Advances in Computer Science Research, volume 82
7th International Conference on Social Network, Communication and Education (SNCE 2017)

Research on Intelligent Rapid Design System of Sheet Metal Equipment

Zhengbo Yuan[1, a], Hong Shi[1,b] and Liangwei Zhong[2,c*]
[1]3392 Zhaolou Road, Shanghai 201112, P. R. China
[2]516 Jun Gong Road, Shanghai 200093, P. R. China
[a]jambo8@126.com, [b]sh6071@163.com, [c]zlvcad@126.com

Keywords: Sheet metal machinery; Bending machine; Knowledge engineering; Rapid design; Parameterization

Abstract. In view of the long development cycle and the heavy workload of sheet metal equipment development, the method of intelligent rapid design system that secondary development of sheet metal equipment is operated through 3D CAD software is proposed. This method constructs the expert design knowledge base of sheet metal equipment and develops a rapid design system based on knowledge engineering in the use of modular and parametric product design and development technology. The secondary development of 3D CAD that uses 3D design software as application platform, utilizes the SQL Server database to manage the product's component information and takes advantage of VB.NET improves the design efficiency greatly, which avoids man-made design errors, optimizes design quality and realizes the integration of design data and PDM.

Introduction

The traditional design method of sheet metal equipment is to revise design by reference to the previous design cases, which has several deficiencies like the design cycle is long, there are many mistakes in design, designers' experience can not be inherited, data such as BOM can not be shared by other systems and data management is not perfect. Hence many scholars have studied the intelligent rapid design of the bending machine. The theory of applying knowledge engineering to rapid design was put forward by Shibiao Liu [1]. A rapid design system of shearing machine was proposed by Yan Sun [2]. These studies are aimed at the research and development of one kind of bender or shearing machine. On the basis of these studies, this paper presents a platform for intelligent rapid design of sheet metal equipment. On this platform, users can increase their knowledge and adapt to all kinds of sheet metal equipment design after configuring the module.

The Framework of Intelligent Rapid Design System of Sheet Metal Equipment

Users being able to input the knowledge or rules of the design autonomously, establishing 3D digital model and engineering drawing template and forming an intelligent parametric design system for sheet metal equipment are major functions of Intelligent rapid design system of sheet metal equipment. Knowledge management module, three-dimensional digital model module, engineering drawing module, calculation module, hydraulic design module, process module, data management module and system management module are involved in this system. System architecture functions are shown in Figure 1.

Knowledge management module. The case library,rule library, Design knowledge library, model library ,database and inference engine are involved in knowledge management module. The representation of knowledge base is mainly production type. Knowledge access uses relational databases and some of which use XML. The inference engine adopts positive item rule inference and positive item case-based reasoning.

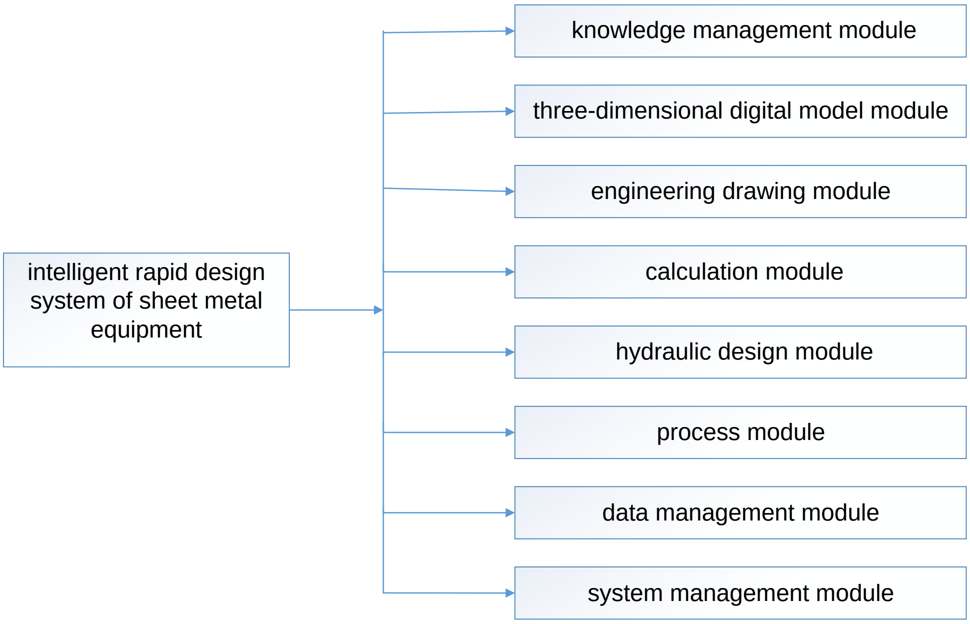

Figure 1. The functions of system

Three-dimensional digital model module. This module analyzes the structure according to the design of the product. According to the similarity theory, the product is divided into modules. On basis of the different forms of the selection, every module is divided into its module family. The design of assembly rule base *Ru* and size-driven rule base *Rs* is contained in three-dimensional digital model module. First, determine the module which should be adopted according to Ru. If the size of the module is not appropriate, the module should be selected by Rs. This approach will meet design requirements.

Calculation module. The two methods are used to calculate the force components. One is analytic method and another is Finite element calculation. The calculation of other drive components includes hydraulic system design.

Other modules. Engineering drawing module mainly projects the 3D model into the engineering drawing, including dimensions layout of pages. Hydraulic design module designs hydraulic cylinders and hydraulic stations according to different types of sheet metal equipment and force and structural requirements. Process module creates numerical control codes of machining parts and information of heat treatment and other process. Data management module integrates product data with PDM system, which can generate design BOM and manufacturing BOM.

Key Technologies of Intelligent Rapid Design System of Sheet Metal Equipment

Case - based reasoning technology. Case - based reasoning technology produces the initial solution by retrieving the closest example to the current problem from the previous successful designs. The example of initial solution is modified partially to satisfy the requirement of the design problem [4]. In order to solve the new problem during the design process, users can input the relevant parameters, such as the form of structure, the maximum pressure, etc. to match the parameters of the existing instances in the instance library. The optimal matching strategies of intelligent rapid design system of sheet metal equipment are as follows: product component module division principle and the most adjacent strategy method. Essentially, the process of optimizing the design of the sheet metal equipment is the matching process of the same attributes of every module of the sheet metal products. The description of the specific algorithm of modular product instance retrieval of coating machine using the most adjacent strategy method is as follows:

Supposing that the sheet metal device has n configuration attributes,S_i,S_i^*(i $\in [1,n]$) Represent the i-th configuration attribute value of the product and the i-th configuration attribute value mapped to the product after conversion of the users' requirements. $Q_i(i \in [1,n])$ represents the weight of the i-th configuration attribute of the product and satisfies

$$\sum_i^n Q_i = 1 \quad (1)$$

Let R_i be the match probability of S_i and S_i^* . There are only two cases of matching results for S_i^* and S_i^*. When the two match, then R_i=1. When the two do not match, R_i=0. Thus, the similarity degree U in the retrieved set of instances is only related to the weight and the matching degree of each configuration attribute in the instance. Similarity degree U between the configuration attribute of the instance and the configuration attribute of the customers' requirements can be written as

$$\mathrm{U} = \sum_{i=1}^n R_i Q_i \quad (2)$$

In it, $\mathrm{U} \in [0,1]$, when the retrieved instance attribute value is exactly the same as the customer's requirement, the U value is 1, which means they match exactly. This illustrates that the closer the U value is to 1, the more satisfied the user's needs are.

Engineering drawing match Automatically. Sheet metal mechanical design needs to first establish a three-dimensional model. And then according to the production of the template in the parametric drive, projection into engineering drawings .However, due to size, shape changes there will be view ratio is not coordinated, the view position is chaotic, dimension line, center line drift or even error, size accuracy can not be displayed according to the actual size, linear proportion does not meet the requirements and other issues.

View Scale Adjustment. In the size of the drive after the view may be the size of the template is not appropriate, you need to re-set the ratio. However, the three-dimensional system can not automatically set the ratio, so the need for system development to achieve the view scale of the automatic adjustment, view scale adjustment can be divided according to the view Line length changes are set. (Xmin, Ymin) and (Xmax, Ymax) are the points of the lower left corner and the upper right corner of the view boundary rectangle respectively. First, the diagonal length L0 of the view in the template is obtained by the API function and stored as a constant in the database. Then, after the parameter is driven, the GetOutline function in the API is used to get the position parameter of the view envelope. According to the rectangle diagonal length calculation formula, the length of the view diagonal is:

$$\mathrm{L} = \mathrm{SQRT}[(X_{max} - X_{min})^2 + (Y_{max} - Y_{min})^2] \quad (3)$$

Find the current scale S_{c0} of the view. If the diagonal length of the view is driven by the parameter, the value of S_{c1} is the ratio of S_{c0} to the diagonal of the parameter before and after the parameter drive product.

$$S_{c1} = S_{C0} L / L_0 \quad (4)$$

After getting Sc1, using the API function can be automatically driven according to Sc1 view.

View Position Adjustment. After the size is driven, the view position moves because of the change in size, resulting in errors such as overlap. The solution is to create a view position information table in the database to store the coordinates (x, y) of the center point O of the different views in the different drawing templates. Use the view position parameter to find the coordinates of the center line O ' of the view envelope after the view scale is adjusted and compare it with the coordinates of the center line of the view envelope in the database.. Calculates the offset xlen, ylen for the center coordinates of the view envelope as

$$\begin{cases} x_{len} = \frac{(x_{max} - x_{min})}{2} - x_d \\ y_{len} = \frac{(y_{max} - y_{min})}{2} - y_d \end{cases} \quad (5)$$

Where x_d and y_d are the ideal envelope center point coordinate values for the view in the database. And then you can use the API function to move the current anchor point P '(x, y) of view to the direction of the view offset x_{len}, y_{len}.

Applications

In the system, after we establish a repository of plate shears, three-dimensional map template and other necessary data, we can use VB.net to design a human-computer interaction interface, which is shown in picture 1. Importing the initial parameters of the necessary plate shears, the system automatically generates a three-dimensional model of the plate shears, as is shown in Figure 2. While generating engineering drawings, as is shown in Figure 3. And recorded the historical design data, as is shown in Figure 4. Providing the subsequent redesign with convenient.

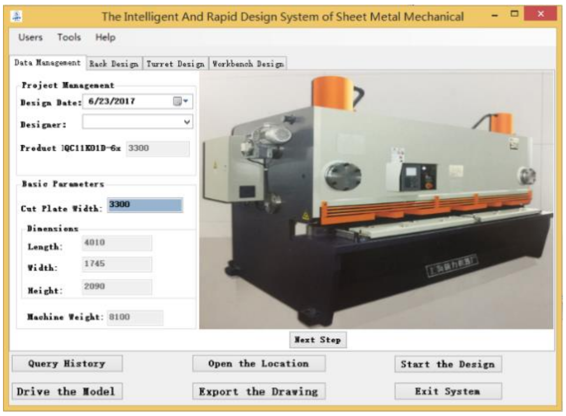

Figure 1. Sheet metal design system interface

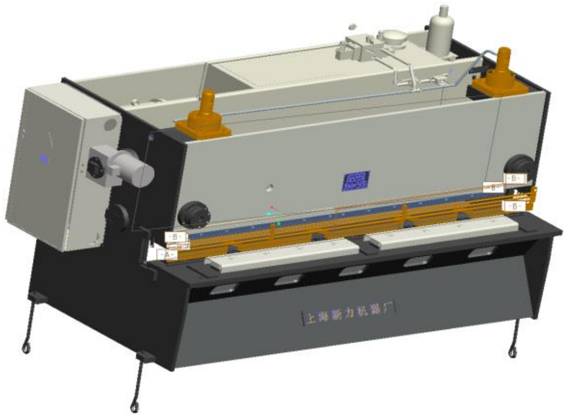

Figure 2. system design of the 3D model

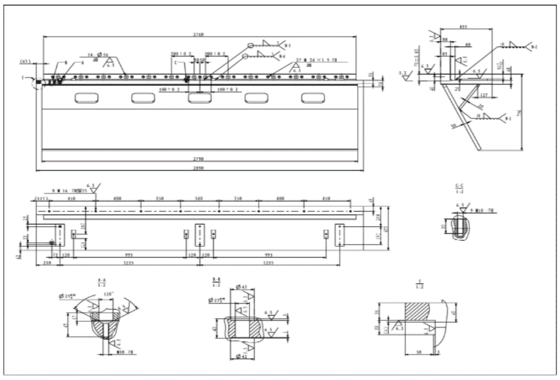

Figure 3. Sheet metal design of the 2D map

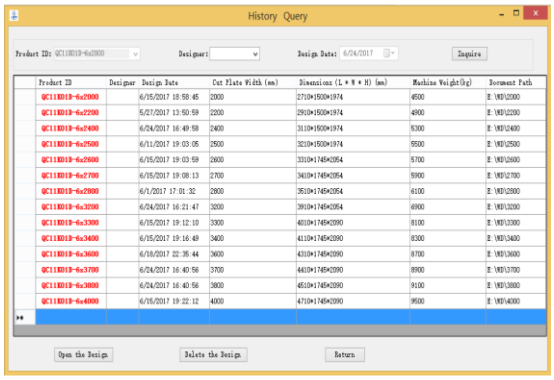

Figure 4. Historical data records

Conclusion

The intelligent and rapid design method proposed in this paper has been applied in the design of bending machine and shearing machine at present. It has been proved that the design of repository, parameterized 3D model library, two-dimensional graphics library and the repository system, realize the automatic modeling of sheet metal machinery products, automatic generation of CAD graphics and data management functions, reducing the unnecessary duplication of work, saving a lot of labor, making the product development cycle that has been greatly shortened and to ensure the accuracy of product design.

References

[1] S.B. Liu, G.H. Zhao and L.W. Zhong: Research on The Rapid Design System of Bending Machine Based on Knowledge Engineering[J] In Chinese (2016) No.1, p.131.

[2] Y. Sun, L.W. Zhong and Y.Y. Liu: Rapid Design System of Shearing Machine Based on Pro / E Secondary Development [J] In Chinese (2017) No.4, p.139.

[3] R.K. Xia, L.W. Zhong and L. Hong: Research on Intelligent Design System of Waste Heat Boiler Based on Knowledge Engineering [J] In Chinese (2015) No.1, p.34.

[4] D. Li and L.W. Zhong: Research on Generalized Modularization Design of Product Families [J] In Chinese (2015) No.7, p.66.
[5] H.Z. Tan and L.W. Zhong: Research on Product Family Planning Based on Generalized Modularization [J] In Chinese (2013) No.12, p.93.
[6] Z. Huang, C.F. Chen and L.W. Zhong: The Modular Design of The Waste Heat Boiler Research-based CBR[J] In Chinese (2016) No.2, p.84.
[7]C. Han and L.W. Zhong: Research on drawing technology of SolidWorks digital design model[J] In Chinese (2012) No.3, p.42.