge, heat treatment knowledge, knowledge of process structure, etc.).

The methodology for generative approach is influenced by the following methods of individual modelling tasks:

- process planning: forward or backward planning strategy,
- engineering knowledge: forward or backward chaining of knowledge,
- micro and macro planning strategy,
- optimisation of manufacturing operation: one or multi-criterion optimisation.

The methodology for variant approach consists of the following main activities and tasks:

- design and statement of group representative for engineering parts,
- identification of engineering properties,
- statement of similarity of engineering properties,
- design of classification systems,
- coding of engineering parts,
- retrieval of similar engineering parts,
- classifying the engineering parts to the groups.

The methodology for variant approach is not possible so exact to explain and describe. The process plan is not created according formulas and rules, however the process plan is retrieved and edited. That means there is not need for methodology for creating of process plan. Though there is need of methodology for retrieving and editing of process plan.

There are two scientific areas for methodical elaborating of process planning:

- theory of Group Technology for variant process planning,
- Expert process planning for generative process planning.

4. INTEGRATION OF CAD AND CAPP

As process planning is one of engineering activities, it is necessary to integrate CAPP system with other activities

and corresponding CA systems. Integration between CAD and CAPP systems is task solved by many universities and scientific units. This integration is resolved to satisfaction. However there is many problems with this task. Geometry recognition as recognition of CAD data and their interpretation belongs to the most complicated tasks in CAD/CAPP integration.

Integration of CAD and CAPP systems are solved especially by the following ways:

- Standard graphical and geometrical formats (DXF, DWG, SAT, SET). The CA systems support these files however for complex integration they are unfit;
- OLE method (Object Linking and Embedding) known from operating system MS Window;
- OLE for Design&Modeling Applications – extension of OLE method suggested by Intergraphem and accepted by DMAC (Design&Modelling Applications Counci) enables to solve integration in CAD/CAM/CAE systems easier way;
- API interface – many application support API interface as tool for integration of CA systems;
- STEP protocol and corresponding Application protocols – protocol is standardised by ISO 10303. It is enabled to integrate all activities and corresponding CA systems during life cycle of product.

5. DEVELOPMENT OF CAX SYSTEMS

The CAPP methodology has been elaborated during several years on the Department of Machining and Automation, University of Zilina. Especially PhD thesis are oriented to the solving of the automated process planning. In the following text will be described the topics of CAPP methodology based on utilising of Group Technology which are in process.

5.1. Group technology for non-cutting technologies

CAPP systems based on the Group Technology (GT) are very good elaborated especially for cutting technologies. The non-cutting technology area (welding, casting, forming) is not so supported by the current GT CAPP systems. Utilising of cutting tools and other equipment are different in non-cutting technologies as in the cutting technologies. According the comparison of CAPP systems for cutting and non-cutting areas is possible to state that automation of machining process planning is on the greatest quality level. The basic idea of the GT is possible to utilise for non-cutting technologies however by other way. The similar engineering parts (produced by non-cutting technologies) belonging to family, will have the similar technological conditions and similar utilised instruments and equipment. The order of process operations is not important. The GT CAPP system for forging and casting was elaborated on the University of Zilina. The basis is in graphical classification system Fig. 3 and Fig. 4, finding of similarity of new and produced parts, retrieving of process documentation and modifying of technological parameters. The modification and calculation of technological parameters are the most important in area of GT utilisation in non-cutting technologies.

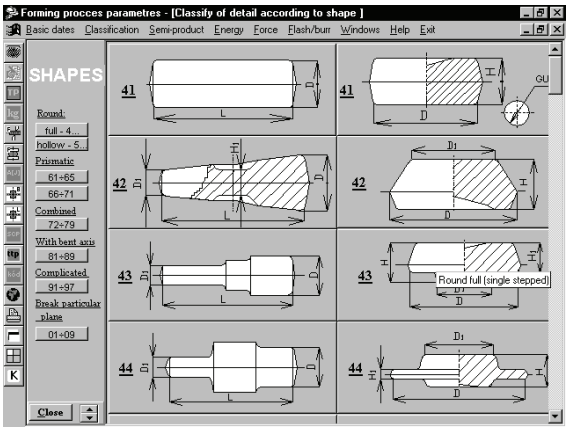

Fig. 3. Developed visual classification according the geometry.

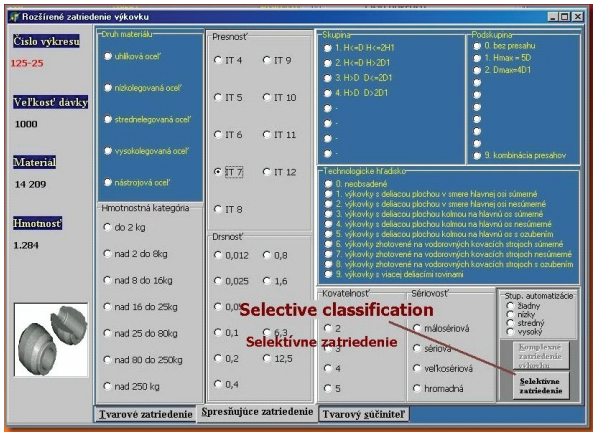

Fig. 4. Developed selective classification according important part properties.

5.2. Dynamic classification as a new methods for CAPP systems based on GT

There is an idea to create flexible classification system for area of non-cutting technologies. The engineering parts should be dynamic grouped to the individual groups according to classification aims. For example the engineering parts will be dynamic grouped to the family groups according the total costs (or operational total times, number of produced parts, series, etc.). There is a mathematical method – cluster analysis – which seems to be a very good candidate for support of dynamic classification system creation. Clustering techniques have been applied to a wide variety of research problems. The term cluster analysis actually encompasses a number of different classification algorithms.

5.3. Rapid cost valuation system based on Group technology

"To receive or not to receive" the job-order is standard question of human evaluator in the enterprises. Receiving determination is based on subjective taking measure of job-order. There is experience that difference of cost valuation for concrete job-order among human cost evaluators is 40%. The human cost determination is not realized according systematic analysis but according human opinion based on long-time production experiences. Real cost monitoring is uncertain and consequently control effects are very small.

Cost calculation and cost estimate are important inputs for decision about job receiving. Accordingly the above mentioned problems of job-order cost valuation there was effort to utilise software to increasing time to valuation and increasing of desinterestedness. The CA systems seem to be a very good candidate for the cost problem solving.

The developed methodology is based on the following aspects:

- similar engineering have similar process plans and consequently similar production cost,
- majority of engineering parts of job-order is similar to produced parts,
- there is a section of parts dissimilar to produced parts,
- CA system based on Group Technology is utilised for cost valuation of similar engineering parts,
- for similar engineering parts are retrieved process plan of similar produced part,
- exact methodology based on expert system is utilised for dissimilar engineering parts,
- for dissimilar engineering parts are generated frame process plan.

The designed CA system was verified in the factories and it is still in development.

5.4. Parametric aspect and association – a new method in CAPP based on Group technology

New approach base on parametrisation and association Fig. 5 is new method of Group technology utilising in process planning. The developed approach consists of parameterisation of process plan and making of association with part features. The association is realised between part feature and process operations.

Association between part features and process operations creates the link between design features and manufacturing features located in process plan Fig. 6.

6. CONCLUSION

The Department of Machining and Automation, University of Zilina systematically engages in research into CAPP methodology and its application in factories. The building of CAPP system is time demanding and very labour task. The CAPP tasks require the theoretical elaborating, working out the serious methodology of process planning and used advanced programming technique. The above mentioned topics are elaborated as Ph.D. thesis.

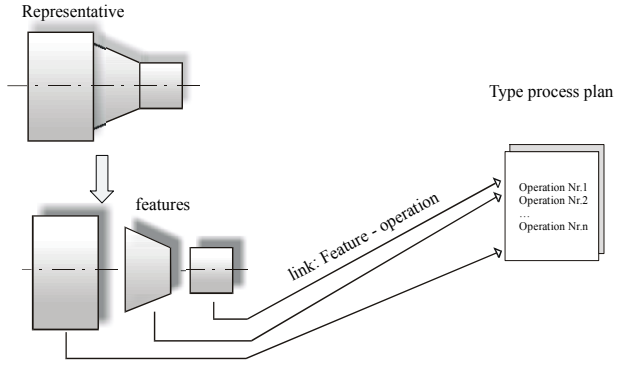

Fig. 5. Association-links between parametrised design features and process operations.

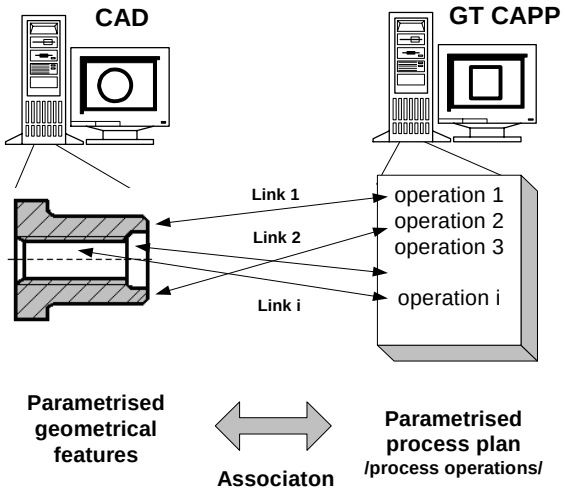

Fig. 6. Principle of parametrisation and association in GT CAPP.

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