The virtual manufacturing technology application in modern mould

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Abstract—Virtual product, mould design, mould manufacturing, virtual assembly and virtual mold tooling adjustment methods, skills are discussed in this paper. The mould of virtual manufacturing process on automobile panels is studied. The results show that the development of CAD/CAE/CAM technology in mould industry application scope is expanding. Domestic mould manufacturing has been developed quickly by relying on scientific analysis of autonomy instead of on experience according to the development of die forming process of computer numerical simulation technology. The development cycle and the production cost can be reduced, and the production efficiency and product quality can be improved for the virtual manufacturing technology application in mold industry. Simultaneously mold industry has a fast response, continuous changeable adaptability, high quality standard selectivity and low cost to the market. By dynamically combination technology, using every entity CAD/CAE/CAM integration technology for the whole project to provide strong technical support, the global optimization can be achieved. Therefore, it is the important auxiliary means of mould design and production.

Index Terms—virtual manufacturing; mould design; mould manufacturing

I. INTRODUCTION

Virtual manufacturing (VM) is a new kind of manufacturing technology. It can build an unified modeling based on simulation technology, information technology and virtual reality technology. The process of the unified modeling can simulate the manufacturing process in real-time and parallel operation, which is also affected the design of the production. It makes one feel the performance or manufacturing system state of future product before its physics come into reality, which make factories organize production with more effective, more economical and more flexible manner. The reasonable allocation of resources to develop new products can achieve successful one-time product development cycle and minimization of the cost as well with the quality of product design and production efficiency optimization. Thus the prospective decision can be made to optimize the operated plan[1].

The main characteristics of virtual manufacturing are:

(1) Virtual manufacturing is not true manufacturing, but in the manufacturing of computer and network system related with software. The machine tool is not the substances but systems and related software performed.

(2) Virtual manufacturing deals with the information and data of the product and manufacturing system. It mainly contains the digital model of product and manufacturing equipment, rather than physical reality raw material.

(3) Virtual manufacturing processing results are digital products, rather than the real material products. The result is a physical model of digital products, which is a virtual product, and is a real product in a virtual environment. Therefore the virtual products must have characteristics and performance of real products[2].

(4) The manufacturing activity and management of an enterprise is based on Internet or Intranet. The entire virtual manufacturing activity is highly parallel. The simulation of product design, processing and assembling process can be parallel operated.

(5) Virtual manufacturing is a disperse system. Personnel and equipment can be separated. The technical personnel from different places can finish the same virtual manufacturing process through the network.

II. VIRTUAL PRODUCT AND MOLD DESIGN

Generally the mould design by using computer can not effectively and reasonably combine the product design, mould design and mould manufacturing. Thus, in actual manufacturing process, there are more modification, rework, and assembling which doesn't satisfy the requirements of users, and is out of the mould design production flexibility.

The virtual design process of virtual manufacturing technology can overcome these shortcomings, because the virtual design can make full use of the existing CAD software based on the design platform of features which better reflects the design idea for assembly design and manufacturing design. During virtual design process, virtual assembly and virtual manufacturing technology can be fully used on the virtual assembly plan, thus the disadvantage of preliminary design scheme can be removed in early detection of virtual assembly and design issues. The future development direction of mould design is on the basis of virtual 3d CAD design. According to the 3d description of product, the main parts such as cavity, die cores, punch and die can be rapidly determined. Then formwork can be selected from the formwork libraries and other auxiliary parts can be quickly generated from the standard library. Thus the time of virtual design can be greatly shortened. It can provide complete product model of 3d data which is suitable for different applications. The
three-dimensional product engineering drawings can be generated according to 3D data.

III. VIRTUAL MOULD MANUFACTURING

Virtual mould manufacturing fully uses the computer simulation. On one hand, the virtual manufacturing technology is used in the mould. On the other hand, the design of mould can be considered from the perspective of manufacture. It can provide guidance to the design optimization and also provide analysis and auxiliary tools for the optimization of manufacturing process. During virtual mould manufacturing process, the various parts of the mould processing method, machine tool, process parameters selection, and the process of possible processing defects are all in virtual manufacturing process, and the transferring information are all data.

Milling simulation processing is one of the most widely used processing methods. Virtual milling process can simulate and forecast various transformations of the dimension and physics related to the actual milling job such as surface milling, drilling, chamfer, curved surface milling and so forth. Milling is most commonly used in the manufacture of moulds processing method. According to a representative of CNC milling machine, all the functions from design to manufacturing can be integrated in a virtual NC milling machining environment constructed by the computer technology. In the process of simulation, the tool path and the problems existed can be observed in processing. Then the errors can be modified and NC code will be transformed into the CNC milling machine.

IV. VIRTUAL MOLD ASSEMBLY

If the product is very hard assembled, the design development of mould parts is difficult to perform though there are good designing plans and high machining precision. Mold assembly often yields design errors. In the past, all of these errors are often found until in the final assembly, thus the mould construction period is delayed, which causes huge economic losses and reputation losses. The correctness of design can be achieved and losses can be avoided due to the verification in the design stage by using the virtual manufacturing technology.

The virtual assembly process of mould includes assembly process simulation, tolerance, assembly process planning and dynamic simulation of the actual parts assembly process. It can perform large assembly roaming, thus interferences will be found. In the mould assembly, through the virtual technology, design can be intuitively performed and possible interference and other unreasonable problems can be avoided. Product design must solve various problems such as the coordinate relation of motion component, the scope of design, the inspection of possible interference, the dynamic performance, the strength, stiffness and so forth. For example, in the working line, the action coordination and cooperation is very complex. However, by using simulation technology, configuration and design can be intuitively performed to ensure the coordination work.

V. VIRTUAL MOULD COMMISSIONING

Mould commissioning mainly refers to the movement process of virtual mould, the unreasonable design should be adjusted. The mould trial stage is a marked route before the mould leaves the factory. Virtual testing is a virtual manufacturing mould product. It verifies the virtual products to determine whether the products satisfy customer demand, and then to determine whether the mould can be normally produced. For example, in the plastic injection mould, defective parts can be inspected through the virtual injection process which can also determine whether the sprue gate and mould design is reasonable, whether the mould can be normal filled[3,4].

VI. MOULD CAD/CAE/CAM IN THE APPLICATION OF VIRTUAL MANUFACTURING TECHNOLOGY

Domestic mould manufacturing has been developed on the guidance of relying on scientific analysis of autonomy instead of by relying on experience of blindness, which dues to the expanding of CAD/CAE/CAM technology in mould industry application, especially that of die forming process of computer numerical simulation technology[5]. Now, the principle and method of the virtual manufacturing technology can provide an effective means and tools for the development of the mould industry. It can also achieve optimization by the rapid reaction, continuous changes adaptability, high quality standard selectivity and low cost advantage in mould industry. The optimization for the whole project can be achieved through the dynamically combination technology and using every entity CAD/CAE/CAM integration technology to provide strong technical support.

The virtual manufacturing technology is the integration and extending of actual CAD/CAE/CAM technology. Therefore, mould industry application in virtual manufacturing technology must base on all kinds of advanced application in currently design and manufacturing technology and thorough understanding and absorption of them[6]. At present, various 2d and 3d CAD software technologies (such as AutoCAD, UG, CATIA, Pro/E MDT, Solid, Edge, etc.) develop very quickly and are easily accepted by the domestic manufacturer due to their lower cost. Therefore the application of CAD technology in mould enterprise is already widely used and the technology has become the indispensable tools for the size calculation of the mold and the geometrical modeling, especially for the geometrical modeling of complex parts. CAM technology plays significant effect in mould manufacturing, especially in precise mould manufacturing. The mould cavity geometric data can be directly transformed into the path of tools. Consequently the results are transformed into numerical control (NC) code. In domestic enterprise, the application of CAE technology (It mainly represents the simulation technology in mold filling and solidification process.) is less than foreign country. The technology is still in theoretical research and experimental application. One reason is that foreign commercial simulation software is very expensive. On the other hand, there is not a kind of suitable simulation software for
domestic conditions. The important task at present is to develop a kind of simulation software for die and mould industry. At the same time, the product data management (PDM) software also must be developed quickly. The application of CAD/CAE/CAM integration technology (that is sharing unified database) can promote the establishment of CAD model. All the data are automatically modified with the relevant update data in the stage of CAE/CAM. All of these will help the mold production process to be agile and economical, as well as the production management and control to be efficiency and intelligent.

VII. THE DEVELOPMENT OF VIRTUAL MANUFACTURING MOLD ON AUTOMOBILE PANELS

Fig. 1 shows the development process of mould virtual manufacturing. At first, the desired production is analyzed, and then concept design is performed. After that, the optimized design and system integration can be performed. In a virtual environment, the virtual product model can be constructed by using relevant software [7]. This is a gradual process. According to the product development requirement, virtual model function, the behavior of simulation model and performance of the virtual simulation analysis are compelled by adopting corresponding simulation analysis tools. Then modeling and simulation analysis are repeated which bases on the results of the simulation analysis. When the improvement and model of virtual manufacturing mold meet the original design objective, then the real manufacturing is expected to start. Fig. 1 shows that before the automobile panels being put on production, all the production has gone through the inspection of virtual practice. Thus the potential difficulties of production and unreasonable design can be removed through the virtual analysis. Then all the design can be modified or redesigned until the entire manufacturing process can be reasonably and smoothly finished. Therefore it can not only shorten the period of development cycle and reduce the cost of development, but also can improve the quality of products [8].

VIII. CONCLUSION

Virtual manufacturing technology will become an inevitable trend in the development of manufacturing industry in the 21st century due to the accurate simulation in the product life cycle and control ability of the product. The application of the virtual manufacturing technology in mould industry can reduce the time of development cycle, improve the production efficiency and product quality, and reduce the production cost. Therefore, virtual manufacturing mould industry will be in gradually applied in China with the improvement of comprehensive national strength and unremitting efforts of die designing and manufacturing workers. Consequently, the overall levels of the mould design, manufacturing and management can be improved. The virtual manufacturing technology and related technology will make the whole manufacturing industry achieved the second transformation of production manner.

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REFERENCES


Fig 1 Virtual Manufacturing Procedure of Automobile Panels