A PBOM configuration and management method based on templates

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Abstract. The design of Process Bill of Materials (PBOM) holds a hinge position in the process of product development. The requirements of PBOM configuration design and management for complex products are analysed in this paper, which include the reuse technique of configuration procedure and urgent management need of huge quantity of product family PBOM data. Based on the analysis, the function framework of PBOM configuration and management has been established. Configuration templates and modules are defined in the framework to support the customization and the reuse of configuration process. The configuration process of a detection sensor PBOM is shown as an illustration case in the end. The rapid and agile PBOM configuration and management can be achieved utilizing template-based method, which has a vital significance to improve the development efficiency for complex products.

1. Introduction
Manufacturing process technique keeps an important position in modern manufacture industry, which is closely related to the process of design and fabricating. Bill of Materials (BOM) is regarded as the core of the organization of product information by many manufacturing enterprises. It is efficient to acquire, organize and apply various data and information of products from BOM. PBOM connects Engineering Bill of Materials (EBOM) and Manufacturing Bill of Materials (MBOM). And it can be converted from EBOM and then converted to MBOM[1-4].

The configuration method is a reasonable combination process to meet the individual needs of customers[5]. Researches on product configuration methods have been carried out widely and deeply, including product configuration methods based on feature matching, instances-based product configuration methods, and rule-based product configuration methods and so on[6]. Feature matching based method realizes the product configuration scheme to meet feature requirements of customers, in which main structure of component information is established[7]. The approach of configuration cases retrieval, matching, and adjustment are used to obtain the solution to meet the demand in the process of instance-based product configuration method[8]. Rule-based product configuration method can make logic explicit, which is widely used in knowledge expression field[9]. In order to improve the reusability of the configuration design, the process description and configuration management have become popular research points. Product configuration template that can be constructed by functional module units is able to effectively support the management of configuration process[10].

Currently the research of product configuration management is mainly focused on the classification of configuration modules, the expression of configuration rules and methods of results evaluation. The PBOM configuration and management method based on templates is described in the perspective of customization in this paper.
Nowadays, market demand is diversified, personalized and uncertain. It is increasingly becoming the pursuit goal for enterprises to respond to market demand with the shortest time of product development and the lowest cost. PBOM plays an important role in the process of product development. As product family, especially complex product family needs to be constantly varied and updated. The original PBOM cannot meet the requirements easily, thus it is necessary to redesign the PBOM. In order to reuse the original PBOM resources, improve the efficiency of design and development, and implement the rapid generation of PBOM, the configuration method aimed at PBOM reconstitution can be utilized and mined. On this basis, the configuration and management implementation technology of complex products is researched.

In order to achieve rapid and effective allocation, new requirements are added to the description of the configuration process and configuration object, including:

(a) Highly reusable configuration process. Some components have strict process specification. Therefore, the standard process design flow could be reusable.

(b) Simplified and time-saving configuration process. The configuration process requires simplification. Meanwhile existing instances data, related standards, and specifications need to be fully utilized.

(c) Efficient management of huge data. The quantity of complex products, accumulated instances, and product family PBOM is enormous, and the constraints between configuration objects become more and more complex, which makes configuration become a heavy engineering.

On account of the requirements of PBOM configuration and management mentioned above for complex product, it is significant to structure a configuration and management function system which plunk for PBOM configuration solving, configuration process reuse and configuration process easy implementation to support PBOM design, accumulation and achievement application.

2. PBOM configuration and management method

According to PBOM configuration requirements for complex products, the configuration method of data view based on product process structure is adopted. Existing PBOM data and manufacturing process knowledge are managed and organized in this method to accomplish PBOM instance structure quickly and accurately.

2.1. A PBOM configuration and management framework

To meet the requirements of complex product PBOM configuration and management, the configuration management system of PBOM has been set up from the view of PBOM related information management and configuration procedure management. PBOM instance information, standard process parameters and configuration design procedure are organically combined in the framework.

As shown in Figure 1, configuration and management framework consists of PBOM configuration process management and configuration database management. Configuration process management mainly involves requirement features, configuration customization, configuration execution and configuration results management.

(i) Requirement features

Requirement features describe a technical parameter and/or a design essential factor of the product. They are associated with the nodes of the PBOM and act as entry parameters for the product or component PBOM configuration process.

(ii) Configuration customization

To make configuration process and data possessing controllability and reusability, configuration template is established to apply to configuration process, and data definition is actualized in the template.

(iii) Configuration execution

In this step, existing PBOM instance property parameters, standard process parameters and configuration rules are extracted from the configuring base database so as to determine the allocation of configuration process parameters, and ultimately to obtain new PBOM configuration instances.
Configuration execution is composed of a series of ordered configuration activities, and the order of activities is defined in the configuration template and configuration module.

(iv) Configuration results

As the result of configuration process, PBOM structure is managed through a unified defined BOM view. PBOM structure consists of assemblies, subassemblies, machined parts, process parts, dummy parts, fixtures, moulds and etcetera, which are generated by configuration. Newly generated process components due to requirement change are managed through creating BOM view version.

(v) Configuration database

The configuration database is the basic data source that supports the configuration process. The database provides configuration object information and configuration rules constraints for configuration process. It mainly includes requirement feature database, PBOM instance database, standard process parameters database, etc.

2.2. PBOM configuration template construction

The purpose of template customization is to make a unified description of configuration object and configuration process, including configuration procedure and procedure nodes. Configuration template is an abstract expression of associated set of configuration activities. Configuration activities take configuration modules as base operation objects, and configuration template is structured through combination and association among different modules.

2.2.1. Configuration template definition.

Template is a form of business process model, which contains data association and activity methods. And it is the foundation of business process definition and management. PBOM configure template is an abstract description of the configuration process, where configuration modules are associated and connected according to the configuration precedence order. It can be represented as following tuple:

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\text{PBOMCT} = \{\text{Attributes, Modules, Process, Constrains}\}, \text{in which}
\]

\text{Attributes} is a set of properties which describes configuration process. Such as the ID of PBOM, name, etc.

\text{Modules} describes the configuration objects and is the nodes in the configuration template. Module defines the information of configurable component object, such as assembly, subassembly, machined part, process part, dummy part, fixture, mould, process parameters, rules, etc.

\text{Process} represents the relations between configuration process, organizations, resources, and activities.

\text{Constrains} describes the constraint relations of configuration object, such as prodromic, subsequent and mutex relationship.

As shown in Figure 2, PBOM function model consists of assembly hierarchy relationships between parts, components, fixtures, moulds and so on. Activity process model describes the precedence relationships between activities that implement product process design and configuration. Process features and hierarchical relationships of products or components drive the generation of activity process. The activity is aimed at the realization of the product process. As to the business configuration procedure of PBOM in product development process, configuration templates are relational integration of product structure, component process information and configuration process activities. Template construction is the realization of data mapping and process mapping. Different combinations of parts and components are produced through the collocation of templates, modules and submodules in the PBOM configuration template structure according to certain configuration rules. And the PBOM configuration template is a dynamic structure, so as to express serialized PBOM of product through version management.

2.2.2. Configuration module construction.

Configuration module is the node in the configuration template. It is a structural unit with interchangeability, versatility, independent structure, specific function and standard interface[11]. The
configuration module is a classification module for the PBOM configuration. And configuration module is a composable object that can be configured as a single entity. The module has the function to centrally organize and manage process components, fixtures, moulds, and other process information in the configuration process.

First of all, it is necessary for configuration module to be provided with the configurability of process components of product family in the configuration process. As the functional and structural unit of modular configuration, module is characterized with low coupling and high cohesion. In the process of configuration and management of PBOM, configuration template corresponds to the whole PBOM, and configuration module corresponds to the decomposed PBOM combination, such as components, fixtures, moulds and standard process parameters. And module can further be decomposed into sub-modules.

The information model of configuration module is established as shown in Figure 3 in order to make a further description of the relationship between the relevant information that constitutes the configuration module. The model is centered on the PBOM configuration module class, and associated with configuration process components class, configuration fixture and mould class, and configuration process parameters class. The PBOM correlation class has the unified definition of BOM view to make it easy to manage PBOM process and results. Association class is used to represent the relationship between configuration modules, and to express prodromic and subsequent module object in the definition process of configuration template.

When a variety of market demand appear or market demand changes rapidly, module classification focuses on fast variant design. If the requirements are modified, functional modules that are associated with requirements also need to be varied. However, the original loosely coupled modules should be retained as much as possible. Classification and decomposition is actualized from top to bottom according to product functionality structure and meanwhile functional modules keep independent. The constraint relation between configuration modules should be maintained as little as possible in module construction phase.

An inspection sensor is used as an example to build the configuration template in this paper. The directional graph representation of the configuration template of the sensor is presented as shown in Figure 4. The different nodes correspond to the configuration module of process parts and assembly in the directional graph. The information of configuration process parts, components and process parameters is defined in the module. This PBOM configuration process improves the development efficiency of the inspection sensor.

3. Conclusion
Based on the demand analysis about complex products, the system for PBOM configuration and management has been established. Configuration templates and modules are defined in the framework to support customization and reuse of configuration process. The PBOM configuration of an inspection sensor is shown as an illustration case. The rapid and agile configuration and management of PBOM can be achieved by utilizing this template-based method, which has a vital significance to improve the development efficiency of complex products.

References
[1] Guo J F, Qiao L H and Liu W A 2005 Comput. Integra. Manuf. Sys. 11 1301-06
[2] Lee J H, Kim S H and Lee K 2012 Comput-Aided. Des. 44 253-73
[3] Liu X B, Huang X W, Ma Y, Meng Q N and Meng Y Y 2002 Comput. Integra. Manuf. Sys. 8 983-87
[4] Chung Y K and Fischer G W 1994 Computers. Ind. Engng. 26 321-39
[5] Brown D C 1998 Ai. Edam. 12 301-05
[6] Lu H, Yue T, Ali S and Zhang L 2016 Inform. Software. Tech. 72 68-89
[7] Schuh G, Rudolf S and Riesener M 2014 Procedia CIRP. 17 290-95
[8] Tseng H E, Chang C C and Chang S H 2005 Expert. Syst. Appl. 29 913-25
[9] Zhang J S 2006 J. Huazhong. Univ. Sci. Techno. : Nat. Sci. Ed. 34 108-10
[10] Zhou C J and Lin Z H 2007 Comput. Integra. Manuf. Sys. 13 845-49, 876
[11] Qi Z Y, Wang J Z and Han X M 2007 Chin. J. Mech. Eng. 43 87-94

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