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Brief Introduction of Key Modules and Functions of Intelligent Production Line for Engine Connecting Rod

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Abstract

Engine connecting rod belongs to a large number of parts, and the market demand is large. Improving the processing efficiency of connecting rod is one of the core issues in the field of connecting rod production. Production line is a kind of processing and manufacturing system suitable for mass production of parts, and the operation level of connecting rod production line has been greatly improved by using network data transmission technology. Combined with the processing process of a certain type of connecting rod, the key modules and functions of the intelligent production line of connecting rod are analyzed and summarized.

Keywords

Connecting rod, Production line, Networking, Manufacturing system.

1. Introduction

Connecting rod is one of the key components in the engine to change the power working mode. The linear reciprocating motion of piston is transformed into the rotating motion of crankshaft through crank-connecting rod mechanism. The output torque provides power for the vehicle to move forward. With the rapid development of the automobile industry, automobile production and consumption are increasing year by year. The production of core components represented by engine connecting rods is gradually becoming specialized, integrated and internationalized [2-3]. With the change of market environment of connecting rod, the forming method of connecting rod is gradually developed from powder forging to one-time high temperature powder sintering, and the mechanical processing method is upgraded from traditional single machine to professional flexible production line, which greatly improves the production efficiency of connecting rod [4-5]. At the same time, with the addition of network information technology, the operation and management of production line, data processing, product quality analysis and so on have new development trends [6]。

2. Connecting rod process analysis

Take a connecting rod as an example, as shown in Figure 1 below. There are 33 processes from blank cutting to product packaging and warehousing. The key processes and equipment involved are shown in Table 1 below.

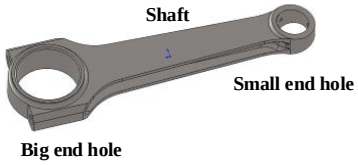

Fig. 1 Connecting rod

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Table 1 Connecting rod process and equipment

operation number	Procedure Content	Name of device
1	Rough grinding of two sides	Surface grinder
2	Drill a small hole	Special machine tool
5	Honing small head hole	Honing machine
6	Fine milling of two bolt surfaces	CNC milling machine
7	Milling cover bolt support surface	CNC milling machine
8	Boring large holes	Special machine tool
10	Cutting connecting rod	Sawing machine
12	Drilling Bolt Hole on the Joint Face of Finish Milling Body Cover	CNC milling machine
14	Enlarged bolt hole	CNC milling machine
18	Fine grinding of two sides	Surface grinder
24	Chamfer of large head hole	Turning machine
25	Honing large head hole	Honing machine
26	Rolling small head hole	Honing machine
28	Milling lock mouth	Special machine tool

From the table 1 above, there are 14 machining processes of the connecting rod, and the processing process is relatively independent and dispersed in the whole production process. As far as the whole processing process of the connecting rod is concerned, the traditional single-machine production mode is easy to split the production rhythm, and the production efficiency needs to be improved. The intelligent production line of the connecting rod is the main solution to this problem. Technical approaches are needed.

3. System Composition Module of Connecting Rod Production Line

Based on the principles of lean manufacturing, flexible production, lean automation and lean layout of production line planning, the automatic production line of connecting rod is mainly composed of processing equipment, logistics system, automatic feeding and unloading device, testing station, sensor control system and other modules [7-8]. The modules, main functions and equipment are shown in Table 2 below.

Table 2 Main Composition and Function of Connecting Rod Production Line

Component module	Main Function	Equipment
Processing equipment	Complete the Machining of Work Connecting Rod	All kinds of machine tools
Logistics system	Complete the handling of connecting rod between workstations, and connect each processing sub-unit into a whole.	Delivery mechanism, AGV logistics car, logistics robot, etc.
Automatic feeding and unloading device	Complete automatic feeding and unloading of connecting rod during processing	Joint robots, special manipulators, etc.

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Detection Station	Check whether the current machining quality of connecting rod meets the technical requirements	On-line detection station, off-line detection station, etc.
Sensor Control System	Complete production data acquisition, feedback, data transmission, instruction delivery, production scheduling	Sensors, data transmission devices, data display devices, processors, etc.

4. Main Functions of Production Line

In order to improve the quality and efficiency of connecting rod processing, Henkde Swaan Arons, Anglani and others used discrete event simulation model to store the model in a specific database and studied the inventory replenishment strategy in Arena simulation software[9-10]. Zheng Shunshui proposed simulation and optimization technology based on production line, and established application objects, class libraries and The simulation model carries out logistics and production scheduling simulation, evaluates and analyses equipment failure and production line capability, and provides a reliable scientific basis for production line planning and production scheduling planning[11].

4.1 Flexible Adjustment of Overall System of Production Line

At the beginning of the production line construction, the main consideration is to process a certain type of parts. The equipment layout of the production line system is adjusted according to the same kind of parts of different sizes and models. The typical representative is the corresponding adjustment of cutting tools and fixtures for machine tools. At the same time, the machine tool itself needs to be invoked under the scheduling of the master control system. In the NC system of machine tools, corresponding G codes of workpiece processing should be adjusted at the same time in the logistic system, such as AGV trolley and logistic handling robot. That is to say, each module in the production line system will adjust adaptively and pertinently according to the processing requirements, so as to enhance the programmability and controllability of the system [12].

4.2 No-load Operation Monitoring

Connecting rod processing equipment needs start-stop, maintenance and maintenance according to requirements during operation, especially for high-end CNC machine tools. In low temperature working environment, no-load operation is required before formally entering the processing link. The function of no-load operation monitoring is to make the temperature of the spindle, lead screw, guide rail and other core transmission components of the machine tool reach. To the default value. The temperature sensor collects the temperature value of the machine tool and compares it with the data from the machine tool system. When the temperature of the test points reaches the reasonable preset value, the NC system of the machine tool uploads the temperature signal to the general control system of the production line through the network transmission interface. After the signal is received by the general control system, the instructions are given to the NC system of the machine tool. At the same time, the auxiliary modules such as cleaning, cooling and lubrication are also in the ready state, waiting for the logistics system to send the connecting rod to the machine tool workbench.

4.3 Tool monitoring

The machining process of connecting rod is complex. There are many kinds of cutting tools, large amount of processing, and the wear degree of cutting tools is inconsistent. Therefore, the wear amount of cutting tools needs to be measured in real time, and the dynamic compensation of processing parameters is carried out at the same time. The material of the connecting rod in this paper is 40Cr. Taking several processes with large processing capacity as an example, the statistics are shown in Table 3 below.

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Table 3 Matching of process and tool usage

Process name	Tool name and code	Tool rating
Grinding large surface	grinding wheel 600×75×20	8000 /Piece
Bolt support surface of rough milling body	Vertical milling cutterΦ19	400/Piece
Fine milling joint surface and drilling bolt hole	Milling cutterΦ25	800/Piece
	Center drillΦ12	100/Piece
	Drill Φ88	700/Piece
	ReamerΦ9	100/Piece

As shown in Table 3, the types, materials and parameters of cutters for grinding and milling are different, and the rated amount of cutters varies greatly. Traditionally, the machine tool is checked manually when the machine tool stops running or the spindle is not working at rest, that is, by the experience judgement of the measuring instrument or the operator to complete the test. In this way, the machine tool will be in a state of unprocessed. From the point of view of efficient production, shutdown means that the production schedule and operation rhythm of the production line will be interrupted, which ultimately affects the efficiency of the production line. Flexible production line needs to consider intelligent tool monitoring. At present, the mainstream tool monitoring schemes are mostly the integration of wireless sensor network technology and network communication technology. Tool wear is detected online and non-contact by sensors, and the measured value is uploaded to the database of the master control system by network data transmission technology for tool status classification. After analysis and judgment, the test results are fed back to the NC system to perform the next operation, even if the tool is used to continue processing or automatically send out the tool change signal.

4.4 Anti-collision monitoring

Most of the machine tools equipped in the production line are CNC machine tools. The G codes of CNC machine tools are manually programmed when connecting rods are processed. CNC machine tools can not judge the reasonableness of the programmed manually. For complex parts of aeroengine blade and other curved surfaces, special CAM software is used for automatic programming. The G code generated by CAM software must match the processing ability of NC machine tools. In order to avoid collision of knives, excessive travel and excessive processing load on machine tool transmission system, the G code needs to be pre-processed and simulated. The general control system detects the running state of G code of machine tool in real time, and makes the judgment of the rationality of the processing state. In the case of reasonable state, the general control system gives instructions to make the machine tool into the state of processing preparation. If not, the unreasonable causes are analyzed and feedback, and the CAM system corrects G code. This avoids the physical damage of machine tool caused by processing program, and improves the safety of machine tool operation and the intelligence of production line monitoring.

4.5 Logistics Signal Transmission

An important reason for the continuous and efficient operation of the connecting rod production line is that the connecting rod has been flowing precisely and orderly in the logistics system from blank to finished product packaging. Figure 2 below shows a logistics simulation model of the connecting rod production line.

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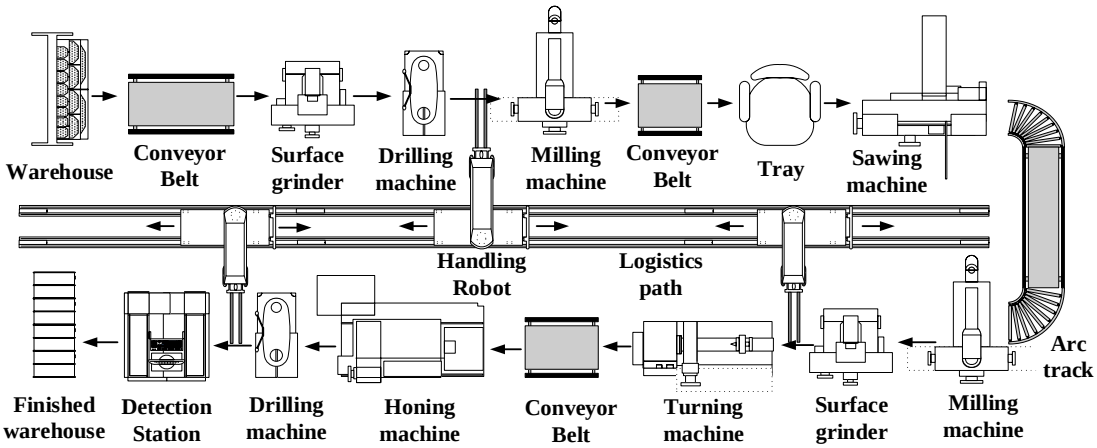

Fig. 2 Logistics simulation model of connecting rod production line

From the figure, it can be seen that a series of processes, such as machining, testing, packaging and warehousing, will produce a large number of logistics signals in the logistics system. From warehouse to each station, the position and status of the connecting rod on the production line can be traced by the master control system, which can schedule the processing and logistics transportation as a whole. Wang Hongbo and Li Jiandong proposed an automation solution based on industrial robots and machine vision. They constructed an automatic logistics system consisting of Siemens S7-1200 as the main control PLC, robots and machine vision, AGV car, stereo warehouse system, product sorting pipeline and so on. The robot was realized by using MODBUS-TCP communication protocol. Data and I/O signal exchange between machine vision, subordinate PLC and main control PLC has promoted the digitalization and intellectualization of logistics information of production line as a whole[13].

4.6 Loading and unloading monitoring

Connecting rod production line is to complete different processes in different workstations, through the logistics system to complete the handling of connecting rods between different workstations, it is necessary to equip processing and testing equipment with corresponding automatic feeding and unloading equipment, and the automatic feeding and unloading equipment is unified dispatched by the master control system. The detection of connecting rod's feeding and unloading involves four aspects: ①For different types of connecting rods, it can automatically identify and select the appropriate fixture according to the identification information, so as to improve the clamping flexibility. ②It can detect whether the clamping force reaches the preset value and improve the clamping accuracy. ③ It can automatically coordinate the feeding and unloading mechanism according to the operation status of the whole production line and logistics information. Work status, improve the adaptability of clamping conditions, and give full play to the working efficiency of the feeding and unloading mechanism. ④The data communication between the feeding and unloading mechanism and the logistics system and the general control system can be completed to improve the clamping efficiency. Luo Yingjun and Zhang Jun have designed the automatic feeding and unloading mechanism of the robot and the automatic code playback mechanism of the finished product on the production line through the combination application of the vertical machining center equipped with FANUC 0i-MD system, the CNC lathe equipped with FANUC 0i-TD system and the FANUC robot. The application technology of the interface between FANUC robot and CNC machine tool has been analyzed. The communication technology between FANUC robot and Mitsubishi PLC based on C-LINK bus has greatly improved the production efficiency [14].

5. Conclusion

Taking connecting rod as an example, this paper analyses the operation of connecting rod production line from its main technological process, processing mode and testing equipment, and briefly

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describes the core components of connecting rod production line from the aspects of logistics system, automatic feeding and unloading device, testing station, sensing control system, etc., and from the overall system of connecting rod production line. Through the analysis of flexible adjustment, no-load operation monitoring, tool monitoring, anti-collision monitoring, logistics signal transmission, loading and unloading detection, as well as the network data communication relationship of production line, the main functions and core technologies of connecting rod production line are summarized. At the same time, it is known that the upgrading and application of network technology can also improve the number of production lines. According to the level of communication, production scheduling management, production quality management and operation, and more and more intelligent network data technology, especially under the vigorous development of 5G technology and Internet of Things technology, the production capacity of connecting rod production line will be greatly improved.

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