A 3D Process Design Method based on MBD Machining Element

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Abstract. In order to solve the problem of information inconsistencies in 3D machining process planning, a 3D process design method was proposed based on MBD machining element. The 3D machining process planning frame based on MBD machining element were established after concept of MBD machining element was given. Operations and steps based on MBD processing element are generated by using feature recognition technology and process knowledge. Process models based MBD machining element is established according Boolean operators and associated replication technology. It provides a process model for 3D marking and process publishing. A 3D machining process design system is developed based on MBD machining element, and the effectiveness of proposed method was verified by the example of a process design for flap part.

Introduction

MBD (Model-Based Definition) is a digital define method which marked process description, attributes, and other management information into 3D model of product. This method make 3D model is the only data source and basis in product manufacturing process. The traditional method of product definition of geometry information is descript by 3D solid model and dimensions, tolerances and process information is defined in 2D drawings is changed completely [1]. Process design based on MBD has some advantages such as flexible management, expression means rich, and more clear. It becomes a effective means for shorten the design cycle process and improve production efficiency.

The research for process design technology under MBD environmental has made great achievements and corresponding digital design and manufacturing software are developed [2], such as DELMIA that introduced by Dassault. This software can achieve functions of machining feature recognition; define machining operations, process model generation and so on. Machining process design and management under integrated environment is achieved by integration of Teamcenter, Tecnomatic and NX in Siemens. At present, scholars are committed to research machining process design application mode based MBD according actual status of manufacturing enterprises under the support of commercial software. Such as literature [3] proposed a 3D process design method based on process model. Literature [4] found some labeling symbol for 3D process information in machining process design application mode. It is provides a standard for 3D process labeling. Wan Neng[5] research on a new model for the machining process design and deeply researched on process model generation technology.

Information which contained in part design model is not contact with processing features in existing 3D Machining process design methods. This defect leads to inconsistencies information in process design, information in 3D model of cannot be fully utilized and process design efficiency is affected seriously. Therefore, this paper proposed a 3D process design method based on MBD machining element and two key technologies are studied.
3D process design frame based on MBD machining element

Because the machining feature is evolving in the machining process, feature is formed by a series of determining machining operations. This machining operations be called machining element (ME). MBD machining element is required information entity which core is machining feature in a particular machining operation. 3D process design frame based on MBD machining element is shown in Fig. 1. It is include machining feature recognition, operations and steps generated based on MBD machining element, process model generated, 3D process information marked and process publishing.

Fig.1. 3D process design frame based on MBD machining element

1. Machining feature recognition. In this stage, part design model is analyzed, processing features are identified, and processing features list is generated.

2. Operations and steps generated based on MBD machining element. MBD machining elements are generated based on part feature. Then, MBD machining elements are sorted under constraints of process scheme and manufacturing resource. Finally, operations and steps are generated.

3. Process model generated. Each operation corresponds to a process model in machining. A Boolean operation is being done using the previous process model and MBD machining elements of current process model. By done this, the current process model is generated. Then, all process models that from part roughcast to end product are generated according to the process route.

4. 3D process information marked. Take the process model as a carrier for process information, and process design information and other manufacturing information can added to process model by property and label expressions method.

5. Process publishing. After process design has been completed, process information and process model are filled in electronic process template and this electronic process documentation is published.

The next are focus on operations and steps generated and process model generated based on MBD machining element.

Operations and steps generated based on MBD machining element

There is no similar technology template for reference in 3D machining process design if parts have quite different structure. In this situation, operations that contain information entity can be obtained by reference knowledge library according to features recognition results of parts. Those operations called MBD machining element. 3D machining process design can be completed creatively by this means. Operations and steps generated based on MBD machining element is shown in Fig. 2.

Operations and steps generated based on MBD machining element include machining method chain decision, resource and parameter decision of operation, MBD machining element generated, MBD machining element sorted, machining element merged and operations and steps generated.

1. Machining method chain decision. It is need to experience different machining operations to complete a machining feature. The appropriate machining methods chain is selected for each feature
according to type of machining features, manufacturing requirements and their manufacturing resources.

(2) Resource and parameter decision of operation. Machining operations is obtained for each feature after machining methods chain is selected. Manufacturing resource and process parameters for each machining operation are determined according to machining method, machining accuracy, surface roughness and others constraint.

(3) MBD machining element generated. MBD machining element is generated after manufacturing resource and process parameters is determined for each machining operation.

(4) MBD machining element sorted. The optimal MBD machining element sequence is obtained in the constraints of machining feature priorities, transform times of equipment and tool.

(5) Machining element merged and operations and steps generated. steps is generated by MBD machining element sequence according to the tool type. Then, operations are generated by steps according to the equipment type.

**Process model generated based on MBD machining element**

Part is obtained by each machining process from roughcast. It reflects a dynamic parts manufacturing process from roughcast to product that accompanied by changes of parts' geometry features, performance and others factor. The process from roughcast to product can be seen as MBD machining element is generated on process model continuously.

(1) Related copy of process model
The technology of related copy can copy or link geometry from any child model node to current work node. The new geometry is created by take current geometry as a reference. Then, the linked geometry can update automatically when changes are happed in source geometry. This technology avoids repeated design of parts and the process design cycle is shortening greatly.

(2) Process geometric modeling based on Boolean operations
From view of machining, part is generated after a series of machining from roughcast to product. Geometric solid mode of parts can be obtained by Boolean operations of design features. In other words, a geometric solid mode generating is a process of Boolean “Minus” operation, and those operations are satisfied
\[ P_{Ma} = P_{Mb} - P_{Mm} \]  

where, \( P_{Ma} \) represents the process model after cutting. \( P_{Mb} \) represents the roughcast model before cutting. \( P_{Mm} \) represents the margin feature which needs to cut.

Case study

To explain the application of the suggested method, a 3D process design system based on MBD machining element is developed by using Microsoft Visual Studio 2008 on NX8.5. Taking a flap part machining process design for example and functional module of operations and steps generated based on MBD machining element, process model generated, 3D process information marked, process publishing are applied. Finally, 3D process published in Adobe PDF. One of application scene for the system is shown in Fig. 3.

![Fig. 3. System application scene](image)

Summary

3D process design is a manufacturing hotspot in MBD environment. The problems of 3D process design are analyzed in this paper, and a 3D process design method was proposed based on MBD machining element. Operations and steps generated based on MBD machining element and process model generated techniques are researched deeply. The proposed method ensures the uniqueness of information source in process design and the efficiency of process design is improved.

References