Research report 51

DFM (A) - Analysis and Aspects of Applying Internet Based Collaborative Design for Axial Eccentric Oil-Pump Design

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ISBN 951-764-931-2
ISSN 1459-2932

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Abstract

The integrated system of design for manufacturing and assembly (DFMA) and internet based collaborative design are presented to support product design, manufacturing process, and assembly planning for axial eccentric oil-pump design. The presented system manages and schedules group oriented collaborative activities. The design guidelines of internet based collaborative design & DFMA are expressed. The components and the manufacturing stages of axial eccentric oil-pump are expressed in detail. The file formats of the presented system include the data types of collaborative design of the product, assembly design, assembly planning and assembly system design. Product design and assembly planning can be operated synchronously and intelligently and they are integrated under the condition of internet based collaborative design and DFMA. The technologies of collaborative modelling, collaborative manufacturing, and internet based collaborative assembly for the specific pump construction are developed. A seven-security level is presented to ensure the security of the internet based collaborative design system.

Key words:

Design for manufacturing and assembly, Internet based collaborative design, Axial eccentric oil-pump

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CONTENT

1 INTRODUCTION

The conventional mechanical systems' and assemblies' design approaches have little interaction, due to lack of unified representation, simulation, and synthesis framework. The integration of DFMA and Internet based collaborative design utilizes a more flexible design strategy, in which heterogeneous system components are designed parallel using specialized models and sharing environment. The designer makes partitioning decisions after having at first evaluated the alternative structures, which concern function, performance, process plan programmability, recurring development costs, manufacturing/ assembling costs, reliability and maintenance, etc [19]. With the rapid development of computer and Internet technology, collaboration between person and person, between person and enterprise, between enterprise and enterprise has turned more and more related on Internet/ Intranet [14]. The Internet based collaboration design includes group awareness, communication and coordination within the group, monitoring and control, data sharing and representation, and the support of the heterogeneous, cross-platform, cross-system and open environment.

The system of Internet based collaborative design can overcome the limits of geography area to exchange information, deal with knowledge, and transfer all kinds of data formats. In this paper, we integrate the information model of general DFMA and Internet based collaborative design. DFMA methodology is used in the field of Internet based collaborative design. Each collaborative client must satisfy the requirements of manufacturing and assembly processes during the concept design and scheme design, integrate the design rules of easy manufacturing and assembly into the product design, and guide collaborative clients to create products, which are easier for manufacturing and assembly. This research deals also with the aspects of group collaboration, object sharing, data exchange, data consistency, and real-time interactivity. Also, according to the assembly rules and influencing factors, collaborative clients can affect on the manufacturability and assembility of product at the earliest stages of the design process, which improves product quality, reduces costs, and shortens the design and manufacturing cycle of the product.

This paper is one of the results of the European Commission project *"Asia-Link: Collaboration for human resource development in mechanical and manufacturing engineering (contract No: ASI/837-301/98/679-023)".*

This paper is organized as follows: Chapter 2 presents the background of the Internet based collaborative design and DFMA. Chapter 3 expresses the components of the axial eccentric oil-pump, including function, geometry and drawing and requirement list of the pump. Chapter 4 presents the design methods, including the design process and the design activities for the axial eccentric oil-pump design. Chapter 5 expresses the system structure of the interned based collaborative design & DFMA. Chapter 6 presents the manufacturing stages for the axial eccentric oil-pump. Chapter 7 presents the collaborative design and manufacturing activities for the pump. Chapter 8 is discussion. Chapter 9 concludes the paper.

2 BACKGROUND

In the earlier stage, product developers communicated by means of postal mail, telephone, fax machine, and face-to-face meetings [20]. Design documentation was paper-based by hands, and development work of product design proceeded step by step.

In the second stage, designers have used CAD software, engineers modelled products, printed drawings for delivery to other collaborative clients, gathered comments, and then revised the CAD model for the next round of review.

In the stage of collaborative design, tools expanded to include email, Internet chat, teleconferencing, web-based meetings, more CAD software, and manufacturing tools and technologies. The number of Internet communications increases while product development becomes more global. A great deal of design documentation now resides in databases and the electronic version of product's CAD-model is available for browser-based design review. Using the Web, development team members in different physical locations could meet virtually to confer on designs together and to view and mark up CAD models. The use of Web-based design reviews have made it possible for many development teams to work more effectively.

Design for Manufacturing and Assembly (DFMA) is a methodology, which goals are to improve the integration between design and manufacturing, to shorten product developing cycle, to reduce costs, to improve product quality and reliability, to shorten lead time, to increase productivity and to response faster to customer requirements.

De Fazio [31] used assembly sequence analysis (ASA) as a basis for complex-assembly DFA. He has also searched for favourable subassembly partitioning and assembly sequences to minimize assembly difficulty as measured by kinematic degrees of freedom, which are secured in assembly moves, while logical constraints that part geometry imposes on sequence choice are satisfied.

Dorador [32] explored the definition of the structure of information models for supporting the related processes of design for assembly (DFA) and assembly process planning (APP), and took the view that the information models required to support DFA and APP is captured in a product model and in a manufacturing model.

Swaminathan [33] presented integrated models applicable at a plant level that can provide quantification of certain operational benefits, through a computational study, also provide qualitative insights on several issues.

Boer, C.R [34] presented the research and development of an integrated computer aided design for assembly system. The project main aim was to obtain methodologies and tools to design and manage a complete flexible assembly system.

3 COMPONENTS OF AXIAL ECCENTRIC OIL-PUMP

3.1 Function of the Axial Eccentric Oil Pump

Axial eccentric oil-pump [21] is one of the cubage pumps, and is a reciprocating pump using a cylindrical mechanism to create a reciprocating motion along an axis, which then builds pressure in a cylinder to force oil through the pump. Pump uses steam power drives, pneumatic drives, hydraulic drives, or electric drives to actuate the plunger. The pressure oil generated by the hydraulic unit is fed to the respective hydraulic cushion cylinder. The pressure in the hydraulic circuit is controlled by a hydraulic relief valve. In the high pressure cylinder, the oil continuously sent from the oil feed unit is pressurized by the reciprocating plunger.

Components may have a number of materials used including bronze, brass, steel, stainless steel, iron, nickel alloy, or other material. For example, axial eccentric oil-pump has an iron cylinder. The solid ceramic plungers may be used when there is a contact with water and oil, but may not be the appropriate choice for use with highly acidic media types. The plunger, discharge valves, and suction valves come in contact with the media type transferred; material choices should be considered based on the fluid transferred [22].

The advantages of the use of axial eccentric oil-pump are:

1) More powerful pressure: the normal pressure of axial eccentric oil-pump is 200~400kgf/cm^2,
2) The maximum pressure can be up to 700kgf/cm^2

3) The efficiency of the volume is more than 95%, and the whole efficiency of pump is more than 90%
4) Long life: the life of the axial eccentric oil-pump is over 10000h.
5) Axial eccentric oil-pump can be used to pump different types of liquids
6) The weight of unit power is light.

3.2 Geometry and Drawings of the Axial Eccentric Oil-Pump

Fig.1 is the drawing of the axial eccentric oil-pump. Fig.2 shows the working principle of the plunger of axial eccentric oil-pump.

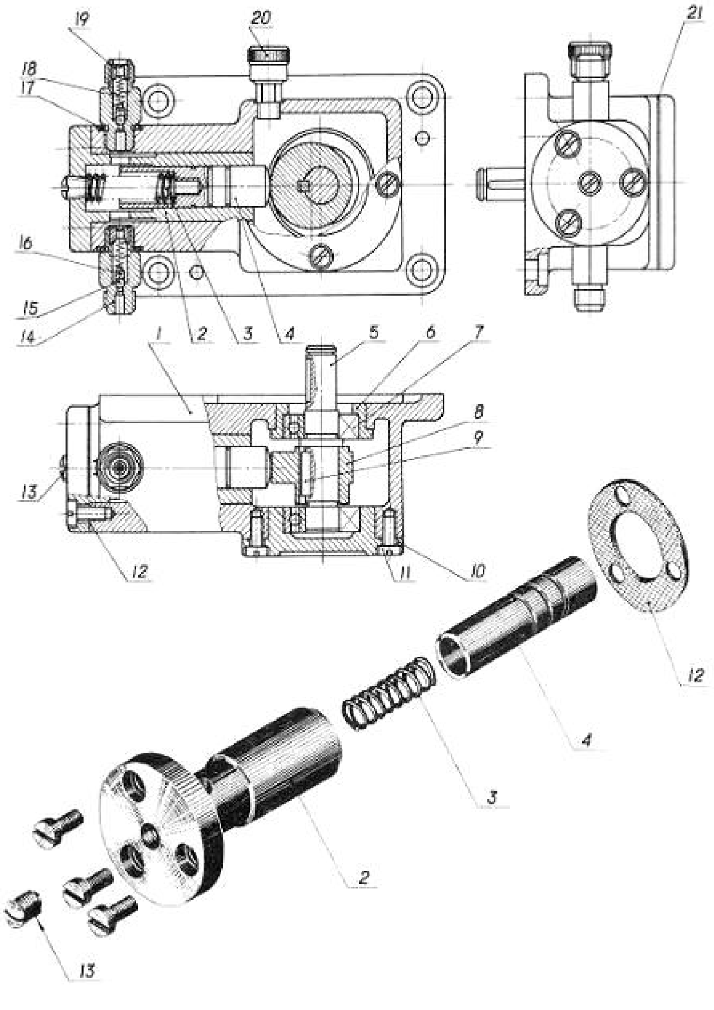

Fig.1 The structure of the axial eccentric oil pump

List of parts: 1-pump body, 2-hydraulic cylinder, 3-Spring, 4-plunger, 5-shaft, 6-ferrule, 7- bearing, 8-eccentric wheel, 9-key, 10-gasket, 11-screw, 12-washer, 13-screw, 14-nozzle, 15-steel sphere, 16-nozzle spring, 17-washer, 18-spring, 19-output nuzzle steel sphere, 20-diathermanous screw, 21-cover of pump body.

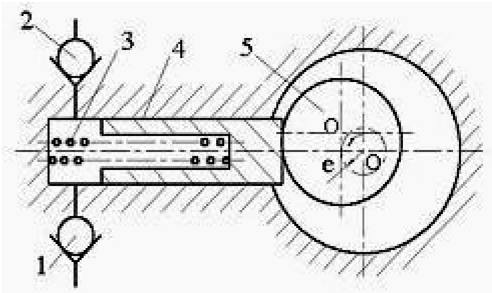

Fig.2 The working principle of the axial eccentric oil pump

3.3 Requirement List

The requirement list for the axial eccentric oil-pump is as follows:
1) compact structure, low noise, high efficiency
2) stability for frequency timing, rotation speed and piston displacement and time and oil temperature,
3) small energy consumption, power supply, and the automatic controlling of oil temperature,
4) multi-grade rotate speed settlement
5) quick speed, quick response
6) sectional area of plunger: 8 cm^2
7) pressure of hydraulic cushion cylinder: 400 MPa
8) pressure of high pressure cylinder: 440 MPa
9) volume of circulating oil inflow to the hydraulic cushion cylinder: 2 l/min
10) volume of a single inflow of oil to the hydraulic cushion cylinder: 100 cm^3
11) required power for total delivery: 20 kW
12) nozzle efficiency: Maximum 95%
13) delivery pressure: Maximum 440MPa
14) delivery volume: Maximum 2.4 l/min
15) plunger stroke: Maximum 100 mm

4 COLLABORATIVE DESIGN

This chapter is divided into three sub-chapters as follows: Design processes, design activities of Internet based collaborative design and design rules/ guidelines for axial eccentric pump design.

4.1 Design Processes

Fig.3 shows the design process for the internet based collaborative design and DFMA technology, which mainly includes the collaborative design control, collaborative manufacturing, DFMA, connections with the Internet, Interface definition, server and analysing activities.

Miller [37] presented, that in spite of some possible risk and control issues (see the details presented in [37]), the collaborative-concurrent design process appears to be the best basis for a CE Design process because it is philosophically consistent, can absorb many design approaches, and can be transitioned into step-wise refinement. The work breakdown structures (WBS) plus the collaborative design at the high end of the design and in various component areas can be employed in order to reduce risk and insure control.

Interference management predefines the content of various areas to preclude interference [23]. Interface definition predefines the interfaces between system and elements which will compose various crossing boundary areas. Fig. 3 expresses how multiple collaborative clients using the holistic approach, and the design control-interface-interference set of activities, monitor and correct potential issues before the design becomes more "fixed." These simultaneous activities must have an end, and they must be kept under control. The end, or schedule adherence, is principally managed by having multiple design releases. The control lays on the responsibility of the server, and it is supported by the process management. The “in-line” process model concept applies design process for Internet based collaborative design across multiple collaborative clients.

The application of Internet based collaborative design makes designer to work within the context of an existing production system which could be enlarged to utilize greater interaction. In the system of Internet based collaborative design, the production system will be freely designed or redesigned in conjunction with the design of the product. When design clients and manufacturing clients work together to design and rationalize both the product and production and support processes in the environment of collaborative design, the methodology is known as “integrated product and process design”. The designer's consideration of design for manufacturability, cost, reliability and maintainability is the starting point for integrated product development. However, the application of DFM must consider the overall design economics [2]. It must balance the effort and cost associated with development and refinement of the design to the cost and quality leverage that can be achieved.

Quality engineering [1] is a continuous demand in product design and manufacturing. The purpose of quality control is to produce the products whose quality is designed and maintained at lowest possible cost, while providing full customer satisfaction. Quality control activities at the product planning, design, and production engineering phases are usually referred to as offline quality control or quality engineering, whereas the quality control activities during actual production are referred to as on-line quality control. During the quality engineering phase, three steps should be followed: system design, parameter design, and tolerance design.A cross-technological approach can be seen also in the variety of design methodologies, such as using of design protocols or cognitive models. The methodology is derived mostly from philosophy or psychology. The underlined goal is to present what the designer should do or how the design process ought to proceeded. It is also significant to notice the meaning of philosophy and psychology to complete the theories of design methodology.

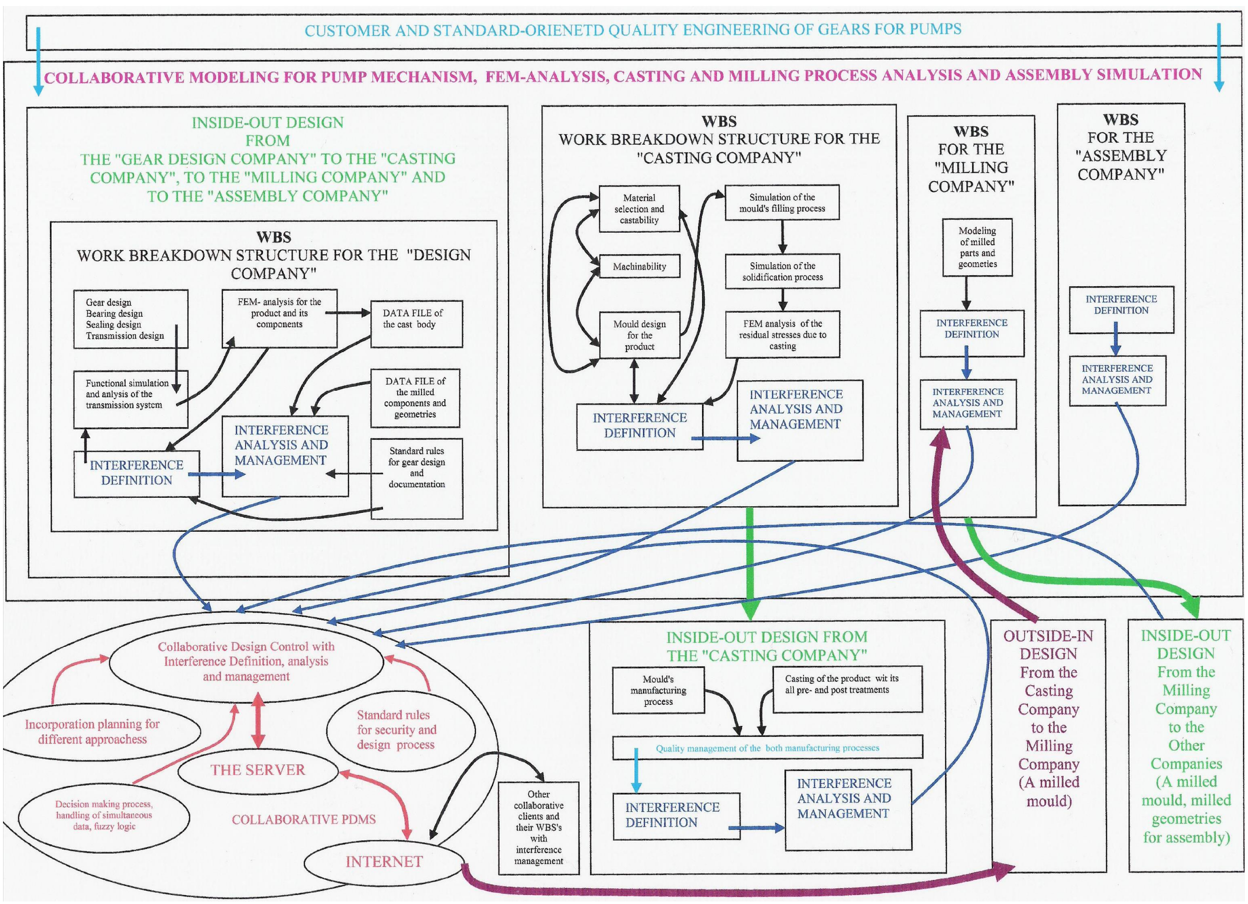

Fig.3 Design process of Internet based collaborative design and DFM for the pump application (only some of the main connections are presented).

The various areas of production manufacturing affected by different aspects of the design are indicated as members of the concurrent engineering (CE) dimension of the collaborative design team. It is this simultaneous interest of design and of manufacturability, which makes up collaborative design. Transition from design to manufacturability is also reflected in the different collaborative design intellectual activities' interaction.

4.2 Design Activities of Internet Based Collaborative Design for Axial Eccentric Oil Pump

From table 1, we can see that the collaborative design activities mainly include the following tasks: modelling, manufacturing, communication, assembly, and system building.

Table 1. The design activities of the Internet based collaborative design for axial eccentric oil pump

Main activities inside collaborative design process	Detail activities inside collaborative design process		File-format out of the activity	File-format into the activity	Who has sent the file?	Who is using the file?
Modelling	Conceptual design		Text-files Figure-files		designer	designer
	Basic geometry		Dwg		designer	designer
	Main dimension		Dwg		designer	designer
	Possible material or material composition		Text-files		designer	designer
	Design valuation				designer	designer
	Solid model:	Pump Body	STL	Any CAD file formats (including DXF,DWG, STEP, IGES, Wrl, etc)	designer	designer
		Hub	DXF(2D), STEP(3D)	Any CAD file format (including DXF,DWG, STEP, IGES, Wrl, etc)	designer	designer
		Shaft	DXF(2D), STEP(3D)	Any CAD file formats (including DXF,DWG, STEP, IGES, Wrl, etc)	designer	designer
		Eccentric wheel	DXF(2D), STEP(3D)	Any CAD file formats (including DXF,DWG, STEP, IGES, Wrl, etc)	designer	designer
		Cover, plunger	DXF(2D), STEP(3D)	Any CAD file formats(including DXF,DWG, STEP, IGES, Wrl, etc)	designer	designer
Manufacturing	Manufacturability analysis				designer	designer
	Manufacturing planning				designer	designer
	Various Manufacturing Method	Machining : shaft, hub, eccentric wheel, cover	STEP	STEP, IGES, DWG, DXF, etc	Machining company	client
		Casting: pump body	STEP	STL	Casting company	designer
		Milling: pump body	STEP	STEP, IGES, DWG, DXF, etc	Milling company	designer
		Standards parts: bearing, screw	STEP	STEP, IGES, DWG, DXF, etc	Standards parts company	designer
	Tolerance :		XML	Doc, txt, or other documents formats	designer	designer
	Roughness		XML	Doc, txt, or other documents formats	designer	manufacturer
Assembly	Assembility analysis				designer	designer
	Assembly precision				designer	designer
	Standard parts: bearing, screw				company	designer
	Assembly solid model		STEP(3D) DXF(2D)	Any file	designer	designer
Communication	Data exchange		STEP	Any file formats	designer server	designer server
	Voice communication		WAV, mp3 etc	Any voice file formats	server clients	server clients
	Video communication		AVI, MPEG1,MPEG2, VCD, SVCD, DVD, WMV, ASF	AVI, MPEG1,MPEG2, VCD, SVCD, DVD, WMV, ASF	server clients	server clients

System based on Internet	Internet	XML, HTML	Web-pages: ASP, JSP	server clients	server clients
	Security tools		Any anti-virus tool formats: Norton, Killer, etc	server clients	server clients
	Keeping the real-time Consistency of files	Consistency between the server and clients	Any files (be lunched the Web)	server clients	server clients
	IP	HTTP: protocol	Any internet protocol	Server	Server Clients
	Resources shared		Any file formats	server clients	server clients

According to the table 1 each collaborative design activity is a component of several different detailed activities. Furtheron, the design activities of Internet based collaborative design for axial eccentric oil-pump include: 1) the main activities inside the collaborative design process, 2) detailed activities, 3) file-formats out of the activity, 4) file-formats into the activities, 5) who has sent the file 6) who is using the file. For example, for the design activity of the pump body modelling, the file-format out of the activity is STL, and the file-format into of the activity is any CAD-file format (including STL, DXF, DWG, STEP, IGES, Wrl, etc), designer of pump body sends the file, and the other designer who needs the file is using the most appropriate file-format from the list of available ones.

4.3 Design Rules and Guidelines

The design rules and guidelines of this system are shown in Fig.4, which mainly consist of the design rules of Internet based collaborative design, the guidelines of design for disposal & recycle ability, design for environmental manufacturing, design for environmental packaging, and the rules of DFMA.

For internet based collaborative design, the design rules and guidelines basically include source and objects sharing, re-configurable and scalable, open and dynamic, coordination mechanisms, the system stability, composed of heterogeneous components (software, hardware and human resources).

DFMA guidelines [2] are as follows: reduce the number of parts to minimize the opportunity for a defective part or an assembly error, decrease the total cost of fabricating and assembling the product, improve the chance to automate the process, avoid tight tolerances beyond the natural capability of the manufacturing, avoid ambiguity in orienting and merging parts, utilize common parts and materials to facilitate design activities, to minimize the amount of inventory in the system and to standardize handling and assembly operations.

There are three major elements of design for the environment: design for environmental manufacturing, design for environmental packaging, and design for disposal and recycle ability [5].

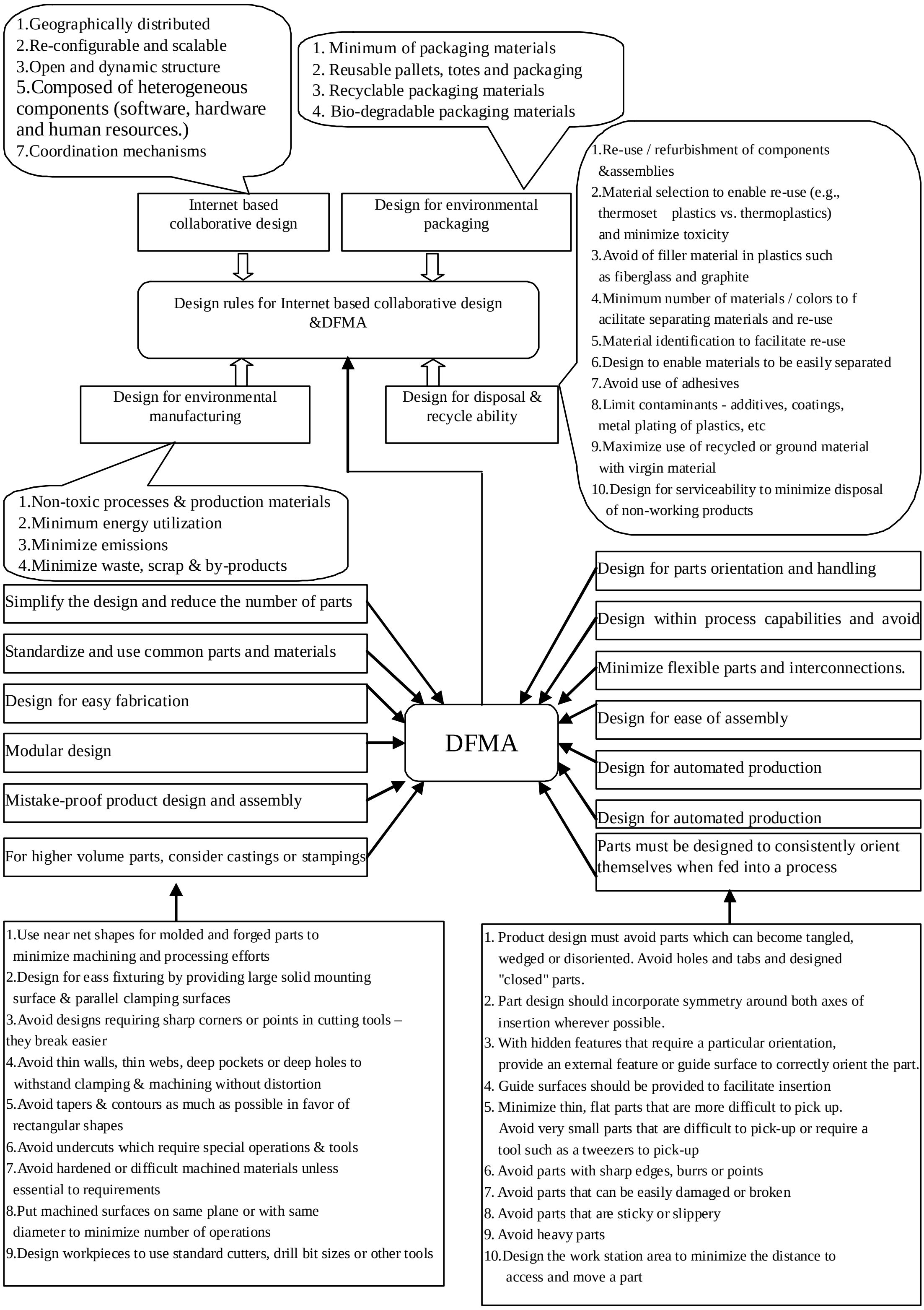

Fig.4 The design process of internet based collaborative design & DFMA

Design for environmental manufacturing involves the following considerations: non-toxic processes & production materials, minimum energy utilization, minimize emissions, minimize waste, scrap & by-products. Design for environmental packaging involves the following considerations: Minimum of packaging materials, reusable pallets, totes and packaging, recyclable packaging materials, bio-degradable packaging materials. Design for disposal & recycle ability involves the following considerations: Re-use/ refurbishment of components & assemblies, minimum number of materials/ colours to facilitate separating materials and re-use, material identification to facilitate re-use, design to enable materials to be easily separated, avoid use of adhesives, limit contaminants - additives, coatings, metal plating of plastics, etc., maximize use of recycled or ground material, design for serviceability to minimize disposal of non-working products

5 SYSTEM STRUCTURE FOR INTERNET BASED COLLABORATIVE DESIGN & DFMA

5.1 Server/ Clients Structure

The architecture of internet based collaborative design is a Server/ Client structure (see Fig.5). In addition to this, it is a hybrid structure, which means that the interaction and communication can be processed not only between the server and clients, but also among the clients. The structural function makes the server to save the important data and files, and the other information can directly communicate among the clients. No access to the server is needed, which reduces the loads of the server and improves the response speed of the system. The system is a component of the server, the internet based communication layer, and the client application layer. The server works as a “bridge” in the system, provides requirement for design and other applications, and is shared among collaborative clients.

The topology of collaborative design environment has been implemented using the server/ client model as it is easier to incorporate the higher level ideas such as synchronization into the system using this model [13].

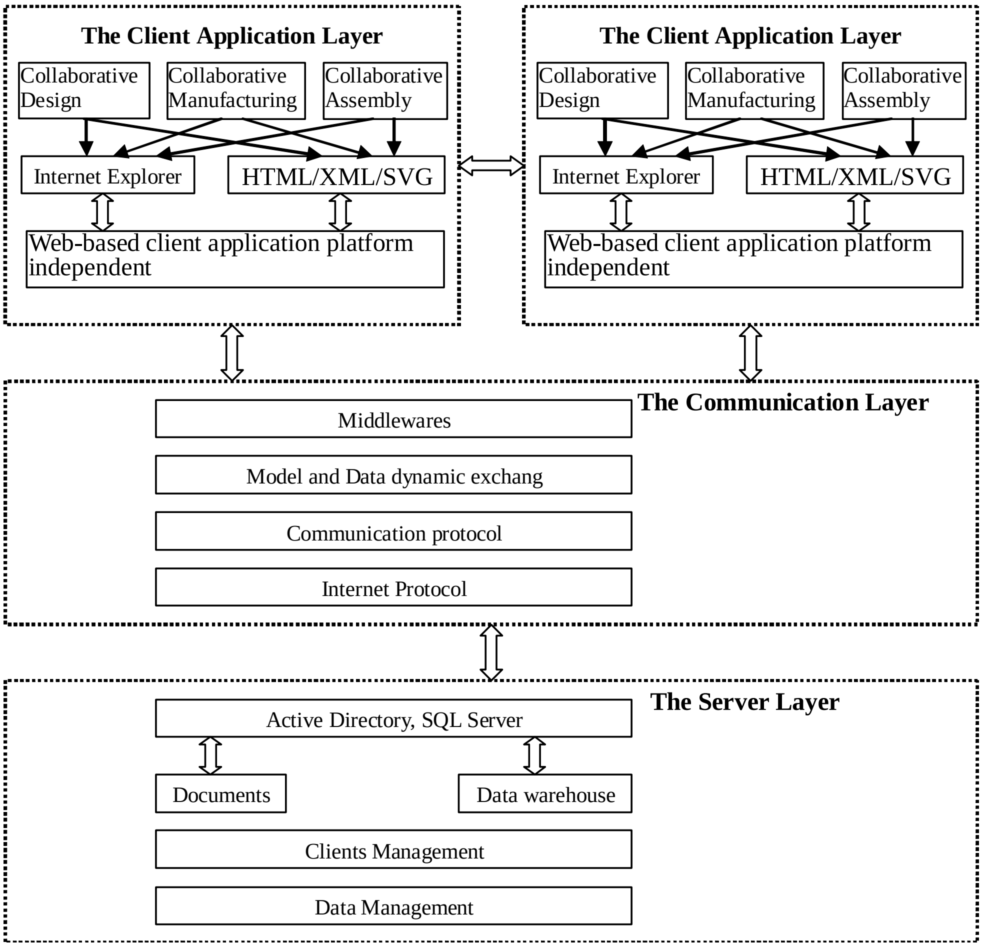

Fig.5 The architecture of internet based collaborative design.

The server /client configuration is also less prone to errors caused by network congestion as it uses fewer channels than a peer-peer configuration. Moreover, a server /client system can be expanded later to support multi-clients communication in the connections from the server to the clients. Designers can also enter design platform according to his (her) design task to participate the collaboration assignments. Events produced by such a client are not broadcast, but the client is able to see a consistent view of the copy being edited. This feature is very useful in the design review phase, where particular parts of the design can be highlighted and hierarchically edited by one or more clients while the read-only client views it.

The server includes cooperative client management, active directory, the kernel database-SQL Server, and data management. The topology of collaborative design environment was developed as a Java applet. The events that are generated because of the actions of a designer prompt the applet to take the necessary action. In the collaborative design system, user can communicate with group members, exchange information, share documents and access enterprise database, etc [25]. The basic modules of the system including process monitoring, work assignment, collaborative clients management, documents sharing/ representation and communication. Processing monitoring is a module that a group leader can use it to monitor progress of a project or design and make some actions. Collaborative client management manages collaborative members, creates schedule and assign duty to members. Data management is the key in this system. Extensible Mark-up Language (XML) and Scalable Vector Graphics (SVG) are effective ways to represent various engineering Documents, text documents and other documents. There are several ways for communication, which include chat, voice message, email and video conferencing. All these modules are based on communication protocol and all kind of middleware.

The framework of Internet based collaborative design supports integrated design, manufacturing and assembly of parts. It supports synchronous collaborative sessions via the Internet, among several members of a product development team. We conclude the properties of the structure of Internet based collaborative design as follows:

1) It is an open and hybrid structure, which means that the interaction and communication can be processed between the server and clients, and among the clients. The structure mechanism makes the server save the important data and files, and the other information can directly communicate among the clients. There is no need to access to the server, which reduces the loads of the server and improve the response speed of the system.

2) The system can adapt to the complicated network environment, the various Internet protocol and communication manners, has the multi-client interfaces and the cross-platforms.

3) The system has dynamic expansibility to all sorts of network structures, because any changes of the network structure have no influence to the exchange system.

4) Data exchange and application transaction are independent from each other. The data exchange is insensitive to the contents and formats of data.

5) The system has better interface mechanism for application system, provides appropriate encapsulation application program interface (API) for application system.

6) The middleware of the product guarantee the safety, reliability, and are independence of the network environment.

5.2 Communication Layer

This subchapter consists of two main topics, which are the communication environment and dynamic data exchange.

5.2.1 Communication Environment

The Common Object Request Broker Architecture (CORBA) is chosen for building the communication environment for Internet based collaborative design [18]. CORBA is an emerging open distributed object computing infrastructure being standardized by the Object Management Group [17]. The use of CORBA enabled existing code to be wrapped as a CORBA object and to be callable form from C^{++} or any other CORBA-supported language.

To operate as efficiently as possible in a distributed environment, inter-component data transfer was minimized and parallel execution was used. The structure of CORBA is shown as Fig.6. Object services are domain-independent interfaces that are used by many distributed object programs. There are also Object service specifications for lifecycle management, security, transactions, and event notification, as well as many others tools. Domain Interfaces fill roles similar to object services and common facilities but are oriented towards specific application domains. Application interfaces are interfaces developed specifically for a given application.

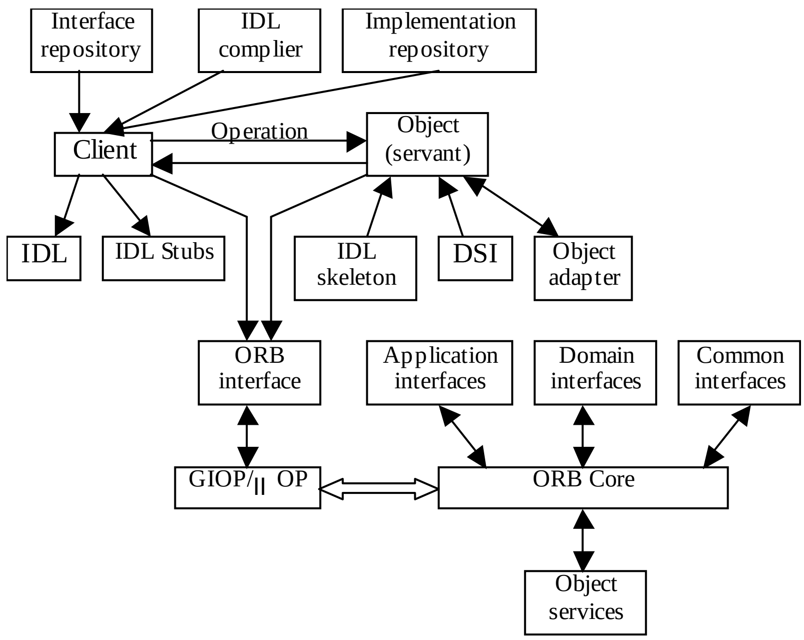

Fig.6 The structure of CORBA

Object Request Broker (ORB) provides a mechanism for transparently communicating client requests to target object implementations. The ORB simplifies distributed programming by decoupling the client from the details of the method invocations. This makes client requests appear to be local procedure calls. When a client invokes an operation, the ORB is responsible for finding the object implementation, transparently activating it if necessary, delivering the request to the object, and returning any response to the caller. ORB Interface is a logical entity that may be implemented in various ways (such as one or more processes or a set of libraries). Interface Definition Language (IDL) stubs and skeletons serve as the"glue'' between the client and server applications, respectively, and the ORB. Dynamic Invocation Interface (DII) allows a client directly access the underlying request mechanisms provided by an ORB. Dynamic Skeleton Interface (DSI) is the server side's analogue to the client side's DII. The DSI allows an ORB to deliver requests to an object implementation that does not have compile-time knowledge of the type of the object, which it is implementing. The client making the request has no idea whether the implementation is using the type-specific IDL skeletons or is using the dynamic skeletons. Object Adapter assists the ORB with delivering requests to the object and with activating the object [18].

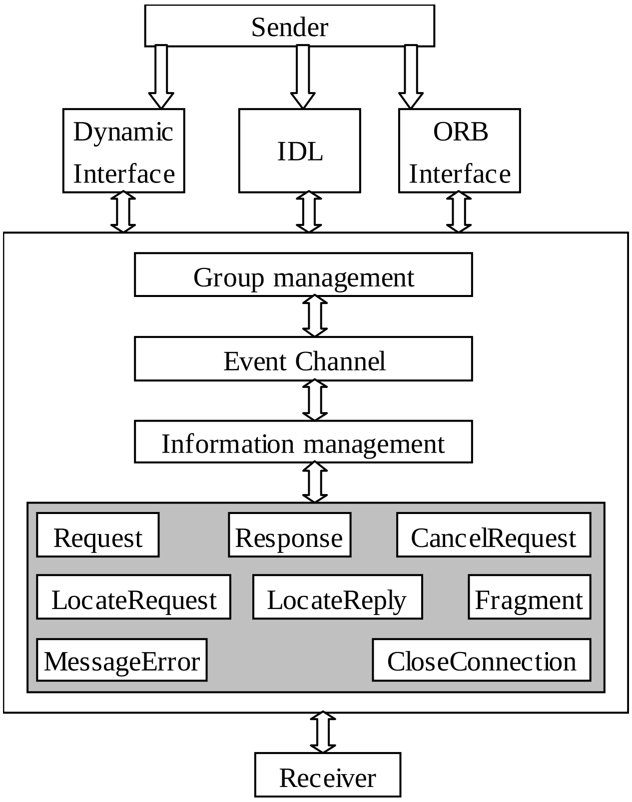

Fig.7 the communication mechanism of internet based collaborative design

The communication strategy of this system is shown in Fig.7. Sender is the information supplier, and receiver is the information consumer. The information management includes the request information, response information, cancel-request information, locate-request information, locatereplay information, close-connection information, message-error information and fragment information.

The information, which is sent by supplier, goes through the ORB interface, and arrives at information operation system. Finally the receiver accepts the information, which is a cycle of information sending and receiving.

The information is passed between the clients and the server, and among the clients. There are a variety of ways in which this information passing can be implemented using the based on CORBA technologies. Distributed object-oriented computing refers to computing environments where programs can make procedure calls to other address spaces, possibly on other machines. Another way of implementing this environment is to send messages as objects, using the Java serialization mechanism and the sockets to send and receive the messages. This approach is used to implement the message passing. Our motivation for choosing this implementation is that it leads to a cleaner architecture and the resulting software follows the intuitive flow of messages.

5.2. 2 Dynamic Data Exchange

The data involved in collaborative design is often produced by some computer aided process, which has been used during product's life-cycle, such as CAD, CAPP, CAE, CAQ and CAM (namely CAX). Any of these processes could create and apply the data. Dynamic data is a subset of product data, however, the dynamic data exchange is the kernel of CAX, because dynamic data exchange can be carried through at the different CAX, the different editions and different product types of same the CAX, even during produce assembly and parts. Data exchange is of high importance in collaborative design, and is the key of data integration, data share, data real-time exchange and data consistency.

In the structure (see Fig.8), server maintains the product information that is accessed by the clients, transfers the data into an appointed data format. The clients can be those who are using a CAD-system or those that view the product data through WWW-browser. For those clients who are using CAD-systems, the data from the CAD -systems is translated to and from the product data standard before being transmitted to and from the server. Communication is carried out using the Internet. Centralized design is no longer necessary, however, at the phases of conception design and detail design, design information can be transmitted between the server and clients, and clients can view and operate the design, at the same time, bring forward the modification suggests and measurements [1]. By this mean, clients can successfully design the product and satisfy the requirements of collaborative design environment. Designers may operate at local sides by using their own CAD-systems. At first the CAD-data is transferred into a standard data format and stored into the product database, and other CAD/ CAM designers and process planners can access the data via WWW.

The system structure is the component of data exchange interface, server, WWW-browser and Internet communication protocol. Server is the kernel of the system, including in WWW-interface, data management system and product database. In the system model, data management system is component of multi-database management, super data management and data exchange interface.

The multi-database management system is a close-coupling mode, manages the design information of various design phases, and provides the valid, reasonable and credible design environment for clients. SQL Server works as the kernel database to store the crucial data. Servers for CAD-system database are used as so-called "child-databases" to store the local data. During specific design phases, data organization and management inside these databases are relatively reliable and independent, which is based on a specific transformation strategy.

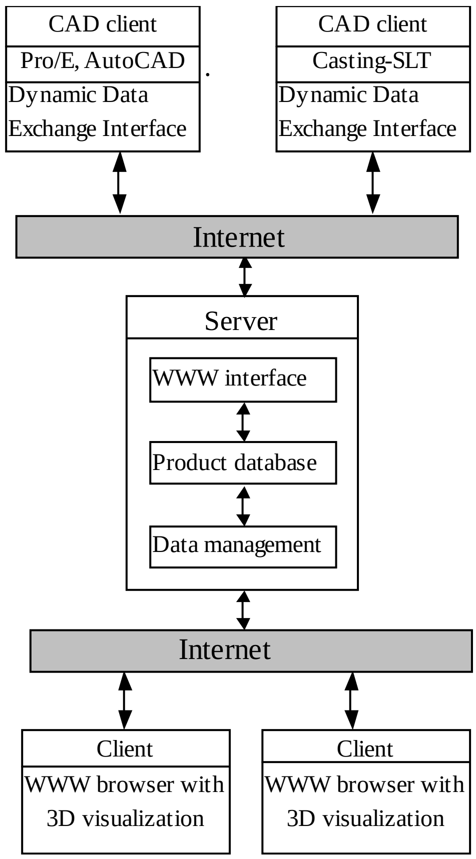

Fig.8 system structure of dynamic data exchange

For close-coupling mode, clients access the data in SQL The task of the server is to help real-time transmit of the information between the kernel-database and child-databases. The transformation strategy of variant databases guarantees the manoeuvrability among the CAD-systems, processes the data and manages the data.

Super data management is the component of edition control, configuration management, distributed access, concurrency control and the data safety. Edition management, which is based on hierarchy network model, can ensure that clients store, read and abstract always the updated information. Configuration management stores the complicated objects, saves the design state, collects the feedback and adjusts the priority of available data. Distributed access and concurrency control guarantees the consistency of the data [2].Data exchange interface is the kernel interface for collaborative design, which helps system to realize the kernel functions. System automatically transfers the design data model into interior data model, in which child-system can abstract the data, which is needed.

WWW-clients use the WWW-viewers, such as NSCA Mosaic, software Explorer, Netscape Navigator, to access these data. The viewers help clients to send requests, launch them to the server, and return the results to users. After having received the request the server validates the request, gains the data, and sends it back to the applicants. WWW-browser integrates the traditional network service and multimedia viewer, so that clients can obtain various services by the intuitionistic graphic transaction interface.

5.3 Client Application Layer

The client application layer is the component of the collaborative design, collaborative manufacturing, Internet based collaborative assembly, Internet Explorer, and the file formats used with Internet-applications, such as HTML, XML, SVG. For client applications, the feature modelling for internet based collaborative design is very important. We present the mechanism of feature modelling for Internet based collaborative design (shown as Fig.9).

The internet based feature modelling server offers the functionality, which is needed for feature modelling and other applications, and is shared among application tools. It consists of collaborative client management, creature models management, and Internet based database management. The collaborative clients management is a meta-object that manages all the agents that serve various clients connected to the server. Each client takes responsibility for answering requested services to each connected client. The feature models management corresponds to an integrated feature-based representation of the product. It is built upon the solid modelling with a generic naming scheme. The generic naming scheme generically names geometric entities that are invariant over geometric processing such as topological changes and Boolean operations. Thus, it is possible to support feature interaction management, transparent relationship between geometric entities of the server and clients, real-time feature modelling update, and attribute mechanism. It is crucial to develop a well-integrated, network-centric, and agential architecture for collaborative and distributed design and manufacturing.

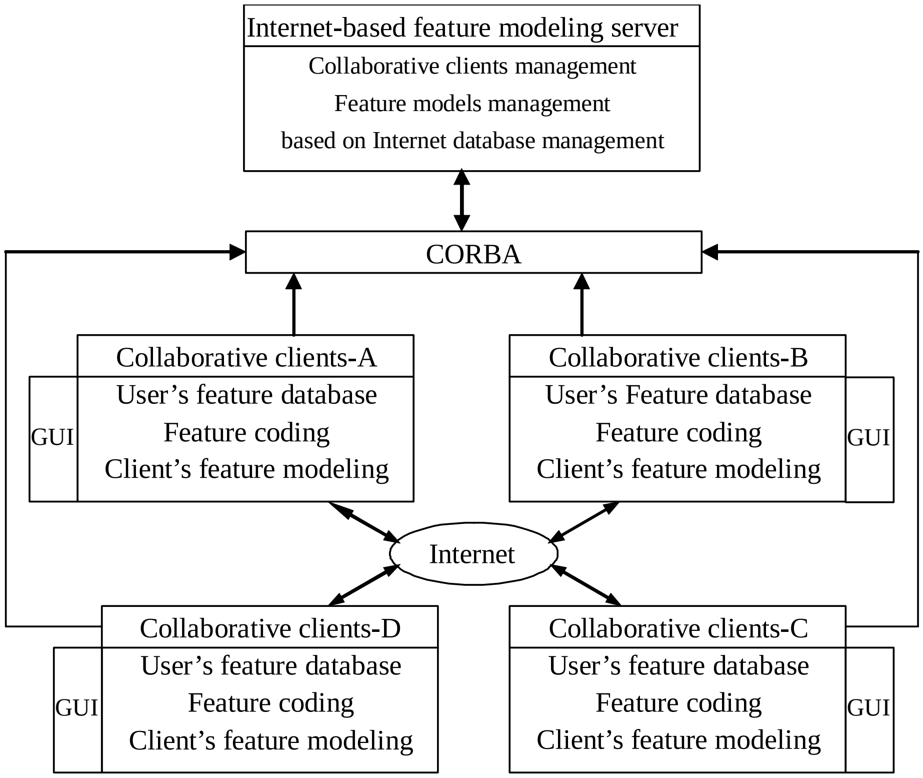

Fig.9 The feature modelling for Internet based collaborative design

The presented approach combines the current feature-based modelling technique with distributed computing and communication technology for supporting product modelling and collaborative design activities over the network. The presented approach is implemented in a client/ server architecture, in which Web-enabled feature-based modelling clients, neutral feature model server, and other applications communicate with one other using a standard communication protocol for accessing remote objects [35].

5.4 Security Strategy for Internet Based Collaborative Design

The Internet is not a single network, but a worldwide collection of loosely connected networks that are accessible by individual computer hosts in a variety of ways, including gateways, routers, dial-up connections, and Internet service providers. The Internet is easily accessible to anyone with a computer and a network connection. Individuals and organizations worldwide can reach any point on the network without regard to national or geographic boundaries or time of day [28]. However, along with the convenience and easy access to information come new risks. Among them are the risks that valuable information will be lost, stolen, corrupted, or misused and that the computer systems will be corrupted. The security of Internet becomes a key problem for collaborative design.

In this paper, the seven-level security strategy is present for internet based collaborative design, which is shown in Fig.10 (in two parts).

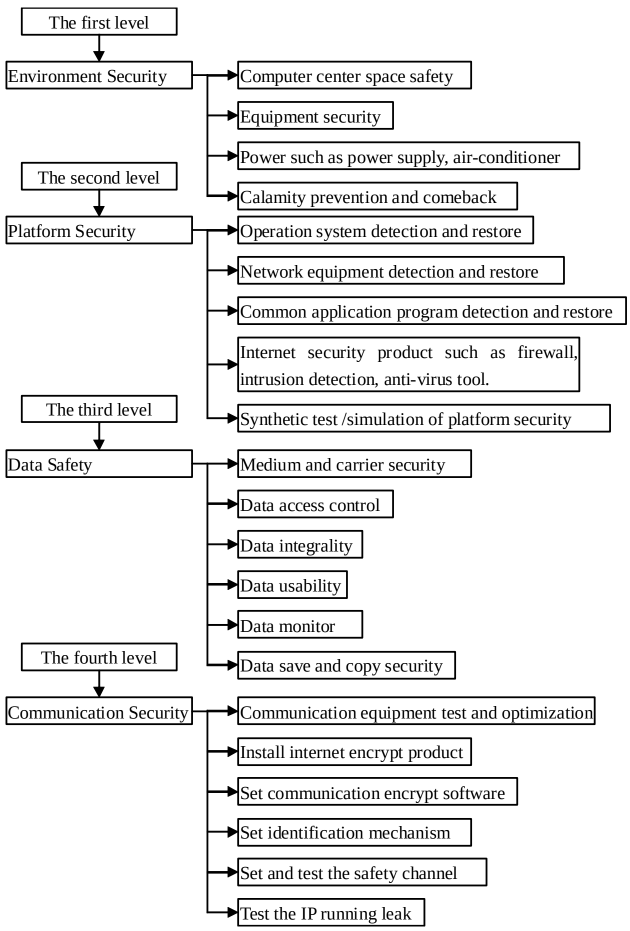

Fig.10 (to be continued) The seven-level security strategy for collaborative design based on Internet

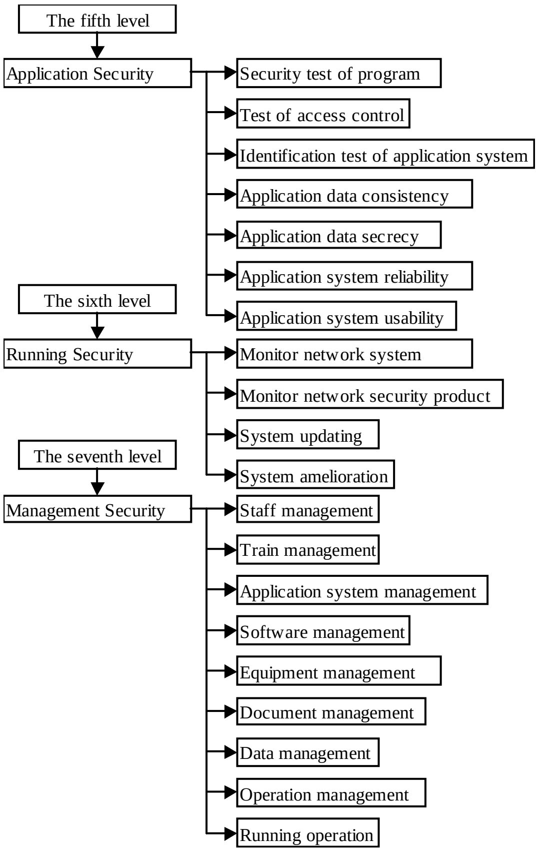

Fig.10 (continued) The seven-level security strategy for collaborative design based on Internet

This seven-level security approach will help to fill security knowledge gaps for internet based collaborative design, and addresses the proliferation of security-regulations, standards, checklists, scorecards, assessments, and audits. Three basic security concepts, which are important for the information used in Internet, are confidentiality, integrity, and availability. The security strategy ensures the authentication, authorization, and non-repudiation of information.

6 MANUFACTURING STAGES FOR AXIAL ECCENTRIC OIL-PUMP

The analysis of product's manufacturing process consists of collecting a list of alternative manufacturing technologies, selecting possible manufacturing technologies and selecting possible construction materials [36]. It is an advantage if the manufacturing technology is known already at the early design stages. During comparison also the possible pre-of post-treatments of each manufacturing stage (e.g. heat treatments, cleaning, various finishing technologies etc.) should be noticed. Different manufacturing technologies have different process stages. Typical manufacturing process includes several stages. For example, the mould could be either the casting iron mould or the ceramic mould, and the casting process could be continuous, centrifugal, based on junction casting or based on the use of external pressure.

Stereo-lithography is a free form fabrication technology which is developed, due to its accuracy and surface finish. It has become the most popular one for rapid prototyping methods [12]. It is a layered manufacturing method that utilizes a photo-curable liquid resin in combination with an ultraviolet laser: A lot of the resin sits underneath the laser, and the laser "draws" on the top layer of liquid. By drawing the outline, then filling the outline of a layer, a solid layer of material is created. By creating one flat layer at a time, a very precise geometry can be created resulting in a complete part. Based on your STL, IGS or other compatible 3D data, drawings or indications of part dimensions, we quickly establish a quotation. If necessary we convert the 2D drawings into 3D CAD data and produce the standard STL format. The 3D CAD data in an appropriate format are available for subsequent tooling operations. The surface of the casting model can be captured by non-contact techniques and represented by a cloud of points which may subsequently be converted by appropriate surface tools into the STL or a 3D CAD format [9].

In this section we present the manufacturing stages of an axial eccentric oil-pump. By applying pressure casting we can reach the final geometry without any additional manufacturing stages. Fig.11 shows the manufacturing process of the pump body. The first step is to prepare the manufacturing model and to collect other relevant information, such as 2D-drawings, 3D-model and 3D-data (file formats: STL, IGES), and surface digitization. The second step is the casting processes of pump body, including casting method and mould type/ material selection.

The third step is casting simulation. The final step before rapid prototyping is the heat treatment (suitable annealing process) analysis. The mechanical manufacturing stages of the pump body are shown in Fig.12

7. COLLABORATIVE ACTIVITIES FOR AXIAL ECCENTRIC OIL-PUMP DESIGN

This design process is presented in a form of a traditional flow-chart in Fig. 13. From the Fig.13 we can derive the collaborative design and manufacturing activities for the axial eccentric oil-pump design. After the collaborative design and manufacturing teams are formed, the clients compose the tuned the questionnaires and function requirements of axial eccentric oil-pump and convey them to the server and other clients. The collaborative design activities include the conceptual design of pump component, basic geometry design, dimensioning, listing the possible materials or material compositions, search for known solutions from CAE-file libraries and databases, and use of creative means to find other product ideas.

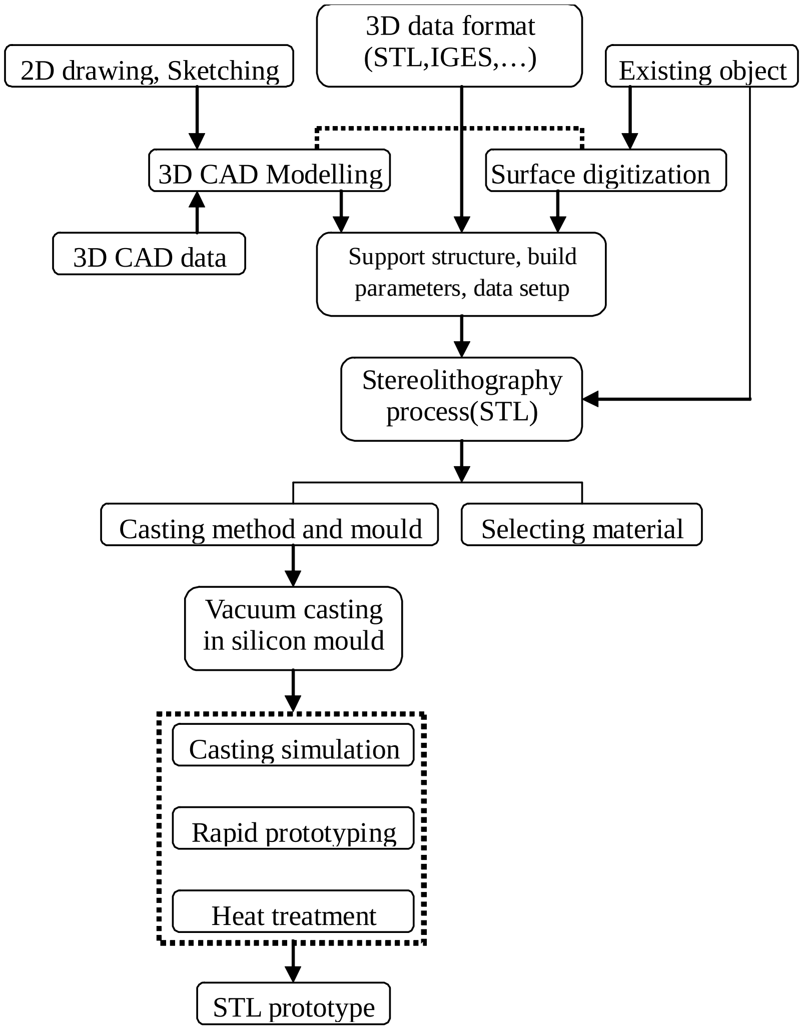

Fig.11 The manufacturing process of the pump body

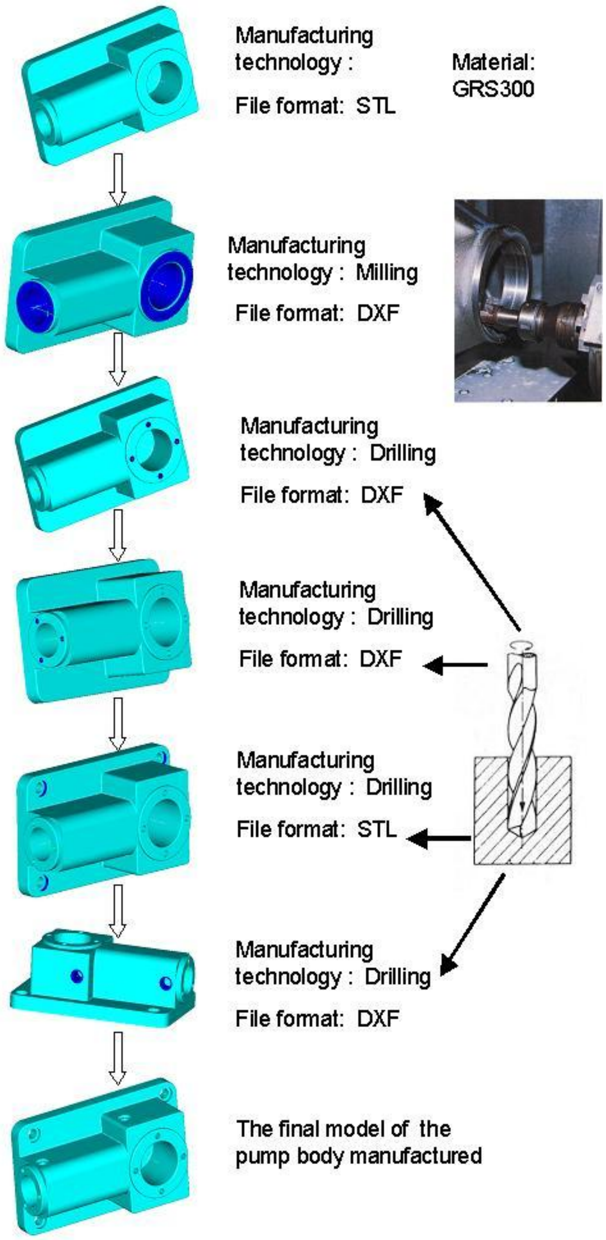

Fig.12 The manufacturing stages and file formats of the pump body

The collaborative manufacturing activities are mainly searching for characteristics for specific manufacturing methods. The task is to try to find some appropriate mathematical methods, which could be utilized for finding the appropriate manufacturing technology already during the early stages of the design process. The other collaborative activities are as follows: manufacturability oriented embodiment design, manufacturability analysis, value analysis, cost examination and parts assembly analysis.

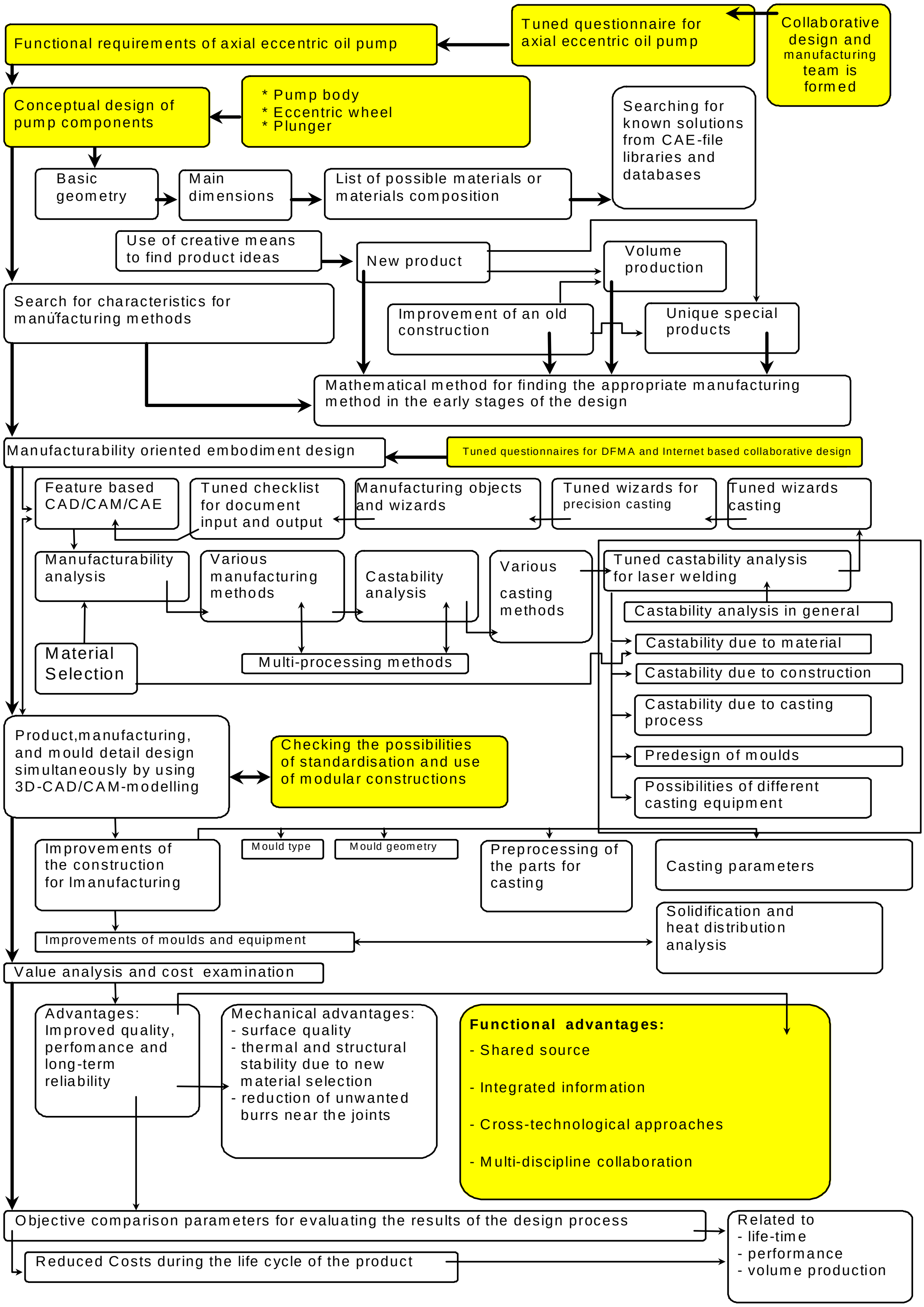

Figure 13. A detailed flowchart of the tested design methodology, which includes also manufacturability analysis.

7.1 Collaborative Modelling for Axial Eccentric Oil-pump

During every day work collaborative clients may design simultaneously something for the same component or construction, performing modelling operations available at their local. Moreover, every client has a local view and a synchronous view in their use. The local view shows the design model made by the designer himself, and the synchronous view shows the design models made by the other designers simultaneously. The synchronous view includes also the assembly model. After any of the collaborative clients has performed a modelling operation on the part at his local computer, all the others will also have that model updated in their synchronous view. Because all designers have the same modelling rights, several modelling operations of the component may be concurrently specified and sent to the server [25].

All clients share the same viewing parameters of the visualized product geometry, possibly in their synchronous views. These parameters are permanently synchronized, so that each time any of the users interactively modifies those, the shared synchronous view and model of the other users are automatically updated [22]. When designers want to discuss about some details of the model or about some previously made changes, the shared platform makes it possible to trace back to any design stage which any of the interlocutors wants point at.

When a modelling operation results in an invalid part model at the server, i.e. one or more constraints are no longer satisfied, the Server takes the role of coordinating the validity recovery process. Initially, to that team member, who has issued the incorrect operation, a validity maintenance panel will be presented. This panel includes useful information about the particular invalid situation together with validity recovery hints [3]. This designer can now specify corrective modelling actions by himself and/or hand over the validity detail design view or manufacturing planning view. Shared cameras with different views of the same component can be used. Maintenance panel is used until the designers agree on the corrective actions. At any moment during the collaborative modelling session, any team member may invite his colleagues to join into a discussion either simply as an advisor or as a participant in a shared design environment.

7.2 Collaborative Manufacturing Activities for Axial Oil-pump

Internet based collaborative manufacturing means that two or more companies are sharing sources, interacting manufacturing information through the Internet, and working together in the creation of finished goods. Internet based collaborative manufacturing includes materials processing, manufacturing, communication and interaction mechanism, assembly, and/or test operations along the way. The quality, quantity and calendar availability of the finished goods varies based on the execution of the distributed production process. Internet based collaborative manufacturing differs from pure procurement or logistics, where standard items of guaranteed specification are moved from one enterprise's finished goods inventory to another's receiving inventory. Matrikon's Mx Suite [29] is a collaborative manufacturing solution, which closes the information gap between plant floor and business systems to enable all stakeholders to make informed, real-time and responsive decision-making when faced with production challenges.

The system of Internet based collaborative manufacturing is a consolidation of the various data stores and management systems that are of easily access by the various information systems environments. It logically integrates the file systems, Web-pages, databases, and libraries used for the storage of data by design, engineering, production planning, real manufacturing systems, simulation model development, and executing distributed manufacturing simulations [26].

The architecture of Internet based collaborative manufacturing includes modelling the behaviour and data of specific manufacturing activities, manufacturing simulation, and manufacturing data management (see Fig.14). Internet based collaborative manufacturing activities include manufacturing organizational system, supply chain systems manufacturing facility, production resources and support equipment, tools and materials, manufacturing information systems, manufacturing documents and data.

The manufacturing data management system must be flexible enough to allow the different system configurations, but still enable increased integration. Many objects in collaborative manufacturing system may reference documents containing more detailed information that are stored in a file system, PDM system, or database [26]. There are many file formats, which are efficient for Internet based collaborative manufacturing, for example, for casting processes the file format could be STL, and for milling DXF or IGES. The conversation and consistency of different file formats are very important to collaborative manufacturing, because appropriate file formats should be easily transmitted and shared in different companies. The collaborative manufacturing data management environment may include the following types of data stores and management subsystems: manufacturing file format, the dynamic exchange of manufacturing data, the transform of manufacturing file format, computer file systems, Web-pages and files, database management system, such as object-oriented database management systems, relational database management systems, and special-purpose library management systems. This will allow the identification of documents, both remotely and locally stored using the well-established, standard, WWW-access mechanism [26].

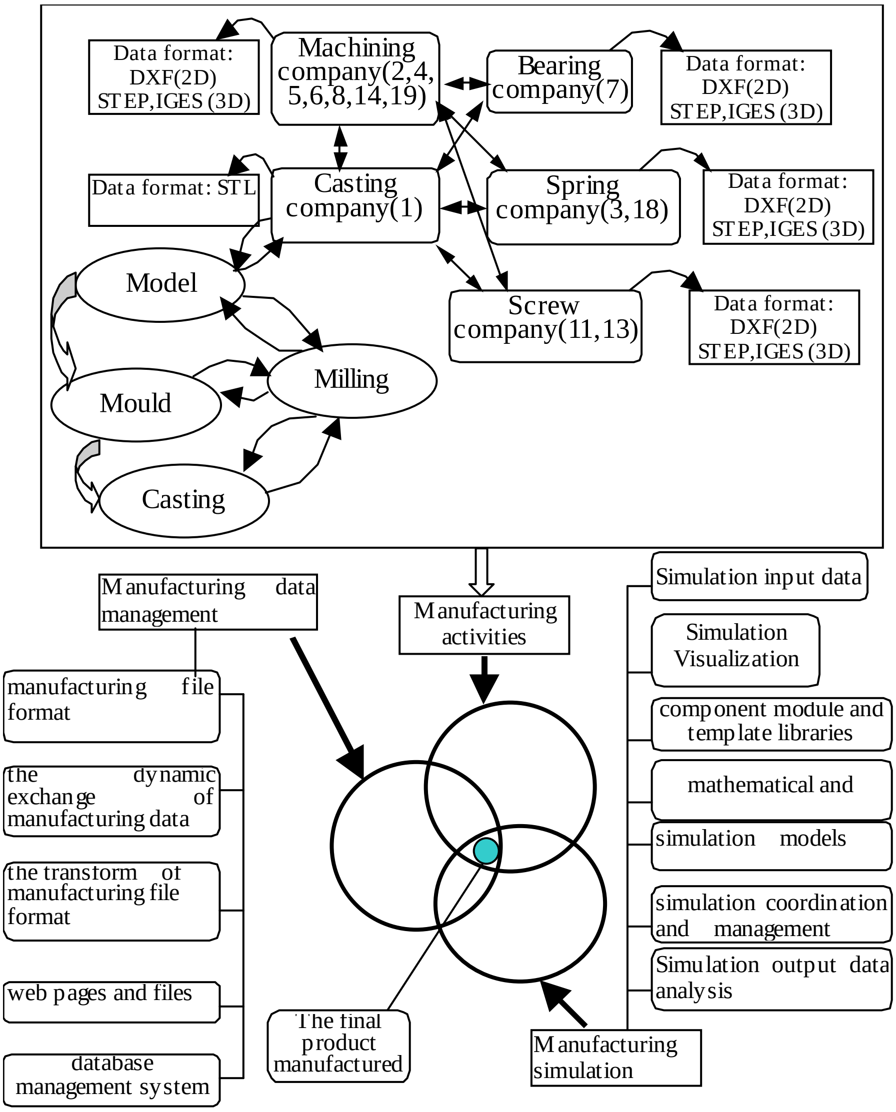

Fig.14 The collaborative manufacturing activities for axial eccentric oil-pump

The manufacturing simulation systems, tools, and supporting applications should be viewed generically; i.e., independent of the manufacturing domain. Major elements of this view include: simulation coordination and management, visualization systems, manufacturing data preparation and model development tools, simulation models, component module and template libraries, mathematical and analytical models, input data analysis, and output analysis tools. A distributed simulation running on different computer systems across a network must use the same Real-Time Interface (RTI) software as an integration infrastructure. However, many manufacturing documents do not have standardized format. While it is easy to come up with acceptable representations for such data that are appropriate for short-term use, it is highly likely that these representations will need modifications, possibly major modifications, over time [26].

XML can be used to define new document types, allow for the definition data that has semantic information in addition to the data values, be easily lunched to the Internet or web pages, be easily extended and modified. XML-documents from other sources can easily be supported. Moreover, XML-enabled browsers can intelligently display the data, so semantic validation of the files is possible. XML-files are often both human and machine readable because of the semantic information that is included [26].

7.3 Collaborative Assembly Modelling for Axial Eccentric Oil-pump

The collaborative assembly model can be considered as a hybrid model of a product model, planning process model and assembly process model. For a mechanical assembly process, model entities and their structures are created from the input data of the part model that contains models of shape features. Moreover some CAPP-procedures use data from geometric model entities that are related to form-feature model entities. Each commercial modelling system has its own model representation. The standard for exchange of product data (STEP) is the first model-based ISO communication standard that gives a solution to this problem [19].

The collaborative assembly model contains components and connection features between components; a set of components connected by connection features forms an assembly model. A component is either a single component or a compound component. A single component represents a part in the assembly model. A compound component encapsulates an assembly for further assembly modelling operations, by hiding its internal structure of components and connection features, and dealing with the boundary of the assembly only. A connection feature is an instance of a connection feature class present in the feature library for assembly design. A connection feature class contains a description of the types of the form features needed on the components for the connection, several constraints that specify the relations between the components, such as the internal freedom of motion, but also the way the connection can be established [10]. A connection feature instance determines the relative position and orientation between the components involved.

An important aspect here is that establishing a connection feature may require the creation of the respective form features on the components involved [25]. Because of the integration of all views, these component changes are propagated downwards in the hierarchy to the respective parts, where new features are also created. It may occur that one such form feature produces a part, which assembly considerations could prove to be invalid. In these kinds of cases, the collaborative validity maintenance scheme mentioned in Subchapter 5.1 assists the team members, which are involved to the project, to recover the validity conditions again.

Collaborative clients can discuss assembly issues, e.g. where and how to create a connection feature, by using shared communication facilities. In the assembly design view, these facilities are available for both in geometric and graphic views. In addition to this, if it happens that any of the single component's assembly conditions requires adjustment, the other clients can either switch to that component's design view and directly adjust it, or invite the other client(s) to join the discussion and perform the required adjustments. Because of the integration of all views, changes performed on this component are now propagated upwards in the hierarchy and the changes will affect on the geometry and/ or dimensioning of each adjacent component.

To create the feature model of the assembly design view, operations are available to add a connection feature between different components, to change the parameters of a connection feature, to remove a connection feature, to make a compound component out of an assembly, and to turn a compound component back into an assembly. Adding a connection feature between components requires the appropriate form features [25]. If the shape for the form feature already exists on the reference geometry of the component, the form feature can be created by feature recognition; otherwise the form feature can be created by adding the form feature, including its shape, to the reference geometry.

The part detail design model and the assembly design model are kept consistent by linking the part models to the related single components in the assembly model. When a form feature for a connection feature is added to some component, and this changes the shape of the component, this change is propagated to the feature model of the related part in its detail design view by feature conversion again. When a part detail design view is changed, the reference geometry of the related single component in the assembly design view is updated.

8 DISCUSSION

For Internet based collaborative design, there are many technological challenges. The interface technology is one of them, and is the key to realize the information dynamic integration for collaborative design. For example, CAPP can't directly read and abstract the geometric model, process parameters, geometric features and tolerance from the CAD-system, which must use certain interfaces to complete the application. The system of internet based collaborative design includes many interfaces, such as all kinds of data interfaces, communication interfaces, application program interfaces, all kinds of database interfaces, CAD-system Interfaces, CAM- and CAPP-interfaces, platform interfaces and Internet interfaces. Each of them uses different data format and respective data structure. If we try to develop a number of these interfaces it will not only costs so much time, money and human resources, but also these special interfaces can not be accessed by other application tools, because they are not the common interfaces.

The authors of this report believe that a standard interface to all tools should be developed to meet all the collaborative design and manufacturing activities, and the standard interface must be open and extensible, which will improve the efficiency and reduce the cost due to developing all kinds of special interface tools.

9 SUMMARY

This paper presents the DFMA-analysis and aspects of applying internet based collaborative design for axial eccentric oil-pump design, integrates the DFMA methodology and Internet based collaborative design. DFMA requires that the designer start the process by considering various design concept alternatives early in the process. DFMA aims at improving the integration between design and manufacturing, reducing product developing time and cost, improving product quality and reliability, shorting lead time, increasing productivity and answering faster to customer requirements. The system of Internet based collaborative design is a very powerful graph based representation, modelling, and analytical tool. Internet with high-level and hierarchical generalizations possesses capabilities for modelling the features of distributed design systems in a concurrent and collaborative environment. These include complex local and global time dependencies, concurrency, asynchrony of activities, restrictions imposed on computing resources, and heterogeneity of these resources.

The integration of DFMA and internet based collaborative design is an important area that needs teamwork. The integration of DFMA and internet based collaborative design through improved business practices, management philosophies and technology tools will result in a more producible product to better meet customer needs, a quicker and smoother transition to manufacturing, and a lower total production/ life cycle cost.

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