A Model for Components Library Based on Multi-level Assemblies and Parts Family

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***Abstract*—Parts (and components) family is presented to realize another information expression method for the tabular layouts of article characteristics, and given a uniform and formal definition, including the template model, the attribute set and the family member. The principles and methods of grading to construct components family is discussed, which components, sub-assembly and parts are described with associated attributes in their respective levels. The links between components, sub-assembly and parts are established through member attribute, reducing attributes number of components and subassembly, reusing parts library, and achieving efficiently for building components library. For an example, the reuse library of die-stamping components is established for the mold design.**

***Keywords*—parts family, component library, design reuse, product design, die sets component**

I. INTRODUCTION

In mechanical product design, designers usually reuse a large number of standard parts and commonly used typical structures accumulated in long-term industry design practice, which have the same function, and similar geometry structure for assembly, parts, and features. The advantages of using these items are that in general they are far more cost effective, and reusable components can effectively shorten product design and manufacturing cycles, and improving maintenance of their products [1]. Therefore, the great significance for researching on reusable components is to support a rapid product innovation design [2,3].

The standard component information is still delivered to designers in the form of printed catalogues. Other advanced methods include the 'electronic catalogue' for standards information stored in CD-ROM [4] and standards information passed on at a web-based system visited by designers [5]. But all these are not easy to computerize standard part data and subsequently make it available for use and reuse. Data that appear in catalogues and web site are frequently not in the format that is most suitable for handling in a system [6].

Although at part level, the development and application of 3-dimension standard library achieves better results, but the reuse for 3-dimension standard and commonly used typical structures components has always been a barrier in product design practice. This paper researches reusable 3-dimension components, which have the same function, the same or similar geometry, and serialized parameters.

II. BACKGROUND

A. Tabular layouts of article characteristics technology

For the function of the same description, the same or similar geometry, and parameters serialized components families, tabular layouts of article characteristics [7] can be used to simply and efficiently express components family information. In the different levels of the products, tabular layouts of article characteristics are used to characterize different information. As in parts level, it describes the geometric characteristics of parts families, and in the components level, it describes constituent parts objects and it's positioning points in the components assembly.

Tabular layouts of article characteristics will not directly drive components 3D model. For building the mapping between tabular layouts and dimension variable parameters, features, and other characteristics of the 3D model, the specialized software interface needs to be developed. This leads to restrict the application of the method in companies.

B. Feature-based parametric 3D-CAD modeling system

Feature-based parametric modeling is the most widely used modeling method in mainstream 3D-CAD modeling system. It is a combination of the feature-based and parametric-based modeling methods. The feature-based parametric modeling approach modularizes the geometrical modeling and makes it easier and more intuitive to make use of existing 3D models and to modify them. It largely facilitates the process of detailed design reuse; for example, to generate a new detailed design based on some existing designs, a user simply needs to decide which features to add or remove and which parameters to alter. The solid modeler [8] will then generate a solid model for the new design.

Currently, the CAD system is mainly handling geometric model. Standard components families have similar geometrical structures (assembly, parts and features), 3D geometrical templates can be modeled for the standard components families. The CAD system will generate a case model for each member of the standard components families.

However, the feature-based parametric modeling approach is not directly implemented in the system as described above. It is combined with the concept of 'parts (and components) family' to facilitate further reuse and data management.

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III. REUSE MODELING OF COMPONENTS ON MULTI-LEVEL ASSEMBLIES AND PARTS FAMILY

A. Definition of parts family

Definition 1 A model template is also known as a master model of parametric-based and feature-based solid modeling. The model template is constructed in such a way that a family of parts (and components) can be built based on it.

Definition 2 An attribute set for the parts (and components) family created from the model template describes the various attributes of the model template (master model).

Parts and components have different attributes. In parts level, the attribute set is described as: (coding, name, main parameters, constrain parameters, features, material, ...). Coding describes the only logo features for the case model, the coding can adopt the method of classification code, can also adopt that of sequence code, or a combination of both.

Main parameters and constraints parameters are dimension variables of the template model. Main parameters are that of ruling the model, and constrain parameters selected after having the main parameters are that of subordinate to the model. It needs to be pointed out that in the template model there is also a category of derived parameters, which is defined in the template model through the function of main parameters and constraint parameters. Such derived parameters do not need to be defined in the attribute set.

The model template is constructed in such a way that a family of parts can be built based on it. The value for a feature attribute is either yes or no, indicating whether the feature is included or excluded in the member product. The feature attributes make it is possible that the similar parts, but not the same one can be expressed uniformly. The material attribute describes parts materials.

In components level, the attribute set is described as: (coding, main parameters, constraint parameters, members, features, …). Members may be parts or components, and its values are a member coding or a member model name, which is uniqueness.

For parts and components, the attribute set is uniformly described as: (coding, main parameters, (constrain parameters), (features), (members), (material),…) , where, attributes in parenthesis are optional according to the product structure.

Definition 3 A family member is a group values checked and assigned to a set of the family attributes, including the member name conferred by the attribute values to drive the template model. Two points should be noted: First, a group values assigned to a set of the family attributes should be checked to produce a legal member; Second, multi group legal values assigned to a set of the family attributes can produce multi members.

The attribute set and the family members make up of a data table, which is called the family table. Each column heading of the family table is a member of the attribute set, including coding, name, dimension variables parameters, features, members, and material property, etc. The values for the corresponding column heading attribute make up of a column of the family table. Rows of the family table include values for coding, name, and other attribute of the family members. Family members are created from, and associated with a model template and its family table. The family table describes the various attributes of the template model that you can change when you create a family member.

Definition 4 Parts (and components) family includes the template model, the set of the family attributes, and family member cases. Family members could be produce by the family table to drive the template model.

Parts and components family can be uniformly, formally expressed by Backus-Naur Form (BNF):

PF :: = 〈PM〉 〈FT〉

〈PM〉 :: = 〈3D〉 〈2D〉

〈FT〉 :: = 〈PA〉 〈PL〉

〈PA〉 :: = 〈ID〉 〈NAME〉 〈DIM〉 { 〈FEA〉 } { 〈MEMBER〉 }{ 〈MATERIAL〉 }…

〈 PL 〉 :: = 〈 VALUE_ID 〉 〈 VALUE_NAME 〉 〈 VALUE_DIM 〉 [〈 VALUE_FEA 〉] [〈VALUE_MEMBER〉] [〈VALUE_MATERIAL〉]…

Here, PF-parts or components family, PM-the template model, FT-the family table; 3D-3D modeling, 2D-2D modeling; PA-the attribute set, PL-the family member; ID-the coding, NAME-the name for the family member modeling, DIM-dimension variables, FEA-features, MEMBER- parts or components, and its values are a member coding or a member model name, MATERIAL- parts materials, where, attributes in braces are optional according to the product structure. VALUE_ID, VALUE_NAME, VALUE_DIM, VALUE_FEA, VALUE_MEMBER, and VALUE_MATERIAL, etc. are illegal values for ID, NAME, DIM, FEA, MEMBER, and MATERIAL, etc., where, the values for attributes in brackets are optional.

Figure 1 show a model for parts library based on parts family, which is described with the template model (Part_temp_model), the attribute set (Part_attri), and the family members (Part_member). The attribute set is defined by the attribute of the template model. A family member is produced through the values assigned to the attribute set to drive the template model.

For components library, if treating it as parts library, the components family table is built for parameterized dimension variables, feature, etc. and the attribute values are used to drive directly the components template model to produce the family member, but it exists the follow shortages.

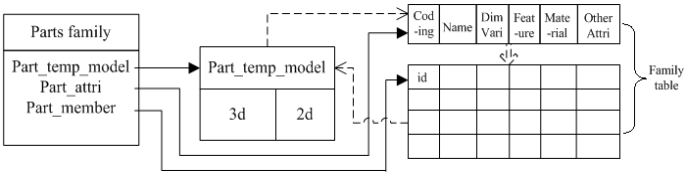

Figure 1. A model for parts lib based on parts family

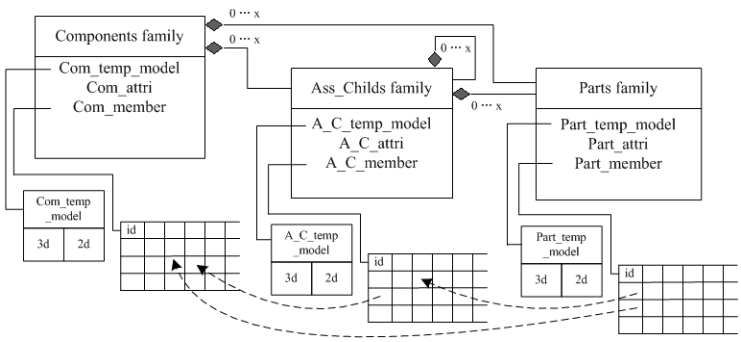

Figure 2. A model for components lib based on multi-level assemblies and parts family

1) Too many components variables attributes

The number of components dimension variables and features increase rapidly with the increase in the number of constitute parts for components. Too many variables attributes make too many columns in the family table, making it difficult to manage, and do not facilitate the establishment of the parameters library for the components;

2) Unable to reuse the parameters library of parts

Components variable attributes are mainly extracted from parts variable attributes. For the different components, each attribute variables need to be summarized and to establish the corresponding family table, which make unable to reuse the parameters library of parts. Building the family table for components, including parts, sub-assembly and components attribute modeling, is work hard, and the quality of building library is not guaranteed.

In this paper, member attribute encapsulating information of next level sub-assembly and parts is introduced to establish the multi-level components library.

B. Building components library based on multi-level assemblies and parts family

Component is made up of subassembly and parts, and subassembly is made up of sub-subassembly and parts, there is a recursive relationship between components, subassembly, and parts. Component, subassembly, and parts being similar structure can be generated from its family template model. Therefore, respectively building the component family, sub-assembly family and parts family is also to establish each corresponding template model, and the family table. But the attribute set of the components and subassembly includes only the next level member attribute, and other attributes for the next level of subassembly and parts are described in themselves, and so recurring expression like this until to the last nodes, parts. In other words, the member attributes encapsulate their own information, and through member attributes to achieve hierarchical model-driven.

Figure 2 show a model for components library based on multi-level assemblies and parts family. Components family, sub-assemblies family, and parts family is made up of the template model, the attribute set, and the family members. The template model for Components family and sub-assembly family is the assembly model. The attribute set for components, sub-assembly and parts family is defined in the template model, but the attribute set for components and subassembly family includes the member attribute, which is different from the attribute set for the parts family. The values for components and subassembly family members attribute is the coding or the name, which composites the components library based on multi-level assemblies and parts family.

The method of building the components library based on multi-level assemblies and parts family is that describing their own level associated attributes for components, sub-assembly, and parts, but establishing contacts through the member properties, therefore it reduces the attribute variable numbers for components, sub-assembly, and reuses the parts library, so it efficiently builds the components library. The building steps for the components library:

Step1: Building the parts library

Analyzing the tabular layouts of article characteristics for parts, to establish the template model(Part_temp_model) and the family table (Part_attri) formed with the attribute set and the family members, the family member should be checked.

Step2: Building the subassembly library

To establish the template model for the subassembly (A_C_temp_model) and the family table formed with the attribute set (A_C_attri) and the family members (A_C_member), the family member should be checked. The attributes set for the subassembly family is composed by its coding (A_C_id), the codes for the next level subassembly (A_NC_id), and the codes for the next level parts (Part_id). The A_C_id, the A_NC_id, and the Part_id respectively and uniquely describe the subassembly, the next level sub-subassembly, and parts, encapsulating other variable attributes for the subassembly, the next level sub-subassembly, and parts. If the component is composed of parts, the step is omitted.

Step3: Building the components library

Similar to building the subassembly library, to establish the template model for the components (Com_temp_model) and the family table formed with the attribute set (Com_attri) and the family members (Com_member), the family member should be checked. The attributes set for the components family is composed by its coding (Com_id), the codes for its subassembly (A_C_id), and the codes for its constituting parts (Part_id).

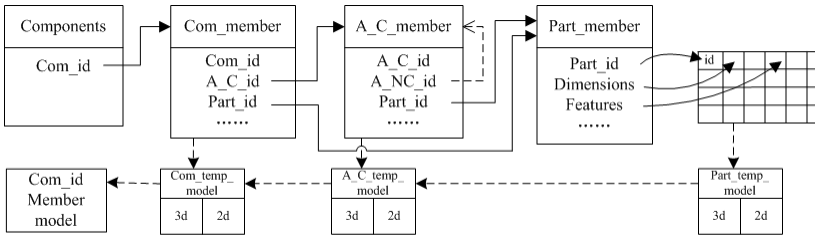

Figure 3. A model for reuse of components using linklist data structure and the template models

DB_PART_NO	OS_PART_NAME	DIE BOUND	CLOSED HEIG	SHANGMOZUO	XIAMOZUO	AXINGDAOZHU_1	AXINGDAOZHU_2	AXINGDAOTAO_1	AXINGDAOTAO_2	STANDARD
110309001	DJMJ63_50_110-130	63*50	110-130	SMZ63_50_25	XMZ63_50_30	A16_100	A18_100	A16_65_23	A18_65_23	GB-T2851.1-90
110309002	DJMJ125_100_140-170	125*100	140-170	SMZ125_100_35	XMZ125_100_45	A22_130	A25_130	A22_80_33	A25_80_33	GB-T2851.1-90
110309003	DJMJ200_160_160-200	200*160	160-200	SMZ200_160_40	XMZ200_160_45	A28_150	A32_150	A28_100_38	A32_100_38	GB-T2851.1-90

Figure 4. The template model and the family table for the combination diagonal pin type die set

Figure 3 show a model for reuse of components, which gets a component member in accordance with the Com_id. A component member is produced using linklist data structure from top to bottom to transfer the member information. The Com_id is an identifier for the component, to query the Com_member with the Com_id can obtain the A_C_id for its subassembly and the Part_id for its constitute parts. Then, to query the A_C_member with the A_C_id can obtain the A_NC_id for its subassembly and the Part_id for its constitute parts, and then to do the same enquiry with the A_NC_id like with the A_C_id, its essence for the enquiry is a recursive query operation until obtaining the Part_id. Finally, to query the Part_member with the Part_id can obtain other attribute values for a part member.

The model of the components member is generated from the model of the parts member, the model of the sub-assembly member, to the model of the components member. First, the model of the parts member is generated by the attribute values for the Part_id member to drive the template model for the parts. Then, the model of the sub-assembly member is generated by the attribute values for the A_C_id member to drive the template model for the sub-assembly. Finally, the model of the components member is generated by the attribute values for the Com_id member to drive the template model for the components.

IV. A CASE STUDY

Die sets is commonly used standard components in die design. The reusable library for the combination diagonal pin type die set (GB/T2851.1-90) is established with the above methods. A combination diagonal pin type die set is made up of six parts for four parts family, which are One upper shoe, one die shoe, two guide pillars, two guide pin bushing.

In UG NX4.0 environment, this paper establishes the template model and the family table for the combination diagonal pin type die set. The upper shoe table leader attributes include 9 dimensions variables, coding, name, the die boundary, material, and the standard name, etc. The die shoe table leader attributes include 11 dimensions variables, coding, name, the die boundary, material, and the standard name, etc. The type A guide pillars family table leader attributes include 2 dimensions variables, material, and manufacturing precision etc. The guide pin bushing family table leader attributes include 7 dimensions variables, 1 feature variable, material, manufacturing precision, and the standard name, etc..

Figure 4 show the template model and the family table for the combination diagonal pin type die set. The table leader attributes include 6 members, the die boundary, shut height, etc. The values for the members attribute are relevant the family member names, two guide pillars are one parts family, but not the same part, the two guide pin bushing is also.

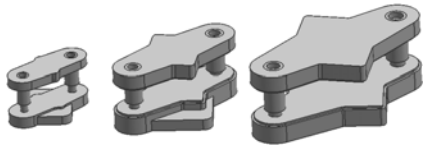

Figure 5. Series 3D model for the combination diagonal pin type die set

Figure 5 show series 3D model for the combination diagonal pin type die set with the method of components family.

V. CONCLUSIONS

(1) Research on reusable standard components is of great significance to support rapid product design.

(2) Parts (and components) family is another method for parts (and components) information expression. It is combined with the concept of 'parts (and components) family' to facilitate further reuse and data management.

(3) The method of building the components library based on multi-level assemblies and parts family is describing their own level associated attributes, but establishing contacts through the member properties, therefore it reduces the attribute numbers for components, sub-assembly, and reuses the parts library, so it efficiently builds the components library.

(4) The reusable library for the combination diagonal pin type die set is established, which explains that the method of constructing component library is highly efficient.

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