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Research on intelligent design system for refrigeration engineering

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ABSTRACT

In order to implement the intelligent and rapid response design on refrigeration engineering, this paper aims to give a knowledge-based intelligent method. After information modeling and system framework were analyzed, the major technologies such as rule based equipment selection, and case based reasoning on providing a reasonable refrigeration system solution from the similar engineering scenarios were solved. Refrigeration engineering intelligent design system has been used in the enterprise. In addition, the methods can also be popularized to other design fields.

Key words: Refrigeration engineering; knowledge-based; case based reasoning

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INTRODUCTION

With the implementation of CAD application, professional CAD has been greatly developed. Due to the complexity of refrigeration engineering technology [1], the refrigeration engineering CAD software is mostly based on 3D CAD drawing environment or designed for a particular function or process at the moment. It cannot meet the design habits of domestic refrigeration companies which are used to adopting two-dimensional design platform and the requirements of auxiliary engineering design. Therefore, to design and develop an easy operating and fully functioned CAD system becomes a hotspot for refrigeration engineering currently.

The intelligent design based on knowledge is a comprehensive technology which combines knowledge engineering with CAD theory, the essence is to use computer instead of human experts for analysis to complete the complicated design tasks more rapidly [2]. Based on the comprehensive analysis of design characteristics and requirements of refrigeration engineering, object information model is established, and intelligent methods such as selection technology based on rules and case-based reasoning technology are introduced into the refrigeration engineering design process in this paper. By doing this, the design quality is improved and the development cycle is shortened.

SYSTEM OVERALL DESIGN

At present, the refrigeration engineering design process can be divided into several steps such as equipment selection, project concept design, engineering layout and BOM calculation. The designers will configure the equipment first according to the specification. Then, a primary solution is created mainly depending on the designer's individual experience and the references on the existing similar project. After that, the engineering principle diagram is drawn, and then the layout drawings such as the plan of machine room and storeroom, foundation drawing, elevation drawing and axonometric drawing, and the other auxiliary drawings such as hanger layout are produced. The designers need to check every drawing carefully to keep the consistency and get the information from the whole project to produce the BOM. The detailed design flow chart is showed in Fig.1.

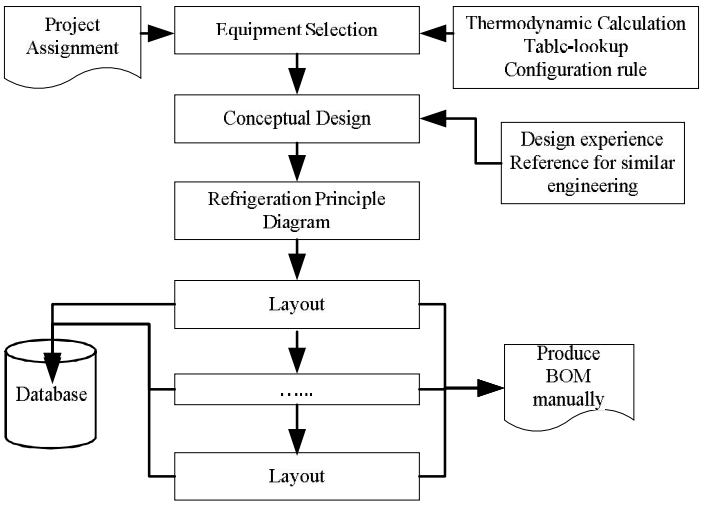

Fig. 1: Process of refrigeration engineering design

Now the main issues during the design phases are listed below. (1) When doing the equipment selection, the designers need to do complicated thermodynamic calculation and check the chart, which need very long time and the precision cannot be guaranteed.(2)The project design is mainly generated from the designers' experiences, inexperienced designers can not accomplish the design, the experiences reusing is weak.(3)Due to the adoption of 2D design platform, several different engineering layouts for one design scheme have to be drawn, the workload is heavy and the design cycle is quite long.(4)When the project needs to be modified partly, the corresponding drawings also need to be modified respectively by manual work. The repetitive work wastes a lot of manpower and the consistency cannot be maintained.(5)The BOM is calculated by manpower, which wasting time and the precision cannot be assured.(6)There is no specified graphic library established, the engineering drawings lack of effective management.

By acknowledging and analyzing the existing issues in the refrigeration engineering design process, on the basis of object information model, the concept of refrigeration engineering intelligent design system is raised. The structure of intelligent design system is showed in Fig 2, including mainly 3 parts:

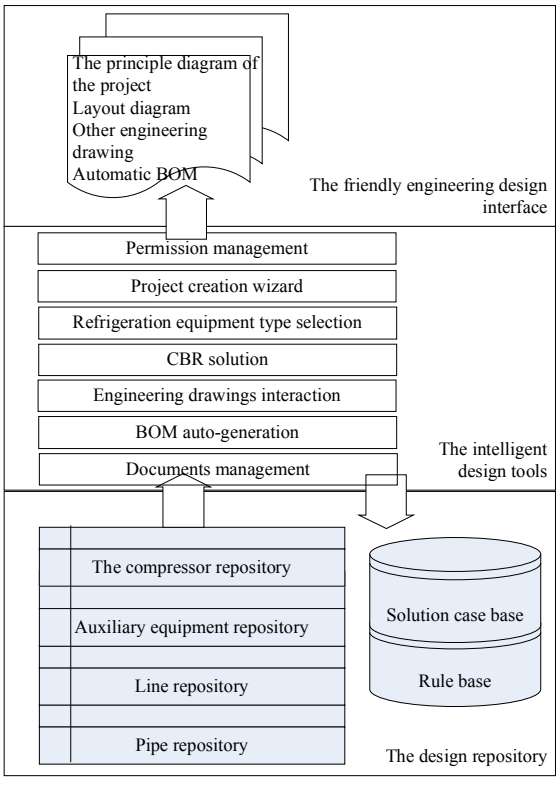

Fig.2: Architecture of refrigeration engineering intelligent design system

(1)The design repository: consists of compressor repository, auxiliary engine repository, pipeline repository, rules repository and engineering scheme instance repository, includes all the information related to engineering design. (2) Refrigeration intelligent design tools: including user authority control, engineering creation guide, equipment selection, CBR similar schemes solvent, engineering drawings interaction, BOM automatic generation, schemes saving etc. Firstly, one set of drawings is generated after engineering parameters initializing. Then the equipment are selected based on the engineering requirements; setting the parameters and searching the most similar scheme in the engineering scheme instance library; If exists, the scheme is modified to satisfy the requirements, if not, a new scheme is designed. Engineering drawings interaction refers to drawing, modifying and deleting the layout of one of the engineering drawings can be reflected to the other drawings, thereby all the drawings can be created and updated simultaneously, the consistency of the engineering drawings can be guaranteed. After the drawing, the BOM is generated automatically; last, the set of engineering drawings is updated to the database. (3) User-friendly engineering design interface: under the support of the digital resource library and the intelligent design tool set, the engineering principle drawing, layout drawing and other auxiliary drawings are designed by CAD, for instance, If using the linkage tool to implement the information connection between the principle drawing and the other engineering layout drawings, designing once can generate multiple drawings of various views, the consistency is assured; After finishing the design of engineering layout drawings, The BOM is generated by using the BOM automatic generation tool. This intelligent design system can provide fully support for refrigeration engineering design, simplify the design process greatly, reduce the design cycle and improve the efficiency.

The intelligent design system of refrigeration engineering is the CAD software designed for refrigeration enterprises. It is aimed to provide the whole support for the engineering suit. It can free the designers from heavy and complicated works, improve accuracy, simplify the design process, reduce the design lifecycle and improve efficiency. According to the analysis on system architecture, the man functional components included in the system are: digital resources library, refrigeration equipment selection, design schemes searching, integrated design of drawing etc. The functional components of the system structures are listed in Fig 3.

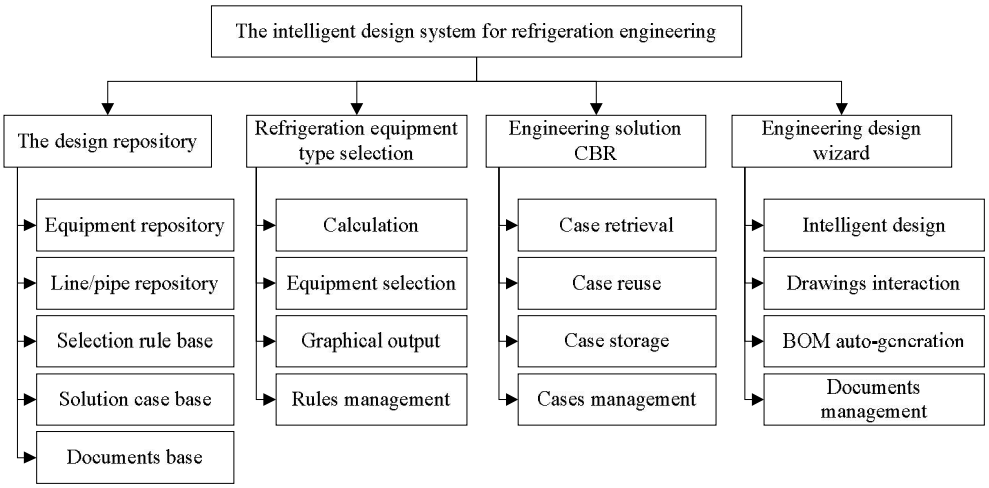

Fig.3: The functional model of the system

The components are described as below.(1) The design repository: the equipment and pipeline resource library store all the 2D drawings of refrigeration resources and its information of additional properties, rules selection library saves the main performance specifications and configuration rules of the refrigeration equipment, the design scheme instance library saves the instance descriptions of the projects existed and the save paths for the corresponding engineering drawings, The engineering drawings library stores all of the completed engineering drawings.(2)The refrigeration equipment type selection: the compressors and auxiliary engines are primarily selected based on the calculation and configuration rules, the user is allowed to modify the results to get the final refrigeration equipment list. Meanwhile, the user is also allowed to do some operations such as add, delete and modify on the calculation and configuration rules to ensure the rules library updated constantly. (3)The engineering solution CBR: the most similar instance is retrieved based on the characteristics and weights, the search results are output in the order of their similarity. The instance preview function is offered, the user makes the decision on whether to reuse the instance or modify the conditions to search again. The selected instance can be modified to makes it satisfy the design requirement. The characteristics of the instance is extracted and saved to the design instance library, the drawing is saved to the engineering drawings library. It is allowed to do operations such as browsing, deleting and restoring on the instances in the instance library. (4) Engineering design wizard: the whole set of engineering drawings can be

managed by creating drawing set tool and the integrated design for the principle drawing and each layout drawing can be achieved. The post-processing tool is provided for the drawings to generate the profile map, graphics blanking, pipeline and valve dimensioning, and isometric view etc. The statistics can be achieved automatically to generate the BOMs of one single drawing and the whole engineering project separately.

KNOWLEDGE-BASED TECHNOLOGY IN REFRIGERATION ENGINEERING

Selection design is a design method and process which searches the already designed parts to find and assemble the part which satisfy certain requirements and meet certain restraints [3]. As a design method, selection design can choose the components and parts to compose new products and provide the design instance rapidly based on user requirements. It has become a hotspot for refrigeration engineering design. The refrigeration equipment selection is implemented based on the rules method, which using production rule (if conditions then results) to express the domain knowledge of selection and control strategy. This method effectively solves the issues that what kind of actions should to do to get the effective selection and when related actions should be proceed [4].The convenient, flexible and efficient configuration rule is the precondition for implementing the selection design successfully[5].

For example, the screw refrigeration compressor is composed of various equipment, including: screw refrigeration compressor, electromotor, air circuit system (suction line valve, suction filter, suction check valve), oil system (oil pump, oil separator, oil filter, oil-pressure adjusting valve and oil distribution pipeline), control system (startup control cabinet, machine room control board) and other equipment and the pipelines which connect the systems. The calculation of compressor selection needs to be based on the already known duty parameters and selected working substance to do the thermodynamic cycle calculation. The stroke parameters of the compressor can be obtained by searching the manuals, along with the results above to get the performance parameters of the compressor, then the right compressor is chosen, meanwhile, the corresponding auxiliary products can also be chosen based on the preparation rules of refrigeration industry. An example is shown in Fig.4.

rule1:

IF “the heat transfer area30<S<40”

THEN select “LN35 Vertical condenser”

rule2:

IF “the heat transfer area20<S<30”

THEN select “DWN-25 Horizontal condenser”

rule3:

IF “the heat transfer area80<S<100”

THEN select “SN-90 condenser”

Fig.4: Some configuration rules of single-stage screw compressor

Case Based Reasoning is one kind of analogical reasoning model that adopts successful experience and instances which have solved the similar issues in the past to resolve the current issues [6].It is a very attractive method in the artificial intelligence field and expert system design. The major advantages appear in fault diagnosis, project planning and product design fields [7].It has been discussed by experts that if one design scheme similar to the new project can be found in the scheme library [8].The design scheme can be modified and there is no need to redo the design, thus the efficiency can be improved greatly [9]. So, the Case Based Reasoning can be adopted.

The process of CBR system of refrigeration engineering is showed in Fig 5. The new project need to finish is described to target instance, The designers who based on their experiences combines the particular situation of the target instance to choose the combination of characteristics, such as working parameters, chosen medium, refrigerating type to search information of characteristics in the instance library in order to get the similar instance; By reusing and correcting the instance, a new instance can be got for use, and the new instance is save to the library, the reasoning is finished.

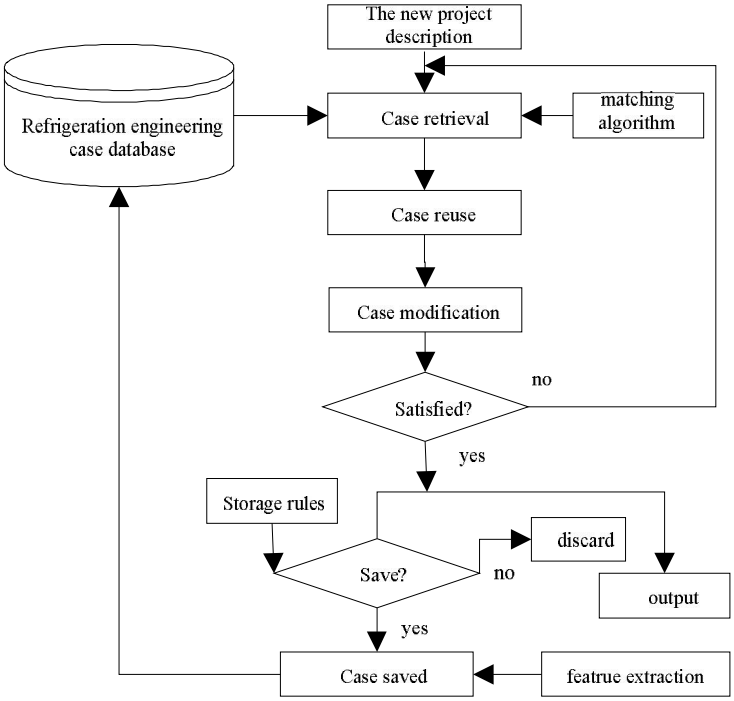

Fig.5: Solution process of CBR system

The formula of CBR of refrigeration engineering is described below:

$$C = \{C_k \mid k = 1,2,\cdots \mathrm{m}\}$$
$$C_k = (S_1^k, S_2^k, \cdots, S_{\mathrm{n}}^k) \quad k = 1,2,\cdots \mathrm{m}$$
$$S_l^k = (p_l, x_l, w_l) \qquad l = 1,2,\cdots \mathrm{n} \tag{1}$$
$$\sum_{l=1}^{n} w_l = 1$$

In the above formula1, C_k refers to the *k* engineering instance, M refers to the No of instances in the instance library, S_i^k (*i*=1 …, n) is the characteristic parameters of the instance C_k, n represents the No of characteristic parameters of C_k, p_l refers to the parameter name of the characteristic parameter S_i^k, x_l refers to the value of the characteristic parameter; w_l represents the weight of the characteristic parameter in the matched searching characteristic index, CBR of refrigeration engineering system uses expert evaluation method to determine the weight.

CONCLUSION

The intelligent method supporting the whole process of refrigeration engineering design is raised. Based on the technology of equipment selection and CBR, most repetitive works can be avoided. The intelligent design system is developed based on the actual demand of one famous domestic refrigerating enterprise. It is run on the general graphic platform AutoCAD, easy for enterprises to reuse design knowledge. The system can simplify the design process of refrigeration engineering enormously and reduce the design lifecycle. The principle, mechanism and structures of refrigeration engineering intelligent design system are also suitable for the other engineering products suit. As long as changing the product model and the design resource in the system design platform and developing corresponding user interface, it can be applied to the other product auxiliary design.

Acknowledgments
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