Research on Wind Power Equipment Selection System
Based on Axiomatic and Knowledge

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Keywords: Wind power, Axiomatic, Knowledge, Selection, Renewable energy.

Abstract. With the changes of product market requirement and fierce competition, there are kinds of wind power equipments. Combined with the current situation and development trend of wind power enterprise, the establishment of wind power equipment selection system for wind farm design would be proposed and researched. Axiomatic design method is adopted to realize express of customer requirement analysis, and mapping relationship between function demands and design parameters are researched. Wind power equipment selection model based on knowledge is adopted and studied, the reuse of resource is actualized mostly by management of model information and knowledge. Axiomatic design method is adopted to design the platform system, and wind power equipment selection system structure would be established by the method, knowledge of related field and wind power equipment selection process are embed in the system. The reusability method for wind power equipment selection is researched, which realized the reuse of model, information, data and knowledge for wind power equipment selection process. The system structure of wind power equipment selection for wind farm design will be established by the above theories and methods, which would improve wind power equipment selection effectively.

Introduction

Wind power is a renewable energy, it is clean and has an abundant reserve, which has a great significance to environmental protection and the energy structure improving. China is a vast country, which has a long coastline and abundant wind energy resources. The amount of wind energy resources potential development on 50m height of the land and offshore is about 26 billion kilowatt. Developing renewable energy actively would save and replace part of the fossil energy sources, promote energy structure adjustment, and reduce the environmental stress, which would be the inevitable strategy choice to promote the economic and social sustainable development.

With the rapid development of wind power, it has become an important part of sustainable development strategy in many countries. The scale of wind power projects is large and wind power equipments are complex, which involve aerodynamics, mechanical, power electronics, automatic control, communications technology, new materials and other disciplines and knowledge.

Wind power equipment selection has become one of the major factors for wind power project investment. The wind power equipment selection not only bases on the given wind conditions to choose the most appropriate type of structure from the existing structure type, but also proposes design requirements for the main technical parameters, which would conform to the selection principle of safe, reliable, advanced technological, economic rationality and convenient construction. How to choose the right wind power equipment for the wind power projects has become the focus attention for investors and designers. In this paper, the axiomatic design and knowledge engineering theory and methods used in wind power equipment selection system are researched. It is the foundation for the development of wind power equipment selection system. And it would be a great significance to improve the level of wind power equipment selection.
Wind Power Equipment Selection System Multi-express Based on Axiomatic Design

In order to establish the wind power equipment selection system structure reasonable, axiomatic design method to establish the system structure is presented, which makes the system design accord with the user and design requirement, and the related affection relationship of system module is given. Axiomatic design could provide designers to establish the design ideas in the early design. Based on the axiomatic design principle, designers could analysis the design requirements, solutions and design process conveniently. The basic idea of axiomatic design could be used for software design, organizational design, system design, material design, manufacturing design and process design [1, 2].

Axiomatic design mainly includes domains, hierarchies, zigzagging, design axioms, and so on. Domains are the basic conception in axiomatic design. Design progress could be made up by customer domain, functional domain, physical domain and process domain. The relationships between the four domains are as Figure 1. The left domain and the right domain would establish relationships by design matrix. Adjacent two domains are used mapping to design, and using design axiom to decide axiomatic and optimization [1].

Axiomatic design method has two basic axioms, which are independence axiom and information axiom. The relationship between functional domain FR vector and design parameter DP vector which satisfies FRs in physical domain could be expressed as:

\[ \{FR\} = [A]\{DP\} \]

In order to satisfy independence axiom, design matrix would be diagonal matrix or triangular matrix. If the design matrix \([A]\) is diagonal matrix, every function requirement would have one design parameter to satisfy, and this design called no coupling design. If the design matrix \([A]\) is triangular matrix, while the design parameter should have an appropriate array to satisfy function requirement independence, this design called decoupling design. And other matrixes are coupling design, which could not satisfy independence axiom requirement. If there is only one program to satisfy independence axiom, it would be the last design program. If there are many programs to satisfy independence axiom, information axiom would be used to evaluate them, and the least information design program would be the last design program.

Wind power equipment system structure design could be expressed as: FR1-wind power equipment basic information, FR2-wind power farm design project, FR3-saving the product model which satisfies the design requirement. The DPs which satisfy the FRs are as: DP1-the wind power equipment specification set, DP2-wind farm design module, DP3- wind power equipment model case and case-based reasoning module. The design equation which represents the relationship between function requirement and design parameter is as:

\[
\begin{bmatrix}
FR1 \\
FR2 \\
FR3
\end{bmatrix} =
\begin{bmatrix}
X & 0 & 0 \\
X & X & 0 \\
X & X & X
\end{bmatrix}
\begin{bmatrix}
DP1 \\
DP2 \\
DP3
\end{bmatrix}
\]

The relationships of function requirements and design parameters for wind power equipment are canalized by axiomatic design method, which could give corresponding reasonable solutions for the
questions of system design and development. The wind power equipment system design would meet the requirements of software axiomatic design.

Wind Power Requirement Selection Based on Knowledge

With the scale of wind power construction is expanding, the technology of wind power equipment would continue to make progress, the wind turbine capacity is increasing, and the adaptability of wind turbine is more important in wind power project development.

With the development of current wind power project development turning to low wind speed, high altitude, offshore wind power and other fields, and the application of new large wind turbine capacity, the output of wind turbine is more sensitive to the variety of wind speed, the wind turbine difference of generation performance is greater, and the wind turbine selection is more affecting the investment decision of the wind power project.

If the power generation is underestimated, the investment income of the project would not be satisfied; if the power generation is overestimated, the wind power project would incur losses, and the best choice of cost-effective models would not be selected.

The electricity price of the wind power project is dropping gradually, and the difficulty of the project development is more and more, in order to improve the revenue of the wind power, we should pay more attention to the optimization of the wind equipment type selection, and so as to control the cost of project.

The wind power equipment selection is a complex and meaningful work, especially to the offshore wind power project and complex mountain wind power project. Such as the offshore wind turbine selection, which involves the distribution of wind energy resources, the development situation of offshore wind turbine, the foundation type, the offshore distance of the wind turbine, the depth of the water, the geological condition and the economy. To the wind turbine selection of complex mountain wind power project, the first task is obtaining wind energy resources of the wind farm, then, according to the distribution of wind resources, wind shear and turbulence intensity, and the basic principles and requirements of the standard, the preliminary model is selected. The second, according to the terrain conditions and wind resources, the wind turbines are arranged, the power generation calculation software is used to carry out preliminary simulation result. The technical and economic comparisons of different wind turbine generation schemes are given, and the different hub heights of the selected models are compared. At last, the final wind turbine type is determined.

Wind power equipment selection is a comprehensive technology associated with many factors. And it is a very complicated system. It associated with the geographical conditions, design parameters, the estimated cost of construction, environment, and many other factors. Type selection design not only to determine the structure of the wind power equipment, but also to determine their main technical parameters. To accomplish these onerous tasks, mainly depends on a small number of experts. And expert knowledge and engineering experience will be organized into knowledge and by the computer to achieve its reasoning.

Type selection belonged to integration design, and it was very important in wind power equipment selection design. On the age of type selection design, aimed at the complex problem of design, expert thoughts mainly include logical thought, visualization thought and creativity thought, we always used some kinds of the thought, and for only use one type cannot solve the problem properly. The reasoning design method based on knowledge and case-based reasoning design method could realize that.

Case based reasoning method is adopted to complete the knowledge learning and reasoning for the fountainhead case, and the product model which mostly satisfies the customer’s requirement is selected [3]. The process of case-based reasoning is as Figure 2. Case-based reasoning includes case retrieval, case reuse, case revise and case retain.
Wind power equipment selection knowledge model need to research the key technologies of knowledge representation, acquisition, and implementation, and so on. And it would establish a reasonable and effective product knowledge model; combine with the product knowledge analysis, acquisition, expression, and retrieval. Wind power equipment selection process to achieve decision-making and reasoning would be realized by a knowledge integration environment. And it would be applied to the establishment of design system, which would realize the wind power equipment selection ultimately.

With the technologies improvement, such as human-machine interaction, machine learning and pattern recognition, AI has become a new trend in this technological era[4]. With the increasing of product knowledge model, for the next stage, using AI technology for equipment selection and project management may be an important development direction for renewable energy projects.

Summary

Wind power is an important component of renewable energy. This paper studied on the method of product model which can be used in wind power equipment selection and the method of how to establish the system structure. Our work can be summarized as:

(1) Adopting axiomatic design method to establish the wind power equipment selection system is introduced, which makes the system design accord with the user and design requirement, and the related affection relationship of system module is researched.

(2) Case based reasoning method used to select wind power equipment is presented, the most similar case retrieval could satisfy the customer’s requirement.

(3) The wind power equipment selection system established by the above theories and methods would improve wind power equipment selection effectively.

(4) The wind power equipment selection is a complex task, especially to the complex offshore wind power projects, AI technology would be an important development direction for renewable energy projects.

Acknowledgement

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