61
Methods and Tools for Technological Databases to Support Concurrent Engineering

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Abstract

Modern production concepts requires new approaches. Better than before must succeeded the integration man in production process. Therfore fexible goals for the problems with alternativ possibilities and strategies for specific solutions are important. Because of more decentralized decisions local experts needs more global informations about the processes. Technical information systems are in this connection most important. Technological data in particular represent a special bottleneck, in this case. That means, we have to find out creative approaches especially for this data type. There is demonstrated to solve this problem by means of tools and methods for a technological database.

Keywords

Concurrent engineering, technological database, optimization model, neural network, cutting values

1 INTRODUCTION

Present trends of development influence the production engineering and the often existing conventional methods are insufficient. The flexible marked demands, the increasing complexity of products, processes and structures are the cause of this development. This leads to concepts of development, planning and production with decentralization, team work and parallel sequences of activities and tasks. Such changes make high demands on information systems. Especially the intelligent usage of resources are in great demand. Knowledge and experience have to be made available for a wide range of experts out of different working disciplines in an efficient manner. Mostly ensured and updated information to be taken from various business-oriented- and business-independent data stocks; standardized data access; rapid information processing and easy-of-use data supply. Thereby it is possible to cope with changing requirements on market immediately. Additionally, essential suppositions for cooperative problem solving can be gained in the stages of product design and product manufacturing.

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2 STATE-OF-THE-ART AND PRESENT DEMANDS

To tackle with these problems, there is no doubt about the recent market - and research and develpment dominance of *tool management- and resource management systems*. Those systems accepted to be efficient means of rationalization are planning- or process-oriented. From their content, tool data management activities are linked with efforts *to make available cutting values* supported by firm databases summarizing best cutting parameters. Trends towards *CAD/NC based on manufacturing features* are underlined by data linkage combining geometric and technology via product models.

All of these development subjects are strictly oriented to technological data. Technological data are available *concurrently*, on the one hand. On the other hand, those data are *mostly oriented to a predefined user system* which is the only one determining data structure, - content and application alternatives for this range of users. Even the very sensitive technological data type are more complicated concerning integration. Tools and methods of present technological databases results from functionalities of relational data base management systems.

Especially the technological data area based on firm-dependent and standardized ordinal systems for instance number systems, thesauri, classification methods and so on. In addition to data bases also used other conventional and knowledge based methods in practical operation for data storage and -supply: macro techniques (higher progamming languages C++, FORTRAN, EXAPT, ...), table techniques, decision tables (decision rules, IF-THEN-conections, ...). All systems needs data exchange with strange systems. Standardized data interfaces for export/import and programmable interfaces for the adaption are important evaluation criterions.

The following demands for information processing results from present working methods. The general characteristics (Kimura 1992, Krause 1993) are applicable for technological data area:

- Informations are incomplete, uncertain and heterogeneous
- Flexible solutions fields (enviroments, constraints) desirable, allow scope for variants
- Distributed problem solving and simultaneously processes data keeping.

In consideration of creative aspects tools and methods for operativ and decentral user support makes available for different user demands in different business departments.

3 CONTENT AND INTEGRATING FUNCTION OF TECHNOLOGICAL DATABASE

Technological data type is an essential part of computer aided manufacturing. It is very difficult to make available technological data. To fulfill system integration requirements, there is a special need for novel systems especially considering this data type.

A joint project carried out by the Dresden University of Technology and the Research Association for Programming Languages Aachen*) which title is *Technological database* was first of all, directed to find out appropriate tools for production planning and NC manufacturing. As to be demonstrated following, the gained results - methods and data support - are able to contribute entire system integration.

*)The paper presents results gained by project 92D promoted by the Working Group of Industrial Research Associations (AIF). The project's title is "Development of a production planning - and NC manufacturing database considering the needs of small- and medium-sized enterprises in the East German Federal States".

Using this technolological data, design to manufacturing is influenced in the planning stage, CAP processors are supplied for production planning and Requirements for production equipment and -facilities in manufacturing can be derived, too. To cope with different user demands out of the production planning departments, we can apply flexible data structures and standardized methods of access.

In this case, the understanding of a *technological database* (production planning- and manufacturing database) is focussed on a software tool for storage, handling and management of data, necessary or generated by production planning and NC manufacturing. Additionally, selected algorithms and methods to process, link, calculate or visualize the managed data are a part of this database, too.

Similar software systems put the main emphasis on management functions, for instance - resources management. However, the target of the technological database consists in supplying the necessary planning data *near to the user*. To carry out CAP- and CAM functions even by advanced programming systems, we have to make available data on manufacturing process. Relevant data ranges to be solved for technological data are structuring, collection, processing and supply. Information out of technological data are covering subjects as in tab 1.

Machine tools, Attachments	Clamping devices, Fixtures, Chucks	Tools, Tool holder, Measuring instrumets, Testing instruments	Workpiece materials, Cutting materials, Cutting values	Manufacturing features, Manufacturing operations, Cycles

Tab. 1: Technological data areas

If those data are input into a user system, for instance an *NC programming system*, we can set the user free of everyday activities. Simultaneously, the user is supported in essential cases of manufacturing decision making, for instance: selection of tools and clamping devices, determination of cutting values, subdivision of cuts and manufacturing strategies, simulation in connection with collision avoidance check, and so on. To reduce lead times in production planning and NC programming is one of the targets. Simultaneously, security and manipulation of planning results should be very flexible.

These data are an essential foundation stone *not only for production planning and NC-programming*. If there are made available these data out of different business departments, it is possible to update resources and generate production plans concurrent with manufacturing sequences planning. Following this strategy, *early* planning stages can integrate up-to-date information out of *late* planning steps. As described, a technological database is an essential part of business' manufacturing data management carried out by distributed information systems (fig. 1).

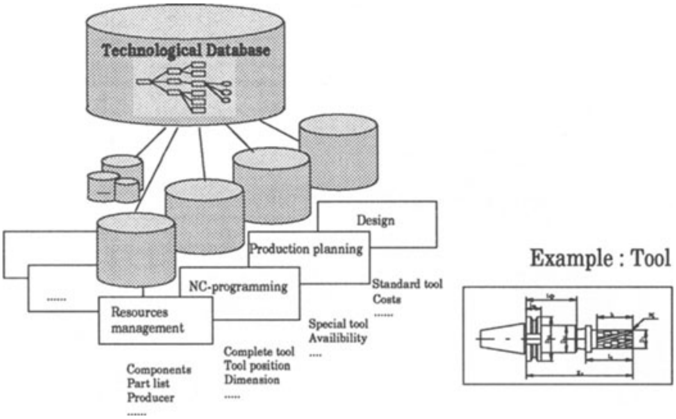

Fig. 1: Technological data in different business departments

4 DESCRIPTION OF SELECTED TECHNOLOGICAL DATABASE MODULES

The technological database is to be shaped as an autonomous software tool in order to be as independent as possible of any kind of user systems. The software tool is focussed on the EXA-TDO (*T*echnology*D*ata*O*rganization) system (N.N., 1993) used for technological data management, as an example (fig.2). Delivering necessary interfaces there are available functions as data exchange with import and export, easy-of-use communication and integrated access.

The user is enabled to carry out data records and - updates in a centralized mode, where as data can be used in a decentralized one. The technological data can be transferred to various already existing business software environments for instance databases or file management systems. In addition to pure data handling functions, a technological database has to solve another sophisticated task directed to differentiated data supply and data evaluation at various using levels - design, production planning, NC programming, resources management, and so on.

The necessary data volumes are to be supplied depending on the use of available functionalities of a technological data management system or a user system as, for instance, an NC programming system. To cope with *complex correlations among data*, it is useful to enable allocation of technological database areas. Linkage via *identifyers* is one method to be applied. Basing on a machine tool, there can be linked accompanying resource components. Additionally, there can be predetermined cutting values coping with the foreseen material which can be allocated to manufacturing features. Updated manufacturing data can be concurrently used by the NC programming staff as well as resource management - and design departments during process planning. Already recorded data can be supplied for business process chains; those data can be added, if necessary.

A new technological database quality can be gained if there can be considered *various data sources* by means of different data processing methods alternatively - for instance *tables, mathematical models, knowledge based methods* etc. Alternative data recording and data supplying functions oriented to an NC programming system should be demonstrated for the example of the *technological data area c u t t i n g v a l u e s.*

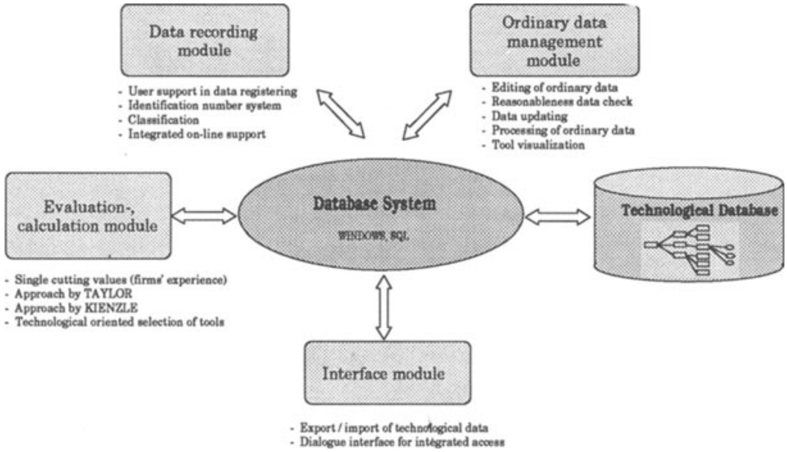

Fig. 2: Structure of a technological database (example, represented for EXA-TDO)

Alternative data sources can be shaped by *discrete cutting values* tested under practice demands and cutting parameters derived from empiric series of tests (wear- and force measurement) to be made available for user via production technological data baseas. Firm-independent recommended values have to be adapted according business-oriented to machine tools and materials in the majority of cases. Data collections can be added by *mathematical (calculation) models* based on primary data. This is another possibility to determine starting values for the manufacturing process. Being part of a technological database, these models are available for an extended group of users - in comparison with an internal module realization integrated into a manufacturing processor of a special NC system. As an essential supposition, workpiece- and cutting material data as well as machine tool- and manufacturing element data must be available for all alternatives determined before.

In the following the trend from complex, rigid and exactly models towards a clearly, flexible system with new characteristic features should be demonstrated. Rough technological models with a high ability to adaption is an integrated part of the developed database.

5 INTEGRATION OF MATHEMATICAL MODELS

A module on complex cutting values' determination shaped for any milling tasks (Kochan, 1992) has been applied for manufacturing features. This module SAFRAE is an integrated part of a technological database. Within the *technological module for milling*, determination of cutting values is based on technical constraints. First of all, these are force-determined constraints acting for maximum feed, as, for instance, shank load, cutting edge strength, moment load, tool dislocation a.o. technical constraints.

From the user's point of view, to apply the module for determination of cutting values can be advantageous in two cases: In the first case cutting values predefined for a special manufacturing subject the loads of technical constraints (tool dislocation, roughness,...) are calculated. As a result, we are enabled to evaluate the recommended values' validity resp. feasibility. Furthermore, there can be found out critical constraints in the case of selected manufacturing features (grooves, pockets,...). In the second case of a manufacturing subject there are calculated cutting values (maximum values) based on technical constraints. As a result, these values can be used as initial data for manufacturing.

Load of technical constraints is visualized by numerical and graphic means. Percentage loads of discrete technical constraints give some information on their influences' priority. Help-texts are integrated to support the results' interpretation. Each technical constraint is represented by its essential influencing parameters. Additionally, the user is proposed alternative activities to handle the influence parameters (fig. 3).

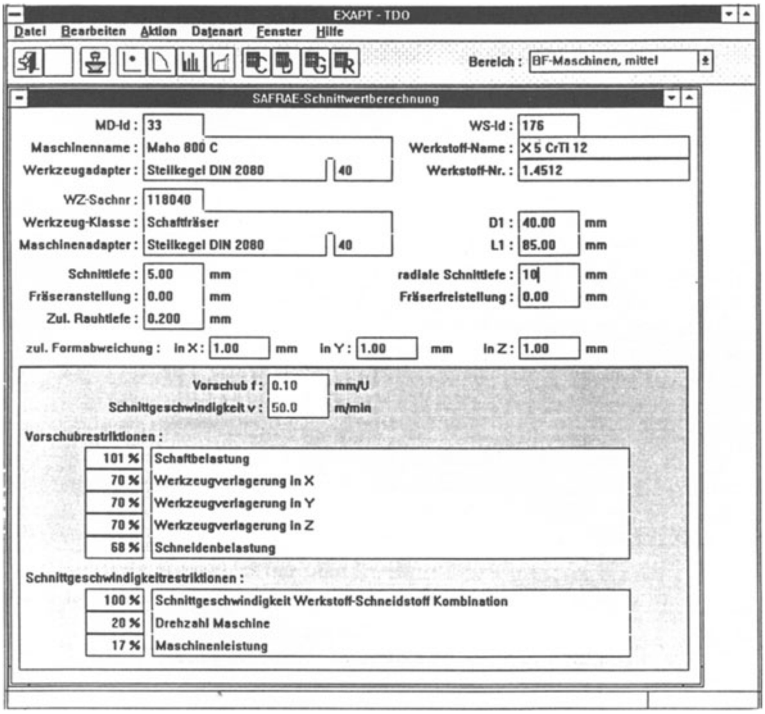

Fig. 3: Usage of EXA-TDO with access to the intergrated optimization modul for milling

Before taking over one feasible variant (one cutting value, for instance) into the application (the NC program,...), the user is enabled to improve the result by considering and comparing with other variants (other tools, cutting materials and so on). Evaluating this methodology for the example above mentioned we see, that the user is enabled to call in question the given variants; he can find out *creative results* by means of system's support.

6 ADDITION OF KNOWLEDGE BASED METHODS

The use of experience knowledge within a technological database is a rather necessary alternative for the determination of cutting values. Applications of mathematical models for technological data determination give useful start parameters for the using in different technological software systems. Nevertheless it is necessaray to specify the cutting values after practical tests, for instance by running in a new NC-program on the machine tool. Also, for technological problems, which are too difficult to describe by mathematical formular, it is better to use suitable knowledge based methods or use them in addition.

To acquire knowledge on technical and manufacturing correlations, the triple assignment among object-feature-feature value is the foundation. First and most difficult part of knowledge processing process is characterized by knowledge acquisition methods.

With the knowledge akquisition the complexity of mathematical models are better available. The technological influence parameters can prepared for declaration components as one possibility for an *intelligent help*. Especially for planning variants and the application of different equipments the knowledge of the relationsship between different parameters is indispensable (Kochan, 1992).

Another way is to reduce the technological models for specific form features to get a 'rough model' applications with specific restrictions. At the same time it is interesting to add specific knowledge to the technological rough models. *Neural networks* are applied for knowledge acquisition and - processing in rising extent (Barschdorff, 1991). The computerized model 'neural network' is directed to automated knowledge processing, being similar to the function of human brain. At present, neural networks are especially used to solve sophisticated problems; influence of various input parameters on the system can not be found out at all resp. incompletely, on the one hand. On the other hand, this influence is too sophisticated to be modeled. Unknown correlations among input- and output parameters can be analyzed and assigned to by means of neural networks.

Sequence of operations necessary for practical use of neural networks can be subdivided in the steps:

- Supply of learning database for the neural network
- Determination of network structure and learning parameters
- Train a neural network
- Application of the neural network.

In the following, two manufacturing problems will be demonstrated. The primary use is the determination of cutting values. The second use is the decision support for specific working conditions in manufacturing section. It is necessary to get useful parameters to describe a technological situation and to make a evaluation. Now ist is possible to chosen out the necessary parametrs for a learning database. This data represents the praxis relevant database. In this case, it must be guaranteed, that there are no data lacks in records of learning database. The Development is based on the state of the art of the technological database, their cutting values and describing attributes.

With the technological database the neural network will be traind on base of known *individual cutting values*. Using network for new manufacturing operations cutting values are not known yet for, describing attributes are defined. In this case, a new manufacturing operation may be to manufacture a workpiece material characterized by special mechanical properties or to use a tool being of general new cutting edge geometry or consistency. That means, input data for neural network are not part of the learning database (fig.4).

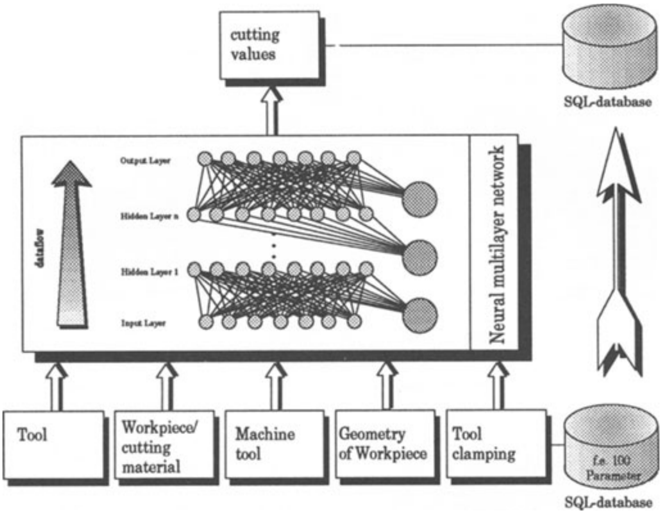

Fig.4: Use of the neural network for cutting value determination

Applicability of cutting values determined via neural network are to be checked according to their reasonableness by an expert. If these values have been evaluated to be appropriate, corresponding practice investigations on a test are carried out to verify theoretical values feasibility. The results of practice work are useful for a rather training and qualification of neural network. So we have a flexibility part of a database by using actual technological data from monitoring.

Another example is the *determination of cutting edge mismatch* in 5-axes milling. Tool change is necessary before finishing, partially for tools characterized by large operating times. This behaviour becomes a special problem, if the tool is to be changed within a tool path. In this case, it is to be guaranteed, that both tools - one to be taken off and the other to be set in - cause no free cutting scores at the workpiece surface.

At the beginning, significant features are evaluated out of the set of possible parameters influencing cutting edge mismatch in 5-axes milling. Tests have been carried out for these significant parameters. In addition to tool parameters there are varied milling mode (climb - or cut-up milling), leading angle and cutting values. Test specimens have been evaluated and classified acoording to resulting axial- and radial cutting edge mismatch. Input- and output values for the neural network are summarized in fig.5.

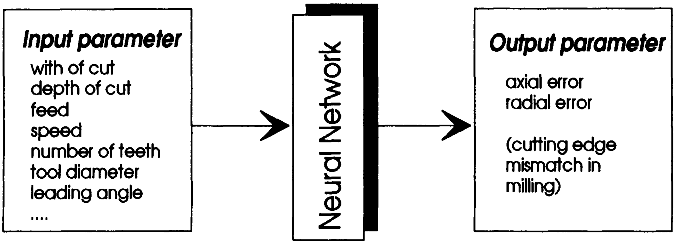

Fig.5 : In- and Outputparameter of neural network for determination of cutting edge mismatch in 5-axes milling

This application shows, how neural network can used for decision support before manufacturing. So it is possible to plan the practical operation of tool, the selection of cutting cinematics for special working conditions more effektive.

7 EFFECTS AND APPLICABLE FIELDS

The presentation illustrates the realized access to efficient flexible technological modules. To use this result in combination with a technological database, there can be gained effects which are variously contributing to the target of Concurrent Engineering.

The chosen example of the technological data area in connection with the complex problem cutting values illustrates approaches to be used for team-based methodologies. User's creative decision making is improved caused by simultaneous availability of discrete cutting values as firm-dependent best values, on the one hand , and cutting values which have been determined by computations, optimization and knowledge processing on the other hand. Computation modules and neural networks are enabled to cope with specific problems to be solved meeting the demands of user groups:

- Using technological information in design
- Precalculation
- Computing criterical loads
- Using knowledge about manufacturing conditions
- Reducing tests
- Flexible resource allocation
- Case studies.

That means, within appropriate information systems there we can derive approaches on generally applicable fields for decision making in design, resources' application and - supply as well as quality assurance a.o. business departments only by supplying information originally destined for NC programming.

8 SUMMARY

Further tasks ranging in alternative technological data supply out of various sources have to be solved by simultaneous development of system development. Further methods and tools - genetic algorithm for optimization and simulation, multimedia in connection with natural linguistic access - have an importend influence on future demands.

In addition to continuous development of new technological database areas, existing areas can be made more qualified by means of advanced methods and extended manufacturing data contents. To cope with maximum functional reliability, process security and a better utilization of Know-how much better, advices on application, machine tool influencing parameters and manufacturing situations have to be made more transparent.

An essential supposition to coincide conventional data (resource data, computation models,...) and additional alternative knowledge sources (experience,...), on the one hand, and to cope with the demands for supplying data on new manufacturing techniques (High-Speed Cutting, Solid Freeform Manufacturing,...) and resources (cermets, ceramics,...), on the other hand, is represented by an integrated application of conventional CAx-solutions and knowledge processing.

Concurrent Engineering in the field of technological data is based on novel approaches including *alternative methods for various using levels*. A technological database represents an essential link with other data management systems of technical production planning.

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