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par

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Design of a product oriented CAD/CAPP integration system

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Avertissement

Abstract

CAD (Computer Aided Design) is one method and technique that uses the computer's hardware and software system to assist people design products or projects. It includes such designing activities as design, plot, project analysis and technological file's execution, etc. It is not only a new designing method but also a multi-subject comprehensively applied new technology.

CAPP (Computer Aided Process Planning) is the manufacturing and processing course that uses computer to assist design the parts. In a narrow sense, it mainly refers to the completion of processing design and outputting process regulations.

On the basis of analyzing and studying PDM system's function, this thesis carries out the research on the key technology of CAD and CAPP integration. The main research contents are summarized as follows:

1: Study the key technology together with its realization method of CAD/CAPP integrated system based on PDM; build up the product-faced integrated system's framework; realize the integration of the enterprise's applied system that is based on file management and with the shared database as its basis.

2: Construct the knowledge-based product's modularized model and the product's information management system; study the expression and management technology of the product's design information facing the product's life cycle.

3: Apply the product's structure based information integrated technology and modularized design technology to the construction of CAD subsystem, thus realize the development of deformed product faced CAD subsystem.

4: Adopt the feature and product's structure based parts' information inputting technology to study the product's structure based processing information model construction technology.

5: Adopt such multi-technics decision mixture technology as interaction, searches, recension and creation, etc. with the repository as the core to study the repository based flexible process decision making mode.

6: Study the organic amalgamation technology of the multi-technologies in the CAPP fast development tools system, including the feature and product's structure based parts' information inputting technology, flexible process decision making technology, COM based subassembly technology and modularized process design technology, etc.

The following knowledge can be learned from this thesis:

1: How to realize the interconnection and interoperation among distributed application systems, application systems and multi isomeric data source.

2: How to draw ideas and technology of PDM into CAD/CAPP intergradations.

3: How to realize derivative design of products.

4: To improve the ability in dealing multi database documents, the design of program frame and the planning of systematic flow.

In this thesis, the following points are unique and creative:

1: The characteristics of integrated technology are stressed, which make CAD and CAPP phases of product design integrate organically.

2: Obtain the CAD mode of the design parts from PDM database. Through the interactive interface offered by the system, finish the parts' information input based on the feature in the way of man-machine interaction.

3: The process data will be more structural and normative, if we make the product structure the basis for CAPP system to organize process design.

4: The organic integration of four decision-making modes by this system will not only meet the advanced manufacturing mode's needs represented by the agile manufacturing, but also the practicality of factory

Key words: CAD, CAPP, PDM, the integrated system, twice development

Preface

In the course of writing this thesis, I have got the full cooperation of the adviser YangShuYing and professor ZhuShiHe and professor Zheng QingChun and the student ZhuShiJun who was in a seminar with me . Because of their help the thesis could be finished smoothly. I express hearty thanks to them.

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List of Acronyms

CAD ---------Computer Aided Design.

CAPP---------Computer Aided Process Planning

CIM----------Computer Integrated Manufacturing

CIMS---------Computer Integrate Manufacture System

PDM----------Product Data Management

COM----------Component Object Model

CBC----------The COM based component

CAM----------Computer Aided Manufacturing

BOM----------Bill of Material

Chapter 1

Introduction

With the development of computer's integrated manufacturing technology, people have realized day by day that CAD (Computer Aided Design) and CAPP (Computer Aided Process Planning) are the main technological foundations for information integration. So, the development of integrated CAD and CAPP system is not only the demands of information integration, but also the developing trend of CAD and CAPP.

In the integrated environment the components of the system's data are quite complicated. There are structural data information and a great number of non-structural data; there are anomalies of data sources and allopatric distribution; there are also independently designed data source that exists in each isolated island system. All these data sources should exchange and share information, as well as keep relative independence and local integrality. One of the key points of CAD/CAPP integrated technology is how to realize the interconnection and mutual operation among the distributed application systems as well as the application systems and many kinds of anomalies of data sources; and how to realize the sharing and distribution of data on grounds of all types of data sources. [4]

PDM (Product data management) technology appears under the demands of data management in the enterprise's computer manufacturing environment and the automation in the design process in the late 1980s. It can provide a cooperative environment for product development, under which the processed controlled information transmission and the orderly management of the data can be realized. Ed Miller, the president of CIM (Computer Integrated Manufacturing) data Company, points out in <PM Today> that PDM is a technology used to manage all the information related to products(Including parts , configuration, graph file, CAD files , structure , authority ,etc) and all the processes related to products (Including work flow , change flow, etc.). It can effectively define, organize and manage the product data at every stage of its whole life cycle from conceptual design, computational analysis, detailed design, process design, processing and manufacturing, experimental verification, sales and maintenance to the products' dying out according to certain mathematical model in order to make the product data consistent, newest, sharing and secure throughout the whole life cycle. It offers the information management of cycle of the product's whole life cycle. It builds up a deserialized cooperative environment when the enterprises design and manufacture the products. As soon as PDM system appears, it becomes a hot point of application and attracts enterprises' attention.

In recent years, PDM technology has already developed very quickly. As CAD system, CAPP system and PDM system are used in the CAD/CAPP integrated system, types of product data involved diversify, for example, three-dimensional entity, two-dimensional drawing, BOM (Bill of Material) form, etc.. As the product data management technology is developed on the basis of database and its starting point for application is to manage the product data well, it can manage effectively the shared product data, thus PDM becomes the technology of information integration, function integration and process integration in every system of enterprise.

The integrated technology of CAD, CAPP is the key technology in CIMS (Computer Integrate Manufacture System) integration. PDM is the new technology managing all information and processes related to products developed on the basis of database. The PDM based integration is the developing direction of future CAD, CAPP, and CAM (Computer Aided Manufacturing) integration. In recent years, PDM based CAD/CAPP integrated technology has already got much concern from researchers. Product structure based CAD/CAPP integration has got recognized, too. But most researches focus on the study of data and product model integrated. Moreover the integrated technological characteristics under PDM frame, the organic fusion of the product design's CAD and CAPP period research on integrated CAD and CAPP unit need further researches. So the subject introduces the thought and technology of PDM in CAD/CAPP integration to construct the CAD/CAPP integrated system based on PDM frame, and to study the key technology of CAD/CAPP integration.

In a word, the emphasis of the research includes the following three respects:

1: CAD/CAPP integrated modeling technology under PDM frame.

2: CAD unit technology under CAD/CAPP integrated environment.

3: CAPP unit technology under CAD/CAPP integrated environment.

The main content of the thesis is:

Chapter 1: Introduction.

Chapter 2: The second chapter of the thesis generally introduces the main functions of the CAD/CAPP integrated modeling based on the PDM frame and platform needed when it operates.

Chapter 3: The third chapter introduces the components of the frame of CAD subsystem, and elaborated on the critical technology of CAD system development, and introduces design process of CAD with Operation instances.

Chapter 4: The fourth chapter introduces system framework and Achieve flow (Realization flow) of CAPP unit technology, the critical technology of CAD system development, and uses system operation instances to prove it.

Chapter 5: Conclusion.

In the respect of unit technology of CAD and CAPP, study focuses on the PDM based CAD and CAPP technology, the combination of advanced design methods and means with PDM to set up the CAD and CAPP subsystem that can satisfy the products' fast design.

The product design target for this system's research is the products that need deformation design on grounds of existing product structure. Choose the hydraulic jar as the product target in the system's research and development to realize the development of CAD/CAPP integrated system based on PDM frame.

Specifically speaking of the system work distribution:

CAD sub-system :

My work :

1: Designing the functions realized by CAD sub-system.

2: Constructing SQL SERVER database of background.

3: Making use of VC++ to develop functional interface of outlook (including sub-modules of project management, source management and tool linking, and the second development of parameter).

4: Making use of the modeling tool CATIA of three-dimensional entity to establish model example in the system.

5: Testing in the latter period after compiling commissioning procedure.

The work of my supervisor :

1: Inducting me to pick up the technology fit for this system.

2: Constructing system frame, programming design flow.

3: Checking the testing result of the latter period.

CAPP sub-system :

My work :

1: Finish the flow of CAPP system's design under the guidance of tutor.

2: Finish the development of mutual surface in visualization system.

3: Finish two function blocks of CAPP system—input of spares information and process engineering, under the guidance of tutor.

4: List systematically the data in product database.

5: Unit testing in later period.

The work of my supervisor :

1: Constructing the system overall framework.

2: Directed the student finish the flow of CAPP system's design.

3: Directed the student fully realize the key technical of the CAPP fast development.

4: Finish two function blocks of CAPP system —process design and process plan.

5: Provide the product databases used by the process design.
6: Checking the testing result of the latter period.

Chapter 2

The CAD/CAPP integrated modeling base on the PDM frame and the skill of data management

Base the theory of WuRuiRong in his book I learned that the construction of CAD/CAPP integrated system uses the PDM frame based integrated platform of customer/server system. On the one hand, it can effectively manage the data and files produced by the various system integrated application software (CAD, CAPP); on the other hand, information sharing among the application software, cooperative work among users, consistency of the data objects between application system and management system and the integration of design information and management information under the system's environment can also be realized [6]. Fig 2-1 shows its specific integrated system frame. Its main functions are as follows:

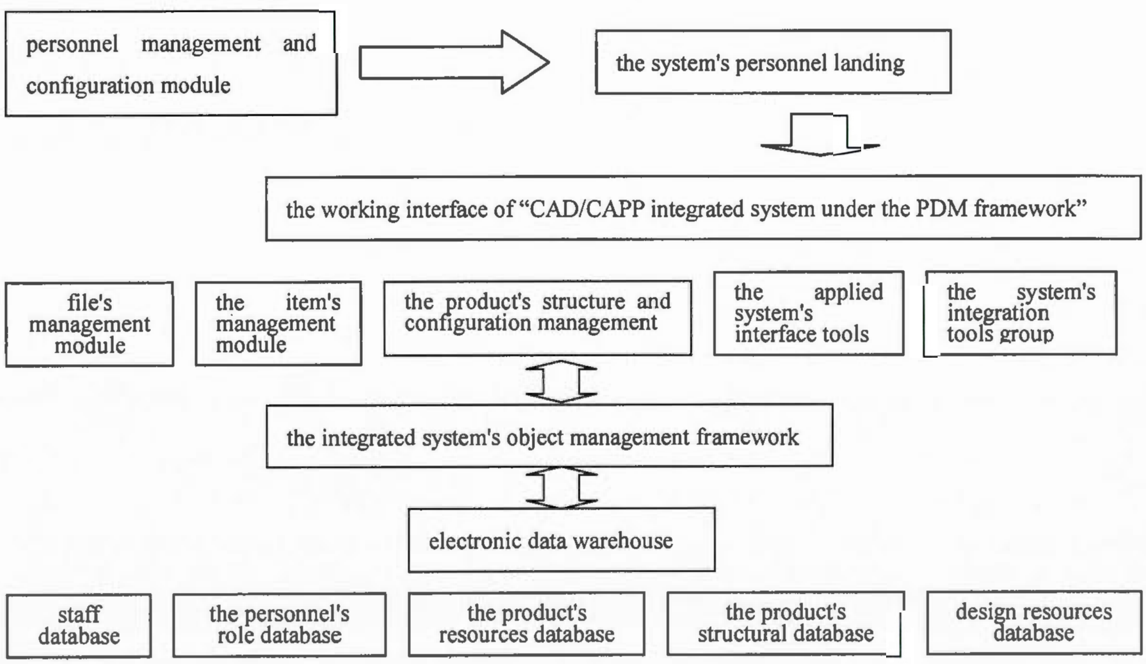


Fig 2-1 PDM based product CAD/CAPP integrated system frame

1. Item management module:

The system's item management function is set for managing the items. We need to make an item module to carry out the item management. Describe the item's assignment, personnel and time arrangement in the item module.

2. File management module:

The system takes the file folder and product structure BOM as the bridge linking parts objects with files; sets up the connection pointer among the file folder, file and parts through BOM; thus classified management to the products' different files is achieved.

3. Personnel configuration and safety management module:

The integrated system's personnel management function mainly involves the management of user, working group and role, etc. as well as the assignment of authority; meanwhile provides the solving schemes to such problems as ensuring the safety and security of the products' data management, etc.

4. The application system's interface tools:

As the integrated system running under net environment, the system provides the integrated interface for structure design subsystem and process design subsystem.

5. Product structure and configuration management:

The system's product structure embodies in the form of product BOM tree. The perfection of product structure and attribute needs the product function tree offered by the system. The system realizes the function of product function tree through the configuration and management of its resources.

6. The system's integrated tools:

Some relative design and calculating tools provided by the system.

Besides, the system is equipped with several databases to provide system support. The management of database and file is realized through electronic storehouse.

The system selects Windows 2000 Server as its operational platform that net runs; Visual C++ as its developing instruments which support the object faced program and has strong capacity of database development; uses the large-scale commercial CAD software-CATIA together with its twice developed API to complete the graph moduling and procedure graph generation; uses SQL Server net database as its background server's data management software.

CHAPTER 3

The CAD unit technology under the CAD/CAPP integrated environment

3.1 The frame of CAD subsystem

CAD subsystem completes the design assignment starting from user's order to the completion of the products' detailed design. I take charge of design and develop of this subsystem. This subsystem adopts modular design process; submits the product model with function information, space topological information, assembly information and product processing information. Base of the requirement I design the CAD subsystem includes 5 sub-function modules (Fig.3 - 1): item management sub-module, product management sub-module, function management sub-module, modular body management sub-module, tool collection sub-module.

1. Item management sub-module: realize such functions as item selection, item browsing, etc.

2. Resource management sub-module: realize such managements including product management, function management, the product structure tree management and modular body management etc. resource of this part is the basic data for the system's design.

-Function management tools as shown by Fig.3 - 1, realize the construction, edit and deletion of the function.

-The product structure tree management tool realizes the construction, edit and deletion of the product structure tree.

-Modular body management tool realizes the construction, edit and deletion of the function. Modular management subsystem. Realize such operations as addition, edit and deletion, etc. of the intelligent modular body as well as the clustering analysis; help classify and group the functions.

3. Tool collection offers the necessary design and calculating tools used in product design, such as check the thickness of jar's wall; check the stability of piston rod, etc. Moreover, it offers the interface with other analysis software (such as ANSYS, etc.).

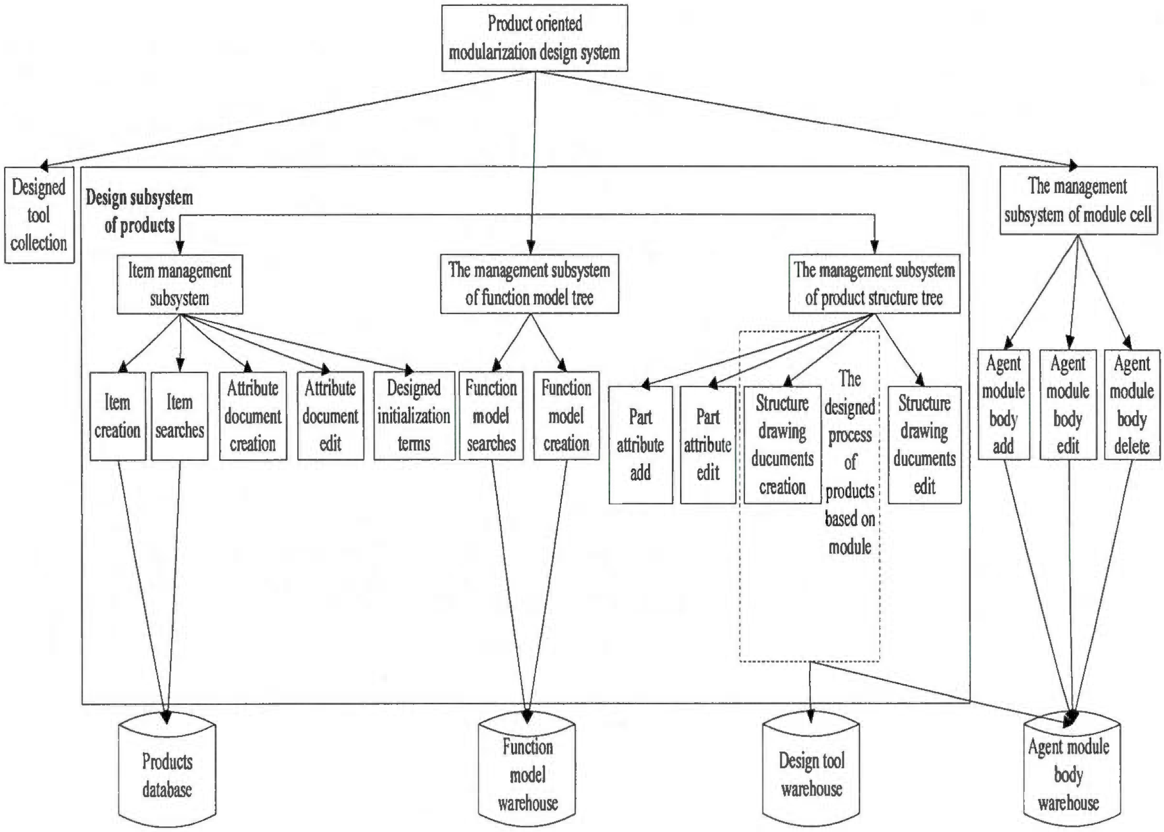


Fig 3 – 1The frame of CAD systematic

3.2 The crucial technology of CAD system development

3.2.1 Research content

1. The product's deformation design refers to: maintain the product's working principle and function, change the structure, configuration and size of the present product's components to make it adapt to the user's requirements. Take the hydraulic jar as an example. The hydraulic jar is the most frequently used execution component in the hydraulic system. It is widely used in such trades as machinery manufacture and jack-up transportation, etc. Products belong to seriation products. Standardization of hydraulic jar is prior in the hydraulic components. In the hydraulic component standard already issued, the proportion of hydraulic jar is the greatest. But in practical application, because there are many types of hydraulic jars, the installation way is also multiple, design structure of the hydraulic jar is various, meanwhile deformation design to the parameter and structure on grounds of standard jar is necessary according to the requirements on power, speed or journey, etc. in design.

The non-standard hydraulic jar design has the following 3 situations

-On the basis of standard jar, better design, and specific parts of the hydraulic jar or refit it.

-The non-standard hydraulic jar used some parts of other hydraulic jars.

-Totally non-standard hydraulic jar.

These situations adapt to other product deformation designs, too. There are four ways to realize the product deformation design.

-On the basis of standard module, the deformation design altering types or parameter--Horizontal series or vertical series of design;

-Module combination –cross-series design;

-Maintain the main function model. It is necessary to redesign one certain function module among them --Construct new module;

-Exert local changes on the function model.

The deformation degree of each deformation design is different. There are product-level deformation module-level deformation, combinatorial deformation, and simple deformation. Therefore the construction of deformation products faced design system should fully provide each deforming ways with technological support.

Meanwhile if define the products as the carrier in order to satisfy the user's needs and have relevant functions, then design becomes the course that describes the formation of sub-function together with its assembling into the whole function. Thus, I designed the Fig 3-2 shows the system's product design course.

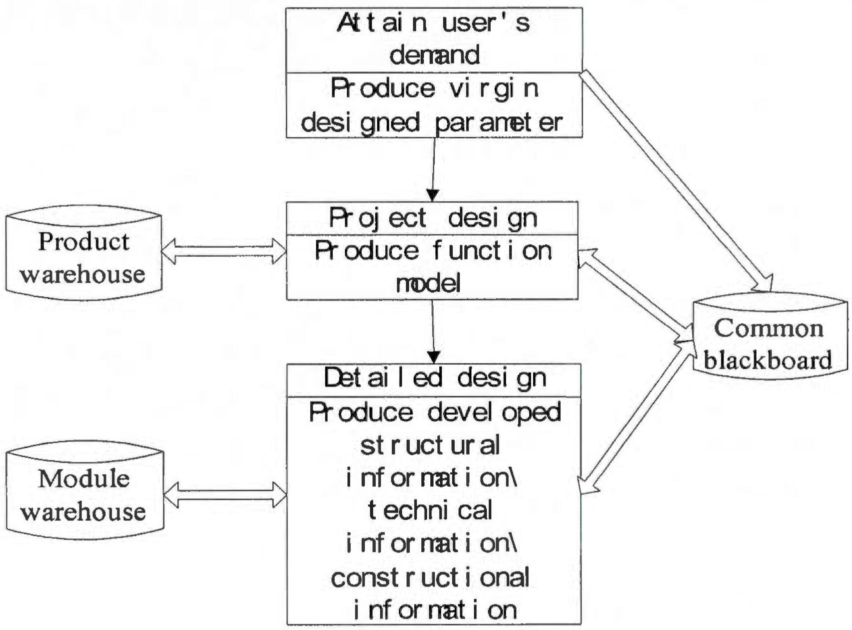


Fig.3-2 The designed process of products

(1) The user's needs are obtained

Designer inputs such primitive information of the design as user's demands, design condition, etc. into the system through man-machine interface. While the user's needs are obtained, the system has offered such measures as relevant parameter calculating, structure checking, etc. thus the key size and key structure can be determined according to the parameters' input by user; store them in the public blackboard as the primitive design parameter; offer the basis for the after design process.

(2) Scheme design

According to the user's needs, taking function as the goal, set up the products' principle structure frame--Function model; use the function model tree to express. The generation strategy of the function model tree is: Search the close function model from the existing products at first; quote or edit the function model until meeting the demands. If there is no close function model in the product base, designer can deal with the module through the system's function model and construct it. The system has offered the products' function model search, and such functions as addition, deletion and edit, etc. of the functional nodes. After the function model is confirmed, store the result in the public blackboard. After the design process of the products is finished, store the function model in the product base with the products, which can be taken as design resources and used by the enterprise's future design

(3) Detailed design

It is directed against the concrete primitive design parameter: the structure's specification and detailization on the basis of detailed design; design the product with high quality and low cost that meets the user's needs finally. Detailed design process refers to map the function model as the product structure model, that is, the product structure tree. After the detailed design is over, each node of the function model is described by concrete BOM and picture file.

The detailed design of the system has adopted the module based design method. Design principle is from simple to the complex; from horizontal and vertical series of design-> the cross-series design-> construct new module -> construct the new function model. Moduling adopts the intelligent module body. Intelligent module body adopts parameter design, variable technology, and comprehensive application of CBR technology, according to the design demands; design the structure meeting the demands. The intelligent module body adopts VC ++6.0 to develop.

When each function node has finished the detailed design; have already finished mapping the function model as the product structure model; when the products' design process is over, the system carries out the following two steps:

a. Store the products in the products base.

b. Taking the deformed module as a new instance, store it in the intelligent module body.

Through the above two steps, this design can be taken as the design resource, thus offer the basis for enterprise's future product design.

2. In a word I designed this Product design procedure of the deformation design

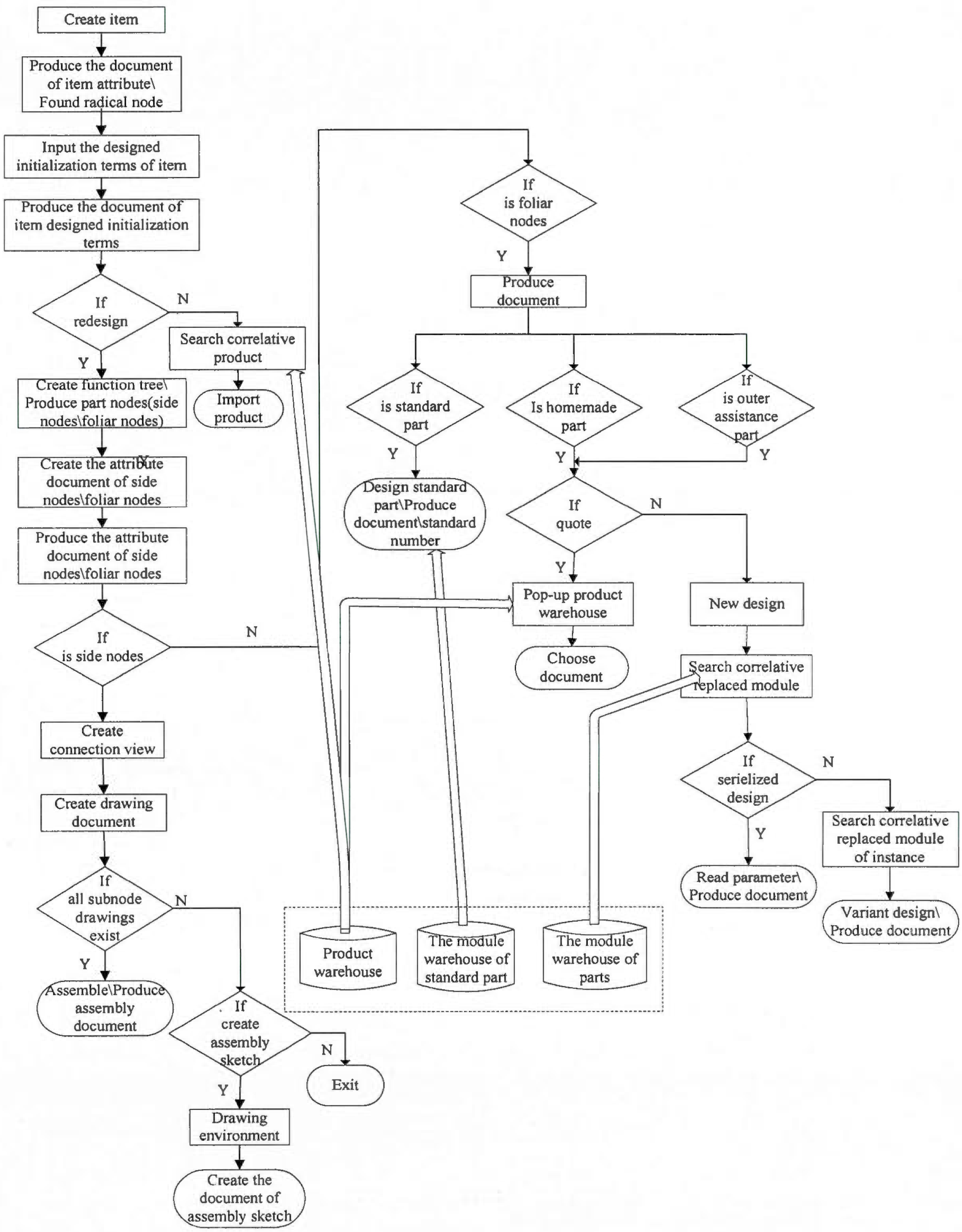


Fig 3-3 Product design procedure of the deformation design [9]

3.2.2 Construct the product model based on product structure

The product structure design process should face the whole life cycle of the product's development. The project data produced are transferred directly or indirectly through alternating to every application department of the enterprise for their analysis, manufacturing and purchasing. Through the management of product structure, organize the product information through the relation of product level assembly; connect all the project data and files that define the ultimate products, maintain and manage the product objects together with the connection among one another. The connection among product objects not only includes the multi –to-multi assembling relation between products, parts, assembly and components, but also other related data such as manufacturing data, cost data and maintenance data, etc[8].

All the data in enterprises related to products come from CAD system directly or indirectly. Through analyzing and summing up, the design information of the products can be summarized as two kinds abstractly: First: the attribute of the part itself, such as parts' name, code name, quantity, and materials; Second: the reciprocal subordinate relation in structure among parts. It is also called father-and–son relation too. Under the traditional serial integrated mode, CAPP system can relatively easily obtain the product's description information in the CAD's heading column of the blueprint through the form of data interface, but there is not ripe technological support to structural information.

The system takes "product structure tree" as the backbone, and collects、processes and deals with the product information. Assign every function or task of the system's each part reasonably to each dealt node through the tree-typed hierarchical structure, gather every node, taking which as a whole to complete a full assignment.

1. Product structure tree

The types of product structure tree's nodes and relevant describing files are shown by Fig 3-4. The types of node include: the product-level node, namely the root node; the part-level node, namely the branch node; the component-level node, namely the leaf node.

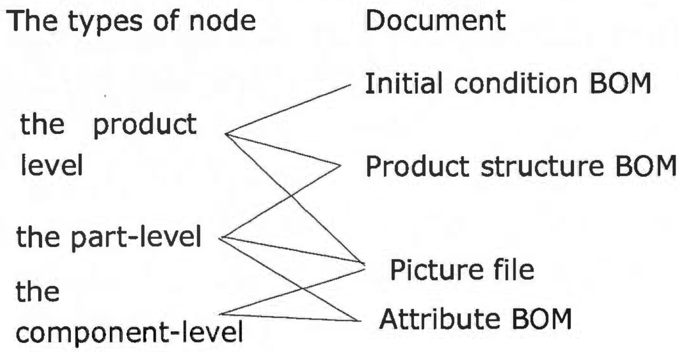


Fig3-4 The types of product structure tree's nodes and relevant describing files

Initial condition BOM (Bill of Material): Write down user's needs, for instance working pressure, load, reciprocating speed, journey and connecting way etc, and the key size determined through the intensity formula directly, such as diameter of the jar and thickness of the wall, etc.

Product structure BOM: Namely product structure tree. Write down the level relation of product structure; link the parts with relevant information as the mainstay.

Attribute BOM: Write down such nonstructural information as node number of the product structure BOM, parts' name, picture number of the parts, function, serial standard component, nonstandard one, number of the module, material type, material trade mark, designing date, designer, classification (international standard piece, self-made piece, external cooperation piece) design condition, remarks, type of parts, etc.

Picture file: Write down the topological information of the parts' structure produced by relevant CAD tools. CAD tools of this system adopt the three-dimensional entity software CATIA; use API to realize the three-dimensional parameter and variable design process of relevant parts.

The assembling connection graph: This is the special file of the component-level node.

2. Function tree and instance tree

Function tree: The tree is composed of abstract functional nodes.

Instance tree: After the detailed design, according to the mapping of function - structure, turns the functional node into the concrete structure. So the production of instance tree is the realization course of the products' detailed design.

3. The course of constructing the product model

The product information is frequently produced generously at all stages of the product's life cycle, and is shared by these stages. The product information includes two kinds of forms: structural information and non- structural information: Structural information refers to picture file and assembly association graph, etc., and generally unformatted files, stored in PDM electronic warehouse as files. The non-structural information refers to attribute of the parts, information of the heading column and related information of parts, etc. This information is stored in PDM database.

The course and way of production are: Set up function tree at first, then do the detailed structural design taking node as unit, describe the structural information produced by relevant picture file; store it according to certain rule.

When the design is finished, finally submit it to PDM. The information submitted is: attribute information of the products, structural information of the products, attribute information of the parts, structural information of the parts.

3.2.3 Product's design resources together with its management technology

The product's base and module base are the two main databases of the system. They are constructed taking MS SQL Server as the platform. With the product's development, store products' data and module data in it respectively as design resources to offer the instances for future design.

The product's base writes down the product's structure BOM (Bill of material) taking the product as the unit. Attribute BOM of the parts is the characteristic form of the things. Structure BOM describes the composition of the products and the assembly relation of parts; the attribute BOM records such characteristic attributes as the materials, technological condition, etc. of the products' each part.

The module's base adopts function cluster's analytical method; taking function as the core, organize and manage the structure that meets the same function.

Products' base is connected with the module's base through the "module symbol" in the attribute inventory of the parts. Through association, reduce the superfluous data; at the same time apply the products based structural design technology and module design method facing products' clan to the design and management of the products.

3.2.4 Knowledge expression of the products

The knowledge processing of the products adopts the hierarchical expression, and knowledge follows the knowledge subject closely. Specific realization is shown by the Fig.

System ---the knowledge used by system

Products --- the product-level knowledge

Module body --- the parts-level knowledge

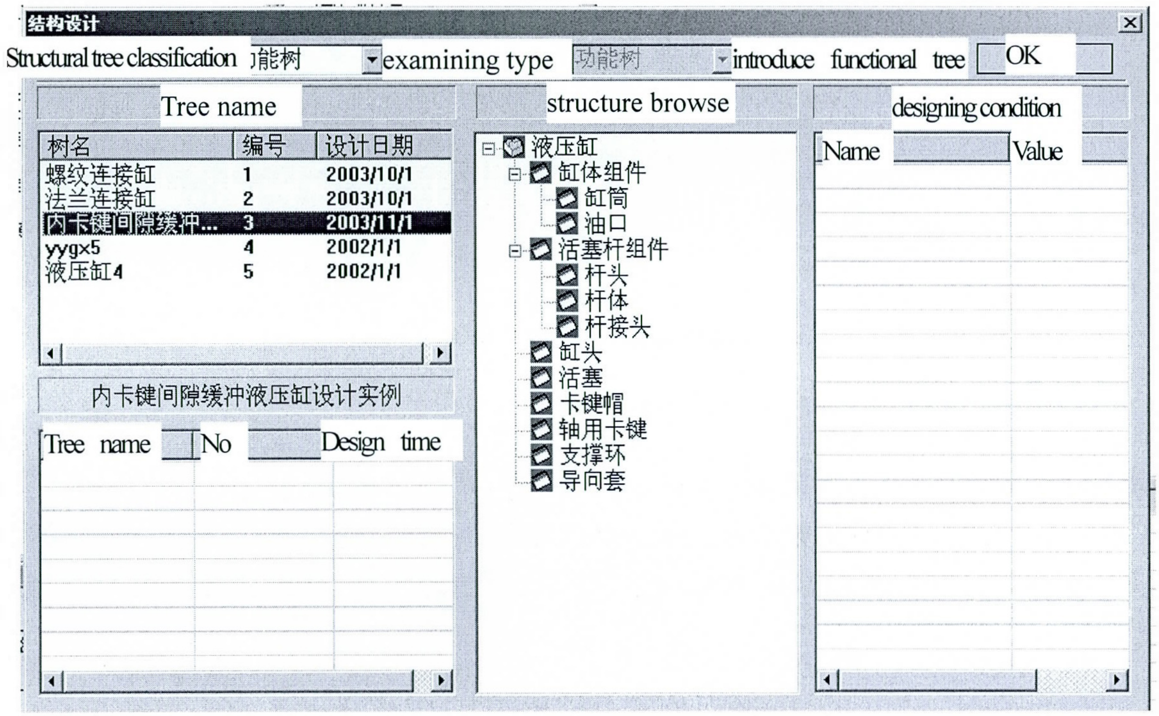
The operation method of the system's knowledge adopts the searching method based on example. The course of example searching adopts second searching tactics. First of all, carry out functional searching to search out the functional module body; do relevant example searching in the functional module body; if meeting the demands, quote directly, if not, revise example until meeting design requirements; and store the design result as a new example into corresponding functional module body as design resource to offer the basis for product's design of enterprises in the future.

3.3 Operation instances

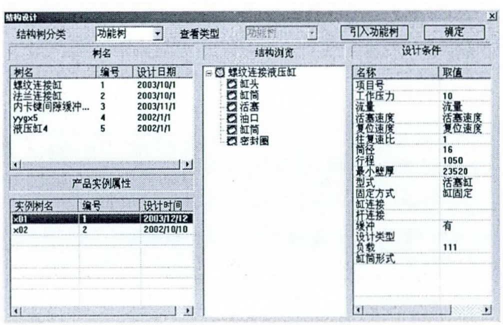
3.3.1 CAD design process

This part of functional interface and database of background finished by myself. First, log with legal user and role; choose the design project; read user's design information, and do relevant design calculation; determine the main design parameter; produce the product's function tree; detailed design; produce the product's example tree.

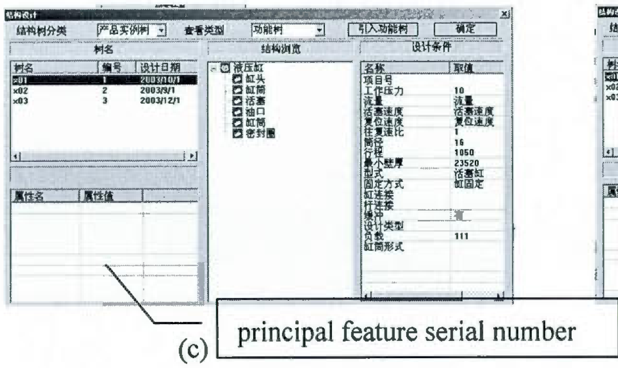
Product's structure design interface is shown by Fig 3-5. The product's structure tree can produce (c), (d), through leading function tree (a), (b) or directly producing other products' example tree. In the process of producing function tree, the system has offered the editing function to the function tree.



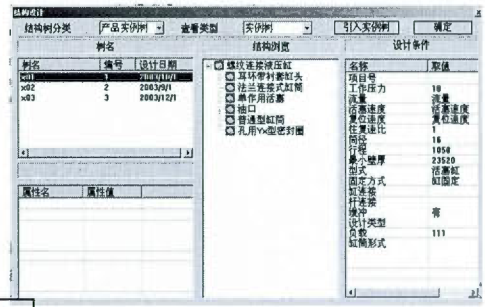
(a)



(b)



(c)



(d)

Fig 3-5 Products' structure design interface

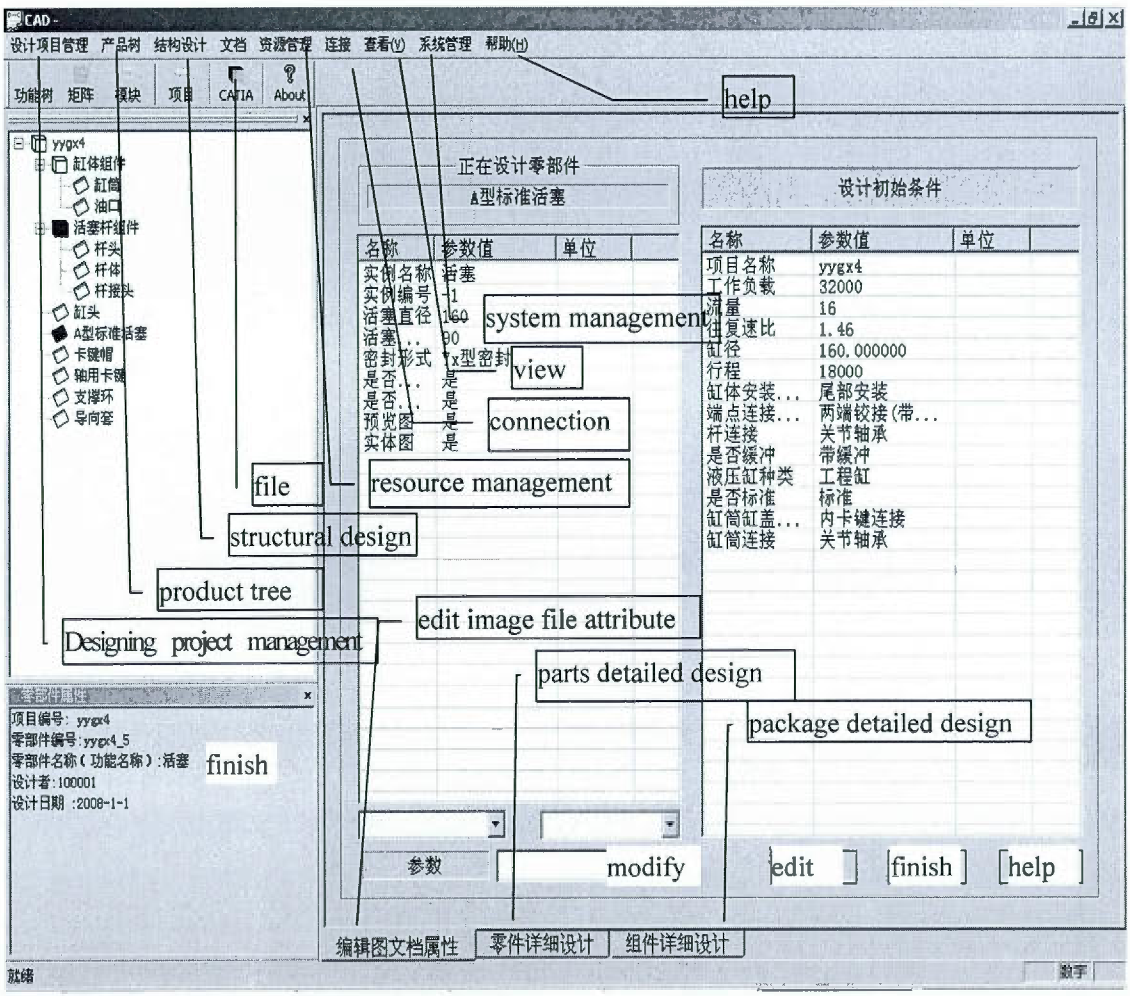


Fig 3-6

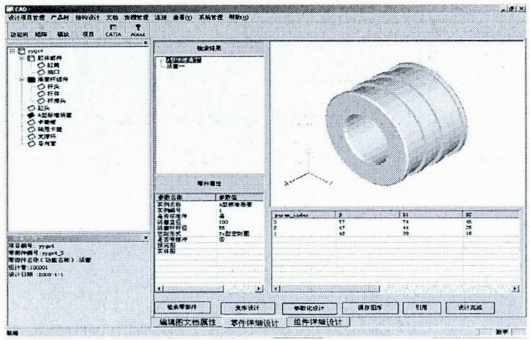
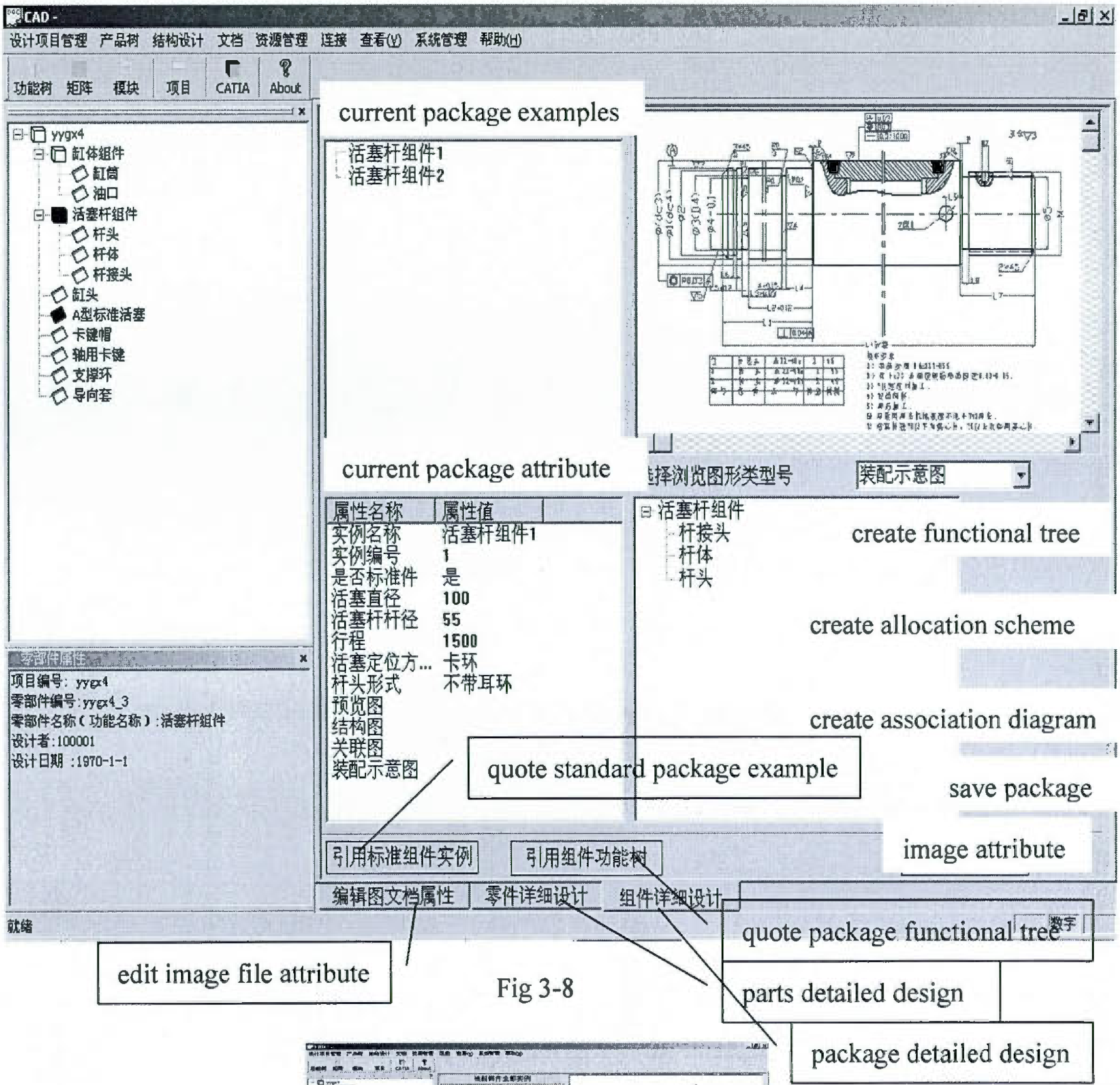


Fig 3-7

Parts' design process can be parameter design of the standard components (Fig.3-7), or the deformation design on the basis of similar parts. At this time, open CATIA and carry out relevant designs.

Because the components are assembled by several parts, the design of parts should reflect the top-down scheme design and bottom-up products' assembling process. So the component-level design tools offer the multi-vision picture of design information, such as using assembling sketch to express the product's design plan, using composition tree to express the composition of the components, using the association graph to show the connection and localization way of the components' parts; After the design of the components' sub- parts is finished, the bottom-up product assembling can be realized, and the assembly graph and two-dimensional project graph are produced (Fig. 3-8 , Fig. 3-9).


CAD -
设计项目管理 产品树 结构设计 文档 资源管理 连接 查看(V) 系统管理 帮助(H)
功能树 矩阵 模块 项目 CATIA About
yygx4
缸体组件
缸筒
油口
活塞杆组件
杆头
杆体
杆接头
缸头
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零部件编号: yygx4_3
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设计日期: 1970-1-1
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活塞杆组件2
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活塞杆杆径 55
行程 1500
活塞定位方... 卡环
杆头形式 不带耳环
预览图
结构图
关联图
装配示意图
选择浏览图形类型号
装配示意图
活塞杆组件
杆接头
杆体
杆头
create functional tree
create allocation scheme
create association diagram
save package
image attribute
quote standard package example
引用标准组件实例
引用组件功能树
编辑图文档属性
零件详细设计
组件详细设计
数字
quote package functional tree
edit image file attribute
parts detailed design
package detailed design

Fig 3-8

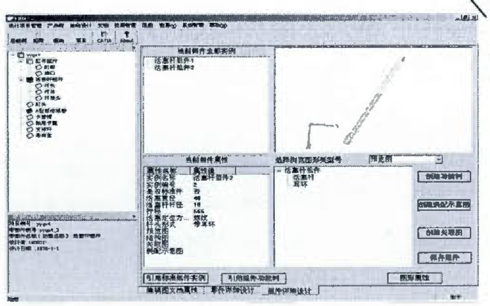


Fig 3-9

3.3.2 Demonstration of CAD system's other functions

Fig 3-10 shows the management interface of module body, which can describe the attribute customization to different functional module bodies, and add the structural examples.

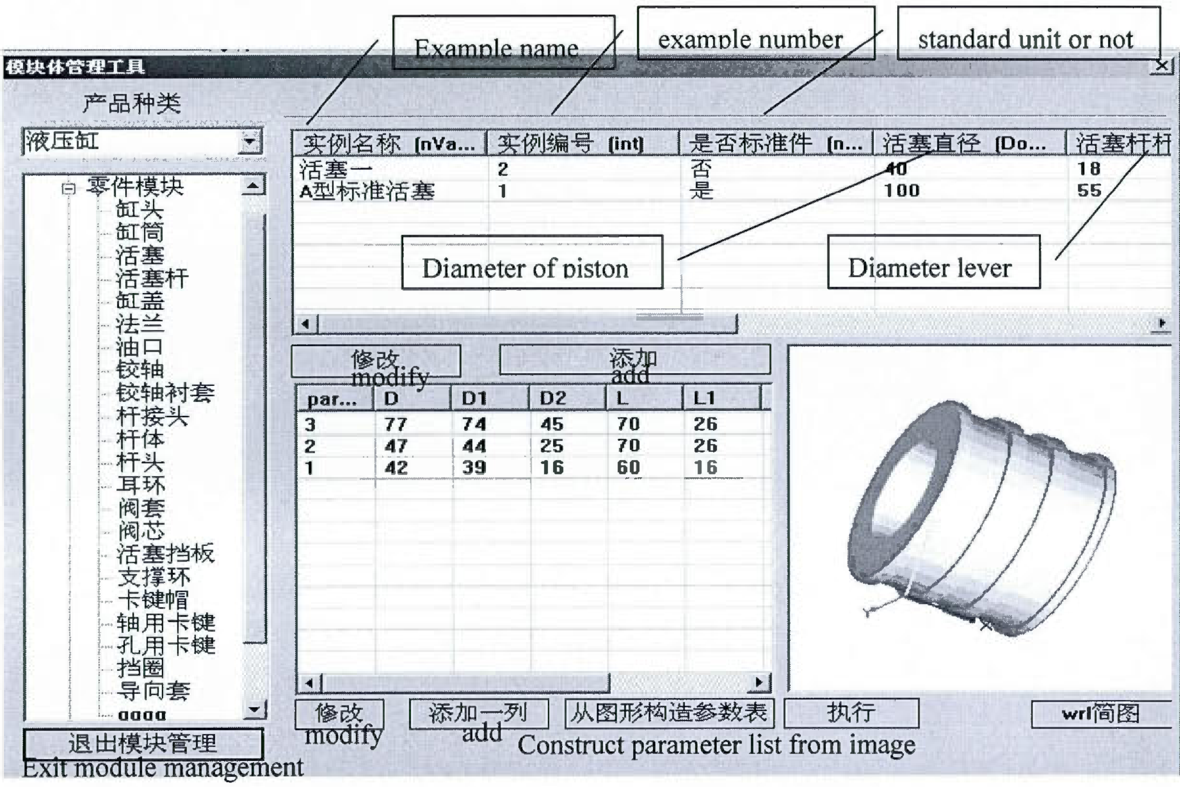


Fig 3-10

Chapter 4

CAPP unit technology under CAD/CAPP integrated environment

4.1 The system's framework

CAPP system framework constructed by my supervisor. See fig.4-1. The system consists of the following layers

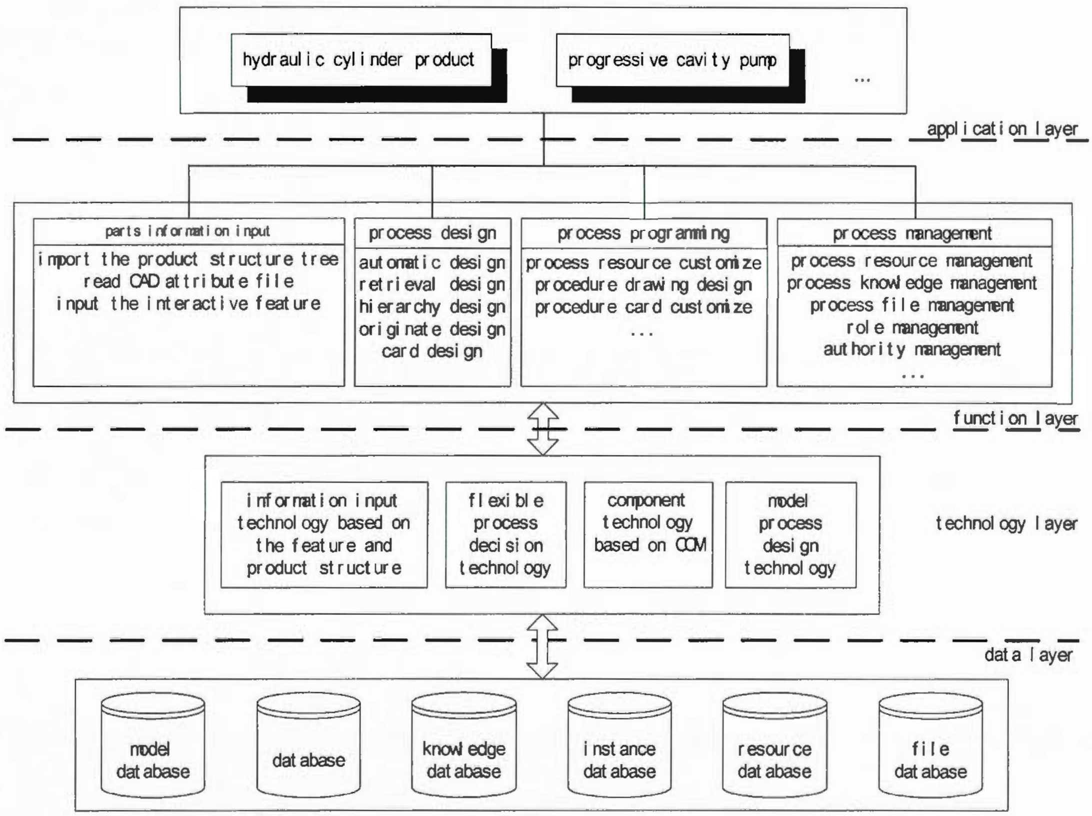


Fig 4-1 overall framework of the CAPP system

1 Application layer

Application layer is the interactive interface of visible system. It is used to control the whole system's normal running. It selects out the function of each sub-module according to the different requests and orders sent by user.

2 Function layer

Complete CAPP system's main functions which include:

(1) Input the parts' information

It adopts the method based on feature and product structure to finish the description and input of parts' information. Specific operation is as follows:

- Lead the product's structure tree: after CAD design has produced the design BOM of relevant products produce the process design tree of the products according to the parts' assembling relation
- In the process design tree's corresponding nodes, according to the course of module structure design, pick up and complete the information inputting of relevant parts through reading CAD's attribute file and interactive characteristics.

(2) Process design

According to the user's different requirements, use the floppy process deciding mode to finish the process design.

(3) Process plan

Finish the design of procedure graph, customizing the process card and process resources, etc.

(4) Process management

Finish the process knowledge management、process resource management、process file management、role management and authority management, etc.

3 Technological layer

Provide the key technology of CAPP's quick development. It includes information input technology based on feature and product structure, floppy process-deciding technology, COM based assembling technology and the modular process design technology.

4 Data Layer

It includes all the product databases used by the process design, such as: module base, database, knowledge base, example base, resource base and file base, etc.

4.2 Realization flow

The system's design flow is shown by Fig 4-2

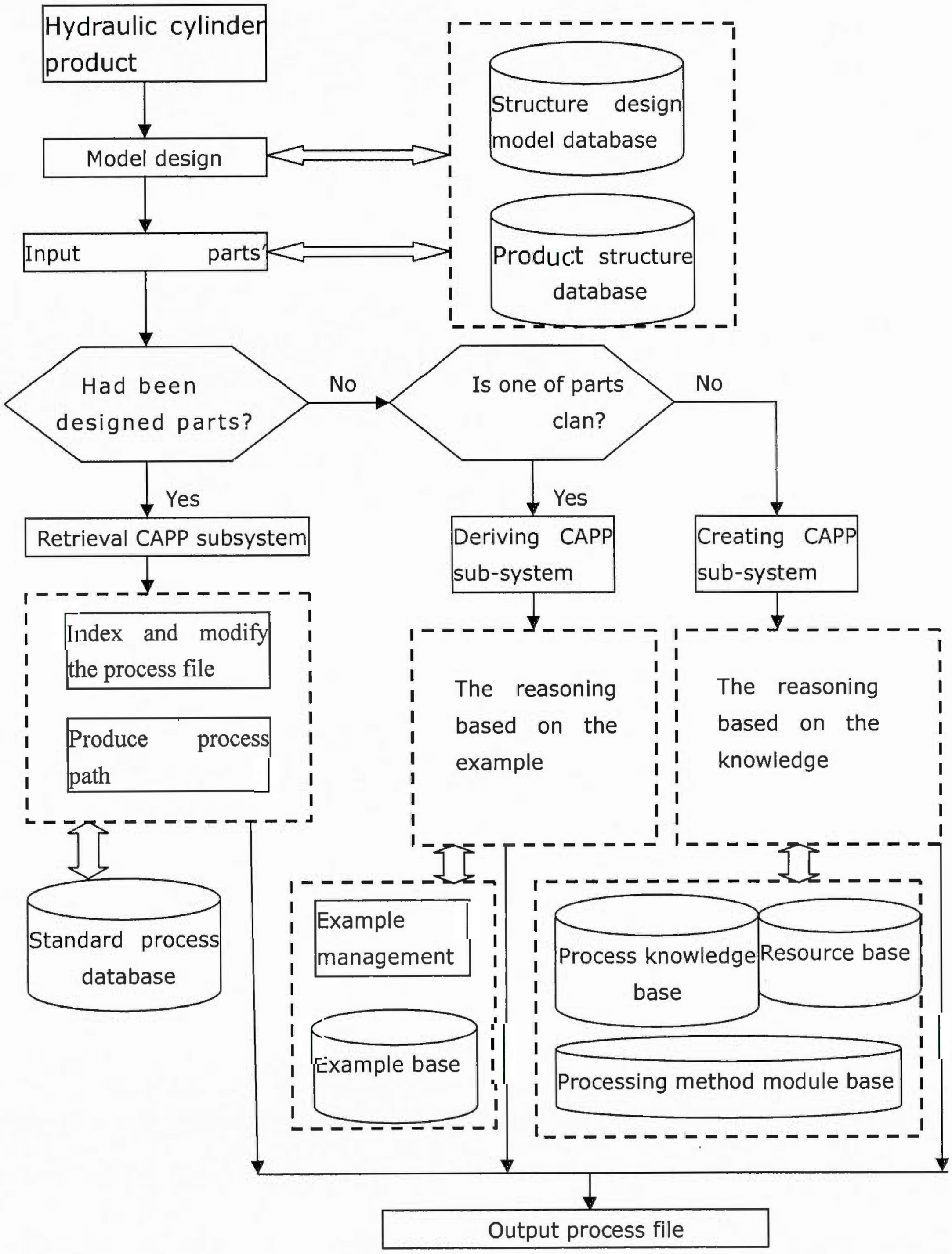


Fig 4-2 Design flow of the CAPP fast development tools system

4.3 The key technology of the CAPP system development

4.3.1 Input and description of parts' information base on feature and product structure

1. Interactive parts information input based on feature and product structure

Parts' information includes overall information (such as parts' name, graph number, material, etc.), structure, size, allowance, surface roughness, heat treatment and other technological requirements. The system adopts the way of combining the feature and product structure to input the parts information. I developed the interface of Parts' information input.

(1) Parts' information input based on feature: According to the parts' node on the product structure tree, obtain the CAD mode of the design parts from PDM database. Through the interactive interface offered by the system, finish the parts' information input based on the feature in the way of man-machine interaction. It includes the parts' characteristic size, allowance, surface roughness, accuracy grade, etc. Interactive information input interface based on feature is shown by fig 4-3.

CAPP system main function includes:

(2) Parts' information input based on product structure: Lead the overall attribute information of parts to the product structure BOM such as parts' name, graph number, material, heat treatment and other technological requirements, etc. Information interface based on the product structure, see fig 4-4

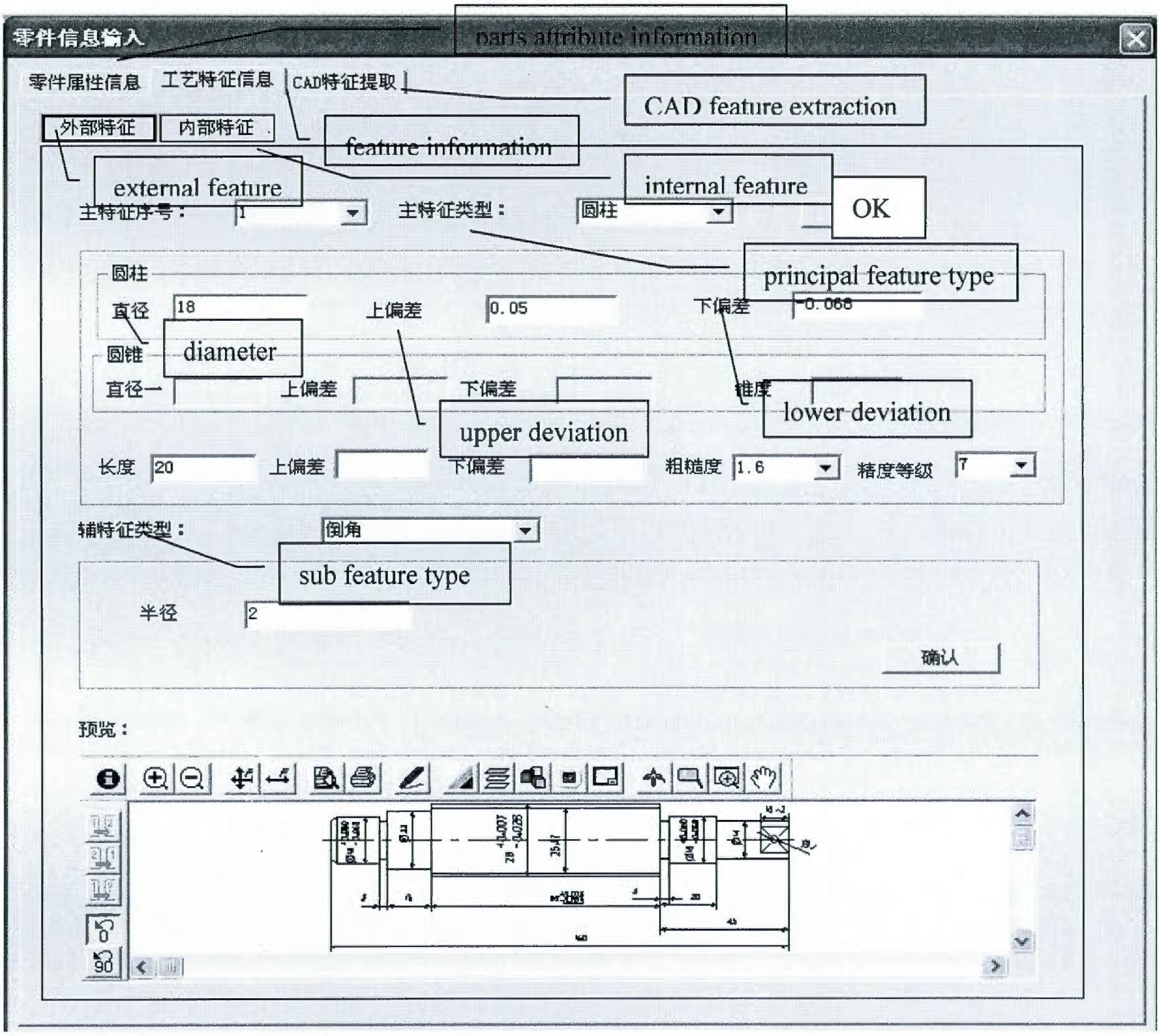


Fig4-3 the interactive information input interface based on feature

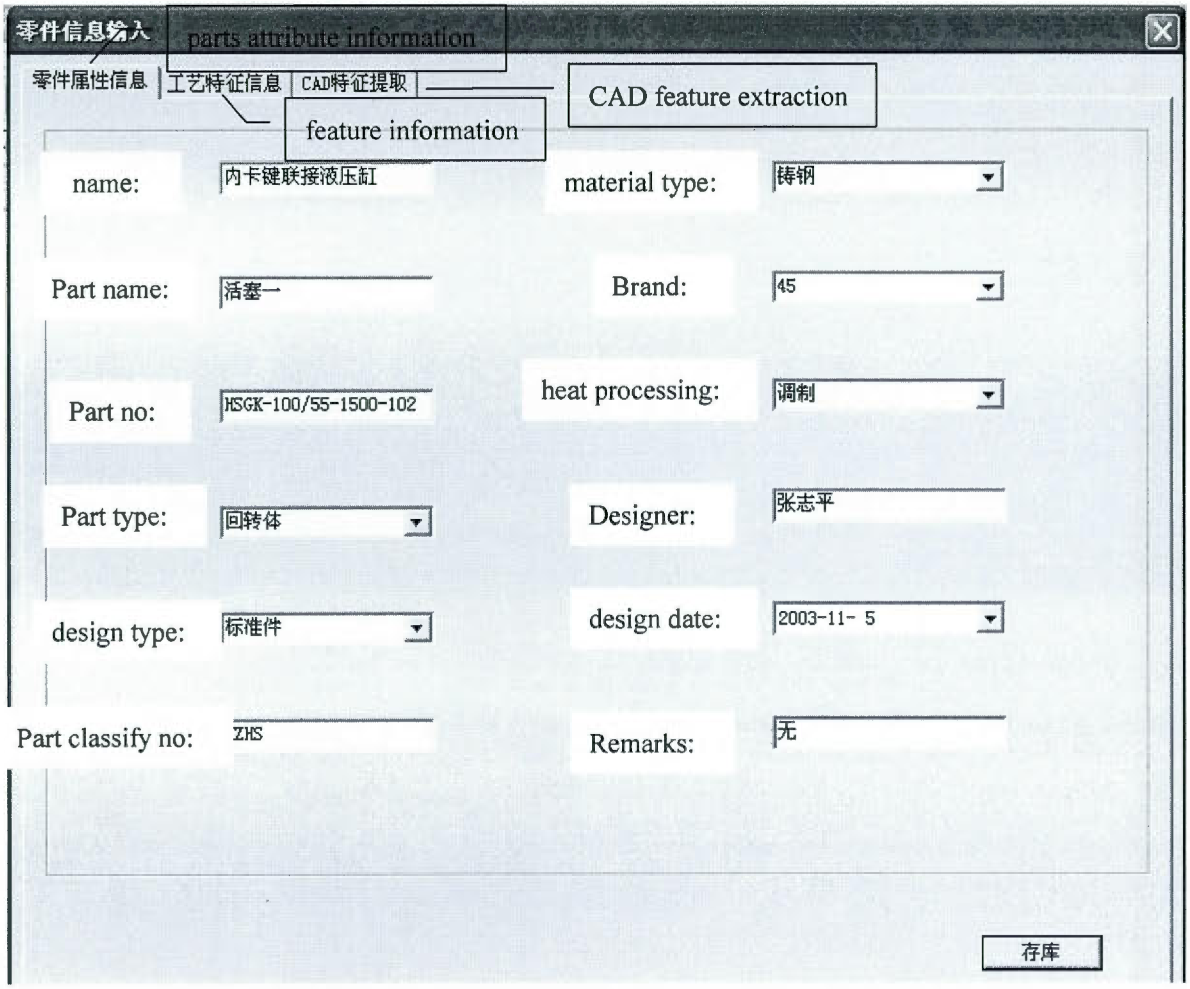


Fig 4-4 the information input interface based on the product structure

2. Construct the process information model with product structure as the core.

There are many kinds of process files. Most of them have both the graphs and files. How to manage the process information effectively is the first of all problems that CAPP system has to solve. With the development of PDM technology together with its further application, it becomes a trend that develop CAPP on PDM platform and realize the process design and process management facing the whole products[7]. Based on the analysis of the practical and implemental CAPP system's design demands, we make the process structure the core of the process information model to do process design and management. The process data will be more structural and normative, if we make the product structure the basis for CAPP system to organize process design.

(1) Map from the product structure tree to process design tree

If we want to make the product tree the form of the CAPP's data organization and management, CAPP should integrate the product structure information in CAD and produce corresponding product process tree automatically according to certain rule. Process design tree is not only the processing view of product structure tree, but also the mapping of the product structure tree. Compared with the product structure tree, it omits the standard-parts, external structures on the structure tree which do not need to process design and it adds the process card which is used to describe the process property of the parts. Representative process design tree is shown by fig 4-5. Root node is the product; middle nodes are the component; leaf node is the part. The process card information can be added to corresponding node on the product tree (such as process card, procedure card, examination card, assembling process card, etc.)

(2) The process information model with product structure as the core

Product structure displays in the form of process design tree in CAPP system. In the course of process design, each process item corresponds to one tree. Thus the process design assignment can be effectively organized and managed. The process information model with product structure as the core is shown by fig 4-6.

In the process model, map the product structure BOM produced by the CAD system into the process design tree of CAPP system through the structure tree's leading instruments. In the uniform product data management platform, the process files can be managed. In the CAPP system, use the process design tree to organize the process files. Use the floppy process-deciding method to finish the process design rapidly and construct the process file. Thereby the process design course will have certain organizing form and restriction, and process design and process management can be realized effectively.

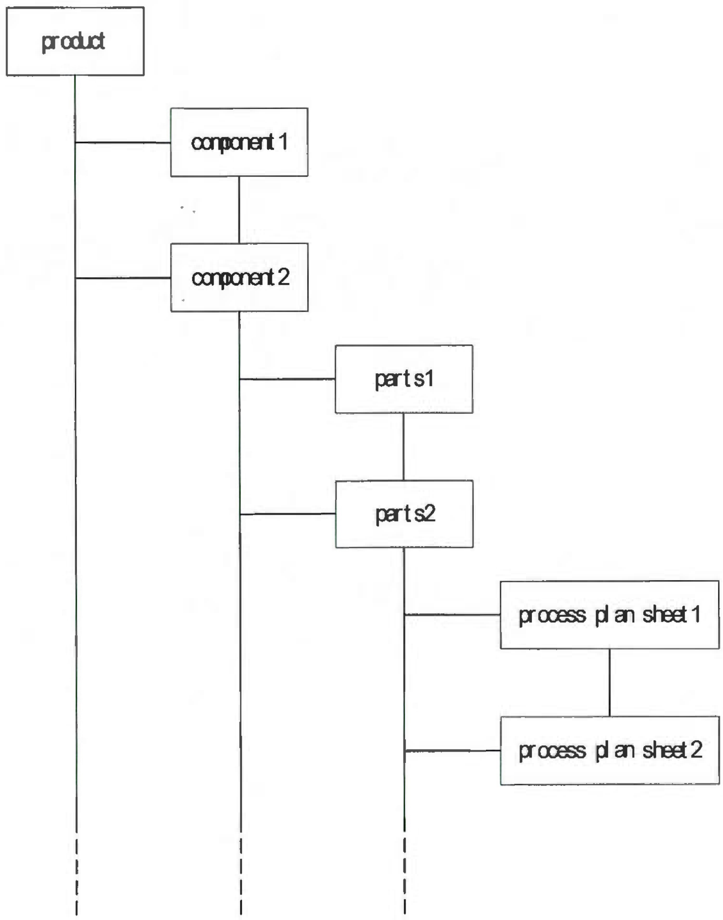


Fig 4-5 typical process design tree

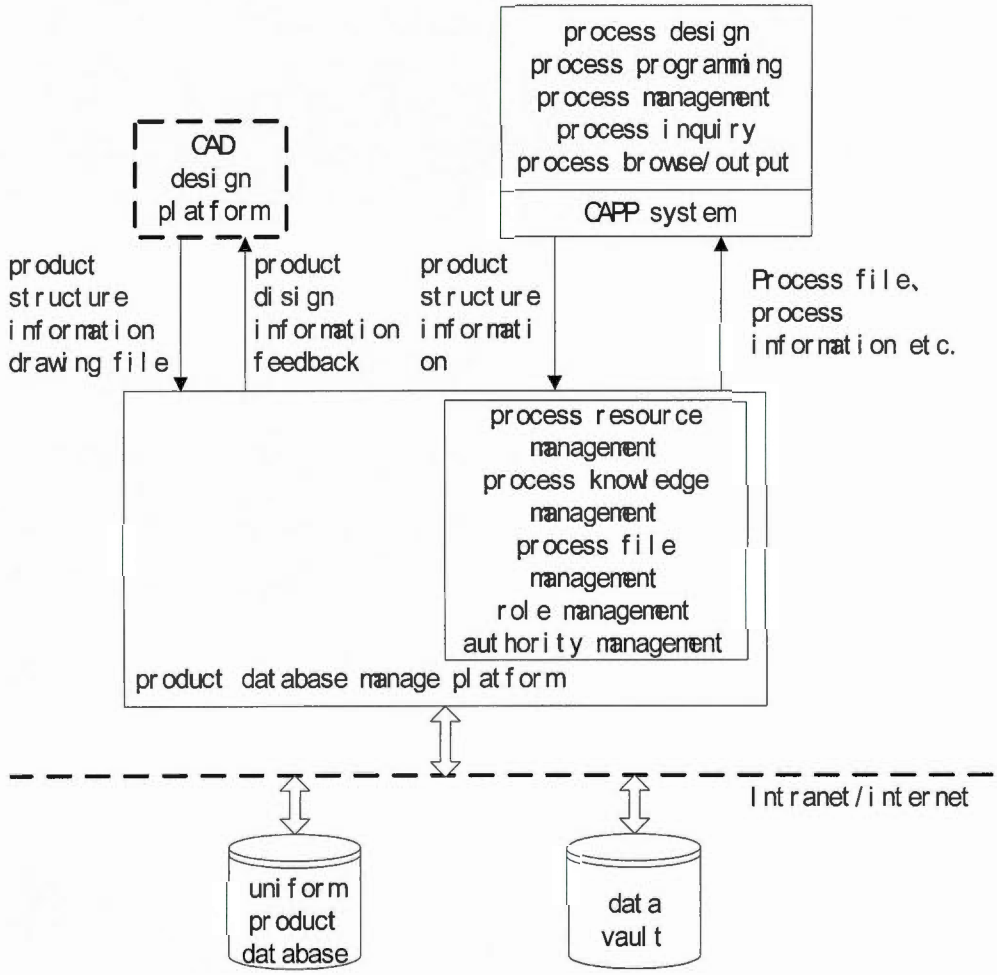


Fig 4-6 process information model with product structure as the core

In this model system, parts' defining model in the CAPP system is expressed as drawings' table data and drawings' heading column data. The process card uses the process template to save the card's geometric description. The data filled in this template is saved in the database as process data. Thus realize the separation of process data and process card. In the process design, it is allowed to open or create a new process design tree. Taking the intact process design tree as the mainline, through the process production, modification after process of the process design, etc. thus the technologist can finish the whole process design and output all the process files and data.

In this system, CATIA adopts the CAD software. Therefore in designing the CAPP system, we use object faced method to create an interface module which connects CAD and CAPP. Map the product structure tree produced by CAD into the process design tree in CAPP system. This process design tree remains the attribute relationship among the parts in the product tree. Thereby even though the processing personnel do not know CAD at all, they can use the product information CAD fully and conveniently. It not only avoids the excrescent work but also realizes the integration of CAD and CAPP, greatly improves the efficiency of process design.

(3) Process information description based on template technology

Seen from the abstract angle of data, data information of the process file can be described by a graph file, several one-dimensional and two-dimensional databases. Take the procedure card as an example, its description method is shown by fig 4-7. Describe the basic attribute of the process file, one-dimensional and two-dimensional data table through the database's realm model. It is saved in the PDM's information database, which is the sub-module of product information model. Dataset is the corresponding report file of the process file. It is saved in PDM's file database. Database table and the dataset are connected by the parts' number. So we can get the process file swiftly by product structure tree.

Process file is the synthesis of graphic characters and table. The system compiles out the dataset file corresponding to the process file. Make this file associate with corresponding one-dimensional data table, two-dimensional data table in the SQL- Server database. Then it becomes the template. These templates correspond to different process technological files. In the system's specific implementing stage, create several process data tables according to the enterprise's requests, and construct corresponding data information model. Then customize corresponding templates, that is, customize the editing interface and final report form of the process file the user needs. Thereby connect the process information with the process file through the template meanwhile make the system customized and configurable.

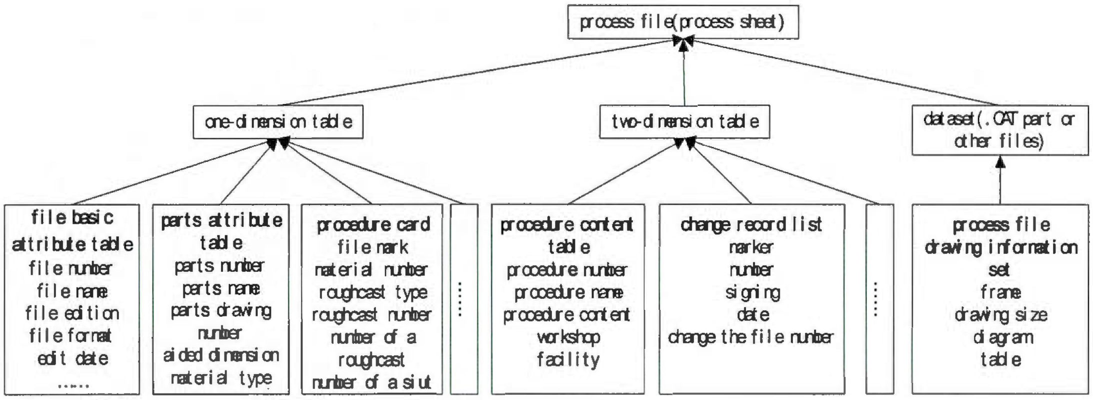


Fig 4-7 process file's relation model graph

(4) Standard modeling of the process card

We abstract process card into card format and cognition document through introducing the object faced technology. The card format can be further abstracted into three basic objects: static file, fixed frame and mapping area. The cognition document can be abstracted into the organic combination of several meta-objects.

From the angle of the process information's integration, the process card can be regarded as the organic combination of card format and cognition file. Take the description of BNF (Backus - Naur Form) as an example:

Process card ::=< Card format> {<Cognition file>}

Card format ::={< Fixed frame><Static file><Mapping area>}

Mapping area ::=< line mapping area>< row mapping area>

Cognition document ::={<metaobject>}

Among them:

a. Static document is the indicatory character forced in the card format defining course. After finishing the card format defining, we do not change it any more, such as procedure number, procedure name, procedure content, etc. of the procedure care.

b. Fixed frame is a closed rectangle area whose inside is filled in the static document and gives the details of the content;

c. Mapping area is also a closed rectangle area. It differs from the fixed frame in that the process design or process management content in the inside of mapping area is filled in by user or produced automatically by the process system. It expresses corresponding process design information or process management information.

Mapping area is displayed alone to show the information interaction between user and the card's displaying area. User can browse and fill in the card information already blocked in the mapping area. It interacts the information with the temporary operating table in the database. User creates his necessary information input by manual operation and save them in the database. Temporary operating table in the database table is an intermediary. When it receives the information input by user, it returns the information back and show it in the process card for the user's browsing.

According to the relative relationship of the contents filled in the mapping area, define the line mapping area and row mapping area. Line mapping area describes the composition of one object's each attribute, such as procedure number, procedure name, procedure contents of the procedure object, etc. Row mapping area describes the neighboring objects in the object set. For example, tale each corresponding data group in one step as an object, express the No. m step and No. m+1 step in the row mapping area.

d. The cognition document corresponds to the process information expressed by the term user recommended or the structural term or its own language in the process card. Compared with static file, cognition file is changeful and dynamic and has good compounding relations with the mapping area. The cognition file's objects consist of several inseparable sub-objects. We call them meta-objects. An intact cognition file's object is the derived object of the meta-object. I developed the process card module. The standard template of the process card designed in this system consists of table displaying area and table editing area. See Fig. 4-8.

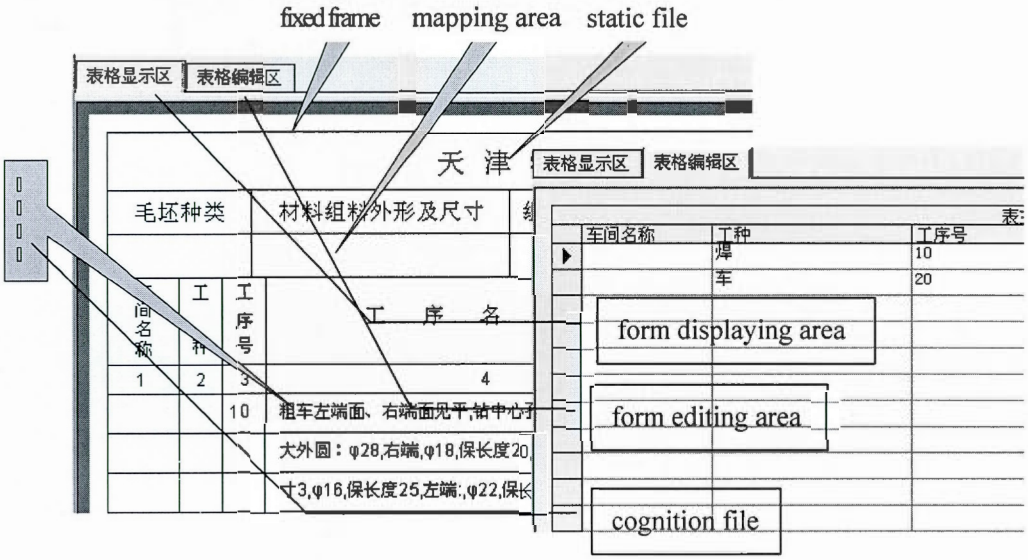


Fig 4-8 standard template of the process card

3. The table displaying area : It consists of the static file and fixed frame; mainly provides user with corresponding process design information and process management information in the form of fixed template. The user can browse the process design information related to the original template through the displaying area, meanwhile, he can open the modification area and recreate corresponding process design information and process management information he needs according to his own needs. The procedure will save the information that the user input in the temporary operation table of the database, moreover, takes the database as an intermediary and display the information that the user input once again in the displaying area.

4. The form editing area: Equaling to the card format's mapping area; it can carry out the line mapping and the row mapping to the card. In the modification area, the user can carry out the blocking process to the card in the displaying area according to his needs. What is called blocking? It refers to separate the card into several sub-objects and make the user operate the card concentratedly and clearly, meanwhile make it easy to process when interactive operation between the user's area and the card occurs. For example, the procedure file table is divided

into one-dimensional table (the heading information table, the tail information table), two-dimensional table (the step's content table, the location clamp table). There is just the heading information table, the process content table and the location clamp table in the modification area, while the heading information table of the same kind of parts is concentrated together for the user's convenience.

4.3.2 The flexible process decision-making technology based on multi-decision making mode

1. The overall structure CAPP system based on various decision-making modes

Floppy means that after the CAPP system modified and adjusted to certain degree, it can be used for different parts and different manufacturing environments. The easier this kind of modification and adjustment, the higher is the degree of flexibility. In the process decision-making of the CAPP system, we adopt floppy process decision-making technology based on various decision-making modes. The system organically integrated such four decision-making modes: process searching modes, deriving modes, creating modes and aided filling in card modes. Every mode has its best usage scope and the characteristics of processing problems, according to which user can choose proper modes reasonably .The key of realizing the system is how to organically integrate the four modes and complement one another's advantages. First, the realization of the shared functional module is considered, which includes the information description of parts, the process knowledge base, the typical process base, the process database and the visible process editing interface. Then, the characteristic functional module is added or revised in each sub-system. Through its special interface, each decision-making module is effectively called by the reasoning machine, thus the floppy process design based on various decision-making modes is done.

Facing the double pressure of automation and practicality, the floppy decision-making modes is the sole choice for CAPP system. It does not refer to the simple combination of several CAPP decision-making modes but the organic integration. Each module is connected each other, each functional unit, database and the mid-date are adequately shared. The organic integration of such four decision-making modes as the process searching mode, the filling in card mode, deriving mode and the expert system proposed by this system will not only meet the advanced manufacturing mode's needs represented by the agile manufacturing, but also the practicality of factory. The reasoning technology of floppy process decision-making is simply introduced in the following part. The overall structure of the CAPP system based on floppy decision-making mode is described in fig.4-9.

From this structure, we can see that after processing CAD's product data directly or through interactive method and setting up the uniform parts' data model; it is the meta-reasoning machine that decides what reasoning method the system adopts. The reasoning process is as follows:

(1) The meta-reasoning machine calls the retrieval CAPP sub-system, and carries out the standard process searching.

(2) If the search of the same process parts is failed, then the deriving CAPP sub-system which is based on feature should be called. And this sub-system can find out example part which is similar to the current one in the example base, and then can call corresponding example process and modify it to meet the needs of current design. This modification partly depends on reasoning which is based on knowledge.

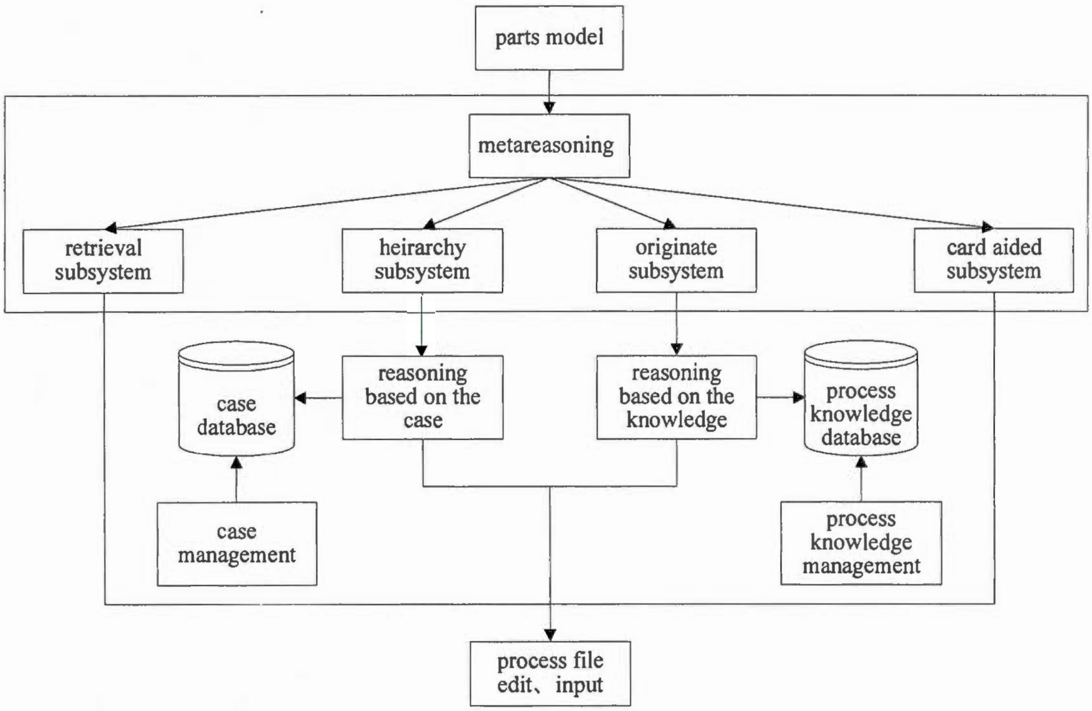


Fig 4-9 The overall structure of CAPP system based on floppy decision-making mode

(3) The meta-reasoning machine calls the deriving CAPP sub-system when it fails to find the similar example in the example base, then begins the part's process design once again through the meta-reasoning machine based on knowledge. After the reasoning design, the system can calculate the process size chain and draws the procedure graph by using the design results and the geometric data of the parts' model, finally the intact process design results can be output and become the process card after being edited or be saved in the example base for further design's reference. The examples in the example base are sort saved according to the parts' different types in order to withdraw them conveniently.

(4) If the reasoning based on knowledge is unsuccessful, then the meta-reasoning machine calls the filling card mode CAPP sub-system, with the help offered by the system, complete the process design interactively.

The reasoning strategy and realization of the CAPP sub-system based on example and knowledge is mainly introduced in the next part.

2. Reasoning strategy and realization of the deriving mode CAPP based on example

(1) Main idea of the system

a. Replace GT-code with the parts' information based on feature; describe the process regulation (including the standard process regulation) by the procedure-steps, two furcated tree (or other models) , thereby accurate and complete description to the parts' information and process information can be carried out, meanwhile set solid foundation for the high quality process design.

b. Replace the parts' grouping with example sort index tree. The examples are sort saved according to the parts' sort index tree. User can save the example newly established in the example base at any time, without grouping the parts establishing the matrix of parts clan. The customization of example isn't relied on the great deal of existing parts' drawings and process regulations, but sorts out the typical parts factory owns at present and establish one or some examples in terms of each kind; compile its standard process regulation; then, conveniently input and edit the example information and the example standard process regulation on the man-machine interface provided by the system, thus increase the flexibility and practicability of the system greatly.

c. Replace the process screening strategy based on the matrix of parts' clan with the feature based reasoning, that is, the automatic screening to the standard process regulation is no longer based on matrix of the parts clan, but on the grounds of the parts' information model based on feature. Match and screen out the current parts' process regulation automatically in the standard process regulation based on feature.

(2) The acquisition of example and the coding regulation

a. The acquisition of example

If all the examples produced by the system in the process are saved in the example base, it will explode. Therefore, such representative examples are saved in the example base for searching and managing the examples conveniently; furthermore, certain arithmetic and strategies are established for managing and ejecting the examples. The examples mainly come from two aspects: ①the process design result and its corresponding parts' information produced by the CAPP system and notarized by the process experts; ②after artificial compilation and arrangement, the standard process regulation and its corresponding parts' information input the system.

b. The coding regulation of examples

One of the most important contents of the deriving mode CAPP system based on feature is how to eject example accurately and quickly. This item adopts a kind of sort management and coding regulation, and taking which as the foundation to eject the examples. The main idea of this regulation is: first sort the mechanic parts into several types in terms of the shape characteristics, uses one letter to replace one type sorted, for example, use h to replace the gyroscopic parts. Then re-sort each type sorted; use one letter to replace corresponding smaller type; add the sort coding of the upper layer, for example, use z replace the shaft type subdivided in the gyroscopic type, at that time, the coding of the shaft type is hz. On the analogy of this rule, subdivide corresponding types; use one letter to replace it; meanwhile add the sort coding of the upper layer, until no subdivision can be done; then the last layer is concrete part, which constitutes a kind of tree-form structure. Actually the regulation is to locate the parts step by step, find the part's orientation in the n dimension coordinates. The key point of this method is to sort the parts managed, then code it correspondingly and take the code value as one of the parts' attributes. So long as sort the parts in detail and accurately, classify the products property while inputting the information, it is quite easy to find out similar parts.

The method takes the parts index tree as the foundation, which is different from the traditional GT sort management way. Taking the gyroscopic parts as an example, explain the coding regulation. The parts' sort index tree is described in fig.4-10.

The codes shown by fig.4-11are obtained in terms of the above-mentioned coding regulation.

(3) The reasoning strategy of deriving mode CAPP system based on example

a. Eject the example

The main task is: seek out the condition of information matching between the new parts and the examples to be chosen; determine the most suitable example and the more suitable example to the new part; make preparation for screening the example process information and revising the process path. The process of example ejection is carried out on grounds of the feature coding. Obtain the codes of parts to be designed first, then look for this code in the example base; find out the parts' type this part belongs to. the searching course is to compare the codes of parts to be designed with the codes of parts in the example base from the first letter, if their first letter is the same, it means that the part belongs to the type of parts represented by this letter (big type in here), then compare the second letter in the parts with the same first letter. On the analogy of this rule, until find out the example having the most letters same with the characteristic codes of the parts to be designed. If they are completely equal, then draw the process file of the example directly as the process regulation of parts to be designed. Certainly, there may be several examples, then draw all the parts that are in accordance with the example, and calculate their similarity coefficient.

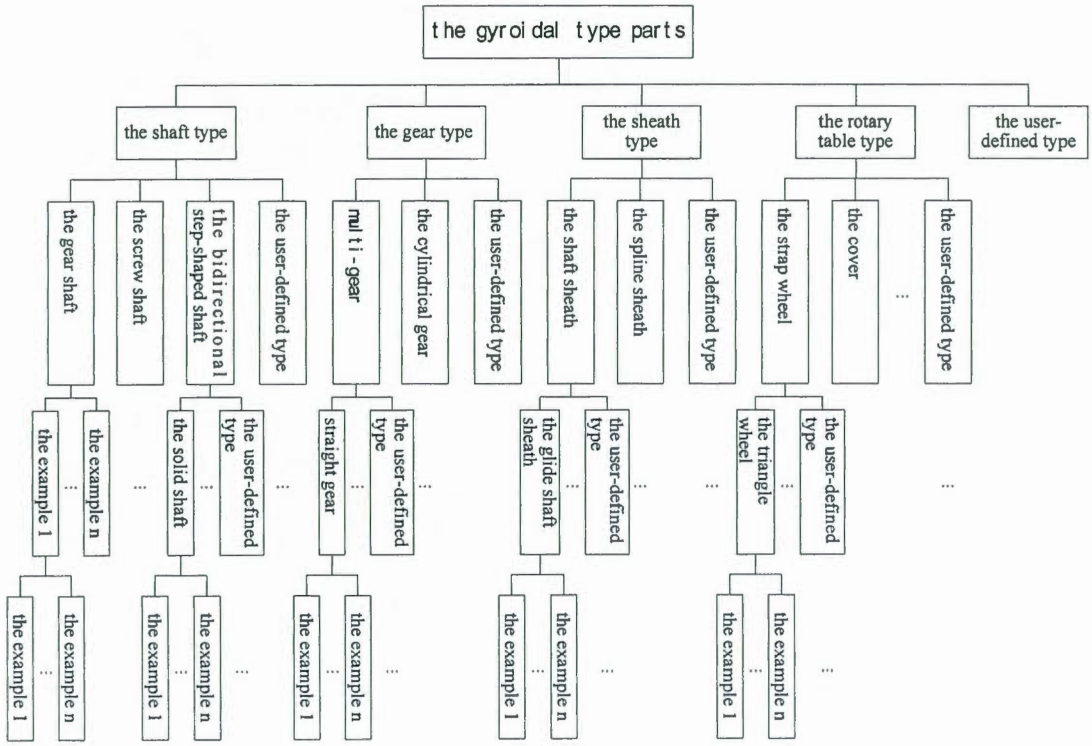


Fig 4-10 Sort index tree of the parts

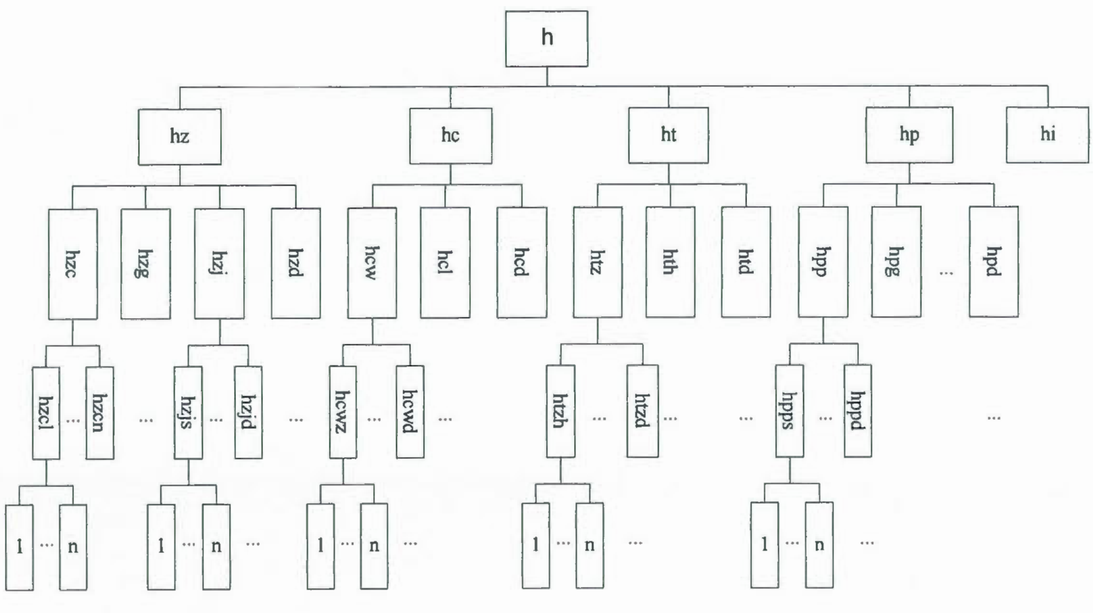


Fig 4-11 The index tree's coding graph

b. Calculation of the similarity coefficient

The similarity coefficient is a parameter which is used for measuring the similar degree between the new part and one certain example. ks is used to express it. The similarity coefficient is not only related to such elements as parts' type or example type (such as product variety, the example functional structure, the shape's size and the length to diameter ratio, etc.), the processing mode, the type of feature (including the main and subsidiary features, etc.), but also such elements as the material type of parts, heat treatment method, the type of semi-finished product and the precision grade, roughness and allowance of the shape feature. So these factors must be considered comprehensively while calculating the similarity coefficient. According to the immense practices and analysis, construct the following calculating formula of the similarity coefficient:

$$k_s = \frac{a_{mt} \times k_{mt} + a_{ht} \times k_{ht} + a_{bt} \times k_{bt} + a_{mf} \times k_{mf} + a_{af} \times k_{af}}{a_{mt} + a_{ht} + a_{bt} + a_{mf} + a_{af}} \qquad \text{(i)}$$

In the formula: k_{mt} is the matching coefficient of material; k_{ht} is the matching coefficient of heat treatment; k_{bt} is the matching coefficient of semi-finished product, k_{mf} is the matching coefficient of main feature, k_{af} is the matching coefficient of subsidiary feature, k_{mt}, k_{ht} and k_{bt} are the matching coefficient of total information, k_{mf} and k_{af} are the matching coefficient of features, a_{mt}, a_{ht}, a_{bt}, a_{mf} and a_{af} are corresponding weighting coefficient. As we have to search and estimate the example type that the new part belongs to, meanwhile estimate their processing modes are the same or not before comparing, matching and computing the k_s to the new parts and the example to be chosen, so there are not the part's type and the matching coefficient of processing mode in the formula(i).The calculation formula of k_{mt} , k_{ht} , k_{bt} , k_{mf} , k_{af} are described as follows:

$$kmt = \begin{cases} 1, \text{the material type of new part and example are suited} \\ 0, \text{the material type of new part and example are not suited} \end{cases}$$

$$kht=\begin{cases}1, \text{the heat processing method of new part and example are suited} \\ 0, \text{the heat processing method of new part and example are not suited}\end{cases}$$

$$kbt=\begin{cases}1, \text{the semi-manufactured type of new part and example are suited} \\ 0, \text{the semi-manufactured type of new part and example are not suited}\end{cases}$$

$$kmf=\frac{(\text{the number of matching towards the primary feature of new part and example})\times 2}{\text{the number of primary feature of new part + the number of primary feature of example}}$$

$$kaf=\frac{(\text{the number of matching towards the accessorial feature of new part and example})\times 2}{\text{the number of accessorial feature of new part + the number of accessorial feature of example}}$$

"The main feature (or subsidiary feature) of the new part matches the main feature (or subsidiary feature) of the example"

① The feature type of the new parts and their corresponding features is the same; for example, they are the cylinder or the keyway.

② Meet any one of the following two conditions or both of them (It is set by user):

- Roughness degree of the new parts and the example's corresponding feature is the same.
- Accuracy grade of the new parts and the example's corresponding feature is the same.

③ The partial heat treatment method of the new parts and the example's corresponding feature is the same or their total heat treatment is the same.

Whether the two shape feature match each other or not in size is a comparatively blurry concept. The basic principle of partition the example type and establishing example sort index tree is: the examples belong to the same example type on the condition that their basic parameters such as functional structure, shape size (for example, the biggest length and the biggest diameter, etc.), the length to diameter ratio, etc. are the same. It is unnecessary to consider whether the concrete size of the two is the same or not when judging the two features match or not. If the above-mentioned conditions (the feature type, roughness or precision and the heat treatment mode etc.) are satisfied, then we think that the two match each other and their artifactitious chains are basically the same.

Generally, take $a_{mt}=0.1$, $a_{ht}=0.2$, $a_{bt}=0.1$, $a_{mf}=0.4$, $a_{af}=0.2$, and $a_{mt}+a_{ht}+a_{bt}+a_{mf}+a_{af}=1$; and the formula (i) is simplified as:

$$k_s=a_{mt}\times k_{mt}+a_{ht}\times k_{ht}+a_{bt}\times k_{bt}+a_{mf}\times k_{mf}+a_{af}\times k_{af} \qquad \text{(ii)}$$

If $k_s=1$, it means the example completely matches the parts to be designed; If $0.7< k_s<1$, they are basically matched; If $k_s<0.7$, it means that their matching conditions are not perfect. Use other methods to design.

c. the example reasoning

① Reasoning

The example reasoning refers to compare and match the geometric shape feature of the parts and that of the example, through which determine what procedure or process in the example process regulation is preserved and what others are deleted. As to the shape feature that is not matched while reasoning, the system will automatically calls the reasoning machine based on knowledge to search corresponding feature's processing method in the choice rule base of the processing method, and inserts it into the current process file according to certain rule.

② Modification

After reasoning, the process regulation file obtained may be intact and imperfect which needs modifying.

3. The reasoning strategy together with its realization of CAPP system based on knowledge.

The reasoning machine based on knowledge can not only be used in the parts' procedure/step design as the complete process design sub-system but also in such operations that the reasoning machine based on example can not complete. The realizing strategy of reasoning based on knowledge is mainly discussed in the following part.

(1) Expression of the knowledge

The knowledge expression is the most basic problem of processing knowledge. Whether the knowledge of process design can be reasonably expressed or not in computer affects the quality and efficiency of process design directly.

The knowledge of process design can be divided into two big types: the static data and rule. The former reflects the descriptive knowledge, which is used for expressing various fact and relations in the process design field; the latter reflects the process knowledge, which is used for expressing various decision-making logic in the process design. The system uses a mixed knowledge expressing method based on frame to unify the expression of static data and that of rule in the frame. Concretely speaking, as to the frame of expressing static date, the number and meaning of the upper groove are fixed; while in the frame of expressing rule, there is not only the groove with fixed meaning, but also one or more condition grooves and one conclusion groove. The value in condition groove reflects the premise of executing rule and the value in conclusion groove reflects the conclusion or movement of executing rule.

One example that the rule of choosing the processing method using frame is described in fig.4-12 the sequence of machining {

the fixed groove the mark of rule, 3:

the condition groove {
- the feature type, cylinder: precision, the highest 7; roughness, the highest 1.6;
- the material, 45 steel carbide; precision, the lowest 9; roughness, the lowest 6.3;

the conclusion groove {
- machining 1, rough grinding;
- machining 2, semi-precise grinding;
- machining 3. precise grinding;

Fig 4-12 Frame expression of the processing method choice rule

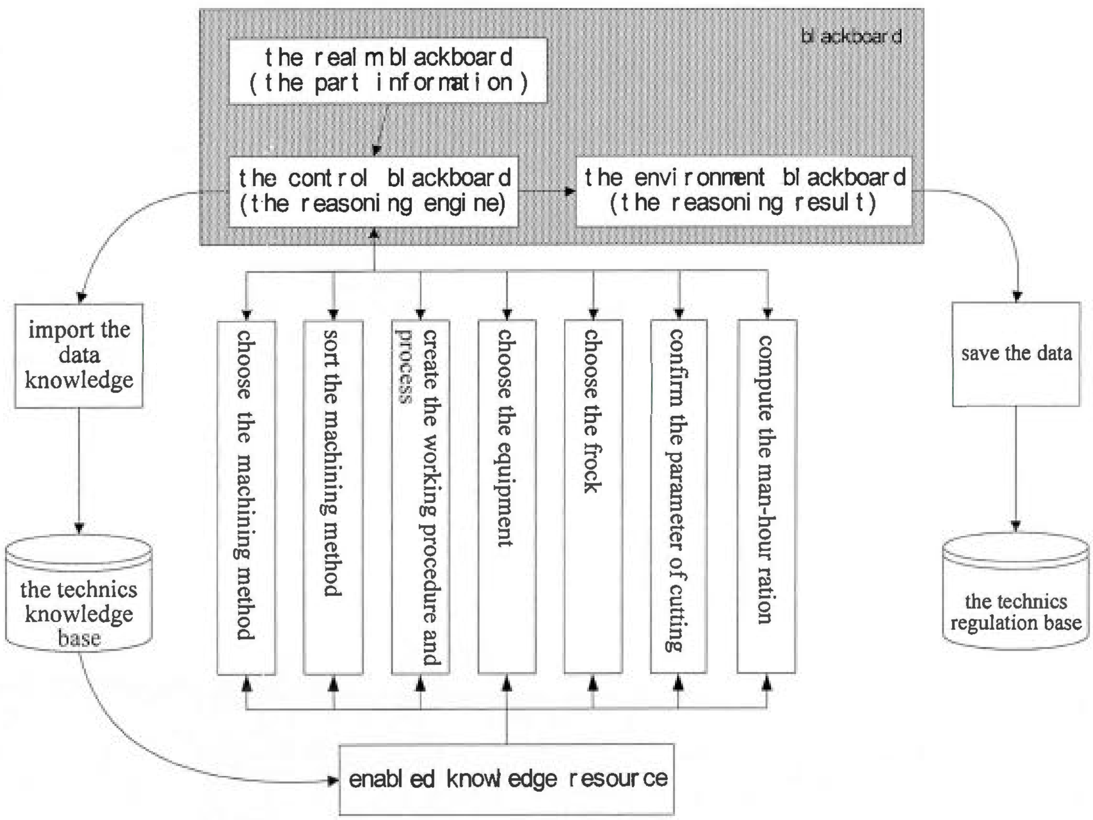


Fig4-13 reasoning course based on knowledge

(2) The reasoning strategy based on knowledge

a. Stratified programming: According to the contents of procedure /

process design, divide the whole reasoning design process into a series of sub- assignments, including confirming the semi-finished products, choosing the processing method, producing the procedure / process, choosing the processing equipments, confirming the location and clamp, choosing the working clothes, confirming the grinding parameter, calculating the man-hour ration. All the sub- assignments take shape of a structure system of step-up hierarchical reasoning which is convenient for phased design. Knowledge in the knowledge-base corresponds to sort storage of each sub- assignment. With the realization of each sub-assignment's design aim step by step, the whole reasoning process is done.

b. The reasoning based on blackboard structure: There is a publicly shared whole process data exchanging area in the reasoning machine based on knowledge, which is the blackboard. The whole blackboard is divided into three parts—the control blackboard, the realm blackboard and the environment blackboard. The control blackboard controls the reasoning process of the whole reasoning machine and the calling of knowledge source, that is to say, the reasoning process of reasoning machine is controlled by the control blackboard, and what knowledge source in the knowledge base is called at what time is also controlled by the control blackboard. The reasoning sequence of each module (correspond to one sub-assignment) in the reasoning machine is memorized in the control blackboard. The realm blackboard is divided into two parts. One is the parts' data area; the other is the processing data area. Their expression mode is the same as the expression mode of expressing example parts and example process. The environment blackboard is used for depositing the process design results of current parts. When the reasoning is going on, by controlling the information of control blackboard on grounds of the parts' information in the realm blackboard, call each module to reason step by step, and the reasoning result is saved in the environment blackboard in turn.

Reasoning way of each model in the reasoning machine adopts forward reasoning, that is, match the known data with the value of condition groove in the frame expressing knowledge. If the marching is successful, the value of conclusion groove in the frame is the needed goal data. If not, go on searching the next knowledge until obtain the conclusion. After each model's reasoning is finished, the processing data area of the blackboard realm is filled up. Save the data in the database and finish the process/ step design. The reasoning process based on knowledge is described in fig4-13

4.3.3 The component technology (CBC) based on COM

COM (Component Object Model) refers to the component object model. It is the binary standard of Software Component interacting mutually. It is a kind of object model taking the component as releasing unit. This model makes each software component interact in a uniform way. The COM based component (CBC) can interact, quote and reuse expediently. These components can be developed by different people and in different languages and can also be used in different operation systems. We can construct a software system conveniently and agilely using component technology. It has the following superior features: (1) independence of the module; (2) independence of language; (3) reusability.

The component displays its function through the interface. One component can construct several interfaces according to the function provided. The component interface and its realizations are separated. The realizing details of the object's inner part are invisible. It is completely packed and only an interface is exposed to the outside. Therefore, the component has good packaging capacity.

Inheritage exists among the component objects, but it differs from that of the object faced method. Only the interface inheritage exists among the components because while components are used in work, to derive another component by one component is forbidden, but to derive another interface by one component interface is permitted, thus the extension of function is realized. However, realization inheritage exists in the constructing process of the component's inner part.

In CBC technology, one component can include several sub-components which are connected with one another through interface. The component interface is described through the COM IDL (the Interface Description Language). The software system made up of components can call, integrate, and maintain the components conveniently and in the improvement, expansion and maintenance process of the components' function, work on corresponding components only and leave others aside. Making use of the component technology to design and develop the system guarantees the reusability, easy maintenance, independence and mutual operability of the system.

1. The design thought of the fast development tool of CAPP based on CBC

The general and floppy CAPP system must combine the actual circumstances of the factory. However, the concrete circumstance of each enterprise are different, even if in one enterprise, its production resources, production environment and product structures are also dynamically variant. Therefore, at present it is impossible to develop the CAPP system which can suit all the enterprises. Making use of the CBC technology to develop the CAPP system can increase reusability, flexibility and easy expansion of the system.

This item divides CAPP system into several tool components according to the function. One component is a component module. The anomalous network platform is the soft total line of the tool component's module unit. Each tool component unit is floppy; the user can configure according to concrete circumstances, so it can realize the integration, practicality and flexibility of the CAPP system, and finish the design of CAPP system quickly. The system's structure frame is described in fig 4-14.

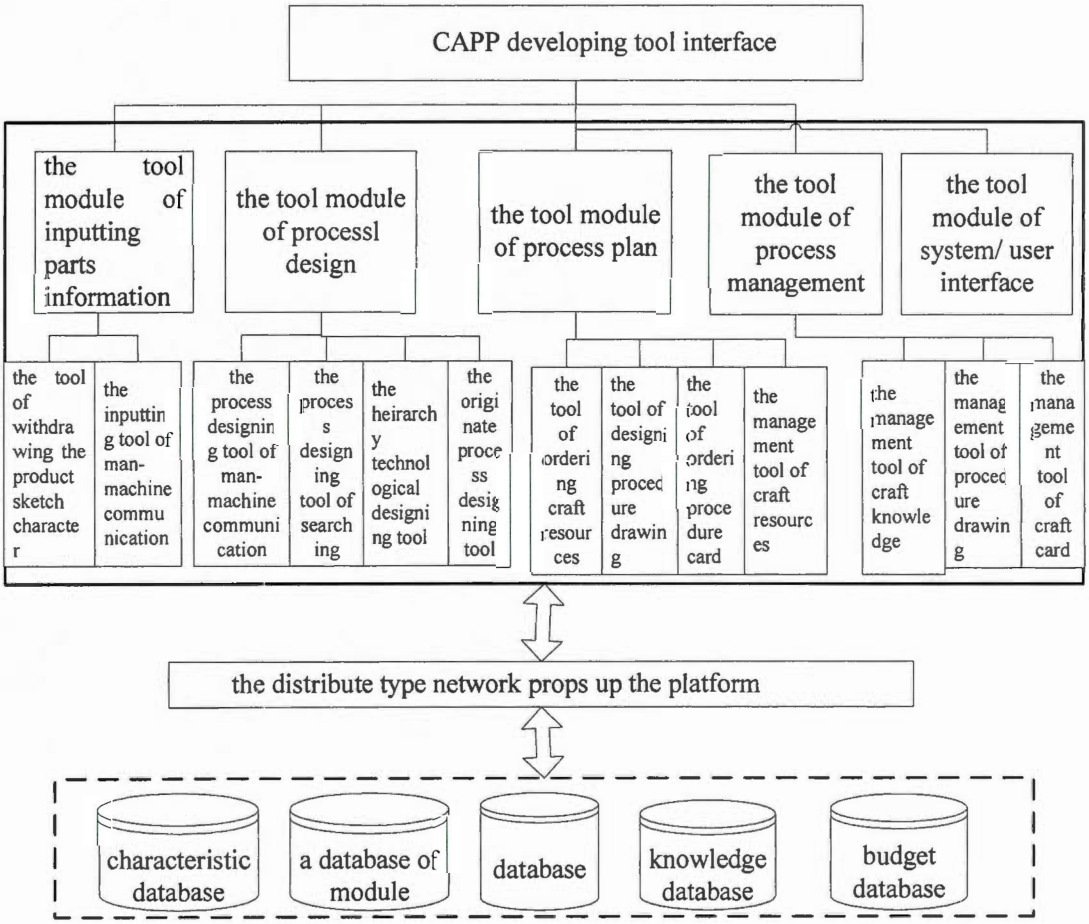


Fig 4 -14 frame structure of CAPP tool system based on CBC

2. The design steps of CAPP tool system

(1) Build up the work flow of the system. The work of this part finished by my supervisor.

Determine the work flow of CAPP tool system in terms of enterprise's process flow and needs; divide the workflow; then divide the functional module of the system according to the work flow obtained.

(2) Build up the object type of the system. The work of this part finished by my supervisor.

On the basis of functional analysis, determine relevant object type and describe their functions in detail.

(3) Analyze the component model. The work of this part finished by myself.

According to the difference of the component's function, in the process of component analysis, divide the components into three types:

a. The general component Actually it is a kind of tool. It does not depend on the concrete production environment, and can be developed independently and used repeatedly.

b. Semi-general component It partially depends on concrete production environment; take shape of the comparatively fixed production structure in detail; convenient filling in and modification are allowed according to the concrete enterprise.

c. The special component It depends on the concrete production environment completely. It is the software part developed according to concrete enterprises.

On the basis of the initial division of the component, subdivide each component according to function and divide into multi-grade component; describe the function of each grade function in detail. The component classification and functions of the CAPP tool system is described in table 1.

(4) The component design. The work of this part finished by myself.

Complete the structure design, function definition and detailed design of the component and interface during this stage. Concrete steps are as follows:

a. The component design. According to the function to be finished by the component, determine the component's detailed structure including sub- component, it includes type and its data structures. Among the applied component detailed cooperation agreement should be worked out.

b. Illustration of the interface's function. The component displays its function through interface. According to the function of each component, ascertain the character and methods that the interface includes, and build up the interface catalogue including the corresponding relation among interface and the components.

c. Interface design. According to the illustration of interface's function, determine the interface's structure, including its type object and data structure. Ascertain the relation among each interface. Some interfaces' functions can be obtained through other interfaces' inheritage.

d. Code realization. After the above steps, it is allowed to code the components. Then after compilation and registration, it can call the component and realize corresponding functions.

Table 1 component classification and functions of the CAPP system

<table>
<tr><th>component name</th><th colspan="2">sub- component</th><th>component category</th><th>component function</th></tr>
<tr><td rowspan="2">the tool of inputting parts' information</td><td colspan="2">withdraw the product's sketch characteristic</td><td>Semi-general component</td><td>withdraw the product's sketch characteristic data from CAD</td></tr>
<tr><td colspan="2">man-machine interactive inputting</td><td>Semi-general component</td><td>input parts' information by man-machine interaction</td></tr>
<tr><td rowspan="7">process design</td><td colspan="2">the process design of man-machine interaction</td><td>Special component</td><td>complete the process design by man-machine interaction</td></tr>
<tr><td colspan="2">the process design of searching</td><td>Special component</td><td>search the process regulation of the same parts from the existing parts' process based and do proper modification</td></tr>
<tr><td colspan="2">the deriving process design</td><td>Semi-general component</td><td>Use the reasoning method based on example to search similar parts' process regulation; complete the parts' process design through the example's withdrawing, screening and modifying</td></tr>
<tr><td rowspan="4">the originating process design</td><td>process method chain choice</td><td rowspan="2">Special component</td><td>ascertain the process method chain</td></tr>
<tr><td>processing method collation</td><td>used for the step's procedure's collation</td></tr>
<tr><td>Grinding quantity choice</td><td rowspan="2">Semi-general component</td><td>ascertain the grinding parameter</td></tr>
<tr><td>machine tool choice</td><td>ascertain the machine tool</td></tr>
</table>

		tools choice		ascertain the tools
		the man-hour ration calculation		ascertain the man-hour ration
		the procedure size calculation	Special component	ascertain the procedure size and surplus
process plan	process resource's customization		Semi-general component	Customize the factory's equipment, property, the on-line usage state, etc. as well as the clamping tools, measurements, etc.
	procedure drawing design			Complete the procedure graph design using the parameter design method based on feature in the CAD software development environment. link the procedure graph to the procedure card by way of OLE
	procedure card's customization			Customize all kinds of procedure card formats meeting the enterprise's requirements
process management	Process Knowledge's management		Semi-general component	manage the generally used process knowledge including addition and deletion, etc.
	Process resources' management			manage all the process resources
	Process plan's outputting			used for the printing and outputting of process plan card and procedure card, etc.
system/ user interface			Special component	used for the interaction between the system and user

3. The realizing method of CAPP system

After the above steps, process design to the whole system can be carried out. Concrete steps are as follows:

(1) Build up the overall frame of the system according to the factory's concrete requirements.

(2) Build up the enterprise's special module;

(3) Call the component to debug through the user code. Its process is shown by Fig.4-15:

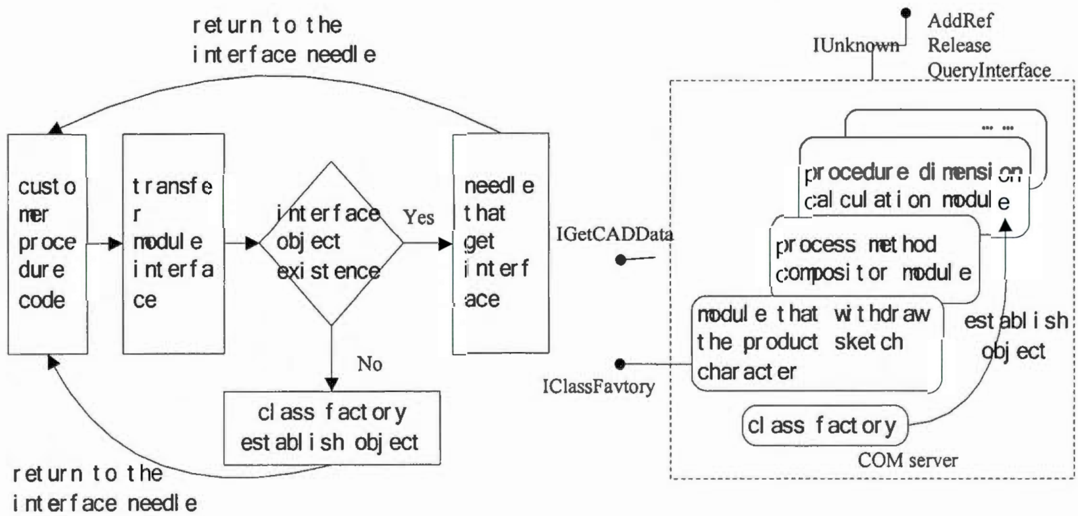


Fig 4-15 user code's calling the component

IUnknown is the root interface owned by every component. Other interfaces derive from it, and it includes the most basic three methods: AddRef, Release, Query Interface. When the user calls some component interface IGetCADDate, the COM server first judges whether the interface object exists or not. If nonexistent then establish through a class factory, and return to the interface pointer. Otherwise, obtain the interface pointer through Qvery- Interface method of the IUnknown interface and deliver it to the client. The client realizes the component's function by way of calling the interface pointer. While introducing the interface, calling AddRef makes the quote record number add 1 when the customer does not need the interface object any longer, call Release; thus make the quote record number reduce 1; when the quote record number is reduced to 0, interface object will be released.

We can see from the above analysis that the application of CBC technology in the CAPP system increases the generality, reusability, and flexibility of CAPP system. There is no doubt that component development based on COM is the developing direction of future software. This kind of software development method based on component actually realizes the integration and reuse of the system's each module, and provides a new kind of tool and method for the design and development of CAPP system. It will push forward the integrated tool and practicability of the CAPP system greatly.

4.4 System's operation instance

1. The standard hydraulic jar's process design

(1) Log on the CAPP sub-system according to the role number granted by PDM. In CAPP system's main interface's " file " menu, choose " import the product structure "; select " YYGX 4 " from them, at the same time produce corresponding process design tree (shown in Fig 4-16), read the part's attribute information.

(2) On the process tree's corresponding nodes, select the part's name to be designed, such as " piston rod component", then choose " retrieval CAPP subsystem" from the menu " process design"; the system searches the standard process automatically from "hydraulic jar's process index tree" (Fig 4-17) and completes the standard by hydraulic jar's process design.(Fig 4-18 is the processing card of the rod body)

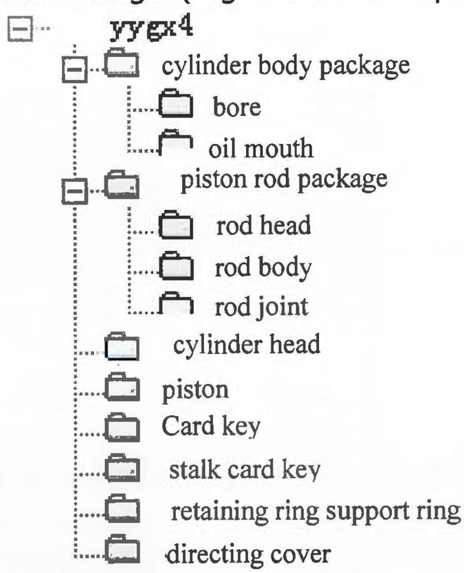


Fig 4-16 process design tree of the hydraulic jar

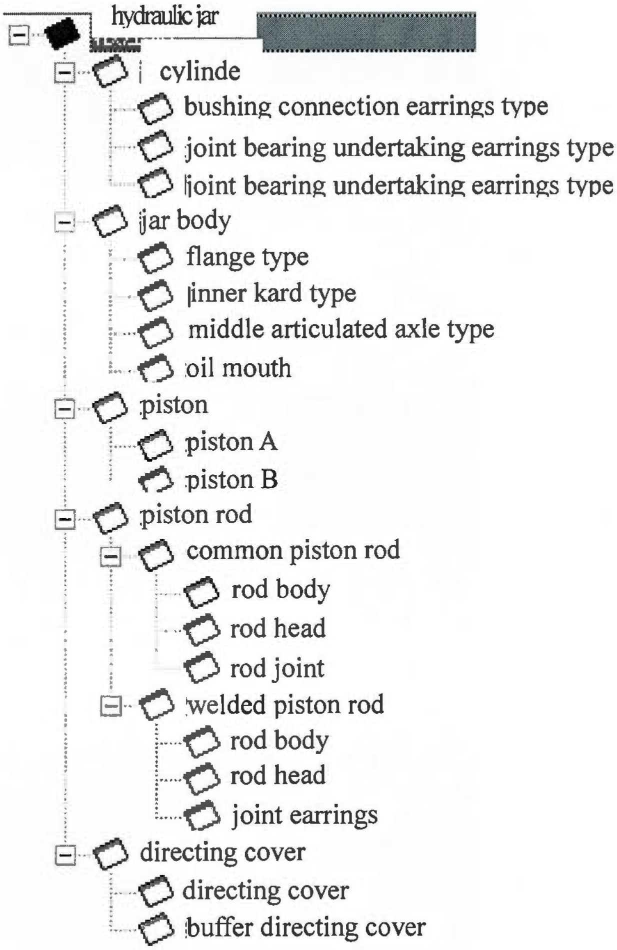


Fig 4-17 process index tree of the hydraulic jar

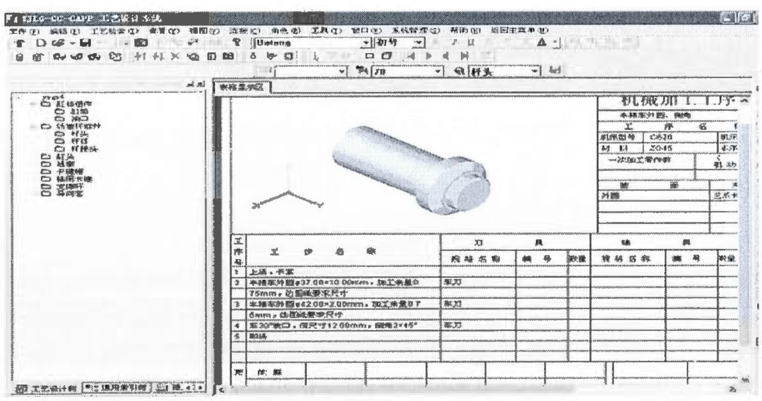


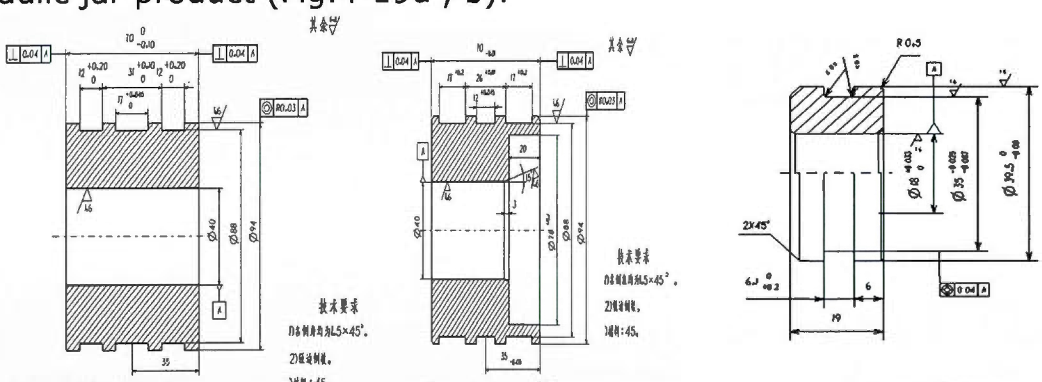
Fig 4-18 processing card of the rod body

2. The process design of the nonstandard hydraulic jar

(1) Choose "import product structure tree" in the CAPP system's main interface's "file" menu; select item "YYGX 5" and produce corresponding process design tree.

(2) On the process tree's corresponding nodes, choose the parts' name to be designed such as "piston (Fig. 4-19 c)"; choose "deriving CAPP subsystem "from" process design "menu; enter the deriving CAPP subsystem's design interface; choose " the parts' information input " from the right key attribute menu of the process design tree's corresponding nodes; read into the parts' attribute information, and input the characteristic process information of the parts interactively; Then choose " the deriving design " from the right key attribute menu; the system searches the similar instances automatically from " hydraulic jar's process index tree "; finish the process design of the nonstandard jar's parts. The deriving course is as follows:

a. Search the example base. Search the piston's process module example base from the standard hydraulic jar's process index tree; two relevant examples are found, that is, piston A and piston B. in the hydraulic jar product (Fig.4-19a , b).



a piston A　　b piston B　　c new piston

Fig 4-19 pistons' part graph

b. Similar coefficient calculation

- Similar coefficient of the new piston and piston A

$$k_{mt1}=1\ ;\ k_{ht1}=1\ ;\ k_{bt1}=1\ ;\ k_{mf1}=\frac{2\times 2}{2+2}=1\ ;\ k_{af1}=\frac{6\times 2}{9+11}=0.6$$

Similar coefficient: $k_{s1}=0.1\times 1+0.2\times 1+0.1\times 1+0.4\times 1+0.2\times 0.6=0.92$

- Similar coefficient of the new piston and piston B

$$k_{mt1}=1\ ;\ k_{ht1}=1\ ;\ k_{bt1}=1\ ;\ k_{mf1}=\frac{2\times 2}{2+3}=0.8\ ;\ k_{af1}=\frac{4\times 2}{9+10}=0.42$$

Similar coefficient: $k_{s1}=0.1\times 1+0.2\times 1+0.1\times 1+0.4\times 0.8+0.2\times 0.42=0.804$

The calculation results indicate: the similar coefficient 1 is higher than the similar coefficient 2, so choose piston A to derive as the similar process, on the basis of deriving results, complete the new piston's process design through editing and modifying. It deriving interfaces is as Fig. 4-20.

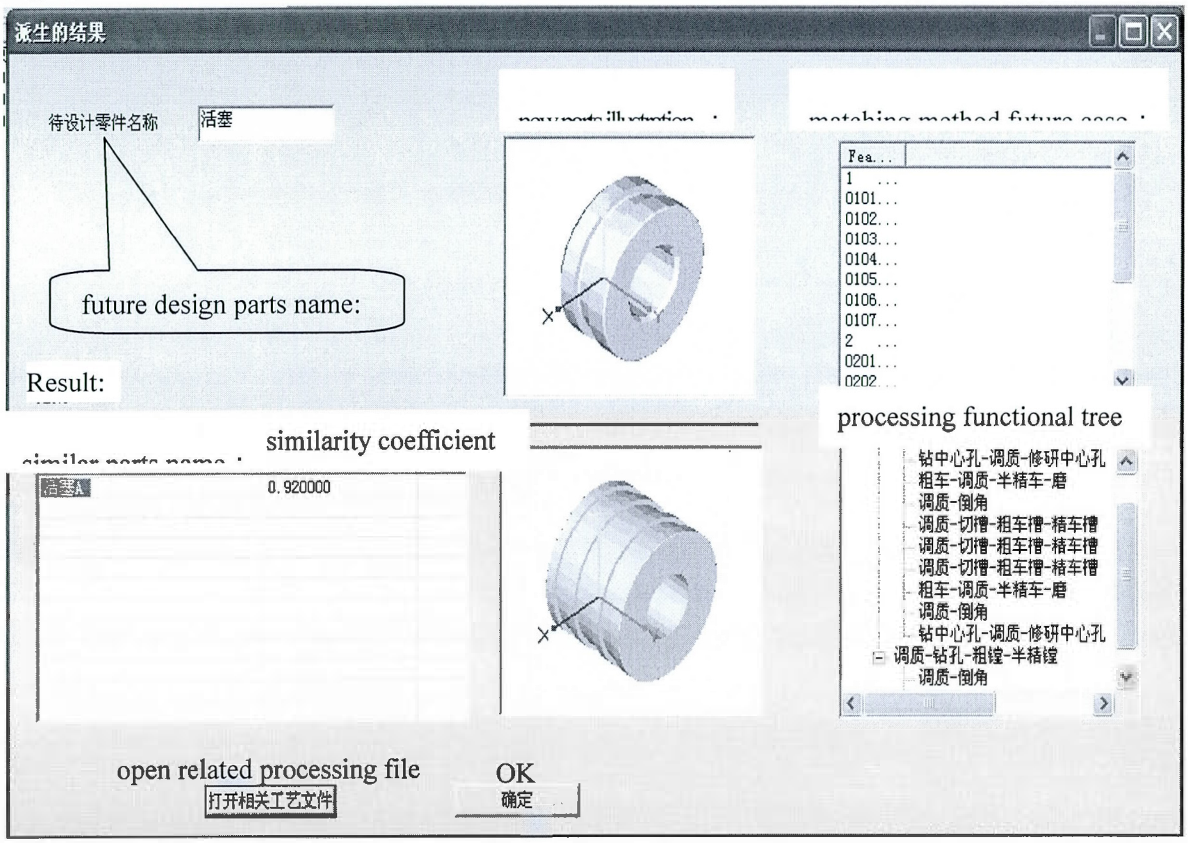


Fig 4-20 the deriving of the piston

3. Demonstration of CAPP system's other functions

(1) Process design of the typical parts

Take one typical ladder axle part as an example (as Fig 4-21), carry out the floppy decision-making. The concrete steps are as follows:

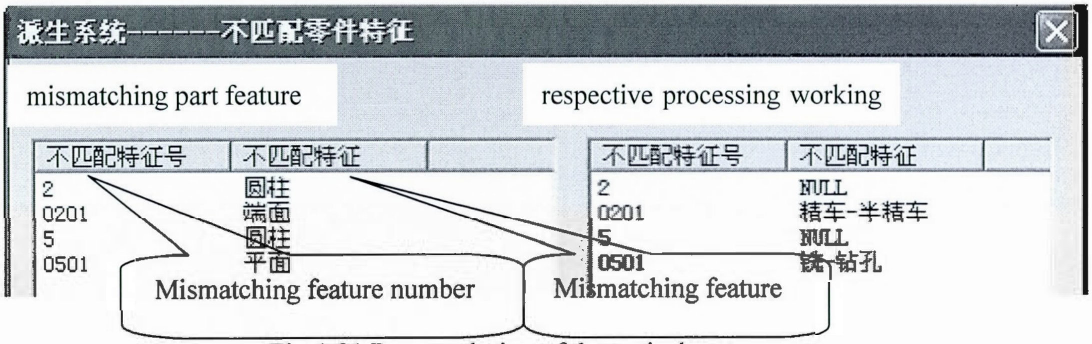


Fig 4-21 Process design of the typical parts

a. Start the searching CAPP subsystem; carry out the standard process searching; the system fails to find the same process.

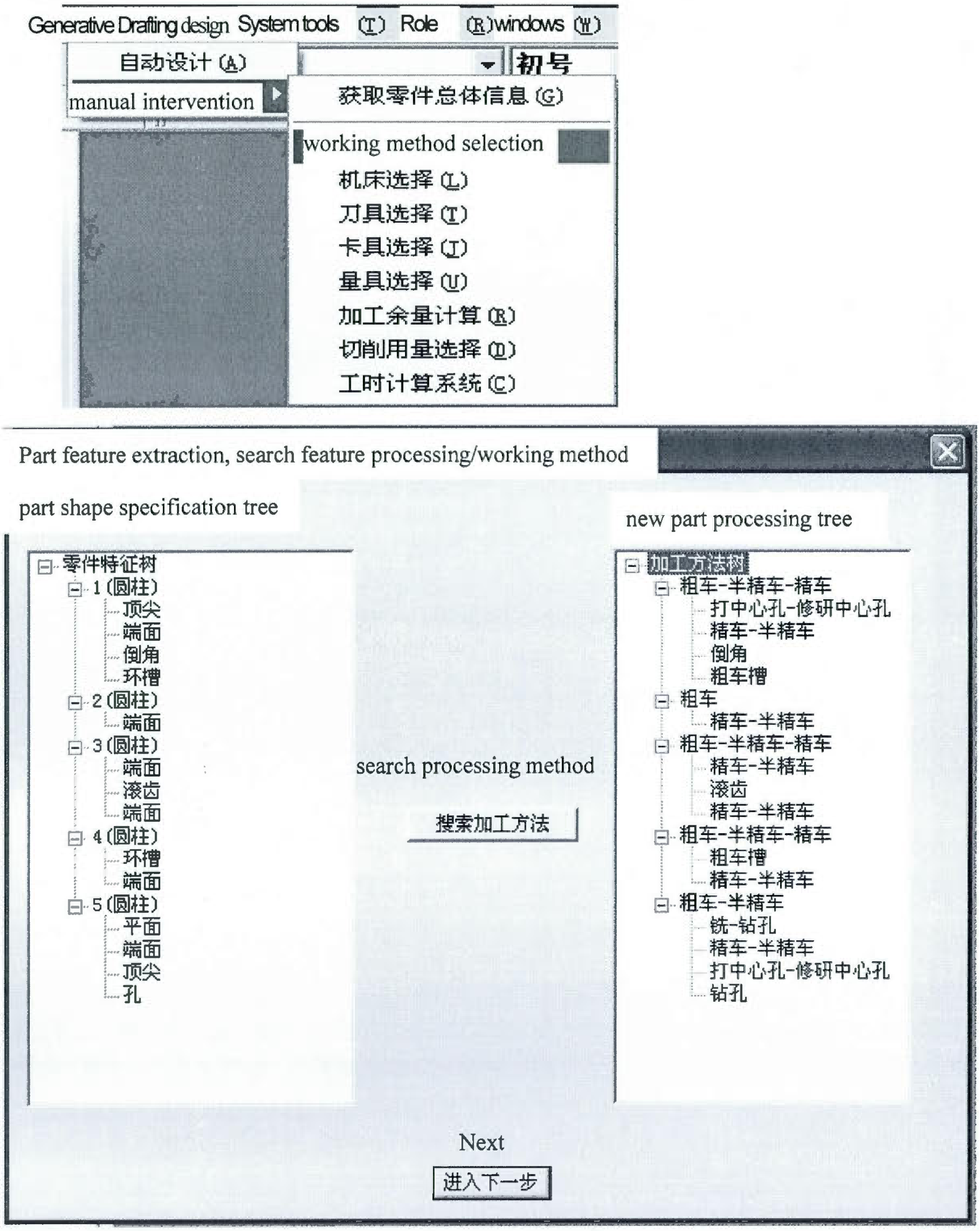
b. Start the deriving CAPP subsystem; carry out the similar process searching and deriving. The system finds two similar parts through the process index tree; through calculating similar coefficient, choose the example two with higher coefficient as the similar example; compare and match the characteristic process of the new part with the example part; keep the characteristic process method.

c. Start the creating CAPP subsystem; design the unmatched characteristic process. Search corresponding processing method in the processing method choosing rule base by way of CAPP subsystem, and insert it into the process file according to certain rule.

d. Start the filling in card CAPP subsystem; carry on the interactive editing to the process file produced, finish the process design.

(2) The creating process design

Take the typical ladder axle as an example; introduce the functions of the creating CAPP subsystem (as Fig. 4-22).



Generative Drafting design System tools (T) Role (R)windows (W)
自动设计 (A)
manual intervention
初号
获取零件总体信息 (G)
working method selection
机床选择 (L)
刀具选择 (T)
卡具选择 (J)
量具选择 (U)
加工余量计算 (R)
切削用量选择 (D)
工时计算系统 (C)
Part feature extraction, search feature processing/working method
part shape specification tree
零件特征树
1 (圆柱)
顶尖
端面
倒角
环槽
2 (圆柱)
端面
3 (圆柱)
端面
滚齿
端面
4 (圆柱)
环槽
端面
5 (圆柱)
平面
端面
顶尖
孔
search processing method
搜索加工方法
new part processing tree
加工方法树
粗车-半精车-精车
打中心孔-修研中心孔
精车-半精车
倒角
粗车槽
粗车
精车-半精车
粗车-半精车-精车
精车-半精车
滚齿
精车-半精车
粗车-半精车-精车
粗车槽
精车-半精车
粗车-半精车
铣-钻孔
精车-半精车
打中心孔-修研中心孔
钻孔
Next
进入下一步

加工方法选择

processing method selection

No	processing scheme	accuracy class	surface roughness	field of application
1	粗车	11--12	>10-80	不适用淬火钢
2	粗车-半精车	9--9	>2.5-10	不适用淬火钢
3	粗车-半精车-精车	7--8	>0.63-2.5	不适用淬火钢
4	粗车-半精车-精车-滚压	7--8	>0.02-0.63	不适用淬火钢
5	粗车-半精车-磨削	7--8	>0.03-1.25	不适用有色金属
6	粗车-精车-粗磨-精磨	6--7	>0.08-0.63	不适用有色金属
7	粗车-半精车-粗磨-精磨-超精加工	6--6	>0.01-0.16	不适用有色金属
8	粗车-半精车-精车-金刚石车	5--6	>0.02-0.63	适用有色金属
9	粗车-半精车-粗磨-精磨-超精磨	1--6	≯0.01-0.04	适用极高精度的外[
10	粗车-半精车-精车-精磨-研磨	6--6	≯0.01-0.16	适用极高精度的外[

Fig 4-22 Creating process design

(3) The process management

The system has realized the management and maintenance of process knowledge, process data, process resources and process file, etc. Some functions are as Fig. 4-23 to 4-25 shows.

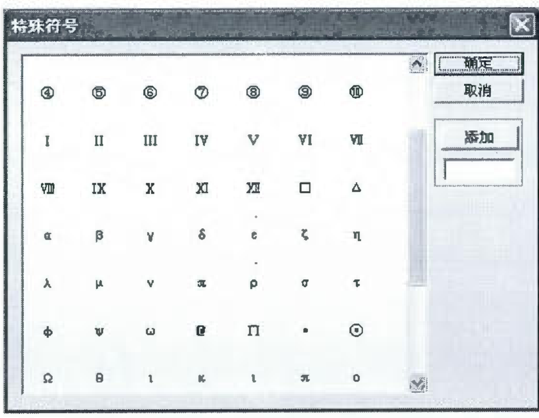


Fig 4-23 The symbol inputting tool

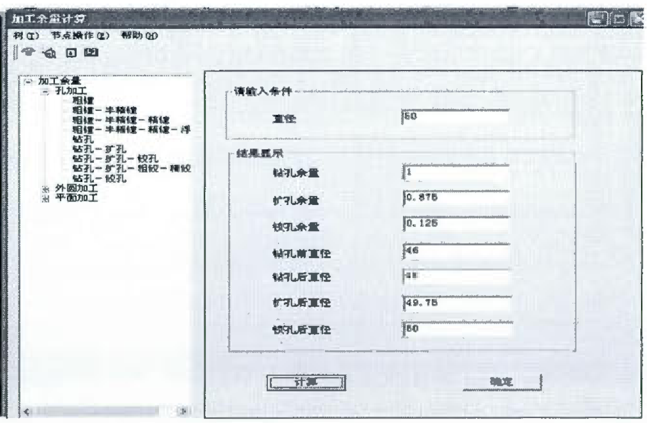


Fig 4-24 The procedure size and surplus computational tool

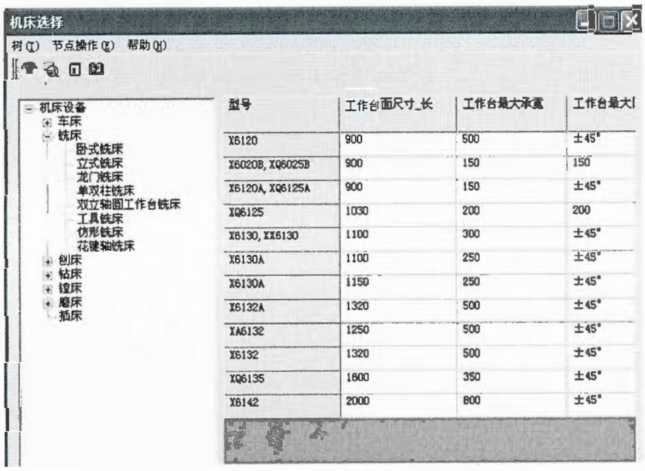


Fig 4-25 machine tool choice tools

Chapter 5

Conclusion

This project researches the key integrated technology of CAD, CAPP on the basis of analyzing PDM system's function. Including:

1: CAD/CAPP integrated model's construction under PDM frame;

2: Research of CAD unit technology under CAD/CAPP integrated mode;

3: Research of CAPP unit technology under CAD/CAPP integrated mode.

The mainly contents of this thesis is the drawing of ideas and technologies into CAD/CAPP intergradations, thus CAD and CAPP subsystem are established on this foundation.

1: The CAD sub system: finish the designing work from customer's order to the ending of detailed design of product.

2: The CAPP subsystem: finish the work from the input of spares information to the output of engineering documents.

The main accomplishments of this thesis include:

1: Research the key technology and implementation method of CAD/CAPP integrated system based on PDM; construct the object faced integrated system frame; realize the integration of the enterprise's application system based on file management and shared database.

2: Set up the product module model based on knowledge and the product's information management system; study the expression and management technology of the product design information facing the product's life cycle.

3: Apply the information integration technology based on product structure and the modular design technology in the construction of CAD subsystem; realize the development of CAD subsystem facing the deformed products.

4: Use the parts' information inputting technology based on feature and product structure to study the constructing technology of the process information model based on product structure.

5: Use the multi-process decision-making mixed technology with database as the core and the artificial intelligence technology to study the floppy process decision-making mode based on knowledge base.

6: Study the organic integration technology of many kinds of technology in CAPP fast developing instrument system, including the parts' information inputting technology based on the feature and product structure, floppy decision-making technology, component technology based on COM and modular process design technology, etc..

Problems and shortcomings lie in the application of current CAPP:

1: The application scope is relatively narrower. The application of CAPP should turn from the partial application with components as its main objects to the application of the whole life cycle with the total products as its objects; realize the integration of the product's process design and management; build up the enterprise-grade process information system.

2: The process design and management based on the three-dimensional CAD. At present, the application of CAPP is basically carried out on the basis of two-dimensional CAD. Its integrated application with the three-dimensional CAD is still at the starting stage which needs further research and overfulfillment.

3: The integration of CAPP system with other application systems.

4: The conflict of CAPP with the managing function in CAD.

On the basis of these, there are still some directions need further research:

1: The CAPP system facing the product's whole life cycle.

2: The CAPP system based on knowledge. Up to now, CAPP has successfully solved the problem of process design efficiency and standardization. One important direction of CAPP's application and development may be how to summarize the enterprise's process design knowledge effectively and improve CAPP's knowledge level.

3: The CAPP system based on three dimensional CAD. With the universal application of enterprise's three-dimensional CAD, how the process supports the application based on three-dimensional CAD, especially the assembly process design based on three-dimensional CAD is becoming a hot point the enterprise needs.

4: The CAPP system based on platform technology and that can be reconstituted. Openness is an important factor used to measure CAPP. As the process has strong individuality, meanwhile the enterprise's processing needs may vary, so CAPP has to continuously meet the needs of client's individuality and changes. Therefore, the CAPP system based on platform technology, which can be developed once more and reconstituted will be an important developing direction.

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