Application of Intelligent Manufacturing in the Production Line of Hydraulic Support Coal Machinery Plant

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Abstract. From the definition of intelligent manufacturing, the status quo, shortcomings and solutions of the hydraulic support coal machine factory are introduced. Intelligent manufacturing is a human-machine integrated intelligent system composed of intelligent machines and human experts. Combined with research and the implementation of its own work, it introduces the current production lines of China's hydraulic support coal machine factory from cutting, welding, spraying, and processing. The application situation of intelligent manufacturing, finally analyzed the problem of limited site, tight construction period, and unreasonable production process in the intelligent manufacturing of the hydraulic support coal machine factory, and proposed solutions that must be lean first, combined with automation and informatization. Realize the intelligent construction of the factory on the basis of optimized technology and modern management concepts, and finally establish a CPS system based on digital twins to realize a predictable intelligent factory.

Keywords: Intelligent Manufacturing, Coal Machinery Plant, Informationization.

1. Introduction
At present, the development foundation of intelligent manufacturing in China's industrial application is different, with different emphasis and needs, so the development of different industries is different. At present, the real intelligent mechanical engineering is basically not available, and most of the so-called intelligence has the functions of automation, self-protection, Informa ionization, remote operation and maintenance (expert database, self-diagnosis, self-maintenance), and energy conservation and emission reduction by adjusting speed according to working conditions.

Hydraulic support is one of the important equipments in the underground, which is complicated in structure, heavy in weight and large in size. The processing procedures involved include flame or plasma cutting of steel plates, grooving of parts after cutting, positioning welding of workpiece groups, continuous welding, machining after welding, spraying, assembly, debugging, etc. This paper introduces the intelligent production line of the hydraulic support coal machine factory, and introduces some advanced production lines or workstations in this field.
2. Connotation of intelligent manufacturing
Intelligent manufacturing is a man-machine integrated intelligent system composed of intelligent machines and human experts. It can carry out intelligent activities such as analysis, reasoning, judgment, conception and decision-making in the manufacturing process. Through the cooperation between human and intelligent machines, we can expand, extend and partially replace the mental work of human experts in the manufacturing process. It updates the concept of manufacturing automation and extends it to flexibility, intelligence and high integration [1].

3. Application status
At present, China's mechanical engineering has different development foundations in different industries, with different emphasis and demands, so the development of different industries is not the same. At present, intelligent mechanical engineering basically does not exist, and most of the so-called intelligent mechanical engineering has the functions of automation, self-protection, Informationization, remote operation and maintenance (expert database, self-diagnosis, self-maintenance), and energy conservation and emission reduction by adjusting speed according to working conditions.

Hydraulic support is one of the important equipments in underground, which has complex structure, heavy weight and large size. The processing procedures involved include steel plate flame or plasma cutting, grooving of parts after cutting, positioning welding of workpiece groups, continuous welding, post-welding machining, spraying, assembly and debugging, among which some procedures realize automatic operation after manual programming, such as plate cutting, grooving and continuous welding. The intelligent application of the production line of hydraulic support coal machine factory is introduced in the following order: cutting, sorting, grooving, welding, machining and painting.

3.1. Cutting and sorting of plate blanking
Plate cutting realizes automatic typesetting after drawing import by technical department, and remote distribution to workshop cutting control center. After workers confirm the distribution, automatic steel plate loading and automatic cutting are realized on cutting machine platform. After cutting, the cutting pieces are automatically transported to sorting platform, and the cutting wastes are automatically rolled to waste hopper. The subsequent sorting work of transporting the cutting pieces to sorting platform needs to be carried out manually, as shown in Figure 1.

![Figure 1. Loading and cutting workstation for electromagnetic sucker of traveling crane](image)

Another way implemented by our company is to pour various parts loaded in the material frame into the feeding equipment of the system, and compare the configured cameras with the drawings of the parts library. Automatic identification of parts specifications, transportation of parts in a straight line by six-axis industrial robot, automatic laser recording of two-dimensional code (two-dimensional code has parts information and process details, etc.), automatic sorting of groove-removed products, automatic code scanning, intelligent sorting of robot non-groove finished products, rejection of unqualified products, etc. [2]. As shown in Figure 2 and Figure 3.
3.2. Beveling

At present, the automatic operation of the grooving workstation adopts one robot loading and unloading and one robot grooving automatic workstation. The workflow is that after manually placing the material frame containing Blank parts in the designated area, the loading and unloading robot first grasps the Blank parts in the material frame through visual recognition and puts it on the positioning workbench for precise positioning; Then grab and put it on the grooving workbench, and the grooving robot will groove according to the set trajectory. Then the loading and unloading robot will grab and put the finished product into the finished product material frame, and manually change the material frame after the whole operation, as shown in Figure 4.
The vision tracking system is composed of laser vision sensor and vision tracking system software. It can track the groove track and height information of parts. After optimization of vision algorithm, it can meet the requirements of high frequency acquisition and image processing.

3.3. Welding workstation

At present, it is very common to use automatic welding workstation for continuous welding. Robot trajectory is programmed by manual teaching or off-line programming, loading and unloading parts are performed manually, and welding work is completed by robot, which can realize automatic tracking and correction of small distance deviation [3], as shown in Figure 6. However, for point group positioning welding, at present, all manufacturers are manually completed.

Figure 5. Schematic diagram of full-range visual recognition process

Figure 6. Automatic welding workstation for three large pieces
3.4. Coating line

At present, there are two ways to spray the structural parts of hydraulic support, one is ground rail flat car transportation, as shown in Figure 7(a), and the other is hoist suspension transportation, as shown in Figure 7(b). The upper and lower parts are all manually sprayed, and the spraying is a combination of robot and manual. The advantages of ground rail flat car are accurate positioning and heavy bearing weight, but the disadvantages are that the delivery trolley will be damaged during shot blasting, so the shot blasting cannot be integrated into the spraying line body before spraying, and secondary transportation is needed, while the shot blasting can be integrated into the spraying line body by using hoist suspension, but the positioning is not as accurate as that of ground rail flat car, and the bearing weight is also small.

Most hydraulic cylinders are sprayed by hanging type (except for extra heavy cylinders), the upper and lower parts are manually hooked, and the driving wheels drive the circulating chain to run (the structure is similar to aerial rope way), and they enter the spray booth for automatic spraying and drying.

3.5. Machining production line

For the processing of parts such as disc sleeves in hydraulic cylinders, an automatic processing workstation is adopted, as shown in Figure 8. After processing, a robot (with ground rail) is used to carry the parts between machine tools, which are put to the inspection desk for manual inspection. The inspection desk is manually controlled and transmitted from the processing area inside the guardrail to the manual inspection area outside the guardrail.
Figure 9. Automatic production line of middle cylinder

The middle cylinder realizes automatic production, is equipped with information kanban, and has the functions of fault alarm, scheduling management, equipment status monitoring, etc. The line body is equipped with guide rails and V-shaped brackets for automatic transportation between stations.

3.6. Laser cladding

Figure 10. Automatic laser cladding of outer surface

According to customer's requirements, for high-end bracket, laser cladding technology is adopted on the outer surface of the middle cylinder block, and iron-based stainless steel is clad on the outer surface. The traditional electroplating is guaranteed for two years, and this technology is guaranteed for five years, which greatly improves the life of the cylinder block. This technology belongs to additive technology, and it is also widely used for wear repair in remanufacturing, such as the re-repair of cylinder block during bracket overhaul [4].

3.7. Hydraulic cylinder assembly

Automatic assembly has been realized in some hydraulic cylinder assembly factories. Figure 11 shows the intelligent hydraulic cylinder assembly production line implemented by our company. Three-dimensional automatic loading and unloading of parts such as disc sleeve, sealing ring and retaining ring has been established, and large parts such as cylinder block have been stored on the ground, and AGV
trolley has been configured to realize the transportation of parts and realize the automatic assembly of hydraulic cylinders and jacks.

3.8. Informatization application
At present, each coal machine factory basically has an ERP platform to realize information management such as finance, sales and procurement. Some manufacturers have built an information MES platform on local production lines to realize the docking of order data, warehousing materials and production lines in ERP. The following figure shows the MES system function of the blanking workshop of a factory implemented by our company.

![Figure 11. Intelligent hydraulic cylinder assembly production line](image)

The following figure shows the MES system platform architecture of spraying production line implemented by our company. By configuring PLC, RFID or barcode, robot, data acquisition board, server and software platform, MES system control of spraying workshop is realized, which has the
functions of equipment management, monitoring platform, material management, energy consumption management, etc., and is a leading intelligent spraying production line in the industry.

Figure 13. MES system platform architecture of spraying production line

4. Shortcomings and solutions
At present, in the production system construction of hydraulic support coal machine factory, it is basically the integration of automation and information MES. Some automated production lines need more manual participation, even semi-automation, such as robot spraying production lines. Therefore, the future development trend of hydraulic support coal machine factory has the following suggestions:

In the process of advancing intelligent manufacturing with lean first, there is the principle of "three noes": Don't be highly automated on the basis of backward technology—corresponding to the industrial 2.0 stage, we must first solve the problem of automation based on optimized technology; Don't be highly informationized in backward management—corresponding to the stage of Industry 3.0, we must first solve the problem of realizing informationization on the basis of modern management concepts; Don't be highly intelligent without digital network—To realize Industry 4.0, we must first solve the problems of digitalization and networking of manufacturing technology and manufacturing process, and make up lessons, popularize and improve them.

Most coal machinery plants are existing coal machinery plants, and the layout of factories and production lines has been arranged. In the current implementation process of automation and intelligence, there is a process of realizing automation first and then信息化ization, but the existing production tasks cannot be interrupted during the implementation process, so there are some problems such as limited site, tight construction period and unreasonable production process. Therefore, first of all, lean management should be carried out to optimize the whole production process and production process, and improve from easy to difficult and from point to line. First, an information platform should be established to realize the functions of equipment management, material management, warehouse management, energy consumption management, quality management and intelligent production scheduling. On this basis, CPS (Cyber-Physical Systems) based on digital twins is realized by using sensors, communication and control, which can realize real-time simulation and optimization decision of production process, and can operate and accurately control actual production equipment and production process in real time from CPS system, and support intelligent management and control of
production facilities, production systems and processes in intelligent mode. Realize the intelligent perception of the whole process from the beginning of order to product design, production planning, production execution and post-production and after-sales operation [5,6]. Suppliers can obtain and exchange real-time production information in the production value chain through the industrial Internet. Under the control of the manufacturing operation management system, they can deliver the supplied parts to the production line at the right time and in the right order, and command and control the equipment to carry out autonomous and self-organized production to meet the personalized customization needs of customers.

5. Conclusions
This paper mainly introduces the current situation of intelligent construction of hydraulic support coal machine factory, introduces various implementation schemes for some production lines, and the future direction of intelligent development. Intelligent construction of coal mining plant is of great significance to the development of coal mining equipment. In the new era of rapid development of technology, with the support of new technologies and industries such as wireless network, big data and cloud computing, the production system of coal mining plant is also developing rapidly. At present, some production lines have realized the integration of automation and Informa ionization, but they still lag behind other industries such as automobiles and construction machinery. At present, only automation and Informa ionization are achieved, and there are still many people involved in some production lines, which do not realize full automation. Therefore, in the future development, there is great room for improvement, and we need to introduce existing technologies from other industries, carry out transformation, transplantation and innovation according to the characteristics of coal machine industry, establish intelligent factories suitable for coal machine production systems, and promote the intelligent degree of coal machine factories.

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