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(54) TEST DEVICE AND TEST METHOD FOR SIMULATING HIGH-SPEED CONTINUOUS ELECTROPLATING OF BAND STEEL

(57) The present invention relates to a test apparatus for simulating high-speed continuous electroplating of strip steel, which is characterized in that the test apparatus comprises a supporting underframe, a workbench is arranged on the supporting underframe, a working bath is fixed on the workbench, the test apparatus also comprises a working electrode system, a circulating pump, a reservoir and a cleaning bath, the reservoir is arranged under the working bath, a specimen for testing is mounted on the working electrode system, and by adjusting the rotation of motors, a high-speed strip steel production process is simulated. All the baths of the test apparatus are mounted at fixed positions on the supporting underframe, the specimen for testing is mounted on the working electrode system, and the working electrode system is mounted on the workbench. The whole electroplating process can be operated automatically, and the whole operation process is simple, efficient and good in safety.

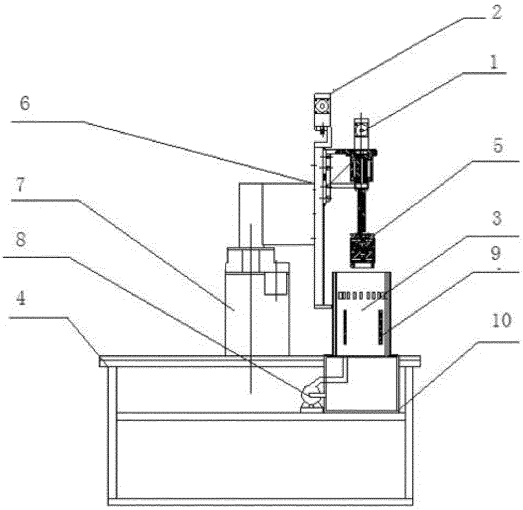

FIG. 1

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Description

BACKGROUND

Technical Field

[0001] The present invention relates to an electroplating test apparatus, and in particular to a test apparatus for simulating high-speed continuous electroplating of strip steel, which belongs to the technical field of electroplating.

Related Art

[0002] With the rapid development of automobile, household appliance and food packaging industries in our country, the usage of various plated steel products is increasing rapidly, requirements for surface quality of products become higher and higher as well, and this brings forward higher requirements for electroplating units for producing such products. An electroplating process is a complex electrochemical process, and the quality of a plated product is related to factors, such as the surface condition of a plated part, the flowing condition of electroplating solution and the degree of contact between the electroplating solution and air, besides the formula of the electroplating solution.

[0003] A traditional simulative electroplating test adopts a Hull cell, a Hull cell test can test the influence of current density and electrode distance on plating surface quality, but this test method cannot reflect the influence of flowing condition of electroplating solution on plating surface quality. In an aspect related to electroplating test, the utility model patent 201320146361.8 proposes an electroplating bath for uniform electroplating, and the uniform electroplating test bath comprises a bath body, an anode and a cathode, and is characterized in that the anode and the cathode adopt a flat plate structure, and the anode and the cathode are arranged in parallel to each other. Since the anode and the cathode in the test bath adopt the flat plate structure and are arranged in parallel to each other, a uniform electric field is generated between the anode and the cathode, and thereby a sample with uniform plating can be obtained. It can be seen from accessible literature information that the prior art is mostly flat plate electroplating, the rotational speed is low, moreover, only single-bath electroplating can be carried out, high-speed electroplating and process flows, such as alkaline wash, pickling, reflowing and passivation, cannot be simulated, and therefore a test apparatus which can meet the requirement of a high-speed continuous electroplating test needs to be developed.

SUMMARY

[0004] Just aiming at the technical problems existing in the prior art, the present invention provides a high-speed continuous electroplating test apparatus with an ingenuously designed structure, and the test apparatus can be utilized to carry out high-speed continuous electroplating of strip steel, and is applied to the development of new products and the evaluation of electroplating process parameters.

[0005] In order to achieve the above-mentioned purpose, the technical solution adopted by the present invention is as follows: a test apparatus for simulating high-speed continuous electroplating of strip steel, characterized in that the test apparatus comprises a supporting underframe, a workbench is arranged on the supporting underframe, a working bath is fixed on the workbench, the test apparatus also comprises a working electrode system, a circulating pump, a reservoir, a cleaning bath, a transmission shaft, an auxiliary electrode and a specimen working electrode, the reservoir is arranged under the working bath, the transmission shaft is connected to the working electrode system, both the auxiliary electrode and the working electrode system are connected to a rectifier to form a closed loop, the specimen working electrode is mounted on the working electrode system, and by adjusting the rotation of motors, a high-speed strip steel production process can be simulated.

[0006] As an improvement of the present invention, the working bath includes one or the combination of several of an alkaline wash bath, a pickling bath, an electroplating bath, a reflowing bath, a passivation bath and a fluxing bath.

[0007] As an improvement of the present invention, a heater and a temperature controller are arranged in the reservoir, a centrifugal pump injects working solution into the working bath after the working solution is heated to set temperature, and the upper part of the working bath is provided with overflow orifices to ensure the height of solution level. The bottom is provided with a weep hole to ensure that no test solution remains under a non-working state. The flow velocity of the solution is regulated by the flow of the centrifugal pump, the centrifugal pump adopts a variable-frequency motor, and flow control is realized by changing the rotational speed of the motor.

[0008] As an improvement of the present invention, the motors are a rotating motor and a vertical lifting motor, and the vertical lifting motor is connected to a rotating platform to realize vertical motion; the rotating motor is connected to a moving screw of the vertical lifting motor, and high speed rotation of the working electrode system is realized by means of the transmission shaft.

[0009] As an improvement of the present invention, the working electrode system comprises an upper sealing ring nut, a lower sealing ring nut, an upper sealing ring, a lower sealing ring and a polytetrafluoroethylene filling layer, the upper sealing ring and the lower sealing ring are arranged respectively on the upper and lower sides of the polytetrafluoroethylene filling layer, and are fixed respectively by the upper sealing ring nut and the lower sealing ring nut, the working electrode system also comprises carbon brushes, and the carbon brushes are ar-

ranged inside the polytetrafluoroethylene filling layer.

[0010] As an improvement of the present invention, the working electrode system comprises a fastening nut, a fastening bolt, an upper sealing ring, a lower sealing ring, a bottom cover, a polytetrafluoroethylene filling layer and carbon brushes, wherein the carbon brushes are horizontal carbon brushes and vertical carbon brushes, the carbon brushes are embedded in the outer wall of the polytetrafluoroethylene filling layer, and extend to the internal axis of the polytetrafluoroethylene filling layer, and the upper sealing ring and the lower sealing ring are arranged respectively on the upper part of the polytetrafluoroethylene filling layer and the bottom cover.

[0011] As an improvement of the present invention, there are four horizontal carbon brushes and four vertical carbon brushes, the horizontal carbon brushes are located inside the polytetrafluoroethylene filling layer, the four horizontal carbon brushes are perpendicular in pairs, the outer ends of the horizontal carbon brushes are connected respectively to the vertical carbon brushes embedded in a groove of the outer wall of the polytetrafluoroethylene filling layer, the inner ends of the horizontal carbon brushes extend into the transmission shaft, and the horizontal carbon brushes are not in direct contact. When the fastening bolt is screwed into the fastening nut, the four horizontal carbon brushes are pushed away, the horizontal carbon brushes push away the vertical carbon brushes to be in tight contact with a specimen, and thereby the specimen, the transmission shaft and the carbon brushes form a three-in-one conductor; the upper sealing ring and the lower sealing ring are arranged respectively on the upper part of the polytetrafluoroethylene filling layer and the bottom cover; one end of the fastening bolt is big, the other end is small, and the adoption of the big- and small-end arrangement facilitates screwing and unscrewing the fastening bolt; when the fastening bolt is screwed, the small end of the fastening bolt pushes away the four horizontal carbon brushes, as a result, the vertical carbon brushes embedded in the groove of the outer wall of the polytetrafluoroethylene filling layer are pushed away, the vertical carbon brushes are connected tightly to the specimen, the contact area between the specimen, the carbon brushes and the transmission shaft is enlarged, and the conductive effect is improved; and the small end of the fastening bolt is made of a conductive material. The bottom of the polytetrafluoroethylene filling layer is provided with an internal thread, and the upper part of the bottom cover is provided with an external thread. The interior of the polytetrafluoroethylene filling layer is hollow, the bottom cover is connected to the internal thread of the bottom of the polytetrafluoroethylene filling layer through the external thread, and the upper sealing ring and the lower sealing ring can firmly fix the specimen on the outer wall of the working electrode system.

[0012] As an improvement of the present invention, a quenching bath is arranged on the bottom in the reflowing bath, an induction coil is arranged at the middle upper part of the reflowing bath, the induction coil is connected to the rectifier, and an on-line infrared temperature detector is arranged in the induction coil, wherein the on-line infrared temperature detector is connected to a temperature controller, and is used to measure the surface temperature of strip steel.

[0013] As an improvement of the present invention, the auxiliary electrode plate is shaped like a cylinder, the specimen working electrode is inserted into the center of the auxiliary electrode plate via a working platform, both are connected to the rectifier to form a closed loop, and the functions of a cathode and an anode can be exchanged by changing the positive and negative electrodes of the rectifier, so as to simulate the process of cathode and anode exchange in the processes of alkaline wash and pickling.

[0014] As an improvement of the present invention, a sprinkler is arranged in the cleaning bath, the sprinkler comprises nozzles and a pipeline connected to the nozzles, and the nozzles are connected to the centrifugal pump through the pipeline. After the specimen arrives at the cleaning bath, the nozzles in the cleaning bath automatically perform sprinkling to clean the specimen, preventing the subsequent test from being affected, and the cleaned specimen enters the next working process.

[0015] A test method adopting the test apparatus is characterized in that the test method is as follows: the test process can be controlled automatically; test parameters are set before a test begins, firstly, a test type (alkaline wash, pickling, electroplating, reflowing, passivation or the combination of them) needs to be set, and secondly, working parameters, including bath solution temperature, current density, retention time of a specimen in bath, etc., are set; after parameter setting, a system is prepared, so that the test apparatus is in a standby state; after system preparation is complete, the system requests an operator to send an instruction for starting the test; and after the system receives the instruction, the test process is carried out automatically until all test work is complete. The test apparatus simulates the whole process of continuous strip steel production, including technical processes, such as alkaline wash, pickling, electroplating, reflowing and passivation, or separately simulates one technical process, the whole process of continuous strip steel production is simulated by adjusting the trends and rotational speeds of the two motors, the horizontal motion and vertical motion of strip steel can be realized, and the rotational speed control range is between 0m/min and 350m/min.

[0016] As an improvement of the present invention, the test apparatus also has a reflowing step and a quenching step to implement the production of a plated plate, such as a tinned plate, by the reflowing step, a strip steel specimen is first dipped in flux by a moving unit, and is lifted to an induction heater of a moving support for reflowing after dipping, and after reflowing is complete, the specimen is immersed into water of the cleaning bath, so that the quenching function is carried out.

[0017] Relative to the prior art, the technique has the

following advantages: (1) the test apparatus can simulate the whole process of continuous strip steel production, including technical processes, such as alkaline wash, pickling, electroplating and passivation, and not only can simulate the whole process, but also can separately simulate one technical process, the simulative tests do not interfere with one another, consequently, the accuracy of the tests is further ensured, and electroplating-related personnel can conveniently carry out work, such as development of new product processes and evaluation of electroplating process parameters; (2) a specimen is mounted on the working electrode system, the working electrode system is mounted on the workbench, the vertical lifting motor is used to realize vertical motion, the rotating motor is used to realize the high-speed rotation of the working electrode system, the whole process of high-speed strip steel production is simulated by adjusting the rotational speed of the rotating motor, and the speed control range is between 0m/min and 350m/min; (3) the simulative test of each technical process uses a unique power supply, the specimen is always connected to one electrode of the power supply, while electrodes in each working bath are switched according to needs, and when the specimen moves to each working bath, the electrodes in the working bath are connected to the power supply, while the electrodes in the other baths are in a disconnected state; (4) the whole test process is controlled automatically, after parameters, including bath solution temperature, current density, retention time of the specimen in the bath, etc., are set, a system is prepared, so that the test apparatus is in a standby state, the system requests an operator to send an instruction for starting the test after system preparation is complete, and after the system receives the instruction, the test process is carried out automatically until all test work is complete; (5) the alkaline wash bath, the pickling bath, the electroplating bath and the passivation bath of the test apparatus can simulate the flowing effect of fluid, the flow velocity of the solution can be regulated by the flow of the centrifugal pump, the centrifugal pump adopts the variable-frequency motor, flow can be controlled by changing the rotational speed of the motor, and the test apparatus is easy and convenient to operate, high in efficiency, safe to operate and high in test accuracy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

FIG. 1 is an overall structural schematic diagram of a test apparatus described in the present invention;
FIG. 1-1 is a partially enlarged diagram of FIG. 1;
FIG. 1-2 is a partially enlarged diagram of FIG. 1-1;
FIG. 2 is a top view of a high-speed continuous electroplating test apparatus;
FIG. 3 is a simplified structural diagram of a working bath;
FIG. 4 is a simplified structural diagram of a cleaning bath;
FIG. 5 is a simplified structural diagram of a reflowing bath;
FIG. 6 is a structural schematic diagram of a working electrode described in the example 9 of the present invention;
FIG. 7 is a structural schematic diagram of the test apparatus provided with the working electrode described in the example 9;

[0019] Parts in the drawings: 1. rotating motor, 2. vertical lifting motor, 3. working bath, 4. supporting underframe, 5, working electrode system, 6. moving screw, 7. rotating platform, 8. circulating pump, 9. auxiliary electrode, 10. reservoir, 11. transmission shaft, 12. overflow orifice, 13. anode plate, 14. specimen working electrode, 15. test bath, 16. weep hole, 17. heater, 18. cleaning bath, 19. nozzle, 20. centrifugal pump, 21. upper sealing ring nut, 22. lower sealing ring nut, 23. upper sealing ring, 24. lower sealing ring, 25. carbon brush, 26. polytetrafluoroethylene filling layer, 27. bottom cover, 28. induction coil, 29. on-line infrared temperature detector, 30. quenching bath, 31. fastening bolt, and 32. fastening nut.

DETAILED DESCRIPTION

[0020] In order to better understand the present invention, the present invention is further described and introduced hereinafter in conjunction with the drawings and specific embodiments.

[0021] Example 1: See FIG. 1, FIG. 1-1, FIG. 1-2 and FIG. 3, a test apparatus for simulating high-speed continuous electroplating of strip steel. The test apparatus comprises a supporting underframe (4), a workbench is arranged on the supporting underframe (4), a working bath (3) is fixed on the workbench, the test apparatus also comprises a working electrode system (5), a circulating pump (8), a reservoir (10), a cleaning bath, a transmission shaft (11), an auxiliary electrode (9) and a specimen working electrode (14), the reservoir (10) is arranged under the working bath, the transmission shaft (11) is connected to the working electrode system (5), both the auxiliary electrode (9) and the working electrode system (5) are connected to a rectifier to form a closed loop, the specimen working electrode (14) is mounted on the working electrode system (5), and by adjusting the rotation of motors, a high-speed strip steel production process can be simulated. All the baths of the test apparatus are mounted at fixed positions on the supporting underframe, the specimen working electrode is mounted on the working electrode system (5), and the working electrode system (5) is mounted on the workbench. The whole electroplating process can be operated automatically, and the whole operation process is simple, efficient and good in safety.

[0022] Example 2: See FIG. 1 and FIG. 2, as an improvement of the present invention, the working bath in-

cludes one or the combination of several of an alkaline wash bath, a pickling bath, an electroplating bath, a reflowing bath, a passivation bath and a fluxing bath. The test apparatus can simulate the whole process of continuous strip steel production, including technical processes, such as alkaline wash, pickling, electroplating and passivation, and not only can simulate the whole process, but also can separately simulate one technical process, separate simulations do not interfere with one another, and thereby the accuracy of test effects is further ensured. The rest of structures and advantages are exactly the same as those of the example 1.

[0023] Example 3: See FIG. 3, as an improvement of the present invention, a heater (17) and a temperature controller are arranged in the reservoir, a centrifugal pump (20) injects working solution into the working bath (3) after the solution is heated to set temperature, and the upper part of the working bath (3) is provided with overflow orifices (12) to ensure the height of solution level. The bottom is provided with a weep hole (16) to ensure that no test solution remains under a non-working state. The flow velocity of the solution is regulated by the flow of the centrifugal pump (20), the centrifugal pump (20) adopts a variable-frequency motor, and flow can be controlled by changing the rotational speed of the motor. The rest of structures and advantages are exactly the same as those of the example 1.

[0024] Example 4: See FIG. 1, as an improvement of the present invention, the motors are a rotating motor (1) and a vertical lifting motor (2), and the vertical lifting motor (2) is connected to a rotating platform to realize vertical motion; the rotating motor is connected to a moving screw of the vertical lifting motor, high speed rotation of the working electrode system is realized by means of the transmission shaft, the vertical lifting motor realizes vertical motion, the rotating motor realizes the high-speed rotation of the working electrode system, the whole process of high-speed strip steel production is simulated by adjusting the rotational speed of the rotating motor, and the speed control range is between 0m/min and 350m/min. The rest of structures and advantages are exactly the same as those of the example 1.

[0025] Example 5: See FIG. 1 to FIG. 1-2, as an improvement of the present invention, the working electrode system (5) comprises an upper sealing ring nut (21), a lower sealing ring nut (22), an upper sealing ring (23), a lower sealing ring (25) and a polytetrafluoroethylene filling layer (26), the upper sealing ring and the lower sealing ring are arranged respectively on the upper and lower sides of the polytetrafluoroethylene filling layer, and are fixed respectively by the upper sealing ring nut and the lower sealing ring nut, the working electrode system (5) also comprises carbon brushes (25), and the carbon brushes (25) are arranged inside the polytetrafluoroethylene filling layer. The carbon brushes are arranged inside the polytetrafluoroethylene filling layer, the carbon brushes have good conductivity, wear resistance and corrosion resistance, consequently, strip steel has good conductivity, and the conductive effect is enhanced; and the upper round sealing ring and the lower round sealing ring are sleeved respectively on the upper side and the lower side of the polytetrafluoroethylene filling layer to prevent electroplating solution from flowing into a part between the polytetrafluoroethylene and the specimen working electrode (14), causing the shift of the specimen working electrode (14), and affecting the electroplating effect. The rest of structures and advantages are exactly the same as those of the example 1.

[0026] Example 6: See FIG. 1 and FIG. 3, as an improvement of the present invention, the auxiliary electrode (9) is shaped like a cylinder, the specimen working electrode (14) is inserted into the center of the auxiliary electrode via a working platform, both are connected to the rectifier to form a closed loop, and the functions of a cathode and an anode can be exchanged by changing the positive and negative electrodes of the rectifier, so as to simulate the process of cathode and anode exchange in the processes of alkaline wash and pickling. The rest of structures and advantages are exactly the same as those of the example 1.

[0027] Example 7: See FIG. 4, as an improvement of the present invention, a sprinkler is arranged in the cleaning bath (18), the sprinkler comprises nozzles (19) and a pipeline connected to the nozzles, and the nozzles are connected to the centrifugal pump (20) through the pipeline. In the process of a test, after a specimen moves to a specified position via the rotating platform, the vertical lifting motor places the specimen at a specified position of the working bath. After working for a certain period of time, the vertical lifting motor lifts the specimen out of the working bath, and the rotating platform moves the specimen to the cleaning bath. After the specimen arrives at a specified position of the cleaning bath, the nozzles in the cleaning bath automatically perform sprinkling to clean the specimen, preventing the subsequent test from being affected, and the cleaned specimen enters the next working process. The rest of structures and advantages are exactly the same as those of the example 1.

[0028] Example 8: See FIG. 5, a quenching bath (30) is arranged on the bottom in the reflowing bath, an induction coil (28) is arranged at the middle upper part of the reflowing bath, and the induction coil (28) is connected to the rectifier, an on-line infrared temperature detector (29) is arranged in the induction coil, wherein the on-line infrared temperature detector (29) is connected to a temperature controller, and is used to measure the surface temperature of strip steel. A reflowing function and a quenching function are realized in the reflowing bath, the strip steel rotates at certain speed, and passes through the induction coil (28) from top down at constant speed, and thereby a good reflowing effect can be ensured. The reflowing coil is located at the middle upper part of the bath, the quenching bath (30) is located on the bottom, and the reflowing coil is 20cm high, and is connected to the rectifier; the on-line infrared temperature detector is arranged at the middle of the reflowing

coil, is connected to the temperature controller, and is used to measure the surface temperature of the strip steel; when the strip steel gets into the reflowing coil, the rectifier is started, and the surface temperature of the strip steel is monitored by the infrared temperature detector; after completely passing through the reflowing coil, the strip steel gets into the quenching bath on the bottom of the reflowing bath and is quenched; a tinned plate (2.8g/m2) is taken as an example, the rotational speed of the strip steel is 100r/min, and when the time which the strip steel takes to get into the reflowing coil and completely leave the reflowing coil is 4.8s to 5.5s, the reflowing effect of the tinned plate is good.

[0029] Example 9: See FIG. 6 and FIG. 7, as an improvement of the present invention, the working electrode system (5) can also be so configured that the working electrode system (5) comprises a fastening nut (32), a fastening bolt (31), an upper sealing ring (23), a lower sealing ring (24), a bottom cover (27), a polytetrafluoroethylene filling layer (26) and carbon brushes (25), wherein the carbon brushes are horizontal carbon brushes and vertical carbon brushes, there are four horizontal carbon brushes and four vertical carbon brushes, the horizontal carbon brushes are located inside the polytetrafluoroethylene filling layer (26), the four horizontal carbon brushes are perpendicular in pairs, the outer ends of the horizontal carbon brushes are connected respectively to the vertical carbon brushes embedded in a groove of the outer wall of the polytetrafluoroethylene filling layer, the inner ends of the horizontal carbon brushes extend into the transmission shaft, and the horizontal carbon brushes are not in direct contact. When the fastening bolt is screwed into the fastening nut, the four horizontal carbon brushes are pushed away, the horizontal carbon brushes push away the vertical carbon brushes to be in tight contact with a specimen, and thereby the specimen working electrode, the transmission shaft and the carbon brushes form a three-in-one conductor; the upper sealing ring (23) and the lower sealing ring (24) are arranged respectively on the upper part of the polytetrafluoroethylene filling layer and the bottom cover; one end of the fastening bolt is big, the other end is small, and the adoption of the big- and small-end arrangement facilitates screwing and unscrewing the fastening bolt; when the fastening bolt is screwed, the small end of the fastening bolt pushes away the four horizontal carbon brushes, as a result, the vertical carbon brushes embedded in the groove of the outer wall of the polytetrafluoroethylene filling layer are pushed away, the vertical carbon brushes are connected tightly to the specimen, the contact area between the specimen, the carbon brushes and the transmission shaft is enlarged, and the conductive effect is improved; and the small end of the fastening bolt is made of a conductive material. The bottom of the polytetrafluoroethylene filling layer is provided with an internal thread, and the upper part of the bottom cover is provided with an external thread. The interior of the polytetrafluoroethylene filling layer is hollow, the bottom cover is connected to the internal thread of the bottom of the polytetrafluoroethylene filling layer through the external thread, and the upper sealing ring and the lower sealing ring can firmly fix the specimen on the outer wall of the working electrode system. After the cylindrical strip steel sleeves the outer wall of the polytetrafluoroethylene filling layer from the bottom, the fastening bolt is screwed into the fastening nut, as a result, the carbon brushes on the outer wall of the polytetrafluoroethylene filling layer are pushed away around to be in tight contact with the inner wall of the strip steel, and the strip steel, the transmission shaft and the carbon brushes form a three-in-one conductor. The bottom cover is then screwed, at this moment, the strip steel is wrapped by the upper sealing ring and the lower sealing ring, and the good sealing effect can prevent the solution from entering the inner wall of the specimen to affect the test effect. When the specimen needs to be taken down after the test is complete, the bottom cover needs to be unscrewed first, at this moment, the specimen cannot be taken down, and if the specimen is forcibly taken down, the carbon brushes will be damaged; the fastening bolt is then unscrewed, so that the carbon brushes embedded in the outer wall of the polytetrafluoroethylene filling layer retract into the polytetrafluoroethylene filling layer; finally, the specimen is taken down, and other tests are carried out. The rest of structures and advantages are exactly the same as those of the example 1.

[0030] Example 10: See FIG. 1 to FIG. 7, a test method adopting the test apparatus. The test method is as follows: the test process can be controlled automatically; test parameters are set before a test begins, firstly, a test type (alkaline wash, pickling, electroplating, reflowing, passivation or the combination of them) needs to be set, and secondly, working parameters, including bath solution temperature, current density, retention time of a specimen in bath, etc., are set; after parameter setting, a system is prepared, so that the test apparatus is in a standby state; after system preparation is complete, the system requests an operator to send an instruction for starting the test; and after the system receives the instruction, the test process is carried out automatically until all test work is complete. The test apparatus simulates the whole process of continuous strip steel production, including technical processes, such as alkaline wash, pickling, electroplating, reflowing and passivation, or separately simulates one technical process, the whole process of continuous strip steel production is simulated by adjusting the trends and rotational speeds of the two motors, the horizontal motion and vertical motion of strip steel can be realized, and the rotational speed control range is between 0m/min and 350m/min.

[0031] The test apparatus also has a reflowing step and a quenching step to implement the production of a plated plate, such as a tinned plate, by the reflowing step, a strip steel specimen is first dipped in flux by a moving unit, and is lifted to an induction heater of a moving support for reflowing after dipping, and after reflowing is com-

plete, the specimen is immersed into water of the cleaning bath, so that the quenching function is carried out.

[0032] The present invention can also combine at least one of the technical features of the embodiments 2, 3, 4, 5, 6, 7 and 8 and the embodiment 1 together to form a new embodiment.

[0033] The present invention can also combine at least one of the technical features of the embodiments 2, 3, 4, 6, 7, 8 and 9 and the embodiment 1 together to form a new embodiment.

[0034] It is to be illustrated that the above-mentioned examples are not used to limit the protection scope of the present invention, and all equivalent modifications or replacements that are made on the basis of the above-mentioned technical solution fall within the scope protected by the claims of the present invention.

Claims

1. A test apparatus for simulating high-speed continuous electroplating of strip steel, **characterized in that** the test apparatus comprises a supporting underframe, a workbench is arranged on the supporting underframe, a working bath is fixed on the workbench, the test apparatus also comprises a working electrode system, a circulating pump, a reservoir, a cleaning bath, a transmission shaft, an auxiliary electrode and a specimen working electrode, the reservoir is arranged under the working bath, the transmission shaft is connected to the working electrode system, both the auxiliary electrode and the working electrode system are connected to a rectifier to form a closed loop, the specimen working electrode is mounted on the working electrode system, and by adjusting the rotation of motors, a high-speed strip steel production process is simulated.

2. The test apparatus for simulating high-speed continuous electroplating of strip steel according to claim 1, **characterized in that** the working bath includes one or the combination of several of an alkaline wash bath, a pickling bath, an electroplating bath, a reflowing bath, a passivation bath and a fluxing bath.

3. The test apparatus for simulating high-speed continuous electroplating of strip steel according to claim 2, **characterized in that** a heater and a temperature controller are arranged in the reservoir, the upper part of the working bath is provided with overflow orifices, the bottom is provided with a weep hole, the flow velocity of solution is regulated by the flow of a centrifugal pump, the centrifugal pump adopts a variable-frequency motor, and flow control is realized by changing the rotational speed of the motor.

4. The test apparatus for simulating high-speed continuous electroplating of strip steel according to claim 3, **characterized in that** the motors are a rotating motor and a vertical lifting motor, and the vertical lifting motor is connected to a rotating platform to carry out vertical motion; the rotating motor is connected to a moving screw of the vertical lifting motor, and high speed rotation of the working electrode system is realized by means of the transmission shaft.

5. The test apparatus for simulating high-speed continuous electroplating of strip steel according to claim 4, **characterized in that** the working electrode system comprises an upper sealing ring nut, a lower sealing ring nut, an upper sealing ring, a lower sealing ring and a polytetrafluoroethylene filling layer, the upper sealing ring and the lower sealing ring are arranged respectively on the upper and lower sides of the polytetrafluoroethylene filling layer, and are fixed respectively by the upper sealing ring nut and the lower sealing ring nut, the working electrode system also comprises carbon brushes, and the carbon brushes are arranged inside the polytetrafluoroethylene filling layer.

6. The test apparatus for simulating high-speed continuous electroplating of strip steel according to claim 4, **characterized in that** the specimen working electrode comprises a fastening nut, a fastening bolt, an upper sealing ring, a lower sealing ring, a bottom cover, a polytetrafluoroethylene filling layer and carbon brushes, wherein the carbon brushes are horizontal carbon brushes and vertical carbon brushes, the carbon brushes are embedded in the outer wall of the polytetrafluoroethylene filling layer, and extend to the internal axis of the polytetrafluoroethylene filling layer, and the upper sealing ring and the lower sealing ring are arranged respectively on the upper part of the polytetrafluoroethylene filling layer and the bottom cover.

7. The test apparatus for simulating high-speed continuous electroplating of strip steel according to claim 6, **characterized in that** there are four horizontal carbon brushes and four vertical carbon brushes, the horizontal carbon brushes are located inside the polytetrafluoroethylene filling layer, the four horizontal carbon brushes are perpendicular in pairs, the outer ends of the horizontal carbon brushes are connected respectively to the vertical carbon brushes embedded in a groove of the outer wall of the polytetrafluoroethylene filling layer, the inner ends of the horizontal carbon brushes extend into the transmission shaft, and the upper sealing ring and the lower sealing ring are arranged respectively on the upper part of the polytetrafluoroethylene filling layer and the bottom cover; one end of each fastening bolt is big, the other end is small, and the small end of each fastening bolt is made of a conductive material; the bottom of the polytetrafluoroethylene filling layer is

provided with an internal thread, and the upper part of the bottom cover is provided with an external thread.

8. The test apparatus for simulating high-speed continuous electroplating of strip steel according to claim 5 or 7, **characterized in that** a quenching bath is arranged on the bottom in the reflowing bath, an induction coil is arranged at the middle upper part of the reflowing bath, the induction coil is connected to the rectifier, and an on-line infrared temperature detector is arranged in the induction coil, wherein the on-line infrared temperature detector is connected to a temperature controller, and is used to measure the surface temperature of strip steel.

9. The test apparatus for simulating high-speed continuous electroplating of strip steel according to claim 8, **characterized in that** the auxiliary electrode plate is shaped like a cylinder, the specimen working electrode is inserted into the center of the auxiliary electrode plate via a working platform, both are connected to the rectifier to form a closed loop, and the functions of a cathode and an anode can be exchanged by changing the positive and negative cathodes of the rectifier, so as to simulate the process of cathode and anode exchange in the processes of alkaline wash and pickling.

10. The test apparatus for simulating high-speed continuous electroplating of strip steel according to claim 9, **characterized in that** a sprinkler is arranged in the cleaning bath, the sprinkler comprises nozzles and a pipeline connected to the nozzles, and the nozzles are connected to the centrifugal pump through the pipeline.

11. A test method adopting the test apparatus as claimed in any one of claims 1-10, **characterized in that** the test method is as follows: the test process can be controlled automatically; test parameters are set before a test begins, firstly, a test type (alkaline wash, pickling, electroplating, reflowing, passivation or the combination of them) needs to be set, and secondly, working parameters, including bath solution temperature, current density, retention time of a specimen in the bath, etc., are set; after parameter setting, a system is prepared, so that the test apparatus is in a standby state; after system preparation is complete, the system requests an operator to send an instruction for starting the test; and after the system receives the instruction, the test process is carried out automatically until all test work is complete.

12. The test method according to claim 11, **characterized in that** the test apparatus also has a reflowing step and a quenching step to implement the production of a plated plate by a reflowing procedure, a strip steel specimen is first dipped in flux by a moving unit, and is lifted to an induction heater of a moving support for reflowing after dipping, and after reflowing is complete, the specimen is immersed into water of the cleaning bath, so that the quenching function is carried out.

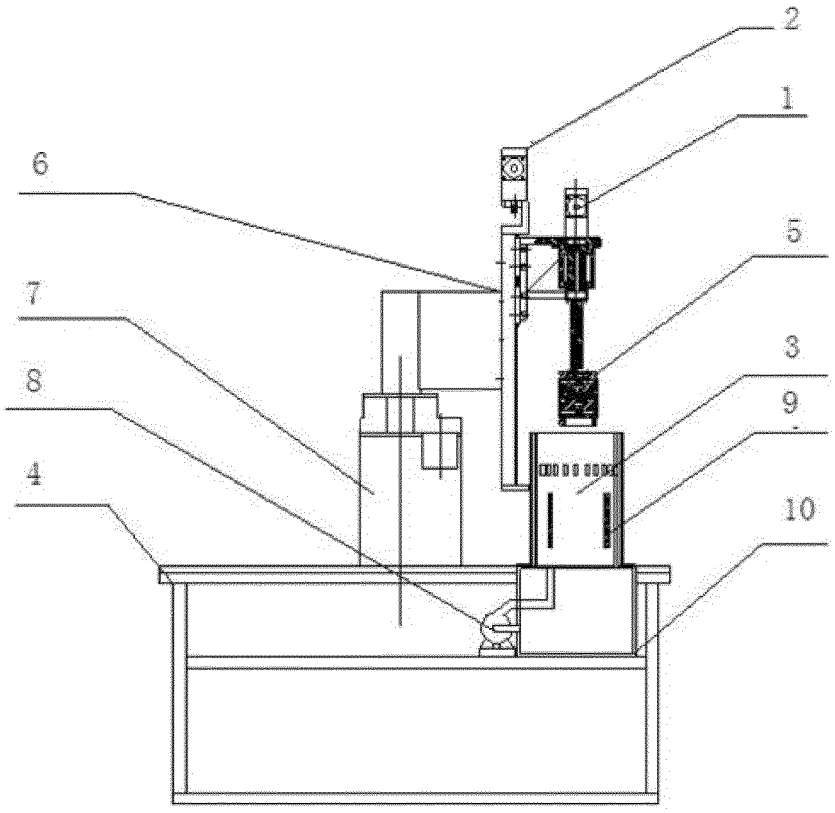

FIG. 1

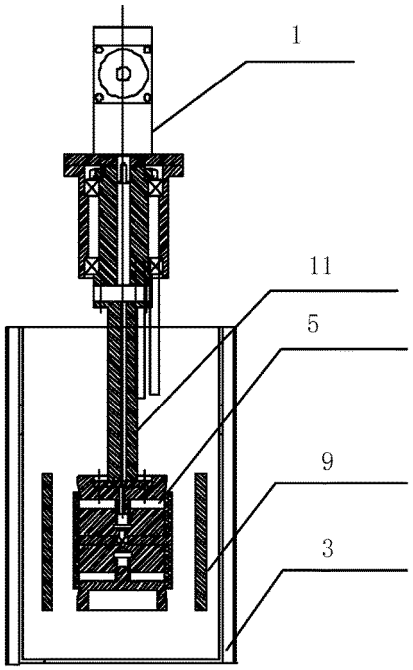

FIG. 1-1

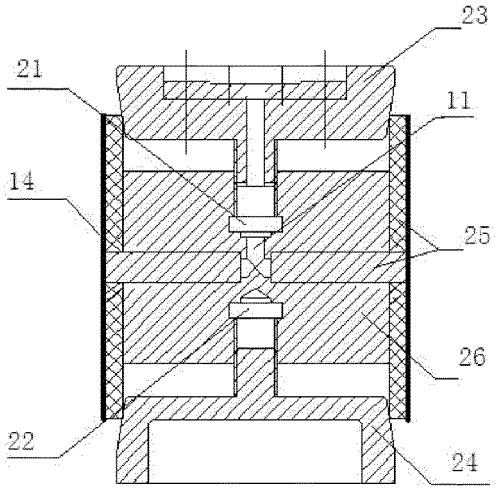
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FIG. 1-2

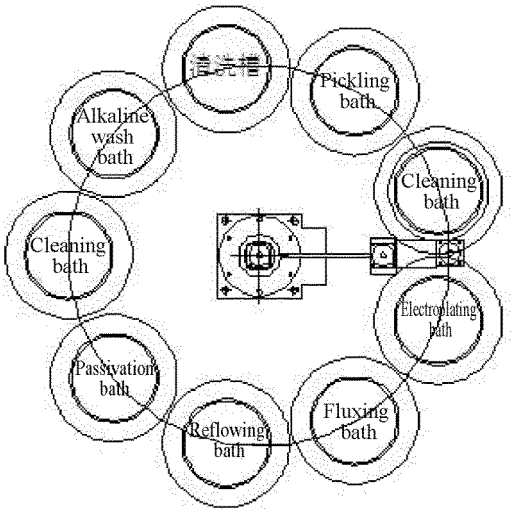
Pickling bath
Alkaline wash bath
Cleaning bath
Cleaning bath
Electroplating bath
Passivation bath
Fluxing bath
Reflowing bath

FIG. 2

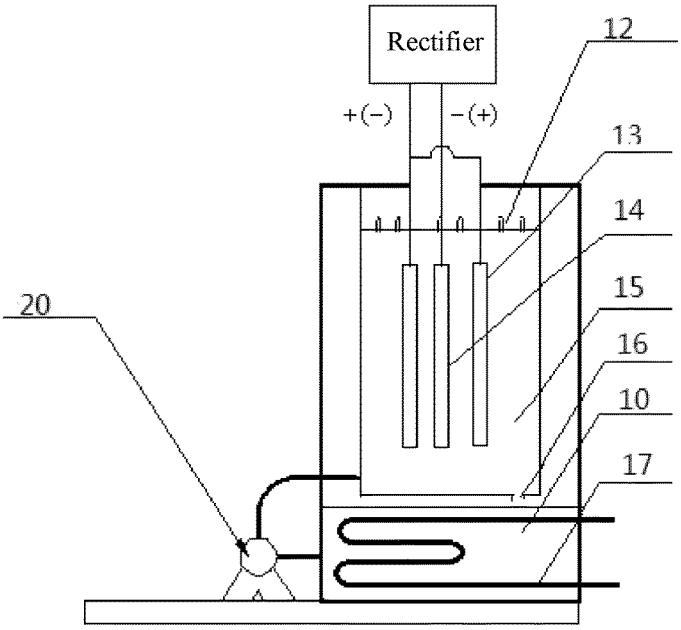

FIG. 3

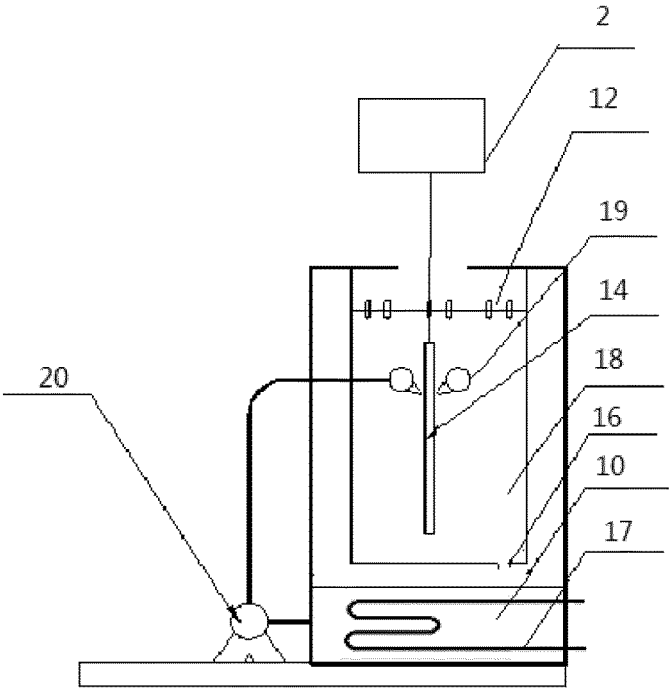

FIG. 4

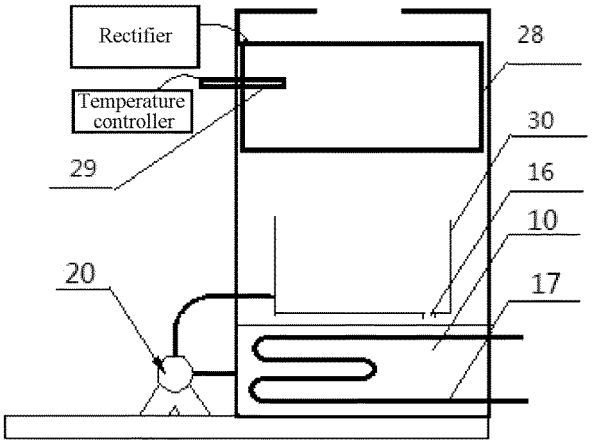
Rectifier
Temperature controller
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FIG. 5

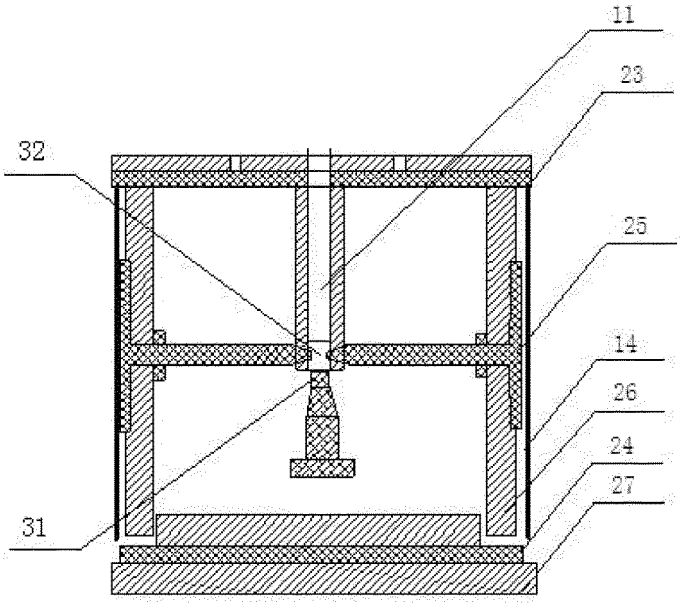
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FIG. 6

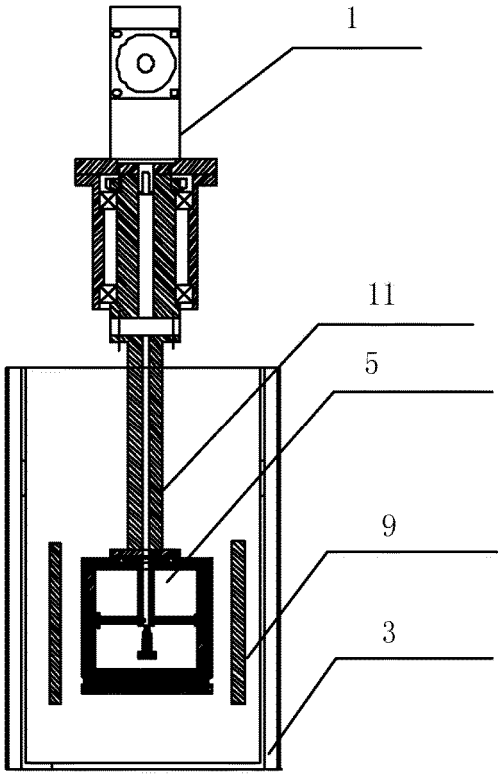

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2014/092602

A. CLASSIFICATION OF SUBJECT MATTER

C25D 17/00 (2006.01) i; C25D 17/04 (2006.01) i; C25D 17/10 (2006.01) i; C25D 7/06 (2006.01) i
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C25D 17/-; C25D 7/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNKI, CPRS, WPI, EPODOC electroplat+, electrodeposit+, simulate+, test+, experiment, band+, hoop, strip, strap, ribbon, steel, tin, Sn

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SHAO, Wenhua et al., The Investigation On the Rotating Cathode Experimental Facility used in Sn-plating, Mateials Protection, no. 06, 31 December 1985 (31.12.1985), see page 40, left column, line 1 to page 42, left column, line 20 and figure 1	1-3, 11
A	SHAO, Wenhua et al., The Investigation On the Rotating Cathode Experimental Facility used in Sn-plating, Mateials Protection, no. 06, 31 December 1985 (31.12.1985), see page 40, left column, line 1 to page 42, left column, line 20 and figure 1	4-10, 12
X	SHAO, Wenhua et al., The Investigation On the WG-1 rotator Experimental Apparatus for electroplating tin, Research on Iron and Steel, section 4, 31 December 1983 (31.12.1983) see page 10, left column, line 1 to page 13, left column, line 25 and figure 2	1-3, 11
A	SHAO, Wenhua et al., The Investigation On the WG-1 rotator Experimental Apparatus for electroplating tin, Research on Iron and Steel, section 4, 31 December 1983 (31.12.1983) see page 10, left column, line 1 to page 13, left column, line 25 and figure 2	4-10, 12
A	CN 2618927 Y (BAOSHAN IRON & STEEL) 2 June 2004 (02.06.2004), see the whole document	1-12
A	US 5985106 A (VELAQUEZ G Z) 16 November 1999 (16.11.1999) see the whole document	1-12

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 February 2015	10 March 2015
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer CAO, Dongfang Telephone No. (86-10) 62084555

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2014/092602

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 2618927 Y	02 June 2004	None	
US 5985106 A	16 November 1999	None	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 201320146361 A **[0003]**