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Research on Maintenance Design Method based Virtual Maintenance

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***Abstract*—**The essentiality of maintenance assessment and maintenance optimization in design stage is analyzed, and the existent problems of conventional maintenance design method are illuminated. MDMVM (Maintenance Design Method based Virtual Maintenance) is illuminated, and the process of MDMVM established, and the MDMVM architecture is given out. The key techniques of MDMVM are analyzed, and include maintenance design based KBE (Knowledge Based Engineering) and virtual maintenance based physically attribute. According to physical property, physically based modeling, visual object movement control, the simulation of operation force and maintenance sequence planning method are emphatically illuminated. Maintenance design system based virtual maintenance is established in foundation of maintenance design method.

***Keywords*—**Digital mock-up, virtual maintenance, knowledge engineering, maintenance sequence planning.

I. Introduction

MAINTENANCE performance is an important parts of product quality, and this connatural attribute is from product design. Development time, development cost and maintenance expenditure are influenced by product maintenance performance, so the influence on next stage of design, use, maintenance by maintenance performance must be take into account in design stage, and the problems in next stage are early detected and solved. Before physical prototype is manufactured, maintenance assessment and optimization are developed in design stage, so product structure and function designs are improved from product maintenance performance. However, the traditional design method involved in the fabrication of a physical prototype, design process is limited serial mode of design-manufacture-assessment-modefication, and many problems are found after physical prototype tests, these factors leads to a long product development time, a high manufacturing and maintenance cost, a low product quality.

In order to making maintenance assessment and maintenance optimization in design stage, and improving product maintenance performance, Many factors in maintenance process of physical prototype are considered. Maintenance assessment and maintenance optimization are solved by MDMVM while virtual maintenance is developing lately, the process is depicted:

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(1) Virtual maintenance model is established based VR that is similar to physical prototype.

(2) Maintenance simulation is developed in virtual environment.

(3) Maintenance feasibility, accessibility, visibility and maneuverability are assessed based simulation results, and many data of maintenance process are given out.

Based MDMVM, product design is guided and improved, and maintenance technics establishment is guided, and people trained and product exhibition are developed [1].

II. Maintenance Design Method

MDMVM is depicted：

(1) Based DFM (Design for Maintenance) ideal, the primary design is finished by KBE.

(2) Based CAD model, maintenance model is established by maintenance modeling method based physical attribute.

(3) Maintenance simulation is developed in virtual environment, maintenance simulation results are provided, design modification and optimization are guided by maintenance aided design module, Final DMU (Digital Mock-up) is ascertained until maintenance performance is satisfied with design request [2]. The design process of MDMVM is a synchronous process, and it is an iterative process between product design with maintenance assessment and validation. The design process is shown in Fig. 1.

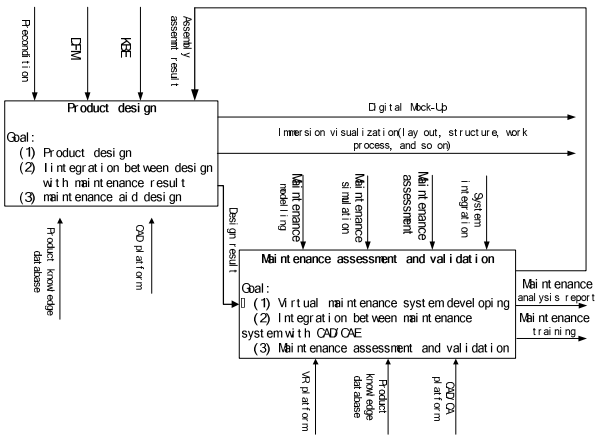

Fig. 1 The process of MDMVM

Based functional analysis of MDMVM, the whole frame includes the management of design knowledge database, design model database and virtual maintenance database, product

design, maintenance modeling, maintenance simulation, maintenance assessment, visualization, and so on, and the relation of every module is established. The whole frame of MDMVM is shown in Fig. 2.

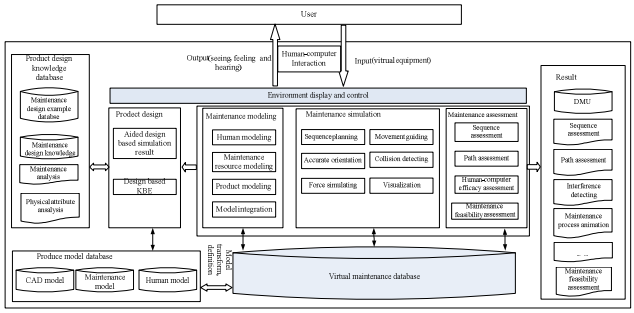

Fig. 2 The process of MDMVM

In order to realizing maintenance design and validation in design stage, two questions must be solve that are maintenance assessment and validation, aided design based maintenance design knowledge and assessment result, the former is solved by virtual maintenance, the latter is solved by KBE.

III. Virtual Maintenance Based Physical Attribute

A. Virtual Maintenance Modeling Based Physical Attribute

Presently, maintenance Model often includes product geometrical information, but excludes product physical information. This maintenance model is not an integrated model, and it can not fully simulate the physical prototype. The actual maintenance process is affected by not only product geometrical information, but also product physical information, such as product mass, product centroid, outside force, and so on [3].

Based the characteristic of actual maintenance process, information need of product virtual maintenance model is analyzed in virtual maintenance process. Virtual maintenance model is established, it includes product geometrical information, product physical information and product maintenance information, and the representation method is founded. Part topology information, part geometrical information, part maintenance mating information are obtained from CAD model by developing, part physical information and part maintenance characteristic are defined by interactive method. Fig.3 depicts the realization way of virtual maintenance modeling.

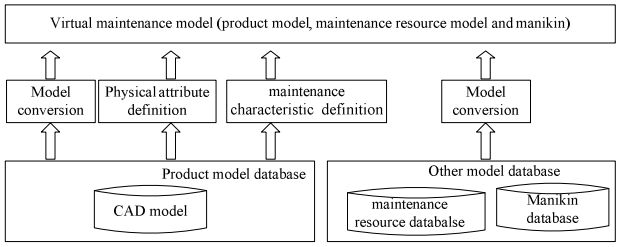

Fig. 3 The realization way of virtual maintenance modeling

B. Movement Controlling Method of Virtual Object

In virtual environment, virtual object (Part, maintenance tool, and so on) is controlled by data glove, voice input device, FOB. The location of virtual object is obtained, controlling order is determined by data glove and voice input device [4]. Human computer interaction is investigated, and advantage and shortcoming of movement controlling method is analyzed recently, movement controlling method integrating FOB, data glove, voice input is established. Because of implementing force-reflective in maintenance simulation process, so the selective device includes force-reflective equipment, data glove, voice input device and FOB [5].

C. Force Simulation Method

Two types of force are realized in maintenance simulation process based force feedback need, one is guided force in virtual object movement process, and the other is operation force after part position is located.

Recently there is not force input device in virtual maintenance environment, force input model is established based part physical attribute and part displacement. Guidance force is calculated by part acceleration and part mass, and operation force is calculated by a force calculation method, the method changes the geometrical displacement into operation force based a spring model, it is contributed to realize the interactive input of operation force. A spring model is founded based Hooke law, spring elongate size is direct radio with elongate force, and the mapping relation between displacements with operation force is decided by spring stiffness. Spring stiffness is calculated by geometrical information, physical attribute, maintenance characteristic, and so on.

Two modes are realized in force feedback:

(1) Feeling force feedback based force feedback device. The mode has more third dimension, but virtual maintenance environment must have force feedback device.

(2) Seeing force feedback based illustration. The mode has less third dimension, but the operators know the operation force. It is very useful for the maintenance process in which force must be controlled, and it can be realize easily.

The process of guidance force add and release: guidance force size is calculated based guidance force model, and then guidance force is reacted on the operator by feeling/seeing force feedback. Guidance force is released when the position is satisfied with accurate location. The process of operation force add and release: operation force size is calculated based operation force model, and then operation force is reacted on the operator by feeling/seeing force feedback. Operation force is released when the position is satisfied with mating need, and maintenance process is finished.

D. Maintenance Sequence Planning Method

Regular MSPM (Maintenance Sequence Planning Method) includes MSPM based knowledge, MSPM base geometrical reasoning and MSPM based human computer interaction. MSPM base geometrical reasoning is fit for maintenance simply model product [6], MSPM base knowledge is fit for the product

existing similar maintenance example. The information of operation process can be tracked and recorded by MSPM based human computer interaction, and it includes maintenance sequence, adding restriction and releasing restriction, part location, and so on. Maintenance sequence planning and maintenance technics planning are made by MSPM based human computer interaction. All factors of actual maintenance simulation process are thought over because of limitation of virtual reality technique, so this method is adopted for complicated model product. By considering advantage and shortcoming of every MSPM, the integration method is founded integrating the three methods. Fig. 4 shows this method.

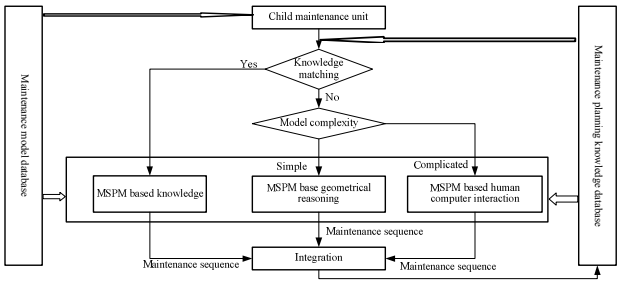

Fig. 4 MSPM integrating the three methods

IV. Aided Design Method Based KBE

Establishing product knowledge database is a base for implementing MDMVM, and it includes knowledge representation, knowledge gathering, knowledge integration and knowledge management [7].

A. Knowledge Representation

The mode of Knowledge representation not only effects knowledge storage efficiency, but also effects knowledge gathering ability and knowledge application effects [8]. The reasonable knowledge representation is satisfied with plenary representation, right reasoning, convenient management, easy comprehension, and so on.

Product design knowledge include many knowledge forms, such as design formula, design example, design model, text aided knowledge, and so on by analyzing the characteristic of product knowledge, so the mix-knowledge representation mode is established. The knowledge includes parameter design parameter, maintenance design example, material, maintenance design knowledge, etc, and it is represent by design rule and design example. Product design knowledge is made up of each knowledge mode.

B. Knowledge Gathering

The bottleneck of the aided design system based knowledge is knowledge numeric- transforming; a majority of workload of the aided design system is knowledge gathering. The knowledge database is founded based product knowledge characteristic. The data structure is established for every data table, product designer and system developer finish knowledge gathering.

C. Knowledge Integration and Management

It is important how to redeploy and utilize multifarious knowledge in order to obtain the maximum value of knowledge in creative design process, so the theory and application technique of knowledge integration and management are attracted consanguineous attention. The dynamic database technique and PDM are mainly adopted in product knowledge integration and management, knowledge integration management system is established, and product knowledge is loaded into database. The new design information(design parameter, design document, design blueprint) is loaded into database at the same time the fore design information is loaded into database, so knowledge system is continually abundant and consummate. MDMVM have self-educated function because of the characteristic of knowledge integration and management method. The knowledge saves the final design results but also the intelligentized decision-making process. Knowledge system is continually extended at the period of using knowledge system, and design knowledge, optimizing knowledge and assessment knowledge are continually abundant and consummate, so the knowledge system is exoteric and continually developmental.

D. Knowledge Reasoning

At the aspect of the solution for knowledge engineering problem, three universal reasoning techniques are adopted, that is RBR (Rule-based reasoning), CBR (Case-based reasoning), and MBR (Model-based reasoning). The method of design, assessment and optimization is integrated based product knowledge system, and the reasoning mechanism that is fitted product design and assessment according as the characteristic of product design, and is a mixed reasoning mode integrating RBR and CBR. The maintenance design result satisfied performance target data is gained by the reasoning mechanism.

V. Conclusion

MDMVM is established based maintenance assessment, the method not only assess maintenance performance of existing product, but also make maintenance assessment and validation of new product in design stage. Because of using KBE, it is an effective way of solving the aided design problem based maintenance assessment result, modification suggestion. MDMVM not only enhances maintenance design ability, short study cycle, and reduces study fee, but also it is an effective means of saving the maintenance design technique and keeping continual development. At the future work, the mend of integration design system based MDMVM must be developed.

Acknowledgment

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