

Design and Application of Flexible Lean Automatic Machining Production Line for Cylinder Block

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Abstract: The cylinder block is the core structure of the engine, many important parts of the engine are installed in the cylinder block, its processing accuracy determines the important performance indicators of the engine, the current customer demand for the engine to customize the change, which brings more and more cylinder block models, and the ordinary cylinder block processing production line is limited by the site, cannot meet the needs of the multi-model cylinder block processing, Reconstruction production line has high investment cost and low income, while flexible lean automatic processing production line can realize mixed line production of multiple types of cylinder blocks, can realize rapid response to the market, and the highest equipment utilization rate. Therefore, flexible lean automatic processing production line is very important in the design and application of modern cylinder blocks.

1. Introduction

The cylinder block processing line uses the horizontal machining center to realize the processing of multiple faces and related hole systems of the cylinder block. The symmetrical layout is used in industrial robots to realize the automatic up and down workpiece. At the same time, the robot flexible technology can realize the joint production of the cylinder block of different process routes in one processing line, which realizes the lean production line and makes the maximum use of the limited space and equipment utilization rate. At the same time, the investment cost is low and the processing efficiency is higher[1~2].

2. Overall layout of production line of flexible lean cylinder block

The production line consists of 6 horizontal double tray processing centers, 1 laser marking machine, 3 special planes, 3 sliding table industrial robots, 2 truss manipulators, 1 turning machine and roller conveying line. The truss manipulator grabs the workpiece from the tray to the conveying line of the roller table, and the conveying line transfers the cylinder block to the laser marking machine for marking. After the marking is completed, the sliding table industrial robot grabs it to the horizontal machining center. After the processing is completed, the sliding table industrial robot grabs it to the conveying line of the next roll table or the manual sampling station. After that, the cylinder block is divided into two roller conveying lines. One part of the cylinder block enters the special machine after adjusting its attitude through the turning machine. After the processing is

completed, the other part of the cylinder block is grabbed by the sliding table industrial robot to the processing center. After the processing of the processing center is completed, the cylinder block is divided into three routes for further processing. The first part is grabbed by the sliding table industrial robot to the special plane after manual sampling station, the second part is directly processed by the special plane, and the other part is grabbed by the sliding table industrial robot to the roller table conveyor line. Then the truss manipulator grabs the cylinder block of the two routes to the processing center after the two special machines are finished. After the processing is completed, the sliding table industrial robot grabs the cylinder block of the two routes to the conveying line of the roller table and the manual sampling station. After passing the inspection, it enters the blanking roller table to complete the processing task, as shown Figure 1 [3~4].

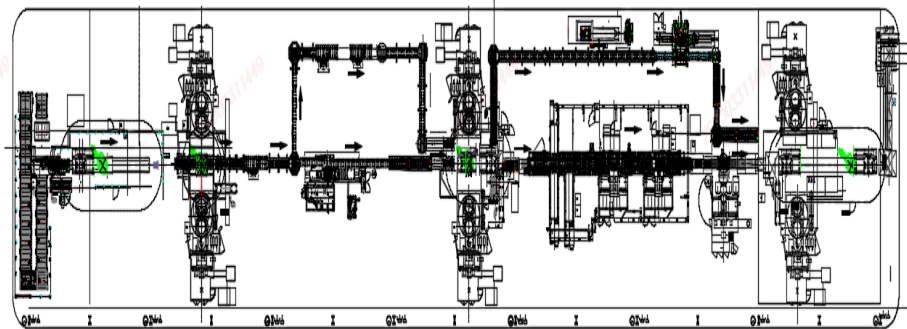


Figure 1: Production line layout diagram

3. Automation, informatization and lean of the production line

3.1 Automation of the production line

Automated production is the mainstream choice of the current production line, can greatly solve the problem of enterprise employment, at the same time to solve the safety risks brought by artificial production, quality risks, on the cylinder block processing consistency has played a very important role.

(1) The production line uses three sliding table industrial robots, which realize the automatic grasp of the cylinder block, reduce the bump, high consistency of clamping, at the same time, the sliding table industrial robot is very flexible to solve the parallel problem of multiple process routes.

(2) The sliding table robot adopts a 360° rotating manipulator to realize the free rotation of 90° and 180° of the cylinder block, and realizes the mixing processing ability of the cylinder block with different process routes and different attitudes in the same production line.

(3) The production line adopts two truss manipulator. In the limited space, the truss manipulator greatly solves the problem of insufficient production line space, and realizes the full automation of grasping, raising the automation rate of the production line to 100%.

3.2 Informatization of the production line

Information has been widely used in all walks of life. The extraction of all kinds of data and the interconnection of data can help technicians conveniently solve bottleneck problems, equipment problems and quality problems, and also realize the dialogue between equipment and equipment in cyberspace, so as to make the production more intelligent.

(1) The production line reads the semi-finished cylinder block part number information with the stationary scanning gun to communicate with the production MES, determine the cylinder block finished product engraving information, and transfer the engraving information to the laser marking

machine, laser marking machine automatically engraving, to solve the problem of manual selection error.

(2) The manipulator communicates with the machining center through PLC, realizing the communication between the grasping information and the machining center. The machining center automatically selects the CNC machining program by reading the grasping information, which solves the problem that the different CNC machining programs of the cylinder block are easy to choose the wrong artificially, and improves the processing efficiency.

(3) The production line has realized the functions of tray information storage in processing center and real-time monitoring of machine tool running state. Through the processing center tray information storage, and upload to the production MES system, can trace the processing information of each cylinder block, once the quality problem, can accurately trace the problem cylinder block, and through the implementation of data collection, record the machine tool running time, processing beat, equipment failure and other information, at the same time upload the information to the general control platform. It is very convenient to view the operation status of the whole production line, which is conducive to technical personnel to solve the production bottleneck and equipment problems.

3.3 Lean production of the production line

Ordinary processing production line can only exist 1 process route, this production line combined with the site, design 2 different processing process route cylinder block fusion into 1 process line production, effectively use the space of the production line, maximize the utilization of equipment, greatly improve the balance rate of the production line, reduce the manual detour between processes, reduce the running time of the production line. Reduced production waiting waste, backlog waste of products in process, handling waste, improve the utilization of space.^[5]

4. The key technology of automatic processing of production line of flexible lean cylinder block

4.1 Slide bench-type industrial robot

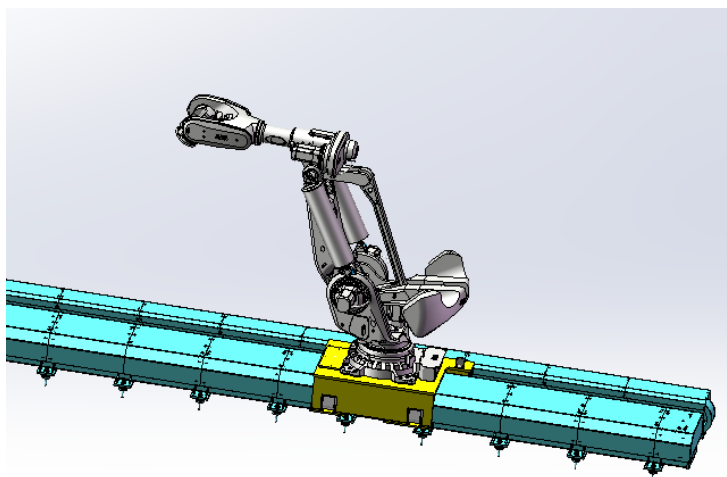


Figure 2: Slide desktop industrial robot

The production line uses three sliding table robots, which mainly undertake the cylinder block conveying, grasping and other functions. The sliding table robot is composed of six-axis robot, sliding table main body, robot base, sliding table protection and so on. The main body of the sliding

table adopts an integrated welding body, and the modular design is convenient for splicing and assembly. The imported servo motor and reducer are used to drive the sliding table to ensure smooth operation and fast response speed. The sliding table adopts fully enclosed protective structure to ensure that the cutting fluid does not fall on the guide rail, rack and drag chain cable in the process of robot grasping the cylinder block, as shown Figure 2.

4.2 Truss manipulator

The production line adopts two four-axis truss manipulator to grasp the cylinder block in the local space. The truss manipulator is mainly composed of column, beam, Z axis, grasping mechanism, driving component and rotating mechanism. The rotating mechanism realizes the change of the cylinder block loading attitude, as shown Figure 3.



Figure 3: Truss manipulator

4.3 Quaxis 360° free rotating manipulator

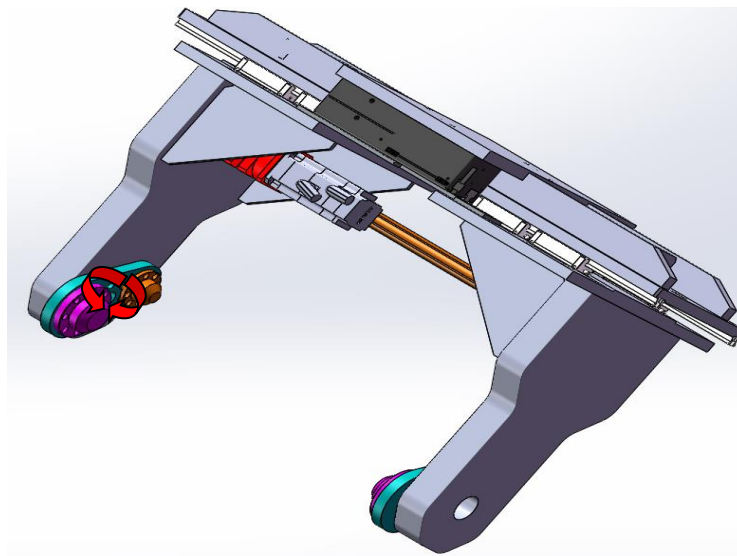


Figure 4: Quad-axis 360° free rotating manipulator

The manipulator is installed in the sliding platform industrial robot, mainly used for accurate grasp of the cylinder block, which is composed of an integrated welding frame body, clamping, servo motor + reducer, transmission device, variable distance mechanism, arm, synchronous rotation mechanism and clamping mechanism, can realize the free conversion of 90°, 180° and other angles of the cylinder block. In order to meet the requirements of different processing units on the cylinder block of different posture, and has the function of turning the cylinder block water control, automatic variable distance mechanism to realize the different types of cylinder block sharing the same manipulator function, improve the efficiency of the actual production, as shown Figure 4.

4.4 Data

This production line combines laser two-dimensional code, code reader, PLC, RFID, sensor and CNC system into a complete set of Internet of Things system, realizes the communication between cylinder block and robot, roller conveying line and robot, robot and CNC machining center, and completes the interconnection between machine information, production MES and robot control system. The tray of the machining center is transformed to realize the anti-error detection of the tray clamping mechanism. The interconnection and interworking of these data protect the robot to the greatest extent. The cylinder block of the machining center is connected with the blank number of the cylinder block and the finished part number of the cylinder block through the transformation of relevant software of the CNC machining center, and the CNC machining center automatically selects the machining program according to the cylinder part number. At the same time record the cylinder block in the NC machining center of each tray processing information, all these data will be uploaded to the total control platform through PLC, and achieve visual, mainly including machine tool running time, real-time running state, production beat, hourly output curve, daily processing total, monthly summary, convenient for technical and production management personnel to analyze the running state of the production line, identify the problem and solve the bottleneck.

5. Conclusion

Flexible lean cylinder block automatic processing production line is a production line that combines automation, lean and the Internet of Things. It is an implementation plan based on maximizing the use of physical space and reducing investment. After the production line is put into operation, the production beat is 180 seconds/piece, after continuous optimization of all kinds of actions, up to 165 seconds/piece, the first processing qualified rate is more than 99.5%, eliminating the problem of traditional flexible production line process backlog products, and the production line runs stably. This production line provides the reference of automation, lean, data and so on for the production mode of small batch and variety.

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