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# Mechanical Product Collaborative Design and Examples Expression Based on the Hierarchy Design

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Based on the mechanical characteristics of product information from life cycle, we analysis the hierarchy structure of the three-dimensional the decomposition product composition information. Information describing the object, and then build three-dimensional mechanical product lifecycle unified information model. While the full expression of the product life cycle of information, there is no redundancy and cross information while a hierarchy of information makes analysis of information more convenient and effective. The establishment of a central view of product lifecycle information models body. According to the three dimensions of products were selected to describe the typical information object establish the appropriate ontology model. To achieve a comprehensive information and mechanical products to describe the relationship, particularly the expression of fine granularity mechanical products to the functional surface for subsequent knowledge discovery and reuse of the foundation.

## 1. Introduction

Mechanical design is based on the requirements of mechanical operating principle, structure, movement, power and energy transmission means (Porter, 2005). Materials and geometry of the various parts, lubrication methods was conceived, analyzed and calculated, and translate them into specific description as a basis for manufacture of the working process (Komoto, 2012). The goal is defined in a variety of conditions to design the best machinery (Chandrasegaran and Gao, 2013). Product design theory and method through research and development of a century, it has been developed from experience-based design pattern is based on scientific principles and knowledge-based design patterns, and the emergence of the theory and methodology of product design has a guiding role (Balog, 2007).

Currently, about mechanical product design patterns has remained mostly limited sharing of resources, designing the physical environment of space limitations (Sun and He, 2013). It can not effectively achieve synergies and designers share geographically dispersed design resources between (Szekely, 2014). It is based on the information needs of design objects lifecycle by certain information exchange, knowledge sharing and collaboration mechanisms with each other to complete the whole process of design goals cooperatively (Zhang, 2016). Based on collaborative product design environment, product information sharing and exchange, discussion, examination results and modify the design of the design, in order to improve design efficiency and shorten the design cycle, and enhance the competitiveness of the target product (Oman and Hatcher, 2013).

With the development of manufacturing and application of information technology, enterprises have accumulated a large amount of historical data products. But the applied product data management system PDM / PLM, based on the composition of the product structure information for the core of the organization, namely products, components, parts organize product information. Thus, breaking the company's existing information objects, depth of product information integration, ontology-based knowledge representation, establish mechanical product lifecycle unified repository of information, and build mechanical product design hierarchy in this case base based on the study of mechanical product design retrieval and modification technologies instance, provides mechanical product design process is the most powerful knowledge support, machinery manufacturing enterprises to achieve a fast, innovative design, thereby enhancing the core competitiveness of enterprises.

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## 2. The related theory and method

### 2.1 Lifecycle information of machinery products

Content needs analysis phase of product information and analysis techniques are closely related to the present stage (Li, 2012). QFD (Quality Function Deployment) and HoQ (House of Quality, quality house in its analysis of the advantages of the design to ensure that products meet the design needs, and is widely used in the requirements analysis phase. QFD includes three models: the Comprehensive QFD mode, ASI (American suppliers Association) mode and the target / product quality characteristics (goal / product Quality Characteristic / OAL / QPC) mode. Typical house of quality composition was shown in Figure 1.

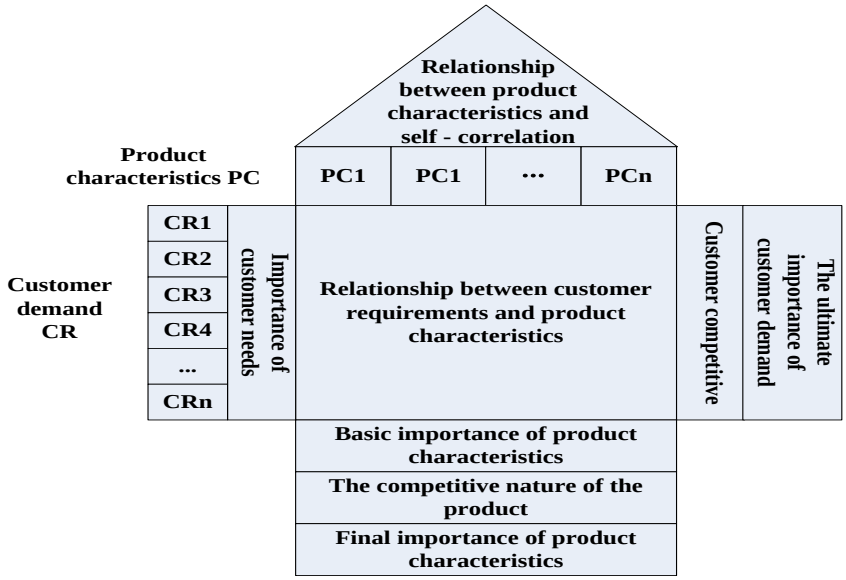


*Figure 1: A typical composition of the house of quality*

### 2.2 Product collaborative design

Conceptual model of collaborative design is a collaborative product design process of abstraction and generalization (Du, 2014). It describes the dependencies of design objects, design, and design environment of collaborative design process (Qingsong, 2012). Constituent elements of collaborative product design concept model relates to the organization and management of collaborative design process management capabilities, product data management, design activities, management, resource management, and constraint management (Raffaeli, 2013). Collaborative Design concept model can be described as follows:

$$CSCD-CM ::= (M_{function}, M_{organize}, M_{process}, M_{resource}, M_{constraint}) \quad (1)$$

Active space to describe the objective and design activities and the establishment of an abstract reference system, a k-dimensional space can be defined as active:

$$AS(k) = A_1 \times A_2 \times \cdots \times A_k \; AS(k) = A_1 \times A_2 \times \cdots \times A_k \quad (2)$$

$A_i$,i ∈[i,k] represents a dimension of active space. Ai constituted by an n-dimensional vector:

$$A_i = (S_1, S_2, \cdots, S_m) \quad (3)$$

$S_i$, i∈[1, m] represents a scale of Ai. Active space Mechanical Product Collaborative Design hierarchical model can be described as follows:

$$CSCD-AS(4) ::= A_{layer} \times A_{objects} \times A_{lifecycel} \times A_{restriction} \quad (4)$$

A typical product of complex mechanical system design is generally divided into: the implementation of the system design, transmission design, power system design, control system design, and auxiliary system design five levels. Mechanical Product Collaborative Design hierarchy dimension can be described as:

$$A_{layer} ::= (L_{transacted}, L_{drived}, L_{powered}, L_{control}, L_{assistanted}) \quad (5)$$

Collaborative design for complex mechanical products can be described as a four-dimensional state space design activities: hierarchy dimension object dimensions, periodic maintenance and dimension constraints. Hierarchical model of collaborative design was shown in Figure 2.

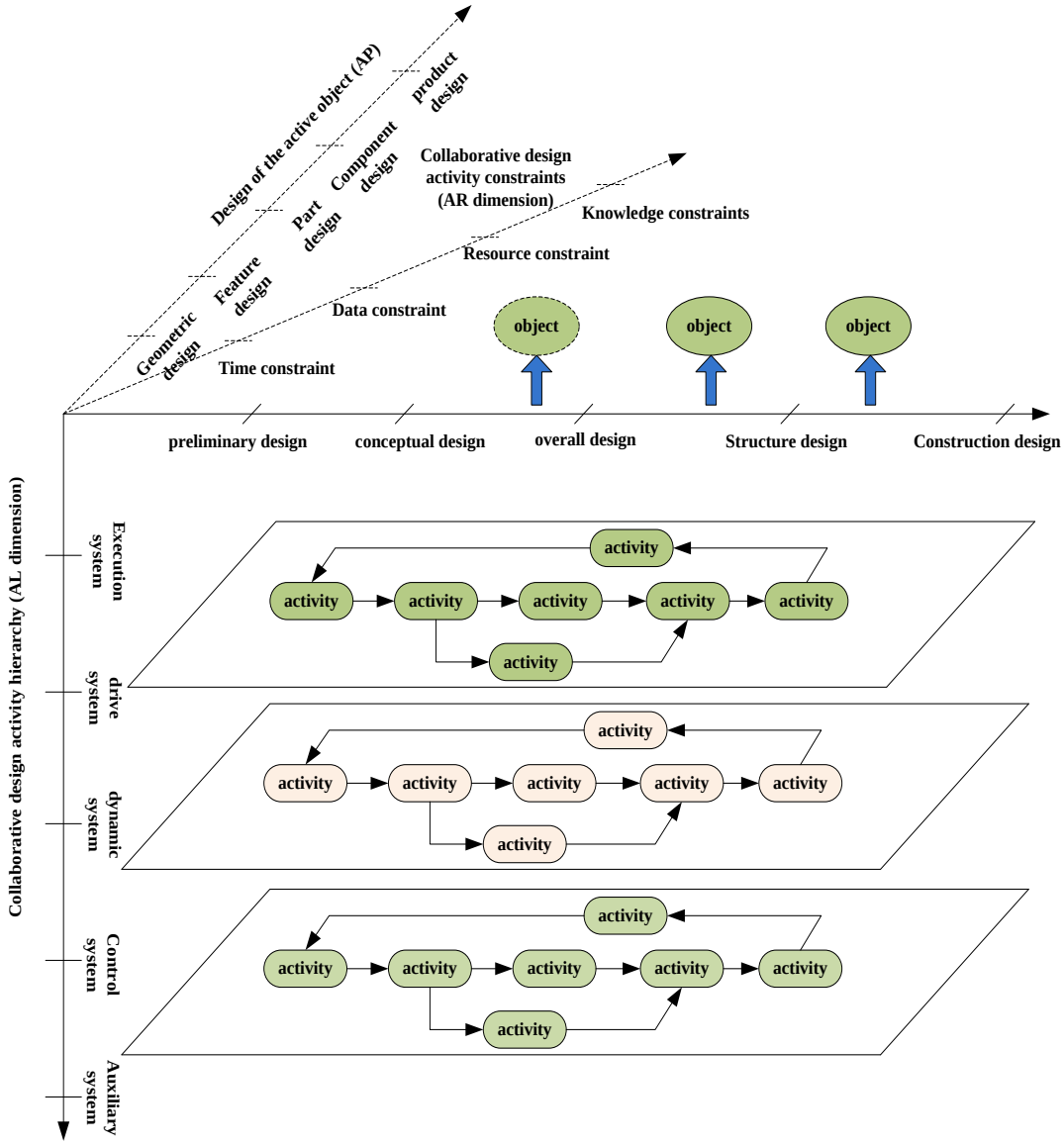


*Figure 2: Hierarchical model of collaborative design*

### 2.3 Product structure and hierarchy design

Product able to finish one or more functional structure called the product design structure. From product hierarchy to consider, product design structure may be a product, organization, component, part, structure design element. Although not a physical structure functional surface, but also has a certain function, and the product is the smallest functional unit, is one of the main product design, it is also referred to as the functional surface of the product design structure. Structural design of mechanical products which mainly contains six types, there is a hierarchical relationship between different types of design structure, consisting of a plurality of functional surface structure design element, a plurality of structural elements designed component parts, multiple parts constituting members, generally made up of two bodies composed of two or more members, the product constituted by one or more bodies. Its hierarchy was shown in Figure 3.

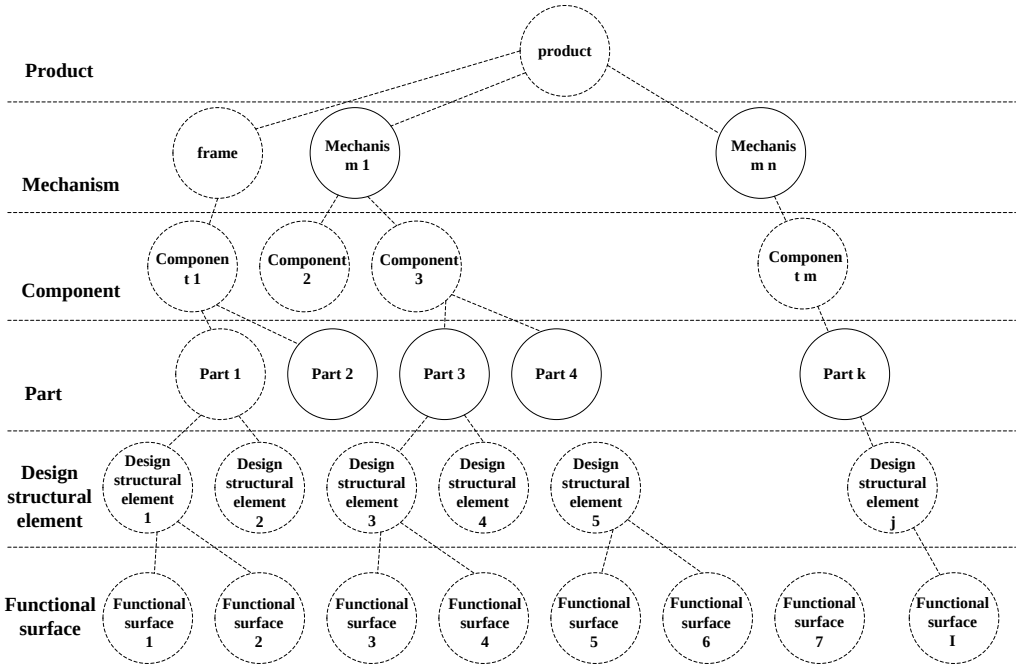


*Figure 3: Product design hierarchy*

Process structure are generally due to the need for processing element design element structure or function of the surface structure was designed, under normal circumstances, this type of structural elements and other parts of the non-contact surface, so the process of structuring element attached to the corresponding element in the design of the structure is represented or function surface.

## 3. Experiments and results

### 3.1 Automatic identification process design structure

The first line, down design configuration recognition process, the part designed to identify the structure as shown in Figure 4.

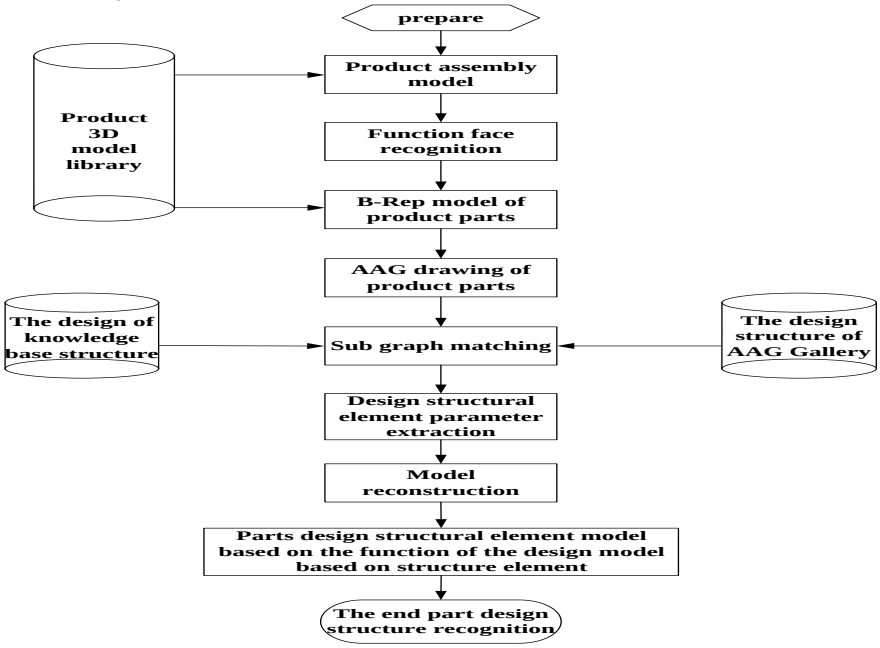


*Figure 4: Part identification process design structure elements*

From the 3D model we found that the product, product assembly model provides geometry, topology information, assembly and assembly relationship between the level of information assembled information, three-dimensional model of parts provides the geometric, topological information and information technology requirements. Of course, 3D model information for the design of the structure is not complete identification, which will lead to the identification information architecture design deficiencies. To solve this problem, according to the human mode of thinking, to establish the knowledge base to identify structural design, structural design under the guidance of knowledge, according to the characteristics of the 3D model structure, the structure design to achieve recognition.

**3.2 The establishment of attribute adjacent graph**

Edge of irregularities is determined on the basis of feature recognition. Only after irregularities edge determination in order to characterize the composition of the sub-picture plane extraction and matching. In mechanical products, while the main types of linear, elliptic curves, parabolic curves and hyperbolic curve. The latter three are collectively referred to as a quadratic curve. Calculate the respective sides of the punch according to the algorithm described above and draw its properties coupled was shown in Figure 5.

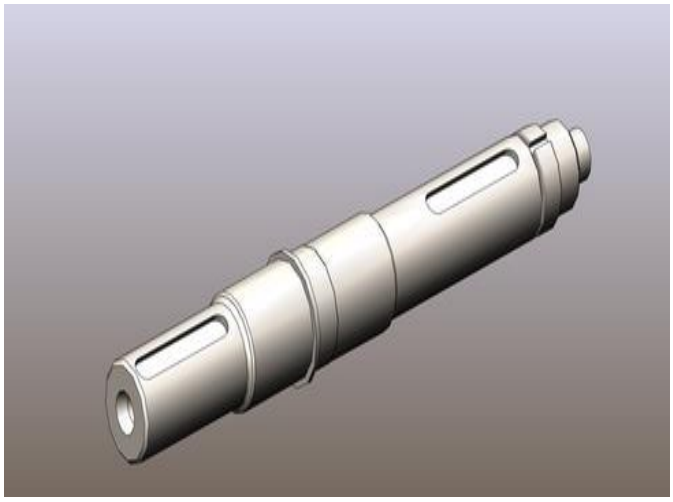

*Figure 5: Calculate the respective sides of the punch*

In the three-dimensional motion of a rigid body, if unconstrained, along the three axes of reference of free movement and freedom around the three axes of rotation, which has six separate basic movement. Or determine a rigid body position requires six independent parameters. When the rigid body motion unconstrained, six parameters can be any number, namely the free movement of the rigid member has six degrees of freedom. When the movement of two components deputy, mutual restraint only for sport, and the relative freedom of movement will be less than the number of f6. Deputy sports but also according to their number of degrees of freedom f = 1, ..., 5 and are called class deputy. The relative freedom of movement between the members of each pair is composed from 1-5. Deputy low number of degrees of freedom f only 1, 2, 3, deputy high degree of freedom of 4, 5. Axis and key constraints was shown in Table 1.

*Table 1: Axis and key constraints*

| The bottom surface constraint | 1 side constraints | 2 side constraints | 1 cylinder constraint | 2 cylinder constraint |
|---|---|---|---|---|
| y negative direction | z positive direction | z negative direction | x negative direction | x positive direction |
| Around two x axis of rotation | Around two y axis of rotation | Around two y axis of rotation | Around two z axis of rotation | Around two z axis of rotation |
| Around two z axis of rotation | Around two x axis of rotation | Around two x axis of rotation | Around two x axis of rotation | Around two x axis of rotation |

## 4. Conclusions

The establishment of a central view of product lifecycle information models body. According to the three dimensions of products were selected to describe the typical information object establish the appropriate ontology model. To achieve a comprehensive information and mechanical products to describe the relationship, particularly the expression of fine granularity of mechanical products to the functional surface for subsequent knowledge discovery and reuse of the foundation. With the development of manufacturing and application of information technology, enterprises have accumulated a large amount of historical data products. But the applied product data management system PDM / PLM, based on the composition of the product structure information for the core of the organization, namely products, components, parts organize product information.

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