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ANALYZING THE KNOWLEDGE - BASE TO DESIGN FORGING DIE OF CONNECTING ROD

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ABSTRACT

Design of forging dies is tedious, tedious and complex process, which is a skill-based activity, and it needs more effort and time, the specialists in the design of the collection of knowledge - forging dies of knowledge and expertise are necessary for the design process. The aim of the present work is to study Computer Aided design of Connecting rod. This is done by analyzing the elements of design and knowledge experience, establishing knowledge bases, using Visual Basic to link knowledge bases and Solid Works. This system is experimental. The results indicate that the benefits of using this system to save time and effort and reduce errors caused by designers and improving the design quality.

ملخص البحث

تصميم اسطمبات الحدادة هى عملية شاقة ومملة ومعقدة، ،وهو نشاط قائم على المهارات، ويحتاج الى مزيد من الجهد والوقت ،ولذا يجب ان تتوفر فى مصممي اسطمبات الحدادة الخبرة والمهارة العالية ، يقوم المتخصصون فى تصميم اسطمبات الحدادة بجمع المعارف والخبرات المعرفية اللازمة لعملية التصميم .

الهدف من هذا البحث تحليل عناصر التصميم والخبرة المعرفية لتصميم اسطمبة ذراع التوصيل بمساعدة الحاسب الالى ،وذلك بإنشاء القواعد المعرفية للتصميم ، وذلك عن طريق استخدام برنامج **Visual Basic** لربط القواعد المعرفية وبرنامج **Solid Work** ، ويعتبر هذا النظام تجريبي ، وأشارت النتائج لإظهار فوائد استخدام هذا النظام إلى توفير الجهد والوقت وتقليل الأخطاء الناتجة عن القائمين بالتصميم وتحسين جودة التصميم

Keywords: Computer Aided Design, Forging Die, Connecting Rod, CAD, Solid Work.

1. INTRODUCTION

In designing of forging dies, the design process variables are: the metal flow characteristics, choose the type of metal die and product, the friction, the temperature, blank spaces in die, the lubrication, and equipment. Computer-aided design is being carried out in CAD and CAM manufacturing is increasingly developed at all stages of the design and manufacture of forging dies. Techniques include analysis of elements used during forming and design [1-3]. The specialists in the design of forging dies collect all knowledge and information necessary for the design process. The design of forging dies depends on the following :

1- The expertise and knowledge of the specialists
2- The complexity and refining processes according to the process
3- The dies design is an innovative process, taking into consideration the variables of the design process such as the flow of the metal ,the type of the product metal, the weight of the product , the case of the hammer --- etc. [4].

The integration of CAD and CAM not only plays a key role in the achievement of digital manufacturing and integrated computer-aided manufacturing, but is also vital to the competitiveness of mechanical manufacturing enterprises and their ability to respond quickly to changes in the labor market. One of the most important links for the integration of CAD and CAM is the link between design and planning processes [5].

The importance of CAD / CAPP integration stems from the fact that CAPP relies on the product model data provided by CAD to perform an accurate and consistent process planning for manufacturing. However, they tend to have different descriptions of product data, that is, CAD is usually based on geometrical form, whereas CAPP / CAM depends on the manufacturing process and is dependent on the field, resulting in unsatisfactory operational performance, or joint weakness CAPP systems usually work as stand-alone functions and do not have a link to CAD or CAM systems. This problem can be solved by developing a feature-based CAD system to provide data directly to CAPP systems, but it inevitably imposes limitations on product design and / or modeling of other applications [6].

From 1970 until now, researchers have made a lot of efforts to develop computer-aided design templates to design different types of dies which used to produce forging dies parts. Very few researchers have attempted to develop a computer-aided design of forging dies scheme, and less research has covered the design of the die. Therefore, there is a need to develop a system for the rapid design of forging dies. Many researchers have done their efforts to develop CADD systems for drilling and cutting of forging [7-11]. Many other researchers have succeeded in developing CADD, knowledge-based systems and expert systems to perform various tasks for designing die [11-14]

2. LITERATURE SURVEY

The process of designing forging dies is based on the expertise and skill of designers, which affects the result of the design of forging dies . Many research efforts have been made to integrate knowledge of experience into a system of design of forging dies molding to improve the design process [15].

Kim et al [16] developed a system based on the experience of the iron design process and the result was the use of the program to design geometric shapes and calculate the weight of the billet and determine the strength of the hammer, the system based on the rules of knowledge and AutoCAD program .

Kim et al. [17] developed an automated computer aided process planning system for a hot forging products. It used the knowledge-based system and knowledge-based design and CAPP system for hot and

cold steel, and a knowledge base for design rules, Choi and Kim [18]. Established

Caporalli et al. [19] developed an expert system for hot forging design and ADHFD (Automatic design of hot forging die) program. This program was used to design hot forging die. All researchers have done a lot of research in the development of computer aided design systems and the integration of specialized knowledge in design Systems . These systems can help engineers to design forging die, improve design results, and reduce design cycle time. However, most of these studies have focused on simple parts (i.e. axial-axis components), and a few studies on complex components. In addition, systems can use CAD Only to help in planning the forging process, a few of which can help in the design of forging dies .

3. THE FRAMEWORK AND MAIN FUNCTION MODULES OF CONNECTING ROD FORGING DESIGN SYSTEM

The disadvantages of traditional CAD systems for the design of forging dies are:

1. They depend on the experience and knowledge of designers. The experience of individuals directly affects the result of the design of forging dies. If the designers do not have enough knowledge about the layout of the die, the design process will be poor
2. There is no mechanism for knowledge management. The system cannot give the designer the right knowledge in decision making. In order to getting benefit from accumulated engineering knowledge and increased design efficiency, a knowledge-based system has been developed for the design of Connecting rod diagram, This is illustrated in Fig. 1

3.1 System structure and main functional modules

The system is composed of four subsystems: product model design, product model analysis, forging process planning, and die structure design. These subsystems are interrelated based on the integrated product model. This is illustrated in Fig. 2

3.1.1 Product Design Model

The three-dimensional shape of Connecting rod is designed by Using the Solid Works software

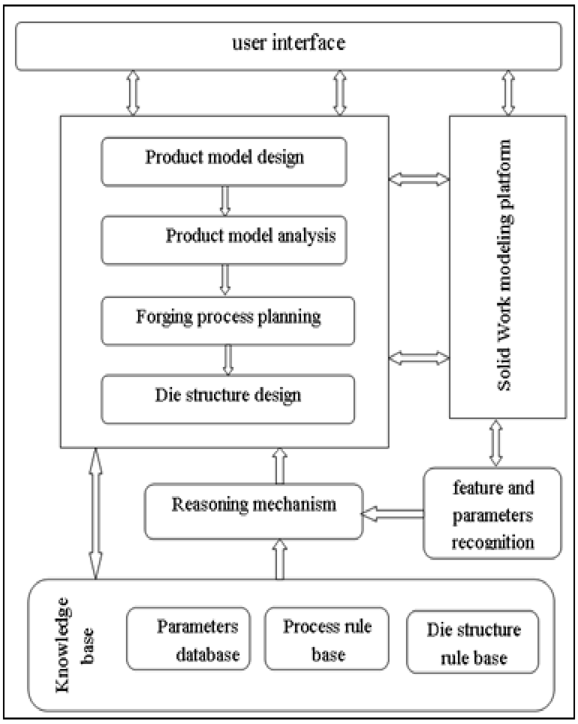

Fig. 1. knowledge-based design system for Connecting rod forging

3 .1.2 Product model analysis

Based on Connecting rod design that was created, analyze drawing elements from Solid Works, and store them in databases. These variables include: space, load used, weight, and all variables will be used in the design process, and store them in databases. These variables include: space, load used, weight, and all variables will be used in the design process.

3 .1.3 Forging process planning

In order to obtain the final design of Connecting rod, several steps must be taken. In this unit of design, the system will plan the forging processes, such as: calculation of load, hot metal design and size of the metal, the line between the two die parts, modification of the shape of the forging part, determination of the shape and dimensions of Connecting rod, adding of radius and drag angle. -etc. ,and choose the formation steps based on forging features and design rules.

3 .1.4 Die structure design

After planning the forging process, the system will design the forging dies: Design of cavity of the die, selection of the appropriate hammer, Choose the forging equipment, design lock valves, design die variables, and exit, as well as design of keyway --- etc.

3 .2.2 KNOWLEDGE-BASED DESIGN SUPPORT SYSTEM

The integration of knowledge, experience and intelligent thinking into the design system is the fundamental difference between the traditional systems of drawing software and the output of the new design system. The system checks the design result of each design step using the design rules stored in the knowledge database and provides the best solution.

4. KNOWLEDGE-BASED DESIGN SUPPORT TECHNIQUES

The design of forging dies depends largely on design process variables, which is a repetitive process of experimentation and error in order to obtain the final design of the die, resulting in the production of intact and flawless products. The process of forging is very complex and difficult, making the growing need to integrate artificial intelligence such as the knowledge-based system to get the best possible advantages by integrating knowledge, experience and design rules into the production using smart computer software.

KBESs are smart computer programs that simulate decision-making based on the design rules stored in the knowledge system [4] . In general, KBESs consist of the following aspects: acquisition of knowledge, representation of knowledge and application of knowledge. In the following sections, the application of KBE technology in the knowledge-based system is discussed in order to form a design support system. The functional unit is chosen to design the structure of the schematic as an example to illustrate the details of the knowledge-based support technology. Its function model as shown in Fig. 3

4. 1 KNOWLEDGE ACQUISITION

The forging process is a flexible formation process which is very complex, and the experience and knowledge of the technicians are very necessary for the design of the dies.

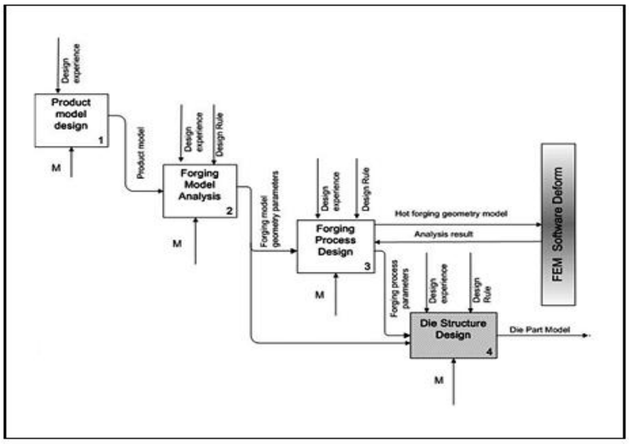

Fig. 2. Functional model for knowledge-based design support system

In order to design a system based on knowledge and experience, it is necessary to extract knowledge and information from knowledge sources and convert them into symbols. This process is called acquisition of knowledge. In this knowledge-based system, scientific research and references on the design of forging dies are the main source. As well as secondary sources such as rules derived from the experience of the workers in this field. In general, the acquisition of knowledge mainly involves recognition, conceptualization, formalization of knowledge and application of knowledge [20,21].

The design system consists of four sub-systems :product model design, product model analysis, forging process planning, and die structure design. Each subsystem has its own knowledge and design rules. , It is necessary to classify all this knowledge and design rules, use a method to represent this knowledge. After the acquisition of knowledge, the design rules and experimental data are stored in the knowledge within the database or incorporated into the program codes in order to provide the correct knowledge to support the designer in decision-making / design selection through the process of designing the forging dies.

4. 2 OBJECT-ORIENTED KNOWLEDGE REPRESENTATION

The integration of knowledge and experience into the design and intelligent thinking system is the fundamental difference between this system and other traditional CAD systems. In the fields of engineering design, knowledge is a description of the various relationships and processes during engineering design and a summary of practical experience in a particular area through investigation and practice over a long period of time. In order to support engineering design, it is necessary to use appropriate methods to represent different types of relationships and processes. Knowledge representation is a general method, which examines the feasibility and validity of expressing knowledge with a computer. It is a group of text and objects.

In the knowledge system, methods of representing knowledge include: logical representation, semantic network representation, production rule representation, frame representation and object oriented knowledge representation, etc. The process of Connecting rod forging design is complex, and uses different forms of knowledge in the design process. These forms of knowledge are interrelated in their application. Therefore, it is necessary to use the

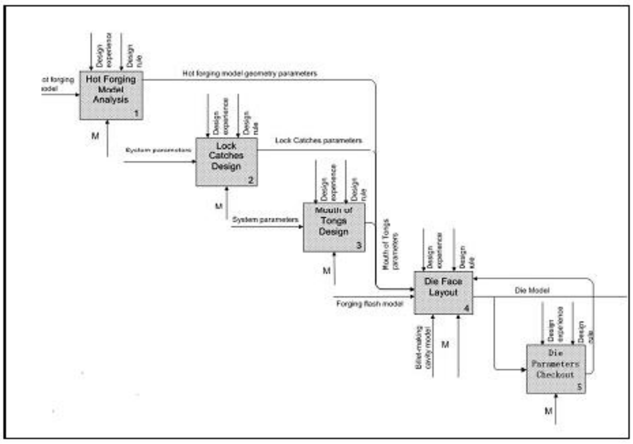

Fig.3. Function model

method of representation of object-oriented knowledge in the design of the flange forging using the knowledge-based system. The knowledge representation of forging die structure design is chosen as an example to elaborate the detail of this method. In order to easily manage knowledge related to the layout of forging die ,the object-oriented representation scheme is employed so that both model creating and reasoning work in a design can be carried out. Knowledge was classified based on the process of forging die structure design and organized with layer structure. In the knowledge layer, every knowledge unit is a knowledge object, and it is expressed in the frame representation method. As an abstract of the rule, every knowledge object is composed of certain number slots. Every slot describes one aspect of forging die structure design. Different type data and process are put in every slot.

1. *The relation slot*: This slot is used to describe the relationship between objects. Knowledge of forging die structure can be classified into four types of objects: the knowledge lock catches design, the knowledge of mouth of tongs design, the knowledge of die face layout, and knowledge of die structure and die part dimensions design. These four types of knowledge are influenced by, and depended on each other. They can be divided into more subclasses. The subclass can be derived from super class. The subclass can share and inherit the knowledge of its super class
2. *The attribute slot*: Every object contains a certain number of attributes. It can describe the geometric parameters of forging parts and the information that needs to transfer to other objects or the design result. For example, part name, material, forging temperature, forging load and so on
3. *The rule slot*: The system requires many design rules during the process of forging die design. These design rules are stored in system rule database and are controlled by corresponding knowledge object. The rule slot is used to store the design rules and the system applies these design rules in the forging die structure design process using rule-based reasoning pattern
4. *The method slot*: During the actual knowledge representation process, the operation of the object is expressed in method slot. Every object has corresponding methods. These methods can be used to calculate some parameters of the object or to access the design rules.

4 . 3 APPLICATION OF KNOWLEDGE

In fact, knowledge-based reasoning is a process of acquiring conclusion from known knowledge. In other words, it is the application of knowledge. In general, human reasoning includes deduction, induction and analogism. However, the present reasoning technology that is applied in computer fields contains logical reasoning, uncertain reasoning and commonsense reasoning. Reasoning technology contains three methods: rule-based reasoning (RBR), model-based reasoning (MBR) and case-based reasoning (CBR)

In the process of forging die design, RBR is the main reasoning technology to provide proper knowledge. In the forging die design, there are many design rules. These rules are stored in the rule database of the system by way of the production rule.

While designing, rule-based reasoning is applied according to specific conditions. Producing rules were put forward by US mathematician Post, and developed by Newell and Simon. Producing representation is also named by rules representation. Each rule is a producing expression. Every rule includes two parts, one is situation recognition (premise/antecedent part), the other is the activity part(conclusion/consequent part). Producing rules are looked at as situation-activity pairs or premise-conclusion pairs.

Base Production Production rule is similar to logic in form: P→ Q,CF. In this formula: P is antecedent, Q is consequent, and CF is the certainty factor of the rule. The following is the BNF description of producing rules using the logical knowledge representation method :

< Predication >::=<Name of predication>

[< Parameter >,...]

< Action >::=< Name of action >

[< Parameter >,...]

<Premise>::=empty| < Predication >1,

< Predication >|

<Conclusion>::=< Predication >| < Action >

{, Conclusion...}

< Production rule >::=< Premise >

< Conclusion >,<CF>

<CF>::=<(0,1)real number>

< Production knowledge>::=< Production rule >1,

< Production rule >2,...|

For example, during system design the type of hammer (H) can be selected according to the diameter (D) of the metal used and can be determined according to Table 1.

$$H = 10\,(1 - 0.005 D)\,(1.1 + 2/D)^2\,(0.75 + 0.001 D^2) \cdot D \cdot \rho \quad (1)$$

Where:

D = diameter (cm) H = hammer (ton)

ƿ = (density)

Table 1. The relationship between the hammer (H) and the diameter (D

The design rules:

D (cm)	4.5<	4.5 ≤ 8.5	8.5 ≤ 17	17 ≤ 20	20 ≤ 24	24 ≤ 31	31 ≤ 44
H(ton)	**0.63**	**1**	**2**	**2.5**	**3.15**	**5**	**10**

IF D<=4.5 THEN H= 0.63

IF D>4.5 AND D<=8.5 THEN H=1

IF D>8,5 AND D<=17 THEN H=2

IF D>17 AND D<=20 THEN H=2.5

IF D>20 AND D<=24 THEN H=3.15

IF D>24 AND D<=31 THEN H=5

IF D>31 AND D<=44 THEN H=10

5. CASE STUDY OF CONNECTING ROD HOT FORGING DIE DESIGN

Connecting rod forging die is designed by the case study to clarify the characteristics of the knowledge-based system and explain the operation of the system. The product model is shown in Fig. 4

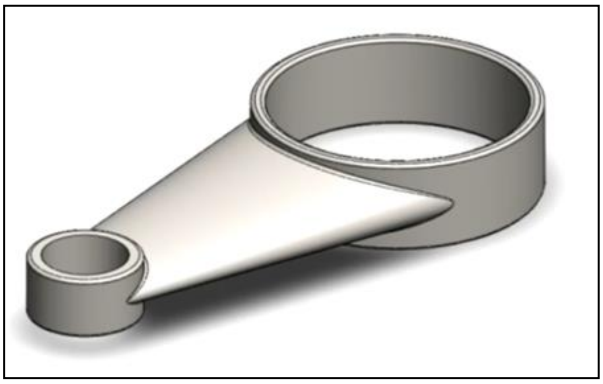

Fig. 4. Solid model of Connecting rod part

According to the three-dimensional hot forging model, as shown in Fig. 5. The system gets maximum limiting dimensions of forging die parting line, the maximum height of the forging , the center of forging die , forging die cavity, and the flash shape and dimensions. Then, The system will calculate diameter, weight, hammer type selection ,The lower die model is shown in Fig. 6, and the upper and lower die model of Connecting rod in Fig. 7

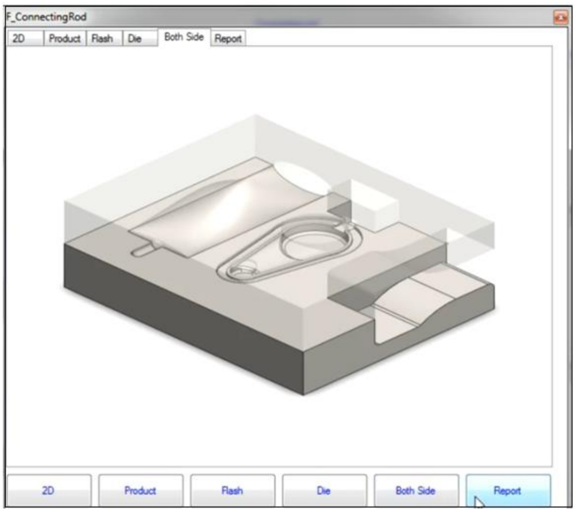

Fig. 5. The hot forging part solid model of Connecting rod

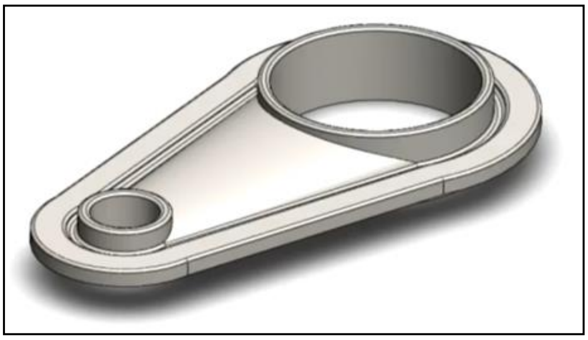

Fig. 6. The lower die model of Connecting rod

The process of Forging is a very flexible and complex formation process, The expertise and know-how of technicians are essential and very valuable for the design of forging dies, the Connecting rod design support system was developed based on knowledge by integrating knowledge and experience into the design support system. Which provides the correct knowledge to support the designer's decision-making / selection and step-by-step design.

Symbol	**Description**	**Unit**
H	Hammer	ton
ρ	Density	Kg / cm^3
D	Diameter	cm^3

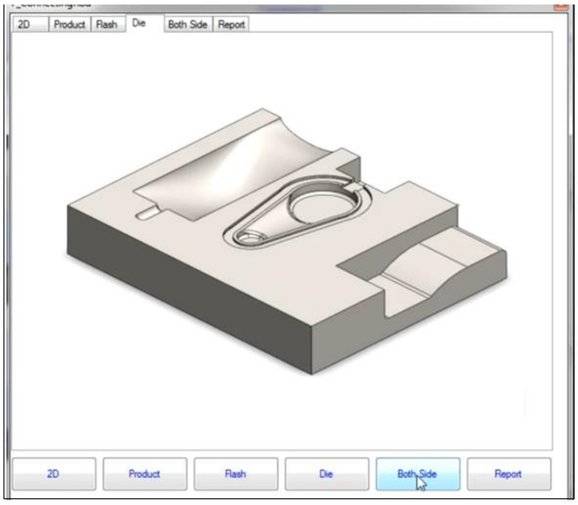

Fig**.**7. The upper and lower die model of Connecting rod

In this method, knowledge and experience can be efficiently shared and reused, the Forging process can be automatically processed by the program. Therefore, the design time of the Connecting rod mold is reduced using the knowledge-based system, compared to the traditional CAD method, resulting in increased design quality.

The application indicates that during the process of designing forging dies the system provides access to the appropriate knowledge and information in a timely manner to support the designer in decision making / selection and design of the entire scheme and step-by-step detail.

6. CONCLUSION

During forging dies design process, the accumulated experience and knowledge of designers is very important. for the design of die. In order to optimize the accumulated engineering knowledge, it is necessary to integrate knowledge and experience in designing forging dies systems into a CAD system and developing a knowledge-based design support system. In this work, a knowledge-based Connecting rod design support system has been developed on the basis of methodology. Through the representation of engineering knowledge, knowledge acquisition and knowledge-based design support techniques. A case study shows that the strategy and methodology discussed in this work are reliable, and indicates that by adopting this system, the product development cost and the lead-time is reduced greatly and the quality of design is improved.

NOMENCLATURE

SUBSCRIPTS

CAPP	Computer Aided process planning
CAD	Computer Aided Design
CADD	Computer Aided Design And Drafting
CAM	Computer-Aided Manufacturing

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