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The Research and Application of Industrial Robot in Steel Deep Processing Field

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Abstract. The paper describes technical research results of four categories of robots in steel deep processing field, including integrated code reading and temperature measuring robot for hot rolling production line, code spraying robot, slag-dredging robot for galvanizing line and coiling machine sleeve mounting robot for color coating line and proposes the development trend of industrial machinery in the steel industry.

1. Foreword

In recent years, steel industry of our country has gradually realized the digitization and automation, and is moving toward informatization and intellectualization. To further implement the "Made in China 2025" plan and the national "13th Five-Year" strategic planning, with the support of China Association for Science and Technology under the subject of "Interdisciplinary Collaborative Innovation in Intelligent Manufacturing in Steel Industry", Automation Research and Design Institute of Metallurgical Industry (hereinafter referred to as ARIM) and other units jointly launch a research work concerning development status and demand of intelligent manufacturing in Chinese iron and steel enterprises. The results show that it is an important trend for the future development of the steel industry to integrate networked and intelligent tools such as big data, Internet of things, cloud computing and robots with the process links such as research and development, production, management and logistics to effectively optimize the structure of the manufacturing process and improve the full-process intelligence level of the steel industry [1] [2]. Among them, the large-scale application of industrial robots in the steel industry is an important foundation, and the application fields include: 1) process before iron-making, iron-making process: more than 20 categories of robots for stacker unmanned, molten iron sampling and transfer, automatic sampling of coke for analysis, automatic mud adding of clay gun etc; 2) steel making process: more than 10 categories of robots for temperature measuring and sampling, tundish operation, bale and long nozzle operation, internal defect detection of continuous casting slab, continuous casting slab grading, automatic heating protection of crystallizer etc; 3) deep processing such as steel rolling and galvanizing: more than 20 categories of robots for automatic bar sampling, automatic welding plate printing for bar, spraying and handling, automatic baling and code-spraying for hot rolled coils, zinc slag removing, roll changing, rolled steel cooling bed tracing, cold rolling stripping etc.

This paper focuses on application technology of industrial robot in steel deep processing field and describes technical research results of four categories of robots in steel deep processing field, including integrated code reading and temperature measuring robot for hot rolling production line, code spraying robot, slag-dredging robot for galvanizing line and coiling machine sleeve mounting robot for color coating line, contributing to the application of robotics in steel industry.

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2. Integrated Code Reading and Temperature Measuring Robot for Hot Rolling Production Line

At present, most steel enterprises do not realize full- process MES system control, and thus it is necessary to manually read the billet code and enter into control system before the billet enters the heating furnace. Therefore, according to the spraying imaging characteristics, process requirements and operation processes, ARIM has developed an integrated code reading and temperature measuring robot for hot rolling production line, which can effectively measure the temperature of five surfaces of the billet and enter all the temperature into control system automatically while reading code. The robot is composed of network camera, infrared thermometer, robot hardware, image identification software based on machine vision with independent intellectual property rights. The robot control system takes pictures of the billet, analyses the pictures and identifies the number; and it verifies the identification results after comparing the number issued by secondary system. At the same time, infrared temperature measurement system is used to measure the temperature of the billet at three points, and the temperature is transmitted to the secondary system (see figure 1). Integrated code reading and temperature measuring robot for hot rolling production line can systematically identify and record the entire billet information, provide data support for the subsequent production, quality control and sales of the billet; in this way, error-prone problems in manual copying and input coding can be effectively avoided, and whole control of recording process can be realized.

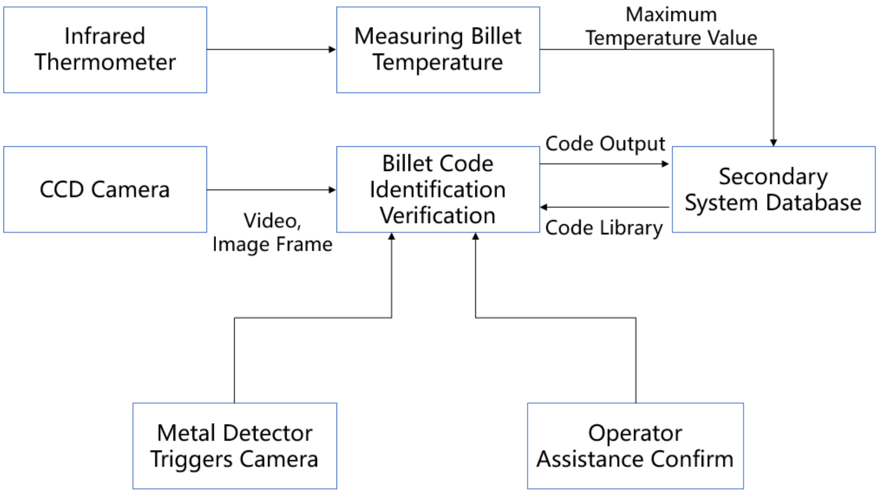

Figure 1. System Structure Diagram of Code Reading and Temperature Measuring Robot for Hot Rolling Production Line

3. Code Spraying Robot

Since hot rolled coil coding process involves high temperature of steel coil, relative movement of work position, close working distance of personnel, heavy workload and other problems, meaning the process has a high risk coefficient and runs in a harsh working environment, the code spraying robot has a wide market prospect. The robot consists of laser coding machine, ranging system, robot body and robot control system. The robot control system receives the coil number, coil weight and other information from the secondary system and waits for the steel coil to be ready. After the coil being in place, the robot detects the distance between the coding machine and the steel coil through with ranging system, and controls the laser coding machine to move to the appropriate distance to complete the code spraying operation (see figure 2).

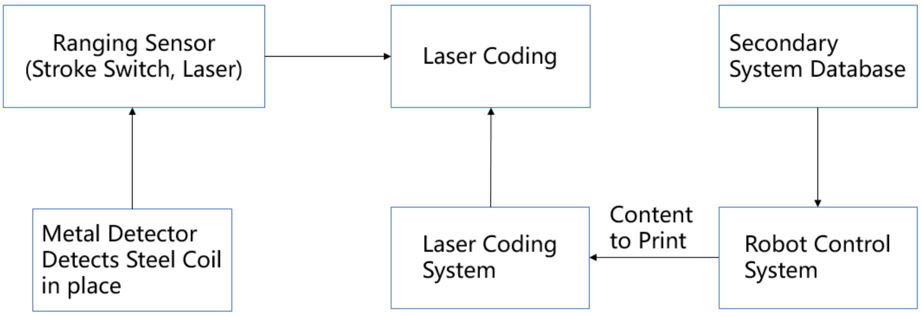

Figure 2. System Structure Diagram of Code Spraying Robot

4. Slag-Dredging Robot For Galvanizing Line

Traditional slag-dredging mode is manual slag-dredging and it has the following problems: 1) safety hazards. During the operation, the worker is only 0.2m away from the high-temperature plating liquid; 2) Harsh working conditions affect health. Position liquid pot reaches 460 °C, ambient temperature at working position reaches approx. 80 °C, air knife noise is as high as 120 db and accompanied by a large amount of dust; 3) slag-dredging process is difficult to control and affects product quality; 4) enterprise cost is difficult to control. The robot consists of CCD camera, image visual servo system, robot body and robot control system. The zinc-liquid surface image is obtained using industrial camera, the zinc-liquid surface slag amount and distribution are obtained through image processing, and slag dredging instructions are output to control the slag-dredging robot for operation (see figure 3 and figure 4). Software identification shows that the calculated proportion of slag is consistent with the actual estimation, the accuracy of zinc slag distribution recognition is more than 90%, the surface of zinc liquid is stable, and galvanized sheet enjoys good surface quality [3] [4].

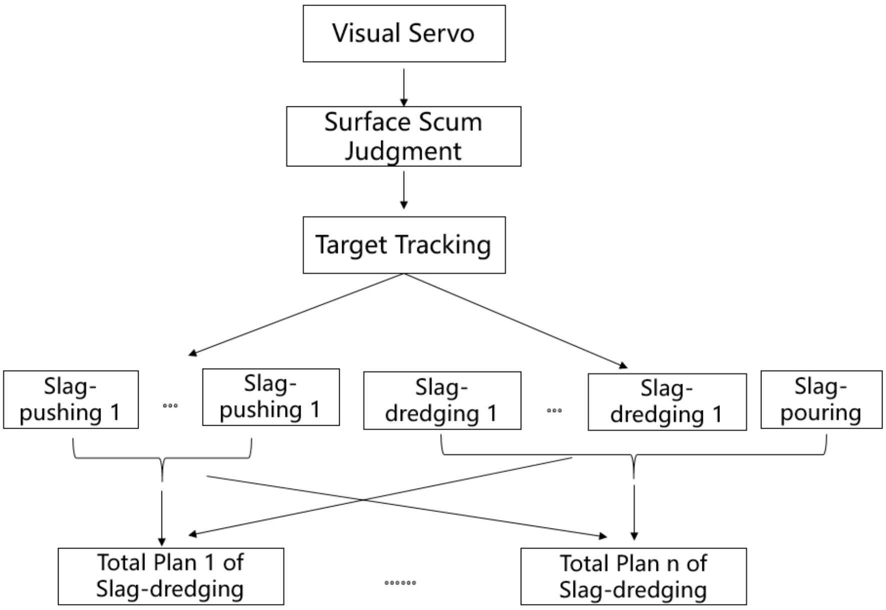

Figure 3. Slag-Dredging Plan of Slag-dredging Robot for Galvanizing Line

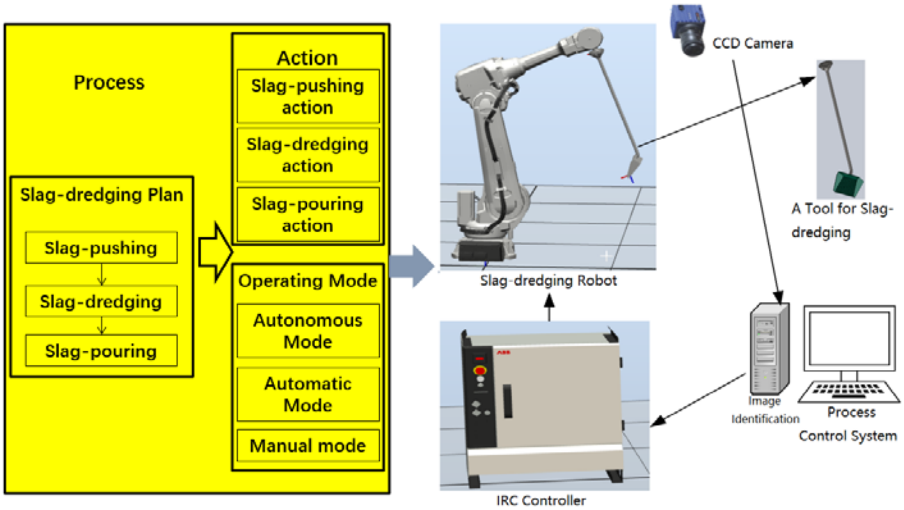

Figure 4. Design Outline of Slag-dredging Robot for Galvanizing Line

5. Coiling Machine Sleeve Mounting Robot for Color Coating Line

Generally, coiling machine sleeve at outlet of color coating line is installed under joint efforts of two operators, presenting problems such as high labor intensity, tight rhythm and small working space, so it is difficult to guarantee the safety of personnel. The robot consists of CCD camera, self-adaptive flexible sleeve grasping equipment, laser measuring instrument, and robot body and robot control system. Coiling machine sleeve mounting robot for color coating line can install paper sleeve of different specifications onto crankshaft to effectively solve coil collapse problem. At the same time, the system realizes the self-determination flexible sleeve measurement and calibration, and the judgement accuracy reaches 100%. The self-adaptive buffering sleeve grasping mechanism is studied and designed and robot is used as a substitute during sleeve mounting process.

6. Conclusion

To sum up, it is an inevitable trend for the future development of the steel industry to integrate the robot with informatization and big data and incorporate it into the full-process control system to form large-scale “machine replacement of human”. ARIM focuses on the design and application of robot system under high temperature, high pressure, high humidity, low temperature, poisonous gas, heavy physical strength conditions, and it modifies robot based on existing technology using intelligent equipment such as robots and sensors through the research of application technology to form a low cost, high efficiency production mode which basically replaces existing workers to improve labor efficiency and precision and provide important means for the transformation and upgrading of iron and steel enterprises.

7. References

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