

Implement and Research on the Expression Methods of Knowledge for the Expert System of Rotary Kiln

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Abstract: Studied on the expression methods of knowledge and using standard, according to the knowledge of rotary kiln's characteristic, such as complexity and connection, it selected the commingling modal of the knowledge representation which composes production rule and object-oriented. It applied in rotary kiln expert system successfully. The method can be used in other complex knowledge representation system.
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Keywords: Rotary kiln, Expert system, Knowledge representation, Knowledge base.

1. Introduction

Rotary kiln is key equipment which is used in many fields, as metallurgy industry, building materials, chemical industry, etc. It consists of cylinder device, supporting device, thrust roller device, transmission device. In order to meet the needs of different field user's requirements, the research of realization design of expert system for rotary kiln which could rapidly and accurately design new production has been carried out [1, 2]. Knowledge base is the core part of expert system. The knowledge representation affects the efficiency of reasoning machine and operation mode [3]. The rotary kiln belongs to large, complex products. And the source rotary kiln domain knowledge [4] is various. The domain knowledge not only includes production practice experience, also has test result and CAE simulation analysis conclusion. How to put

this domain knowledge into expert system of expression is the objective of the article.

In order to meet the needs of different users, the study of the intelligent design system of rotary kiln [1, 2] parametric design has been carried out rapidly and accurately. The knowledge base is the core of the intelligent design system, the representation of knowledge influences the operation mode and operation efficiency of reasoning machine [3]. Rotary kiln is the source domain knowledge of kiln intelligent design system knowledge base [4]. With the general knowledge in expert system of mechanical product is different, the rotary kiln belongs to large, complex and the application fields of many knowledge sources, and has practical experience, also have the test and CAE simulation results. Especially the application of CAE technology, bring about how these knowledge effectively in the intelligent design system expressed in the research is the focus of the article.

2. Research of Knowledge Representation

Knowledge representation is the study of how to most effectively organize all kinds of knowledge in the computer system [5]. Commonly, knowledge representation methods are: the production rule, framework, semantic network, process, the object-oriented, etc [6-8]. Choose the knowledge representation method should follow the following principles:

1) Accurately and adequately express kinds of domain knowledge. Knowledge representation should be accurately and fully express all kinds of the domain knowledge. 2) Convenient call. Knowledge representation can be called by reasoning machine in expert system efficiently, at the same time it could support all kinds of control strategies for the solution of the conflict in the process of reasoning; 3) The knowledge representation is easy to understand. Knowledge representation should be convenient to be understood and operated by design engineers.

3. The Characteristics of the Knowledge of Rotary Kiln and the Realization of Knowledge Representation

3.1. The Characteristics of the Knowledge of Rotary Kiln

Rotary kiln is applied to many fields, including the claimed lime, sintering pellets, dry claiming cement, reduction of alumina, coke, chemical fertilizer granulation, etc. Different filed of rotary kiln has different design parameters. The structure of rotary kiln is complex. Specifically, the domain knowledge of rotary kiln has the following features:

1) Complexity: in the structure of the key components of the rotary kiln, there are many factors affect the design. Although the overall structure of kinds of rotary kilns is the same, but rotary kilns which be applied in different industries, has different structural parameters.

2) Ambiguity: rotary kiln design requires a large number of knowledge of expert experience, and most of this empirical knowledge is uncertain value. Such as the selection for different purposes of rotary kiln tube body length to diameter ratio, tend to choose a range according to experience.

3) Interrelated relationship: rotary kiln is an organic body. Many design parameters influences each other. For example, raw materials in different conditions need different residence time in the rotary kiln. The retention period of material and the slope by rotary kiln, rotary speed, length to diameter ratio and other factors determine the residence time. So, one of the above parameters change will affect the other values of design parameters.

4) Multiplicity source of domain knowledge. Rotary kiln knowledge not only comprises the expert knowledge, but also has innovation knowledge got

from modern scientific means. Fluent, EDEM calculation formula of virtual simulation technology, the trend diagram, for example. [9].

3.2. The Realization of the Knowledge Representation for Rotary Kiln

Rotary kiln domain knowledge's complexity, ambiguity, relevance and diversity characteristics determine that the single knowledge representation method to realize the establishment of the knowledge base of rotary kiln is difficult. Considering the characteristics of the domain knowledge of rotary kiln, used in the expert system for rotary kiln production rule, framework and object-oriented representation method that combines an integrated. The knowledge base of expert system of rotary kiln in VC++ and SQL SERVER is as a development tool.

1) Rotary kiln production rules to express knowledge.

For rotary kiln design knowledge which has the causal relationship, is expressed in the form of production rules. In the database, it consists of prerequisite for the rule premise of table, used to hold rules consequent table and join table of conclusion, such as shown in Tables 1 to 3.

Table 1. IF table of rules.

Pre Con	IF condition
IF_ID	IF ID
IF_Pa_ID	IF parameter ID
Tab	Table ID of parameter

Table 2. Connection table of rules.

R ID	Rule ID
R_Name	Name of rule
IF_ID	IF ID
IF_Couter	Quality of IF
TH_ID	THEN ID
Priority	Priority

Table 3. THEN table of rules.

TH ID	THEN ID
TH_PaID	THEN parameter ID
Con	Conclusion

If rules and conclusion rules can be either a numeric knowledge or it can deposit "fuzzy" descriptive knowledge. Because of the complexity of the rotary kiln knowledge, one precondition may have different matching rules in the process of reasoning. It could lead to conflict. Therefore priority is set in each rule connection table, used to distinguish different rules of high and low priority,

which is more advantageous to support control strategy of inference machine.

Rule knowledge is composed of multiple rules table. They match each other by ID number. Rules in the process of reasoning machine call first premise and premise number and search for all relevant rules related to connection table, then extract the rule premise number in the table, matching the corresponding rules premise number one by one. If there is more than two rules connection table meet the conditions, then the priority of the contrast between them by the reasoning machine, choose the high priority rules connection table, and use the rule table corresponding conclusion. Reasoning machine obtains the corresponding conclusion rule conclusion tables as reasoning results. The link between the rules of table model is as shown in Fig. 1.

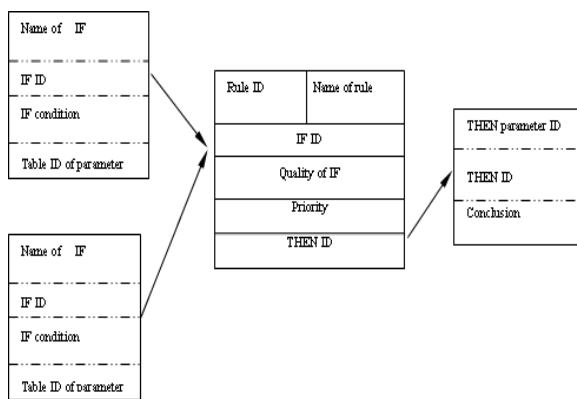


Fig. 1. The module of rules.

As shown in Fig. 1 the premise and consequent rules by the ID number of connections between them. The higher priority value, the higher priority, priority to choose in the knowledge base of expert system of rotary kiln number between 0~1; Priority values in production rule set is formed by knowledge engineers.

A Rule premise table:

(ID): 2106 (parameters) of lime kiln product condition (rules)

(ID): 2107 (parameters) is greater than 1000 m altitude (rule conditions, fuzzy condition)

2108 (ID): fuel calorific value (parameters) > 2800 kcal/m³ (rule conditions, fuzzy condition)

Rule conclusion table:

4101 (consequent ID): rotary kiln support (parameters) 2 priority rules (conclusion) of 0.950.

2) Framework to express rotary kiln knowledge.

Some design parameters in expert system of rotary kiln is relevant. The parameter may changes because of designers or the inference engine. The changed parameters affect other interrelated parameters, so this kind of parameters belongs to the "dynamic" knowledge. Involves the parameters of rotary kiln class knowledge representation is with the knowledge framework. In the heart of the framework

parameters set out with a Boolean value to indicate that differ from the dynamic knowledge. Dynamic design process of "knowledge" can be directly by the design engineer is not changed, in order to reflect the correlation of design parameters. But if let "dynamic knowledge" disorderly influence each other and change, finally causes the confusion or even collapse of expert system. So you need to set parameters of this kind of influence each other priority, low priority parameters of passive accept the high priority parameters affect and change the original value. Rotary kiln design parameters of "dynamic knowledge" of high and low priority by the knowledge engineers based on the set.

Each parameter in the framework of knowledge corresponding to a slot, slot value can be rules referred to in the preceding paragraph, consequent or the results of numerical calculation method. Parameter is activated is determined by Boolean number, the number "1" said parameters are connected, "0" indicates parameters are alone. The design parameters of rotary kiln, the calorific value of fuel, for example introduced frame expression how to store in the database, as it is shown in Table4.

Table 4. Storage table of parameter in database.

Name	Explain	Example
ID	Parameter ID	108
Name	Name of parameter	fuel value
Unit	Unit of parameter	Kcal/3m
Type	Type of parameter	double
Value	Value of parameter	3200
Priority	Priority of parameter	0.988
Boole	State of parameter	1

3) Rotary kiln object-oriented knowledge expression.

Expert system for rotary kiln object-oriented knowledge representation method is implemented by VC++. It consists of parameter structure, rules, and function composition.

1) The parameters of the structure will be parameterized design knowledge of rotary kiln, the decomposition of the complex knowledge, reduce system redundancy. Through parameter structure generated members, read the parameters in the database, complete the parameters of increase, modification, storage, etc. Parameters of the structure are shown below.

```

struct Parameter
{
    int m_Pa_ID;
    CString m_Pa_name;
    CString m_Pa_value;
    CString m_Pa_unit;
    int m_BOOLE
    int m_Pa_datatype;
    double m_Pa_priority;
};
    
```

2) Rules class generated objects read from database. Reasoning machine program can easily complete the rules. The structure of the rule class is shown below.

```
class CRules
{
public:
    int m_IF_ID;
    CString m_IF;
    int m_TH_ID;
    CString m_TH;
    int m_Pa_ID;
    int m_R_ID;
    CString m_R_Name;
    float Priority;
    int m_IF_No;
    int Counter();
};
```

3) Test and CAE simulation analysis of conclusions, curves, graphs, etc., such as the literature [2, 9] parameters involved in the rotary kiln design theory, methods, formulas, etc., will be encapsulated as a function of such knowledge to design the function class. Composition of function classes is shown below:

```
class CFunction
{
private:
    int m_Meth_ID;
public:
    int GetID();
    GO();
    float Lime_Move_time(double L_D;
double rev;double slope;double
material_angle;double stone_D);
};
```

3.3. Knowledge Base of Expert System Framework of Rotary Kiln

According to the characteristics of design knowledge of rotary kiln, the kiln knowledge base is divided into: knowledge base, component repository (cylinder device, supporting device and thrust roller device, transmission device, seal), commonly used materials knowledge base and commonly used fuels knowledge base. They are parameters of the structure, rules, and function is derived, in order to reduce data redundancy system. Derived object from the inference machine to complete the operation and maintenance of the database. Knowledge base system of rotary kiln framework as is shown in Fig. 2.

4. Running of the Sample

In order to convenient management and maintenance the rotary kiln knowledge base, knowledge base management system is established in the expert system for rotary kiln. It can complete the parameter database, rule base. It can add and delete the function, change operations, including complete knowledge and rule conflict check, data update and so on. Fig. 3, Fig. 4 and Fig.5 are running interface of expert system knowledge base management system of rotary kiln.

5. Conclusions

The research of expert system for rotary kiln knowledge representation for large, complex mining and grinding machine provides a rapidly and intelligent design method. The innovations for knowledge representation are as follows.

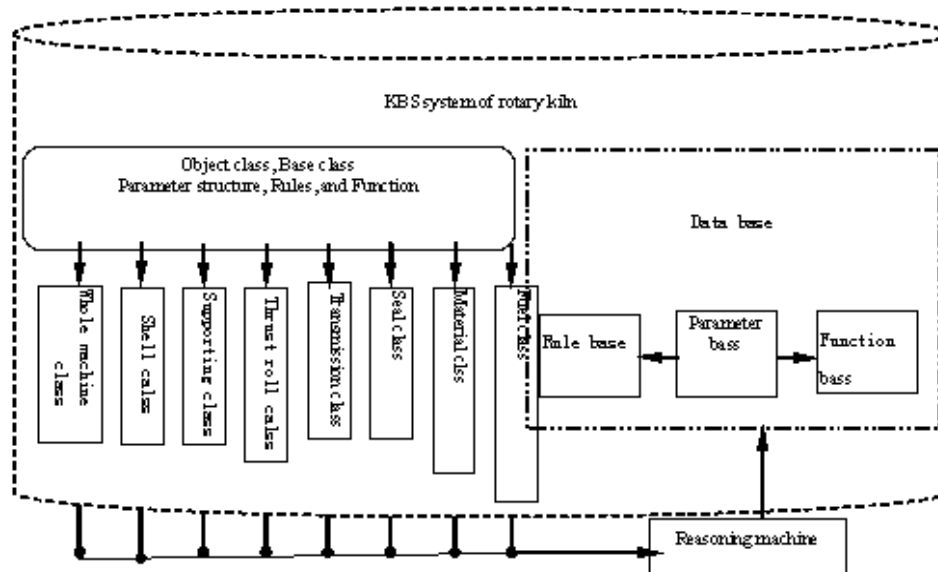


Fig. 2. The structure of knowledge system.

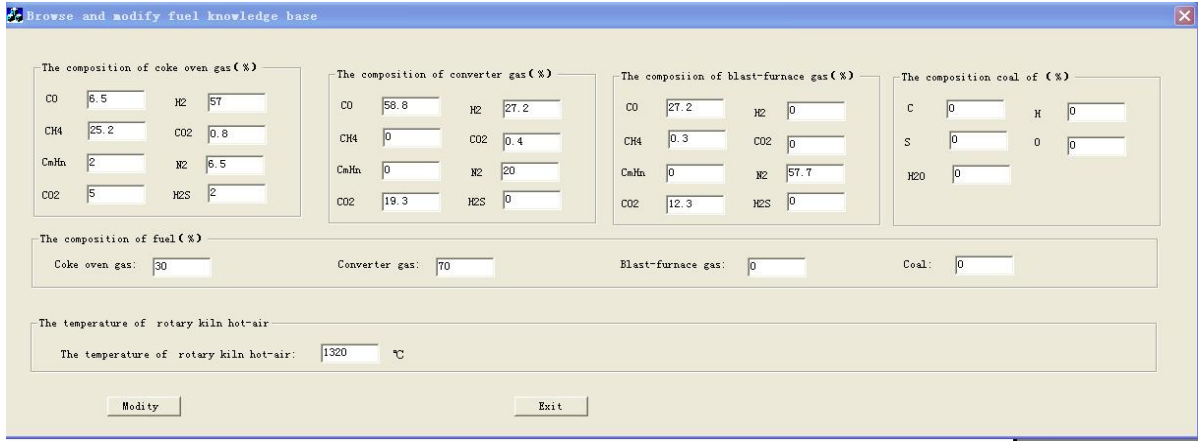


Fig. 3. The interface of adding parameter.

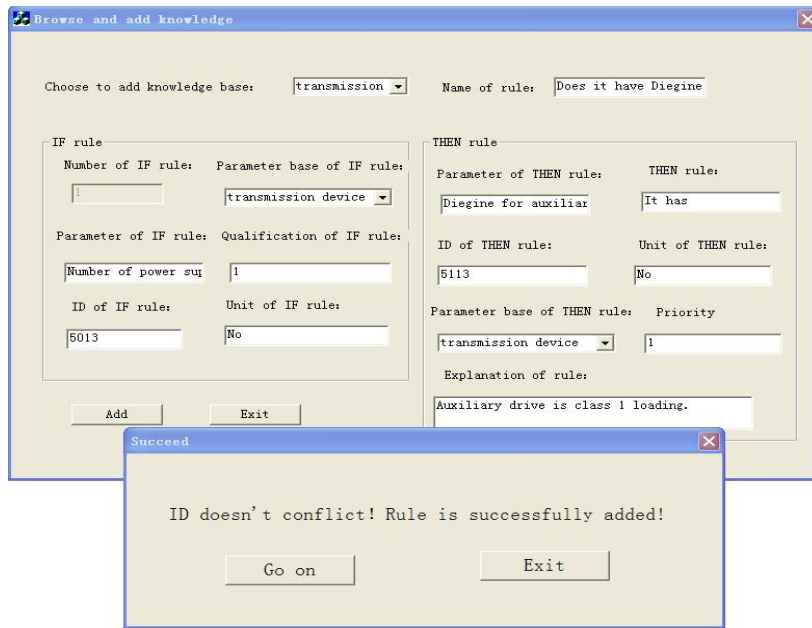


Fig. 4. The interface of adding and browsing knowledge.

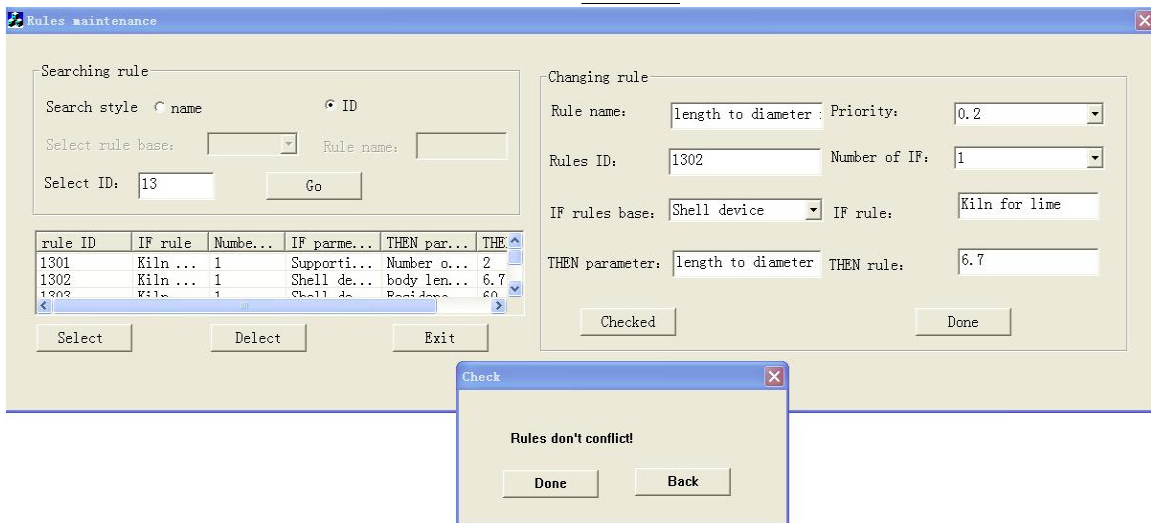


Fig. 5. The interface of administration knowledge.

1) Using production rules to express parameters of fuzzy description of knowledge. It provides a way for fuzzy knowledge express. 2) The interrelated knowledge through expression embodied in the frame with a Boolean value associated with the phase difference, and set priorities, make reasoning work more efficient. 3) Using object oriented expression, structure parameters and the structure of the rule class is given, the parameters used, rules derived by them respectively, and the complex knowledge presentation more concise. Method of structure model is put forward, in particular, the various virtual simulation technology to get curves, graphs and so on innovation of knowledge integration to the knowledge base, to provide accurate data support for the inference machine operation.

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