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Research and Design of Automatic Pipe Blanking Device Based on Adaptive Control

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Abstract: In the development of the modern processing and manufacturing industry, because of the increasingly fierce market competition, processing, and manufacturing enterprises, to further control the cost and improve efficiency, optimize the cutting technology to improve the utilization rate of raw materials. In some factories and workshops that have a demand for pipes, such as the assembly of the whole structure of aircraft, in the process of welding, assembling and molding the frame, the demand for the strength of pipes is high. Cuts made by hydraulic disk saw or toothless saw are not conducive to welding, and can't meet the use requirements, thus affecting the installation or assembly process of other spare parts and reducing production efficiency. In this paper, the design principle and scheme of automatic pipe-cutting technology based on adaptive control are discussed. It is very important to save raw materials by rationally optimizing the cutting technology and making a scientific cutting plan, to reduce the cost of enterprises and improve the benefits of enterprises.

Keywords: Cutting method, Automatic blanking, Adaptive control.

1. Introduction

Implementing green manufacturing and low-carbon manufacturing is an important way for the manufacturing industry to reduce resource consumption intensity, and reducing material consumption and the energy consumption is a concrete means for enterprises to implement green manufacturing. In the process of controlling resource consumption in the manufacturing industry, through reasonable control of energy consumption and material consumption, the cost of enterprises can be reduced, and then the operating efficiency and market competitiveness of manufacturing enterprises can be strengthened [1]. In some factories and workshops that have a demand for pipes, such as the assembly of the whole structure of aircraft, in the process of welding, assembling and molding the frame, the demand for the strength of pipes is high. Because the incision of hydraulic circular saw or toothless saw is not conducive to welding, it can't meet the use requirements, which affects the installation or assembly of other spare parts and reduces the production efficiency [2]. Optimal cutting technology is a concrete and practical technology to reduce material consumption. Optimal cutting refers to the optimal arrangement of a batch of parts with other sizes into raw materials with certain specifications under certain production conditions, to make the waste materials left after the parts are cut as little as possible [3] on the premise of satisfying constraints such as cutting technology.

When cutting pipes, whether it is a circular saw or a toothless saw, the cutting principle is that the circular disc rotates at a high speed to contact the pipes for cutting [4]. During cutting, the circular saw gradually moves down to cut the pipe to realize blanking. The cutting speed of the pipe is slow, the efficiency is low, the power consumption is high, the cut of the pipe is rough, there are burrs, and the metal sparks splash during cutting, resulting in loud noise and a poor working environment. Most of the existing devices that can realize pipe blanking and cutting functions are large-scale complete products, which need to be purchased separately, which increases the production cost of manufacturers, and the handling and installation of complete machines are also very inconvenient [5]. When the varieties of raw materials and finished products are both large, the problem is quite complicated, and artificial modeling is also very difficult. In the traditional optimal cutting stock, we pay more attention to the optimal cutting stock in a mathematical sense, but in some practical projects, it is difficult to effectively solve practical application problems such as special data structure adaptability, system integration, cutting stock process automation and large-scale multi-task integrated cutting stock [6]. Making a scientific and reasonable cutting plan by adopting reasonable cutting technology plays an active and key role in saving raw materials, and has become an important means for enterprises to save costs and enhance competitiveness [7]. Based on this, this paper discusses a design principle and scheme of automatic pipe-cutting technology based on adaptive control.

2. Optimization of Blanking Demand Analysis and Technical System

How to further improve the utilization rate of raw materials is an important issue for enterprises to save costs and enhance competitiveness. With the support of computer technology and network technology, more and more enterprises have adopted integrated cutting by concentrating the cutting tasks of several projects or by concentrating the cutting tasks of several branches, and it has become a new cutting mode. Realizing integrated cutting can reduce the purchasing cost of enterprises, and purchasing large quantities of raw materials can obtain lower raw material prices. Under the integrated cutting mode, enterprises often have independent material purchasing, nesting, cutting, and distribution departments, which can monitor, integrate and schedule the cutting tasks with the support of enterprise information systems, to facilitate the unified management and cost control of material resources [8]. The product design system is the main source of cutting stock data, and its good data communication is the prerequisite for the successful completion of multi-task integrated cutting stock. For the frequent changes in product design in the customer-oriented manufacturing mode, the system should also be able to respond quickly to the changes in product design and adjust the cutting task in time. Aiming at the problem of large-scale parts optimal layout caused by multi-task integrated cutting, the optimal solution should ensure the timeliness of large-scale parts cutting without reducing the utilization rate of raw materials. All the logical operations of the optimal cutting stock can be completed within the time range acceptable to the users, to avoid the negative impact caused by the loss of material utilization rate in exchange for time solution efficiency, and the optimal solution should be able to provide an optimal cutting stock scheme with high material utilization rate. The optimization process of multi-task integrated cutting stock is shown in Figure 1.

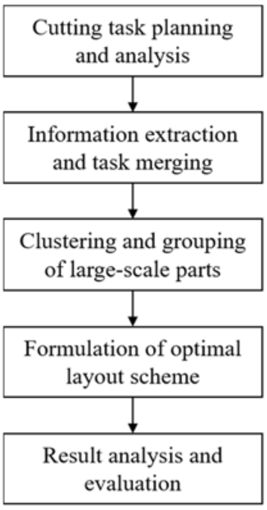

Figure 1. Optimization process of multi-task integrated cutting stock

Multi-task integrated cutting stock not only brings better economy to enterprises, but also makes it difficult for cutting stock algorithm to solve the cutting stock problem in terms of solving scale and data structure adaptability, and puts forward higher requirements for data processing capability of cutting stock system, which makes the traditional optimized cutting stock algorithm face many challenges when dealing with multi-task integrated cutting stock problem. When cutting pipes, whether it is a circular saw or a toothless saw, the cutting principle is that the circular disc rotates at a high speed to contact with the pipes for cutting. During cutting, the circular saw gradually moves down to cut the pipe to realize blanking. The cutting speed of the pipe is slow, the efficiency is low, the power consumption is high, the cut of the pipe is rough, there are burrs, and the metal sparks splash during cutting, resulting in loud noise and poor working environment [9]. In practical cutting-off problems, the types of parts are usually far greater than the types of raw materials, and the combination of cutting-off tasks of multiple projects or products in the same application field is often based on having the same candidate raw materials. Therefore, considering the differences of projects or products, the sharp increase of cutting data in multi-task integrated cutting is mainly manifested in the expansion of parts scale, and the resulting large-scale cutting problem of parts.

Parts of different projects or products for integrated blanking may come from various design systems. These systems are often developed based on different design methods, resulting in the final part cutting data and part drawings coming from different standard design models. The multi-source and heterogeneous feature information of parts makes it difficult to obtain and process optimized cutting data. The reference model with ideal dynamic characteristics in the operation process of the electric vibration machine is determined, and the adjustable controller is adjusted by the adaptive law in the control process, so that the response characteristics of the controlled system are consistent with the dynamic performance of the reference model, and the desired closed-loop performance is achieved. The adaptive control system of the pipe blanking device is shown in Figure 2.

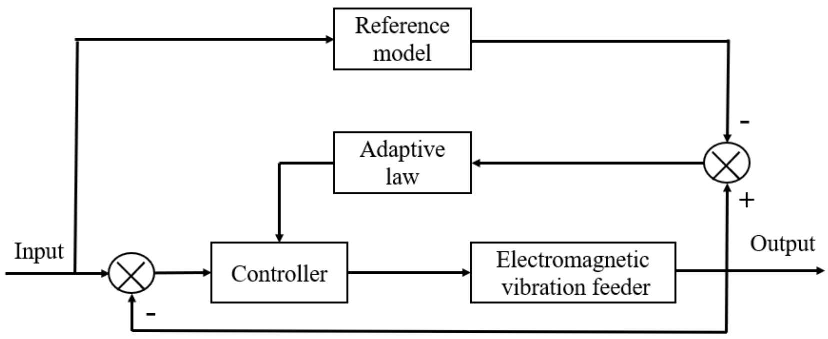

Figure 2. Adaptive control system of pipe blanking device

Most of the existing devices that can realize pipe blanking and cutting functions are large-scale complete products, which need to be purchased separately, which increases the production cost of manufacturers, and the handling and installation of complete machines are also very inconvenient. Large-scale part optimization in multi-task integrated cutting stock makes the contradiction between time efficiency and material utilization ratio of the algorithm more prominent [10]. The integration of multi-source cutting information of parts in multi-task integrated cutting-off results in the complexity of cutting-off data structure and the diversity and unpredictability of changes, which puts forward higher requirements for the stability of cutting-off solution. Otherwise, once there are some problems with unsatisfactory optimization results, it will directly affect the planning progress of many products or projects. The cutting system can not only make use of the optimized cutting results in the current research stage, but also support users or other researchers to expand or upgrade the system.

3. Technical Scheme of Adaptive Pipe Blanking Device

3.1. Automatic acquisition of blanking information

In multi-task integrated cutting, it mainly includes cutting information such as text and graphics. Among them, the text information mainly includes raw material properties, production information, process data, parts properties, etc. The functional interface provided by the system can realize the reading and writing of text information, and has relatively simple operation. In the process of obtaining complex contour information of multi-task large-scale parts, it needs to be realized by graphic algorithm. The task planning and analysis stage is responsible for counting the parts scale, parts specifications and types, raw material specifications, etc. of multiple blanking tasks, confirming the various requirements that the blanking tasks need to meet, and forming the blanking tasks with specific blanking data and indicators. If the shape of the part is irregular, it will be very difficult to input the geometric information of the part correctly. Moreover, if the number of parts is very large, a huge amount of data entry workload will be generated, and the accuracy of input information cannot be guaranteed. In this regard, with the development and application of digital and electronic technology, electronic engineering drawings are gradually widely used in this field. The shape representation method is used to describe the contour information of parts, and through the formulation of the corresponding extraction algorithm, the product contour feature information can be directly extracted from the electronic engineering drawings of the product design system, thus realizing the automatic acquisition of complex contour information of multi-task large-scale parts.

3.2. Cutting grouping optimization

In the multi-task large-scale cutting, due to the large amount of calculation, in order to improve the cutting speed, the iterative process is forcibly terminated by setting the control conditions, which can improve the solution efficiency, but will cause the loss of material utilization rate. In multi-task integrated cutting stock, it is difficult to solve the contradiction of material utilization rate and the problem of cutting stock algorithm from a mathematical point of view in the case of large-scale parts optimal cutting stock. For this reason, the original multi-task integrated cutting stock problem can be split by using the large-scale part grouping optimization technology, and some sub-problems can be obtained. Then, the sub-problems can be solved separately, and then the solution space of the original problem can be decomposed. In the stage of information extraction and task merging, firstly, the documents and drawings provided by each cutting task are standardized, and the corresponding text analysis and drawing information recognition technologies are used to automatically extract the information of part outline, quantity, material, raw material specification, quantity and technological requirements of each cutting task, and then the cutting data is preprocessed. By improving the electrical control part of the punch press, a crystal delay controller and an electromagnetic valve are added to the punch press circuit. The crystal delay controller controls the time when the slider on the punch press starts to descend, and the electromagnetic valve controls the action of the cylinder, so as to realize the linkage between the clamping of the cylinder and the punching action of the punch press. The operator can easily finish the blanking of rectangular tubes by stepping on the foot switch of the punch press, thus improving the production efficiency.

3.3. Cutting concurrent optimization

In order to solve the problems of production cost and handling, the adaptive blanking device is divided into blanking mechanism and pipe clamping mechanism, which can be directly installed on the slider and workbench of a punching machine such as a crank press or a friction press, without being made into a complete product. If only one optimized cutting algorithm or only one optimized cutting software is adopted, it is difficult to produce all good cutting results for all kinds of cutting data. Therefore, an optimization algorithm, a solution strategy, a blanking model, etc. can't be used to solve any number and variety of raw materials and parts. In the cutting task, the integration of different tasks produces a more complex cutting data structure. For different cutting stock data structures, the adaptive ability can be improved by improving the algorithm. However, in the multi-task integrated cutting stock, because of the unpredictable variety of data structure changes, the improvement speed of the algorithm is often difficult to keep pace with the data structure changes of loading and unloading. For different sub-task cutting data structures, because the single optimization cutting software is not universal, the parallel optimization technology of parts grouping can be applied in multi-task integrated cutting, and the cutting problem after parts grouping can be solved by multiple cutting software.

4. Conclusions

Most of the existing devices that can realize pipe blanking and cutting functions are large-scale complete products, which need to be purchased separately, which increases the production cost of manufacturers, and the handling and installation of complete machines are also very inconvenient. In this paper, a design principle and scheme of pipe automatic blanking technology based on adaptive control is proposed. In the clustering and grouping stage of large-scale parts, according to the determined cutting requirements, a specific combination mode of application requirements is formed, and the initial cutting task is split into multiple cutting subtasks by constructing the corresponding part grouping algorithm. In the analysis and evaluation stage, according to the various demand indexes of the cutting task, the layout schemes of each subtask are evaluated, and the overall cutting scheme meeting the requirements of users is formed by combining them. For the cutting scheme that does not meet the requirements, it can be checked step by step, and the cutting requirements can be modified to repeat the above cutting optimization decision-making process until a cutting scheme that meets the requirements is formed. Full research and reasonable application of optimized cutting technology can effectively reduce carbon emissions and resource waste. By using the optimized cutting technology, various problems in multi-task integrated cutting can be better solved, thus promoting the good development of manufacturing industry.

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