Research on the Key Technology Application of Industrial Robot in Grinding and Polishing of Pen and Electronic Industry

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Abstract. Taking grinding and polishing industrial robot as the research object, three key technologies in the process of machining are analyzed. Firstly, the selection method of grinding mode is introduced. Secondly, the tool calibration and workpiece calibration method in the process of robot running program editing are introduced. Finally, the singularity phenomenon and improvement method in the process of industrial robot operation are introduced. Through the analysis, the optimization of robot in control, programming, process and other technologies can be improved to meet the actual production needs of grinding and polishing robot seek.

1. Introduction
At present, with the rise of industrial robot technology, robot technology has been given to 3C industry (computer, communication and consumer). Electronic has brought a new technological change. Robots are widely used in spraying, welding, cutting, grinding and polishing. It can improve the disadvantages of traditional machining, such as poor working environment, great body injury, poor product consistency and difficult to improve production efficiency. However, with the wide application of industrial robots, there are still some technical problems to be overcome.

In this paper, 3C laptop industry as a research platform, analysis and research on the grinding mode selection, tool and workpiece calibration before program operation, and singularity avoidance in robot operation, in order to solve the common problems encountered in the grinding and polishing process of industrial robot, so as to improve the optimization of robot control, programming, process and other technologies to meet the grinding and polishing requirements The actual production requirements of robots.

2. Selection of grinding mode
There are two kinds of grinding methods: unit type and whole line type.

2.1 Unit automatic polishing
Unit automatic polishing is a combination of polishing and polishing of several processes, there is a unit to complete the automatic loading and unloading, polishing and polishing all the process characteristics. The integrated stacking function of robot can complete the automatic loading and unloading function of each material tray. It only needs to manually provide blank and transport qualified finished products within a certain period. Figure 1 shows an example of unit automatic grinding.
Basic programming debug unit automatic polishing process is shown in figure 2.

2.2 The whole line type automatic grinding
The whole line grinding mode is mainly integrated with multiple robots to complete automatic loading and unloading and polishing work together. It can adapt to a variety of process combinations with strong adaptability. At the same time, the production efficiency is significantly improved, the whole line only needs 1 ordinary manual loading and unloading at the beginning and end of the line to continue
Figure 3 whole line automatic polishing

According to the actual processing products and process accuracy requirements, the grinding robot can be divided into several groups, such as three working modes: first rough grinding, middle fine grinding and end polishing. The end fine grinding can also be subdivided into two fine grinding processes according to the process. The whole line automatic polishing process is shown in Figure 4.

The whole line grinding is suitable for mass production enterprises. The whole line is wet cast, free from dust pollution, and saves a large number of production workers, which greatly improves the productivity and quality of enterprises when improving the production environment.

2.3 Contrast the characteristics of the two methods

The main function of unit type and whole line type grinding is consistent, that is, it is efficient and reliable to finish the polishing task of mobile phone case. But the input capacity and other aspects of the characteristics are different.

Unit type automatic grinding has good flexibility and low investment cost. When achieving a certain number of efficiencies, independent stability (each unit to complete all processes) can be realized and is suitable for small batch. The whole line automatic grinding has high input cost, high efficiency and high productivity. It needs the high reliability and stability of the whole line and is suitable for mass production. Figure 5 shows the comparison of the characteristics of the two grinding methods.
3. On-line calibration of industrial robots

Robot calibration technique is to use a parameter identification method to process through advanced measurements of the related data of the robot to identify the accurate parameters of the robot model, so as to improve the process of the absolute positioning accuracy, the calibration method is mainly aimed at the polishing technology of off-line programming, including its main calibration workpiece and tool of calibration, calibration process is shown in figure 6[1-3].

![Diagram of calibration process](image)

Figure 6 On-line calibration of grinding and polishing process

In the coordinate calibration of the tool, the calibration tip is used to calibrate the grinding head tool tip, and the four-point method is adopted in the calibration, because the four spatial points need to form four points on a sphere in order to calibrate successfully.

In the coordinate calibration of workpiece, the tool coordinate is used to calibrate the successful tool tip, and the tool tip is used to record the workpiece origin, the workpiece X direction point and the workpiece Y direction point, among which the origin point should be consistent with the position and direction of the workpiece coordinate system in off-line programming.

Workpiece coordinate correction using have calibration tools coordinate point, good workpiece coordinate moving along the calibration, which is the center of the workpiece fixture two intersecting machining line, if the tool tip can move along workpiece line and offset, rarely shows artifacts calibration is successful, if there is deviation, correction is required, along the base coordinate rotation by default.
Tool coordinate correction, the workpiece adsorption on the fixture, calibration complete all grinding head, and install good grinding head, manual mode select the corresponding tool workpiece coordinate, corresponding grinding process, low speed running on the workpiece, the grinding head pressure from 1 to 2 mm distance, workpiece in four directions try to insert sandpaper to plane calibration, try to insert in the two direction sandpaper to side correction, if the insertion force, suggests that tool and the workpiece is relatively parallel, if there is a direction of insertion force, is the need for tools coordinate correction.

Side workpiece coordinate secondary correction calibration and correction, the main is to use has correct point in the good tools to run calibration procedures, calibration procedure is to simplify the grinding process, run to correct application of point in the program, first of all check points are consistent with the workpiece boundary distance, if inconsistent, modify the workpiece coordinates coordinate, then check the grinding head and the workpiece surface distance is consistent, if have high low, depending on the artifact calibration rotating direction and rotating sequence compensation workpiece coordinate data.

After the calibration, the program can be run. For safety, run manually first. If the operation is normal and there is no abnormal track such as collider, the program can be run automatically.

4. Singularity avoidance
The point of position on the path of the robot's working movement is that the robot moves and rotates with each other through its six joints during the working process of the robot[4-6]. With the increase of robot shaft joint, may appear singular point on the trajectory, these become the points of cartesian coordinate singularity, unable to solve the inverse operation into a robot six axis Angle, and within the coordinate system of tiny change, will cause the violent change of robot shaft Angle, resulting in mobile robot joints in an impossible way, or lock joints, or shaft moment reversal, or even cause some joint angular velocity tends to infinity or not to be up to the set speed, makes the motor load is bigger, lead to robots out of control, etc.

4.1 Common singular point attitude analysis
The singular configuration of the robot includes the boundary singular configuration and the internal singular configuration. The boundary singular configuration can be avoided by avoiding the boundary points during the trajectory planning. The internal singular configuration affects the motion performance and machining trajectory of the robot, so it must be recognized and avoided in the trajectory planning. The singular configuration of a robot is usually determined by determining whether there is an inverse solution to its Jacobian matrix. Since the singularities are related to the attitude of the robotic arm, the singularities of the six-axis grinding and throwing robotic arm are classified into three categories.

4.1.1 Singular point of wrist joint. The fourth axis is collinear with the sixth axis, and if the matrix is not full rank, the fourth axis and the sixth axis will rotate 180 degrees instantaneously as shown in figure 7.
4.1.2 Shoulder singularity. When axis 1 is col-linear to wrist center C (intersection of axis 5 and axis 6), axis 1 and axis 4 will rotate 180 degrees instantaneously. There is a special case, when axis 1 is col-linear to the center of wrist joint and is col-linear to axis 6, it will cause the system to attempt to rotate 180 degrees between axis 1 and axis 6 instantly, which is called alignment singularity shown as in figure 8.

4.1.3 Singularity of elbow joint. When point C of the wrist joint is co-planar with axis 2 and axis 3, it will cause the elbow joint to be stuck, as if it is locked and cannot move any more, as shown in figure 9.
4.2 Singularity avoidance method

4.2.1 Avoid singularity by programming. The maximum speed of each joint of robot is limited by programming. When the wrist is ordered to move at an infinite speed, the software reduces that speed. When the robot reaches the middle of the line, the speed of the robot will decrease. Once it passes through the singularity, the robot will continue to complete the rest of the motion at the correct speed.

4.2.2 Add outer shaft. Singular points often occur when two axes are col-linear. When the number of axes of the manipulator increases, the location and opportunity of singularity point increase simultaneously. However, as the number of arms increases, the degree of freedom will also increase, so there are more routes to avoid singular points.

4.2.3 Using MOVJ instruction in programming. Under the requirement of not having to move in a straight line, the joint motion is used instead of the linear motion, and the MOVJ command enables the manipulator to adjust its posture autonomously to avoid running near the singular point.

5. Conclusion
In this paper, 3C laptop industry as a research platform, analysis of three key technologies involved in grinding and polishing process, selection of unit type and whole line grinding mode, workpiece calibration and tool calibration before the operation of industrial robot program, three kinds of singularity phenomenon in the operation process and avoidance methods, the common problems encountered in the grinding and polishing process of these three key points are analyzed. It can improve the robot in the control, programming, process optimization, to meet the actual production needs of grinding and polishing robot.

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