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INFORMATION TECHNOLOGY AND QUALITY MANAGEMENT

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Abstract. Quality Assurance Management is an integrated management activity that requires up-to-date integrated information system. An information system consists of numerous hardware and software modules which are integrated by computerized network into a unified system. For supporting Total Quality Management (TQM) it is expedient to choose such an integrated information system that supports integration of MIS and CAxx applications and handling of quality management documentations. In addition, the information system chosen is also able to support several different platforms and network protocols and has developing tools of its own, by means of which the application modules can be met the actual requirements of the firm in question.

1. INTRODUCTION

In the market of products and supplies the most characteristic feature of globalisation is the constant presence of competition situations, moreover, their continuous expanding and getting stronger. It can be observed that the majority of firms try to decrease intensity of the competition, however, there is a little chance for success even in the case of considerable investments of capital.

All experience points to the fact that lasting business successes can only be achieved in the way of knowing the market competition situations, analysing them and adapting oneself to them in a continuous way.

Among the factors of the successes achievable in competition sphere, importance of *quality* and *reliability* has recently been growing. The reason of this can basically be found in changing of the customer's behaviour of buyer's market and in modification of the scale of values at the same time. It has also an important role that the number of the industrial branches producing their products on the base of a *multi-step supplying system* has constantly been increasing. In these global production systems not only the end-users are the customers but a complete chain of customer's behaviour is being formed, strengthening the importance of quality and reliabily of the supplied products, subassemblies and services in every step.

The quality assurance expert knowledge sphere being formed on the base of fundamental idea of ISO 9000 standardization package can be regarded as a consequence of continuous increasing of the significance of quality management. Without full knowledge of ISO 9000 a competitive venture is not able to achieve durable successes nowadays.

Quality assurance starts with an accurate assessment and analysis of customers' demands, it includes all the activities of design engineering, production engineering, production/manufacturing, logistics, sale, marketing and service; implementation of recycling technologies is also included.

In this approach quality assurance requires an integrated management activity which is named by today's professional language *Total Quality Management* (TQM).

At present TQM has several ways of approach, numerous methods and tools, as well as several different philosophies. In order to achieve the goals of TQM, in any case, a comprehensive aspect and application of effective methods are needful. These methods have recently formed paradigm-like systems, e.g.:

- Business Process Re-engineering
- Continuous Improvement
- Change Management
- Lean Production
- Computer Integrated Manufacturing.

In this paper we examine how the views of TQM and CIM link and how the integrated information system, that is the most important complex tool of CIM, turns into effective supporting tool of TQM.

2. CONNECTIONS OF INFORMATION TECHNOLOGY AND QUALITY MANAGEMENT

The common goal of introduction and application of TQM and CIM is to achieve a long term business success. It follows that the project-like application of both paradigms requires a defined threshold level of *firm-culture* below which there is a significant chance of failure during implementation. *Firm-culture is a complex practice of all the staff members from management, behaviour, motivation, organisation, responsibility and creativity points of view which can only be formed, maybe, on the base of more generations' work within the framework of a given firm.*

TQM strategy starts from the demands of market, customers and business partners. The more reliable this demand assessment is and the more detailed data base can be used for it, the more reliably the goals of a TQM project can be planned.

Successful introduction of TQM can only be based upon a wide-spreading team-work. Effective communication, as well as rapid and reliable information supply for all the participants of the teams can be considered an important success-factor in this phase already. The local area computer network and the information system operated on the base of it support both information supply and communication in a very effective way. These application systems are named, by using the appropriate term of *Lotus* firm, *Groupware*, i.e. "Groupwork software".

What are the main goals of TQM activities?

- Maintaining a high level market information supply for management in a continuous way;
- Continuous harmonizing and co-ordinating the quality objectives to be achieved;
- Operating the procedures of quality assurance system in accordance with the certificate documents;
- Systematic revision of the quality assurance system established and certified;
- Systematic reorganisation and reconstruction of business processes;
- Systematic self-evaluation and managing the necessary changes;
- Maintaining the quality-oriented interest and motivation of employees in a continuous way.

If we examine the aforementioned activity domains thoroughly it is easy to see the fact that information itself and applied information technologies have a key-role everywhere.

Establishing an information system suitable for supporting *quality management* is usually the main tool of *re-engineering* activities embracing the business technology processes of the firm in question as well. It requires *work-flow analysis*, as well as introducing technical data base and computerized production planning and control (PPS, PPC, MRP etc.).

Close connections of effective management, production planning and control, logistics and quality assurance require unified data base, data handling and an integrated information network.

The great advantage of application of an integrated information system is to give a strong stimulation for closer co-ordination of sub-processes and, at the same time, for sharing responsibility and autonomous decisions, for establishing "holonic" organisation forms and for decreasing of the number of hierarchy levels. All this is a characteristic feature of TQM philosophy, too.

The number of the firms having a certified quality assurance system according to ISO 9000 standard series has also been increasing in Hungary. *However, obtaining such a certificate for itself does not mean an operating TQM yet!* We can say not more than that after a successful audit, good fundamentals have been created for starting a TQM project.

TQM is a management approach of specific view, i.e. *management system*. A certified quality system, due to nature of its own, is not a "*total*" one. It does not connect the maintenance of quality assurance system of production (and/or supply) with its (their) continuous developing and re-engineering by all means. On the other hand, TQM can not exist without a systematic re-engineering and innovation activities. Continuous up-dating of business processes, as management activity, has a close relationship and strong similarity to the view and methods of TQM.

Hungarian experience has also shown the fact that establishing and certifying of ISO 9000-based quality management systems have been carried-out with paper-based tools in the majority of cases. This fact, even itself, increases the idea of increasing of bureaucracy in mind of the operating staff. Practice of TQM requires information-demanding activities, they are as follows:

- unified, firm-level data modelling;
- effectual documentation handling;
- business process modelling;
- systematic internal revision and evaluation;
- information support for managerial decisions;
- systematic training of employees, etc.

Provided that these activities have got a permanent support from a well-functioning information system, the chance of undisturbed realization improves to a great extent.

3. INTEGRATED INFORMATION SYSTEMS

Feature of the greatest importance in progress of computational technology and software engineering for the last decade is appearance of the integrated computer-based information systems. This progress has been founded basically upon the extremely rapid improvement of communication and system integration capabilities of the computer networks.

An up-to-date computerized information system, suitable for supporting Total Quality Management effectively as well, consists of numerous component resources developable in a modular way. These are as follows:

- powerful servers;
- special dedicated workstations;
- computer peripheral equipment (e.g. printers, plotters etc.);
- local area networks;
- network operating system, network management;
- data base management system;
- management information system (MIS);
- integrated office applications (computer aided administration = CAA);
- CAxx-applications for engineering (design, planning);
- applications for shop-floor-control (SFC), production planning and control (PPC) and logistics;
- measuring data acquisition and processing, statistical applications.

The application structures of information technology have changed significantly of late years. In "*main frame*"-based systems both data sets and application programs were stored in the "*host*" computer and ran on the processor of the host machine. The terminals of the users could handle commands, data and messages only; on the network their codes moved.

Due to multitudinous spreading of personal computers and their linking into network this structure has changed in a radical way. Applications have been implemented to the workstations while large-sized data sets to the file-server. In this arrangement data sets themselves move on the network. Both of the mentioned solutions have advantages and drawbacks, but the really effectual solution can only be obtained by means of a consistent application of distributed "*client-server*" architecture.

The internal structure of an application realizing a given information processing task can be decomposed into *four* parts in general. The *first* part communicating with the user directly is the "*viewer*" module. It handles screen graphics, rolling menus, interactive commands (mouse), command lines of character type and it visualizes the data sets and documents required. The *second* part is the "*computing*" module. This part carries - out the computations based upon actual algorithms. For example, such module is the geometric modeller of a design engineering program or the account computing part of a financial program. The *third* part is the "*data base*" that includes the data used for computations, visualization, communication and graphic data sets. At last, the *fourth part* services the machine-machine communication. It can maintain connections with peripheral equipment, local computer network and special equipment (e.g. bar-code reader, programmable logical controller (PLC), digital measuring tool etc.).

The applications obtainable in the software market at present can distribute these partial software functions between the client programs running on the workstation and server programs running on the server computer in very different ways. Up to now those unified principles, which could make it possible that all the software modules should be client and server at the same time by using standardized messages and supplies, have not formed yet.

MMS (Manufacturing Messages Specification) came to be through the famous MAP (Manufacturing Automation Protocol) initiative and SQL, the main tool of data management are the most progressive solutions, but their spreading is slower than the expected one.

Developing of the softwares supporting the use of *Internet*-supplies, as well as appearance of new language-tools (*Java*) have a rapid and resounding success.

In the client-server architecture there can be such resources on the network which have a dedicated server role, e.g.: file server, printer server, application server etc. There can be workstations on the network which run application softwares but they can also have data sets (files) of their own and they can behave as a server for other clients.

For realization of these solutions, the high standard of network supplies is a precondition. It includes the following components:

(1) Modern operating system;
(2) Network management and multiprotocol-based supplies;
(3) Flexible data base management (SQL);
(4) File transfer and management (FTAM);
(5) Availability of program library catalogues (Directory Service);
(6) Message Handling and Mail System;
(7) Handling, transfer and visualization of documents and graphic data sets;
(8) Safety of transactions and high level of data protection;
(9) Integrability of real-time applications;
(10) Effectual developing environment (CASE, 4GL);
(11) LAN-WAN connections (X.25, ISDN, AMT);
(12) Internetwork supplies (Internet, EDI).

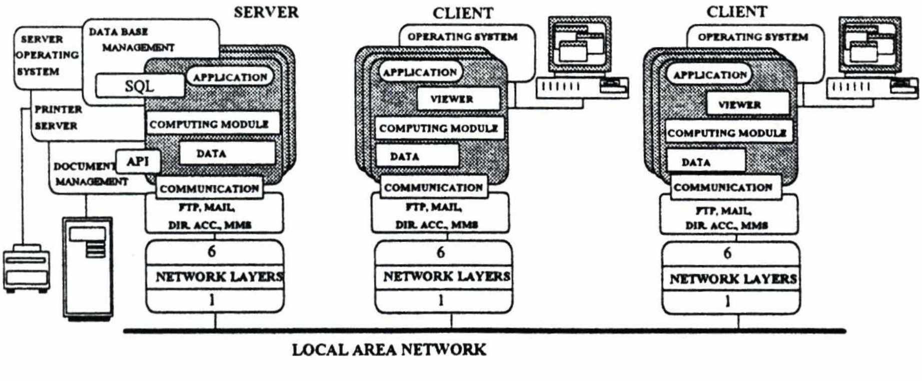

Fig.1. The structure of integrated information systems

Propagation of the aforementioned structure has already been supported by a number of operating systems. A few years ago a user could only hope an appropriate flexibility from *UNIX*-like environments (*Sun Solaris, HP-UNIX, IBM-AIX, SCO-UNIX, DEC VMS*) only. Of the new solutions, supplies of the network operating systems *Novell Netware, Windows NT* and *OS/2 Warp Server* are of very high standard and they make it possible to develop effectual and flexibly enlargable information systems.

Nowadays it has already become an important factor what kind of platforms are supported by the *client-server* type application system in question. It is frequently occurred that a given firm uses several different platforms, possibly at different settlements, which are integrated by a local area network (LAN) and/or a wide area network (WAN).

A further very important tool of integration is the network protocol. The most up-to-date integrated application systems are multi-protocol based ones i.e. they are also capable to support several different protocols, moreover, they are able to hide the heterogeneous environment for the user. The most frequently used protocols in PC-environment are: *IPX/SPX, NetBIOS, Banyan Vines, AppleTalk* and recently *TCP/IP* that was only used in *UNIX*-environment earlier.

The most up-to-date tool of information technology based integration is the *Internet* world-wide area network. Probably there is no one all the world over who knows how many million users are joined by *Internet*. Within the framework of integrated application systems such an application can be started which make it possible to access the *Internet* supplies, the *Mail* mailing system, the *World Wide Web* information and documentation web and other supplies.

4. DOCUMENTATION HANDLING

Quality management can only obtain effectual quality control tools and methods by introducing measurable "conformity" indices. For all this the following requirements have to be documented clearly, unambiguously and exactly:

- What kind of property of the product or the technology process is to be measured?
- How should the measuring process be carried-out?
- What kind of conformity relation has to be met by the measured values?

Hence, the quality control system lives in these documentations. The outstanding importance of documentation handling is also emphasized in the Chapter 4.5 of ISO 9000-2 Standard.

What do we understand on documentation?

Document is an information object containing facts (data) and/or rules (prescriptions, commands, relations) which is identifiable, confirmed and registered. The form (syntax), the content (semantics) and the aim of use (pragmatics) of the document are defined in a prescribed way.

The most important documents of the quality management systems are as follows:

(1) Quality management handbooks;
(2) User's guides for quality management functional systems;
(3) Revision reports;
(4) Descriptions of quality management procedures;

(5) Measuring-conformity data sets (files);
(6) Documents of analyses and conformity decisions;
(7) Confirmation documents and standards;
(8) Certificates (guarantees);
(9) Design and planning documents.

Producing and handling of a documentation is expensive. Therefore it is a fundamental requirement for all the documentation systems that they should be adequate to the quality management system model (E.g.: ISO 9002, 9003, 9004).

Fixing the handling of documents is the task of a *handbook*. It has to be written unambiguously that:

- how the document in question should be handled,
- who is the responsible person for handling;
- what should be tested/checked/examined in a systematic way, as well as;
- when and where testing/checking/examining should be carried-out.

A quality management document differs from any other information document in the fact that it can be found with its identifier in a registration list. This list contains for each quality management document:

- its identifier,
- the level of issue and approval respectively,
- the number of the confirmed copies and their places,
- its revision status.

In documents handling, in addition to producing, approval, issue, distribution and registration, the greatest attention should be payed to the following procedures: changing, modification, actualization, validation, nonsuit, invalidation. The errors occurring in handling of documents are considered disturbances of the quality management system which can jeopardize conformity of the certified system in question.

There are two solution levels for the computerized supporting of documents handling:

(1) Supporting the quality management procedures by means of individual softwares;
(2) Computerized quality management system based upon an integrated information infrastructure.

The first main problem is to produce quality management documents by means of a computer. This is effectively supported by computerized text-editors, publication-editors (DTP), *spreadsheet*-editors, figure and printed form editors. Image digitizers make it possible to input existing drawings and photos into the computerized documents handling system and their inserting and editing into a given document.

Documents handling can be carried-out by means of a professional documents handling system (e.g. *Lotus Notes, ICL Office Power*, etc.) in the most effectual way.

A good documents handling system manages documents in a unified way and stores them in a logical order. Unified manageability endures independently of the fact what kind of text-editor or publication-editor was used to create the document in question. (For example, *Lotus Notes* visualizes a *Word* document in its original form without running *Word for Windows*).

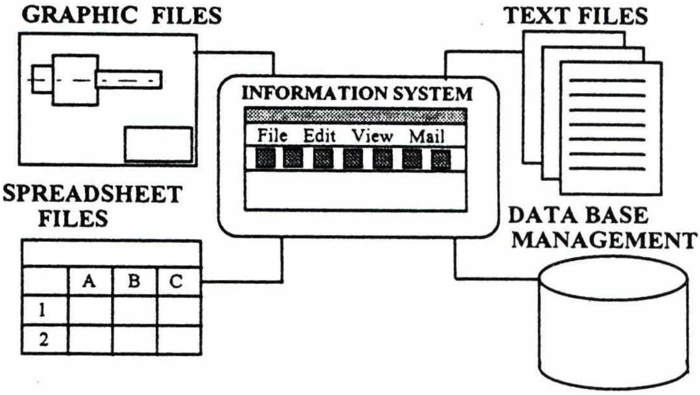

Fig.2. An integrated application structure

In such a documents handling system there can also be different operating systems on the client workstations (*UNIX, Windows, OS/2, Macintosh, Windows NT* etc.). The application field of up-to-date documents handling systems is a graphic interface with comfortable windows technique and rolling menus, handling of which can easily be attained by the user.

One of the important supplies of documents handling systems is searching. It is known that one of the fundamental operations to be executed in the data bases of record structure is searching the records meeting different relations and arranging them into "*views*". Up-to-date documents handlers have also enlarged this operation not only to the documents files semi-structurized but to the documents files completely unstructurized as well.

The "*views*" of a documents handler supply the groups of documents adequate to given aspects as a table of contents, with the most important data of each document. These lists also keep an occasional hierarchy of documents.

The user can execute those operations related to the found documents which are allowed by the safety system. He/she can read, group, modify them, possibly can cancel one or more of them, can transfer one or the other to a local documents storage of the workplace of another user etc.

The powerful documents handlers make it possible to carry-out searching on the base of words and/or expressions/terms occurring in the textual part of the documents, in addition to the data of registering printed forms. This can be combined with the key-words of the printed form, too.

One of the most important supplies of an integrated information system is *replication*, i.e. that process by means of which the modifications of the authorized users actualize documents in the data bases linked into network. In this way each authorized user is always seeing the valid documents. Creation of the new version of each document is managed automatically (date, identifier, author, validity domain, date of validity etc.).

One of the significant problems of integrated information systems is the question of the safety of documents. It includes as follows:

- checking the entering authority of the users;
- checking the authority of availability to information stored in the system;
- checking the rights related to documents handling, at several hierarchy levels;
- keeping the inaccessibility of secret documents;
- keeping the reliability of data transferring processes.

One of the important features of documents handling systems is that how and to what extent they support integration with technical and business applications. The most important feature is the existence of compatibility with data base handling systems because data base handlers are suitable for storing and processing of the large-sized data sets structurized on the base of records. A number of data processing applications are founded on the basic operations of data base handlers that can be accessed through standardized language calls (*Remote Call, SQL*).

In the course of quality assurance procedures data sets of great size come into being usually, processing of which is carried-out by means of statistic (SPC) and other methods. The results of evaluation of data also get into quality management documents.

An integrated information system allows to take over data from standardized data base records by the documents handler, and *vice versa*, one or the other application of the data base handler can acquire data from the printed forms of documents handler.

The design engineering systems use numerous special formats, e.g. for describing the product models. Such ones are e.g. the formats of CAD files (*IGES, STEP, DXF, CADL,* etc.). The documents handlers integrable can be linked to this kind of data sets and the data in them respectively, either directly or through a C-language based interface.

5. CONCLUSIONS

Among the factors of the successes achievable in competition sphere, the importance of quality and reliability has been growing all the more of late years.

Quality assurance requires an integrated managerial activity that is named by the present professional English language *Total Quality Management* (TQM).

A computer network based upon modern servers and workstations and an integrated information system operating on it are capable to support both information supply and communication in a very effectual way. Therefore they are outstanding tools for TQM practice.

6. ACKNOWLEDGEMENTS

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A SURVEY ON CAD/CMM INTEGRATION

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1. INTRODUCTION

In today's industry, the need for an effective process control increases even more than ever due to the growing emphasis towards product quality together with the progressive trends in Computer Integrated Manufacturing (CIM) Systems [1]. In these circumstances, such systems require a powerful feedback for the control of the production and hence the product quality. At this point, the importance of the inspection capabilities of the system reveals itself. Generally, the inspection facilities implemented in a manufacturing environment plays a crucial role in directly affecting the product quality if they are successfully integrated and effectively managed to provide the production requirements.

Being a flexible and an efficient inspection tool, Coordinate Measuring Machines (CMM) become more popular in automated manufacturing systems [2]. A CMM may not only be used to inspect incoming parts but also used for the inspection of components before, during and after the individual manufacturing processes. As highly productive machine tools and just-in-time (JIT) production systems demand a quick and effective inspection of component and the process, CMMs can also be employed in such systems and provide a feedback for verification of the process capability. They can be used as tools for the process refinement. Utilization of CMM can reduce the scrap or rework in small batch size production. The most obvious benefit with CMMs is the lower inspection times which is one of the advantages of such machines in fulfilling the above mentioned features.

2. INTEGRATED INSPECTION SYSTEMS

At the initial stage of the design and development of an integrated inspection system to be implemented in a CIM environment, the key concepts are to be determined carefully. Computer Aided Inspection (CAI) is the primary concept to be assessed consisting of the structure of CAD/CMM connections. Another topic is the processing of the inspection results by the system, which implies the implementation of an integrated CAD/CAPP/CMM system and is discussed briefly in the following sections. The integration of these two main topics will provide the full automation of inspection and process control in CIM Systems.

The development of a CAI system in CIM environment depends on linking the geometrical modeling concept and the CMM [3]. Geometric modeling generates the essential information for process (CAM/CAPP) and inspection. As CAPP systems are considered to be the key concepts in CIM systems for providing the link between design and manufacturing processes, the CAI system can be interpreted as the complement of CAPP in order to provide a more flexible CIM system.

Inspection of a component requires the interpretation of the aim in the design through the engineering drawings together with the knowledge of the processes used in manufacturing and the capabilities of the inspection facilities available [1]. Using these features developing a suitable method can be possible.

In general, the inspection plan will provide the sequence of inspection to be carried out on a certain component. It will present the order of inspection of surfaces and certain individual features of the component. Inspection plan will also provide the evaluation and presentation of the inspection data obtained. Commonly an inspection plan would be embedded in the program which is operating the CMM. Obviously when the inspection is carried out by teaching in the inspection routine manually, which is still often in practice, the time required for such operations become significant, especially for the inspection of few parts. Off-line programming of CMM will provide even faster and more flexible operation in inspection.

The interfacing of CAD and CMM is another concept to be considered. Usually the transmission of CAD model to any off-line programming system is carried out either by special routines or with standard CAD exchange standards such as IGES and VDA [1]. However such standards can not provide the interpretation of tolerance data which is important for both evaluation of inspection results and in automation of inspection planning tasks. A standard format which is called Dimensional Measuring Interface Specification (DMIS) is a high level programming language and is used for bi-directional transfer of inspection data between CAD systems and CMMs. Part programs and inspection results in DMIS format are usually pre- and post-processed in order to become usable by the CAD system or CMM.

Today, there exists a number of automated inspection planning systems that are successful in realizing their frameworks. One of such systems is proposed by Yau and Menq [4], an Intelligent Inspection Planning System, and another one is by CAM-I, Expert-Programming System - One (EPS-1) [5].

Intelligent Inspection Planning System: The system developed by Yau and Menq [4], facilitates the integration of CMM to an inspection planning environment which is implemented and also integrated with a CAD/CAM system. When the desired inspection specifications are given, the inspection plan of the part is planned in CAD environment and executed by the CMM on the shop floor. The developed automated inspection environment is composed of five key stages as follows: Inspection specification module, automatic inspection planning module, CAD/CMM verification module, CMM execution module, comparative analysis module.

Expert Programming System - One: EPS-1[5] developed by CAM-I aims to realize an intelligent inspection planning system with highly automated dimensional inspection planning through CAD/CAPP/CAM integration. EPS-1 provides the inspection plan through several stages of processing, from the definition of inspection strategy and decomposition of task for the features of the object to generating the path of probing and simulation of the inspection sequence for avoiding collision. The system interacts with various external components such as geometric modeller, dimensioning and tolerancing (D&T) modeller, applications interface specification (AIS), dimensioning and tolerancing applications interface specification (DTAIS), dimensional measuring interface specification (DMIS), support databases.

3. A FRAMEWORK FOR METUCIM

In this section, the main target is the interpretation of a particular research work to be implemented in the pilot CIM System (METUCIM) of the Mechanical Engineering Department at the Middle East Technical University (METU). The study includes the integration of a CMM to the system in a manner of process refinement and providing feedback for the process control. The existing environment provides the dynamic control of manufacturing and handling of the material . The proposed work provides a higher level of inspection ability to the system and will certainly enhance the quality of the produced parts.

The production equipment of METUCIM includes three main manufacturing system capabilities as turning, milling and automated material handling. The functional areas, which are either implemented or in the stage of implementation, are basically CAD, CAPP and NC code generation, Production Planning and Scheduling (PPS), CAM and Computer Aided Quality Assurance and Control (CAQA, CAQC) modules. The CIM system consists of a CNC lathe, CNC milling machine, a closed-loop conveyor, a coordinate measuring machine, two robots, host and cell control computers [6]. With the construction of a new rework cell one conveyor, one robot, one CNC lathe will be added to the existing system.

Quality assurance, which is one of the goals in CIM systems concerns the whole life cycle of both product and process [7], thus covering all quality management activities, including quality planning, control and monitoring with suitable feedback actions. The main task of this study is the control and monitoring of the quality in the above mentioned manufacturing environment.

The starting point of integration is between the stand alone CMM and the CAD environment of the system. The objective in such integration is for the processing of the measurement data provided by the CMM as a result of inspection on a particular component [8]. The decision acquired from the resulting data will be accepting or rejecting the produced part. However, the intelligent system that is going to be implemented in the system will allow the further classification of the rejected data as rework or scrap. Oncoming stage is the manipulation of the part that is to be reworked and a new process plan will be generated. Briefly, the measurement data from CMM processed and if necessary, a new process plan is generated by rework CAPP module of the Intelligent Inspection system. Necessary information, then, will be send to host controller by the inspection module and host controller should give a query for the rework cell. The cycle will be finished with the reprocessed rework component. Figure 1. presents the interactive flow of inspection system that is to be implemented.

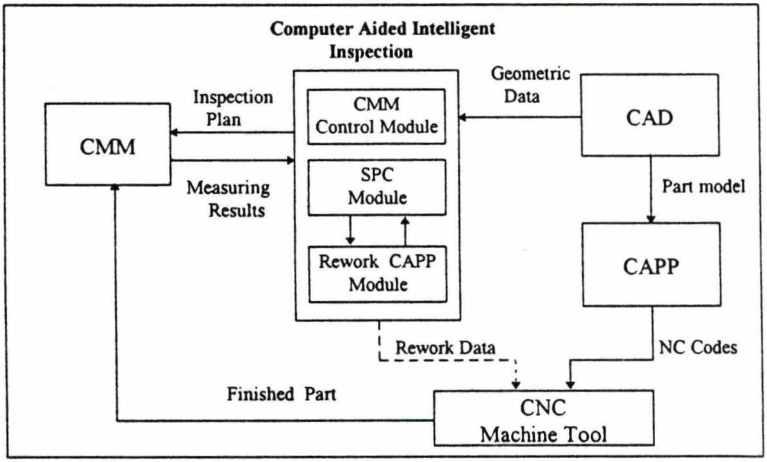

Figure 1.
Proposed Framework of METUCIM

Another feature to be implemented in the system is the Statistical Process Control (SPC) function. This will allow the effective monitoring of quality and process and provide the necessary feedback to the system [9]. The following features of an SPC system will enhance the overall system reliability and provide the fulfillment of quality assurance in order to achieve the goal of a CIM system.

- Monitoring: the continuous comparison of process data with predefined process performance standards and provide a reject/accept basis for decision,
- Interpretation: the inference of process status (i.e. in- or out-of-control) based on specific product and process information,
- Diagnosis: the investigation of sources of process variation and provide a chance for corrective action,
- Planning: the preparation of remedial action or compensation to bring the process into a state of statistical control.

4. CONCLUSION

In this study mainly two stages, two complementary stages in the scope of CAD/CMM integration, are presented. The first stage is the study on Computer

Aided Inspection through a review of some related researches, for intelligent inspection planning applications. This study reveals the benefits of such systems, briefly, avoiding the time consumed with `teach-in` methods in programming of CMMs, which is notable especially when the subject component is very complex or the size of the batch to be inspected is relatively small that prevents an economical inspection. The latter stage presents the ongoing research about the integration of CMM to existing FMS in METUCIM, a pilot CIM environment, with the development of rework CAPP and SPC modules. The aim here is the establishment of a basic structure for an Computer Aided Inspection System providing a higher level of flexibility to the overall system. Obviously, the study presented in the first part will be an initial step in implementing more integrated inspection systems in the above mentioned environment.

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SCHEDULING OF FLEXIBLE MANUFACTURING SYSTEMS

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1. INTRODUCTION

There is enormous research in the area of FMS scheduling. However, due to the uncertainty and unpredictability of the FMS environment, the research has led to the development of very few tools that can solve real problems. The tools that do exist are typically (1)too slow and cannot react to changing dynamic shop floor conditions, (2)based on simplistic formulations that ignore important constraints like material handling, (3)based on a single objective function or simplistic trade-offs like goal programming, and (4)difficult to install and integrate into pre-existing commercial shop floor systems [1]. Generally speaking, the gap between theory and practice can be attributed to the following factors [2]: (1)Researchers often fail to address the right problems, (2)Solutions presented by researchers are often too complex to use, (3)Findings are presented in terms that are often foreign to practitioners, (4)Researchers often focus on certain problems to the exclusion of other, often more important issues, (5)The realities of the shop floor are often ignored in the problems examined by researchers and in the settings found in these studies.

This paper aims at highlighting the facts mentioned above based on a survey in the field of scheduling and Flexible Manufacturing Systems.

2. SCHEDULING ASPECTS OF FMS

The paper by Saygin et al. [3] is an attempt to clearify the fact that a common complaint from the shop floor personnel that scheduling techniques and solutions developed by academic researchers are "out of touch" with the reality of the shop floor. This reality is emphasized in several studies in the literature [4,5,6,7,8,9]. The gap between theory and practice is mainly due to the inter-dependency among the part-tool-machine requirements along with the auxiliary but indispensable transportation and storage facilities in the FMS environment. On the other hand, the dynamic structure of the FMS environment necessitates real-time control over the predictive schedule developed at the planning (predictive) stage. Specifically valid for FMS, any predictive schedule, once determined, is almost immediately subject to new conditions, demands and constraints that require inevitable changes in the existing schedule. Such factors make "rescheduling" mandatory [10,11,12,13]. These factors including a variety of conditions, demands and constraints which necessitate revisions to an existing schedule are referred as "rescheduling factors" [12,13]. Some common rescheduling factors are machine breakdowns, rush orders, shortage of material, quality problems, over/under estimation of machining time, cancellation of an order, due date changes, being behind or beyond the current schedule, and so on.

Scope of Scheduling Approaches in Literature

(ü shows the parameters included in the corresponding study) **Table 1.**

AUTHOR (year)	cutting tool life	batch size	alternate machine tools	Setup Time	Due Date	MHD Capacity	Transportation Time	MB Capacity	Cost	Performance Measure(s)	METHODS and TOOLS
Chang and Sullivan, 1990			✓		✓		✓			due date, makespan	H
Sarin and Salgame, 1990		✓	✓		✓					adherence to initial schedule	AI, ES
Ro and Kim, 1990		✓	✓		✓	✓	✓	✓		makespan, flowtime, tardiness, utilization	LP, DR, S
Speranza and Woerlee, 1991				✓			✓	✓		due date	H, DSS
Tsukiyama et al., 1991					✓					due date	PN, S, DR
Hatono and Yamataga, 1991		✓		✓	✓		✓	✓		several DR	H, PN, DR
Shaw et al., 1992			✓		✓			✓		system util.	AI, DR
Song and Choi, 1993	✓	✓	✓	✓	✓		✓		✓	production cost	NMIP
Logendran, Sriskandarajah, 1993		✓		✓				✓		makespan	H
Jones, 1995				✓	✓					flow time, tardiness, system util., throughput	NN, GA, S, DR
Chiu and Yih, 1995		✓	✓		✓			✓		makespan, tardiness, no. of tardy jobs	GA, S, DR

MHD: material handling device, MB: machine buffer,
AI: artificial intelligence, ES: expert system, BB: branch and bound, DR: dispatching rules, DSS: decision support system, PN: Petri-nets, S: simulation
GA: genetic algorithms, H: heuristic, NMIP: nonlinear mixed integer programming, LP: linear programming, NN: neural nets.

3.REVIEW OF LITERATURE

Several papers in the area of scheduling and FMS are elaborated and some selected papers are tabulated as shown in Table 1.

Chang and Sullivan [14] consider the problem of active schedule generation [15] in a dynamic job shop with alternative machines for each operation where jobs arrive at the shop randomly over time. Sarin and Salgame [10] present an interactive, real-time, knowledge-based approach for dynamic scheduling. In their model, they consider machine breakdown, rush jobs, new batch of jobs, material shortage, labour absenteeism, job completion at a machine and change in shift as the frequently encountered dynamic situations in the manufacturing environment. Alternative machine and due date constraints are also included in the presented model. In their study, Ro and Kim [16] propose three new dispatching rules to cope with the limited buffers in FMS including transportation time, capacity of AGVs and alternative machines. The performance of the proposed dispatching rules are investigated by simulation. Speranza and Woerlee [17] describe a Decision Support System for dynamic job shop scheduling environments. The authors state that the supported decision situation includes real-life features such as buffer capacity, transportation time and setup time which are mostly disregarded by conventional scheduling approaches. In their paper, Speranza and Woerlee point out that there are a lot of fuzzy restriction in real life situations which are hard to consider in the solution process, thus interactive scheduling is effective in dealing with such situations where the planner guides the scheduling activity. Tsukiyama et al. [18] propose a dynamic scheduling procedure to cope with unexpected event in FMS. The approach consisting of Petri net modelling of the manufacturing system, simulation, manual schedule editing and evaluation is regarded as a hybrid scheduling support system. Hatono and Yamagata [11] use Petri nets for the modelling and on-line scheduling of FMSs under uncertainty, such as failure of machine tools and variations of processing time. They describe the manufacturing system in two subsystems, namely "transportation" and "processing (machining)" levels. The method developed by Shaw et al. [19] enables the scheduler to classify distinct manufacturing patterns and to generate a decision tree consisting of heuristic policies for dynamically selecting the dispatching rule appropriate for a given set of system attributes. This study develops a framework for incorporating machine learning capabilities in intelligent scheduling. Shaw et al. state that one of the goals of intelligent scheduling is to be able to generate schedules more flexibly whenever alternative machine routing is possible while simultaneously taking the dynamically changing system state information into account. Song and Choi [20] describe a procedure for optimizing the route selection and production conditions considering alternate process plans in a flexible cellular manufacturing environment. Their model which is formulated as a nonlinear mixed integer programming problem in order to minimize the production cost includes the unexpected orders, i.e products, resulting from changing environmental conditions. Song and Choi take the effect of cutting parameters into account while performing the scheduling of unexpected orders based on the initial schedule upon which the unexpected orders are distributed. In their study, Logendran and Sriskandarajah [21] propose a heuristic approach while investigating a realistic two-machine scheduling problem to minimize the makespan where buffer inventories are not allowed. The model includes sequence dependent set up time. Jones et al. [1] propose a hybrid methodology that integrates neural networks, simulation, genetic algorithms and learning techniques which is applicable to both single and multi machine scheduling problems. In their model, the arrival times of jobs, processing time distributions, due dates and sequence-dependent setup times are considered. In their study, Chiu and Yih [22] propose a learning-based methodology to extract scheduling knowledge for dispatching parts to machines. The approach uses simulation techniques, genetic algorithms and a learning algorithm to improve the system performance by providing the background for the machine to intelligently switch dispatching rules based on the current system status. The proposed methodology considers the routing flexibility to switch among alternative machine tools. Lane and Evans [23] decompose scheduling into small-scale problems, instead of considering it as a single problem. They present an alternative method in which individual difficulties are viewed as problems, and the task is to maintain a suitable schedule by resolving as many of these problems as possible. Lane and Evans describe a decision support software that has facilities for defining policies to handle numerous minor problems and complete problem solving strategies to deal with major problems. In their paper, the potential for this style of decision support to improve the performance of human schedulers is also discussed.

4. CONCLUSION

In the scope of Table 1., the idealized conditions can be stated as follows: (1)only "part scheduling" (like "n" jobs, "m" machines) is considered, (2)setup times are neglected, (3)capacities of the storage units (like machine tool buffers) for work-in-process are assumed to be infinite, (4)material handling devices are considered to be always available and have an infinite capacity, (5)part and tool transportation times are neglected, (6)machine breakdowns are not considered, (7)cutting tool allocation as regards the capacity of the tool magazines are neglected, and cutting tools are assumed to have infinite lives, and (8)alternative routing is not considered. On the contrary, in FMS environments: (1)for machining; the part, the necessary tool (cutting tool, jig, fixture) and the appropriate machine must be available at the same time and at the same place, (2)setup times may be significant and sequence dependent, (3)buffer capacities are limited and may be part size dependent, (4)capacity and transportation time of the material handling devices are limited, (5)cutting tools have finite lives, (6)capacities of the tool magazines are limited, and (7)each machine may perform a range of operations and each operation may be performed on different machines (alternative routing).

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SOURCES OF TECHNOLOGICAL INFORMATION IN PRODUCTION PROCESS

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1. Introduction

The great development of information technology caused the information revolution which could be compared with industrial revolution in the end of 19th century. While industrial revolution were characterised like "the best quality the less cost" the information revolution feature is "the best quality the less time". Nowadays, are characterised like the information society which is self-evident using information technology. Information technology influenced on all human activity like production, market business, transport, education and management. Information system are the main source of decision making proces in management and the information is source of production like working power production equipment and money.

What does mean information? One can said information are data. Data is the product of human activity which determines other human activity. Each data has its own value which determine its information contain. Each information is a data, but not every data saved in computer becomes information. The data became information feature when it give some new for user it means the information decrease the indefiniteness of system. Using of information system is the actual task nowadays and of course in the near future in all stages of manufacturing system. There is no doubt that for information society the sources of information are more valuable because of right decisions making proces the right information are needed.

It is commonly known that information system ensure the right information for right people in just time. But using right information in time is more difficult as can be assume. After [1] the right timing of information is very important for competitiveness of product especially for small and middle type enterprises.

For about mentioned reason the article describe one part of production function information and try to show the way for decisions making process for proper production technology choice from point of view information requirement about innovative production process.

2.Information flow in manufacturing production

Information system application to the management means as an essential weapon for manufacturing competitiveness in the market economy. Each level of management in manufacturing system and stage of manufacturing has its own data management which is connected each to other. The direction of main information flow in manufacturing engineering production is illustrated on Fig.1.

Information flow in the vertical direction joint management information between manufacturing corporation and manufacturing system and production function.

Besides that each level of management has its own horizontal information flow which joint the main fields of corporate policy or manufacturing system strategy to take an example production policy joint product policy and market policy in horizontal level of information flow in corporate policy.

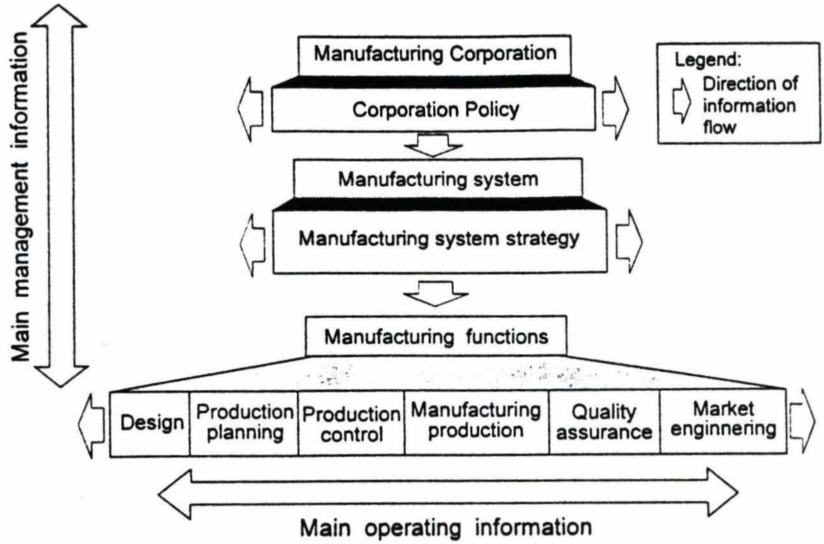

Fig.1
Information flow in manufacturing system

The horizontal information flow (see Fig.1) is concentrated on the role of production function. As known, the most information flow goes on the horizontal direction when the main production functions are concentrated. As illustrate Fig.1 one part of manufacturing function is manufacturing production which contain processing as operation, work elements, operating parameter, equipment and tooling, further assembly, finishing and transport and database, etc.

More of technological information using in production process such as for example information about cutting tools and fixtures and cutting conditions etc., are nowadays a part of database management programmes. The problem and question are how can the user effectively managed these informations, and what the users need to know about technological informations for its applications in decision making process. Because of various structuring and systemizing of data.

3. How find sources of information for production process

Nowadays, exists many information system based on databases and bibliographic information which give enough data for users. It is true that weekly appear approximatelly 15.00 patents and about 650.000 improvements in the world [1]. The manufacturing technology offer contain about 1,2 Million pages printed in Germany for Mechanical

Engineering and Electrical Engineering. One can use, but for fast decision in the world competition it is know the right way in less time. It seems the competition aims have Olympic dimensions " better, cheaper, faster". That is mean " better quality, minimum cost, and shorter time". So these aims appear in each part of manufacturing production. Now, for part manufacturing is the great problem how to select the proper manufacturing method to effectively produce a given part.

There exists a wide variety of manufacturing process today which can be roughly devided to three main group illustrated on Fig.2 after van Luttervelt [2].

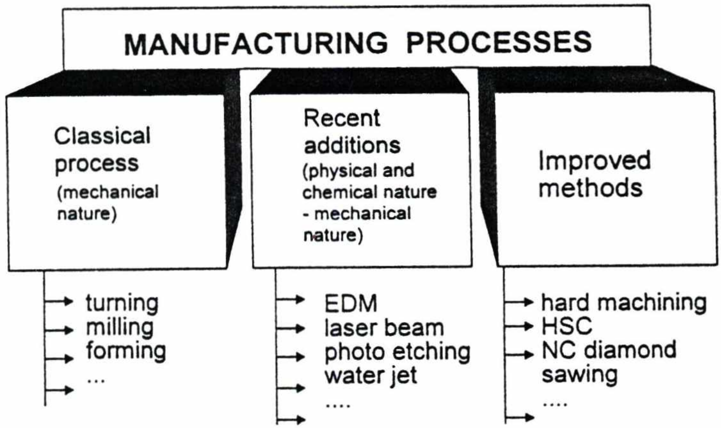

Fig.2
Main types of manufacturing processes

First there are the well known classical processes, mainly of mechanical nature. Then there are more recent addition mainly of physical and chemical nature but, there also a few non-conventional mechanical methods like waterjet. In between them is a wide range of so called improved methods.

This improved method could be classified as innovative manufacturing process devided after Eversheim [1] like new principles process and improved conventional (or classical) processes, Fig.3.

About the same situation is encountered in the variety of materials. There are also about three type of materials. Large group of conventional materials like metal, wood. Then a group of real new material like plastics, ceramics, composite materials. And the end the group of improved material like high strengh and refractory metals.

It seems, the main problem is how to select the proper manufacturing method to produce a given part. One of solution is describing all production processes coinvient for manufacturing a given part and with help of value analysis find the optimal technology method. This is a difficult task for designers and process planners. More articles appear with this evaluation [3] [4].

The number of available innovative technology process improved work material and other factors to be taken into account is increasing considerably and the importance of each factor to be taken into account varies from situation to situation and also with time.

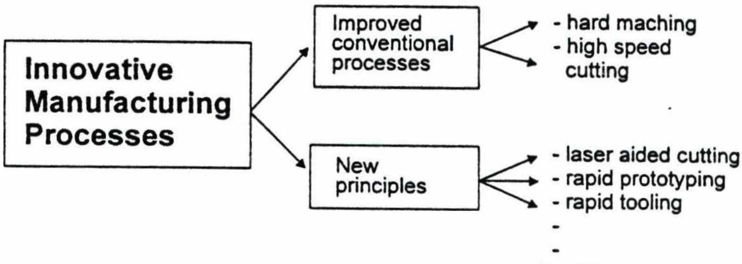

Fig.3
Types of innovative production processes

The results of above mentioned facts cause information asymmetry between sources of technological processes (research and development of new processes, laboratory testing of improved processes) and process using in part manufacturing.

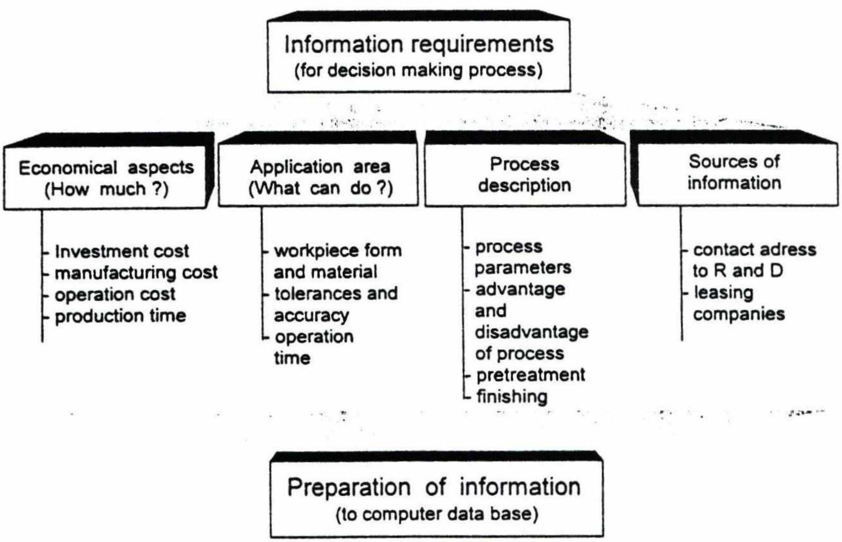

Fig.4
Main fields of information demands for right decision

Mostly, the users have enough information about innovative technology but for right decision the value of information is not sufficient. After [1] the main question for information demand about technology process arise from users is "which information about production process technology is most significant". Five area of demand were preferred: 1.Technology process describing, 2.Application of technology, 3.The technology process potential, 4. Process economy, 5. Accessibility of technology.

Accordingly the results of answer of above mentioned question stress both the possibility of technology application and economy of technological process. That is mean the main question of users are concentrated on "what can do" and "how much". The next priorities concerned on process description (short explanation of technical possibilities) and farther the sources of .accessibility of innovative technology.

Figure 4 illustrates information requirements and all possibilities of information preparing like database for information system. Information system based on above mentioned results were created and published in [1]. That is seems as one of the right way for help in management a decision making process. The choice of proper technology is based on two criteria. Firstly, comparison of two or more similar technology process and choosing depend on cost and other important indicators. Secondly, the properties of work material play the important role in right choice of technology.

4.Conclusion

The article is a part of my lecture in the 9th study course in specialisation Engineering Technology Information which integrated both knowledge about process technology and information system. The subject of lecture Engineering Data Management stress the importance of information quality and proper orientation available and also choice for right decision for man in production technology. The article strongly shows the various manufacturing method and quantity of information which is need to prepare friendly-user database after users requirements. Finally, there is a questions this is a right way for engineering data management?

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KNOWLEDGE BASED CONCEPT IN EXPERT SYSTEM FOR THE CHOICE OF FLEXIBLE TOOL SYSTEM

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1.0 INTRODUCTION

By the design of technological processes in automated flexible technological structures with numerical control, choice of cutting tools takes an important place in the process of design. At the same time, we must point out that the quality of the designed solutions of technological processes greatly depend on the quality of chosen cutting tools, but also, on the type and efficiency of their choice.

Accordingly, automated choice of cutting tools greatly provides for higher efficiency of designed technological processes of machining, either in automated flexible, or in conventional technological structures.

Within expert system for automated design of technological processes of machining, where even the cutting tools are chosen in the automated way, basis for their efficient and quality choice makes the adequate knowledge basis and prepared expert shell, or especially developed computer program.

General development model set for the knowledge basis development for the choice of cutting tools within expert systems for automated design of technological processes, or, expert systems for automated choice of tools and regime of machining, makes it possible for the application even for the knowledge basis development for the choice of flexible tool system which is the subject of this study.

2.0 KNOWLEDGE BASED MODEL FOR THE CHOICE OF FLEXIBLE TOOL SYSTEM

Model of this knowledge basis, as pointed out, should provide its application for the choice of these tools within the expert systems for automated design of technological processes of machining, and also, for the development of expert systems for automated tool choice and regime of machining which can significantly contribute to the efficiency of manual programming of automated flexible technological structures and design of technological processes of machining on the conventional technological structu res.

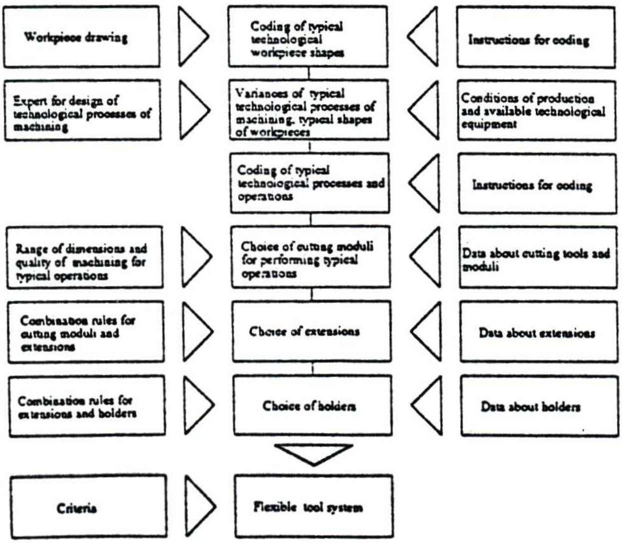


Fig. 1.
Model of knowledge basis development for choice of flexible tool system

Development model of knowledge basis set in this way for the choice of flexible tool system shown in figure 1 will be explained in detail.

2.1. Coding of workpiece typical shapes

Starting with the workpiece drawing, as for example of medium plate for plastic injection mold [2.3], figure 2, it is possible to determine typical shapes TO1, TO2, TO3, TO4 and TO5, which are marked, with dimensional range according to the standard DME given in the study [2.3].

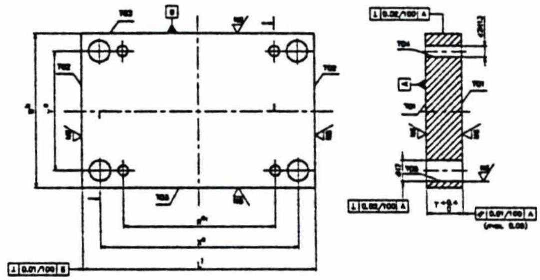


Fig. 2
Medium plate for plastic injection mound according to DME standard, with typical technological shape smarked

2.2 Design of variances of typical technological machining processes

Generally, with regard to various conditions of production and available equipment, it is possible to put up more than one variance of typical technological process of machining. The study [3] includes one variance of typical technological process of machining parts of plastic injection mold under the conditions of production in small series.

Table 1. shows typical machining operation of technological shapes TO4 and TO5 of medium plate shown on fig. 2, which, as a part of a typical technological process, is done on the CNC boring and milling machine "MAHO 1000-C".

Typical machining operation of medium plate on CNC boring and milling machine "MAHO 1000-C" [3].

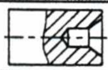
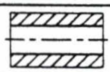
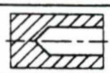
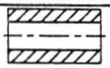
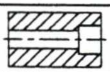
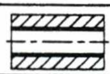
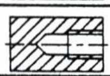
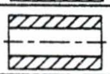
Table 1

Typical technological shape	Denomination of a typical operation part	d_2 H13 = 6,5 8,5 10,5 L = 12 20 26 Quality (N10)	d_2 H13 = 13,5 17,5 L = 36; 46 46; 56 Quality (N10)	Code of operation
TO4	TTS1	Marking drill ϕ2,5/5 Drill through ϕ5 Bore ϕd_2 H13	Marking drill ϕ4/7 Drill through ϕ10 Bore ϕd_2 H13	BZ 01 BS 01 BP 01
TO5	TTS2	dH7 = 14 18 L = 12 20 Quality (N10)	dH7 = 24 28 32 L = 26 36 36, 46 Quality (N6)	
		Marking drill ϕ4/7 Drill through ϕ10 Bore ϕ12 or ϕ16 Drill finely ϕ14 H7	Marking drill ϕ4/7 Drill through ϕ18 Bore ϕ22 or ϕ26 or ϕ30 Drill finely ϕ24 H7 or ϕ28 H7 or ϕ32 H7	BZ 01 BS 01 BP 01 BF 01
	TTS3	dH7 = 42 50 L = 56 56 Quality (N6)		
		Marking drill ϕ4/7 Drill through ϕ18 Bore ϕ30 Bore ϕ40 or ϕ48 Drill finely ϕ42 H7 or ϕ50 H7		BZ 01 BS 01 BP 01 BP 01 BF 01

Part of this typical machining operation of technological shape TO4 is denoted by TTS1, of shape TO5 it is TTS2 and TTS3. Coding of the appropriate typical operations is made according to the developed coding system [1] the review of which is partly shown in Table 2. Codes of typical operations of technological shapes TO4 and TO5 of medium plate, with measure range and economical quality of machining shown in the Table 3.

Partial review of machining operation coding system [1]

Table 2

Opera-tion sketch	Typical operation	Typical operation code
	Boring without protective enlarging	BZ01
	Cylindrical through hole drilling	BS01
	Cylindrical non-through hole drilling	BS02
	Cylindrical through hole boring	BP01
	Making rectangular shallow hole	BU01
	Thread cutting in through hole	BN01
	Thread cutting in non-through hole	BN02
	Fine drilling in through hole	BF01

Codes and data about machining operations of technological shapes T04 and T05

Table 3

Code of typical operation	Range of dimensions for typical operations		Class of roughness	Tolerance of machined hole
	Diameter of machining (mm)	Length of machining (mm)		
BZ01	2.5	5		
	4	7		
BS01	d_4	T	N12	—
	10	12,20		
	18	26,36,46,56		
	d_6	T		
	5	12,20,26		
	10	36,46,56		
BP01	$d_4 \rightarrow d_7$	T	N9	—
	10→12	12		
	10→16	20		
	18→22	26		
	18→26	36		
	18→30	36.46		
	$d_4 \rightarrow d_5$	T		
	18→30	56		
	$d_5 \rightarrow d_7$	T		
	30→40	56		
	30→48	56		
	$d_6 \rightarrow d_2$	T	N10	H13
	5→6.5	12		
	5→8.5	20		
	5→10.5	26		
	10→13.5	36,46		
	10→17.5	46,56		

2.3. Choice of cutting moduli

Based on the data about cutting moduli of specific producers arranged in the form as shown in figure 3.

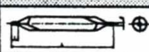
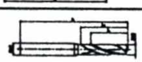
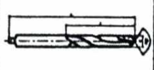
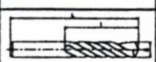
No.	Cutting modul												
	Item	Sketch	Producer	Denotation of cutting piece or cutting edge	Class of roughness	ISO tolerance	Catalogue denotation	Characteristic dimensions					Code
1	marking drill		FRA	HSS	—	—	5.163520	2.5	6.3	3.1	45	—	RZ01.02
							5.163523	4	10	5	56	—	RZ01.03
2	spiral drill Coromant Delta S		Sandvik-Coromant	TM+ TIN	≥N9	≥IT11	R410.5-1000-60-01 TIN	10	10	137	87	69	RB01.06
3	spiral drill with hard metal plates		FRA	TM-P20	≥N9	≥IT12	5.023412	dh8 5	L 63	l 28	—	—	RB02.01
							5.028963	6.5	71	32	—	—	RB02.02
							5.025740	8.5	90	50	—	—	RB02.03
							5.022408	10	100	56	—	—	RB02.04
							5.028965	10.5	100	56	—	—	RB02.05
							5.028971	18	160	90	—	—	RB02.07
4	spiral drill with TIN		FRA	HSS+ TIN	≥N9	≥IT12	5.094256	17.5	191	130	—	—	RB03.03
...	...	...	...	...	...	...	...	...	...	...	...	...	...

Fig. 3
Part of data about cutting modulus

It is possible to determine the rules for their choice for every coded operation, range of dimensions, class of roughness and tolerance of machining as, for example, for operations of typical shapes T04 and T05, table for medium plate as shown in figure 2. Rules for choice of cutting moduli for the above example are given in Table 4, where coding of chosen cutting moduli is also given.

Part of rules for choice of cutting moduli for machining the typical technological shapes T04 and T05.

Table 4

Code of typical operation	Range of dimensions for typical operations		Class of roughness	Tolerance of machined hole	Code of cutting modul
	Diameter of machining (mm)	Length of machining (mm)			
BZ01	2,5	5	---	---	RZ01.02
	4	7			RZ01.03
BS01	5	12,20,26	N12	---	RB02.01
	10	12,20,26,36,46			RB02.04
		56			RB01.06
	18	26,36,46,56			RB02.07
...	...	...	...	...	...

2.4. Choice of extensions and holders

Based on the data on extensions and holders, arranged in figures 4 and 5, it is possible to develop rules for combination of cutting moduli, extensions and holders. In form of Table 5, in which flexible tool element combination rules are developed for machining typical shapes TO4 and TO5 of medium plate, according to Table 1 and figure 2.

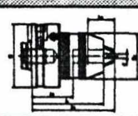
No.	Extension									
	Item	Sketch	Producer	Catalogue denomination	Characteristic dimensions					Code
1	extension for cilindrical holders		Sandvik-Coromant	391.31-13150092	d 1-13	D 50	D_1 49	l_4 83		NA01.01
...	...	...	...	...	...	...	...	...	...	...

Fig. 4
Part of data about extensions

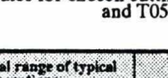
No.	Holder							
	Item	Sketch	Producer	Catalogue denomination	Characteristic dimensions			Code
1	basic holder "VARILOCK" for manual change		Sandvik-Coroant	390.00-4050022	ISO 40	D 50	l_2 22	D01.01
				390.00-5050027	50	50	27	D01.02
...	...	...	...	...	...	...	...	...

Fig. 5
Part of data about holders

Part of combination rules for chosen cutting moduli for machining typical technological shapes T04 and T05, extensions and holders

Table 5

Code of typical operation	Dimensional range of typical operations		Class of roughness	Tolerance range	Code of cutting modulus	Code of extension	Code of tool holder
	machining diameter (mm)	length of machining (mm)					
BZ01	2,5	5	---	---	RZ01.02-	-NA01.01-	-D01.01
	4	7			RZ01.03-		
BS01	5	12,20,26	N12	---	RB02.01-	-NA01.01-	-D01.01
	10	12,20,26,36,46			RB02.04-		
		56			RB01.06-		
	18	26,36,46,56			RB02.07-	-NA10.04-NA09.01-	
...	...	...	...	...	...	...	...

Developed rules for element choice of flexible tool system for given example according to figure 2 and table 1, enable precise definition of flexible tool system for typical machining operation on CNC boring milling machine "MAHO 1000-C" (figure 6)

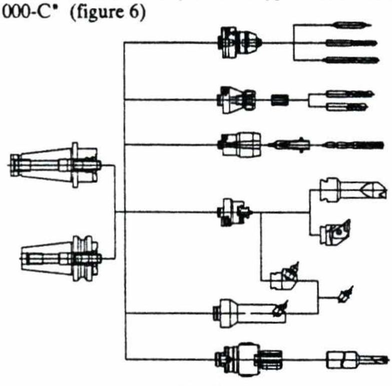


Fig. 6
Graphic display of flexible tool system for typical machining operation on CNC boring milling machine "MAHO 1000-C", according to table 1

2.5. Criterions for choice of flexible tool system

One of basic criterions for choice of these tools is static and dynamic rigidity which must be determined for individual variances of tool element combinations. According to Bibliography [4], figure 7 shows the influence of element combinations of flexible tool system on the static and dynamic rigidity.

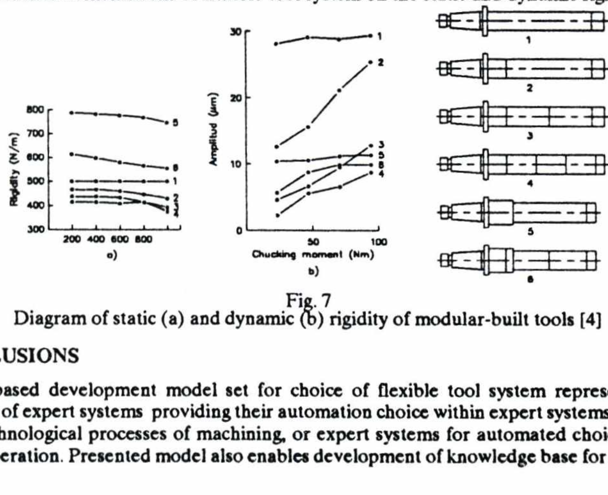


Fig. 7
Diagram of static (a) and dynamic (b) rigidity of modular-built tools [4]

3.0. CONCLUSIONS

Knowledge based development model set for choice of flexible tool system represents basis for development of expert systems providing their automation choice within expert systems for automated design of technological processes of machining, or expert systems for automated choice of tools and regimes of operation. Presented model also enables development of knowledge base for choice of other cutting tools.

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ANALYSIS OF CAPP AND CAM SYSTEMS BASED ON EXPERT SYSTEMS

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1.0 INTRODUCTION

Automated design of technological processes is essential to the computer integrated manufacturing (CIM) as it is a link between product design and manufacturing. In the past, the development of systems for automated design was focused at the computer aided design (CAD) automated part programming for CNC machine tools (SAP) while CAPP has been considered a weak point in the context of integrated information flow [3].

Since 1955, when the system for automated programming (SAP) was first created at MIT (USA), until now, great number of institutions, computer manufacturers, control units and machine tools manufacturers have been involved in the development of SAP. It is difficult to estimate the number of developed systems. Some of them saw practical industrial application, some remained at the level of laboratory research while some have been abandoned.

This paper is aimed at creating the methodology for survey and analysis of the features of the developed CAPP and SAP systems.

2.0 STATE OF THE ART AND FUTURE TRENDS IN DEVELOPMENT OF CAPP AND SAP SYSTEMS

In the last few decades a number of CAPP and SAP have been developed worldwide. The analysis of their features and performances is essential both for users and for researchers who develop such systems. For the researchers the trends in further development are of special interest, as it is not easy to foresee these trends, having in mind the variety of different technologies involved.

Three different development directions can be observed regarding the CAPP and SAP systems [3], [4] (fig. 1). Basic development directions are: development of new and improvement of existing systems, functional integration CAPP and SAP, integration with CAD systems, development of systems for flexible technological structures of higher complexity. It should be noted that at the present intensive work is going on in order to integrate CAD, CAPP and CAM systems.

In recent time there is a trend to design technological processes on the base of expert systems (ES). A number of investigators apply new methods and software tools in the development of CAPP and SAP systems.

Literature survey from the end of the last decade leads to conclusion that expert systems were mostly in the development phase and only a few of them were commercially available. Today, of course, we have quite a different situation.

Intensive development of computer technology lead to higher performances and lower costs of hardware, which spurred on intensive development of CAPP and SAP systems, widening their application in engineering.

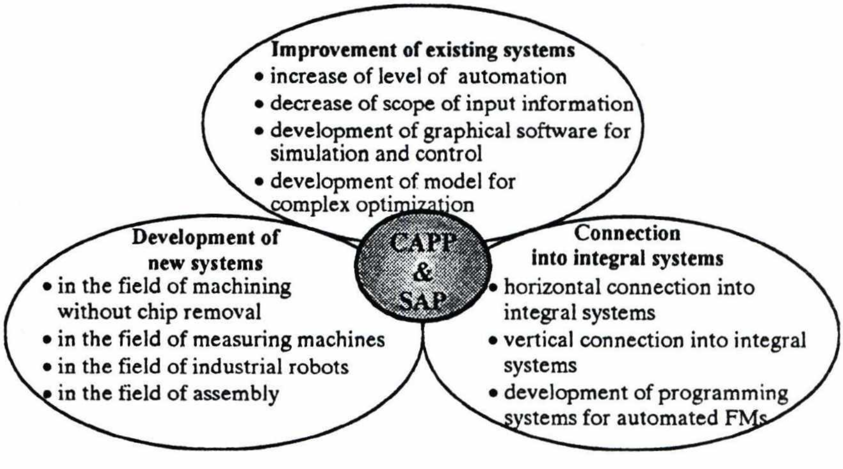


Fig. 1
Development trends of CAPP and SAP systems

3.0 ASSESSMENT METHODOLOGY AND PARTIAL REVIEW OF THE RESULTS

For the assessment of the CAPP and SAP systems based on ES it is necessary to analyze a number of characteristics which are classified in 6 groups. In the first group the basic system characteristics are given. Next 4 groups contain the characteristics of a particular sub-systems and the last group refers to the ES specifics. For some of the characteristics, abbreviations have been introduced which are given in Table 1 for the presentation of the characteristics of the developed CAPP and SAP systems based on ES. The following system characteristics have been analyzed:

a) basic system characteristics
b) sub-system for formatting of input information
c) main computer program - processor
d) technological data-base (knowledge base)
e) sub-system for the adaptation and for forming output information - postprocessor
f) for the systems based on ES following characteristics are of great importance:
  - **knowledge base**: a) knowledge representation: mathematical logic, production rules, semantic nets, frames, object oriented; b) acquisition of new knowledge c) maintaining of knowledge base (adding of rules, ...)

Review of the characteristics of CAPP and SAP systems based on ES

Table 1.

System characteristics \ System designation			EXCAP	GARI	KAPPS	PART
Manufacturer			UMIST-Manchester	Univ. u Grenoblu	Univ. of Kobe	Univ. of Enschede
BASIC CHARACTERIST.	parts spectrum		R	BL	R,P	P
	machining processes		Tu	Dr	Tu, Dr, Mil	Dr, Mil
	level of automation		interactive	interactive	interactive	interactive
	programming techniques		C, AI-L	AI-L	AI-L	C
	user interface		K	K	K	K
	links to other systems	links to	CAD,CAM		CAD,CAM, MRP,DBMS	CAD,MRP, DBMS
		interface	IGES			
	hardware system	hardware	VAX 11/750	CII-Honeywell Bull HB-68	Textronix 440S	VAXstation 2000 i 3000
		operating system	VMS 4.2	MULTICS		VMS
DATA FOR.	Geometry input and input data formatting method		CAD	CGS	CAD	CAD
	Source data input		CAD		CAD	CAD
	Level of integration of technology-related data					
PROCESSOR	Approach to design of technological processes		G	G	G,VG	G
	design of technological information	workpiece definition	+	+	+	+
		definition of basic technological flow		+	+	+
		machine tool selection	+	+	+	+
		fixture selection and clamping definition			+	+
		tools selection			+	+
		definition of sequence of cuts	+	+	+	+
		cutting regime definition	+		+	+
		definition of passes				+
	tool path generation					+
	preesentation of output data		T	T	T	T,Gr
BZ	contents of technological data base					
	knowledge presentation		rules	rules	rules, frames	
	knowledge acquisition					
	maintenance of technological data base					
PP	postprocessor (PP) type					
	user defined PP					
IE	decision logic		BC	BC, CS	CS	
	evaluation		numerical	numerical		
	search method					
UI	reasoning explanation		+			
	help functions		+			
	communication with user					
ES building tool			Pascal Poplog shell	MacLISP	'CommonLISP, Smalltalk-80'	C,Fortran

R - rotational; BL - box - shaped; P - prismatic; K - Keyboard; G - generative;
VG - variant-generative; CGS - complex geometric shapes; T - textual; Gr - graphical;
BC - backward chaining; CS - conflicting sitautions; AI-L - AI programming language;
IE - inference engine, UI - user inference

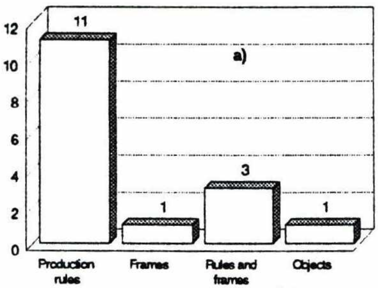
- **inference engine**: a) logic - decision strategy a-1) design of technological processes: forward planning, backward planning; a-2) solution of conflict situations; a-3) experience; a-4) rule sequence; b) assessment - quantification b-1) numerical, binary, heuristics.
- **user interface** a) result explanation, b) help functions, c) communication with user
- **tool for the creation of ES** - implementation

For the assessment and continuous review of the developed CAPP and SAP ES systems the table which is based on the above mentioned characteristics is proposed (Table 1). Table 1 presents partial review of the characteristics of some CAPP and SAP systems based on ES, comprising 23 analyzed systems.

Most of the analyzed systems has been developed for the design of technological processes for the rotational 47,8%, prismatic 21,8%, rotational and prismatic parts 17.4%. Most of them enable application of CAD models as a entrance in the system via standard interface for the connection of CAD and CAPP i.e. CAD and SAP.

Generative approach to the design of technological processes is dominating with most of the systems (91,3%), which generally do not include all phases of the process planning.

Some characteristics of the developed systems based on ES are presented in Figure 2. It should be noted that the decision logic of the systems which apply the rules for the knowledge representation is mostly based on the back chaining.



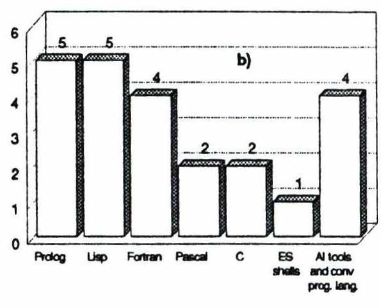


Fig. 2
Comparative review of the characteristics of the developed systems
a) knowledge representation b) tool for the creation of ES

4.0 CONCLUSION

In order to realize development of new CAPP and SAP systems, the analysis presented in this paper should be used as the relevant basis. The objective was to emphasize tendencies in the development of the discussed systems.

Methodology was introduced for the assessment of CAPP and SAP systems with the emphasis on characteristics of the systems based on ES.

The proposed methodology was used for analysis of a larger number of systems with the comparative analysis of certain characteristics which were presented in this paper.

Further efforts should include updating of information on the existing and new systems, based on the proposed methodology.

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A PRACTICAL APPROACH TO BUILDING SCANNER/PARSER MODULE WITHIN STEP POSTPROCESSOR

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1.0 INTRODUCTION

Development of software applications intended for postprocessing of STEP exchange files can be entirely based on the original software solutions or, otherwise, utilize any proprietary software tools for building STEP[1] processors which, in turn, allow greater degree of conformance with the existing solutions.

In either case, the adopted postprocessor architecture dictates all ensuing steps in the realization of software solution, which is why the general structure of STEP processor shall be further examined in some detail.

2.0 STEP PRE/POSTPROCESSOR ARCHITECTURE

Illustrated in Figure 1 is the structure of STEP pre- and postprocessor based on some developed solutions [2]. One can notice that preprocessor and postprocessor share common structure of the *front-end - IDS[2] - back-end* type, while the particular functions of the consisting modules differ with respect to their basic purpose.

The process of product-data exchange begins in the *front-end* module of the preprocessor of CAD system A, where the conversion of geometrical, topological and other entities, from the system- specific to IDS format, takes place. Data within IDS are organized in
C-language *structures* with direct mapping of STEP entities into entities of structures. The only exception to this rule are the attributes coming from the *supertype/subtype* inheritance, where direct mapping is avoided.

By allowing random access within the data base, IDS provides faster and more reliable manipulation of the entities as opposed to sequential structure of the STEP exchange file. To facilitate manipulation with entities within the IDS, each type of STEP entity is assigned three routines for writing, reading and modification, respectively.

The next phase in the data exchange process is carried out within the back-end module of the preprocessor, where the data from IDS is formatted in order

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[1] STandard for the Exchange of Product Model Data
[2] Intermediate Data Structure

to be translated into STEP exchange file, without checking out their semantic correctness.

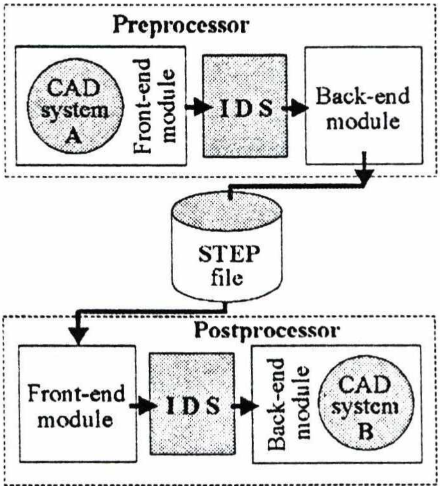

Fig. 1
Basic structure of STEP pre/postprocessor

On the postprocessor side of CAD system B, the *front-end* module performs reading, lexical and syntax analysis of the STEP exchange file, also checking for context-related constraints of the '*where*' type. Finally, the back-end module of the postprocessor performs conversion of the IDS structures into the system-specific format of the receiving CAD system.

Should data exchange between different systems occur, as for instance might be the case between a CAD and a FEM system, there is need to additionally convert different types of models from one type of representation to the other.

2.1 Functions of the postprocessor front-end module

Basic functions of the *front-end* postprocessor module can be broken down into

- definition of neutral data structure (IDS) as well as routines for installing, accessing and modification of STEP definition instances, according to the appropriate application protocol (AP)
- definition and analysis of rules for formatting of physical STEP file, i.e. definition of the grammar which is based on the particular AP

- checking against the context-related constraints for certain data types (the so called '*where*' constraints)

The following part of this paper shall deal in some detail with the problems related to definition and check-out of grammar of the STEP exchange file with emphasis on the practical realization of scanner and parser routines.

3.0 REALIZATION OF SCANNER/PARSER MODULE

STEP exchange file is of a sequential type, with the data stored in free-format. The file also contains modules or sections, which are designated as the *data* and *header* sections. File structure is defined by the unique context-free grammar in order to allow efficient parsing by use of computer. The grammar is specified in Wirth Syntax Notation (WSN), whose detailed description is given in [3].

The scanner and parser programs are generated using *Lex* and *Yacc* as the most widely used token and grammar specification languages found in the UNIX environment.

3.1 Realization of scanning functions

Since the STEP exchange file, in general, consists of a sequence of pre-defined tokens, the scanner routine has to recognize them and, according to their specific meaning, generate the appropriate action. It is, therefore, necessary to translate STEP tokens from WSN to *Lex* notation. Figure 2 illustrates how this translation was done for STEP tokens *integer, real, standard_keyword* and *enumeration* .

```
INTEGER = [ SIGN ] DIGIT { DIGIT }
[+\-]?[0-9]+

REAL = [SIGN]DIGIT{DIGIT}"."{DIGIT}["E"[SIGN]DIGIT{DIGIT}].
[+\-]?[0-9]+\.[0-9]+?"E"[+\-]?[0-9]+

STANDARD_KEYWORD = UPPER { UPPER | DIGIT }.
[A-Z]+[A-Z0-9]+?

ENUMERATION = "." UPPER [ UPPER | DIGIT ] "."
"." [A-Z] [A-Z0-9]?+"."
```

Fig.2
Translation of STEP tokens from WSN to Lex specification

Based on the source code, *Lex* compiler generates C code which has to be compiled in order to generate the program for lexical analysis, i.e. the STEP scanner.

3.2 Realization of parsing functions

Based on the lexical analysis, i.e. scanning of the STEP exchange file, it is possible to define modules for syntax analysis, i.e. parsing. As has been mentioned earlier, the parser routine is generated using *Yacc* as the parser generator. Similar to the process of lexical analysis, a process of translation of a STEP grammar rule into *Yacc* specification is illustrated below for application protocol AP 204 (B-rep models):

edge : TOKEN_EDGE TOKEN_LP TOKEN_REF TOKEN_COM TOKEN REF TOKEN_COM TOKEN_REF TOKEN_COM TOKEN_RP
{ C language code which is executed in case the program has recognized the defined STEP token}

According to the AP 204 grammar [5], topological entity *edge* must contain token *edge* , followed by the following sequence: left parenthesis, a reference to an edge start, a comma, a reference to an edge end, a comma, a reference to an edge curve, and finally, right parenthesis. Compilation of *Yacc* source code produces C code, which has to be compiled and linked with *Yacc* library in order to produce an executive version of AP 204 - compatible parser.

3.3 Modular structure of the scanner/parser

The structure of scanner/parser module is defined according to basic assumptions that the solution should allow modular development while at the same time avoid build-up of a massive grammar which would impede the operative efficiency of the code as well as its maintenance.

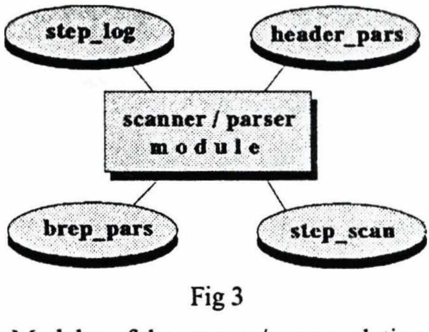

Fig 3

Modules of the scanner/parser solution

In keeping with these assumptions, the software solution has modular structure which is shown in Figure 3.

File *step_log* contains routines which allow the results of scanning and parsing sessions to be written for later examination. Routines within *step_scan* contain definitions of basic STEP tokens which are used for scanning purposes, while *header_pars* comprises tokens necessary to parse the STEP exchange file header-section, which is not related to any specific application protocol. Finally, *brep_pars* contains grammar definitions based on AP 204.

The module was realized and tested on the PC-compatible configuration (AMD 486/40, 8Mb RAM) running operating system *WGS Linux - RedHat (R 3.0)*.

4.0 CONCLUDING REMARKS

Modular building of STEP postprocessor is based on the *front-end - IDS - back-end* structure, defined in [2]. By emphasizing the logical structure of the postprocessor, i.e. the modular approach to solving this problem, a simplified realization of programming tasks as well as the more efficient code maintenance are supported. Application of standard software tools for the tasks of syntax and lexical analysis simplifies and accelerates generation of the necessary routines.

Based on the discussed modular structure of the scanner/parser, it is possible to expand grammar to accommodate application protocols other then AP 204, without any major reworking of the existing code.

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FERTIGUNGSMÖGLICHKEITEN VON ELEMENTEN MIT VARIABEL VERÄNDERLICHEN MECHANISMEN IN BEZUG AUF DIE MÖGLICHKEITEN DER FERTIGUNG MIT CNC-MASCHINEN

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EINFÜHRUNG

Oft auftretende Aufgaben während jedes Fertigungsprozeßes sind Einteilung und Wechsel. Deshalb ist es wichtig, daß wir die Konstruktionsmethoden der Antriebsglieder der herzustellenden Nockenmechanismen und die statischen und dynamischen Eigenschaften dieser Mechanismen untersuchen. Eine immer größere Rolle spielten im letzten Jahrzehnt, die Analyse der dynamischen Einwirkungen bei der Anwendung der sich schnell bewegenden Mechanismen. Der Erhöhung der Schnelligkeit bei Wechselprozessen setzen das Steigen der Massenkräfte und der dynamischen Wirkungen eine Grenze. Es ist daher zweckmäßig, in besonderen Fällen, die Beschleunigungsverhältnisse der Mechanismen vorzuschreiben und ihnen die ableitbaren Verschiebungsverhältnisse zuzuordnen [1]. Die sich daraus ergebende Aufgabe für die Konstruktion und Fertigung ist deshalb die Aufgabe, der Konstruktion und Fertigung der Nockenkörper der Mechanismen, die die vorgeschriebene foronomische Kurve verwirklichen.

Während der Fertigung müssen die früher durch Konstruktion oder Berechnungen bestimmten Nockenkörper mit ihren festgelegten Maßen und mit Hilfe von dafür geeigneten Fertigungsmitteln hergestellt werden. Diesen spanabhebenden Vorgang können wir als einen besonderen ansehen, da nicht nur Gerade- oder Kreis-Grenzlinien bearbeitet werden müssen, sondern auch Varianten mit besonderen Kurven. Während dieser Bearbeitung treten ungleichmäßige Verhältnisse bei der Spanabhebung auf. Die Nockenkörper wurden bisher mit traditionellen Fertigungszeugen nach auf Kopiermaschienen angefertigten Schablonen hergestellt. Die direkte Bearbeitung kann mit modernen CNC Fräs- und Schleifmaschinen erfolgen. Hierbei kann die Geometrie der Nockenkörper durch eine entsprechende große Zahl von Punkten bzw. durch Ausrechnen ihrer Koordinaten vorgegeben werden. Die weiteren Untersuchungen und Betrachtungen setzen einen derartigen Fertigungshintergrund voraus.

HERSTELLUNGSKONZEPTION

Die weiteren Untersuchungen stellen wir unter Anwendung der Angaben, einer während einer früheren Konstruktionsarbeit [2] konstruierten Steuerscheibe, zum Zweck der besseren Darstellung dar. Bei der Formulierung der Herstellungskonzeption müssen wir die Tatsache berücksichtigen, daß die meisten CNC-Steuerungen nur Möglichkeiten der Linear- und der Kreis-Interpolation besitzen. Am Lehrstuhl für Werkzeugmaschinen steht jedoch eine CNC-Schleifmaschine unter der Entwicklung, in der auf Grund einer geregelten Kreis- und geregelten Linear-Bewegung verschiedene Spiralen bearbeitet werden können. So liegt es nahe, wenn wir uns bei der Bearbeitung, die durch eine Spirale begrenzte Steuerscheibe, und auch die Produktivität vor Auge halten, kann durch Fräsen und als letzten Arbeitsgang durch Schleifen, eine geometrisch auch entsprechende Arbeitskurve erreicht werden.

Die Vorbearbeitung der herzustellenden Kurvenfläche kann mittels Fräsen ausgeführt werden, sowohl mit linearer Interpolation zwischen jeweils zwei während der Konstruktion bestimmten Punkten, als auch durch eine Kreisinterpolation zwischen geeignet ausgewählten Punkten. Im ersten Fall tritt das Problem auf, daß die hergestellte Fläche praktisch eine vieleckige Fläche ist. Zu selten angegebene Oberflächenpunkte verschlechtern in großem Maße die Annäherung an die geometrische Genauigkeit, zu dicht aufgenommene Punkte erhöhen jedoch bedeutend die Prozeßzeit [3]. Eine erfolgversprechende Lösung bedeutet ein solcher Weg, bei dem wir die anzunähernde Fläche mit einer Reihe der Kreisinterpolation herstellen, daß heißt, mit vielen Kreisen annähern. Im weiteren werden wir diesen Weg verfolgen.

DIE BERECHNUNG DER GEOMETRIE DER THEORETISCHEN UND ANGENÄHERTEN STEUERSCHEIBE

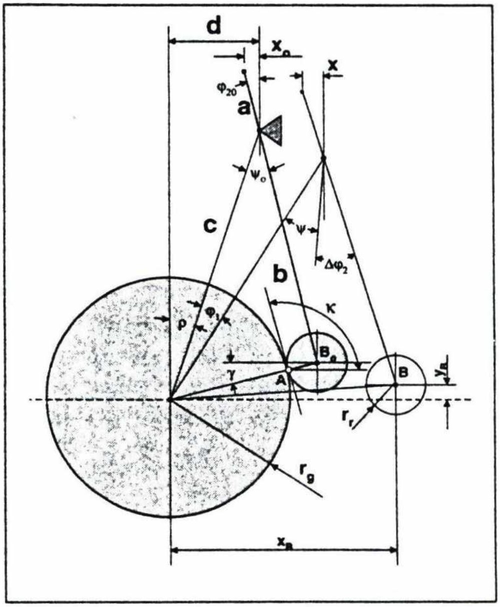


Abb. 1

Abb. 1 zeigt das kinematische Schema des als Beispiel ausgewählten Mechanismus. Der Nockenkörper muß im Abschnitt der Vorwärtsbewegung (I.) über eine große Hebelübersetzung (b/a) einen Vorschub mit kleinem Hub und konstanter Geschwindigkeit (x) absichern. Diese Bedingung wird von solch einer Steuerscheibe erfüllt, bei der auf den Grundkreis mit dem Radius r_g eine archimedische Spirale superponiert wird. Beim Rückwärtsgang (II.) kann die Charakteristik der Bewegung nicht bestimmt werden, daher ist es in diesem Fall wichtig, eine günstige Bahnkurve auszuwählen.

Unter Berücksichtigung, daß $\varphi_2=\varphi_{20}+\Delta\varphi_2$ ist, die Gleichung der Bahn des Rollen-mittelpunktes gemäß Abbildung 1 ist, erhalten wir die folgenden Gleichungen:

I. Abschnitt ($0\leq\varphi_1\leq 3\pi/2$):

$$x_B = c\cdot\sin(\varphi_1+\rho)+b\cdot\sin(\varphi_2-\varphi_1), \tag{1}$$

$$y_B = c\cdot\cos(\varphi_1+\rho)-b\cdot\cos(\varphi_2-\varphi_1); \tag{2}$$

II. Abschnitt ($3\pi/2\leq\varphi_1\leq 2\pi$):

$$x_B = r_{B\max}\cdot\cos\varphi_1-\frac{H}{2\pi-\varphi_{1n}}(\varphi_1-\varphi_{1n})\cdot\cos\varphi_1+\frac{H}{2\pi}\cdot\sin\left(\frac{\varphi_1-\varphi_{1n}}{2\pi-\varphi_{1n}}\right)\cdot\cos\varphi_1, \tag{3}$$

$$y_B = r_{B\max}\cdot\sin\varphi_1-\frac{H}{2\pi-\varphi_{1n}}(\varphi_1-\varphi_{1n})\cdot\sin\varphi_1+\frac{H}{2\pi}\cdot\sin\left(\frac{\varphi_1-\varphi_{1n}}{2\pi-\varphi_{1n}}\right)\cdot\sin\varphi_1. \tag{4}$$

Auf Grund der Gleichung [4] der Arbeitsfläche bezieht sich das Folgende auf die gesamte Scheibe:

$$x_A = x_B - r_r \cdot \cos\gamma, \qquad (5)$$

$$y_A = y_B - r_r \cdot \sin\gamma. \qquad (6)$$

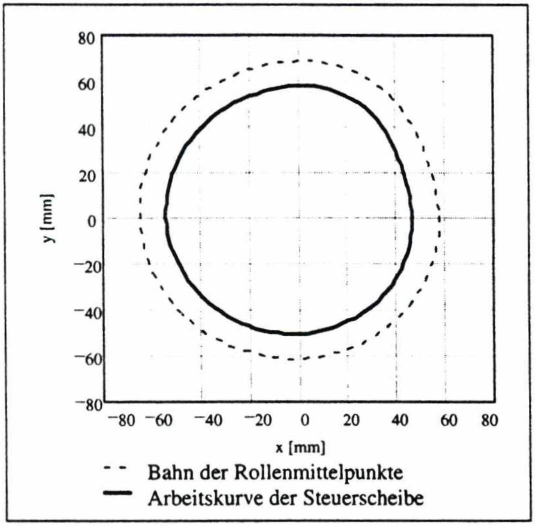


Abb. 2

Abbildung 2 zeigt die auf diese Weise bestimmte Ortskurve des Rollen-mittelpunktes und die Arbeitskurve.

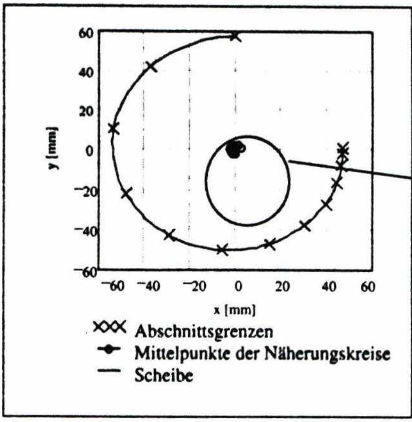
Die folgende Frage: wie dicht berechnen wir die Punkte des Nockenkörpers, wenn wir die theoretische Arbeitskurve mit einer Kreismenge ersetzen, um als Ergebnis der Fertigung, einen umso glatteren Kurvengang bei der Annäherung zu bekommen.

Im ersten Schritt haben wir die Arbeitskurve gleichmäßig aufgeteilt und an die Punktreihe Kreise angepaßt. Die erste Tangente ist bekannt, so daß der Mittelpunkt des durch die ersten zwei Punkte gehenden Näherungskreises gesucht werden kann. In den weiteren Schritten jedoch können wir auf der Grundlage der Endtangente und dem nächsten Punkt die Mittelpunkte berechnen. Als Ergebnis der Berechnungen haben wir die Erfahrung gemacht, daß bei dieser Verteilung und neben der relativ hohen Teilungsdichte, Sehnehalbierenden auseinandergehen und sich so die Mittelpunkte der aufeinanderfolgenden, sich nähernden Kreise wechselnd an zwei Seiten der theoretischen Kurve anordnen, daß heißt, wir bekommen eine wellenförmiges Arbeitsoberfläche. Deshalb mußten wir nach einem anderen Weg suchen.

Nachdem wir die Eigenschaften der Steuerkurve untersucht haben, sah eine solche Lösung als erfolgreich aus, bei der wir den gesamten Winkelbereich nicht gleichmäßig aufgeteilt haben, sondern mit steigenden Teilungen. Unter den in Frage kommenden Lösungen, gelang es eine solche steigende Gesetzmäßigkeit auszuwählen, bei der sehr gute Annäherungen zu erreichen sind. Der j-te Punkt (j=0, 1, 2, ...) der neuen Verteilung mit den steigenden Teilstücken ergibt sich aus jedem i-ten Punkt der ursprünglichen gleichmäßigen Aufteilung, für den der folgende Zusammenhang gilt:

$$i = \sum_{k=0}^{j} k. \qquad (7)$$

Nachdem wir die Mittelpunkte und die Radien der annähernden Kreise nach dieser Aufteilung bestimmt haben, stellte es sich heraus, daß die Anordnung der Mittelpunkte der Kurve regelmäßig waren, wie das in Abbildung 3 zu sehen ist. In diesem Fall weisen die Krümmungsradien nur in kleinem Maße voneinander ab, und ihre Änderungen waren ausgeglichen, was aus dynamischen Gesichtspunkt als günstig zu bezeichnen ist. (Abb. 4).



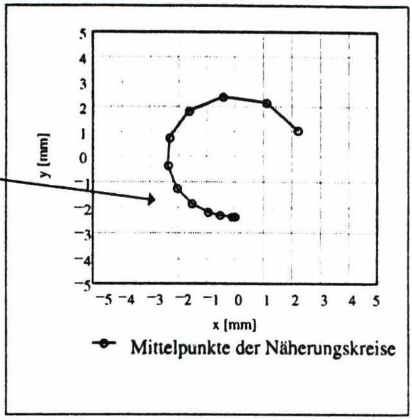


Abb. 3

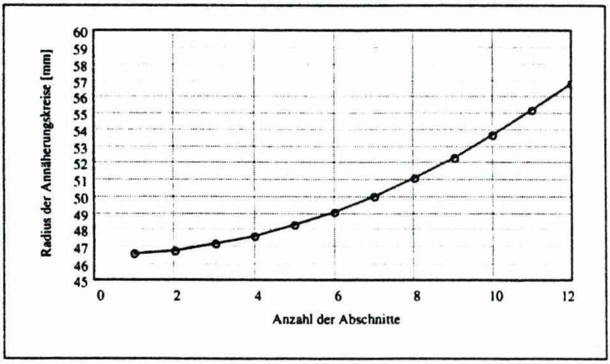


Abb. 4

ANALYSE DER FEHLER DER ANNÄHERUNG

Die Richtigkeit der Annäherung können wir auf Grund der zahlenmäßigen Auswertung der Fehler einschätzen. Wir können voraussetzen, daß sich die größten Abweichungen der Arbeitskurve zwischen den theoretischen und den wirklichen Steuerscheiben aus der Umgebung der Sehnenhalbierenden ergeben. Hieraus resultiert, daß wir die Entfernung zwischen der Näherungskurve und der theorethischen Kurve in der Umgebung der Sehnenhalbierenden durch Veränderung der Zahl der Teilpunkte bestimmt haben. Danach haben wir die Grenzwerte der Fehler, die sich in den einzelnen Fällen ergeben, in Abhängigkeit von der Zahl der Teilpunkte aufgezeichnet.

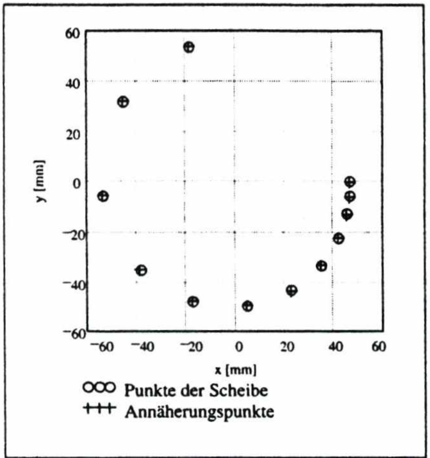


Abb.5

Auf Grund dieser Berechnungen können wir die folgenden Feststellungen machen:

- bei der Anwendung einer sehr kleinen Zahl von Näherungskreisen ergeben sich Abweichungen in höherem Maße,
- erhöhen wir die Zahl der Näherungskreise, verringert sich der Fehler,
- diese Verringerung setzt sich nach einer Grenze nicht mehr fort, und so kann eine minimale Teilzahl angegeben werden, bei der eine dichtere Teilung keine qualitäts-mäßige Veränderung mehr bedeutet,
- bereits bei einer relativ kleinen Zahl von Annäherungskreisen können wir spüren, daß die theoretischen und die Annäherungspunkte der Scheibe gut übereinstimmen.

Abbildung 5 zeigt, daß gute Übereinstimmen der theoretischen und Annäherungspunkte der Scheibe bei 9 Annäherungskreisen.

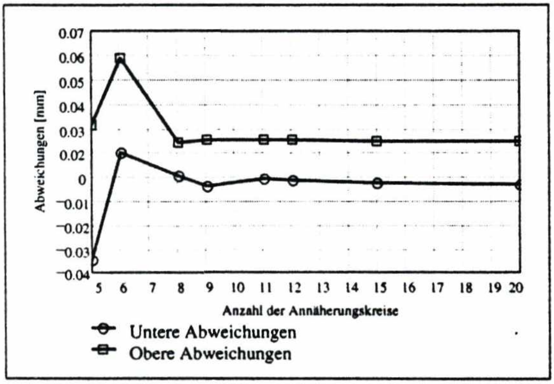


Abb. 6

In Abbildung 6 sehen wir die Veränderung der Maxima der Fehler in Abhängigkeit von der Zahl der Teilpunkte. Nach Einführung einer sehr kleinen Zahl von Kreisinterpolationen sind die Fehlerwerte bereits so klein, daß die sich hieraus ergebenden Schlichtaufmaßschwankungen, die geometrisch genaue abschließende Bearbeitung nicht stören.

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FLEXIBLE PROCESS PLANNING AND FLEXIBLE MANUFACTURING SYSTEMS

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1. INTRODUCTION

Manufacturing paradigms are continuously changing due to the diversified customer needs. In this respect, the need for automation and flexibility restructures the nature of production and its management. Capability to respond more rapidly to dynamic changes both in demand and product mix motivates the implementation of Flexible Manufacturing Systems (FMSs). The dynamic manufacturing environment of FMS requires continuous monitoring of the production activities and to respond effectively to the unexpected events such as breakdowns, tool breakage, lack of material, rush orders, bottleneck machine tools, and so on. Traditional process planning includes the determination of the "specific" machine tools and cutting tools to perform a set of manufacturing activities on the shop floor. In this respect, traditional process plans (TPPs) are "linear" in the way each operation is sequenced one after another having single predecessor and successor [1]. The lack of flexibility does not allow the effective management of the unpredictable events on the shop floor. In this respect, flexible process planning plays an important role to provide "alternatives" to be considered in avoiding undesired events in the FMS environment.

2. FLEXIBLE PROCESS PLANNING

Flexible process planning (Non-Linear Process Planning) represents alternatives in terms of operation sequences, process alternatives, machine tool preferences and tooling requirements. Hutchinson and Pflughoeft [2] define three classes of process plan flexibility.

They are as follows:

1. Sequence flexibility occurs when an operation can have more than one predecessor or successor.
2. Process flexibility provides alternative paths for the completion of the plan.
3. Machine tool flexibility provides a choice of a machine tool type to perform the operation rather than dictating a specific machine tool.

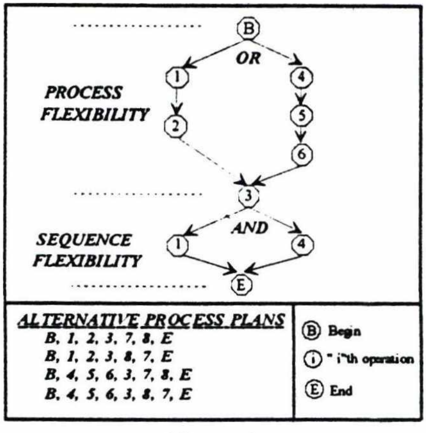

Figure 1.
Sequence and Process Flexibilities

As shown in Figure 1., "And" branching provides "sequence flexibility". sequence flexibility requires all operations to be performed and must incorporate all technological constraints, but allows choices in the "order " in which they are realized. "Or" branching provides "process flexibility" . Although TPPs dictate the specific machine tool for each operation at each node, flexible process plans only specify the machine tool type, thus a choice among the "alternative machine tools", so-called "machine tool flexibility", on the shop floor is available. In addition to the inherent flexibility types shown in Figure 1., this paper suggests to include "alternative cutting tools" for each operation. As the FMS environment inherits the inter-dependency among the part-tool-machine requirements, an operation can not be performed unless the part type, the right machine tool and the right cutting tool meet at the right time. By considering alternative cutting tools, operations can be allocated to the machine tools more efficiently regarding the corresponding tool magazine capacity, thus an appropriate tool management policy can be adapted.

In the study presented by Lin [3], a flexible process planning format which is similar to the one presented by Hutchinson and Pflughoeft [2], is given. Based on the definition of Lin [3], Ho and Moodie [4] investigate cell formation problems in FMS with flexible routing and processing capabilities.

The readers are recommended to refer the studies of Browne et al. [5], Barad and Sipper [6], and Brill and Mandelbaum [7] for a detailed review on types of flexibility and FMS.

3.REVIEW OF LITERATURE

It is not the aim of the current study to present a comprehensive survey on CAPP systems, but rather to emphasize the importance of flexible process planning approach based on the requirements of the FMS environment. Due to this fact, several studies are presented in the following sections of this paper. For an exhaustive survey on CAPP systems, it is suggested to refer to the study of Alting and Zhang [8].

Hou and Wang [9] investigate the integration of a CAPP system and an FMS involving (1) the development of a variant CAPP system, (2) its integration in an FMS and (3) the evaluation of the impact of alternate routing and/or alternate machines on the performance of FMS. Hou and Wang state that bottlenecks on the shop floor may be avoided if the CAPP system is able to provide several alternate process plans for the FMS controller. Kruth and Detand [10] model a flexible process planning (non-linear process planning) format by using Petri nets. Similar to the existing studies in the related literature, they also state that the use of FPPs increases the flexibility in the scheduling activities and allow to remedy quickly to disturbances on the shop floor. In their study, the process plans are modelled in a network-like structure where each node corresponds to an operation. The network-like structure provides operation-sequencing flexibility but does not contain any information about alternative machine tools and other tooling requirements. In a similar manner, Lee and Jung [11] present a methodology for flexible process planning using Petri nets. In their paper, a Petri net is used as a unified framework for both operation planning and plan representation. Their methodology comprises (1) modelling operation selection and sequencing knowledge using the Petri net framework, and (2) representing a flexible sequence of operations. Emphasizing the importance of process planning being the principal input to a shop floor control system, Cho et al. [12] and Lee at al. [13] present studies on the integration aspects of process planning and shop floor control. Both studies focus on the necessity to provide the shop floor control system with dynamic process plans involving alternatives in terms of operations, machines, machining sequences, and tooling requirements. It is concluded that by providing alternatives in shop floor decision making, shop floor control system can remain "flexible" and improve system performance. Zhang [14] states the importance of integration of process planning and scheduling. He points out the lack of integration in the process planning and scheduling systems. The proposed CAPP system prepares alternative process plans. All these process plans are then ranked according to process planning criteria. The first priority process plan is always ready for submission to the shop floor. When the first priority process plan is not suitable as regards real-time scheduling activities, then the second plan is provided. with alternatives by considering the status of the shop floor. Liao et al. [15] present a new approach through the modification of an existing CAPP system for achieving CAPP/Scheduling integration. Highlighting the importance of "alternatives" on the shop floor, Liao et al. state that none of the existing CAPP systems takes into account the shop floor conditions while developing the process plans. Thus, the process plans are not completely followed on the shop floor. In their paper, Liao et al. focus on selecting the best machine tool from all the alternatives in the process planning stage. In their paper, Jasthi et al. [16] discuss the need for modelling the process plan, and propose a framework for process plan internal representation for the effective integration of CAPP and CAM functions. Jasthi et al. emphasize the importance of being able to generate and evaluate "alternative plans".

4. CONCLUSION

In the framework of FMS, CAPP draws the border of planning and control functions. Since a process plan provides the principal input to a production planning and control system, it is necessary to provide the process plan information in a manner suitable for use on the shop floor. In this respect, FPPs play a vital role. As the result of sequence, process and machine tool flexibilities, alternative routing concept can be used to avoid bottleneck machines, reduce machine queues and thus balance machine utilization. If multiple routes are identified for manufacturing a part type, then the route that is most suitable for a particular status of the manufacturing system can be used. Similar approach is valid for tool management in FMS. In case of determining alternative cutting tools for each operation, common tools among the alternatives can easily be determined for the operations to be performed on the same machine tool, thus tool magazine capacity can effectively be utilized. As flexible process plans reduce the work-in-process inventory, increase machine tool utilization and reduce flowtime, they enhance the performance of FMSs. The inherent dynamic nature of flexible process plans allows dynamic process selection taking into account the current manufacturing system status ensuring the ability to generate alternative and feasible plans using different routes and cutting tools.

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ON COMPUTER AIDED PROCESS PLANNING OF PRISMATIC PARTS

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1. INTRODUCTION

Process planning is one of the most important features in a typical CIM environment. Computer Aided Process Planning (CAPP) is defined as the application of computers to assist process planners in the planning function. In its most advanced state, it establishes the crucial link between CAD and CAM functions [1]. Two approaches to computer aided process planning are traditionally recognized, the variant approach and the generative approach. However, with the rapid development of new techniques, many CAPP systems do not exactly fit in this classification and combine both approaches [2]. In this paper, attention is focused on generative process planning which is simply the generative approach is the logical creation of process plan from information available in a manufacturing database with little or no intervention by the planner [3]. Tremendous efforts have been made on CAPP systems since Niebel first highlighted the practical aspects of using computers in process planning tasks in 1965. With the rapid advances in computer technology since then, more than 250 papers have been published in this area. For an exhaustive survey on CAPP, it is suggested to refer the study of L. Alting and H. Zhang [2].

2. FEATURE RECOGNITION

Feature recognition is the task of determining the features of a part from a given geometric description. Considerable research has been conducted in the area of CAD databases for Computer Aided Manufacturing (CAM) and Computer Aided Process Planning (CAPP) related studies. However, the feature recognition process is complex and there are some severe problems. In particular, the features that can be extracted are limited to a small number of form features and the definitions of features is not precise. In general terms, features can be considered as a way of classifying particular sets of geometric entities into higher level representations that have some meaning for activities beyond those of geometric specification [4]. The definition of a feature depends on the specific application. Design information associated with the component design can be classified into three groups [5,6], namely Geometric Forms, Topological Relations and Technological Attributes. For example simple mechanical parts can be described by a set of features such as hole, slot and pocket and each of these features can be associated with manufacturing attributes such as tolerance, surface finish and material.

Feature based design, which is a recent advance in evolution of CAD differs substantially from previous CAD techniques. A CAD model might be capable of completely describing the geometry of a mechanical part, but it requires enhanced information beyond that available in the CAD database. Feature technology enhances the determination of the alternative part representations for wider applications throughout product's design and production processes.

All process planning algorithms are initialized by the description of the part that the process plan is to be established for. The input format of this description draws the borders of the effectiveness of the process planning system. Input can be achieved in three ways [4]:

Code Type: The use of GT methods for coding and classifying components requires a high degree of manipulation and translation of a part. Numerous GT software packages, having their internal data storage, have limited capability for integration with other engineering databases [4,7].

Descriptive Language: The description of a part must be prepared by a human operator. The main drawback of this system is that much effort is needed for part description [4,7].

CAD Data: CAD systems for geometric modelling have gained much more importance in recent engineering analyses. However, research on applying CAD data is still incomplete since CAD data are not directly usable for process planning. CAD data files must be transformed into suitable formats to serve as an input to process planning systems. The transformation process requires two main stages that is (1) translation of CAD data to neutral data interchange formats such as IGES, PDES/STEP and DXF and (2) recognition of neutral data related to machining [4,7,8].

3. FEATURE RECOGNITION OF PRISMATIC PARTS

As it is mentioned in the previous sections of this paper, there are several successful examples of feature recognition models and process planning systems for rotational parts. However, most reported studies emphasize that there are certain difficulties in implementing generative CAPP systems for prismatic parts. The reason for the absence of applicable and effective CAPP systems for prismatic parts is actually the difficulty encountered at the feature recognition stage of prismatic parts.

In feature recognition of rotational parts, cylinders, tapers, arcs; internal holes, off axis holes, grooves and chamfers are the basic external and internal profiles that can be distinguished. Speaking for a generative CAPP system, recognition of these features requires 2-D reasoning using the symmetry of rotational parts across its centerline. While turning is the main machining process for rotational parts, the machining of prismatic parts requires different processes like milling, drilling, grinding and so on [2,6].

In the literature there are several examples of feature extraction and recognition shells. Shah and Rogers [9] developed an expert form modelling shell. Juri, Saia, and Pennington [10] used feature based approach to support product definition of an intelligent planning system. Chang [11] proposed a feature based design and process planning system using a solid modeller. Some researchers have developed algorithms for the extraction of features from a CAD database. Stanley, Henderson and Anderson [12] developed an approach using syntactic pattern recognition to extract product data from a CAD database. Syntactic pattern recognition is applied to the classification of holes from 2-D cross sectional descriptions extracted from a 3-D solid model geometric database. Gulesin and Jones [13] introduced another part module description scheme called FONG (Face Oriented Neighbouring Graph). FONG enables the part models to have more explicit information- angles, neighbouring and convexity-concavity relationship between faces, etc., including vertex and edge information in a compact and ready form which is necessary for operation selection. The task of feature recognition of prismatic parts requires 3D reasoning. Related literature reveals the fact that problems related to 3D reasoning are not simple compared to 2D problems due to difficulties in handling space curves and surfaces. Literature includes several studies in the scope of CAD/CAPP integration. Constructive Solid Geometry (CSG) [7], Syntactic Pattern Recognition (SPR) [12], Feature Grammar [14] and Attributed Adjacency Graph [15] are some of these well-known approaches.

4. A FRAMEWORK FOR METUCIM

The proposed framework to be realized in the Pilot CIM System, namely METUCIM, in the Mechanical Engineering Department of the Middle East Technical University includes feature-based part geometry definition and an object-oriented methodology coupled with a rule-based decision support system to generate process plans. In this study, features include three main attribute classes. They are as follows:

Geometrical Data: Includes data related to the dimensions of the feature like length, diameter, and so on.

Technological Data: Data like tolerance, surface roughness, etc. are included in this attribute class.

Manufacturing Process Data: This section provides a list of alternative processes and tools which can be used for generating the related feature.

In the proposed framework, human intervention, to reach a "realistic" process plan, is of critical importance. Planner selects the general form of the blank material and inputs the relevant dimensions. By using the feature library, the features are placed (extracted and/or added) on the blank material by defining their corresponding locations. Upon completing the product definition, a list of "probable" processes and tools related to all the features on the part are automatically selected. This stage is followed by the selection of the appropriate processes and tools among the alternatives and the sequencing among them by considering location, geometry and other data of the features based on the rules in the rulebase. The location and geometry of features on the blank material necessitate a global look on the features to make the process and tool selection instead of considering each feature on its own. The expertise is stored in the form of rules. During this inferencing stage, human planner keeps the control of the selection process and guides the generation of the process plan as shown in Figure 1.

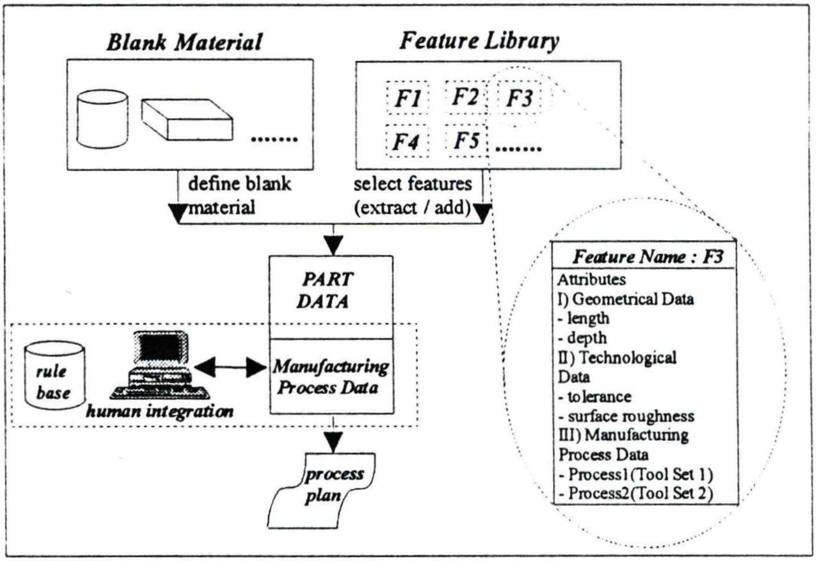

Figure 1.
Proposed Framework for METUCIM

5. CONCLUSION

In this study, the difficulty encountered at the feature recognition stage of the non-rotational parts, which is the main reason for the absence of "realistic" CAPP systems, is pointed out based on several studies in the literature. A framework to be realized in the Pilot CIM System, namely METUCIM, in the Mechanical Engineering Department of the Middle East Technical University is proposed. The authors of the current study believe that the difficulty mentioned above can be avoided to some extent by an effective integration of human planners in the process planning stage. In addition, it also seems essential to provide some kind of "expert knowledge" to the human planner during process planning where AI techniques can be effective. The problems during feature recognition stage can be alleviated by using a feature-based approach where the planner inputs the related data about the features based on a pre-determined feature family. On the other hand, this approach does not seem practical for complicated features.

The difficulty in realizing the proposed in realizing the proposed framework for METUCIM is mainly due to the design of the rulebase to be used for making the selection, and further sequencing, among the several probable processes and tools. At laboratory scale, it seems possible to carry out an approach based on a pre-determined feature library and to make the inferencing about the processes and tools via rulebase which, in the end, will be limited to the capabilities of the pilot CIM system.

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AutoWORM

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1. INTRODUCTION

The advanced gear design and manufacturing are based now on: computerised simulation of meshing and contact of gear tooth surfaces, application of computer controlled machines for gear manufacture and computerised inspection of gear tooth surfaces by coordinate measurements [2]. Simulation allows the evaluation of the meshing even in the design stage. Manufacture and measuring should provide and confirm/ascertain the setting of the contact localisation required by the design.

Litvin defined the purpose of contact localisation at cylindrical worm gears so: getting improper contact areas out of mesh; reducing the time of load running-in; reducing the influence of machining errors, that eliminated the edge contact and reducing the variation of the transmission ratio [3]. AutoWORM achieve the contact localisation by means of three main parameters: profile correction at worm/hob; the hob diameter increase; position of the main point.

AutoWORM is a program developed in AutoCAD Release 12 environment, for computerised simulation of meshing and contact of unloaded worm gear drives. AutoWORM can be used to determine the transmission errors of the gear drive, the paths of contact points on the pinion-gear tooth surfaces, the dimensions and orientation of the instantaneous contact traces, and the shift of the contact traces caused by misalignment (the change of shaft angle, the centre distance and the gear axial displacement).

2. ITINERARY OF DESIGNING

AutoWORM is made up from 4 basic modules: *Worm, Wheel, Tooth contact analysis* and *Final results* (fig. 1). The concatenation of these modules suggests the itinerary in the design of a worm gear pair.

The *Worm* allows the definition and computing of the worm. The worm is generated with a double conical disk cutter. The considered disk has an elliptical axial profile, which can degenerate into circle or straight line. The elliptical form offers practical solutions to the modification of the axial profile of the disk, in agreement with possibilities of settings on classical or computer controlled machines. The main result of this module is the worm represented by an bicubical spline surface.

The *Wheel* allows the definition and computing of the worm wheel. The wheel is generated with a hob. The hob is increased as compared to the worm. The

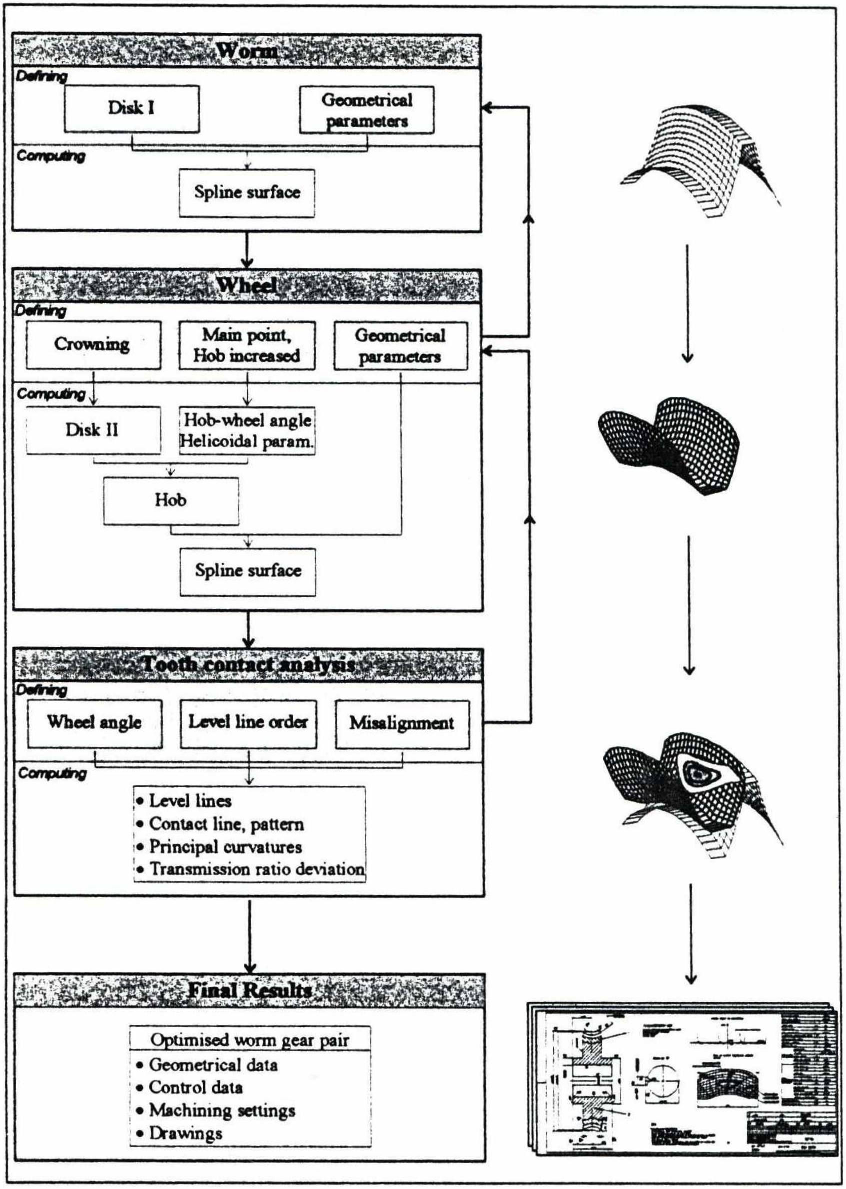

Worm
Defining
Disk I
Geometrical parameters
Computing
Spline surface
Wheel
Defining
Crowning
Main point, Hob increased
Geometrical parameters
Computing
Disk II
Hob-wheel angle
Helicoidal param.
Hob
Spline surface
Tooth contact analysis
Defining
Wheel angle
Level line order
Misalignment
Computing
• Level lines
• Contact line, pattern
• Principal curvatures
• Transmission ratio deviation
Final Results
Optimised worm gear pair
• Geometrical data
• Control data
• Machining settings
• Drawings

Fig. 1

computing of the hob has in view its geometrical, position and profile determination. Starting from the reference diameter it is computed the helicoidal parameter of the hob and the inclination angle at processing the wheel, which thus provides the accomplishment of the main point and of the normal in the imposed main point. The profile of the hob results from the processing with a disk differently profiled when compared to that which processes the worm. The main result of this module is the worm wheel represented by an spline surfaces.

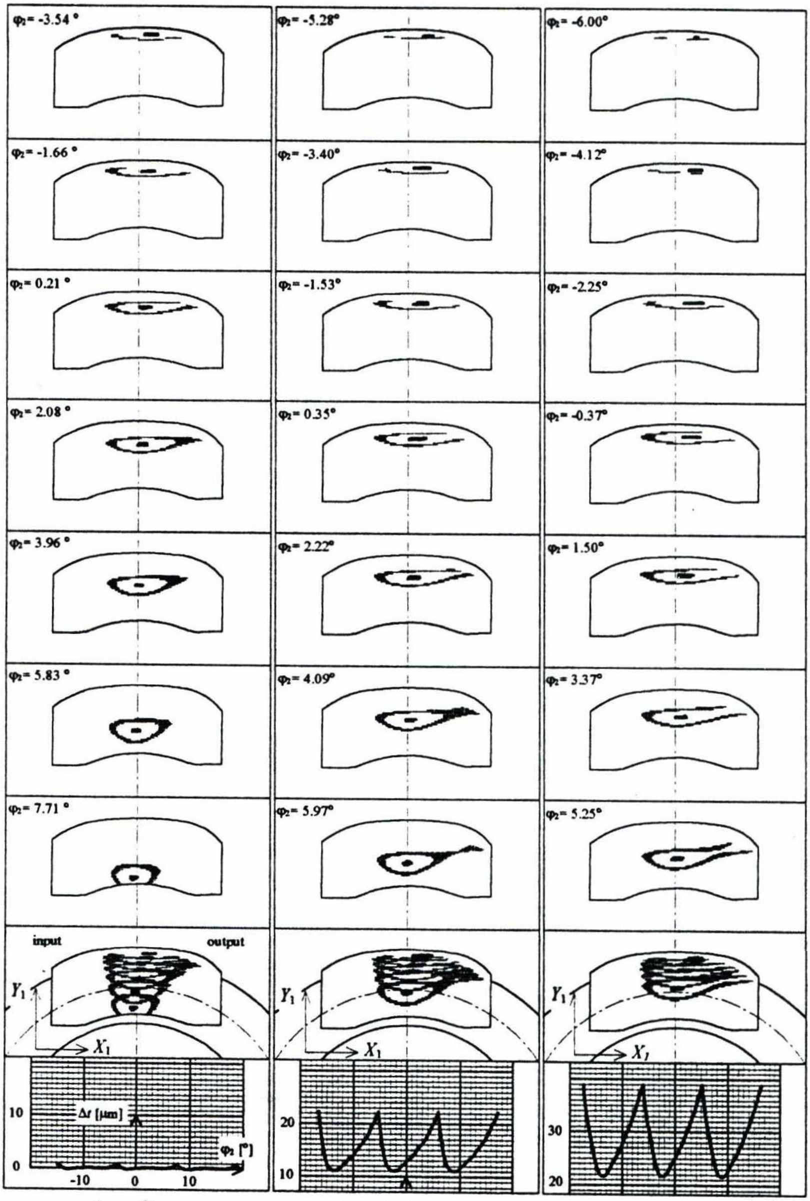
The *Tooth contact analysis* allows simulation of the gearing between the worm and wheel flanks, represented by spline surfaces. This study can take into account the occurrence of assembly deviations. The increment of the movement is the angle of the wheel. For different angles of the wheel can be established the level lines of different orders, contact points, main curvatures in the contact point. As a total of the partial results obtained, there may be traced the contact pattern, the paths of contact points and the variation of the transmission ratio.

The *Final Results* organise numerical data and drawings obtained during the design; thus, for instance, for a worm there are kept the following: defining data (tooth number, axial module, diametral quotient, etc.), computed data (reference diameter, tip diameter, root diameter, minimum length etc.), manufacturing parameters (centre distance when generating by grinding the worm, inclination angle of the disk cutters etc.), axial profile (necessary for the worm control), etc. Using AutoCAD these results offer the base of performing the necessary drawings to the execution of the designed worm gear pair.

3. NUMERICAL RESULTS

Using AutoWORM application it was studied a CAVEX worm gear pair, whose flanks modelled by spline surfaces have undergone position deviations. The flanks were considered not-distortable. It was determined numerically the variation of the transmission ratio, the interval of the real meshing and the formation of the contact line in seven positions of this interval (fig. 2). The increment of the movement is the angle of the wheel φ_2. The variation of the transmission ratio was evaluated by determination of the translation type corrections Δt, necessary to bring into contact the two flanks modelled. The formation of the contact line was evaluated by tracing level lines of 0-0.0005, 0.01-0.02 mm.

The studied worm gear pair proved to be sensitive to the variation of the centre distance deviation Δa_1; thus by the increase of the deviation to the centre distance, the wheel tooth takes part with a restrained area to the meshing, the contact stands still on the edge of the worm, respectively on the root of the wheel tooth. We consider as contact on the edge, the contact where the level line crossing an edge. That is why, we estimate as favourable moments of the contact, only those in which the level line of order 0.02 mm. (0.05) is closed. At big deviations from the prescribed centre distance ($\Delta a_1 \geq 0.05$mm.), during the meshing the level line of order 0.02 mm. remains open. Also, with the increase of the deviation, increases the variation of the transmission ratio. In the same manner it was studied the influence of the change of shaft angle and gear axial displacement.



Δa_1=0 mm. Δa_1=0.02 mm. Δa_1=0.05 mm.

Fig. 2

4. CONCLUSIONS

AutoWORM is a program developed in AutoCAD Release 12 environment, for computerised simulation of meshing and contact of unloaded worm gear drives. AutoWORM can be used to determine the transmission errors of the gear drive, the paths of contact points on the pinion-gear tooth surfaces, the dimensions and orientation of the instantaneous contact traces, and the shift of the contact traces caused by misalignment (the change of shaft angle, the centre distance and the gear axial displacement).

The interface with the user is achieved through dialogue boxes, elaborated on the AutoLISP, DCL and C programs. Calculation is done through AutoLISP and C++ programs. Graphical results of designing can be processed in order to make execution drawings, folders or fair presentation using modelling facilities, randomising and animation offered by AutoCAD and 3D Studio products.

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GENERALISED MULTIOBJECTIVE COST-PRODUCTIVITY FUNCTIONS USED IN MATHEMATICAL MODELS

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1. INTRODUCTION

It is known that the standard mathematical model for cutting parameters optimising is as follows [1]:

$$\begin{cases} F(v,s,t) \to \min/\max, \\ R_i(v,s,t) \le b_i, \quad i \in \{1,2,\ldots\ldots r\} \\ v,s,t > 0 \end{cases} \tag{1}$$

where: F(v,s,t) is objective function; Ri(v,s,t) are problem restrictions; v,s,t are cutting parameters.

The objective function could be a simple one (like manufacturing cost, manufacturing time, etc.) or a multiobjective function (like manufacturing cost - productivity). In the classical method the multiobjective functions must be written for each type of surface[1]. This paper presents a method for establishing a generalised differential form for the cost-productivity multiobjective function (for turning operation) and several particular cases are detailed.

2. COST-PRODUCTIVITY FUNCTION GENERALISATION

In cutting parameters optimising the manufacturing cost must be minimise and productivity has to be maximum. The productivity could be calculated with relation:

$$P = \frac{1}{\tau'_{tot}} \tag{2}$$

where τ'_{tot} is manufacturing time. It is maximum when the manufacturing time is minimum.

Because cost and time for a cutting operation tend to minimum, is possible to write the multiobjective cost-productivity function as:

$$F_{tot} = q_1 \cdot C_{tot} + q_2 \cdot \tau_{tot} \tag{3}$$

where: q_1 and q_2 are weight coefficients and they must satisfy the equation:

$$q_1 + q_2 = 1 \tag{4}$$

C_{tot} is total manufacturing cost per unitary cost,

τ_{tot} is total manufacturing time per unitary time.

2.1 *Differential form*

In case of turning operation, for the differential form determination, we consider the surface from the figure 1, which is obtained through rotation around the Ox axis of curve (C) (generating curve), whose equation is:

$$y=f(x) \tag{5}$$

The curve (C) has to be a continuous one.

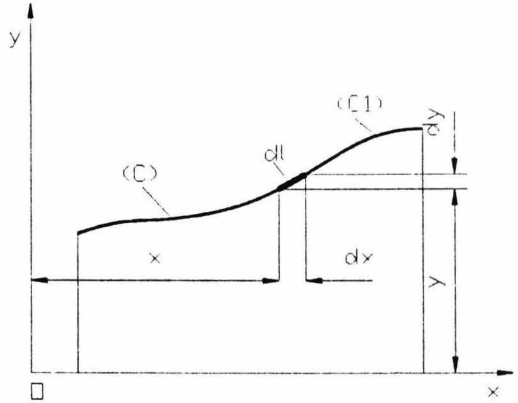

Fig. 1

Considering the relation (3), the total cost-productivity necessary to manufacture the elementary surface of dl length may be written as:

$$dF_{tot}^{dl} = q_1 \cdot dC_{tot}^{dl} + q_2 \cdot d\tau_{tot}^{dl} \tag{6}$$

where: dC_{tot}^{dl} is the total cost per unitary cost for elementary surface manufacturing,

$d\tau_{tot}^{dl}$ is the total time per unitary time for elementary surface manufacturing.

If the Time-Taylor relation is used, for the differential members from relation (6) might be consider [2, 3] equations:

$$dC_{tot}^{dl} = \frac{dl}{n \cdot s} \cdot C_{ct} + k_1 \cdot s^{yv/m-1} \cdot n^{1/m-1} \cdot \left(y^{1/m} \cdot dl + \frac{1}{m} \cdot L_{C1}^{*} \cdot y^{1/m-1} \cdot dy \right) \cdot C_{sr} \tag{7}$$

$$d\tau_{tot}^{dl} = \frac{dl}{n \cdot s} + k_1 \cdot s^{yv/m-1} \cdot n^{1/m-1} \cdot \left(y^{1/m} \cdot dl + \frac{1}{m} \cdot L_{C1}^{*} \cdot y^{1/m-1} \cdot dy \right) \cdot \tau_{sr} \tag{8}$$

where: n,s,t is the cutting parameters,

C_{ct} constant cost per time, it includes the device damping cost, machine-tool damping cost, electric power cost and worker's salary,

C_{sr} is tool sharpening and damping cost,

τ_{sr} is time of changes and regulations for tool,

C_v, m, x_v, y_v are the coefficients from Time Taylor relation,

$k_1 = \left(\frac{2 \cdot \pi \cdot t^{xv}}{1000 \cdot C_v}\right)^{1/m}$ is a constant parameter,

$L^{*}_{C1} = \int_{(C1)} dl$ is the length of generating curve for already manufactured surface; it is a function of x or y variable.

It is noteworthy that equations (7) and (8) is written considering a constant aimed roughness; consequently we considered constant feed while manufacturing along (C) curve.

Substituting the relations (7) and (8) in relation (6), we obtain the differential multiobjective function for the elementary surface manufacturing:

$$dF^{dl}_{tot} = \frac{dl}{ns}(q_1 C_{ct} + q_2) + k_1 s^{yv/m-1} n^{1/m-1}\left(y^{1/m} dl + \frac{1}{m} L^{*}_{C1} y^{1/m-1} dy\right)(q_1 C_{sr} + q_1 \tau_{sr}) \quad (9)$$

The relation is valid for any surface obtained trough rotating a curve of equation y=f(x) or x=f(y) around the Ox or Oy axis. It can be integrated for any type of surface (cylindrical, frontal, conical, profile).

2.2 Particular cases

2.2.1 Cylindrical surface

For cylindrical surface (see figure 2) the generating curve equation is:

$$y = \frac{D}{2} \quad (10)$$

and the particular elements in this case are:

$$\begin{cases} dx \neq 0 \\ dy = 0 \\ dl = \sqrt{dx^2 + dy^2} = dx \end{cases} \quad (11)$$

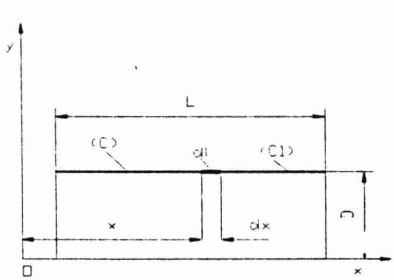

Fig. 2

Through relations (10) and (11) the differential multiobjective function becomes:

$$dF^{dl}_{tot} = \frac{dx}{ns}(q_1 C_{ct} + q_2) + k_1 s^{yv/m-1} n^{1/m-1}\left(\frac{D}{2}\right)^{1/m}(q_1 C_{ct} + q_2 \cdot \tau_{sr})dx \quad (12)$$

Integrating the equation (12), the cost-productivity function is found:

$$F^{cil}_{tot} = \frac{L}{n \cdot s} \cdot \left(q_1 \cdot C_{ct} + q_2 + k_{cil} \cdot s^{yv/m} \cdot n^{1/m}\right) \quad (13)$$

where: $k_{cil} = k_1 \cdot \left(\frac{D}{2}\right)^{1/m} \cdot (q_1 \cdot C_{sr} + q_2 \cdot \tau_{sr})$ being cylindrical constant surface.

2.2.2 Frontal surface

In this case (see figure 3) the curve equation is: $x = \text{const}.$ (14)
and specifically elements are:

$$\begin{cases} dx = 0 \\ dy \neq 0 \\ dl = \sqrt{dx^2 + dy^2} = dy \end{cases} \qquad (15)$$

$$L^*_{C1} = \int_{C1} dl = \int_{D1/2}^{y} dy = y - D_1/2 \qquad (16)$$

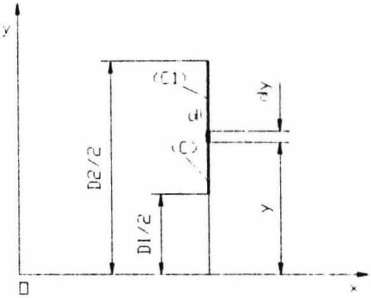

Fig. 3

With relations (15) and (16) the multiobjective function for frontal surface will be:

$$dF^{fr}_{tot} = \frac{dy}{ns}(q_1 C_{ct} + q_2) + k_1 s^{yv/m-1} n^{1/m-1}\left(y^{1/m} + \frac{1}{m}\left(y - \frac{D_1}{2}\right)y^{1/m-1}\right)(q_1 C_{sr} + q_2 \tau_{sr})dy \quad (17)$$

Integrating the equation (17), the cost function is found:

$$F^{fr}_{tot} = \frac{D_2 - D_1}{2 \cdot n \cdot s} \cdot \left(q_1 \cdot C_{ct} + q_2 + k_{fr} \cdot s^{yv/m} \cdot n^{1/m}\right) \qquad (18)$$

where: $k_{fr} = k_1 \cdot \left(\frac{D_2}{2}\right)^{1/m} \cdot (q_1 \cdot C_{sr} + q_2 \cdot \tau_{sr})$ is frontal constant surface.

2.2.3 Conical surface

In conical surface case, the (C) curve equation is:

$$y = a \cdot x + b \qquad (19)$$

where: $a = \frac{D_2 - D_1}{2 \cdot L}, b = \frac{D_1}{2}$, and a dl length element of curve (C) is characterised by:

$$\begin{cases} dx \neq 0 \\ dy = a \cdot dx \\ dl = \sqrt{1 + a^2} \cdot dx \end{cases} \qquad (20)$$

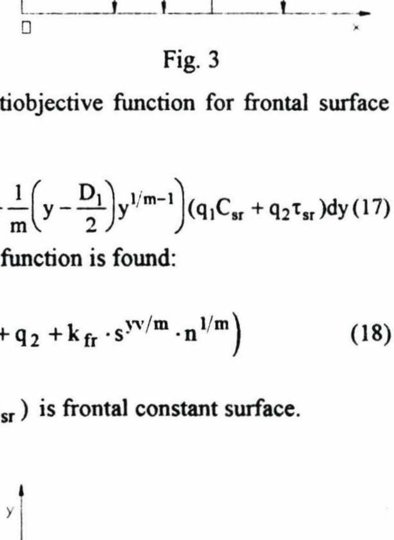

Fig. 4

The length of already manufactured curve is:

$$L^*_{C1} = \frac{\sqrt{a^2 + 1}}{a} \cdot (y - D_1/2) \qquad (21)$$

When the relations (20) and (21) are introduced into (9) the differential cost-productivity function for conical surface is obtained as follows:

$$dF_{tot}^{con} = \frac{dl(q_1C_{ct} + q_2)}{ns} + k_1 s^{yv/m-1} n^{1/m-1}\left(y^{1/m}dl + \frac{\sqrt{a^2+1}}{ma}\left(y - \frac{D_1}{2}\right)y^{1/m-1}dy\right)(q_1C_{sr} + q_2\tau_{sr}) \quad (22)$$

and integrating the equation (22), the cost-productivity function is found as:

$$F_{tot}^{con} = \frac{\sqrt{L^2 + ((D_2 - D_1)/2)^2}}{n \cdot s} \cdot \left(q_1 \cdot C_{ct} + q_2 + k_{con} \cdot s^{yv/m} \cdot n^{1/m}\right) \quad (23)$$

where: $k_{con} = k_1 \cdot \left(\frac{D_2}{2}\right)^{1/m} \cdot (q_1 \cdot C_{sr} + q_2 \cdot \tau_{sr})$ is conical constant surface.

3. CONCLUSIONS

This methodology for generalised multiobjective function determination may be applied for any tool life relation (like Konig, Depiereux, Kronemberg, etc.) and for other functions.

For $q_1 = 0$ the relation (9) becomes relation (8) and for $q_2 = 0$ relation (7) is obtained.

If Time-Taylor relation is used, the cost-productivity function form for any type of surface may be written as:

$$F_{tot}^{sup\,r} = \frac{L_{sup\,r}}{n \cdot s} \cdot \left(q_1 \cdot C_{ct} + q_2 + k_{sup\,r} \cdot s^{yv/m} \cdot n^{1/m}\right) \quad (24)$$

where: $L_{sup\,r}$ is the generating curve length and $k_{sup\,r}$ is the surface constant.

We remark that if in the relation (23) we replace $D_2 = D_1 = D$, typical for cylindrical surface, we have: $F_{tot}^{con}\Big|_{D1=D2=D} = F_{tot}^{cil}$ and, if we replace L=0, typical for frontal surface, we obtain: $F_{tot}^{con}\Big|_{L=0} = F_{tot}^{fr}$. Thus, the cost-productivity function of conical surface includes the particular cases (frontal and cylindrical surfaces).

If equation (9) could not be integrated, it is possible to use numerical methods for solve it.

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RAPID PRODUCT DEVELOPMENT IN METALWORKING INDUSTRY BY USING WEB SERVERS

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Summary

Today the World Wide Web Service is a widespread way of presenting and collecting data in all areas including metalworking industry. At the Mechanical Engineering Faculty of the University of Nis there is a method developed, based on the Web technology, for storing, searching and exchanging data about product model. According to this method, each manufacturer of material, semiproducts and products can have a Web server with all information about his product models according to the standard ISO 10303 (STEP). By using specially developed programs and data base, a typical designer can locate the server which contains the product most suitable for his purposes. Then the designer approaches the located server and acquires detailed characteristics of the product. If the product suits his needs, the designer can download the model of that product and incorporate it directly into his project. This methodology can be especially useful for designers in metalworking industry because many products made by other manufacturers are implemented in machines.

1. INTRODUCTION

The life cycle of a product does not only comprise the phases of product development, design and production, but also those of its selling, maintenance and destruction or of its recycling. The product data that describe all his characteristics are named "the product model" in today's literature. During the product life cycle diverse computer-aided systems are used for the sake of supporting its creation and use. However, diverse data formats of these systems make an efficient inter-system communication difficult, requiring a repeated input of data or their transformation.

On the other hand, the basic task of the development and design office is to transform a product idea into a product on the market in the shortest possible period of time. Due to this, there is a series of new methods [1], program tools and computer devices used nowadays in designing.

At the Mechanical Engineering Faculty of Nis, the development of new product methods and technologies has been worked upon in the last several years; at the same time new tendencies in the world related to this field have also been

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followed. Consequently, the WEB ENGINEER initiative has been undertaken which would alleviate the exchange of data about product model throughout its whole life cycle. The basic task of this initiative is to create conditions that would alleviate and quicken the process of product and technology design and to raise the product quality to the level required by the world market.

2. BASIC CHARACTERISTICS OF MODERN DESIGN METHOD

Modern way of product and technology design implies the use of computer as well as of a series of program packages that provide for CAD. The development of complex products requires the implementation of a series of semiproducts and of other manufacturers' products. In order to collect necessary information the designer uses catalogues and technical documentation about materials, semiproducts and products as well as a great variety of instructions and standards. During the process of technological procedure design the designer also needs data about cutting, clamping and measuring tools. In order to make a choice, he also uses manufacturers' catalogues. His troubles start when he finds information either insufficient or outdated (for instance, when some product has changed its characteristics). Due to this, the designer has additional consultations with those who offer the elements he is going to implement into his product. All this requires a considerable amount of time; likewise, mistakes are possible in interpreting the offered information.

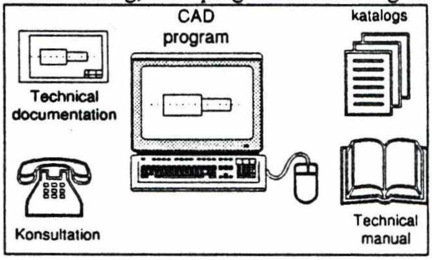

Fig. 1 Typical Work Environment in the Computer-Aided Design Conditions

With all the information collected, the designer implements the required elements into his project. This can mean the drawing of a semiproduct model and of products bought from other suppliers and/or the input of information about it into the product technical documentation.

3. WEB ENGINEERING INITIATIVE

On the basis of experience obtained while working upon a series of projects in the field of computer-aided product and technology design [2] and in the field of simultaneous engineering [3], it was to realise the idea of creating software with information about materials, products and standard elements that are used in metalworking industry. Regarding the fact that data organisation will be realised through the Web server, the whole project is named the WEB ENGINEERING INITIATIVE.

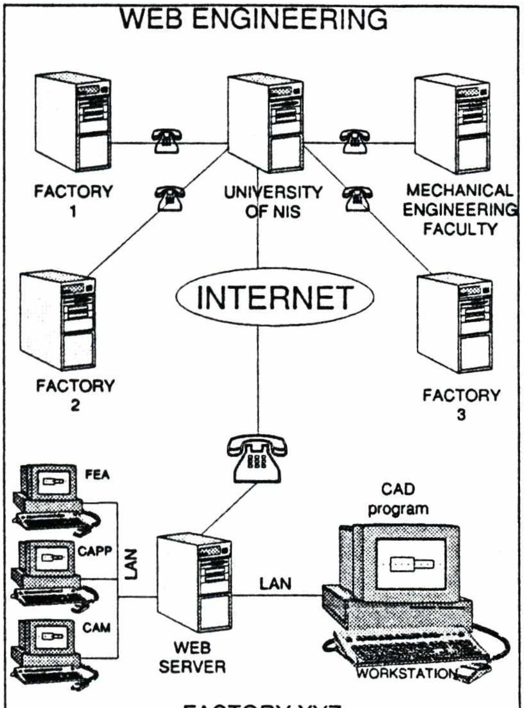

Fig. 2 WEB ENGINEERING Environment - Example of the Factory "XYZ"

The project envisages that all interested manufacturers should form their own Web servers with information about their products' models. The information here implies all relevant geometric and non-geometric data about products. The geometric data comprise a three-dimensional geometric product model with all dimensions and tolerances in the format that can be read by other users. The non-geometric data can be diverse since they depend on the kind of product. For instance, typical non-geometric data are: weight, material, product color, etc. In addition to the product model, the Web servers will also comprise data files for product representation (for instance, in the VRLM format) which would help the users choose a right product.

The information Web servers will be located in manufacturers' premises and will be connected with the Internet as shown in Fig. 2. The central Web server will be located at the University of Nis with basic data about products and addresses of the Web server's manufacturers. The server will also include the program that, by the questionnaire system, enables the application of a new product to the central server or the location of Web servers of those manufacturers who offer a required product.

4. PRODUCT DATA INPUT

When a potential user wants to apply certain product, he has an access to the central web server by using the program Netscape (or some other similar mesh browser). The application program, as shown in Fig. 3, requires that the user should input the number of attributes (data) which will describe a given product in the file. The number of attributes depends on the kind of product. A minimal number of data that precisely define the product's characteristics should be introduced. Besides, the user also defines the number of data files with the product model that will be at his disposal.

PRODUCT APPLICATION

Choose the number of attributes for your product	2

OTHER PRODUCT MODEL ELEMENTS

Number of files you want to put on Web:	1

In order to apply choose "application"

APPLICATION

Fig. 3 Product Application

After that, a new mask appears (Fig. 4) whose form has been created on the basis of these data. The user introduces into it data about manufacturers' name, product's name and other product's names (for instance, screw or stud). Names and values are introduced for a given number of attributes (for instance, length 15). Finally, the user introduces the names of data files that comprise data about the model, more precisely, their type, contents and Internet path.

NEW PRODUCT INTRODUCTION

Manufacturer:	XYZ	**Product name:**	Ball Bearing	**Other name:**	lager

Name of Attribute	Value of Attribute
diameter	50.0
width	10.0

Other Elements of Product Model

Type of file	Path to file
AutoCad dxf	www.xyz.ni.ac.yu

Fig. 4 Input of Attributes' Values and Paths to Data files With Product Model Data

5. SEARCH OF PRODUCT DATA

The search through available products' data starts with an access to the main information center. The user is obliged to input the name of the product that he wants information about. Using this as the basis for his search, he looks for products whose name or other name corresponds to the input name. Since there is a possibility that many manufacturers have applied the same kind of product describing them by various number of attributes, the program will draw a new mask (Fig. 5) which comprises the names of all the available attributes related to the given product. Then the user introduces one or more values for the attributes in order to define the given product as closely as possible.

SEARCH FORM

Attribute	Operator	Value
Diameter	>=	10.0
Length of Cutting Part	<	100.0
Length	=	
Board Length	=	

Search	Cancel

Fig 5.Input about Attributes' Values

On the basis of these data the main information server finds in its file all products corresponding to the given limitations. The search result is displayed on the monitor in the form given in Fig. 6. In addition to the attributes' values there are the links (URL) with the product model data files which are on the manufacturer's server so that the user can immediately obtain more detailed information about the product just as he can have a look at the geometric product model; if he needs some of these data, he can transfer them to his computer. In this way the user can automatically build in a complete product model into his project.

Manufacturer	XYZ
Product name	milling cutter
Diameter	10.0
Length of cutting part	40.0
Length	120.0
Handle Length	70..0

OTHER PRODUCT DATA
3D Model (VRLM)

Fig. 6. Result of Search for Milling Cutter

6. CONCLUSION

The advantages of using Web information servers in the process of product and technology design are the following:.

- Designers/constructors will, instead of a narrowed set of catalogues with standard or uniform elements, have an access to a much wider and richer source of information - manufacturers' information servers,
- Information on Web servers are permanently up-to-dated so that users can always have actual product data at their disposal,
- User will be able to copy relevant information about products, including a geometric (3D) product/element model and to implement it in the product model which he develops with the aid of his own CAD system, and,
- Beside exchanging product information with distant computers, the same Web servers can be also used for manipulating data within a company (Intranet).
- Considerable reduction of the time needed for new products' development,
- Increase of product quality thanks to the implementation of the most recent and modern components, and, easier maintenance and supply of spare parts.

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MODERN STATISTIC PROCESSING OF TECHNOLOGICAL INDICES ON PC

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The contribution deals with a description of advantages of flexible processing and management of production activities in firm, which will be better response on requirements of market. It speeds up the running of preparation of production, it better ensures the fluency of production and also increases the efficiency of production. It is known, the main aim at processing of economical indices is increasing their technical economical level.

Management of great and complicated firm requires also modern tool on control, processing and utilisation of flow of information. Important task of information and their right statistic processing is inescapable. Absence of quality of informational system in firm causes disorder in lot of areas and in final reason, also financial losses. On the other hand, at the selection of right system, offset expenses will be returned in short time. Good system of statistic processing of data characterises with the following characteristic features:

- flexibility
- integration of particular modules
- processing of data in real time
- enough information for management
- interactivity

- comfortable and easy attendance
- independence on HW platform
- minimal failure
- communicational support
- support of multi-user surroundings
- easy solution of capacity problems
- possibility of next widespread of system

Significant part at the introduction of statistic processing of data is the providing of service with the following maintenance and development, with the possibility of solution of new requirements, which are daily required. This product must be developed for requirements responded to our legislation and must accept the condition in each firm.

System is developed in environment UNIX/ INFORMIX and is applicated in environments SCO UNIX ALTOS UNIX , NA HWbasis of PC 386, 486, ALTOS.

Statistic processing of data is possible to provide also by ways of delivery. At the introduction odd statistic processing of economical indices at great firm is usually this procedure: analysis of conditions and processing of technical - economical study, installation of network, installation of SW and train users , small adaptation according to comments of users and all running system. From quality of processing of indices depends also competitive conditions and economical development of firm in cooperation with administration of internal organisation of firm, which helps to increase the informational system.

Statistic processing must connect on keeping of basic and internal firm accounting. Project also gives provisioned accounting books by interactive process (primary accounting, ledger book, evidence of profit and losses, balance sheet, evidence of state taxis). From inputs it is possible to arrange optional evidences according to ordered requirements.

At processing of data, there are comparing supplier s and customer s invoices with remittance. System must ask for reminder, penalised invoices, materials for enforcement, materials for credit and other surveys.

At statistic processing, the payment orders are reciprocally comparing with payment calendar, where is observed real and expected receipts and issues, according to items and bank accounts.

Brutto wage of workers are counted at this processing and after deduction of expenses also netto wages. Documentation for time wages can be attendance system and for task wage technical preparing of production.

System must also enable the evidence of equipment and refuse of machine, their accounted and taxes remissions.

At modern processing by PC, receipts and issues from materials are held from material stocks, administration of stock cards according to type of material.

Modules must reserve some defined type of material on order with specialised requirements customer. This reserved material can not be given to another order. Modules solve also the connection of storage economy and accountancy with including to production for concrete order of further data, which are necessary for requirement to introduce to production. Planning of production activity and reservation of capacities are provided according to required classification of order to production.

System at processing of data must utilise following modules of technical - economical preparation for material technical - economical standards according to creation of technical - economical standards and consumption of materials, where by the consumption of basic material is possible to count from the graduation and positioning. In calculation of consumption is also important type of material. From the consumption of material are following calculated material expenses on product.

It is possible to create efficiency standards by this system, with their actualisation by generating and printing of technological procedures. Assembly is based on particular typed operations and methods. Results of module are wage expenses on product. At price calculation must the added charge expenses, profit and other additional charges to material and wage expenses. Output at processing is calculation of product together with price-list of products and technical characteristics which contains basic information about product as nomenclature, delivery instruction, calculated size, characteristics of product and dimensional tables in assortment analysis.

System of statistic processing of economical indexes is connected with order through invoices to stock of final products.

Orders refer to part of business-production activities, in which are observed concluding contracts. Orders is possible to record as new input, occasionally they can be actualised from contracts.

It is possible to provide permanent orders for firm shops or suppliers and straight selling by cash price from stock.

Invoice enables at processing on PC more types of invoice (proforma invoice, invoice after delivery, summary invoice, credit-note). On the base of fulfilled data about sale, it is possible to print letter after delivery on compatible printer. After take out of store of goods, it is made out invoice. Invoice is printed according to buyer. Module provides statistic survey and joints on accounting.

Receipt and issue of final products from storage in dividing according to nomenclature and trend sale. State of final products are calculated in connection with the consumption of material. Supposed state of final products are compared with real state and is calculated of average deviation. Real state in storage is written to accounting.

Statistic processing data are necessary for financial flow in firm, in calculation of cash-flow, evidence of expenses and returns. It is found out economical result of firm, its evaluation and the ability of firm to refund of outstanding invoice, based on evidenced outstanding invoice and obligations.

Processing on PC is necessary for classifying of production according to requirements of suppliers. Summary of free capacities are joined for following up of real produced orders and their classify to production. Partial modules provide specification according to workshops and record receipt and issue of material storage in connection with large scale material capacities.

Statistic processing of data is necessary at receipt and issue in storage of final products, at survey and creation of orders, creature of invoices and joined to accounting.

Modern processing of economical values is the base for creation of technical and economical documentation for product and is also deduced firm technology and standards of consumption of materials.

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UTILIZATION OF COMPUTER TECHNIQUES AT CONTROLLING AND MANAGERING OF PRODUCTION OF THIN STEEL - SHEETS

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The contribution deals with the knowledge of control and managering of production process of thin steel - sheets. Basic characteristics of these activities. Utilisation of computer techniques in these production process for increasing of quality of these products. By introducing and by utilisation of computer techniques, a calling for it will increase those products and it will make selling easy. Also it will decrease the rejects of productivity.

Contribution deals with the philosophy, that the competitive position at firm is an ability to produce on requirements, based on the market and also only these firms are successful, which are enable to overcome with their products quick changes of requirements of market and they utilize computer techniques in their production.

Efficient manufacturing strategy is possible to deduce from some answers:

- Have firm reach recommended production costs, quality, reliability of supply and utility properties ?

Each type of products is produced on requirements, which based on the customers. That' s why, to fulfil the requirement of concrete customer for example, requirements on steel sheets, it is necessary to control and manage the manufacturing process by computer techniques.

Since, it is not enough in the fight with competitors to improve only one parameter in manufacturing process, based on the compilation of statistics from manufacturing. But ,it is necessary directly to influence on manufacturing process by immediate evaluation with help of computer techniques. It is the way, how we can shorten the reaction time on the requirements of customer and also to improve the reliability of products.

With utilisation of computer techniques in respondence with TBC(time based competition), we can reach higher quality and quantity parameters in the production of sheets.

The evolution process in each firm, so that in mechanical engineering branches, must be done in all phases (from first idea to design of product ,scheme of management of its manufacturing ,technical processing of product, training tests and process of manufacturing as whole by computer techniques).

The most famous world firms usually pass through these stages at the evolution of product by introducing of these changes into manufacturing ,but not with the same efficiency. Firms ,which are enable more quickly to provide changes into manufacturing are more successful ones, also at customers and it presents on better and higher economical result.

It is necessary at the production of sheets to maintain already famous idea on Japan style of manufacturing ,where the workers on each steps of manufacturing take much time to decision process by continuous utilisation of computer techniques and modern method of control of production process.

The main aim is to influence and to improve the quality of production on each step of manufacturing and as a result to improve mechanical and physical properties of thin steel sheet.

If these steps are arranged, also actually changes can be provided more efficiently. In our sheet production, it is four times slower, the introduction of changes and the influence of quality of these products as in comparison with world firms. It means, that it also can appear in the rate of fulfilling of requirements of concrete customer.

Although the starting conditions are the same, the introduction of changes deals longer and this is the way or time how the world firms can achieve to remove insufficient quality of sheets.

This advanced research enables to make place for competition position of world firms, for example our firms are provided changes after eighteen months, but the world producers of sheet can enable to decrease partial problem places in manufacturing and to decrease partial costs of parts or to decrease value of product.

Transfer of technology from the world firms is not possible without computer technologies in our countries. New designed workplaces are interested in this transfer of computer technologies in our firms and producers ,who longer time communicate with each producers.

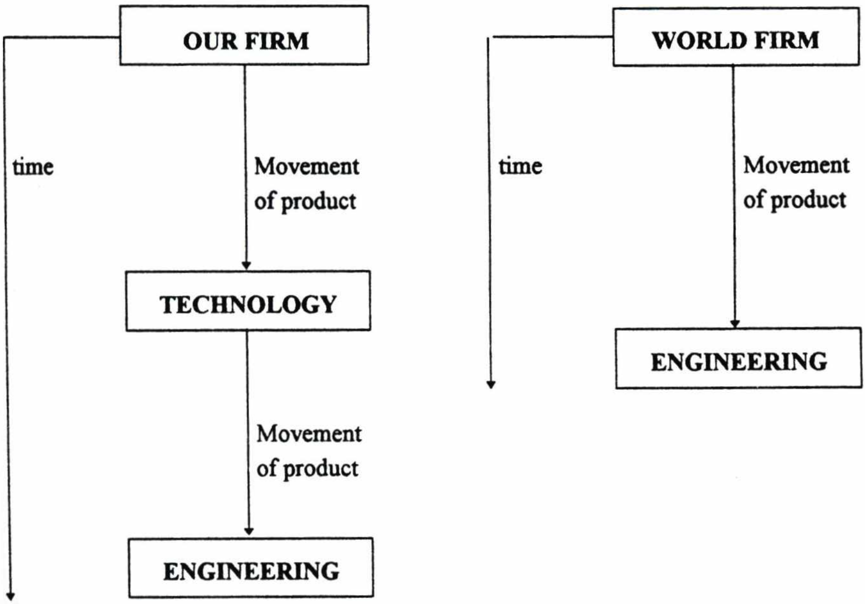

Fig. 1
Comparing of competitive positions of firms

In the world firms, these workplaces and production sections are connected with the net and this is the way , how the whole manufacturing process enables to influence the present state in real time. The mechanical-engineering firms have developed new technologies, based on the requirements of manufacturing and customers, which is exactly determined.

The main outlines of MANAGERING model of MANAGERING and control of sheets with utilisation of computer techniques are following:

1) Shortage of continuing time of manufacturing

2) Processing of smaller series of products

3) Increasing of effectiveness

4) Shortage of preparing of manufacturing

Efficient production strategy can create only with the help of computer technologies and that is the way, how we can take answer, which deals with the comparing of manufacturing of steel sheets and with comparing in each parameters with world firms.

These analysis and optimal managering of manufacturing process contribute to development of firm and increasing competitive position of product.

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EXCEL 5 APPLICATION PROGRAMME FOR WORK STUDY

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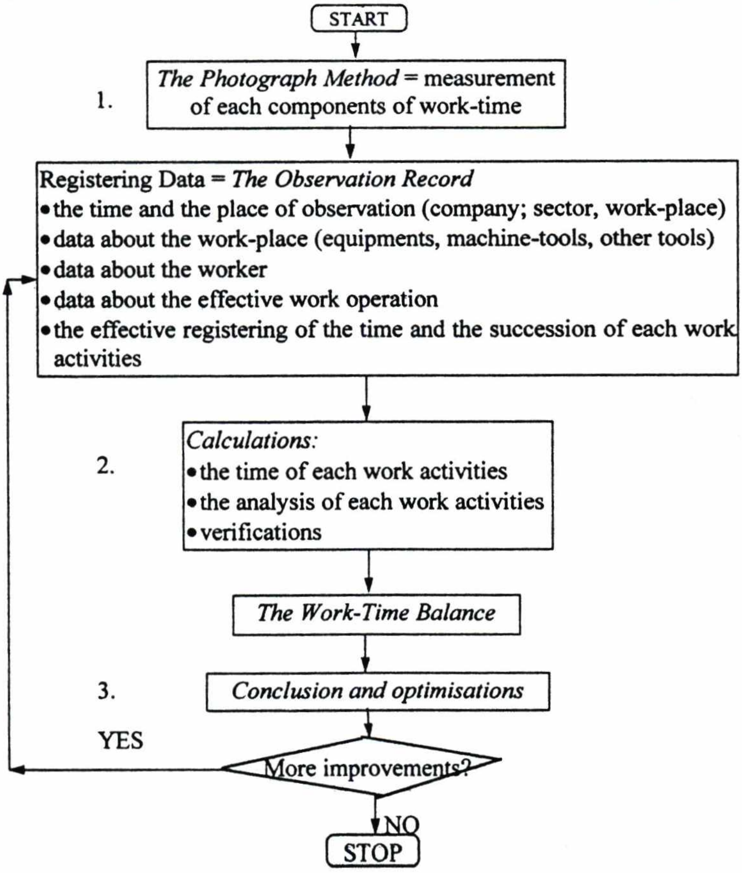


Fig. 1

The ergonomical analysis of every work activity determinate the knowing of each operations parts and their meanings. In this type of analysis we have to delimit the technological breaks from the physiological one and to make a complet definition of all work-times that are contented in that work activity. The most important think is to know the succession of each activity and their length.

The Excel 5 application in this particular case of work-study has three parts:

1. the work-time evaluation by measuring each of them;
2. the group of work-time by using the work-time scheme for the human operator (worker);
3. conclusion and recommendations for the optimisation of the work-time using.

The programme logic scheme is present in figure 1 and it shown exactly the three steps of the work analysis.

The theoretical method that we used is call "The Photograph Method". It is a scientifically research "tool" that evaluate how and in what measure the human operator (the worker) is using his work-time (the whole 8 hours of work). So, we can discover and we can analysis the cause that determinate a nonrational using of the work-time and we can eliminate them.

The porpoise of the Photograph Method is to take out the increase reserve for work productivity (the breaks, the non-productive works and other work-time loosing).

The Excel 5 application is made for the calculations for "The Individual Photograph Method". The data that are collected with this method are centralise in a document that is call "The Observation Record". The structure of this kind of record is shown in table 1.

Table 1

Company... Service/sector.......................................	Researcher.. Start of observation activity................... Finish of observation activity................ Time of observation activity................. Date...

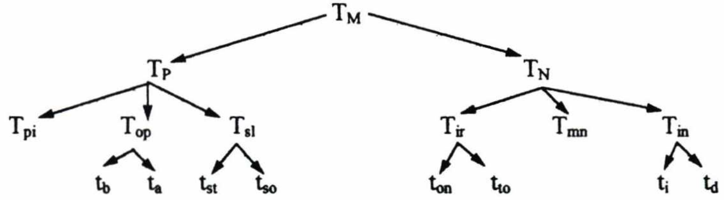
OBSERVATION SHEET NUMBER:....................

Individual Photograph Method of Work-Time

Data about the worker:	Data about the work place:
Name... Code... Age of worker.................................... Length of service............................... Training .... The achievement of work norm in the last month:..	Description of the work......................... .... Tools.. Others... Machine-Tool....................................... Characteristics.....................................

No	The name of the work-time consumption	Current time		Time	Symbol
		[hour]	[min]	[min]	
	TOTAL			x	

The work-time symbols are named in the Romanian standard: STAS 6909-80 and for the complet description of the programme we present them in figure 2.



T_M - work-time
T_P - productive work-time
T_N - non-productive work-time
T_{pi} - time for the start and the end of the work-day
T_{op} - operative work-time
T_{sl} - time for serving the work-place
T_{mn} - non-productive work-time
T_{ir} - regular interruption of work-time
T_{in} - non-regular interruption of work-time
t_b - base work-time
t_a - auxiliary work-time
t_{st} - technical serving of work-place
t_{so} - organisational serving of work-place
t_{on} - time for leisure and physiological needs
t_{to} - time of interruptions caused by the technology and work organisation
t_i - time of interruptions that is independent of the worker
t_d - time of interruptions that dependents of the worker

Fig. 2

After the calculations that are require by the Observation Sheet, the computer programme help us to make the Work-Time Balance which is presents in table 2.

After the Work-Time Balance the programme calculates some indicators and after that we can make some recommendations for the work-place improvements and for the work-time using.

Table 2

THE WORK TIME BALANCE

No	The category of work-time	Symbol	Work-time Register [min] / %	Admitted [min] / %	+/- [min] / %
	TOTAL	T_M	X	X	D_t

The indicators that are calculate for the conclusions are:

1. The percent of outrun the total admitted work-time: P_{dt}

$$P_{dt} = \frac{D_t}{T_{to}} \cdot 100 \quad [\%] \tag{1}$$

in which D_t is the outrun of the total admitted work-time and T_{to} is the total time of observation;

2. The percent of probable increase of work productivity: P_w

$$P_w = \frac{P_{dt}}{100 - P_{dt}} \cdot 100 \qquad [\%] \tag{2}$$

The Excel 5 application programme for work study is used in the scientifically research and for didactic calculations with the students in the practical lessons of ergonomy.

[1] NEAGU, VALERIA: **Ergonomy** - University "Transilvania" Braşov 1980

[2] BURLOIU, P.: **Economy and Ergonomically Organisation of Work**, Bucureşti 1990

TURBO PASCAL APPLICATION FOR THE CAD OF PRESSING MACHINE

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These three computer programmes in this case are used for the pressing machines CAD activities, particular for crank-press. The logical schemes for these applications are:

1. The calculation of the main parameters for crank-press (figure 1);
2. The cinematic study for the main executor mechanism of crank-press - the calculation of space, speed an d acceleration and there graphics (figure 2);
3. Preliminary calculations for the design of the main executor mechanism for crank-press - the evaluation and the graph of the available force and the dimensions of the connecting rod-crank mechanism (figure 3).

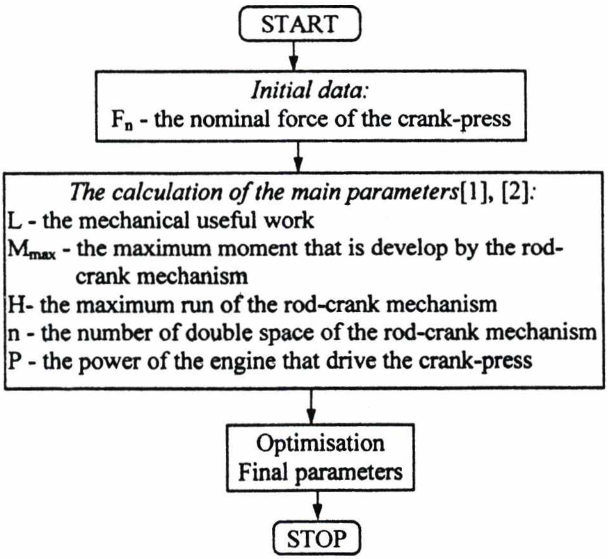

Fig. 1

START

Initial data:

F_n - the nominal force of the crank-press

λ - the parameter that characterise the rod-crank mechanism (0,06 ... 0,25)

α_n - the nominal angle = 30°

H - the maximum run of the rod-crank mechanism

n - the number of double space of the rod-crank mechanism

The calcualtion of: space (s), speed (v) and acceleration (a):

$$s = \frac{H}{2} \cdot [(1 - \cos\alpha) + \frac{\lambda}{4} \cdot (1 - \cos 2\alpha)], \qquad (1)$$

$$v = \frac{\pi \cdot n}{30} \cdot \frac{H}{2} \cdot (\sin\alpha + \frac{\lambda}{2} \cdot \sin 2\alpha), \qquad (2) \quad [1], [2]$$

$$a = (\frac{\pi \cdot n}{30})^2 \cdot \frac{H}{2} \cdot (\cos\alpha + \lambda \cdot \cos 2\alpha), \qquad (3)$$

The graphics: $s = f(\alpha)$

$v = f(\alpha)$

$a = f(\alpha)$

$\alpha = 0° \ldots 360°$, it is the angle of crank

STOP

Fig. 2

During the whole calculations that are made, the computer programmes consider:

1. the correct mathematical relation for the main parameters, because the pressing-machines could be faster or slow in accordance with the F_n value;
2. some of the main parameters have to be numbers of geometrical series. For example: n - the number of double space of the rod-crank mechanism have to be a number in the series R10 (ration is $\sqrt[10]{10} = 1,25$) or R20 (ration is $\sqrt[20]{10} \cong 1,12$). After the calculation of the parameter there is a break in the programme were the user have to decide about the write value of the parameter;
3. the position of the main shaft, along or perpendicular with the front surface of pressing machine determinate different construction of the rod-crank mechanism and of the whole machine;

4. the pressing machine that are characterise by F_n the nominal force more than 63 tf needs a reduction mechanism and it's transmission ration is also considered.

START

Initial data:

F_n - the nominal force of the crank-press

λ - the parameter that characterise the rod-crank mechanism (0,06 ... 0,25)

α_n - the nominal angle = 30°

H - the maximum run of the rod-crank mechanism

n - the number of double space of the rod-crank mechanism

The estimation of some parameters that determinate the design of the main shaft. Preliminary resistance calculation of the main shaft.

The calculation of:

$b_{\mu 1}$ - the rub-arm in case of the crank-press that have the main shaft along the front surface

$b_{\mu 2}$ - the rub-arm in case of the crank-press that have the main shaft perpendicular with the front surface

F_D - the available force of the crank-press

[1], [2]

$$b_{\mu 1} = \frac{\mu}{2} \cdot [(1+\lambda) \cdot d_A + \lambda \cdot d_B + d_0], \tag{4}$$

$$b_{\mu 2} = \frac{\mu}{2} \cdot [(1+\lambda) \cdot d_A + \lambda \cdot d_B + d_{01} \cdot \frac{l_1 + l_2}{l_2} + d_{02} \cdot \frac{l_1}{l_2}], \tag{5}$$

$$F_D = F_N \cdot \frac{\frac{H}{2} \cdot (\sin\alpha_N + \frac{\lambda}{2} \cdot \sin 2\alpha_N) + b_\mu}{\frac{H}{2} \cdot (\sin\alpha_x + \frac{\lambda}{2} \cdot \sin 2\alpha_x) + b_\mu}, \tag{6}$$

The graph: $F_D = f(\alpha)$, $\alpha = 0°...180°$

STOP

Fig. 3

The advantage of using these Turbo Pascal Applications is that the time for design of the crank-press is shortest. The optimisation of the main parameters and the cinematic study for the rod-crank mechanism can be done faster.

The computer programmes were used for the scientifically research of crank-press that are made in Romania. Also, we used them with didactic propose. The students from the machine-tools speciality have to design the main mechanism for a pressing machine, in particular case of the values of parameters F_n and λ and the position of the machine's main shaft.

[1] TABĂRĂ, I., TUREAC, I., **Pressing machines**, Bucureşti 1983
[2] TUREAC, I., CIOARĂ, R., KLEIN, V., **The design of the pressing machines**, University "Transilvania" Braşov 1992

ANALYSING THE LOGICAL GAME PLAYING CAPABILITY OF A BACK-PROPAGATION ANN

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ABSTRACT

The back-propagation learning algorithm for artificial neural networks invented by *Werbos* in 1974 is a famous and frequently used model for training of multi-layered feedforward neural networks. It has a good capability of association of many patterns presented as input and required output pairs. After training the network can remember the used output for a given input and has some more interesting features.

It seems to be a different area the logical game playing. In these cases we can generate the tree of the game having graph points symbolizing the possible states of the game. There are well-known playing tree evaluation methods, the mini-max algorithm, α-β pruning and so on, but there is a problem if the tree is very big. If this happens we have to use a heuristic static evaluation function which can give as good result as good the heuristical evaluation function itself. This problem suggests an another resolution possibility: merge the knowledge represented by the static evaluation function with flexibility and generalisation ability of the back-propagation artificial neural network.

The paper shows the used method in details and gives the experiments we have got.

Keywords: artificial neural network, back propagation, logical games.

INTRODUCTION

The research of artificial neural networks (ANN) is fashionable tendency nowadays. There is a big challenge to understand the human thinking as well as simulate working of brain. Interested readers may know lots of ANN models: Perceptron, ADALINE, linear associator, Neocognitron, ART, Boltzmann machine, BAM, and so on. Fortunately, we have a BrainMaker software [1] based upon the back-propagation neural network teaching theory. It is a simple input-output pattern associator and has some advantageous features: easy to understand working, capability to use noisy inputs, to give fairly good output in spite of the fact that the input is new. The back-propagation networks have given proof of good ability to predict, evaluate, extrapolate results and to tolerate messy or incorrect data [2].

One of the areas of artificial intelligence is logical game playing. There are some well-known games: chess, go, gomoku, Othello, Tic-Tac-Toe, and so on which have good procedural representations writen in Assembly, C, Pascal. We have about a dozen gomoku programs of this kind. The best can beat every people. But there is a question: can a back-propagation ANN play gomoku ? Can it evaluate in an acceptable manner situations never trained using its interpolating ability ?

CONCEPTION OF THE ANN-BASED GOMOKU

The rules of gomoku are: two player write O and X signs on the squared paper alternately. The winner will be that, which can make five sign in a horizontal, vertical or diagonal line. Look at *Fig. 1.* on the next page.

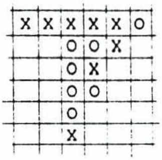


Fig. 1. The gomoku game

In the ANN-gomoku the first player will be a human with sign O, the second will be the ANN, activated by the computer and using sign X.
But how can we train a simple pattern associator to play gomoku ?

There is a Tic-Tac-Toe example in the BrainMaker software package. This game is similar to gomoku, but its playing area has 3 rows, 3 places per rows only. The winner will have three same signs in a line. The applied training method is the next: the input picture consists of two playing area. The second area has one more sign than the first area. The given training output (a real number) is close to 1, if the plus sign realizes a good step, or close to zero, if do not. See *Fig. 2.*

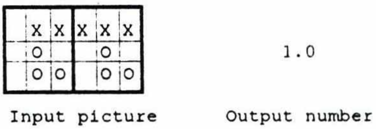


Fig. 2. A training pair of Tic-Tac-Toe

Unfortunately, the example of Tic-Tac-Toe for the input is not suitable for us because of many possible patterns of O and X signs. In the next section we will discuss the possible inputs and generating the output for trainings pairs.

PREPARATIONS FOR TRAINING THE ANN

<u>Input:</u> We will use picture input (not numbers) because it suits to the easy handling of game. Possibilities are:

- <u>a picture of the whole game area:</u>
  <u>Problem:</u>
  - the planned area has 20 * 20 = 400 places for signs, so this results 3^{400} different possible input patterns,
  - the knowledge represented by trained network would be dependent upon size of whole game area.
- <u>a picture of the little part of the game area:</u>
  this idea presumes a procedural program-environment, which can scan the whole game area, like human eyes scan the game and produce the input patterns. The scanned area may be:

- a 9 by 9 square, with an empty place in the centre. Taking into account this pattern we can give the goodness of central place as the possible place of the next step performed by the ANN. See *Fig. 3.*

  Problem:
  - many ($3^{(81-1)}$) possible different input patterns,
  - 81 input neurons are needed.

  Advantage.
  - the knowledge represented by the trained network would not be dependent upon size of whole game area,
  - the scanned part of the game area appears in BrainMaker user screen as a picture input and gives possibility to manipulate input pattern and analise output given by the network,
  - we can utilize maximum capability of symmetry input function of BrainMaker which can make seven more mirrored input pattern from a scanned one.

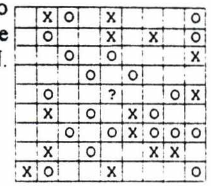


Fig. 3.

- a star-form, transformed into a 4 by 8 input picture.The central place of the star has the same role as the central place in the 9 by 9 square. See *Fig.4.*

  Problem:
  - the 4 by 8 input picture transformed from the star is different from the real relations of O and X signs in the game when appears in the BrainMaker user screen, but the difference is not big.

  Advantage:
  - only 32 input neurons are needed,
  - 3^{32} possible different input patterns only,
  - the star-form suits to the logic of gomoku, it consists of all signs which may have direct connection to the evaluated central place,
  - we can utilize a medium level of the symmetry function of BrainMaker, the diagonal mirroring is not valid only, so we can get 3 more input patterns from one scanned input pattern.

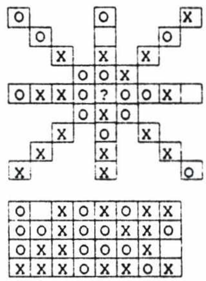


Fig.4.

Output: We need thousands of input-output pairs to train the network. Input is ready. But there is a question: How can we evaluate the goodness of the input picture, that is the goodness of next step performed in the central position of the scanned star? How can we generate the proper output easily and quickly?

The solution: we have to use a procedural gomoku program that plays gomoku fearly well to give the value of own evaluation function as output number for training the ANN. Fortunately we had a Pascal gomoku written by *Lás:ló Dudás* earlier for same purposes. After some modifications it cud generate the training files for BrainMaker. To produce the output for BrainMaker we applied a trick: the positive integer number (0-65535) resulted by the evaluation function of Pascal gomoku we represented as a binary number using 16 neurons, because the ANN is a bad calculator: sometimes 2 * 2 = 5. Using this trick we can allow a very big error for output neurons, it may be the half of the 0 - 1 output interval.

To generate the training (and testing) files we scanned surroundings of empty places everywhere and cleaned the repeated training patterns to achieve a rich and small training file.

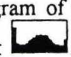
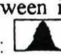
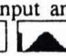
The network definition file: We had the training and testing files, but it was not enough. We had to make a definition file to give the features of the network and the training process. The input layer had 32 neurons and the output layer had 16. We applied one hidden layer only. Unfortunately there is no rules for determination of number of hidden neurons. To inform interested readers we would like to give some experiences in the next table. The used PC had the next characteristics: DX4 100 MHz, 256 kByte cache, 12 Mbyte RAM (4 Mbyte RAM drive), 540 Mbyte winchester.

Table 1. Parameters of the training experiments

Variant:	1	2	3	4	5	6	7	8	9	10	11
Hidden neurons:	48	64	128	256	512	384	448	416	384	448	450
Training time:	24'	20'	125'	17'	∞	20'	22'	21'	4:01'	3:55'	15:20'
RUNs:	384	381	144	90	∞	66	67	69	299	268	620
Number of I/O patterns / file:	388								841		968

The RUN gives the number of reading the complete training file.

EXPERIENCES PROVIDED BY THE TRAININGS

- The bigger is the training file the more hidden neurons are required.
- The training facts - training time function is strongly progressive.
- If the number of hidden neuron is little, the histogram of the weights of connections between hidden and output layers has the next form: . Too many hidden neurons give same histogram for the weights of connections between input and hidden layers. The healthy training process shows the next histograms:  , so the second histogram has some weights at value -8, too.
- The successful complete training process characterised by average error, RMS error and standard deviation functions. These values have to become near zero at the end of training. The *Fig.5.* shows an example.

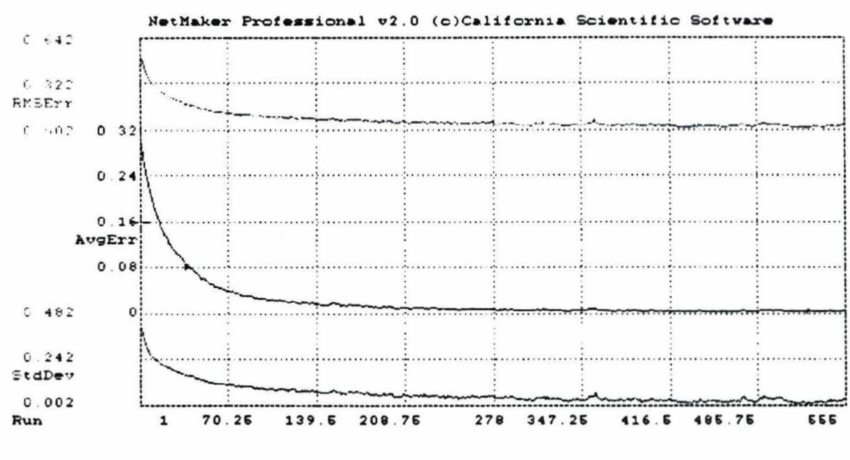


Fig. 5. The errors depend upon number of RUN-s.

- The applied training tolerance was 0.3 at the begining of the training process and was 0.1 at the end.
- We have tested the trained network using a testing file. The fearly big number of bad input-output pairs indicated that the training file contains few patterns.

EMBEDDING THE KNOWLEDGE REPRESENTED BY THE ANN INTO A GOMOKU PROGRAM

The trained network needs an embedding program to make it working. This program uses the RUNTIME.C module from the BrainMaker software packet. The program written in C programming language gives a gomoku-screen, a user interface for the game, scans the surroundings of possible places, produces the transformed input vectors for the ANN module, calls it at every places and interprets its outputs. Finally using the best output it writes out the sign of the computer in the board.

The improved version gives a testing possibility to control the thinking of the neural network.

CONCLUSION

The accomplished work has proved that the back propagation ANN is suitable for playing logical games, for example gomoku. The level of playing quality is determined by the number of trained patterns and similar to playing level of a human beginner. The biggest problem is the slow training process that needs dozens of ours to train a few thousands patterns.

We have some new ideas resulted by the experiences and we will apply them to improve the level of logical game playing ability of the gomoku.

REFERENCES

[1] California Scientific Software:**The BrainMaker Users Guide and Reference Manual**, Grass Valley:CSS,1990

[2] Jeanette Lawrence: **Introduction to Neural Networks** California Scientific Software, Grass Valley:CSS,1991.

ACKNOWLEDGEMENT

Authors would like to say thank to *prof. Tibor Tóth* for possibility of using BrainMaker.

DEVELOPMENT OF A SEMANTIC DATA MODEL BASED QUERY SYSTEM

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Abstract: The SFQ is a running internal research project at University Miskolc. The aim of the project is to create a query layer for existing relational databases. The query system is based on an own semantic data model and contains fuzzy elements too. This paper focuses on the theoretical backgrounds of the query system. It describes the semantic model, the fuzzy components and the generation of the semantic model.

INTRODUCTION

One of the current fields of database technology is the problem of querying the user is provided with. We can say that the available DBMS's mostly suffer from lack of flexibility. The use of traditional query interface implies several requirements as shown in [2]. In the case of a relational DBMS, the user has at least to know the relational data model, the contents of the database, the names of the relations and attributes, the SQL query language and the Boolean algebra. Several research works that cover among others the fuzzy query, semantic data model query, object oriented query or natural language query, have been undertaken to relax some of these constraints.
SFQ is an internal research project to create a flexible user interface for the local information system where the data are stored in a relational database. The flexibility means here that the user can use a more natural query language that enables imprecise terms and the user does not need to know the relational structure of the database. The paper presents the theoretical backgrounds of the proposed query interface. The user can use the SFQ data model to query the relational data model. The semantic data model is built from the existing relational data model in the model building phase. The user gives the query in the semantical model formalism, and the query system determines how the data can be retrieved from the relational system.

SDM BASED AND FUZZY QUERY SYSTEMS

A user finds it easier to understand and use a database if it can be described using concepts with which he is familiar. The traditional data models and their user interfaces have limited the capabilities for expressing the meaning of the database. The semantic based description is intended to serve as a natural modeling mechanism. The first step into this direction after the relational data model was the development of semantic data models (SDM). Semantic data models have gained in popularity mainly because of the modeling power they provide. They are able to handle semantically meaningful objects rather than normalized tuples or single records. Entities were introduced to model real-world objects. The entities have

unique identifications that are system generated. The attributes are allowed to be complex objects. The first best known semantic models are [3],[7].
Further progress of SDM may be characterized by the involving the OOP concepts to support behavioural object orientation[6]. According to [9] the semantic expressiveness and high levels of abstraction of OOP and SDM make the differences between semantic data models and OOP vanish. According to [5], the essential and good new features of OOP are the existence of classes and the class hierarchies, inheritance.
The research activities carried out in this field cover among others the development of query interfaces to SDM. Wong and Kuo[13] queried the Entity/Relationship model, Heiler and Rosenthal[8] queried the functional data model using DAPLEX.
Several approaches are proposed to capture imprecision in user queries too. This area is strongly related to the fuzzy theory. Some proposals are defined for fuzzy data models that are able to store fuzzy values [11][12]. In the other approach, the data model is one of the traditional ones and only the query contains fuzzy elements[1][2]. In this case, we can differ three main directions. One idea is to consider the query made of two parts: a crisp part and a fuzzy part. The crisp part contains the usual Boolean logic and it is used to determine the result set. The fuzzy part is intended for the ranking of the elements in the result set. Another approach is to allow combine crisp and imprecise expressions, but the imprecise expressions are first transformed into Boolean expressions using some threshold values and after then the query is evaluated as a normal Boolean query. In the third approach that also combines precise and imprecise expression, the Boolean expressions are converted into fuzzy expressions and the results are treated as fuzzy sets.

THE SEMANTIC DATA MODEL OF SFQ

We choose for the SDM layer a functional data model (FDM) like data model. Functional data models use the concept of mathematical function as fundamental modeling construct [3][10]. The main primitives of FDM are entities and functional relationships among the entities. The relationships may be single valued or multivalued. The FDM's usually contain tools to incorporate the concepts of composed, derived and IS_A functions.

Structural part

The schema that we developed has two components like FDM: entities and relationships. The main characteristics of the model:

- Entities may be atomic or complex.
- The model does not contain the entity types.
- User can only access the values of atomic entities.
- There are three types of relations: normal, IS_A and key relations. The key relations are used to identify the complex entities: the referred entities should exist and their values should be unique.
- Every complex entity must have key relationships.

The diagrammatic representation contains the elements shown in Fig 1. The schema may have several schema instances. The schema instance contains only normal and key relations. One important characteristic of the schema instance is that every value of an entity occurs only once in the schema instance.

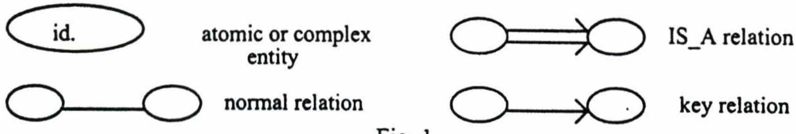


Fig. 1

The next figure shows an example schema and a corresponding schema instance.

Operational part

We defined the following operations for querying the schema:

- basic selection
- Cartesian product
- collection
- association

The operation of *basic selection* retrieves all instances of a given entity that meet the given selection criteria. The form of the operation is:

$$\sigma\{D \mid \text{expression}\}$$

where the expression is the selection criteria defined on the instances of D resulting true or false values.
The operation of *Cartesian product* results in all possible tuples of entity instances combined from the operand entities. The formal description of the operation is:

$$\sigma\{D_1 \times D_2 \times \ldots \times D_n \mid \text{expression}\}$$

The operation of *collection* results in value sets which consist of the instances of a given set of entities that are connected to the same instance of a given entity D_1 along the default link chain defined in the schema. The form of the collection is:

$$\sigma\{D_1 \rightarrow (D_2, D_3, \ldots, D_n) \mid \text{expression}\}$$

The selection criterion is given by the expression in the tail. We define the default link chain between two entities as the union of the shortest paths between the entities. By using the collection as a subselect in the selection criteria, we can give constraints not only on the values of the operands, but on the values of other entities related to the operands, too. If the selection criterion contains a subselect, then all its references to the operand-domains are only substituted by the instance currently accessed in the head of the selection. In some cases, the default link chain defined by the system may not be appropriate for the user. In this case, the user has to give a detour, a roundabout way, along which the connected instances are searched for. A detour is defined by giving some relations of the schema, which must be included in the link chain.
In the case of *association,* the instances, between which an arbitrary link chain in the schema instance exists are connected. An instance d_1 is connected to instance d_2, if there exists a chain of link instances from d_1 to d_2 in the database schema instance. The form of the association is:

$$\sigma\{ D_1 \circ D_2 \mid \text{expression}\}$$

Two entity instances are associated if there exists a chain of link instances between them in the schema instance.

Fuzzy components

In order to manage the fuzziness simple and efficient, a functional formalism is applied. The fuzzy relations and modifiers are expressed by functions. As all the entity identifiers within a query correspond to the entities of the data model, we can deviate the type of the expressions, thus we can use some kind of overloading to denote the similar fuzzy operators over different domains with the same name. For example, we can define a same() function over the age entity too. The implementation of this same() function would differ from the implementation of the other same() function. The modifiers are also given as functions, for example:

very(young(E1->age)).

The meaning of the logical operators is the usual, AND corresponds to the minimum, OR to the maximum function.
Every element of the result set obtains a true value between 0 and 1 and they are ranked by this true value. The threshold value that determines whether a result element is provided to the user or not can be assigned for every selection operation.

CREATION OF THE SFQ MODEL

The semantic model is generated from the existing relation model by help of a system analyst. The purpose of this phase is to make a reverse normalization of the model. The starting ER model is namely decomposed during the normalization process. We try to create an SFQ model from the relational model. During this reverse normalization, we determine the conversation rules between the SFQ objects and the relational objects.
Every entity is assigned to a set of relational objects that store the values belonging to the entity. The atomic objects are assigned to attributes, the complex objects are assigned to a set of attributes, usually tuples. The values, instances of an entity may be spread among several relations, attributes. The relations in SFQ may denote relationships among values and structural relationships among the attributes of a relational table. Every relation in SFQ is assigned the corresponding relationship expressed in relational formalism.
The generation of the SFQ model consists of the following steps:

- Generating the initial SFQ model from the relational schema. Every table corresponds to a complex entity, every attribute corresponds to an atomic entity. The structural connections within a table are denoted by relations in the SFQ model.
- Assigning alias names to entities. Entities of the same name are unified.
- Performing the reverse normalization. We differ the following types of reverse normalization:
    - 1:N relation
    - N:M relation
    - multivalued attribute (1NF)
    - partial key-FD (2NF)
    - transitive FD (3NF)
    - compound attribute

- IS_A relation

As an example, we take the following simple relational schema, that represents the cars, the people and the children of people:

car

code	type	owner

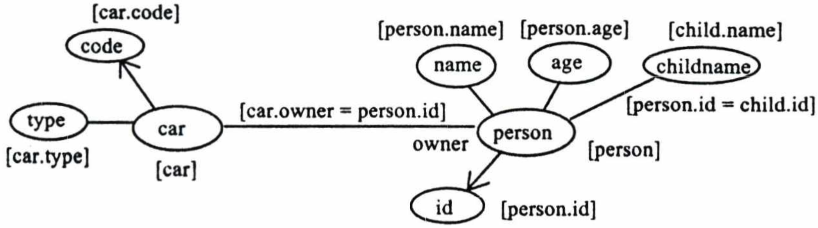
person

id	name	age

child

id	name

The result SFQ model after the reverse normalization is shown in next figure:



A sample query formulated in SFQ to retrieve the names of children of young car owners:

$\sigma\{car \rightarrow owner \rightarrow childname \mid young(owner \rightarrow age)\}$

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EFFICIENT AGGREGATION TECHNIQUES IN MULTIDIMENSIONAL DATABASES

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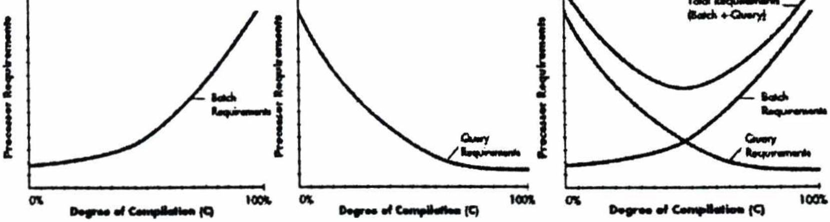
Abstarct: The paper gives a short overview about the technologies used in Data Warehouse Systems to increase the efficiency of processing of user queries. The pape focuses on the following topics: effiency of OLAP systems, data cube, queries in OLAP systems and greedy algorithm.

MULTIDIMENSIONAL OLAP: ARCHITECTURE OVERVIEW

The decision support systems used by IT organizations are referred to as On-Line Analytical Processing (OLAP) systems. Multidimensional OLAP (MD-OLAP) utilizes a proprietary multidimensional database (MDDB) to provide OLAP analyses in Data Warehouses. The main premise of this architecture is that data must be stored multidimensionally to be viewed multidimensionally. In MDDB systems data are stored not in simple tables as it is usual in the relational databases, but in cubes, that means every data item can be accessed through several keys at the same time. This structure is impelmented by means of a complex index structure ([3].[5]). Information from a variety of operational systems is loaded into a multidimensional database through a series of batch routines. Once this atomic data has been loaded into the MDDB, the general approach is to perform a series of calculations in batch to aggregate along the orthogonal dimensions and fill the MDDB array structures.

QUERY PERFORMANCE AND BATCH REQUIREMENTS

OLAP reports display information at both the base level and at higher consolidated levels. When data needs to be consolidated, OLAP systems can either calculate these values dynamically or retrieve them from a pre-calculated data store. To provide the required performance, OLAP systems typically pre-calculate some (or all) of these values. Later we will see more details about the level of aggregation.



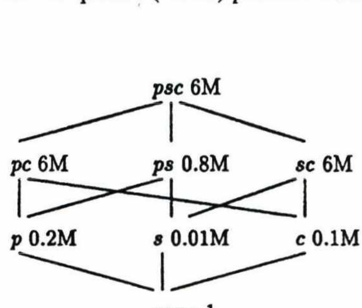
The size of the data warehouse and the complexity of queries can cause queries to take very long to complete. This delay is unacceptable in most OLAP environments, as it severely limits productivity. The usual requirement is query execution times of a few seconds or a few minutes at the most.
There are many ways to achieve such performance goals. Query optimizers and query evaluation techniques can be enhanced to handle aggregations better, to use different indexing strategies like bit-mapped indexes and join indexes, and so on.
A commonly used technique is to materialize (precompute) frequently-asked queries. In this paper, we present a framework and algorithms that enable us to pick a good set of queries to materialize. Our framework also lets us infer in what order these queries are to be materialized.

THE DATA CUBE

Let us take an example to demonstrate the multidimensional data model: we analyze the turnover of an enterprise. There are three dimensions we are interested in: **part, supplier**, and **customer**. The "measure" of interest is the **total sales.** So for each cell (p,s,c) in this 3-D data cube, we store the **total sales** of **part** p was bought from **supplier** s, and sold to **customer** c.

There are three implementation alternatives to impelment the data cube:
1. Physically materialize the whole data cube. This approach gives the best query response time. However, precomputing and storing every cell is not a feasible alternative for large data cubes, as the space consumed becomes excessive.
2. Materialize nothing. In this case we need to go to the raw data and compute every cell on request. This approach punts the problem of quick query response to the database system where tha raw data is stored.
3. Materialize only part of the data cube.
We consider the third approach in this paper. There is also the issue of where the materialized data cube is stored: in a relational system or a proprietary MDDB (multi-dimensional database) system. In this paper we assume that the data cube is stored in "summary" tables in a relational system. Each of the sets of cells (rows, columns, etc.) corresponds to a different SQL query. The queries corresponding to the different sets of cells, differ only in the **GROUP-BY** clause. Deciding which sets of cells to materialize is equivalent to deciding which of the corresponding SQL queries (views) to materialize. The investigated database works with three attributes: **part, supplier, customer.** We list all the queries (views) possible below with the number of rows in their result.

1. **part, supplier, customer** (6M, i.e., 6 million rows)
2. **part, customer** (6M)
3. **part supplier** (0.8M)
4. **supplier, customer** (6M)
5. **part** (0.2M)
6. **supplier** (0.01M)
7. **customer** (0.1M)



The symbol **none** indicates that there are no attributes in the **GROUP-BY** clause. We assume the cost of answering a query is proportional to the number of rows examined. Queries can be answered by using different materialized views. In the above example, a fully materialized data cube would have all the views materialized and thus have slightly more than 19 million rows.

THE DEPENDENCE RELATION ON QUERIES

We may generalize the previous observations as follows. Consider two queries Q_1 and Q_2. We say $Q_1 \subseteq Q_2$ if and only if Q_1 can be answered using only the results of query Q_2. We then say that Q_1 is dependent on Q_2. For example, the query (**part**), can be answered using the results of the query (**part, customer**). Thus (**part**)$\subseteq$(**part,customer**). There are certain queries that are not comparable with each other using the $\subseteq$ operator. For example (**part**)$\not\subseteq$(**customer**).
The $\subseteq$ operator imposes a partial ordering on the queries. We shall talk about the views of a data-cube problem as forming a lattice. In order to be a lattice, any two elements (views or queries) must have a least upper bound and a greatest lower bound according to the $\subseteq$ ordering. However, in practice we only need the assumptions that $\subseteq$ is a partial order, and there is a *top* element, a view upon which every view is dependent.

Hierarchies

It is common to represent a lattice by a lattice diagram, a graph in which the lattice elements are nodes and there is an edge from a below to b above if and only if b is in $next(a)$. Thus, for any two lattice elements x and y, the lattice diagram has a path downward from y to x if and only if $x \subseteq y$.
In most real-life applications, dimensions of a data cube consist of more than one attribute, and the dimensions are organizes as hierarchies of these attributes. A simple example is organizing the time dimension into the hierarchy: **day, month,** and **year**. When we use this time hierarchy, we have the following three queries possible: (**day**), (**month**), (**year**), each of which groups at a different granularity of the time dimension. Further,

$$(\mathbf{year}) \subseteq (\mathbf{month}) \subseteq (\mathbf{day}).$$

To make things more complex, hierarchies often are not total orders but partial orders on the attributes that make up a dimension.
There are query dependencies caused by the interaction of the different dimensions with one another and there are query dependencies within a dimension caused by attribute hierarchies. If we are allowed to create views that independently group by any or no member of the hierarchy for each of n dimensions, then we can represent each view by an n-tuple $(a_1, a_2, \ldots, a_n)$, where each a_i is a point in the hierarchy for the ith dimension. This lattice is called the *direct product* of the dimensional lattices. We directly get a $\subseteq$ operator for these views by the rule

$$(a_1, a_2, \ldots, a_n) \subseteq (b_1, b_2, \ldots, b_n) \text{ if and only if } a_i \subseteq b_i \text{ for all } i.$$

The lattice framework, we present and advocate in this paper, is advantageous for several reasons as it provides a clean framework to reason with dimensional hierarchies, since hierarchies are themselves lattices and We can model the common queries asked by users better using a lattice framework.

OPTIMIZATION OF DATA-CUBE LATTICES

Our objective is to develop techniques for optimizing the space -time tradeoff when implementing a lattice of views. The problem can be approached from many angles, since we may in one situation favor time, in another space, and in third be willing to trade time for space as long as we get good "value" for what we trade away. We shall begin with a simple optimization problem, in which

1. We wish to minimize the average time taken to evaluate a view.
2. We are constrained to materialize a fixed number of views.

We are motivated to look at heuristics to produce approximate solutions. The obvious choice of heuristic is a "greedy" algorithm, where we select a sequence of views, each of which is the best choice given what has gone before. We shall see that this approach is always fairly close to optimal and in some cases can be shown to produce the best possible selection of views to materialize.

THE GREEDY ALGORITHM

Suppose we are given a data-cube lattice with space costs associated with each view. The space cost is the number of rows in the view. Let $C(v)$ be the cost of view v. Suppose also that there is a limit k on the number of views, in addition to the top view, that we may select. After selecting some set S of views (which surely includes the top view), the benefit of view v relative to S, which we denote $B(v,S)$, is defined as follows.

1. For each $w \subseteq v$, define the quantity B_W by:
   (a) Let u be the view of least cost in S such that $w \subseteq u$. Note that since the top view is in S, there must be at least one such view in S.
   (b) If $C(v) < C(u)$, then $B_W = C(u) - C(v)$. Otherwise, $B_W = 0$.
2. Define $B(v,S) = \sum_{w \subseteq v} B_W$.

In perhaps simpler terms, we compute the benefit of v by considering how it can improve the cost of evaluating views, including itself. For each view w that v covers, we compare the cost of evaluating w using v and using whatever view from S offered the cheapest way of evaluating w. If v helps, i.e., the cost of v is less than the cost of its competitor, then the difference represents part of the benefit of selecting v as a materialized view. The total benefit $B(v,S)$ is the sum over all views w of the benefit of using v to evaluate w, providing that benefit is positive.
Now, we can define the *Greedy Algorithm* for selecting a set of k views to materialize:

```
S = {top view}
 for i=1 to k do begin
   select view v not in S such that B(v,S) is maximized;
```

```
    S = S union {v};
  end;
resulting S is the greedy selection;
```

We can show that no matter what lattice we are given, the greedy algorithm never performs too badly. Specifically, the benefit of the greedy algorithm is at least 63% of the benefit of the optimal algorithm. The precise fraction is $(e-1)/e$, where e is the base of the natural logarithms.

Let $v_1, v_2, \ldots, v_k$ be the k views selected in order by the greedy algorithm. Let a_i be the benefit achieved by the selection of v_i, for $i=1, 2, \ldots, k$. That is, a_i is the benefit of v_i, with respect to the set consisting of the top view and $v_1, v_2, \ldots, v_{i-1}$

Let $w_1, w_2, \ldots, w_k$ be the optimal set of k views, i.e., those that give the maximum total benefit. The order in which these views appear is arbitrary, but we need to pick an order. Given the w's in order $w_1, w_2, \ldots, w_k$, define b_i to the benefit of w_i with respect to the set consisting of the top view plus $w_1, w_2, \ldots, w_{i-1}$. Define $A = \Sigma_{i=1,k}\, a_i$ and $B = \Sigma_{i=1,k}\, b_i$.

It can be proved that

- for any k the ratio $A/B = 1 - (k-1/k)^k$ can be reached.
- for all k, the lower bound on the ratio of the greedy and optimal benefits is exact. That is, the ratio $1 - (k-1/k)^k$ actually occurs for at least one lattice for each k. As $k \to \infty$, $(k-1/k)^k$ approaches $1/e$, so $A/B \geq 1-(1/e) = (e-1)/e = 0.63$.

EXTENSIONS TO THE BASIC MODEL

There are at least two ways in which our model fails to reflect reality.

1. The views in a lattice are unlikely to have the same probability of being requested in a query. Rather, we might be able to associate some probability with each view, representing the frequency with which it is required.
2. Instead of asking for some fixed numbers of views to materialize, we might instead allocate a fixed amount of space to views (other than the top view, which must always be materialized).

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Programozási Paradigmák

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Abstract:
The identification of the „software crisis" in the late 1960s and the notion that software development is an engineering discipline led to the view that the process of software development is like other engineering process. Thus, some models of the software development process were derived from other engineering processes. Like all engineering, software engineering is not just about producing products but involves producing high-quality products in a cost-effective way with a finite amount of resources and to a predicted schedule Let's surway some of models to specificate and develop mentioned above like waterfall approach, exploratory programming, prototyping, formal transformation and so on.

1. Tervezési Modellek

Az 1960-as évek végén jelentkező software krízis, és az ebből következő software tervezési igény vezetett el arra a felismerésre, hogy a tervezés folyamata ez esetben is hasonló lehet más mérnöki tervezéséhez. Néhány honosított modellt nagy lelkesedéssel vezettek be vezető programozók, de csakhamar kiderült, hogy nem mind használható megfelelően minden esetben.

Mint minden mérnöki tevékenység esetében, itt is fontos megfogalmazni néhány elengedhetetlenül szükséges alapelvet, mely megfeleltethető ezen tervezési tevékenység céljainak. Lennie kell minden jól tervezett software-nek néhány közös jellemzőjének, melyek meghatározzák ezen alapelveket. Egy átlagos követelményszintet figyelembe véve négy ilyen közös jellemzőt sorolhatunk fel:

- *Karbantarthatóság*: a programokat úgy kell megírni és dokumentálni, hogy azok minden nehézség nélkül minimális költségszinten módosíthatóak legyenek.
- *Megbízhatóság*: Az elkészített rendszer úgy működjön, ahogy azt a felhasználó elvárja. Nem történhet több hiba, mint az a specifikációban megadott.
- *Hatékonyág*: A program takarékosan, szükségleteinek megfelelően bánjon a keretrendszer erőforrásaival. Ez nem feltétlenül jelenti azonban a hardware kizsigerelését. Gondoljunk a portabilitás követelményére: a programnak nem csak a tervezői környezetben kell működnie.
- *Emberközelség*: A software rendelkezzen jól használható, jól áttekinthető és értelmezhető felhasználói interfece-szel, melyet direkt a felhasználó képességeit figyelembe véve terveztek.

Figyelni kell arra, hogy ezen tulajdonságok egymásra ellentétes hatással lehetnek. Egy jobb felhasználói interface növeli a software méretét, ezáltal csökkentheti annak hatékonyságát. Továbbá figyelembe kell venni, hogy minden egyes tulajdonságnak költségvonzatai vannak. Ebből következően a tervezés legfőbb szempontja a költségigény legyen. A költségszintet azonban felülbírálhatják a felhasználó igényei, tehát minden esetben egyeztetni kell velük már a tervezés kezdeti stádiumában.

2. Néhány tervezési modell áttekintése

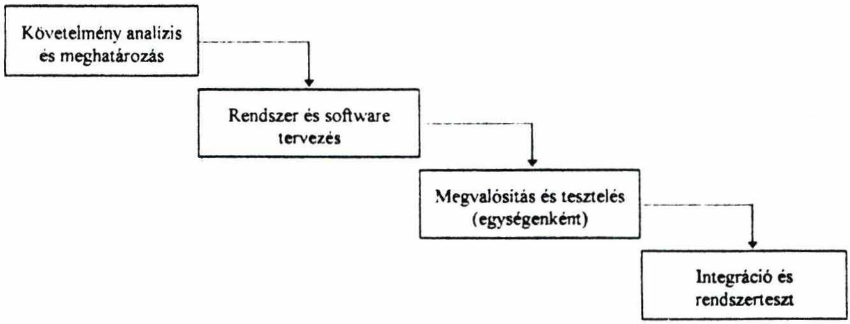
A legelsőként elterjedt honosított tervezési modell az ún. *vízesés modell*. Hamar kiderült azonban róla, hogy a software megkívánt bonyolultsága és sokfélesége miatt nem kielégítően alkalmazható. További technikák keresése indult meg, s ez a tendencia napjainkban is tart. Megemlítünk még néhány ismert modellt. Ezek:

- Felderítő programozás (Exploratory programming),
- Prototípus készítés (Prototyping),
- Formális átalakítás (Formal transformation),
- Rendszerösszeállítás többször felhasználható komponensekből (System assembly from reusable components),
- stb.

2.1. Vízesés modell

Ez a megközelítés néhány tervezési fázis egymásra következése, melyben csak akkor léphetünk az egyik fázisból a másikba, ha annak előírásait már kielégítettük. Ezen fázisok a következők (*1.ábra*):

- *Követelményanalízis és -meghatározás:* Tisztázni kell a felhasználókkal a rendszer szolgáltatásait, megkötöttségeit és mindenekelőtt a célját. Mindez meghatároz egy olyan metódust, amelyben mind a felhasználók, mind a fejlesztők egyetértenek, s azt mindkét fél számára világosan megfogalmazva kell rögzíteni.
- *Rendszer- és software tervezés:* Hardware és software architektúra kialakítás. Figyelembe kell venni az előző lépésben készített dokumentáció irányelveit. A software tervezés a következőt jelenti: a software funkcióinak olyan ábrázolása, hogy azokból egy, vagy több lépéssel egy, vagy több futtatható kódot lehessen generálni.
- *Megvalósítás és tesztelés:* A program egységek (alegységek) kódolása és ellenőrzése, hogy megfelelnek-e a specifikációnak.
- *Integráció és rendszerteszt:* A program egységek egyetlen rendszerbe integrálása és tesztelése.



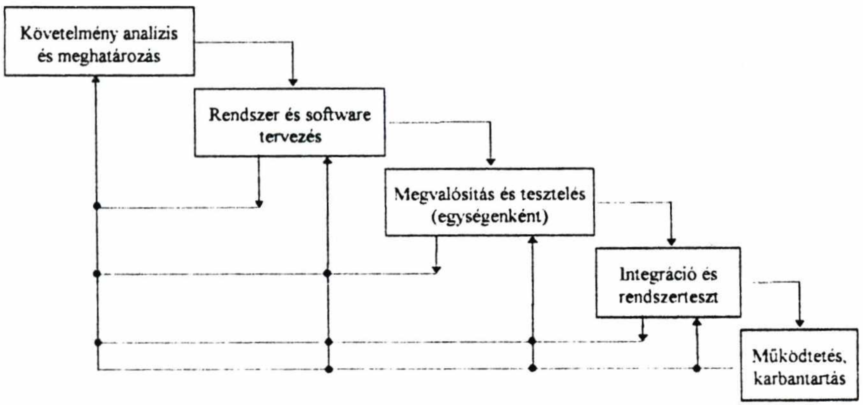
1.ábra A vízesés modell alapfolyamata

Az ezen fázisok során elkészült termék már a felhasználóhoz kerül. A folyamatnak azonban nincs vége, mindössze a tervezésnek. Minden mérnöki tevékenység vége a karbantartás kell legyen, tehát van egy - az ábrán nem mutatott - ötödik fázis is:

- *Működtetés, karbantartás:* Installálás, oktatás, hibajavítás, továbbfejlesztés, bővítés.

Ez az alapmodell. A dolog persze nem ennyire egyszerű. Munka közben előfordulhatnak különböző nehézségek, amelyek az előző tervezési fázis eredményének a helyességét megkérdőjelezhetik. A tervezés közben pl. kiderülhetnek a követelmény-feltárás problémái, kódolás közben pedig a tervezésé, és így tovább. Emiatt az egyes fázisok között visszacsatolás szükséges, melyet iteratívan kell alkalmaznunk (*2.ábra*). A visszacsatolás szabályozásához *ellenőrzés* (Jól csináltuk-e a dolgunkat?) és *kiértékelés* (Tényleg ez kell a felhasználónak?)szükséges. Mivel munkacsoportok esetében a különböző fázisokat nem feltétlenül azonos emberek csinálják, ezért szükséges, hogy a kiértékelés eredményét is jól dokumentáljuk.

A modellel kapcsolatban felmerülő probléma a rugalmasság hiánya. Ugyanis egy következő lépcső megvalósításához az előzőben már egy lerögzített specifikációt kell adni, és csak a megvalósítás után derül ki, hogy az jó volt-e. Ha nem, akkor újabb specifikáció készítése szükséges.



2.ábra Iteráció a vízesés modellben

Így együtt a tervezés, a kivitelezés, a működtetés, a karbantartás, valamint közben az ellenőrzés és a kiértékelés folyamatát a software életciklusának nevezzük.

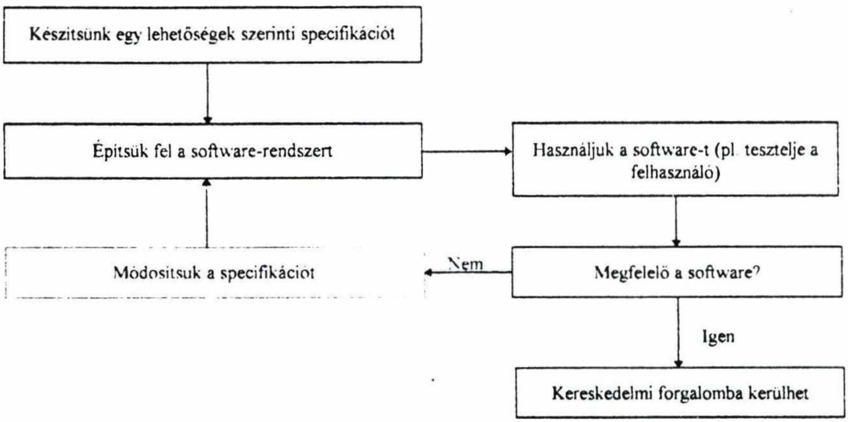
2.2 Felderítő programozás

A modellt a *3.ábra* szemlélteti.

A modell tartalmaz egy olyan fázist - ez a software-rendszer építése -, amelyet további két lépésre bonthatunk, mégpedig a következőkre:

- Software tervezés és
- Kódolás.

Olyan esetekben használható modell, amikor valamiért nem készíthető részletes és pontos specifikáció. Emiatt főleg MI rendszerek tervezésére használatos, és csak igen ritkán nagy, hosszú életciklusú rendszerekhez. Ennek három fő oka van:



3.ábra Felderítő programozás

- Nagy munkát igényel és sok dokumentációt eredményez.
- A modellből adódó folyamatos változtatások összekuszálhatják a software tiszta szerkezetét. Mivel nagy rendszerek esetén a karbantartók általában nem ugyanazok, mint a fejlesztők, ezért a karbantartás idő- és költségigénye jelentősen megnő.
- A nem kellőképpen elkészíthető specifikáció alapján történő munka kiváló fejlesztő szakembergárdát igényel. Leghatékonyabban a kis teamek tudnak együtt dolgozni. Kis csoportnak viszont nehéz feladat egy nagy rendszer elkészítése.

A modell hatékonyságát növelhetjük, ha az első néhány iteráció után, amikor a specifikáció már kielégítő pontosságot ért el, áttérünk egy másik modell használatára.

2.3. Software prototípus készítés

Ez egy olyan programtervezési módszer, amely egy prototípus elkészítésével a felhasználói követelmények kielégítésének hivatott minél nagyobb mértékben eleget tenni. Így teljes ellentétben áll a hardware prototípussal, amely általános esetben a design kiértékelésére szolgál.

A prototípus készítés előnyei:

- Segít eloszlatni a félreértéseket a felhasználó és a tervezők között a rendszerfunkciók bemutatása során.
- Segít felderíteni a hiányzó szolgáltatásokat.
- Segít kiszűrni a használati nehézségeket.
- Segít az alapvető hibák és következetlenségek feltárásában.
- A prototípus szolgál alapul a termék minőségi specifikációjának megírásához.
- Rövid fejlesztési idővel rendelkezésünkre áll egy működő rendszer - habár korlátozott lehetőségekkel. Demonstrálhatjuk vele a működőképességet, valamint a használhatóságot.

2.4. Formális átalakítás

Ez egy módszer formális specifikáció készítésére. Ennek eszköze valamely leíró jelrendszer kell legyen, amelynek szókészlete, szintaxisa és szemantikája formailag definiált, s amely egyértelmű kiértékelést tesz lehetővé, hogy megállapíthassuk a specifikáció hiányosságait, hibáit, következetlenségeit. Ez a jelrendszer célszerűen a matematikai jelrendszer kell legyen. Az így nyert specifikáció alapján készíthetjük el a rendszersoftware-t. Előnyei között megemlíthetjük, hogy javítja a rendszer minőségét és csökkenti a költségeket.

A matematikai eszközöket magában foglalva, lehetőségeinek körét kibővítve és az érthetőséget javítva elkészítettek több különböző specifikációs nyelvet is, amelyek közvetve, vagy közvetlenül szolgáltatják a specifikáció dokumentációját. Ezek némelyike még prototípus készítésre is alkalmas.

2.5. Rendszer összeállítás többször felhasználható komponensekből

Előfordul, hogy a programrendszer összeállításakor olyan software-elemeket alkalmazunk, amelyeket egy régebbi alkalommal egy másik programhoz írtunk, de viszonylag általánosan használhatóra sikerültek. Az ilyen elemeket újrafelhasználható komponenseknek nevezzük, tervezésük természetesen célirányos is lehet. Bár ezen célirányos tervezés költségei kezdetben nagyok, ez hosszútávon (a beépítéskor) megtérül, mivel lényegesen lerövidül a fejlesztési idő. További előnyei:

- szabványok testesíthetők meg újrafelhasználható komponensekkel, valamint
- növeli a rendszer megbízhatóságát.

3. Irodalomjegyzék

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A FRÖCCSÖNTŐ SZERSZÁMGYÁRTÁS AJÁNLATTERVEZÉSI FOLYAMATÁNAK SZÁMÍTÓGÉPES TÁMOGATÁSA

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BEVEZETÉS

Egy vállalat versenyképességének biztosításához elengedhetetlenül szükséges, hogy az ügyfél egyedi igényeinek megfelelő terméket gyorsan, hatékonyan, jó minőségben állítsa elő. Ennek előfeltétele az ember és a technika harmonikus együttműködése, melyet alkalmas szervezeti formák, megfelelő technikai berendezések és a feladatokhoz illesztett információs és kommunikációs rendszer támogat illetve tesz lehetővé.

Megállapítható, hogy a modern informatika lehetőségei jelenleg a fröccsöntő szerszámgyártásban csak részterületeken, szigetszerűen, és túlnyomó részt a CAD/CAM eljárásláncban használatosak. A költségtervezésre már néhány módszert kipróbáltak, de még hiányoznak azok a rendszerek, melyek lehetővé tennék az ajánlatkészítés és megrendelés lebonyolítás folyamatának átfogó számítógépes támogatását.

A FRŐCCSÖNTŐ SZERSZÁMGYÁRTÁS

A megoldási eszköz keresésénél a fröccsöntő szerszámgyártás alábbi sajátosságait kell figyelembe venni:

- a szerszámok igen bonyolultak, akár több száz alkatrészből is állhatnak,
- jellegzetesen egyedi gyártás,
- a termék részleges (koncepcionális) definiálásakor is már nyilatkozni kell az árról illetve határidőről,
- ügyfél változtatási igényei a termelési lánc bármely szakaszában felléphetnek.

AZ AJÁNLATKÉSZÍTÉSI FOLYAMAT

Az ajánlatkészítés folyamata az ügyfél ajánlatkérésétől az ajánlati ár és határidő meghatározásáig terjedő folyamat.

Grabowski szerint az ajánlatkészítés az alábbiak szerint definiálható: ügyfélspecifikus problémamegoldásoknak a termékforgalomra irányuló kidolgozása, melyek nem kifizetődő előzetes teljesítmények, azonban a megbízásokhoz szükségesek, és a vállalat gazdaságosságát figyelembe véve képviselhetőek.

Az általam vizsgált szerszámgyártó cégnél az ajánlatkészítésből megvalósult megrendelések aránya 10%. Mivel az ajánlatkészítés így 90%-ban nem megtérülő tevékenység, igen fontos, hogy gyors és pontos ajánlattétellel (vagyis az ajánlatkészítés eredményességének emelésével) csökkentsük a nem megtérülő ráfordításokat.

A szerszámgyártásban az ajánlatkészítésnek az alábbi feladatai vannak:

- a szerszám műszaki tervezése illetve megoldásvázlatok készítése,
- a költségek kalkulálása és az ár megállapítása,
- a szállítási határidő megállapítása,
- jogi kondíciók meghatározása (szállítási fizetési illetve garanciafeltételek).

A pontos és gyors ajánlatkalkulációnak óriási szerepe van a vállalat eredményességének emelése szempontjából. Az ügyfél döntésének meghozatalakor több ajánlat közül választ. Ebben a döntési folyamatban az ajánlott szállítási határidőnek legtöbbször nagyobb súlya van, mint az árnak. (Például az adott divatcikk minél hamarabb kerüljön a piacra).

Az ajánlatkészítési folyamatot a vevő ajánlatkérése indítja el. Az ajánlatkészítés, az ajánlat elkészítéshez szükséges vevőtől származó adatok összegyűjtésével kezdődik. Ez a legtöbb esetben egy CAD rajz a szerszámmal gyártandó termékről, valamint a vevő egyéb specifikációi a gyártandó szerszámról. A szükséges információigényből összeállított táblázat alapján ellenőrizhető a kapott információk teljessége.

Ezzel a lépéssel párhuzamosan az ajánlatkérés értékelése is elvégezhető, ahol a vevő korábbi ajánlatkéréseinek adatai alapján az ajánlatkérést minősítik aszerint, milyen valószínűséggel várható belőle megrendelés.

Az ajánlatkérés értékelése és az információigény összeállítása után következhet a műszakilag és gazdaságilag optimális szerszámkoncepciók kidolgozása és ellenőrzése. A megoldási koncepció kidolgozásánál a vevő követelményeit (ár, határidő, sorozatnagyság stb.) maradéktalanul figyelembe kell venni. A már létező illetve hasonló megoldások kikeresésére számítógépes keresőrendszer alkalmazandó. A megoldási koncepciónak tartalmaznia kell a szerszám működésének leírását (beömlési rendszer, kiformázás, hűtés, kidobás stb.), a szerszámmozgásokat, bontásokat, a szerszám geometriai tervét, fő szerszámanyagokat, fő technológiai előírásokat a vevő kérésének mélységéig.

A megoldási koncepció lezárása és zsűriztetése után a részfeladatok határidőinek megállapítása és a gyártási hálóterv összeállítása következik (durvaprogramozás). A részhatáridők megállapításánál statisztikai időnormák és a hasonló szerszámok tapasztalatai segíthetnek. A gyár termelőkapacitásainak jövőbeni terheltségének ismeretében a vevő által kívánt határidő betartása különböző költséggel (pl. túlóra) járhat, melyet az árképzésben figyelembe kell venni. Belső kapacitások hiánya esetén külső kapacitások keresését már ennél a pontnál el lehet kezdeni.

A szállítási határidő megállapítása után következik az önköltség kiszámítása, mely üzem specifikus költségfüggvények és kalkulációs algoritmusok alkalmazásával történhet. Lehetővé kell tenni, hogy a már legyártott termékek utókalkulációs adatai valamint munkatervei rendelkezésre álljanak az ajánlatkészítésnél.

Az ajánlatkérés „komolyságának" függvényében, még az ajánlat elfogadása előtt leköthetők a belső termelési kapacitások.

Az ajánlati ár képzésénél a vállalat költségfedezeti pontjait és nyereségcélját kell figyelembe venni. A végleges árképzésnél a kapacitások terheltségi szintje, a megbízások volumene, a versenyhelyzet, a lehetséges konkurens ajánlatok és az ajánlat jelentősége (várható-e további ajánlat) játszik szerepet. Amennyiben a kalkulált ár vagy határidő eltér a vevő által megszabottól, de van lehetőség arra, hogy a vevő egy másik szerszámkoncepciót is elfogad, akkor alternatív szerszámkoncepció kidolgozása is érdemes.

Az utolsó munkalépésben létrehozzák az ajánlattevő dokumentumokat, majd azokat az árral, a szállítási határidővel, valamint a szállítási- fizetési és garanciateljesítési feltételekkel az ajánlatkérőnek továbbítják.

INTEGRÁLT SZÁMÍTÓGÉPES TÁMOGATÁS

A fenti folyamat integrált számítógépes támogatásának eszköze az *Engineering Data Management* (EDM) lehet, mely egy új termék fejlesztésénél, módosításánál illetve a termék teljes életciklusa alatt előállított és felhasznált valamennyi adat illetve folyamat egységes, strukturált és konzisztens kezelését jelenti. Az EDM rendszerek olyan információs platformokként funkcionálnak, melyek a termékfejlesztési folyamatoknál szükséges rendszereket (pl.: CAXX alkalmazások, Office programok, NC tools-ok stb.) interfészeken keresztül egységes rendszerré kapcsolják össze. Az EDM rendszerek alkalmazásával megteremthető az integrált adathozzáférés és biztosítható az adatkonzisztencia. Az adott rendszerek adatai (pl.: darabjegyzékek, CAD rajzok, dokumentumok, projekt és munkatervek stb.) mellett, a folyamatok és azokkal kapcsolatos tevékenységeket is kezelik illetve irányítják.

Az EDM rendszernek semleges platformon általános adatkezelési funkciókat (pl.: keresési és adminisztrációs funkciók) kell megvalósítania. Az ajánlatkészítés szempontjából itt különösen nagy jelentősége van különböző hasonlósági kritériumok alapján történő kereséseknek, valamint a különböző termékvariánsok és azok darabjegyzékeinek tárolásának.

Az EDM rendszereken belüli Workflow-management funkciókkal termékenként követhető a folyamatok előrehaladása, és vizsgálhatók az azokat gátló okok. Fontos eszköz lehet az egyes folyamatok költségeinek mérésénél is. Alkalmas ügymenetkezelő rendszerekkel nemcsak egyazon folyamat intézéséhez kapcsolódó információk mozgathatók, hanem az ügyintézést automatizáló alkalmazások létrehozása, az adminisztratív folyamatok javítása, sőt időről időre való áttervezése (reengineering), esetleg megadott körülmények közötti optimalizálása is lehetséges.

A rendszer architektúrája nyitott, szabadon konfigurálható valamint moduláris felépítésű kell legyen ahhoz, hogy egy folyamatosan változó vállalat igényeit kielégíthesse. Az egységes felhasználói felület biztosítása érdekében azt a rendszer architektúrájában el kell választani a az alkalmazásoktól.

Adatmodell a termékstruktúra leképezésére

Az egységes adatkezelés alapja a terméket leíró információnak valamennyi vállalatterület követelményeinek megfelelő strukturálása. Minél több vállalatfunkció integrálását csak úgy lehet elérni, ha valamennyi terület egy egységes termékstruktúrát használ. Ezt a termékstruktúrát úgy kell definiálni, hogy az ajánlatkészítésben jelentőséggel bíró valamennyi vállalati területet támogassa.

Az adatmodellnek a fröccsöntő szerszámgyár speciális követelményeit és összefüggéseit kell leképeznie, és biztosítani kell annak bővíthetőségét. Az adatmodellnek lehetővé kell tennie a termék teljes életciklusa során megvalósuló változtatások leképezését is. Az adatmodell megtervezésénél különös jelentősége van az egyes változtatások miatti adatváltoztatások összefüggéseinek előzetes tisztázásának.

Az egyedi és kis-sorozatszámú termékek strukturálásához a gyártmánynak egyre kisebb komplexitású csoportokra történő felosztása kínálkozik. Ehhez a mindenkori gyártmányspektrum csoportosítása vezet el. A fröccsöntő szerszámok alkatrészeinek felosztása funkcionális szempontok vagy gyártási szempontok szerint lehetséges. Az ajánlattervezés műszaki és gazdasági feladatainak megvalósításához a funkcióorientált struktúrák felelnek meg. A szerszám funkcióorientált felosztásával funkciócsoportokat, majd további felosztásával funkcióelemeket kapunk. Ennek bázisát egyszerű szerszámstruktúrák és azokhoz rendelt jellemzők képezik. Egy funkcióelem meghatározása az ahhoz tartozó jellemzők meghatározásával történik. Egy fröccsöntő szerszám az alábbi funkciócsoportokból állhat: szerszámfelépítmény, beömlőrendszer, kidobórendszer, fűtő rendszer, formázó rendszer stb.). Egy funkcióelem kikeresése a hozzá köthető jellemzők (attribútumok) alapján lehetséges. A DIN 4000/4001 szabvány alkalmazása ezen jellemzők rugalmas bővíthetőségét is figyelembe veszi.

Az ezen alapuló metodikával a vállalat teljes termékpalettája áttekinthetővé válik, és egy hierarchikus struktúrává alakul. Lehetővé válhat az ajánlatkészítési folyamatban a szükséges információkhoz való gyors hozzáférés, és azok közötti keresés.

Újrafelhasználható objektumokat (pl. reprezentatív szerszámok illetve funkciók) lehet felépíteni, melyeket a tudásbázis tárol. A tudásbázis tanulási képességét az újonnan gyártott szerszámmal történő feltöltése biztosítja.

Munkatervek leképezése

Az ajánlatkészítésekor a korábbi munkatervekben meglévő információkat is felhasználják a költség illetve határidő kalkulálásakor. A munkatervben levő információkat 3 területre lehet felosztani. Az első terület a munkatervhez tartalmaz adatokat, mint pl. azonosítószám, érvényességi feltételek, származási adatok. A második terület a munkadarab megmunkálása előtti (kiinduló állapot) és a megmunkálás utáni állapotáról (kész állapot) tartalmaz adatokat. A harmadik terület foglalja össze a munkalépés sorrendet és a munkalépésektől függő adatokat.

Alternatív megmunkálási lehetőségeket illetve a munkalépések alternatív szekvenciáját alternatív munkatervekben rögzíthetik. A lehetséges munkalépés struktúrák leképezhető állapotorientált hálómodellekké (Beckendorf, FLEXPLAN), melyeknek előnye, hogy ajánlatkészítéskor alternatív megmunkálási lehetőségek és alternatív megmunkálási sorrendek is kereshetők.

ÖSSZEFOGLALÁS

Napjainkban az informatika nem csupán az üzleti folyamatok egyszerű kiszolgálására alkalmas, hanem stratégiai eszközként is felhasználható új piaci szegmensek meghódítására. A technológiai beruházások egymagukban nem elégségesek, az informatikai rendszerek bevezetésének ki kell terjednie az üzleti folyamatokra és az emberekre is, mivel csak így lehetséges az informatika segítségével egy hatékony vállalatot megalkotni. Ehhez lehet eszköz az integrált számítógépes támogatása az ajánlatkészítési folyamatban

Tartalom/Content