Simulation of Mechanical NC Machining Based on CAD/CAM

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Abstract. In order to solve the problem that the actual utilization rate of simulation technology in the design of modern industrial parts is not high, the author proposes a simulation system based on machining Computerized Numerical Control (CNC) parts. The system combines the numerical control machine tool simulation analysis software VERICUT with the CAD/CAM software PRO/ENGINEER, and carries out the motion simulation of the complex mechanical system twin-cylinder engine, and completed the simulation processing of the crankshaft die for typical parts, and verified it with the actual experiment. The result obtained is as follows: After optimization, the whole processing man-hour is reduced by 38.43% compared with the man-hour before optimization. Furthermore, the yield rate is increased by 23% after optimization after optimization. It shows that it is an effective method to use VERICUT system and PRO/ENGINEER to carry out complex mechanical motion simulation motion and numerical control machining simulations to achieve complete simulation from design to machining with reliability.

Keywords: CAD; simulation; machining; CNC machine tools
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1 INTRODUCTION

In recent years, with the development and popularization of numerical control technology and computer-aided design, analysis, and manufacturing (CAD/CAE/CAM technology, the machining industry has undergone fundamental changes, computer-aided (CAM) and CNC machining technology has become an important symbol to measure the technical level of a processing and manufacturing enterprise. Computer Aided Manufacturing (CAM) is the core of the computer integrated manufacturing system CIMS [1, 2]. In fact, the function of the CAM system directly determines the success or failure of the entire product production process, and the benefits of CAD are ultimately reflected through CAM [3, 4]. In the current machining industry, the product update cycle is getting shorter and shorter, the product quality requirements are getting higher and higher, and the shape of the parts is getting more and more complex, therefore, the CNC machining technology combined with the CAM system will become the most important machining method in the manufacturing industry [5].

Mechanical manufacturing is an engineering discipline, and it is also a complex and dynamic process, including a series of links such as production and technical preparation, blank manufacturing, parts processing, product assembly, and production services, it is not only affected by the properties of raw materials, density and other attribute factors, but also by multiple factors such as fluid rheology and heat transfer during manufacturing and processing [6].

Therefore, in order to calculate or simulate the mechanical manufacturing and processing process, it is not enough to only incorporate basic subject knowledge such as materials science, rheology, chemistry, physics, and mechanics, lots and lots of experiments are needed, obtain more accurate parameter values of raw materials, manufacturing process and processing process. However, according to the current situation of mechanical manufacturing, accuracy is the most basic requirement for numerical simulation or modeling in the practice of mechanical manufacturing, and it is also one of the most difficult goals for simulation design or modeling [7, 8].

In the process of CNC machining and production, CNC professionals are required to have strong operational capabilities, be familiar with CNC machine tool operations and manufacturing processes, and master data program programming capabilities, this not only requires understanding of relevant theoretical knowledge, but also practical training is more important. If you just draw nutrition from theoretical knowledge and lack the blessing of practical training, it may form an embarrassing situation of talking on paper [9,10]. With the development and application of technologies such as virtual reality, simulation software has gradually been popularized and applied in the field of CNC machining, however, in the early stage, many numerical control simulation software had great limitations, and there were many obstacles in simulation training [11].

After a period of development, the functions of the current CNC simulation software have been continuously enhanced, focusing on the simulation of CNC milling machines, lathe parts processing, etc., it can realize functions such as selecting fixture tools, setting part benchmarks, and editing CNC programs, and is suitable for a variety of CNC systems and machine tools [12]. At present, there are many types of CNC simulation software in China, although each software is slightly different, they all greatly improve the performance of CNC simulation software, it solves the problems of high price of numerical control equipment and real operation safety, and the operation is simple and convenient, which provides a lot of convenience for professional teaching and production practice [13, 14].

However, simulating or modeling such a complex and dynamic process, it is impossible not to simplify some links or adjust some steps and parameters, and the error brought by the process of simplification or adjustment is fatal to the actual engineering effect [15]. Computer-aided technology with powerful computing power and high computing accuracy, after decades of efforts, it has been gradually applied to machinery manufacturing and processing, and has played an increasingly important role in temperature prediction and fluid fluidity prediction in machinery manufacturing and processing, it can improve the accuracy of the simulation design or modeling process, predict the problems that may occur in the practice process, and improve the quality of the final product [16]. This also means that the application of computer-aided technology in mechanical manufacturing and processing is the general trend.

2 LITERATURE REVIEW

Simulation technology, or simulation technology, is a technology that uses one system to imitate another real system. Due to the development of computer technology, simulation technology has gradually become a self-contained system, it has become the third basic method for human beings to understand the objective laws of nature after mathematical reasoning and scientific experiments, and it is developing into a universal and strategic technology for human beings to understand, transform and create the objective world. At the same time, people's expectations for simulation technology are getting higher and higher, in the past, people only used simulation technology to simulate a certain physical phenomenon, device or simple system. Now, people are required to use simulation technology to describe complex systems, even systems composed of many different systems. This requires that simulation technology needs to be further developed, and other related technologies should be absorbed and integrated.

With the development of simulation technology, the application purpose of simulation technology tends to be diversified and comprehensive. Simulation techniques were initially applied as an aid to experiment with real systems, and later for training purposes, the application of simulation system now includes: System concept research, system analysis and design, system feasibility study, system development, system operator training, system prediction, system testing and evaluation, system use and maintenance, etc. Its application field has developed to military and various important fields related to the national economy. Today, with the gradual development of science and technology, any high-cost scientific and technological research activities are inseparable from the simulation system to ensure the rigor and correctness of scientific research results. With the development of simulation technology, the simulation industry has become a new type of industry with considerable scale [17].

CNC machining technology is the foundation and core of advanced manufacturing technology, and CNC machine tools are the basis of factory automation, the popularization of CNC machining technology will bring about huge changes in modern manufacturing technology, the numerical control rate is a symbol of the modern level of a country's manufacturing industry, the development of numerical control processing technology directly affects the improvement of the manufacturing level of the national economy, with the continuous development of electronics, optics, and fine products, higher requirements have been placed on the cutting process in terms of productivity and machining accuracy, and simulation manufacturing is an important means to solve this series of problems.

CNC machining technology mainly refers to the control of special machine tools with numbers recorded on the media, a programming technique that enables it to automatically complete prescribed programming tasks. The use of CNC machining can ensure that the product achieves extremely high machining accuracy and stable machining quality; The operation process can be automated; the production preparation cycle is short, which can save a lot of special process equipment and meet the needs of rapid product replacement. It is closely connected with CAD, and can directly generate processing instructions from the digital definition of the product, so as to ensure that the product has accurate interchangeability and coordination; The product is finally inspected by a coordinate measuring machine, which can strictly control the shape and dimensional accuracy. The more complex the shape of the part, the higher the machining accuracy, the more frequent design updates, and the smaller the production batch, the easier it is to exert the advantages of CNC machining. NC machining programming technology plays an important role in the production of modern mechanical products and has been widely used.

The CNC machining simulation system can complete the whole process of CNC machining such as input and output of CNC machining programs, work piece processing, CNC machine tool operation, and virtual measurement on the computer screen, in this simulation processing environment, the processing operation method of CNC machine tools can be mastered by learning [18]. Therefore, through the CNC machining simulation system, the training can not only achieve the purpose of physical operation training, but also greatly reduce the investment of expensive equipment.

To sum up, the author uses the CAM software Pro/ENGINEER Wildfire3.0 to perform CNC machining on a typical mechanical system, a two-cylinder engine, for a typical crankshaft die, and generate a CNC tool path trajectory. Then use VERICUT and Pro/ENGINEER Wildfire3.0 software to build a three-axis vertical milling machine of model DM2418C, the created three-axis vertical milling machine not only has a similar structure to the real machine, but also has the function of machining simulation. It has made a practical attempt for the development of modern industry and has practical significance.

3 RESEARCH METHODS

3.1 Mechanism Kinematic Simulation

The mechanism is composed of components, and each component is connected to at least one other component in a certain way, so that the two components are in direct contact, and the two components produce a certain relative movement [19].

The premise of performing mechanism motion simulation is to create a mechanism and both the creation of a mechanism and the assembly of parts is to assemble a single component into a completed mechanism model, so there are many similarities between the two. In the assembly obtained by assembling the parts, the internal components do not move relative to each other, while the mechanism obtained from the connection can produce a certain relative movement between the internal components.

The mechanism motion simulation can be divided into 6 parts as a whole: Creating primitives, testing the model, adding modeling primitives, preparing for analysis, analyzing the model and obtaining the results. The specific flow of the mechanism motion simulation is shown in Figure 1.

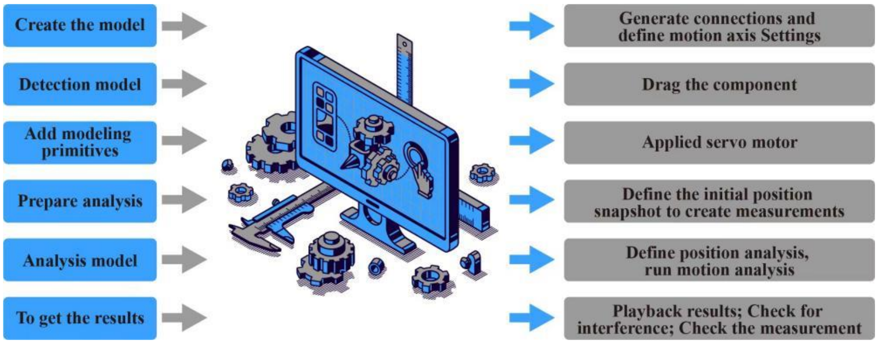

Figure 1: Flow chart of mechanism motion simulation.

3.2 NC Programming

The automatic programming is realized by the numerical control automatic programming system. Automatic programming consists of two parts, hardware and software. The hardware mainly includes computers, plotters, printers, punching machines and other peripheral devices; Software is a computer programming system, also known as compiling software, and its workflow is shown in Figure 2.

3.3 Pro/Engineer Programming

First, use the CAD part of Pro/ENGINEER to establish the part model and the blank model, and do the preparatory work. Then, the part model and the blank model are loaded into Pro/NC, and the manufacturing model is generated by assembly. Next, according to the shape of the blank and the shape of the surface to be processed and its constraint surface, the machine tool equipment and construction fixture are selected, which is the setting of the manufacturing environment parameters. The software can define the machining procedure of the machining part and automatically generate the tool path. Finally, edit and modify the tool path to generate the tool location data file [20]. See Figure 3 for details.

3.4 VERICUT Software Simulation

Using VERICUT software to simulate the processing machine tool, it can be divided into the following steps:

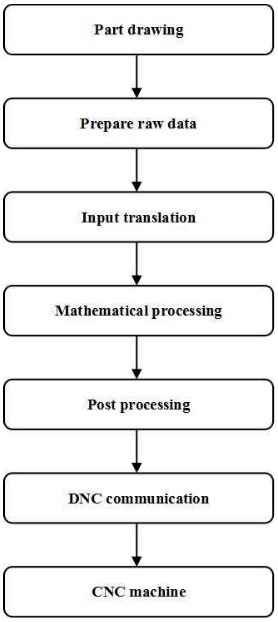

Figure 2: Automatic programming flow chart.

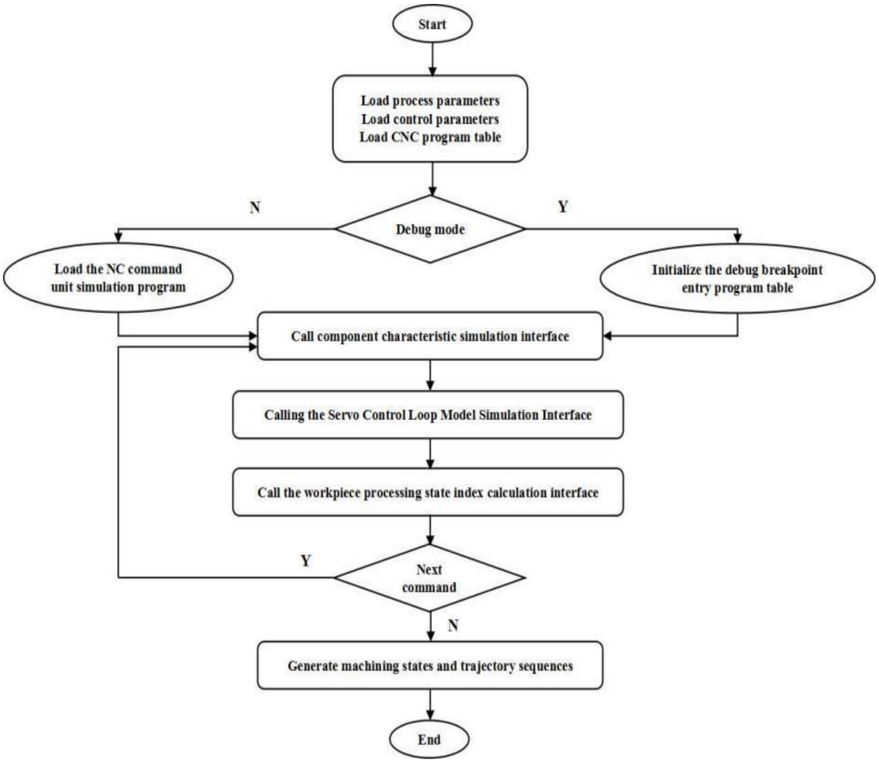

Figure 3: Pro/ENGINEER software running flow chart.

3.4.1 *Preparation stage*

CNC machine tools, blanks, fixtures, tool modeling. Create blanks, fixtures, and tools in VERICUT, and form corresponding control files, machine files, and workpiece files according to the initial position of the machine tool.

3.4.2 *Processing stage*

Set relevant processing parameters, including workpiece programming origin, tool compensation, work piece offset, etc. The NC program generated in Pro/ENGINEER is loaded into VEIUCUT, and the process simulation is carried out according to the NC program. Define the tool list to establish the corresponding relationship between the tool number specified in the code (generated NC program) and the tool number in the tool library file.

3.4.3 *Result optimization*

Compare the blank machining simulation model with the part model, determine whether there are overcuts and undercuts in the machining process, and then modify the machining parameters and tool path files. The tool path is optimized by setting the machining parameters, and the feed and cutting speed of the tool during machining is adjusted. The specific operation process is shown in Figure 4.

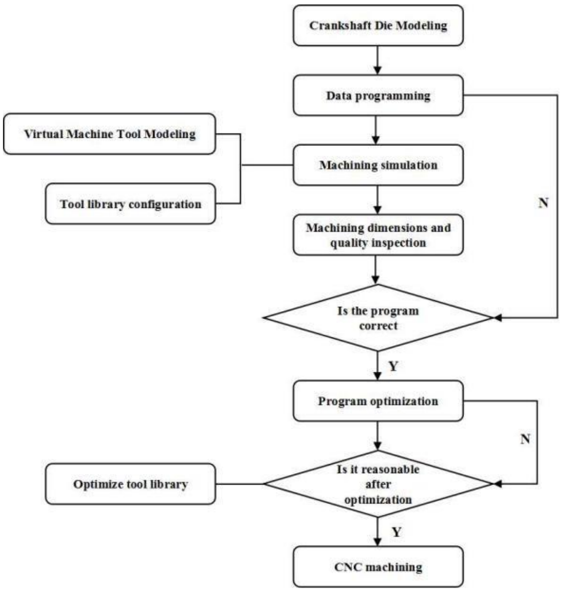

Figure 4: Flowchart of CNC machining simulation.

This program can check the collision and interference that may occur in actual processing, and verify the correctness of the NC program. Evaluate the manufacturability of the parts and the accuracy requirements to be achieved by processing, and finally process the resulting model of the designed product. It can replace the first trial cutting of the machine tool and improve the production efficiency. In addition, it is possible to understand the machining process of the designed product in the design stage, and simulate the entire actual machining process through the CNC machining instructions generated in the CAM software. Understand the machinability of the machined product based on the machining process shown by the simulation, and use this as a basis to improve potential weaknesses and errors in the design [21].

4 ANALYSIS OF RESULTS

4.1 Comparison of Processing Time

After the optimization is established, after the simulation processing of the NC program before the optimization is completed, the simulation system will automatically load the optimized NC program for processing, after the simulation processing is completed, viewing the processing man-hours before and after optimization, the entire processing man-hours after optimization are reduced by 38.43% compared with the man-hours before optimization. The author's method significantly reduces the processing time and improves the production efficiency of the workshop, as shown in Figure 5.

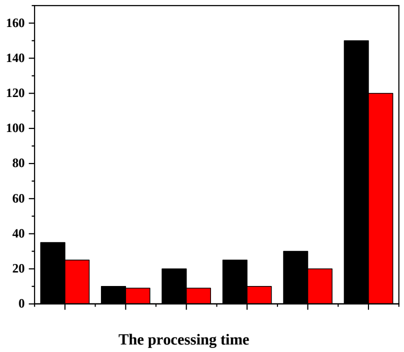

Figure 5: Comparison of processing time before and after optimization.

4.2 Yield Comparison

Select the same batch of 6 parts of different sizes and process 100 times, compare the yield rate before and after optimization as shown in Figure 6, it can be seen that the yield rate after optimization has increased by about 23% [22, 23].

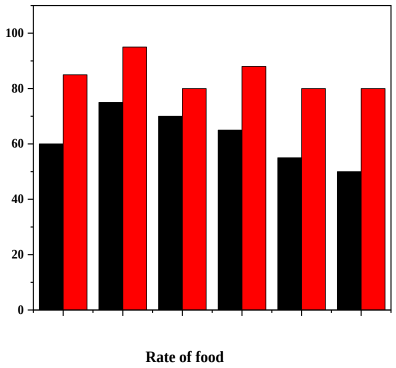

Figure 6: Comparison of yield before and after optimization.

5 CONCLUSION

In this study, the numerical control machining simulation software VERICUT is combined with the CAD/CAM software Pro/ENGINEER, taking a two-cylinder engine as an example, a three-dimensional solid model and a DM2418C virtual CNC milling machine are established, and the simulation processing of the complex curved surface of the crankshaft die is completed, and on this basis, the simulation tool path is optimized. The conclusions are as follows:

1. Establish a solid model of the main components of the twin-cylinder engine, so that the design of each component of the entire mechanism can meet the design requirements.
2. Using Pro/ENGINEER software, referring to the method of the model, the crankshaft concave die is established and the processing of the crankshaft concave die is taken as the object, the process of using CAM software system to simulate the processing of specific work pieces is realized.
3. Establish the simulation processing process of the crankshaft die, use VERICUT to test the accuracy of the simulation processing, and optimize the design of the tool path, and use the actual experiment to prove that the author's simulation model and method can shorten the processing time of the parts, greatly improve the yield rate, and improve the utilization rate of the machine tool.

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