Research on Design Method of Packaging Machinery Based on KBE

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Abstract: In the design process of packaging machinery, designers often need to learn from similar products' design methods that they have been used. How to apply knowledge such as principia, guidelines, standards and experiences to the CAX system, so that the system can construct the required digital geometric model by automated reasoning based on relevant knowledge after designers input parameters and application requirements to the system? This is precisely the problem that the Knowledge-Based Engineering (KBE) can solve. This paper introduces the meaning and key technologies of KBE. The digital design method of packaging machinery based on KBE is brought forward compared with the traditional design process. The structure of packaging machinery design system based on KBE is analyzed, and the user interface is shown. The system is developed using programming tools VB.NET and SQL Server database development tools taking the three-dimensional software SolidWorks as a platform. The system established repository of principles and design knowledge for packaging machinery using object-oriented technology and database technology, and realized the reuse of design knowledge using Rule-Based Reasoning and Case-Based Reasoning. The developmental efficiency and market responsive speed of the development for packaging machinery is improved notably.

Keywords: packaging machinery; design method; KBE; knowledge reuse

1. Introduction

Nowadays, global competition is becoming more and more universal, and it has empowered customers who now constantly demand new and better quality products. To meet the challenge of competition and survive in the market, manufacturers in packaging machinery industry are now under tremendous pressure to improve their efficiency in terms of product development and resource utilization. To stay competitive in today's global economy a company must build on its intellectual capital and create time to innovate and assess more advanced, complex types of tools to eliminate uncertainty and repetition from the design process. The Knowledge-based competition of new products becomes the core of enterprise technology competition in a global manufacturing surrounding. How to make the human knowledge as the driving force behind the transformation of traditional industries has become an important research topic. KBE (Knowledge-based Engineering) is an important tool of intelligent design and decision-making automation suiting for the modern design requirements.

In this paper, the design method of packaging machinery based on KBE was researched, and the system of packaging machinery design based on KBE was developed. The aim of the KBE system is to integrate the whole design process into a single computer model and to create a framework for efficient capturing of a company's most important asset—the knowledge and experience of its engineers. A relational database is used to encapsulate the design rules as well as their complex interdependencies on material, production unit, and manufacturer capabilities.

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2. The Basic Principia of KBE

2.1. The Conception of KBE

KBE was first put forward by Professor Edward A. Feigenbaum of Stanford University in 1977. Its basic idea is to find and record the various engineering, design and product configuration knowledge, and it should be understood, abstract, description, use and maintenance [1]. A KBE system stores knowledge about a product in a comprehensive product model containing engineering rules that describe how products are designed, analyzed and manufactured. The rules can be design rules, standard engineering rules, or experiential 'rules of thumb', which reflect years of design experience. Artificial intelligence system has been integrated with the CAX system by KBE. The objects are extended from geometric modeling, analysis, manufacturing to the field of engineering design. The tools are available for the application problem that can only be solved by expert knowledge. Thus, the quality new products with knowledge can be produced at the fastest speed.

2.2. The Frame of KBE

KBE is a new opening technology integrated with

other technologies, and it is a production of the combination of knowledge and engineering. The knowledge presentation, modeling, acquisition, propagation, reasoning, integration and management are all key technologies of KBE. The frame of KBE is shown in Fig. 1[2][3].

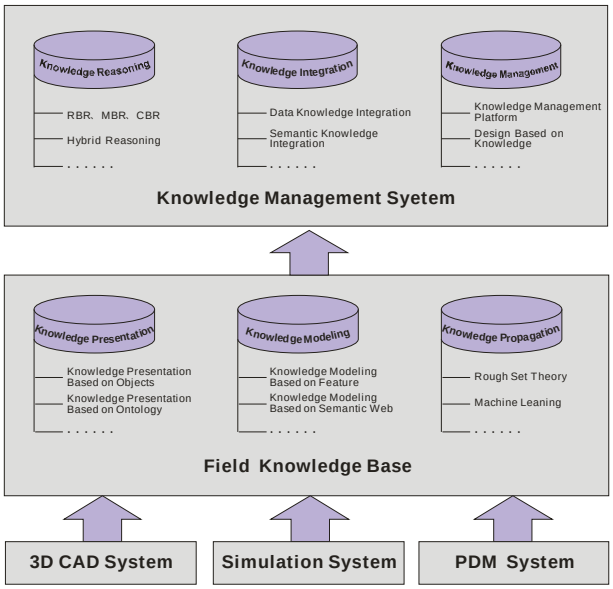

Fig.1 The frame of KBE

3. Design Method of Packaging Machinery Based on KBE

3.1. Traditional Design Method of Packaging Machinery

In the traditional packaging machinery design, the design process is still mainly based on very inefficient iterative 'trial and error' procedures, and it centered entirely on designers, and they need to complete repetitious design tasks, then it leads to bottlenecks in the design process. Fig. 2 shows a traditional packaging machinery design process [4].

As illustrated in Fig. 2, the traditional design process of packaging machinery contains several stages starting with the defining design requirement and concluding with the completion of technologic files. This design process is really a loop, which is repeated until a satisfactory design is found, therefore the effect of the bottleneck is multiplied by the number of times the loop is repeated.

3.2. Design Method of Packaging Machinery Based on KBE

According to statistics, more than 70% design of parts is carried out based on the original design in manufacturing industry. Most successful designs are from the acquisition or modification of similar design, and from the reuse of the existing design knowledge.

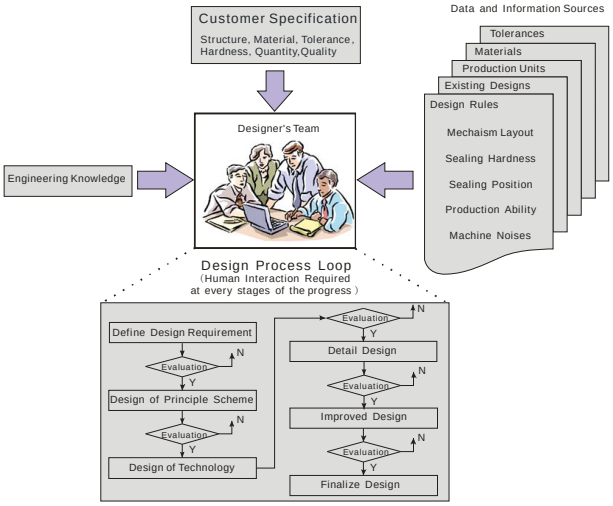

Fig.2 The traditional design process of packaging machinery

The packaging machinery design based on KBE takes knowledge model as the center, and all kinds of database, knowledge base and design case base are associated with it. What designers have to do are to input requirements and to make decisions. Once engineering knowledge about the product is collected and stored as a product model, design engineers can generate and evaluate new designs quickly and easily by changing the input specifications for the product model, or modify designs by extending or changing the product model. It can greatly improve the design efficiency and design quality. The design process of packaging machinery based on KBE is shown in Fig. 3.

It can be seen from the Fig. 3 that the design parameters are read from the user interface, then, the case base is checked based on the similar rules. When the design scheme is very similar with the case, the case can be reused, or else the most similar case will be selected and propagated according to the design parameters and rules. In the detailed design stage, the feature parameters of parts are modified according to the sequence of structure and assembly, and the case evaluation and decision will be done. After that, the model is showed, and the simulation is analyzed, and the structures and characters of the production can be evaluated. If the design meet the user's requirements, then the new case will be stored into the case base, otherwise, the redesign is needed. After several loops, the final fast digital design model can be built. AS shown in Fig. 3, a KBE system is also able to integrate other engineering programs such as FEA software as a kind of pre-processor for the analysis applications.

4. Design System of Packaging Machinery Based on KBE

Constructing a high level of developmental platform of

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KBE is the core of applying KBE technology that had been shown in Fig. 1. The following discussion is concerned with the packaging machinery design system based on KBE.

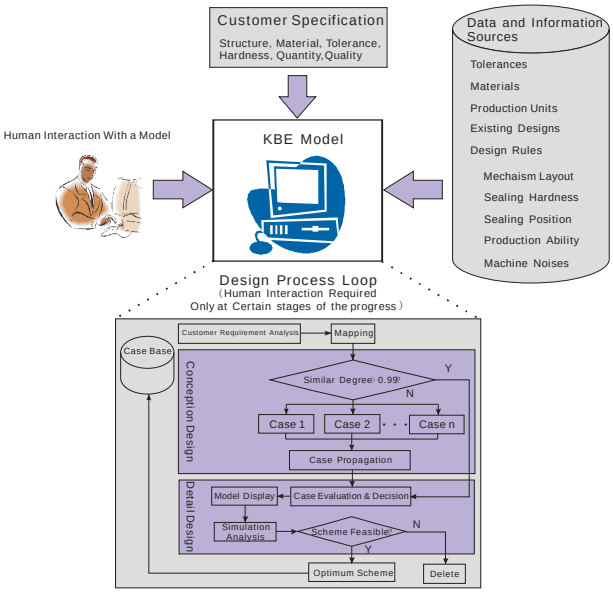


Fig.3 The design process of packaging machinery based on KBE

4.1. The Structure of the Design System

The system structure of packaging machinery design system based on KBE is shown in Fig. 4. The main task of the man-machine interactive module is to provide convenient, intuitive user interface, including design input, the entry of product parameters, the modification of part parameters and assembly model, the output of design schema and the pointing of information. The blackboard control module is the system's working area, and the information of different modules communicate with each other through it, and its function is to record the technical requirements, intermediate design results and the final design schema. Knowledge and its management module take charge in the definition, loading, operation, maintenance, and consistency and integrity checks of knowledge base [5].

In order to facilitate the rapid digital design, the system uses three-dimensional software SolidWorks as the parametrized design tool, and uses programming language VB.NET as the second developing tool.

As the work way was concerned, firstly, designers establish the design knowledge base of packaging machinery common parts, including design standards, features association, design parameters, size constraints, specific product data, examples of mature products, engineering data sheets, experience and rules of field experts, etc., and these knowledge were progressed as forms of relation, rules, cases. The date base is built using Microsoft

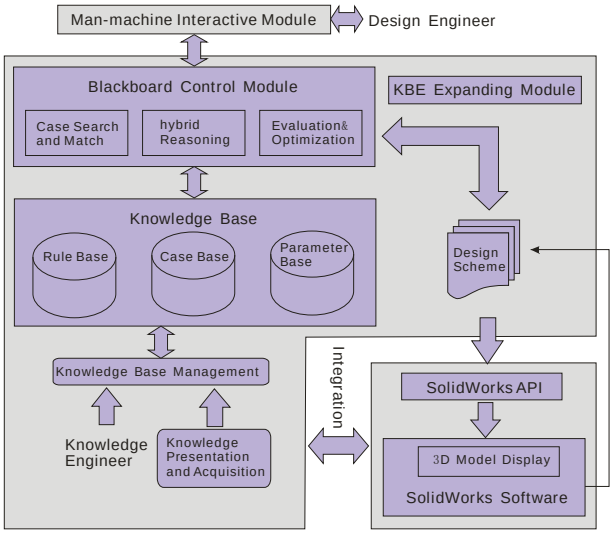


Fig.4 The system structure of packaging machinery design system based on KBE

SQL Sever. Secondly, if there haven't a similar case suiting for the requirements, then the KBE model will be built by the parametrized feature modeling function of SolidWorks software. Thirdly, the design knowledge of packaging machinery common parts are extracted from knowledge base using tools of knowledge propagation and reasoning, and these tools are a program compiled by VB.NET. Finally, the data of knowledge base are input into the SolidWorks system using SolidWorks API and second developing tools, and the ultimate 3D model of packaging machinery parts can be built.

4.2. User Interface

The user interface of packaging machinery design system based on KBE is shown in Fig. 5. All the system functions based on the secondary development of KBE are stored in "PMD-KBE" menu, including Knowledge Presentation, Knowledge Modeling, Knowledge Acquisition, Knowledge Propagation and Knowledge Reasoning. Among them, the rule, case and parameter bases can be created or added or modified or stored in the "Knowledge Presentation" submenu. The Knowledge modeling uses the parametrized feature modeling function of SolidWorks software, and all kinds of parameters are stored in parameter base, otherwise, the model can be obtained from the case base when the similarity of the requirement and one case is big enough. The packaging machinery principia and knowledge base is created using the object-oriented technology. The hybrid reasoning model of Rule-Based Reasoning (RBR) and Case-Based Reasoning (CBR) is being used [6][7][8].

The system is effectually integrated with SolidWorks software system, and realized the reuse of design knowledge, then, the developing efficiency of packaging machinery and the speed of market response are all be im-

proved.

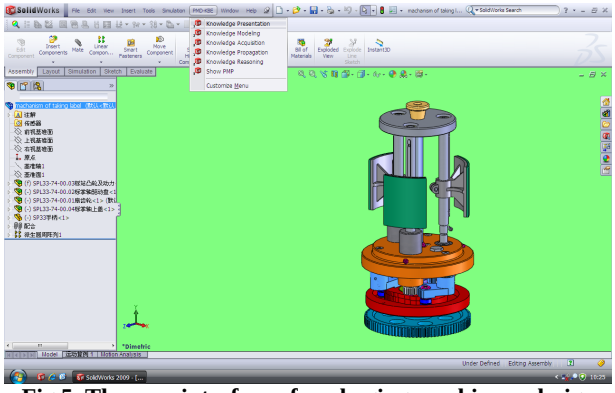
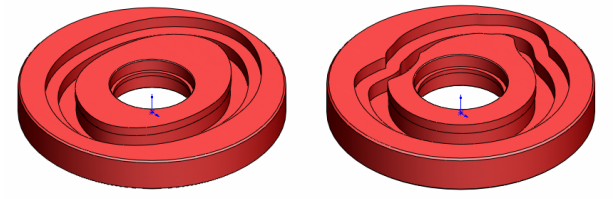


Fig.5 The user interface of packaging machinery design system based on KBE

4.3. The Application of Packaging Machinery Part Design Using the KBE System

For example, how to design a key part cam of labeling machine using the KBE system? It is supposed that there are some cam cases in the case base.

Firstly, the KBE system will find if there have a cam case in the knowledge base that the similarity of the requiring cam and the case is high enough, and if a case is be found, then, the case can be used. Secondly, the knowledge acquisition and propagation module will be working, and the different between requiring cam and the case will be analyzed, then the system will find that there is a cam case having eight label plates, while the requiring cam only need three label plates. Finally, the hybrid reasoning model of RBR and CBR will be working, and the new cam will be created according to the requirement parameters and the cases. The case and the new designed cam structures are shown in Fig. 6.



(a) (b)

Fig.6 The case and the new designed cam structures of labeling machine

(a)The case cam structure (b)The new designed cam structure

5. Conclusion

KBE is a new field of intelligent research, and the comprehensive research is still at its initial stage. New ideas, new theories, new technologies are emerging in this field frequently. So there have broad research and development in both fundamental and applied research.

This paper analyzed the design method of packaging machinery and put forwarded the design method based on KBE and developed the system of packaging machinery design based on KBE. The system can reuse the design knowledge that had been store in the knowledge base, and it affords technical support and intelligent design platform. Thus, the developing efficiency and market respondent speed are improved remarkably.

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