Research on the structure of green-product integration development system

Jiang Jibin, Wu Qisheng, Lin Jiuguang, Liu Zhifeng, Liu Guangfu
Hefei University of Technology, Hefei 230009, China

ABSTRACT

In order to conduct green design effectively and scientifically, it is an important premise to build Green-product Integration Development System orienting product life-cycle. In this paper, viewed from practicality and integration, current green products' design tools are firstly analyzed, the structure of current accessible green-product integration development system is secondly discussed, and the strategy of system development from practicality and integration is lastly brought forward. *

1 SUMMARY

Green-product is compatible with environment, resource and energy. Its green attribute is implemented on its whole life-cycle. Green-product development means that its function and structure. are designed and the green degree of the life-cycle's different stage is virtually designed and assessed its digital-product stage. So the demands of time, quality, cost etc. are fulfilled on the precise of meeting environment and resource's demands. There are many design tools about green-product design now. But most of them which are on theoretic stage aren't integrated with traditional design tools such as CAD, CAM etc and can not support the enterprises' product development. This paper studies on the structure of current accessible green-product integration development system and discusses the strategy of system development on the base of analyzing the specialties of green-product development from practicality and integration.

The aims that different computer aided tools can fulfill are not the same as each other's. For example CAD mainly completes products' geometrical modeling. On the contrary, different aims of functions decide the structure of diverse system. So at the beginning of implementing system development, only to know well the functional aim of established system to be fulfilled, and only to apply those aim to instructing system planning and software development, can one assure the system to be established meeting functional demand.

The aims of traditional design's theories and methods are to meet products' function, quality, time, and cost. These demands include the functions of satisfying customers, need, high quality, short manufacturing cycle, and low cost. Green design adds environmental aim comparing to traditional design and is centered by environmental protection. As to eliminate the potential negative effect, it emphasizes on the bondage between products' fundamental attributes and environmental attributes. The environmental aim is a wide concept. It includes a series of problems such as ecological environment, resource, and the utility of energy etc. The problem about ecological environment means that it affects ecologically environment on its whole life-cycle. For example, polluted air and used water generated on manufacturing procedure affect ecological environment, what's more, the products which are disposed can affect ecological environment also. The utility of resource means the capacity of resource , especial non-recycle resource is utilized comprehensively and optimized. Then the aim is very important because resource is increasingly scarce. Though product's green attribute is important when it is on manufacturing, using and disposed stage, it is decided on product development (digital product or blueprint) stage. Then we can achieve the goat of product's minimum affect on ecological environment, minimum energy consumption, maximal resource using if only if we understand it well and regard environment as one aim by rational design of product structure when we is developing products.

We can make a conclusion from above analysis: Green-product development not only includes traditional design which is applied to fulfill product's function but also carries out environmental capability' design., so the computer aided system which is applied to support Green-product development has characters of multi-tool and integration, and this point must to be considered when the structure of green-product development system is planned.

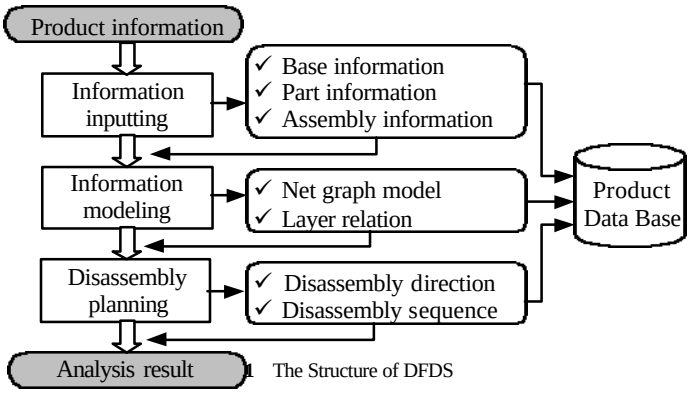
2 THE STRUCTURE OF CURRENT GREEN PRODUCT DESIGN TOOL

The research about green product has been widely carried out since Alting introduced life-cycle engineering in 1993. Many research institutes and universities have studied and developed some green product design tools while many theories have been pointed out after many years' research. Those tools not only validated these theories pointed out but also supported designers informational design tools. The current main green design tools is listed on section 3.5.2 in References[1], and by analysis on those tools, the structure of the system is mainly divided into two style: single-tool structure and integration structure. This section will analyze their characters and applied field as to support theoretically the structure of green product development system which is based on uniform product model introduced in this paper.

* This project is supported by the Nation Natural Science Foundation of China（59935120）

2.1 Single-tool Structure

Green design references to the analysis and estimate of products' green attributes in life-cycle. It is a multi-fact and multi-attribute decision-making process. Early green design tools adopted single-tool structure and developed operating tools for a particular design content. The system existed alone and could not communicate with other design tools. For example, DFDS(Design For Disassembly System)developed by HeFei University of Technology belongs to this kind of structures.



1 The Structure of DFDS

Figure 1 is the structure of DFDS. This system acquires information about the structure, assembling and parts, and constructs product net-graphic model by information inputting system. It calculates parts' disassembly direction and creates product' s disassembly sequence by some relative algorithm about applied graphic and analyzing disassembly plan which is based on net-graph model. Then it estimates product' s sustainability by analyzing disassembly time and disassembly problems. It finally creates files about estimating result which are supplied to the designers , and to be applied to modify product' s design.

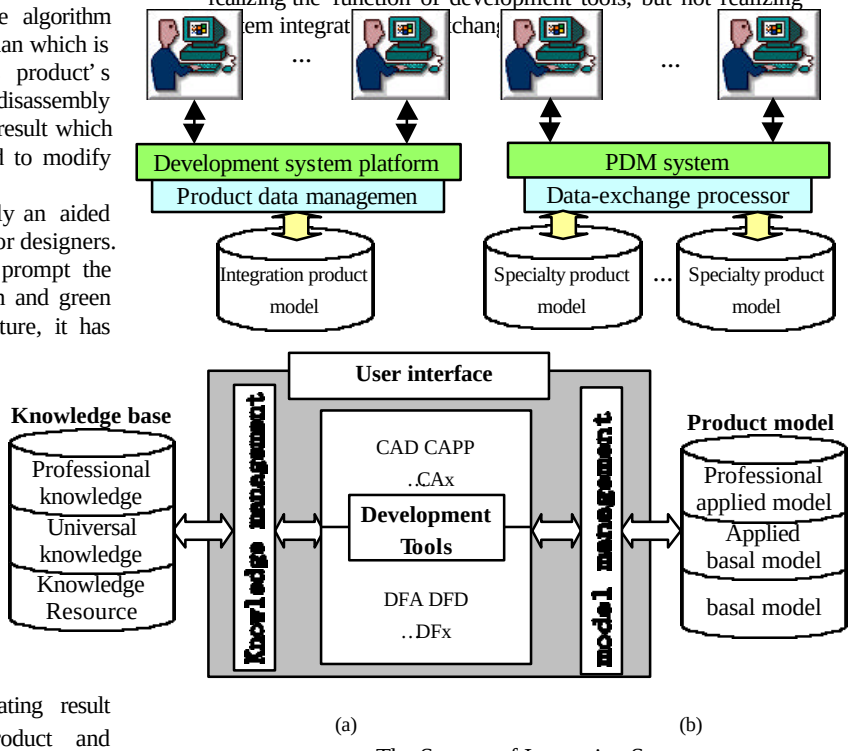
The research and development of DFDS supply an aided tool which can analyze the ability of disassembly for designers. DFDS can achieve interactive disassembly and prompt the research and development of sustainability design and green design. But the system adopts single-tool structure, it has some disadvantages. ① Many years' research on CAD that indicates information about product structure, geometry, and assembly is so much , complicated and diverse that it is difficult to be expressed by simple data structure. DFDS is developed by VC++, because the data structure which is used to store product information is limited, it is too difficult to acquire entirely information, and it is only applied to several parts; ②It is not integrated with development tools such as CAD etc. Then it results to input information again and again and not feedback the estimating result automatically. ③ The visual-ability of product and disassembly' s process is limited. What' s more, its operation is relatively abstract.

2.2 Integration Structure

Integration structure regards information integration as the aim. It realizes the integration of product development process and supports the information exchange and transfer among CAx (CAD, CAPP etc) and DFx (DFA, DFD etc.) by being supplied uniform data model (product model or management model).

According to data model, the structure of product integration development system is divided into two categories:

(1) Integration structure based on uniform product data model This structure plans every life-cycle development tool as a whole system. Product development is based on uniform product data model. It can achieve systemic high integration and shared information of a system. It is shown in figure 2(a). It constructs product integration development system platform by encapsulating development tools with uniform application interface. Different users carry out different product developments basing on this platform. The interactive action between development platform and product model is implement by product data management. Then they achieve information exchanging between development tools and shared information and integration in the process of product development. The essence of this system is product integration model which is applied to exchange, save, pigeonhole of product data in the whole life-cycle. Integration structure which is based on uniform product data model references to uniform and product integration model including life-cycle information about the product. It discards every development tool' s special database. At the same time, it constructs semantic relation between different tool data by managing product model data. Then it avoids dates redundancy and non-consistence between dates. What' s more, the advantage of product model with applied public data format is that it can reduce the developments of data-exchange processor. So researchers can spare more time to realizing the function of development tools, but not realizing



(a) (b)

Figure 2 The System of Integration Structure

(2) integration structure based on uniform data management model The structure is based on PDM(Product Data Management), and integrates many functional software on uniform PDM platform, and achieves integration management of information and process. It is

shown on figure 2(b). PDM usually adopts product data and model management based on product structure model. There is plenty of redundant dates in applied files because on product structure model only proscribes the relation between professional product model and each applied system. The consistence check of files' content can not been carried out by product dates management system either. Low-layer applied systems is forced to establish Mechanism of input and output conformed by standards such as STEP and IGES etc. because it lacks an integrative data model. On the other hand, the work amount is very large. So it is difficult to assure veracity of transforming data from one systemic product model to another.

3 THE STRUCTURE OF GREEN PRODUCT INTEGRATION DEVELOPMENT SYSTEM

Green attribute is the essential character of green product. Because what green attribute references to mainly is manufacturing, using, and disposing which are on life-cycle's material stage. So it usually adopts simulating way on the digital stage of product development. It also constructs virtual manufacturing, using and disposed environment on computer and predicts future green product's character. In the future it appraises product green attribute on the basis of product and modifies irrational design affecting green attribute. The product to be developed finally reaches scheduled green aims. On the other hand, product development references to other simulating characters besides green attribute such as sustainability and manufacturing-ability of product. Those characters need digital product model too. So product model with uniform structure, no redundant information and oriented the whole life-cycle are the bases of realizing green product development , and it must to be considered carefully when researchers are planning product development system. According as above discussions, we think that the integration system based on uniform product data model should be preferred structure. What is shown in figure 4 is the structure of integration development system based on uniform product model. This system mainly consists of some components.

Figure3 The Structure of Green Product Integration Development System

(1) Development tool Product development system supplies correspondent supporting development tools when product is oriented for different applied demands in life-cycle. They are computer aided tools (CAx) and Design for X tools (DFx), and CAx is a platform that can meet demands in special fields of product design. Such as CAD, CAPP and CAM etc, modeling product and planning manufacturing process can be finished on this platform; DFx developed on the basis of CAx is technology and a tools that can meet life-cycle demands, it considers thoroughly what product affects on later procedure of product design stage, such as assembly-ability, manufacturing-ability and maintain-ability etc, designers consider as many factors as possible which can affect function by appraising every CAx designing results and rational decisions. Then it makes product achieve an optimum aim that synthesizes each functional index in the whole life-cycle.

(2) Product model and model management Product model is the object manipulated by design activity. It is the essence of green design, and is the data and information set of product. We consider it consists of different layer model from figure 4. The first model is basal model which is not relative to concrete application, such as product geometrical model. The second model is applied basal model which references to applied function, such as precision model and resource & environment model. The third model is professional applied model for particular application, such as Finite-Element net model. Effective application of product model need supporting from management model. Management model and product model are usually combined into one functional unit. It can realize interactive information between development tool and product model by controlling information exchange and storing. Then shared and integrated information among all development tool's can be achieved. Model management mainly consists of data management which is based on product structure and the mechanism of transforming model information into applied requirement information.

(3) Knowledge base and knowledge management Knowledge base stores much information about all sorts of applied knowledge which references to product development. These information is the applied basis of every development tool and necessary for designing and estimating project. All information is divided into three layers by its specialties and universal character. The first layer is knowledge which is related to project and applied field. Such as design rule of axial parts and the rule of selecting cutting parameters. The second is knowledge which is related to particular product design. Such as enterprise standard and knowledge about enterprise manufacturing resource. The third is knowledge which is independent of application. Such as material standards and mechanical drawing standards. The storing and utility of knowledge data is realized by knowledge management system. These knowledge for product design applied demand which supports the being carried out project is delivered to development tool by knowledge management system interface.

(4) User interface Each development tool(CAx and DFx), product model and knowledge base are encapsulated as a uniform development platform for designers. Each development tool can be harmoniously applied to process of product development by user interface. By user interface, the storing and acquiring of data and knowledge is controlled consistently, and then the uniformly management of process and information is realized. So it is possible to realize integrated and parallel product development.

One important character of this structure is the model based on uniform product. Each life-cycle development tool and shared information is realized by enclosure of user interface. Then it can ensure that developed product achieves not only traditional structure and function aim but also environmental green aim. So green product can be successively developed.

4 THE IMPLEMENT STRATEGY OF GREEN PRODUCT INTEGRATION DEVELOPMENT SYSTEM

Pro/E and UGII which are both commercial supporting software supply functional module such as design, model, analyze, NC programming and manufacture etc. They emphasize on product structure and manufacturing process, and they haven't functional module such as about analysis and estimating environment affected by product and don't

support correspondent green design tool. But This sort of system is open and integrated partially. Viz.①The system supplies three-dimension modeling. Uniform product data model can be constructed by the software. and at any moment, product geometrical and functional description can be acquired for product development tools, such as CAPP and Finite-Element analysis, etc.. ② The system supplies customization modeling. It supplies input interface of project applied information about tolerance and material attribute, and makes a technical basis for constructing product model which includes life-cycle information. ③ The system can be extended and is an open system. User applied system that is seamlessly integrated with the system

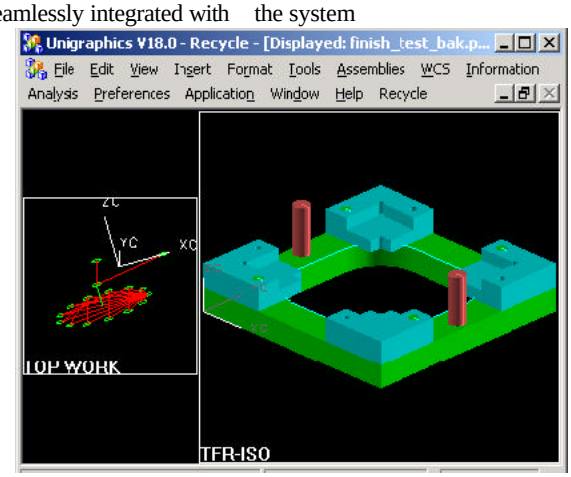


Figure 4 the structure of DFDS

can realize user special function demand with listed development tools. So the paper introduces the implement strategy that the third-party develops green design functional tool on the basis of commercial supporting software platform, and increases and expands the system function, such as DFD etc., adapts the system to green products development. UGII for DFD is a system which is developed on UG platform with the strategy, as figure 4. Its prototype comes from figure 1, and it divides DFDS functional model into UG functional menu and is integrated into UG user interface. Net information that is applied to disassembly analysis can be acquired from UG product model. DFD analysis result is reflected directly on product model. The system adds disassembly process simulating too. So application-ability of the system is strengthened. Now the system is on trial stage and is highly assessed by enterprises.

5 CONCLUSION

The research on the structure of green-product integration development system is systemic and whole planning for the system function, character and running ways. It is applied to decide developed software' final operation model and applied field. The research of structure of green-product integration development system aims to select a appropriate system structure and framework model, and it assures that green design and estimation on each life-cycle stage are realized by the system. So product green attribute is implemented on the whole life-cycle.

REFERENCES

[1] 刘志峰等．绿色设计．北京：机械工业出版社，1999,9.

[2] 刘光复等．绿色设计的体系结构及实施策略．中国机械工程，2000,9：965~968

[3] 刘志峰等．绿色产品评价方法研究．中国机械工程，2000,9：968~971

[4] Jackson, P. and D. Wallace. An analytical method for integrating environmental and traditional design considerations. CIRP Annals Manufacturing Technology 46(1):355-360, 1997