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Research on Application of Laser Quenching of Industrial Robots on Automobile Moulds

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Abstract: This paper starts from the practical application requirements of laser quenching of industrial robot molds. For the characteristics of large size, diverse products and complex shapes of automobile molds, industrial robots equipped with additional lasers are used as flexible hardware devices for induction hardening of automobile molds. An effective laser quenching robot path planning method is proposed based on engineering realization. The method effectively uses the additional laser quenching robot working space on the automobile mold, and can optimize the posture of the robot by using a redundant degree of freedom provided by the additional linear joint, thereby avoiding the robot reaching the joint limit or the singular configuration.

1. Introduction

More than 90% of the parts in automobile production need to be formed by mold. It usually takes about 1000 molds to make a normal car. The quality of the car mold directly affects the appearance quality and performance of the car. Sufficient strength and rigidity are prerequisites for the mold to be used normally, and quenching is one of the most important processes in the heat treatment process, which can significantly increase the strength and hardness of the steel. Induction quenching has the advantages of high heating speed, energy saving, high production efficiency, no pollution to the environment, and easy mechanization and automation. It is especially suitable for the performance improvement of the partial surface of the mold workpiece, such as the chamfered part. It has become a hot trend to apply industrial robots to induction hardening of automotive molds instead of manual operations. The contours of automobile molds are large, and the large molds are more than 6 meters. The rail-type robots have broad prospects in the assembly of large and medium-sized equipment and the processing of large curved surface parts.

In view of the large size of the automobile mold, the variety of products and the complex shape, the industrial robot equipped with additional laser is used as the flexible hardware equipment for induction hardening of automobile mold. Based on the engineering realization point, an effective

laser quenching robot path is proposed. Planning method. The method effectively uses the additional laser robot workspace, and can optimize the posture of the robot by using a redundant degree of freedom provided by the additional linear joints, thereby avoiding the robot reaching the joint limit or the singular configuration. For a long time, the mold quenching generally adopts a flame. . This method not only has great dependence on the operator's experience, but is easy to over-burn, and the quenching depth uniformity is poor, the mold deformation is large, the repairing workload is large, and the flame heat radiation is severe, which makes the site environment worse and lower. Work efficiency, which restricts the output of molds, becomes the bottleneck of high and fine mold production [1].

2. Laser surface modification technology

With the rapid development of the automotive industry, laser surface modification technology has developed quite mature and perfect, including laser surface quenching, cladding surfacing and surface alloying. The surface modification technology is to use a high power density laser to rapidly melt the metal matrix or metal powder on the surface, to phase change the substrate material or to form a uniform gradient structure at a very high speed. The surface obtained after laser quenching is resistant to wear. High hardness. It is found that with the increase of chromium content, the high temperature oxidation resistance of the chromium carbide alloying layer is gradually enhanced, which can significantly improve the performance of the workpiece. The finite element simulation of the workpiece such as the roll bearing due to the fatigue failure occurred during the rolling process shows the martensite transformation and residual circumferential stress in the heat affected zone. The stainless steel surface can significantly enhance the cavitation resistance of stainless steel, and the regular analysis of the material after processing [2].

3. Application of laser quenching of industrial robots on automobile molds

Although the laser industrial robot has achieved a wide range of industrial applications, it is a highly integrated system based on laser technology and robot technology. Laser processing is a complex intelligent engineering. The laser industrial robot is still in the initial stage of development, and many technologies have yet to be developed. Solve. Laser industrial robots have just begun to be applied in China, and they are still unfamiliar with the laser field and industrial applications, promoting the development and application of such technologies [3].

3.1 Laser industrial robot composition

Robots are highly flexible processing systems, so lasers must be highly flexible, and lasers are currently available for fiber transmission. The hardware configuration of the mold laser quenching robot consists of industrial robots, additional lasers, robot control cabinets, quenching tools, industrial routers, and upper PCs. The upper PC uses the mold laser quenching robot offline programming software to generate the robot control file, and the industrial wireless router can download the file to the robot's control cabinet for calling. The mold laser quenching robot executes the control file as the underlying device driver layer [4].

3.2 Laser industry robot working principle

The laser light emitted from the high-power laser is transmitted to the laser beam conversion optical system via fiber coupling and is laser-quenched. Different laser quenching is used depending on the application (cutting, welding, cladding), and different material feeding systems (high

pressure gas, wire feeder, powder feeder) are used. The laser quenching is mounted on the end of the six-degree-of-freedom robot body arm. The laser quenching trajectory and laser processing parameters are provided by the robot digital control system. The laser processing operator first teaches programming on the robot teaching box or offline programming on the computer. The material feeding system inputs materials (high-pressure gas, wire, metal powder) and laser into the laser quenching, and the high-power laser and the feeding material work in synchronization to complete the processing task. The machine vision system detects the processing area and the detection signal is fed back to the robot control system to achieve timely control of the quenching process [5].

3.3 Analysis of laser quenching process

In the laser quenching process, it is not only necessary to reach a certain point, but also needs to reach the point in the vertical posture of the workpiece and process it, so the actual working space is smaller than the total degree of freedom. In actual machining, this situation is often encountered in the calibration process: a workpiece that can be machined completely by a robot, because the position of the robot is different, the robot can reach the joint limit and many areas cannot be processed. Therefore, it is necessary to make an estimate of the working space of the robot during laser processing, and place the workpiece in a reasonable position in the working space to ensure smooth processing. In addition, in order to achieve offline programming, it is necessary to match the offline CAD track with the actual workpiece position to ensure the accuracy of the machining position.

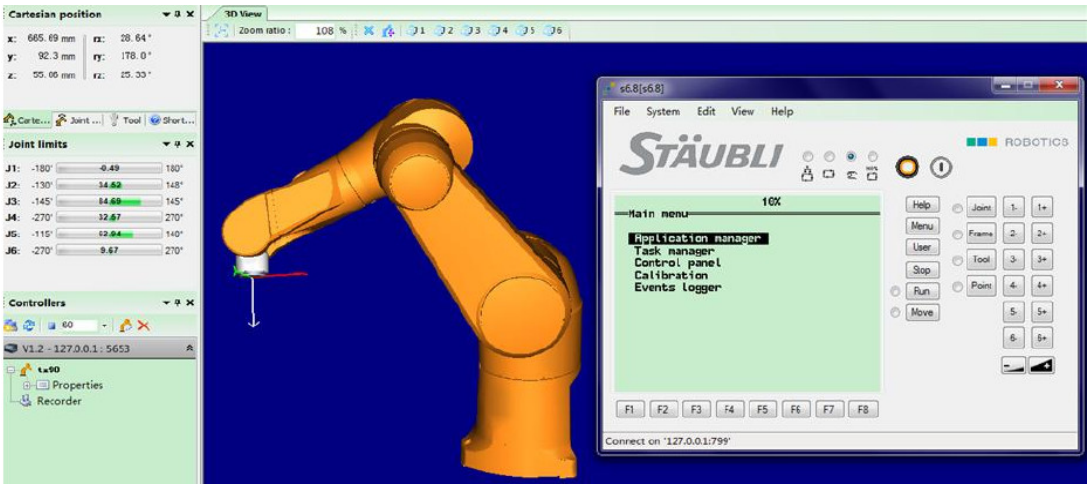

Figure. 1 Industrial robot technology model

3.4 Robot lower position machine control software

The VAL3 programming language that comes with the robot is used as the control software for the lower position of the robot. It has the following features:

A variety of connection options; establish a connection with the PC through Ethernet communication, and then communicate to achieve remote control; the teaching box can be remotely accessed, directly control the various operations of the robot arm; can realize software programming, simulate the operation of the teaching box and The robot's motion trajectory simulation enables

program debugging in multiple modes such as remote mode. Before performing the offline trajectory, it is necessary to do simulation analysis in the simulation environment to guide the actual processing.

In order to realize offline control, it is necessary to combine the above programming language and write the lower computer software to realize the expected function. After the upper computer and the lower computer establish communication connection, the PC can be remotely controlled to power on and off the PC through the PC software. Movements such as speed and path. At the same time, the program is programmed to control the laser generating device on the PC, and the combination of the two can realize the overall control of the laser surface modification quenching process on the PC side.

4. Laser industry robot control method

According to the degree of intelligence of the quenching process control, the robot can have three levels of programming.

4.1 Online programming robot control

Online programming is mainly teaching programming, which has the lowest intelligence and is called the first generation robot. Pre-set the machining path and machining parameters according to the actual working conditions, program in the teaching box, operate the robot to the required point through the teaching box, teach the robot to operate this program once, and set the position of each point. The pose is saved by the teaching box, thus forming a robot trajectory program. The robot stores the teaching action memory, and the robot performs the teaching according to the teaching program during the formal processing. Teaching programming has the characteristics of simple operation, low requirements on personnel programming technology, high reliability, and can complete multiple repeated operations.

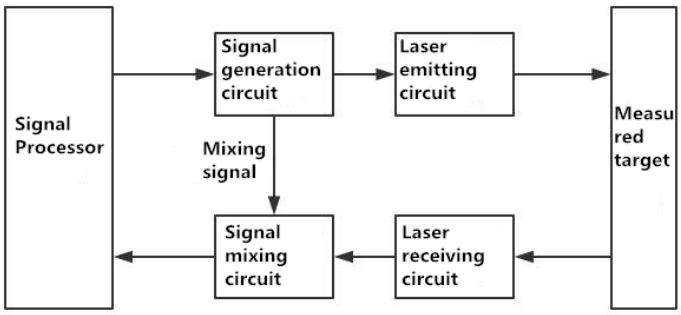

Figure. 2 Automotive mold industrial robot laser quenching system

4.2 Offline programming robot control

Off-line programming of robots means partial or complete departure from the robot. The robot program is programmed in advance by means of a computer. It can also have certain machine vision functions, called second-generation robots. It generally uses computer-aided design (CAD) technology to establish the geometric model of the robot and its working environment, and then uses some planning algorithms to control the operation and operation of the graphics, and then

perform path planning under offline conditions, and process it through the robot programming language. The module generates some code, then performs 3D graphics animation simulation on the programming result to verify the correctness of the program. Finally, the surviving program is imported into the robot control cabinet to control the robot movement and complete the given task. In addition, it can be equipped with some sensors such as temperature and shape, with certain machine vision functions, and offline programming on the computer according to the environment and job information obtained by machine vision. Off-line programming of robots has proven to be a powerful tool for increased safety, reduced robot downtime and reduced costs.

4.3 Intelligent autonomous programming robot control

The intelligent self-programming robot is equipped with a variety of sensors, can sense a variety of external working conditions, has a certain level of human-like advanced intelligence, has the ability to autonomously perform sensing, decision-making, planning, autonomous programming and autonomous execution of tasks, called the third Generation robot. Since the computer modern artificial intelligence technology has not yet achieved a practical breakthrough, the intelligent autonomous programming robot is still in the experimental research stage.

4.4 Wedge block cavity positioning mechanism control

The two main molded part cavity inserts and core inserts of the cavity are mounted in the fixed template of the mold and the frame groove of the movable template in the form of clear angle. For the cavity molding of the large mold part, the processing is completed. When assembling, it is difficult to align the center of the cavity molding with the center of the mold frame. A new mounting wedge positioning mechanism is specially designed to position and mount the cavity molding, that is, through the cavity taper. The positioning block is the degree of wedge of the wedge block in the template to adjust, position and install the cavity molding.

4.5 Mold laser quenching robot hardware configuration

The size of the automobile mold is large, and the large mold is more than 6m. It is difficult for the general automation equipment to meet the processing range. Adding lasers to industrial robots results in a multiplicative workspace and an inherently redundant degree of freedom that can be optimized for robot kinematics and dynamics through joint control of industrial robots and additional linear joints. The mold laser quenching robot hardware configuration in which the robot can move along the axis of the additional moving rail to expand the processing range of the robot.

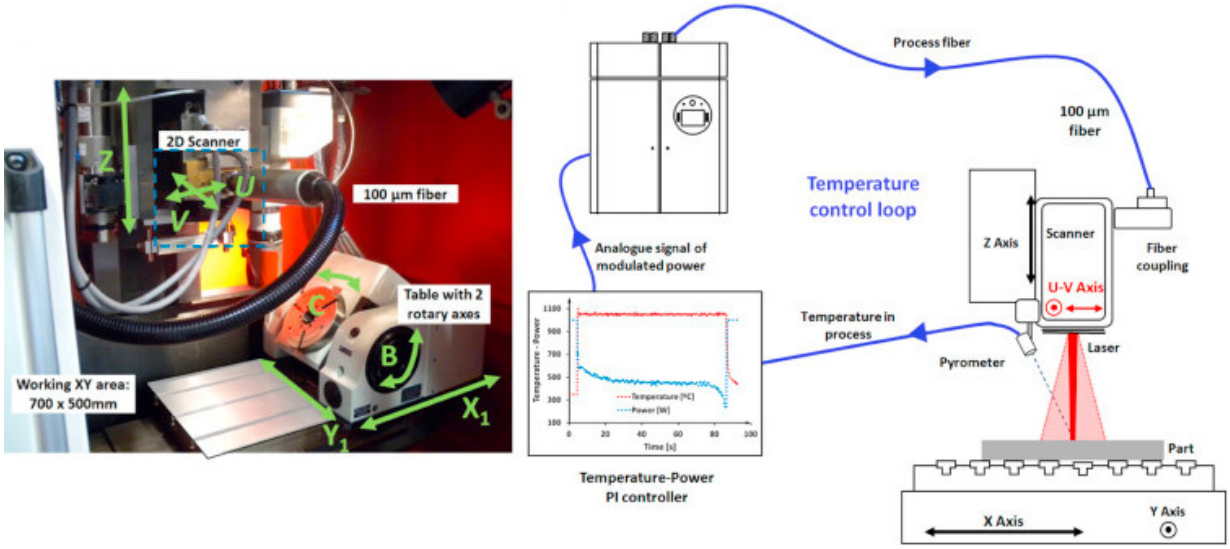

Figure. 3 Industrial robot laser quenching automotive mold system

4.6 Industrial robot track

The trajectory is generated, simulated, verified, modified, and recorded with relevant trajectory data. The main function of the process parameter setting module is to set the process parameters of induction hardening. The target track of induction hardening consists of a series of center lines of the mold to be quenched. The quenching tool moves along the trajectory at an approximately uniform speed and always maintains the axis of the induction hardening tool. The direction coincides with the surface normal. The quenching distance, the quenching current frequency, the accuracy of the target trajectory interpolation point, and the feed rate of the quenching tool can be quickly set by the process parameter setting module according to the depth requirement of the hardened layer. The main function of the target trajectory extraction module is to extract the induction hardening information of the robot, including the coordinate value and the normal vector information, from the center line of the laser to be quenched mold according to the accuracy of the target trajectory interpolation point set in the process parameter setting, and perform the quenching information. Eliminate preprocessing such as overflow points, sorting, and so on.

4.7 Industrial Robot Path Planning Module

The path planning module converts the induction hardening information that is not recognized by the robot obtained by the target trajectory extraction module into the end position and posture information recognizable by the robot. In this module, a mathematical model is established for the laser of the robot and its working environment, and the inverse kinematics solution and offline path planning of the mold laser quenching robot are completed. The path simulation module displays the robot path planning result in a three-dimensional animation form of the induction quenching robot working process, and the operator judges the robot movement and the rationality of the process in the program. The code generation module and the communication module have the functions of file generation and remote communication with the robot. The code generation module generates a complete robot control file according to the target trajectory extraction module and the path planning module processed information data combined with the output format of the robot language, and the communication module and the communication module The robot control cabinet

communicates to realize file uploading, downloading, and information feedback.

5. Conclusion

In this paper, based on the application requirements of large-scale automotive mold induction hardening process, combined with the redundant freedom robot kinematics, the laser quenching path planning of laser quenching robot mold is studied. The simulation results show that the path planning method of the laser quenching robot proposed in this paper effectively uses the robot workspace with the additional laser along its axis, and can optimize the flexibility of the robot by using a redundant degree of freedom provided by the additional linear joints, thus avoiding the robot. Reach the joint limit or singular configuration.

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