Task optimal scheduling model of machining system based on entity modeling

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Abstract. The continuous improvement of national economic level makes people more and more demanding on machining. The key to realize the task optimization scheduling of machining system is manufacturing development. Machining process is a typical manufacturing process. The mechanical processing system transforms raw materials or semi-finished products into finished products or parts with qualified shape, size and precision through machining process, and consumes a lot of energy and material resources, and produces a large amount of waste materials, noise and other environmental emissions. Electromagnetic compatibility plays an increasingly important role in today's scientific research and national defense. In the field of electromagnetic compatibility, electromagnetic compatibility analysis and electromagnetic compatibility prediction are important methods for electromagnetic compatibility research at present. Using software technology to deal with analysis and prediction is a general method, and entity modeling is an essential part of EMC simulation software.

Keywords: Solid modeling; Machining system; Task optimization scheduling model

1. Introduction

With the rapid development of computer technology, the functions of 3D solid modeling and finite element analysis have become stronger and stronger, and the application fields have become wider and wider. Design itself is an innovation, and innovation cannot be separated from the use of innovative thinking and modern design methods. The product design process is actually the presentation process of design thinking. Therefore, a good design method is more important to designers than anything else [1]. Traditional design methods have not adapted to the fast pace of modern engineering design. The development of CAD/CAM/CAE technology has created modern design methods and provided opportunities for the development of modern design methods. With the development of human society, the manufacturing model is also changing [2]. The original manufacturing mode is product centered manufacturing mode, which is characterized by mass production of products to meet the needs of human life [3]. With the fierce competition of global economy and the individualized development of market demand, the customer-centered manufacturing mode begins to appear, which is characterized by the diversification of products to meet the individual needs of human life. At present, these two
manufacturing modes exist in our real world, guiding the production and operation of enterprises [4]. In fact, modern manufacturing industry consumes a lot of limited resources of human society and causes serious pollution to the environment in the manufacturing process of transforming manufacturing resources into products, as well as in the use and treatment of products [5]. Because of the large quantity and wide range of manufacturing industry, it has a great overall impact on the environment, and the problem of human survival begins to be touched, which brings a new change in manufacturing mode, that is, the manufacturing mode centered on the coordination between man and nature begins to receive attention [6]. AutoCAD software package has the function of three-dimensional solid modeling, which provides basic solid entities for drawing three-dimensional drawings: rectangle, cylinder, cone, ball, torus, wedge, stretching body and rotating body of two-dimensional closed graphics, etc. [7]. For some parts with simple shapes, its three-dimensional diagram can be completed by simply intersecting, merging, and subtracting a number of voxels. However, some complex parts such as spatial cylindrical cams, worm-shaped cams, cambered indexing cams, worm gears and threaded connections have complex spatial surfaces, so it is difficult to draw their three-dimensional diagrams [8]. As a key technology for building 3D solid models, entity modeling technology is widely used in computer animation, virtual reality, computer vision and other fields. Entity modeling technology refers to the information describing the shape and attributes of the geometric model coexisting in the computer, and the computer generates realistic and visual three-dimensional graphics technology [9].

2. Task optimal scheduling model of machining system

2.1 Model and method of task optimal scheduling in machining system

Production scheduling problem is a classic problem in the field of manufacturing research, which has been a very active research field in domestic and foreign academic circles. In short, the scheduling problem is to allocate the processing task set on the machine set in a certain period of time, use other production resources reasonably, and optimize a production performance index set while meeting the constraints. Therefore, time $t$, as one of the most basic optimization objectives of scheduling problem, is the most widely studied optimization objective of scheduling problem. In addition, two factors, i.e., processing quality $Q$ and cost $C$, are also considered in some studies, and the objectives such as time, quality and cost can be regarded as economic objectives of production process [10]. The machining scheme should meet the machining requirements, and by making the machining scheme and comparing its advantages, choose the high-quality machining scheme which is economical, reasonable and technologically advanced. Only in this way can the construction level and quality of machining be guaranteed, and the personal safety of workers can be guaranteed [11]. The optimization of mechanical processing methods can make better use of the needs of processing organization construction and give full play to the role of labor. Professor T. Gutowski conducted a comparative analysis of the energy consumption of two different materials, aluminum and steel, on two different machine tools, and pointed out that the energy consumption of the same material processing process is affected by the type of machine tool, and the energy consumption produced is different. As shown in Table 1.

|           | Aluminum | Steel   |
|-----------|----------|---------|
| Machining Center | 15.3KJ/cm3 | 61 KJ/cm3 |
| Automatic grinder    | 3.4 KJ/cm3 | 11 KJ/cm3 |

The optimization of machining system will produce higher economic benefits. Resources need to be reasonably optimized in order to be better used [12]. Resource is an important production factor of machining, which will produce consumption in the process of machining. In the overall development of the construction project, we should continue to optimize the procurement of raw materials, fuel, mechanical and electrical equipment. And in the process of machining, we can use a reasonable way to transport and keep the resources. Rational use of resources will improve the efficiency of resource use [13]. The rational use of resources in the process of machining construction will achieve the overall
management effect of engineering construction and ensure the effective control of machining quality and cost. When the machining system is optimized, the effect of machining management should be fully implemented. The corresponding guarantee system should be established in the process of realizing the expected goal of machining. Ensure that the system in the machining process can be optimized and improve the quality construction effect. Effectively control the construction cost of mechanical processing, so as to maximize the economic benefits of mechanical processing. Technical management should be done while ensuring the quality of machining [14]. According to the actual situation of different mechanical processing, the mechanical technology is fully implemented. Provide professional services for machining to the maximum extent. Strengthening the technical management of mechanical processing systems in the increasingly fierce market competition is the key to ensuring the improvement of mechanical processing economic benefits.

2.2 Problems of task scheduling model in machining system

The design of machining system does not meet the requirements of optimal scheduling. Machining design in the construction stage is mainly the preparation of machining technology, which can better realize the implementation of machining system design stage. The construction of machining project is mainly aimed at the improvement of organization design in the mechanical preparation stage to ensure the further standardized development of machining system content. The key point of machining system should be to ensure the confirmation of budget estimation in machining program. This can effectively control the cost of construction. Ensure that the machining design can be carried out under the machining specification, and make the machining design content more perfect and substantial. Standardization of mechanical processing design management development is the optimal scheduling of green manufacturing development. The overall quality of the designers of the machining system is poor, which can not meet the development requirements of the machining system, so that the machining technology can not be applied reasonably. This results in waste of resources in the machining process. The designers of machining systems have insufficient working experience and cannot adapt to the development trend of machining. Mechanical processing enterprises have not formed effective links with professional colleges and universities, and poor communication has led to poor professionalism of mechanical processing system designers and unable to adapt to work requirements. In addition, in the process of compiling the machining system, the application effect of new technology is poor, the labor rate is low, and a large amount of energy consumption is generated. The lack of work experience also means that the degree of green development of the machining system is relatively low. In the process of designing and compiling the machining system, there is a phenomenon of copying technical specifications, and there is no systematic analysis of the specific work situation. In the task of machining system, it does not give full play to its own role. The gear processing workshop of a machining plant needs to Hobb a batch of gear workpieces, including 6 kinds of different gears. According to the processing process card, the corresponding process data of 6 kinds of gears are shown in Table 2:

| Gear  | Processing time (min) | Loading and unloading time (min) | Completion Time (min) | Speed n/(r.min⁻¹) |
|-------|----------------------|---------------------------------|----------------------|------------------|
| Gear 1 | 23.41                | 6.51                            | 29.92                | 200              |
| Gear 2 | 9.41                 | 6.02                            | 15.43                | 150              |
| Gear 3 | 18.24                | 7.83                            | 26.07                | 250              |
| Gear 4 | 11.93                | 7.41                            | 19.34                | 300              |
| Gear 5 | 29.22                | 6.92                            | 36.14                | 125              |
| Gear 6 | 21.12                | 5.46                            | 26.58                | 350              |
3. Task optimization scheduling model of machining system based on solid modeling

3.1 Establishment of ideal scheduling model

The scheduling problem involves a variety of resource and environment attributes, so the resource and environment coefficient matrix \( RE \) is a set composed of several sub-coefficient matrices of resource and environment attributes, such as energy consumption coefficient matrix, cutting fluid consumption coefficient matrix, noise coefficient matrix and so on. The establishment of these sub-coefficient matrices is used to describe the resource and environmental factors generated by \( m \) machine tools processing \( n \) tasks in the machining system. For example, the establishment of the energy consumption coefficient matrix is used to describe the energy consumption attributes in the scheduling problem, and the coefficient matrix for each element represents the energy consumption of machining task \( j \) on machine tool \( i \). The establishment of other resource and environment attributes is similar. Therefore, from the attributes of resources and environment, the resource and environment coefficient matrix can be expressed as:

\[
RE = \{\rho, \sigma\} = [\rho^1, \rho^2, \ldots, \rho^s, \sigma^1, \sigma^2, \ldots, \sigma^t]
\]

(1)

Where \( \rho \) can be expressed as: \( \rho \) Represents the set of resource consumption coefficient matrices. \( \sigma \) Represents the set of environmental impact coefficient matrices.

At the same time, the resource and environment coefficient matrix \( RE \) in the scheduling model can also be divided into two categories, one is that the establishment of coefficient matrix can be based on the actual collected data for the related attributes that are easy to collect data or focus on. On the other hand, it is difficult to establish the coefficient matrix based on the actual collected data for the related resource and environment attributes that are difficult to obtain accurate data. Accordingly, the set in the resource and environment coefficient matrix \( RE \) is reanalyzed as follows:

\[
RE = A \bigcup \{A^1, A^2, \ldots, A^k\} \bigcup \{C^1, C^2, \ldots, C^v\}
\]

(2)

For the scheduling problem of arranging \( n \) processing tasks to \( m \) machine tools, the coefficient matrix \( A^i \) can be expressed as:

\[
A^i = \left[d_{ij}\right]_{mn}
\]

(3)

Where, \( C \) represents the set of coefficient matrices in the resource environment coefficient matrix that can be based on the actual collected data, and \( A \) represents the set of coefficient matrices that are not directly based on the actual data. The establishment of coefficient matrix in set \( C \) is mainly to obtain reasonable data. For the coefficient matrix in set \( A \), it is difficult to obtain accurate actual data due to its resource and environment attributes, so the method of fuzzy set theory is used for analysis. In addition, in set \( A \), there is another situation. Although the actual data values of its resource and environment attributes can be obtained, due to the strong uncertainty of its attributes, considering this uncertainty factor, the interval analysis method based on actual data is adopted.

The assembly model is assembled from the part model according to the assembly relationship. The entire assembly model can be set to be fully parametric, which is convenient for linkage modification, that is, the size of the part drawing can be automatically changed with the change of the size of the assembly drawing. It is also possible to automatically generate assembly and decomposition renderings according to the needs of users, that is, scene explosion diagrams. Using 3D assembly model, the surface area, mass and volume of parts and assembly model can be calculated, and the interference check and function reorganization of assembly model can be carried out automatically. From two-dimensional sketch to three-dimensional assembly model or to create a three-dimensional whole model directly, we need to analyze and design the structure of the three-dimensional assembly model directly, and from the modification of the three-dimensional assembly model to the generation of a complete two-dimensional drawing, which reflects the working idea of three-dimensional solid modeling. The key link is the accurate transmission of geometric information and topological information, and their relationship is shown in Fig. 1.
3.2 Task optimization scheduling model of machining system based on solid modeling

Three-dimensional solid modeling has powerful design function, which is incomparable to traditional manual drawing and mechanical design methods, and it has had great impact and influence on traditional design methods. Occupational health and safety produced by machining system can be divided into two aspects. On the one hand, occupational hazards, including production poisons and noise caused by cutting fluids, have been analyzed in the previous discussion. On the other hand, it is processing safety. The processing safety of a machine tool refers to the safety guarantee during the use of the machine tool. In international standards, safety standards are mandatory standards, while other standards are mostly recommended standards, which shows the importance of safety, especially personal safety, in modern life. Therefore, modern machine tools take a lot of measures to ensure the safety of the operator, to ensure the safety of machine tools and tools, fixtures. Especially, in the high-speed state, the safety protection design is more important. Based on the analysis of resource and environment attributes of machining system, the overall model of task optimal scheduling of machining system is established. The block diagram structure is shown in Fig. 2.

![Fig.2 The framework of the overall model of the task optimization scheduling of the machining system](image)

The framework of the overall model is mainly composed of two parts: one is resource and environment attribute analysis, the other is manufacturing scheduling model, and the related parameters of machining tasks and machine tools are the basis for optimal scheduling. Various characteristic parameters related to machining tasks and machine tools will have different influences on resource consumption and environmental factors produced by machining systems. These processing tasks and the characteristic parameters of machine tools related to the impact of resources and environment, in addition to considering the relevant process parameters concerned by traditional scheduling problems, also involve more other characteristic parameters. For example, for processing tasks, design parameters such as the type and size of materials have an impact on resource consumption and environmental emissions during processing. For the machine tool, its different structural design, dynamic parameters, etc., in the processing of resources and environment will be different. Therefore, more processing tasks and machine parameters are needed for optimal scheduling, as shown in Fig. 3.

![Fig.3 Machining tasks and the description of the relevant characteristic parameters of the machine tool](image)
The objectives of the task optimization scheduling model of machining system mainly include five objectives: machining time, machining cost, machining quality, machining resource consumption and machining environment impact. In the whole model, each goal has its own characteristics, and there are close relations between them.

4. Conclusions
The continuous improvement of the level of science and technology is the continuous development of the optimization and scheduling level of the mechanical processing system. As a complex production activity, the optimization of mechanical processing needs to be carried out under the guidance of reasonable science and technology, so as to ensure the effect of optimization and adjustment of the tasks of the mechanical processing system. People's awareness of environmental protection has promoted a more comprehensive green manufacturing, and the improvement of the task optimization scheduling model of the machining system has become the development trend of the machining system in the future. The labor of computer has liberated people from the tedious manual labor, and the development of computer hardware technology and software technology has promoted the reform of traditional design methods. In the aspect of engineering design, the wide application of CAD / CAE technology makes the design and analysis which can not be realized by traditional design become reality, and promotes the mutual penetration and development of various disciplines. 3D solid modeling software to better serve other applications, it is necessary to design accurate and concise expression, strong compatibility, easy to maintain and upgrade software framework. The task optimization scheduling model of machining system based on entity modeling can effectively describe the task optimization scheduling of machining system intuitively. Based on the scheduling model, the factors such as machining quality, machining time, machining cost, resource consumption and environmental impact in machining system are optimized, and finally the production efficiency is improved, the resource consumption is reduced, the negative impact of machining on the environment is reduced, and good economic and ecological benefits are obtained.

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