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The Establishment of Three Dimensional Parametric Model of End Mill Based on MBD Technology

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Abstract. The dilemma of tool design and manufacturing in China is analyzed, and a new way of coping strategy is put forward. By introducing MBD technology into tool modeling, the expression frame of MBD data set in tool modeling is expounded, and the concept of parameterization is introduced in the new MBD model of end mill, and a three-dimensional parametric model of end mill based on MBD is proposed. Application of this modeling method enables the end mill model to direct manufacturing process directly in 3D, facilitating researches on the use of tools in digital manufacturing in China, simplifying production, shortening cycle times, and reducing errors and helping to meet industry standards.

Introduction

With the rapid development of manufacturing industry at present, end mill plays a very important role [1]. In order to make the progress of end mill design / manufacturing easier and faster, this paper introduces a MBD technology in tool modeling as it is a high-performance free-form surface processing tool, so that the exchange of information between design and manufacturing cannot entirely rely on the integration of information systems while maintaining an effective connection. It can express the designing idea of end mill better through a series of standard methods, and has a stronger expression force, while breaking the design / manufacturing barriers [2]. The design / manufacturing features can be easily read by computer and engineering staff rather than the traditional definition of method can only be interpreted by engineering staff, this effectively solves the design / manufacturing integration issues [3]. Due to kinds of different angles and sizes of end mill, modeling process becomes more complicated. If different edge diameters and parameters of the end mill need to re-establish a model, it will make the modeling process very cumbersome which will result in low design efficiency and extended production cycle. Therefore, the parametric design process of cutting tools has become an urgent focus research. The structure and shape of end mill have certain standards and they are a serialization of products, the same type of end mills have the same or similar structural features, but size, angle and other parameters are different [4]. Based on the analysis of the MBD technology concept and connotation of the technology, a parametric technology is introduced into the MBD model and a new parametric modeling of the end mill is established.

The MBD Dataset in the End Mill

The MBD dataset integrates all information of the whole product, from the beginning of the design to the final assembly of the whole process, and including the geometric and non-geometric information of products as well as the information in its 3D model [5]. The MBD dataset of the end milling cutter is classified in detail, as shown in Fig. 1.

The MBD dataset for a complete tool contains a variety of information functions; the geometric set of 3D tool model is associated with 3D geometric information of tool, the tool process information and information on tolerances, dimensions and notes necessary for the manufacture of the tool [6]. Through the MBD dataset, we find that the entire MBD dataset contains two categories of data:

(1)Geometric information of the tool, it refers to the design model of the tool, which contains a large number of shape features: holes, grooves, cavities, points, lines, etc. [7].

(2)Non-geometric information of the tool, these non-geometric information are usually stored in the specification tree, they do not exist alone but attached to the geometric shape of these design models, such as size, tolerance, roughness, etc. However ,there are still some non-geometric information are not associated with the design model, but they exist alone in the specification tree of MBD data set , such as annotation, heat treatment methods, etc. [8].

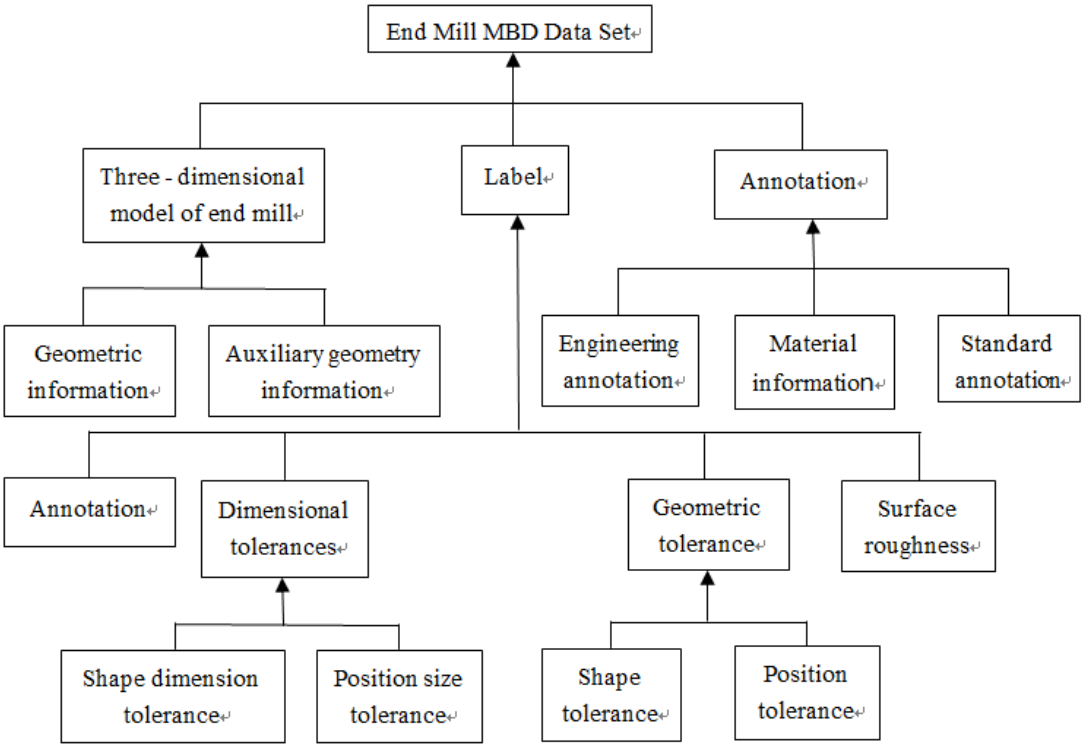

Figure 1. MBD dataset of end mill

The 3-D Parametric Modeling of End Mill Which Based On MBD

Parametric design is a subject which is put forward in the practical application of CAD technology, that is to establish the corresponding relationship between the graph constraint and the geometric relation and the dimension parameter, by changing one or more dimensions of a figure, or modifying the part parameters that have been defined, it automatically responds to changes in the size of the relevant part of the graph, thereby completing the driving of the graph [9]. In the traditional design method, the product design cycle is long, repetitive workload is large, the design efficiency is low, leading to the lack of competitiveness of enterprises, to seek a new design methods will be imperative, the parametric design method came into being. Compared with the traditional design method, the biggest difference is that parametric design stores the whole process of design, and it has incomparable advantages for the parts with similar structure design. After more than ten years of development and application, parametric design is proved to be an advanced and efficient design method [10].

End Mill Modeling. This paper used nine sets of standard data in "GBT6117.1-2010 Straight End Milling Cutter" as an example. Through the following modeling process three-dimensional solid end mill model can be established, and it associates with other dimensions in the modeling process, a template based on the MBD parameterized end mill is obtained. The modeling process is shown in Fig. 2, and the form of the end milling cutter is shown in Fig. 3.

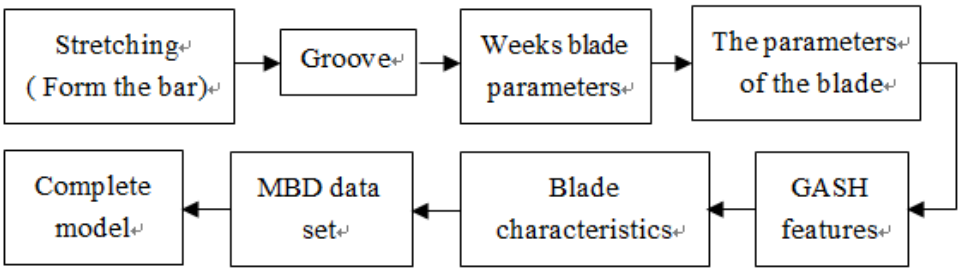

Figure 2. Modeling process

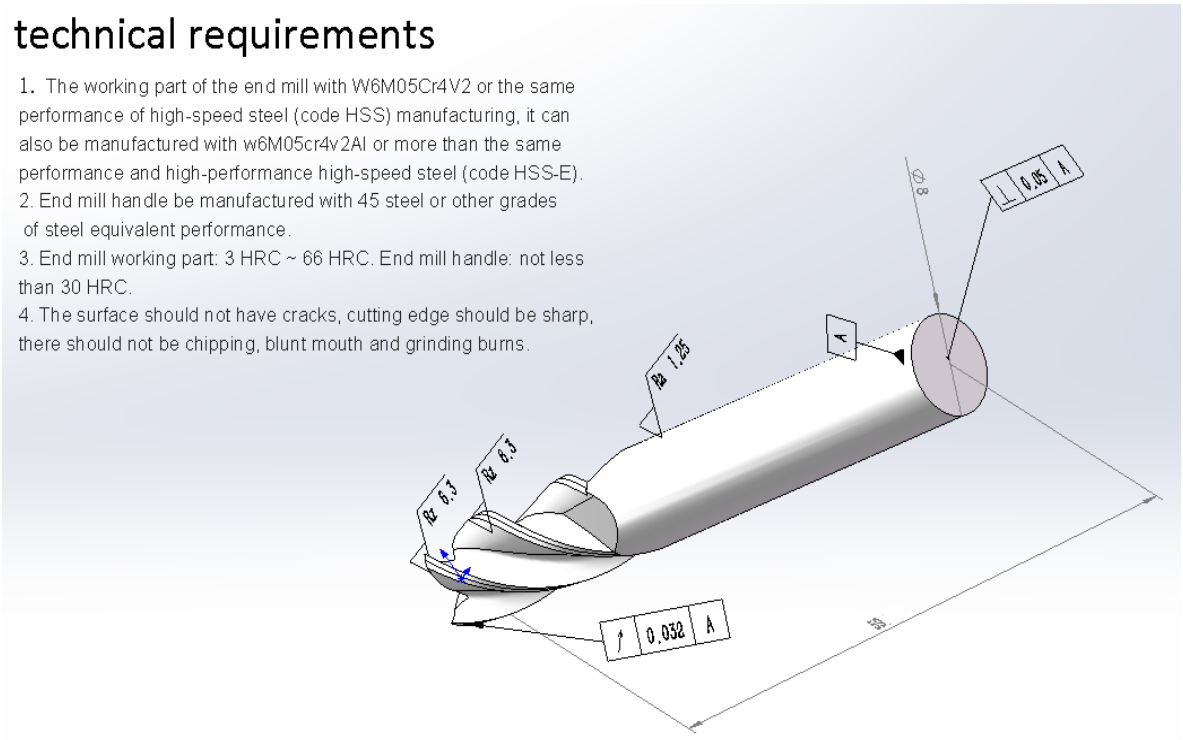

Figure 3. Generates the end mill template

Generate Parametric Model of End Mill. Here part of the parameterized data is inserted into the Excel table taking 9 groups of standard data in "GBT6117.1-2010 Straight Shank End Milling Cutter" as example. Using the parameterized model that has been built to change the parameter values, nine standards short-edged end mill models of different sizes are generated. The data sheet is shown in Table 1, and the resulted parametric model of the overall end mill is shown in Fig. 4

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Table 1 The key parameter table of parametric modeling of end mills [unit: mm]

serial number	Blade diameter d	The length of the cutter L	The blade helix lead P	The blade length l
1	9	69	45	19
2	10	72	50	22
3	11	79	55	22
4	12	83	60	26
5	14	83	70	26
6	16	92	80	32
7	18	92	90	32
8	20	104	100	38
9	22	104	110	38

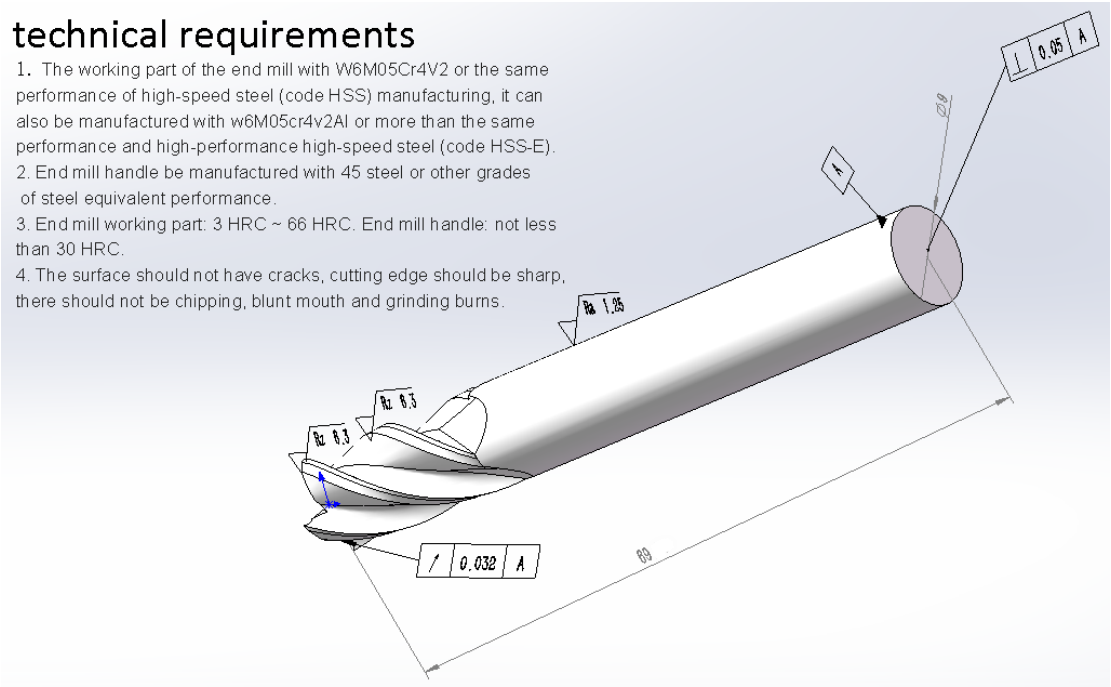

Figure 4. Parametric model of end mill

Introducing MBD technology in tool design / manufacturing makes the three-dimensional solid model become the only basis in manufacturing, changed the traditional manufacturing methods which gave priority to engineering drawings while the three-dimensional solid model supplemented by manufacturing methods. There are three advantages: 1. Realizing a single data source to ensure that the uniqueness of the tool design data; 2. Eliminating inconsistencies possibility between the dual-source data; 3. Making tool data management more convenient and improve data security.

Conclusion

This paper mainly introduces the conception of MBD and datasets by a detailed way. Based on the MBD technology, the MBD model of the three-dimensional parametric milling of the whole end mill is established; all process information in a three-dimensional tool can be completed under the integrated environment are found, without two-dimensional drawings. Compared with the previous two-dimensional drawings, three-dimensional process can be very intuitive to see the formation of each model process, as well as the relationship between all the machining information and the machined features in each process, which will help enterprises reduce the overall end mill time to be listed on the market to reduce operating costs, and help users address design challenges in specific industries and make the MBD technology system have a qualitative leap in the cutting tool manufacturing.

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