Research on Progressive Die Design System Based on Rule-engine

Shaoling Li and Yilin Wang

ABSTRACT

This paper describes a knowledge-based progressive die design system integrated with rule engine technology. Firstly, the basic framework of the progressive die design main modules based on the knowledge engineering is constructed. Second, the author studies the key technologies of the design system. Finally, the system has been put into practice. The dynamic design process of the die base module is demonstrated, which verifies the feasibility and intelligence of the system.

INTRODUCTION

Progressive die design especially using for production automotive structural parts is complex and difficult because of the sophisticated procedure, the high quality demand, the complicated knowledge. The quality of progressive design depends to a large extent on the designer’s skill, experience and knowledge. Therefore, it’s really necessary to develop a die design system to increase efficiency.

During the recent decade, some researchers reported to have developed intelligent CAD systems for progressive die. For example, S. Kumar, R. Singh, et al. [1] developed a knowledge-based system for selection of progressive die components using KBE approach. J.Q. Zheng, Y.L. Wang, et al. [2] developed a design system for automobile panels progressive dies based on the parametric die template. But this systems can hardly handle automotive structural parts which have relatively sophisticated geometry. Thus, there is a stern need to develop an intelligent design system, especially for automotive structural parts.

[1] Shaoling Li, Yilin Wang, State Key Laboratory of Material Processing and Die & Mold Technology, Huazhong University of Science & Technology, Wuhan, Hubei, China.
This paper presents an intelligent progressive die design system combining knowledge-based engineering and rule-engine AI technology to assist the designer to accomplish automatic design.

SYSTEM STRUCTURE

Process of Progressive Dies

As is well known, progressive dies have a complicated dynamic non-linear complex process. A typical progressive die design [3] process consists of some similar stages: 1) Engineering initialization and strip product features extraction; 2) Die base design; 3) Typical structural components design, such as piercing, bending, forming, drawing, flanging, cam components; 4) Standard parts design, such as screw, pin, lifting, guide plate, nitrogen system; etc. This increases the similarity of the Progressive dies design and frequency of using standard and typical components. Therefore, it’s possible to look into the typical structures to divide the design system into common modules before developing the design system.

Systematic Framework

As the progressive die design process comprises of many similar stages, the whole system has been structured into various modules, such as die base design module, typical structural components design module, standard parts design module, etc. According to increase the intelligence and dynamic of the design process of the system, the author developed the system integrated with KBE technology. As we know, the process of the progressive die design demands of various kind of knowledge, such as product design information, design principals and rules, design cases and parametric models. This author divides the knowledge of the system to three databases, for example product DBs, rule DBs and model DBs. On the basis of knowledge reasoning of the rule engine machine, the CAD system integrates with the knowledge base. The rule-engine machine usually uses rule-based reasoning (RBR) and case-based reasoning (CBR) to realize the reasoning of the design process. Systematic framework of the developed system is shown in Figure. 1.
KEY TECHNOLOGY

The Establishment of Knowledge Model

In order to developing KBE systems that are platform independent, well-structured and having high level of knowledge reuse, we should create a global knowledge model for the system, which contains inheritance, encapsulation and extensibility. The knowledge model stores and expresses the relevant geometric and non-geometric information of the product as well as the rules and experiences of design, analysis and engineering. Usually the ontology-based [4] approaches for modelling the product information and design rules for the intelligent system are employed. It has been used to systematically illustrate all things and explore the differences and relationships among entities. In the field of mold design, a considerable part of conceptual knowledge does not change with instances.

Take the typical punch and die components design module as an example, as shown in Figure 2. The modeling of the module consist of some typical type of sub-model concepts such as piercing, bending, forming, drawing, flanging hole and flanging edge structures Each assembly structure has the same components, such as punch and die, fixed set, side force set, etc.
The Acquisition and Express Method of Knowledge

The technical knowledge for the development of system is collected through die design manual, industrial standards. There are different kind of knowledge of the progressive die design system, so only a single express method of knowledge is difficult to fully describe all information of the system. The current express methods of knowledge include predicate logic, semantic network, frame, production rule, object-oriented express method, etc.

As the object-oriented express method is close to the natural thinking way of human, so it is very suitable to for the knowledge in a special field. By the object-oriented express method, some implicit knowledge can be transformed into an expressive object in computer. The progressive die design system overall comprises of more than 1000 production rules of IF-THEN variety. The systems also adopt the production rule way to express knowledge. The design parameters, design rules, design constraints and mathematical expressions are usually buried in code which are inconvenient for knowledge reuse. Production rules coupled with rule engine capable of backward and forward chaining are exploited and preferred than the procedural rule base employed in the system.
This design system employs Java Drools, an open source engine software which based on the Rete algorithm to develop knowledge base. Not only does it increase the object-oriented interaction capabilities of the Java language, it also offer a kind of standard rule format with the DRL language. Each rule consists of a rule header, a condition and an action. The existing object matches condition and actions are executed when the rule is triggered. An example of a design rule is presented to show the rule written format in DRL language, as shown in Figure 3.

The Reasoning of Knowledge

The rule database and the design modules of the system are linked together by knowledge reasoning mechanism. In this system, the author choose Java Drools software to realize knowledge reasoning [5]. The basic framework of the rule-engine machine consist of the inference engine, rule base and working memory. The working memory is the global database used to store facts and the current state of the system. The inference engine consists of 3 parts: the pattern matcher, agenda and the execution engine, which is responsible for the pattern matching of facts and rules on working memory. In forward chaining, the user interactively supplies system data or facts. The system works with input information supplied by the user coupled with knowledge stored in the knowledge base, to draw conclusions or recommendations. The system searches the database to determine which rules are satisfied by the given facts. Whenever a particular IF condition is found to be satisfied then the THEN portion of the rule is activated leading to a conclusion or an advice.
EXAMPLES FOR DESIGN

This system is based on UG8.5 platform, using JNI (Java Native Language) and XML (Extensible Markup Language) to realize the data exchange of design system and knowledge base. Taking the die base design as an example, the specific results are shown in figures as follows.

CONCLUSIONS

The thesis combines knowledge-based engineering theory and the rule-engine technology, and explored the system structure and key technologies for developing the design system of progressive dies. The design example shows that by using KBE and rule-engine technology, the developed module can realize the dynamic design process. Although the system is limited to the design of progressive dies only, yet it can be extended further for the design of other types of dies also. However, How to express the hidden knowledge of die design in knowledge base is still a difficult point.

REFERENCES

1. S. Kumar, R. Singh. A. 2007. Knowledge-based system for selection of progressive die components [J]. Journal of Achievements in Materials and Manufacturing Engineering, 20(1-2).
2. J.Q. Zheng, Y.L. Wang. 2007. KBE-based stamping process paths generated for automobile panels. The International Journal of Advanced Manufacturing Technology, 31(7-8): 663-672.
3. S. Kumar, R. Singh. A. 2011. An automated design system for progressive die [J]. Expert Systems with Applications, 38, 4482–4489.
4. I.O. Sanya & E.M. Shehab. 2014. An ontology framework for developing platform-independent knowledge-based engineering systems in the aerospace industry, International Journal of Production Research, 6192-6215.
5. Miodrag Hadzistevic, Ivan Matin. 2010, Rule Base Reasoning in the knowledge-based module design system [J]. Ekspertni sustav za konstruiranje kalupa primjenom pravila zaključivanja, ISSN 1330-3651.