Development and Application of Hot Dip Galvanizing Simulation Test Machine

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Abstract. Hot dip galvanizing simulation test machine is a large-scale laboratory process pilot system, consisting of high efficiency electromagnetic induction system, short wave infrared heating system, cooling water supply system, drive system, protective atmosphere pneumatic system, pressure supply system, etc. Composition is an important basic equipment for scientific research and development in the galvanizing industry. The simulator can quickly and cost-effectively carry out laboratory process simulation and pilot test of the production line, and can carry out new technology, new product development, process development and performance optimization, thereby saving a lot of development time, pilot cost and labor cost.

1. Introduction
Simulator galvanized on the basis of a continuous hot dip galvanizing process and taking into account modern equipment parameters on the core, achieved for the sample annealed, galvanizing, alloying the core process development and validation under laboratory conditions. At the same time, the simulator can also be used for technical development of high corrosion resistant alloys, bath components, and low temperature annealing[1,2]. Compared with the same type of test device in foreign countries, this device has simple structure, reasonable design and strong adaptability, which can meet the needs of enterprises for research and testing of ordinary steel strip galvanizing. It can also meet the needs of enterprises for new coating development.

2. System composition of hot dip galvanizing simulation test machine

2.1 High efficiency electromagnetic induction system
The high-efficiency electromagnetic induction system is used as the core equipment for the production of alloyed galvanized steel sheets. When the sample enters the electromagnetic induction heating furnace and stops at a fixed position, the sample is heated. The system is mainly composed of an electromagnetic induction furnace body, a protective gas passage and an electromagnetic heating coil. The equipment is heated at a temperature of 490 °C to 650 °C.

2.2 Short wave infrared heating system
The system is mainly composed of a flange, a quartz cover, an infrared heating module, a water-cooled tube, a high vacuum sealer and the like. The double-layer structure is designed, the inner layer is the upper and lower flanges, and the middle is the quartz cover. The outer layer is inlaid with an infrared heating module, and the interior of the heating module is designed to be water cooled to reduce the temperature. The module is attached to an external support platform.
2.3 Closed loop temperature control system
The continuous control of the simulator is realized by adopting a programmable controller as the control core and a manual interface input parameter and according to the production process and equipment of strip hot-dip galvanizing and alloying, combined with the electric control principle and pneumatic control principle of each unit.

2.4 Cooling water supply system
The simulated cooling water system is more complicated. There are two sets of main water supply channels, and about 20 water supply lines (including reserved parts), and corresponding alarm equipment and measuring equipment are set. The cooling water is deionized water, and the water temperature is lower than 40 °C.

2.5 Simulator isolation system
The functions of the simulator isolation system include: 1) isolating the cooling chamber, the infrared heating chamber, and the alloying chamber from the zinc pot to ensure the cavity vacuum and the atmosphere ratio in the upper part of the isolation chamber, thereby improving the adaptability of the system; 2) The lower side zinc pot is shielded to reduce the heat radiation of the plating solution.

The vacuum isolation between the vacuum isolation can reach 50 Pa, the vacuum room is equipped with a water cooling system, and the solenoid valve control mode is adopted, and the isolation valve is driven by the pneumatic cylinder.

2.6 Drive System
The system mainly includes servo motor, bearing, linear guide, ball screw, polished rod, lead screw, clamp, feed rod, side plate, rib plate, etc. The side plate is bolted to the outer frame of the system, and the polished rod is required to be Slide in the cooling room. The system has a built-in temperature measuring device and is able to maintain a good seal under vacuum or pressure. System programmable control, preset feed distance, feed speed, feed direction.

2.7 Protective atmosphere pneumatic system
The design of the protective atmosphere system is mainly based on the amount of hydrogen, nitrogen, dew point, etc. required by the production process, so that it can be fully industrialized under laboratory conditions. The gas data is shown in Table 1.

| Project                      | Air pressure (max) | flow rate (max) | gas type       |
|------------------------------|--------------------|-----------------|----------------|
| Protection and reduction atmosphere (alloying room) | 0.4 MPa | 200 L/min | N₂ and H₂ |
| Protective atmosphere (zinc pot) | 0.4 MPa | 200 min | N₂ |

2.8 Pressure supply system
The pressure supply system comprises an air compressor, a cold dryer, a gas storage tank, a gas valve and the like. The pressure supply system provides a source of air pressure throughout the system to ensure smooth, timely and effective cylinder movement.

2.9 Dew point and atmosphere measurement system
Dew point and atmosphere measurement systems include measuring devices such as hydrogen concentration, dew point, and their associated gas and exhaust systems. The resolution of hydrogen concentration measurement reaches 0.1% (min), the operating temperature is 0-50 °C; the dew point meter range is -60~10 °C below ambient temperature, and the resolution is maintained at 0.05 °C (min), the accuracy range is ± 0.1 °C (min).
2.10 Automation Control System
According to the production process and equipment of continuous hot-dip galvanizing and alloying of strip steel, combined with the electric control principle and pneumatic control principle of each unit, through the use of programmable controller as the control core, manual interface input parameters, to achieve precise control of the simulator.

2.11 Micro-oxygen measurement system
The micro-oxygen meter and its corresponding air supply and exhaust system accurately measure the oxygen content in the upper and lower chambers. The oxygen concentration measurement range is 0 to 1000 ppm, the resolution is 0.1% (min), and the oxygen pressure is controlled at 0.1 to 1 kg/cm².

3. Hot dip galvanizing simulation test machine workflow
The simulation process is shown in Figure 1.

4. Hot dip galvanizing simulation test machine application
The hot dip galvanizing simulation test machine is mainly used in the galvanizing field of the steel industry. The hot dip galvanizing simulation test machine can carry out the pilot test of the galvanizing process, and can also carry out the process research of atmosphere adjustment, vacuum annealing and continuous annealing. The hot dip galvanizing simulation test machine reaches the international
Leading level in the infrared system annealing temperature, heating rate, running speed, alloying temperature, potting capacity, vacuum degree, removal of liquid surface slag precision, coating thickness control, sample size, etc.

According to the hot-dip galvanizing production process, the simulator is used to simulate hot dip galvanizing and alloying processes. The specific process flow is shown in Figure 2. The galvanized sheet sample after the test is shown in Figure 3. It can be seen that the coating is continuous and flat, which can fully meet the test requirements.

5. Conclusion
The hot dip galvanizing simulation test machine realizes the development and verification of core processes such as sample annealing, galvanizing and alloying under laboratory conditions, based on modern continuous hot-dip galvanizing process and core equipment parameters. The test device can completely simulate various process segments of industrial continuous annealing, galvanizing and alloying. Therefore, this test device has an important guiding role for industrial research and technology development. The test device is designed according to local conditions and meets the current status of China's galvanizing industry processes and equipment.

References
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