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The Application of MBD Technology in the Design and Manufacture of Typical Parts

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Abstract. In this paper, the Model Based Definition technology was used based on the development and manufacturing module of 3D model design software. Based on the existing national standards for process symbols, the 3D process information identification, the formulation and marking of 3D process symbols, and the design of 3D process procedures was described in detail. The paper takes the 3D digital process design and manufacturing process of a shielding box component as an example, the secondary development of software such as PDM Link and Product View are used to the process of digitalization, The realization methods of digitalization, standardization and dynamic visualization of process information annotation of its 3D process model are studied, The research results are applied to the 3D process design and manufacturing of product model, realizing paperless manufacturing, and promoting the application of 3D process design and manufacturing in products.

Keywords. Model based definition, 3D process digitalization, process symbol, process information identification, process procedure design, machining visualization

1. Introduction

With the popularization of product digital design in mechanical manufacturing enterprises, nowadays mechanical manufacturing enterprises generally adopt the mode of "Three-dimensional design + two-dimensional production" to manage design and production [1,3]. This production design method has a long process, low inheritance, difficult to understand drawings, and is prone to errors.

Three-dimensional Model Based Definition (MBD) is a representation method that can completely carry the information management of product shape, dimensional tolerance and process parameters [4-5]. In MBD mode, 3-D data transmission of product information (feature size, geometric tolerances, Surface roughness, surface coating, etc.) , process information (equipment information, process method, process reference, clamping location, etc.) from design to manufacturing, engineering designers will carry product information and process information of the three-dimensional model to the workshop, the workshop workers only need to follow the three-dimensional model can be processed and produced, in case of design change, the change information can be sent to the production site directly through the design and

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manufacture platform, which shortens the production cycle and ensures the accuracy of the production data.

As the foothold of MBD technology practice, 3D process digitization has gradually become the focus of development research at home and abroad in recent years, and relevant scholars and researchers have also made some achievements, at present, the research mainly focuses on three-dimensional process flow design, three-dimensional machining, welding, assembly process simulation, three-dimensional process model and process information annotation system standard construction, the practical application of the actual parts engineering involves less [2,6-8]. Taking the 3D process digital design and manufacturing process of a certain type of shielding box as an example, the MBD technology is developed and implemented based on Pro/E Wildfire manufacturing module, the 3D process model of typical parts is designed based on the B/S framework, and the 3D process model of typical parts is designed, using Product View to show the MBD lightweight model, through the MES system that has been built, the production information is published and applied to the production of parts.

2. Shielding Box Traditional Process Design Process

As shown in figure 1, the model of shielding box which is made of aluminum alloy 5A06 is provided with the upper and lower end faces of the shielding box, and the top and bottom end faces of the shielding box are provided with the step faces of the mounting plates, and the cavity of the shielding box is provided with the reinforcing bars and the thread mounting holes, there are mounting holes and grooves around the connector, which involve various machining methods such as heat treatment, ordinary milling, numerical control milling, coordinate boring, drilling, tapping and so on.

The prophase design and manufacture process of shielding box is three-dimensional model building, two-dimensional engineering drawing and text information. There are some defects in this design and manufacturing method, such as non-inheritance of design model, non-intuitionistic process design rules, low efficiency of reading drawings and process design documents, etc.

Figure 1. Three-dimensional model of the upper and lower ends of the shielding box

3. 3-D Process Digital Design Process

3D process digitization is based on 3D design model. The designer designs the relevant design information and process information in the 3D model of the process. The design information mainly includes design elements such as material, dimension, tolerance, roughness, surface coating, etc., some 3D engineering drawing software have already

realized this function. The process information includes manufacturing process, equipment, fixture, datum, cutter, parameter, inspection and so on. It involves a lot of non-geometric information description, it will form a huge annotation information set with other annotation information of the model, which is disadvantageous to the expression of information and the view of users. The digitization of "Text" information and "Symbol" is beneficial to the process information expression by establishing the digital expression method of 3D process. At the same time, the numerical control programming model and the inspection model can be obtained directly for the current automatic manufacturing mode, which improves the processing efficiency, the processing accuracy and the inspection efficiency, at the same time, the accuracy of process step model is also very important.

3.1. Digital Representation of 3D Process

According to the requirement of 3D process technology digital expression method, the 3D process digital production process information expression framework is constructed, which involves process information identification, process symbol formulation and 3D symbol annotation. The process information identification is the basis of the whole three-dimensional process digitization. The process information identification defines the content scope, the content form and the label standard of the three-dimensional process The main standard of the process symbol is the graphical representation, which is based on the established industry standard, national standard and other existing graphical symbols The 3D symbol tagging is mainly based on the existing 3D design platform, and the manufacturing method of process information tagging is developed, which can conveniently and effectively represent the information.

3.1.1. Identification of Process Information

The 3D process information identification mainly involves a lot of non-geometric information description such as the number of process features, machining types, equipment types, tool types, tool parameters, cutting parameters, cutting fluid types, etc. , how can such process information related to the geometric features of the model be effectively normalized in the MBD model, it is necessary to standardize the logo by combining three-dimensional design platform, process information content and three-dimensional graphic display, which can be marked on the three-dimensional model in symbolic form, as shown in figure 2, the form and position tolerance information of the model is consistent with the representation of the process information such as raw materials, fixed working hours, technical requirements, etc. , which are not related to the three-dimensional geometric features, is expressed in the form of part attributes, in the form of text marked on the three-dimensional model.

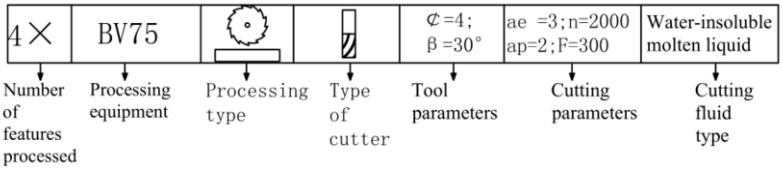

Figure 2. Diagram of process information identification.

3.1.2. Process Symbol Establishment

Process symbol establishment mainly includes the machining type adopted by the part feature and the cutting tool type adopted by the machining type, in order to facilitate the fast recognition and understanding of the three-dimensional process digital marking, make the process symbol. The national standards GB/T3167-2015"graphical symbols for Operation Instructions of Metal Cutting Machine Tools" [9] and GB/T16273.2-1996"graphical symbols for Machine Tools for equipment" [10] have been published. They have made the symbolic expression standard for the commonly used processing equipment, processing types and information of processing tools. The manufacturing process for each industry is quite different, with more types of equipment, machining types and machining tool information, plus the increase of new machining equipment, machining methods and machining tools, the integrity and readability of the original symbolic expression needs to be simplified and increased in combination with the requirements of 3D process digital expression. According to GB/T16900-2008"General rules for the representation of graphic symbols" [11], certain requirements have been given for the formulation of standards for the expression of process information, symbol identification, symbol drawing, etc. , the rules include process flow symbol, cutting machine tool symbol, operation indication symbol, machining location symbol, clamping symbol, tool indication symbol, drawing symbol, etc. , it can be used as the basis of 3D process digital process symbol, and the effect of 3D process symbol based on simplification principle is shown in figure 3. After the process symbol is simplified, the designer can attach the process information to the process design model as the integration of the logo displayed in the 3D process model and other information, follow-up personnel can quickly get the information they need.

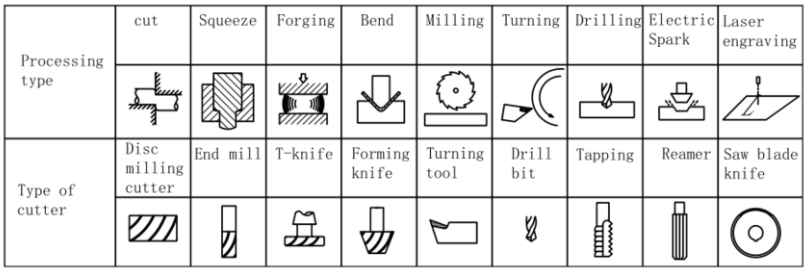

Figure 3. 3D process symbol simplified table.

3.1.3. Three-dimensional Process Symbols

By developing the process design layer of the manufacturing module of the 3D design software, the process step model based on the manufacturing module is created, the 3D process symbol generation and marking module is developed according to the process symbol formulation rules and process information marking specifications, and the process model is marked directly. The development process of 3D process symbol annotation, according to the process specification, information such as step method, number of machining features, type of tool, cutting parameters of tool, selected tool parameters, type of cutting fluid, and reference and Surface finish of machining requirements can be selected directly through the developed module, according to the specification of process information marking, the marking information is generated and

marked directly on the process model. The process model can be used as the reference model of the process, and can be used directly as the numerical control programming model, it can also be used as the test model of this process. The 3D process model with process information can realize the function of 2D drawing and process file design and meet the requirements of 3D process digital design.

3.2. 3-D Process Planning

Through the establishment of 3D process symbol and process information marking standard, 3D process model design and 3D process information tagging can be carried out, and 3D process model can be established. How to use 3D process digitization to design the process planning of parts needs to solve the 3D process planning platform, process design and process design methods and principles. Based on the basic modeling platform of 3D Design Software Pro/E Wildfire, and the secondary development of PDM Link and Product View, combined with the advantages of 2D process expression, the software of 3D process planning is developed and implemented. The software interface includes title area, material area, process tree area and model area. The title area contains information such as product name, product number, process name, process version number, and the material area contains information such as material name, material brand, material specification, blank size and material code The process tree area is the representation of the process, including the types of process methods and process sequence, including the process name, process number and process name The process name contains the process number and the description of the process characteristics. The process name and the process name list are placed in the table of contents on the left side of the design platform, it is convenient for designers and operators to find the content of process or step. The model area covers the 3D features of the part and all the corresponding process manufacturing information. Click on the corresponding process or process steps at the 3D process planning card interface, it can display the 3D model of the corresponding process or step, and the related information and dimension of the machine tool, tool type, tool parameter and machining parameter. The process planning is shown in figure 4.

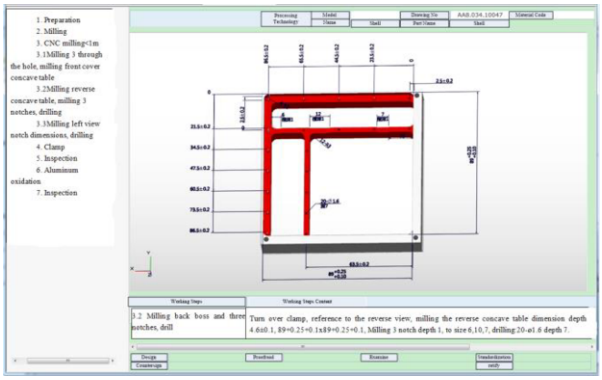

Figure 4. Design process of 3D process specification.

3.3. 3D Process Digital Dynamic Visualization Terminal

The 3D process planning is based on the process step model, and the process information is modeled on the process step model, the process specification is archived on the Product Data Management platform (PDM) , and the structured process specification is pushed to the developed b/s architecture MES –Manufacturing Execution System) terminal browser.

The process planning information integrated into the MES system, according to the corresponding process of site production station matching, when the operator of the process logs into the MES system, according to the priority of parts production scheduling, can directly receive the production task, virtual Reality Modeling (VRML) plug-in embedded in 3D dynamic visualization window can be used to browse the corresponding 3D process model and obtain the process information. The 3D process model can be directly used as the basic model of the process programmer. The 3D process can improve the operators quick understanding of the object and content of the process, and greatly reduce the misreading rate, improve production efficiency and achieve the production site "Paperless" green manufacturing.

Figure 5 shows the design process of a 3D digital process step model for a certain type of shielding box component, The highlighted red part in the 3D view represents the position of the working step machining feature. Firstly, the blanks are annealed after heat treatment, and then the general shape of the part is milling. After the workpiece is deburred by fitter, the parts are turned to NC milling for the characteristics of positive and negative cavities, spacers and so on After being deburred by fitter, the mounting hole of side wall connector is precisely machined by coordinate boring, and then deburring and thread tapping are processed by fitter.

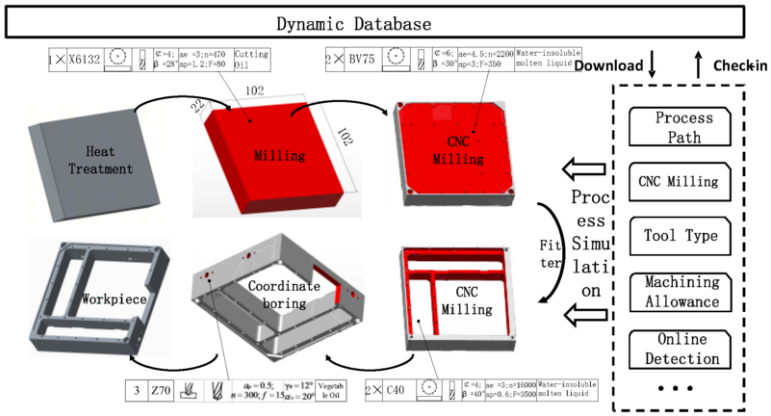

Figure 5. Dynamic visualization of process step model.

Three-dimensional process digital design, archiving, digital production, processing information to achieve a structured, three-dimensional expression, while improving the timeliness of information changes, the feedback of quality problems in production process, collection and realization of information, promote the continuous improvement of product quality, reduce the production cycle of products.

4. Conclusion

With the application of MBD technology, the advantages of 3D model process digitization, such as lean manufacturing and paperless production site, are paid more and more attention by designers, how to label the process information in 3D model in order and norm is the key technology of the process information, which is oriented to a large number of non-geometric information. In this paper, the 3D design and manufacture module based on MBD technology is developed by taking the 3D process digital design of a certain type of shielding box component as an example, the application of 3D model process information digitization, regularization and dynamic visualization of process information in actual parts production will promote the practice of 3D model process digitization engineering.

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