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Construction of Diesel Domain Ontology

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Abstract. At present, a large number of professional diesel databases and systems could support all kinds of unified management and retrieval applications based on the diesel research data, but the actual working environment exists three problems: (1) Data scattered in different databases and not conducive to business development. (2) The normalization of the diesel terminology is relatively low, affecting the retrieval accuracy. (3) The efficiency of knowledge search is low. This paper aims at the knowledge management and application problem in the diesel research and development process of digital design for vehicle diesel, analyzes the construction demand of the diesel domain ontology, proposed the diesel domain ontology construction method, constructed the diesel domain ontology structure, developed diesel professional ontology model management tool and diesel domain ontology service interface, which provides an organizational framework for information integration to facilitate the accurate and effective transfer between knowledge, data and model. The constraint of the ontology could ensure the accuracy and consistency of information, which could help enterprise improve the accuracy and integrity of the diesel knowledge search. The diesel domain ontology can support the integration of different databases, which could support enterprise technology innovation.

1. INTRODUCTION

At present, base on the diesel engine digital research, we built large number of construction design environment platforms, standardized the diesel design process, refined the evaluation criteria, which formed the foundation for the establishment of scientific and advanced diesel digital research system, accumulated a certain basic knowledge for the engine research. But knowledge is primitive, scattered and not standardized management. The research on the diesel domain knowledge is not systematic, standardized and integrated. Furthermore, the level of knowledge reuse is relatively low and the accumulation, precipitation and application of professional knowledge are relatively weak, which greatly restricts the enterprise to enhance the design ability.

The knowledge management as an important part for the digital product development collaborative innovation process is the foundation for the digital product development. Effective management of knowledge resources, effective management of knowledge resources, heterogeneous data integration, precision / accuracy retrieval and knowledge push provide technological platforms for enterprise resource mining, resource integration and data association.

In order to solve the knowledge / accurate retrieval and knowledge reuse problems, the enterprise based on the existing knowledge repository researches the construction method of diesel domain ontology. Through the development of ontology construction tools and data interface, it has initially realized the knowledge resource application based on the diesel domain ontology.

2. DEVELOPMENT OF ONTOLOGY

The concept of ontology originated from the philosophy field, and the ancient Greek philosopher Aristotle defined the ontology as the science of ‘existence’, which is the scientific of the whole objective world basic characteristics.[1] Since 1970s, the concept of ontology has been introduced into the field of artificial intelligence, knowledge engineering and library information science, so that the meaning of the ontology concept has been changed.[2] In these fields, ontology research is about knowledge representation and knowledge organization system. In the field of computer science and information science, the ontology is a formal, explicit and detailed description of the shared concept system in theory.[3] Furthermore, the ontology provides a shared vocabulary, which is the existing object type concepts, their properties and their relationships in a specific field.[4] In other words, the ontology is a special kind of term set, which has structured features, and is more suitable in the computer system.[5] The ontology is a formal representation of a set of concepts and their relations in a particular field. Furthermore, the ontology could be used to reasoning about the properties of the domain, and it could be used to define this field (that is, to model this field). [6]

3.REQUIREMENT OF DIESEL DOMAIN ONTOLOGY CONSTRUCTION

In recent years, the enterprise has carried on the exploration and research on knowledge management, standardized the diesel design process, refined the evaluation criteria, established the design process of diesel components, system and whole diesel, constructed a simple knowledge management system, which plays an important role in promoting the diesel development, but the main problems are:

1. Data scattered in different databases, which is not conducive to business development and knowledge reuse. With decade development and experience accumulation, the enterprise has formed a great deal of knowledge. The diesel product development involves extensive participation of different departments and professionals, hundreds of technical reports and a large number of professional models could be produced in the process of scientific research, the intermediate process data are countless, these data are scattered in different databases, with less access to reuse.

2. There is not a uniform standard for the diesel knowledge naming, which affects the query accuracy. For example, ‘electronic control system’ and ‘electronic management system’, ‘lower crankcase’ and ‘oil sump’ , ‘parameter’ and ‘characteristic’, ‘structural strength’ and ‘mechanical strength’, ‘document’ and ‘file’, ‘validation report’ and ‘demonstration report’, different names for the same knowledge may affect enterprise engineers’ knowledge query accuracy, so it is necessary to regulate the diesel knowledge naming.

3. The accuracy of diesel knowledge retrieval is relatively low. The existing data retrieval system has higher search efficiency for the search of diesel engine knowledge, but the accuracy of the retrieval is relatively lower, and the staff need to be screened from a great deal of knowledge to get the desired knowledge.

4. METHODOLOGY OF DIESEL DOMAIN ONTOLOGY PROCESS

First stage: determine the scope. To construct the diesel domain ontology is not the purpose, the purpose is to establish a specific field for sharing diesel domain knowledge, integrate heterogeneous data in different systems, retrieve semantic association information and so on many aspects.

Second stage: consider reuse. With the rapid popularization of the diesel data platform based on the ontology, the diesel domain ontology will be more widely used, and its main function is to solve the extensive sharing and reuse of the diesel research knowledge. [7]

Third stage: list the concepts. The main purpose of construction diesel domain ontology is to use the model to describe the concept in the field of diesel and relationship between them, so the definition of ontology is to list the non-structured tables of all related concepts that hope to appear in the diesel domain ontology. [8]

Fourth stage: define classification. After determining concepts in the diesel domain, these concepts are classified according to certain characteristics and standards to form a hierarchical structure, then it will used to describe the class and property relationship between different concepts.[9] Furthermore, concepts in the ontology are modularized processing. The definition of classification adopts the synthesis method, which is to define clear and definite concept, then sum up them appropriately upwards, or refine the description layer by layer downward, form a hierarchical structure finally.

Fifth stage: define property. This stage is interleaved with the define classification regularly. In the process of classifying some concepts into hierarchical structures, it is needed to establish the properties association of these classes. When the class is added properties, These properties of domain and range should be stated simultaneously. [10] During this process, The domain and range of statements need to be a compromise, on the one hand to give a general statement for class inheritance; on the other hand to narrow the limit as far as possible, which is helpful to detect the potential inconsistency and conceptual deviation in the ontology through checking the domain and range of violations.

Sixth stage: define facet. This stage stipulates their facet for the properties defined in the previous stage. Three types of facet are cardinality, certain value and relationship feature.

Seventh stage: coding and formalization. According to the construction purpose of the diesel domain ontology, the relationship between the expressive power and the reasoning ability is weighed, the appropriate ontology description language is used to encode and formalize the constructed ontology. [11] The model is formalized in a more standardized and rigorous format than the natural language, in order to enhance the understandability of the machine, the level of logical reasoning and inspection ability.

Eighth stage: define instances. The purpose of the ontology construction is to use the ontology to organize a collection of instances.

Ninth stage: perfection and evolution. In the process of diesel engine research, new knowledge have been produced, and the process of building the ontology is not linear, the above stages may be repeated, any stages in the process is likely to return to a certain stage in the early. [12] The aim of the ontology evolution is to adapt to the new diesel development environment, meet the demand of the new product design, these stages may be a process of continuous cycle.

5. CONSTRUCTION OF DIESEL DOMAIN ONTOLOGY MODEL FRAMEWORK

The diesel domain ontology construction focuses on the structure, considers the ontology construction from the perspective of product life cycle, the main principles to establish ontology are as follows:

1. As few ontology and combination as possible, the knowledge searching ability should be as accurate as possible, as shown in figure 1.

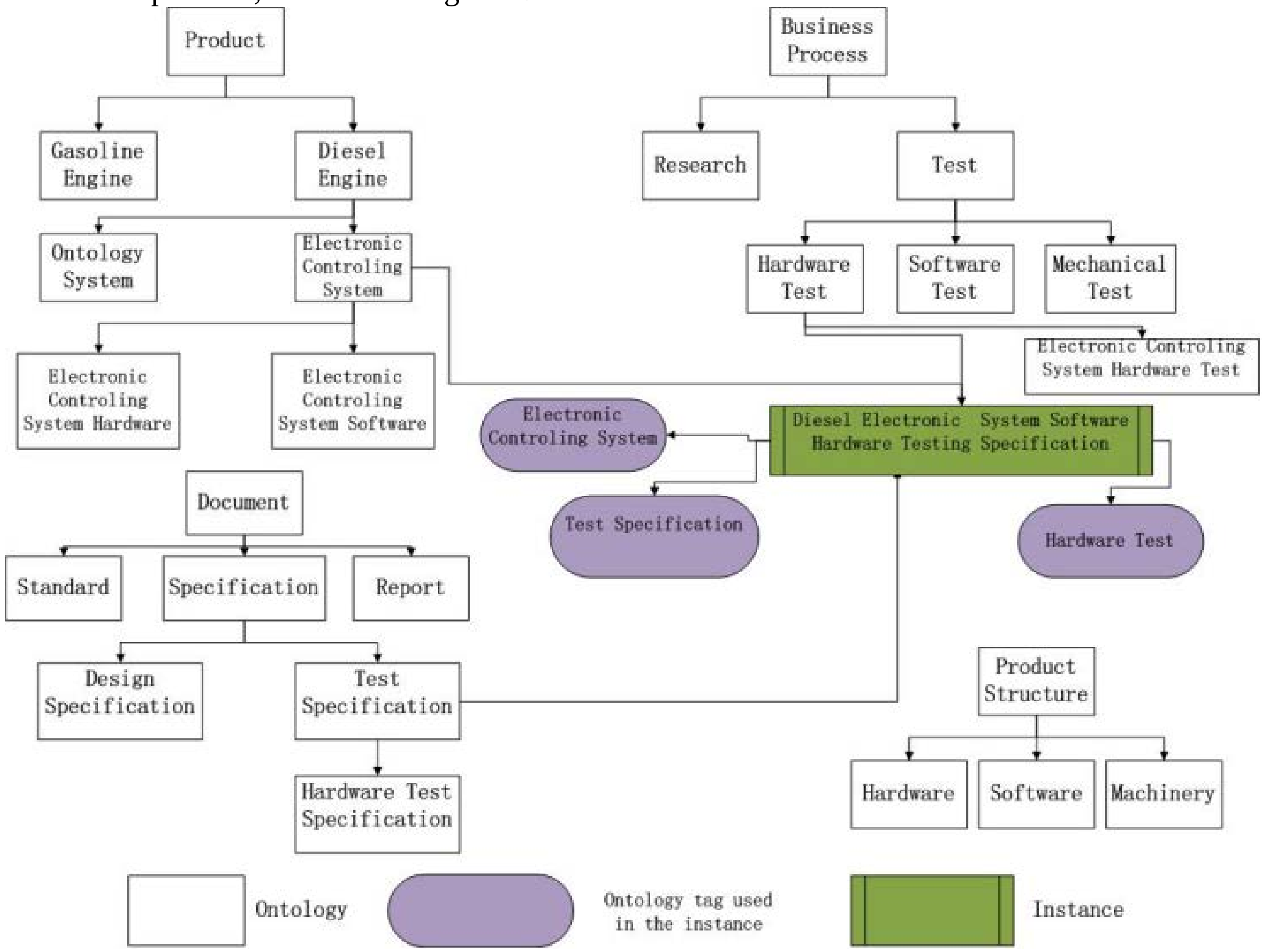

Figure 1 Example of ontology and relation.

For the knowledge instance 'diesel engine electronic control system hardware test specification', 'electronic control system', 'test specification' and 'hardware test' theses three ontologies could be used as the label description. Three labels are located in different ontology trees. Through Using the ontology and the combination for knowledge description as little as possible could simplify the complex ontology.

2. According to the nature of the ontology expansion could facilitate the inheritance of class parameters, as shown in figure 2.

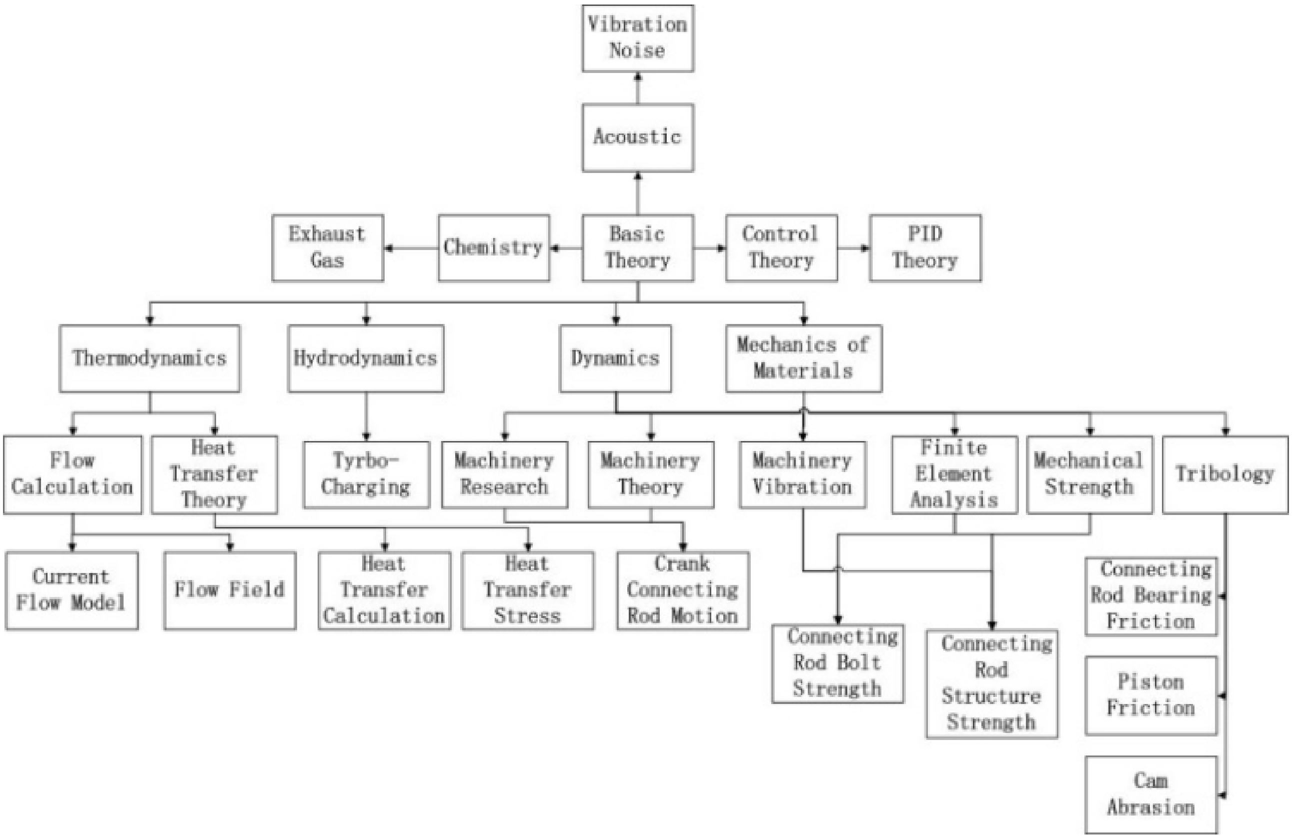

Figure2 Comparison of two kinds of ontology trees.

There are two different types of classification for the document ontology: document type classification and process characteristics classification. Among them, according to the expansion of document type layer by layer could facilitate the inheritance of class parameters.

3. If the instance of a subordinate's knowledge is less than three, it is not recommended to be an ontology term. According to this principle, complexity and workload of ontology construction could be reduced.

4. If the same object has multiple properties, for example, the part is also the universal part, when these properties are relatively more important, it may need archiving process, then constructs different ontologies for description, as shown in figure 3.

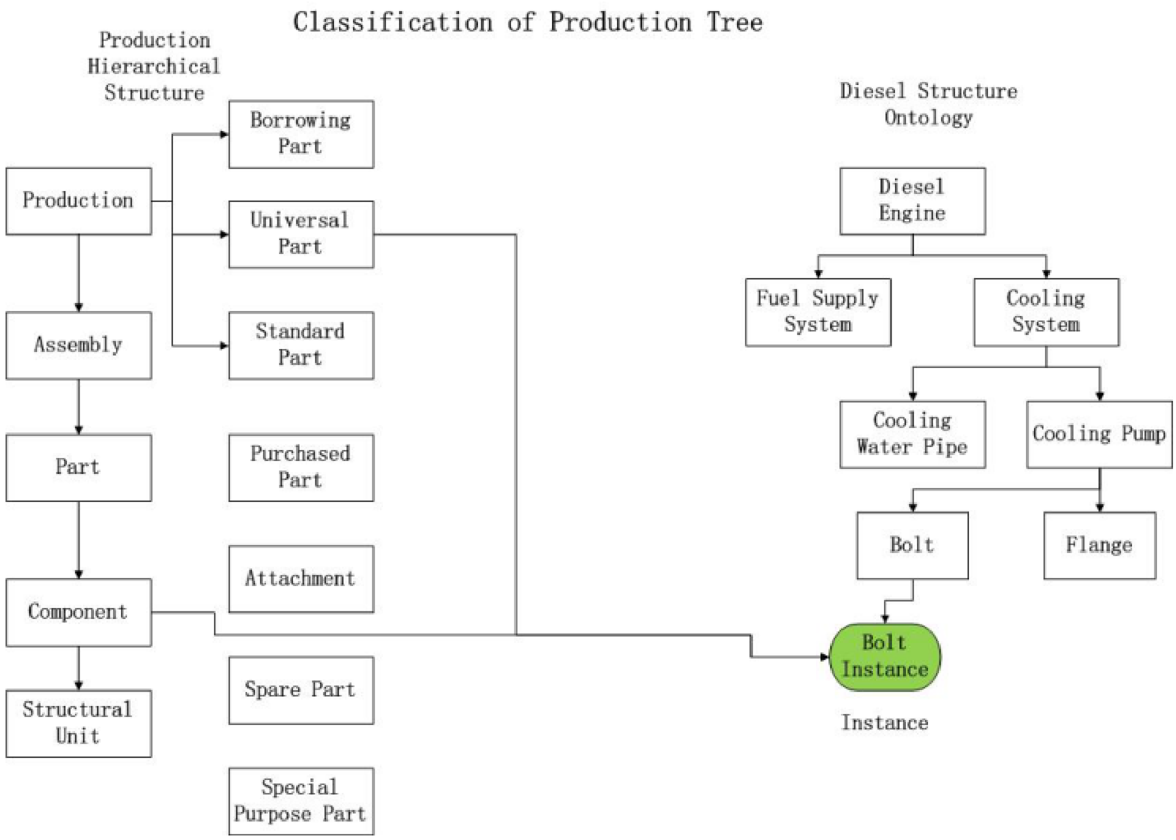

Figure3 Classification of the product ontology tree.

The product can be classified according to assembly, part, component and structural unit, it also could be divided into borrowing part, universal part, standard part and so on.

5. Support the overall search for association relationships, as shown in figure 4.

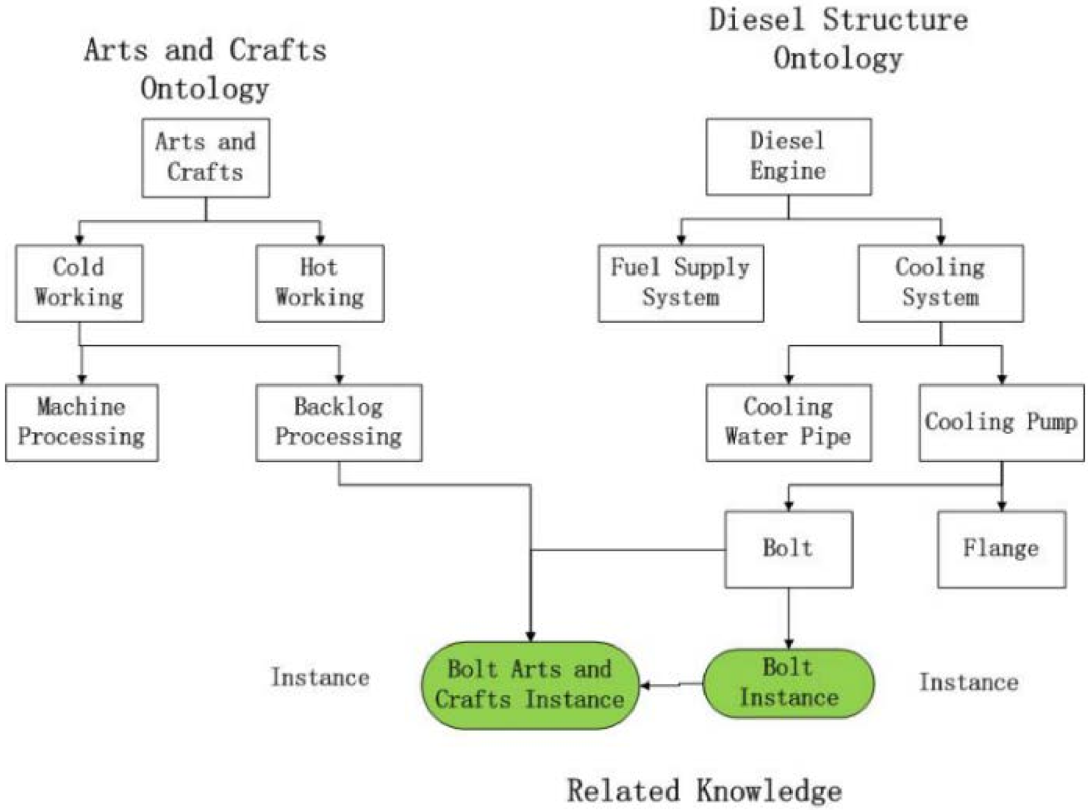

Figure4 Related knowledge.

The related knowledge searching is a feature of the ontology search, which could provide a structured search presentation to present various ontology relations of different knowledge instances and push knowledge instances of similar ontology relations.

6. The systematic principle of improving accuracy and completeness knowledge searching. To improve the accuracy and completeness of the knowledge searching is not entirely dependent on integrity and accuracy of the ontology, it is also related to the standardization of ontology application, timeliness and also initiative of ontology maintenance.

7. Using large-grained ontology for the establishment of knowledge network could contribute to quick and effective search. While the small-grained ontology is used to establish the semantic web for knowledge reasoning, as shown in figure 5.

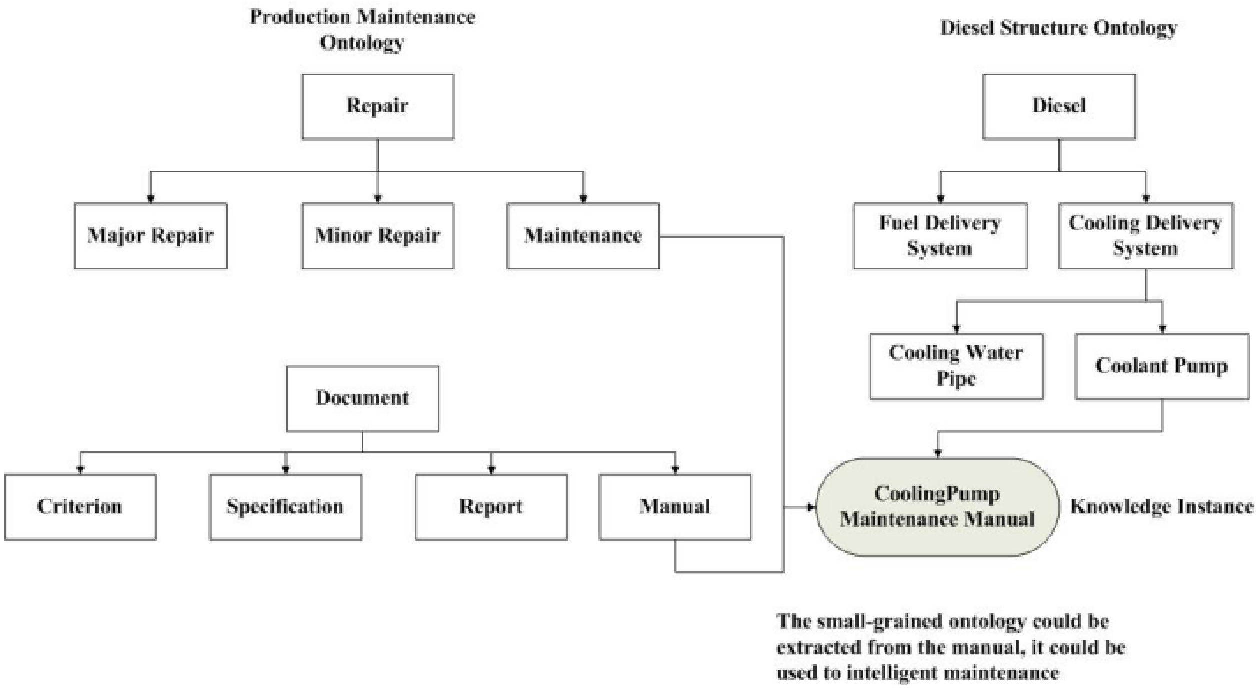

Figure5 Large-grained ontology searching.

The construction of diesel domain ontology model framework includes material ontology, testing ontology, failure maintenance ontology, professional ontology, documentation ontology, product hierarchy ontology and feature ontology for product components. The hierarchical relationship of each dimension is shown in figure 6.

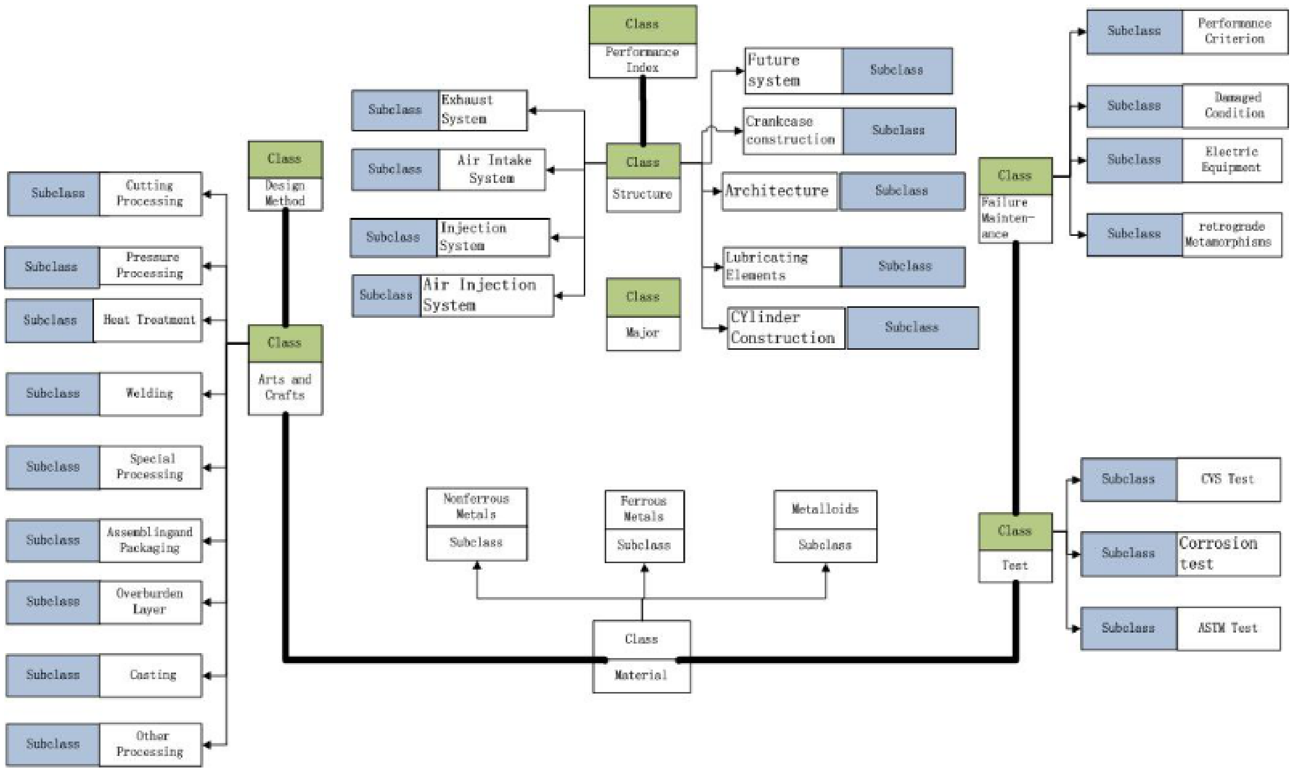

Figure 6 Frame of diesel ontology.

The diesel ontology property figure and relationship figure are shown in figure 7 and figure 8 respectively.

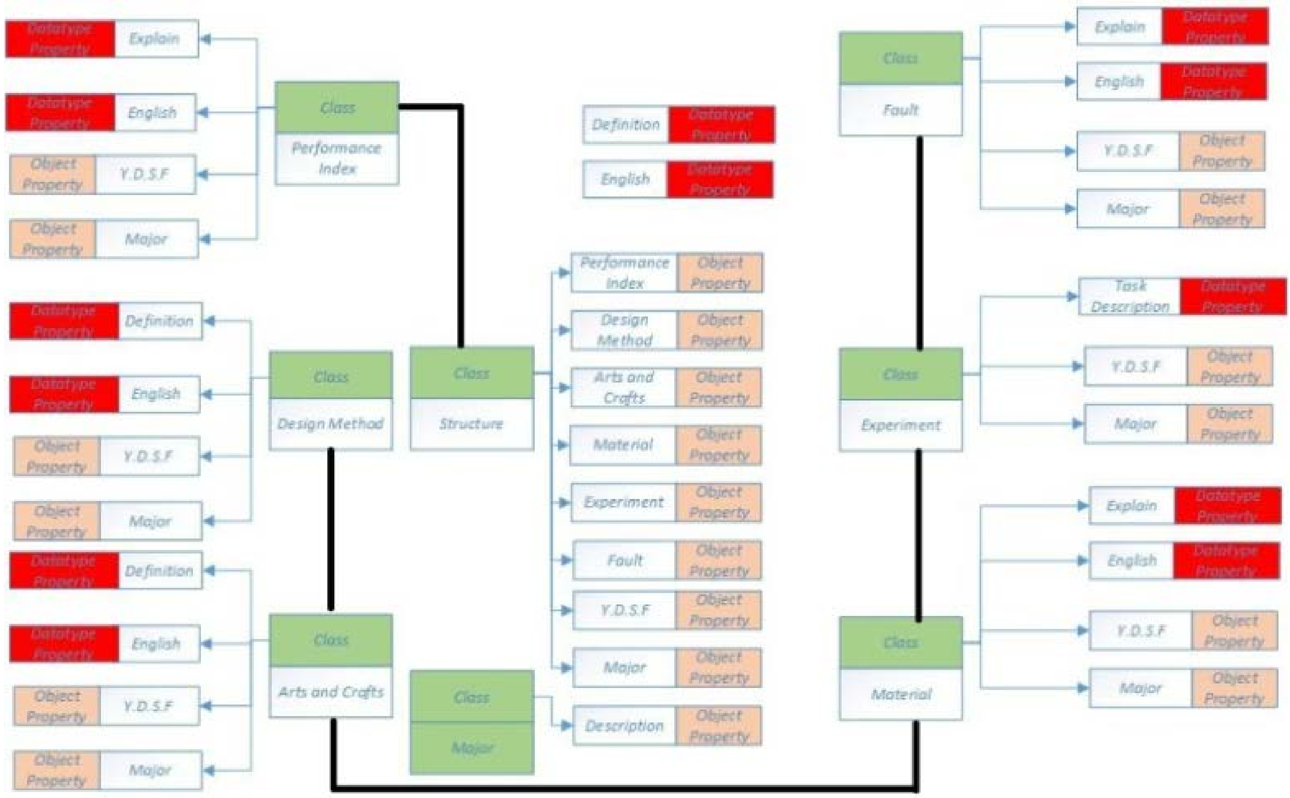

Figure 7 Frame of diesel ontology.

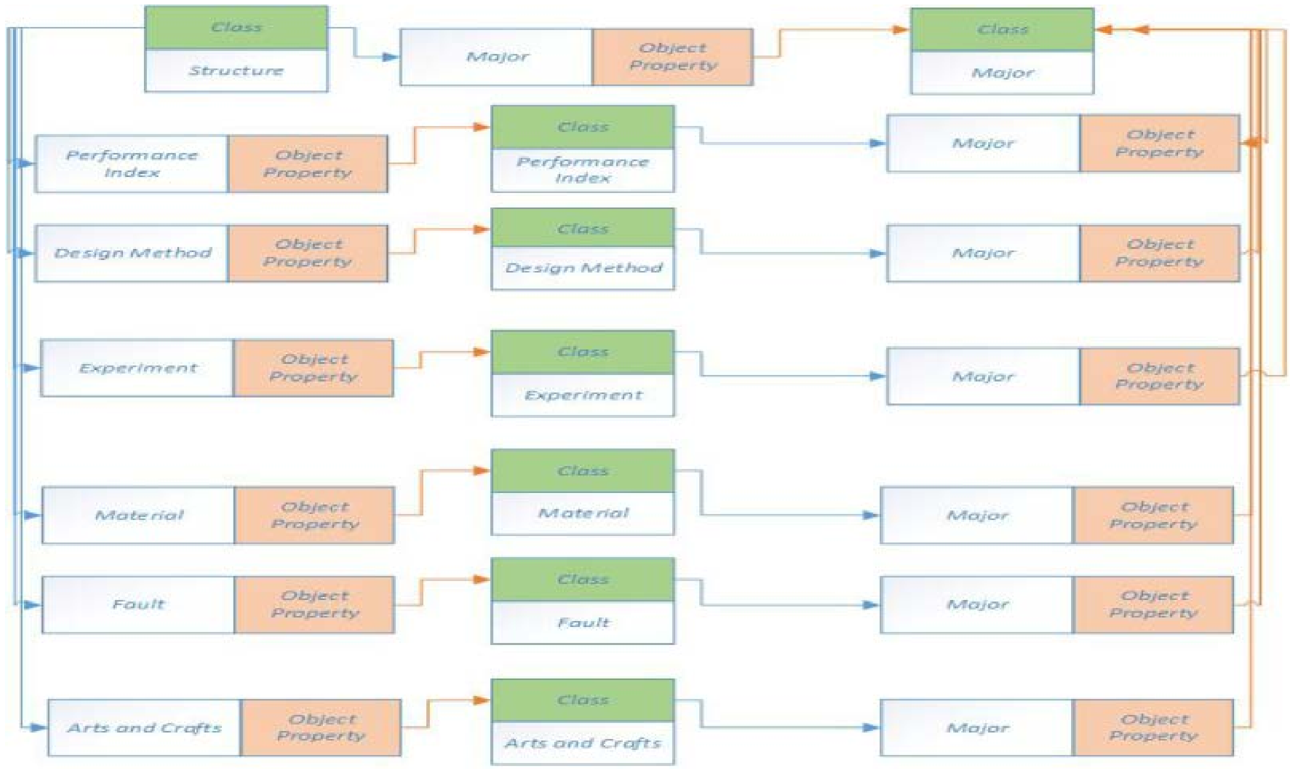

Figure 8 Frame of diesel ontology.

6. ONTOLOGY MODEL MANAGEMENT TOOL AND INTERFACE IMPLEMENTATION

The Jena ontology editing tool has used to develop diesel ontology management tools, it provides the diesel ontology online management function and features the ontology term machine association relation creation, modification and deletion function, which meets requirement of ontology management, achieves the function of diesel ontology library files' adding, deleting and setting ontology library file as a system file, which divided into diesel ontology library file management, diesel ontology library file modification log management and ontology library file creation and deletion management three components, the relative function is composed of createOntofileList class and OntoeditcenterAction class.

The Protégé-OWLAPI interface embedded into the diesel development environment could greatly promote the diesel knowledge acquisition and maintenance. The diesel ontology terminology service interface module provides knowledge ontology terminology and knowledge management system service docking function, [13] it realizes the searching push, terminology usage statistics and terminology update association synchronization functions based on the diesel ontology. Related functions could be implemented in the OntoKmsService class.[14]

7. CONCLUSION

The paper researched on the construction technology of the diesel domain ontology combined with enterprise's requirement, puts forward the ontology model framework of structure and professional knowledge ontology, preliminarily constructed ontology base on the whole diesel life cycle. The construction of ontology management tool and interface were applied in knowledge retrieval of the knowledge management system in order to make it generally or nationwide applicable.

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