

SYSTEM, METHOD, AND APPARATUS FOR CONTINUOUS
ELECTROPLATING OF ELONGATED WORKPIECES

Field of the Invention:

The present invention relates in general to the electroplating of workpieces and, in particular, to an improved system, method, and apparatus for the continuous electroplating of the exteriors and/or interiors of elongated workpieces such as shafts and tubes.

Description of the Related Art

Historically, the metallic electroplating of parts or workpieces that more than 20 feet in length has been problematic and expensive due to the very large plating tanks that are required, and the significant volume of plating chemicals needed to fill the tanks. As the plating chemicals are toxic and have a finite life, there is an additional cost incurred for proper disposal according to EPA requirements.

In addition, large plating tanks have very large electrical power requirements. With a large tank plating operation, the entire part or surface of a workpiece is plated at one time. To successfully plate the surface of a workpiece, a specific amount of power per unit surface area is required, which is also known as the current density. If the entire part is to be plated at one time, such as in the case of large plating tanks, a larger power supply would be required.

For example, some offshore drilling and production platforms use ram-style tensioners having a 28 to 30 foot stroke length that is exposed to acids, etc., that cause corrosion. These types of workpieces are too long for conventional plating techniques. Thus, an improved process for applying plating metals with a different technique than conventional "tank plating" processes would be desirable. In particular, the ability to plate only small areas of the workpiece at a time, rather than all or large sections of a workpiece would be especially desirable.

Summary of the Invention:

Embodiments of a system, method, and apparatus for electroplating one or more surfaces of a workpiece are disclosed. The invention is particularly well suited for the continuous electroplating of metals on the interior or exterior cylindrical surfaces of an elongated workpieces. The invention uses a traveling anode to gradually plate along the axial length of a workpiece instead of plating the entire part or large portions of the part at one time. With a plating system that uses a traveling anode design, a very small amount of plating chemicals are used resulting in a more environmentally friendly solution that also has significantly lower operating costs.

The foregoing and other objects and advantages of the present invention will be apparent to those skilled in the art, in view of the following detailed description of the present invention, taken in conjunction with the appended claims and the accompanying drawings.

Brief Description of the Drawings:

So that the manner in which the features and advantages of the present invention, which will become apparent, are attained and can be understood in more detail, more particular description of the invention briefly summarized above may be had by reference to the embodiments thereof that are illustrated in the appended drawings which form a part of this specification. It is to be noted, however, that the drawings illustrate only some embodiments of the invention and therefore are not to be considered limiting of its scope as the invention may admit to other equally effective embodiments.

Figure 1 is a sectional side view of one embodiment of a system for electroplating an interior surface and is constructed in accordance with the present invention;

Figure 2 is an enlarged sectional side view of an upper portion of the system of Figure 1 and is constructed in accordance with the present invention;

Figure 3 is an enlarged sectional side view of a lower portion of the system of Figure 1 and is constructed in accordance with the present invention;

Figure 4 is a side view of another embodiment of a system for electroplating an exterior surface and is constructed in accordance with the present invention; and

Figure 5 is an end view of the system of Figure 4 and is constructed in accordance with the present invention.

Detailed Description of the Invention:

Referring to Figures 1 - 3, one embodiment of a system, method, and apparatus for electroplating an interior surface is disclosed. This embodiment is particularly well suited for the continuous electroplating of metals on the interior cylindrical surface of an elongated workpiece, such as a shaft or tube.

For example, in the embodiment shown, a cylindrical anode 11 is immersed in a plating fluid solution 27. The anode 11 is centralized or radially aligned with respect to the inner diameter cylindrical bore 15 of the workpiece 17 with upper and lower, non-conductive guides 19, 21, respectively. Guides 19, 21 may comprise circular disks that are rigidly connected to the anode 11. A seal plate 23 (Figure 3) and a non-conductive lip seal 25 are also rigidly connected to the anode 11. Seal plate 23 and seal 25 serve to retain the plating solution 27 in contact with the anode 11 and bore 15 of the workpiece 17. In one embodiment, the plating solution 27 may comprise nickel, chloride, nickel sulfamate, and boric acid, and nickel carbonate may be used to adjust pH. Other plating solutions may be readily employed depending on the application.

A lifting connection 29 is rigidly connected to the upper centralizing guide 19 and provides an attachment point to connect a lifting cable 31. An opposite end of the lifting cable 31 is connected to a drum reel 33 or other suitable lifting device that can lift or lower the assembly through bore 15 at a controlled rate. Alternately, items 29, 31, 33 may be duplicated on the opposite axial end of the anode assembly (i.e., on guide 21) such that the anode assembly can be pulled in the opposite or either axial direction.

In addition, a terminal post 35 (Figure 2) is connected to the anode 11 and is used to connect a positive charge through a cable lead 37. The cable lead 37 is connected at an opposite end to the positive terminal of a DC power supply 39. A terminal post 41 is connected to the workpiece 17 and is used to connect a negative charge to a cable lead 43 from DC power supply 39. By applying a DC voltage with the power supply 39, material is plated onto the inner diameter bore 15 at a rate that is dependent on, e.g., the power supply, concentration of plating solution, and rate of movement of the assembly through the workpiece. In order to plate the entire length of the inner diameter bore 15 of the workpiece 17, the anode 11 can be either

lowered or lifted at a controlled, predetermined rate so that a uniform plating thickness can be obtained over the entire length of the part.

Referring now to Figures 4 and 5, another embodiment of the invention for electroplating an exterior surface is disclosed. This embodiment is particularly well suited for the continuous electroplating of metals on the exterior cylindrical surface of an elongated workpiece, such as a shaft or tube. Like the previous embodiment, only small areas of the cylinder are plated at any one time with a traveling anode that gradually plates along the length of the workpiece instead of plating the entire part at one time.

The process for applying plated metals onto the cylindrical exterior is similar to the process described above. The outer surface plating of round or cylindrical parts is accomplished using a short, cylindrical shaped anode 51 that is immersed in a plating fluid solution 53 held in a cylindrically shaped tank 55. The anode 51 is centrally located by a centering device 56 that is rigidly connected to the tank 55. The centering device 56 also serves to electrically insulate the anode 51 from the tank 55 and may be formed from non-conductive materials such as a wood or plastic rib. However, one skilled in the art will recognize that there are numerous ways to locate the anode 51 with respect to the tank 55.

In one embodiment, the tank 55 uses two non-conductive flanged seal plates 57 with lip seals 59, 61, located at respective ends of the tank 55. Seals 59, 61 form low pressure seals between the tank 55 and the workpiece 63 to retain the plating solution 53 in the tank 55. The flanged plates 57 are used to accommodate the different diameters of various types of workpieces to enable greater adaptability for different applications.

In order to centralize the tank 55 and anode 51 to the outer diameter of the workpiece 63, a set of support wheels 65 are rigidly secured to the tank 55, but allowed to freely rotate. A drive motor 67 is connected to at least one of the support wheels 65 to control the speed or rate of movement of the assembly of tank 55 and anode 51 along the length of the workpiece 63. Alternately, the tank assembly may be moved along the workpiece in manner similar to the previous embodiment.

In one embodiment, the electrical connections are provided by a terminal post 69 located on tank 55. Post 69 is used to attach a positive charge via a spooled cable lead 71 extending

from a DC power supply 73 (e.g., rectifier), before terminating on the anode 51. A cable 77 extends between a clamp 75 or other securing means that is connected to the workpiece 63, and a negative terminal 78 on the DC power supply 73 to complete the electrical circuit of the plating process.

A fill port 79 is provided on top of the tank 55 and serves as a port for adding chemical plating solution and monitoring the fluid level of tank 55. As shown in Figure 4, extensions 81 for plater run out may be installed on the axial ends of workpiece 63. Extensions 81 (left side exploded view; right side installed) allow the plating system to smoothly travel beyond the axial ends of workpiece 63 so that the entire exterior surface of workpiece 63 may be plated.

The present invention has many advantages. This design greatly enhances the ability to plate long parts without having to source or build large tanks that can accommodate parts of this size. With a smaller power supply requirement for the traveling anode, lower initial capital costs are achieved over conventional large tank plating systems. This solution is also much more cost effective than conventional laser-cobalt cladding techniques or brush plating techniques.

Another advantage of the traveling anode plating system over conventional large tank plating systems is a reduction in the size of the anode. As the entire part is plated at one time with a large tank plating system, the plating anode must be as long as the part to be plated. Typically the anodes are designed and made for a particular part to be plated. For parts in excess of 25 to 30 feet in length, the cost can be quite large due to the manufacturing requirements for non-standard, or unique features of such a component, as well as the handling and shipping requirements.

In comparison, the traveling anode plating system uses a short anode that is more economical. The shorter anode has more universal application in comparison to long anodes that are built for specific applications, as it can be used for parts of any length. In addition, the smaller size of the tank and components that make up the traveling anode plating system allow it to be a portable system. With long parts this is a very significant advantage over conventional large tank plating systems since the present invention can be brought to the workpiece, which greatly reduces shipping and handling costs as well as reductions in processing time. This is particularly important in the case of long parts as there is only a small group of vendors that have

the capacity to perform large tank plating operations. Furthermore, these vendors are dispersed in remote areas of the country for environmental reasons.

While the invention has been shown or described in only some of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes without departing from the scope of the invention.

For example, although the first embodiment is shown in a vertical orientation, it may be reconfigured in other orientations as well, including horizontal directions. Such an embodiment may include, for example, means for maintaining a full fluid level of the plating solution between the seals, and means for continuously replenishing the supply of plating solution as well. Likewise, the second embodiment has the same adaptability for vertical configurations instead of the horizontal configuration shown. Moreover, the present invention is not limited to plating round or cylindrical workpieces. The shape of the invention can be reconfigured to the shape (interior or exterior) of almost any workpiece.

Claims

What is claimed is:

1. A system for electroplating a workpiece, the workpiece having an interior with a surface, comprising:

an anode having an axis and located in the interior of the workpiece adjacent to the surface and immersed in an electroplating fluid solution;

a centralizer mounted to the anode for centralizing the anode within the interior of the workpiece, the centralizer being electrically non-conductive;

a seal mounted to the anode for retaining the electroplating fluid solution in contact with the anode and the surface of the workpiece;

moving means for moving the anode, centralizer, and seal through the interior at a controlled rate; and

an electrical power supply electrically connected to the anode and the workpiece for supplying a voltage to the anode, through the electroplating fluid solution, and to the workpiece to plate the surface with the electroplating fluid solution.

2. A system according to Claim 1, wherein the surface is a cylindrical bore, the centralizer comprises non-conductive, circular guide disks located on opposite axial ends of the anode for radially aligning the anode within the cylindrical bore, and the anode is cylindrical.

3. A system according to Claim 1, wherein the seal comprises a seal plate mounted to the anode and a lower portion of the centralizer, the seal plate being located between a lower end of the anode and the lower portion of the centralizer, and the seal plate having a non-conductive lip seal for retaining the electroplating fluid solution in contact with the anode and the surface of the workpiece.

4. A system according to Claim 1, wherein the moving means comprises a lifting connection rigidly connected to an outer portion of the centralizer for providing an attachment

point to connect a pulling cable having an opposite end connected to a drum reel, such that the moving means moves the anode, centralizer, and seal through the interior at a controlled rate for continuously plating the surface of the workpiece.

5. A system according to Claim 1, wherein the electrical power supply comprises DC power for supplying a positive charge to a terminal post on the anode via a cable lead, and a negative charge to a terminal post on the workpiece via another cable lead, such that material is plated onto the surface at a rate that is dependent on the DC power, a concentration of the electroplating fluid solution, and a rate of movement of the anode through the workpiece.

6. A system according to Claim 1, wherein the anode is continuously moved through the workpiece at a controlled, predetermined rate so that a uniform plating thickness is obtained on the surface over an entire length of the workpiece.

7. A system for electroplating a workpiece, the workpiece having an exterior with a surface, comprising:

a tank of electroplating fluid solution surrounding a portion of the surface of the workpiece, the tank having a centralizer extending inward therefrom;

an anode mounted to the centralizer and located external to the workpiece adjacent to the surface and immersed in the electroplating fluid solution, such that the anode is centralized with respect to the surface;

a seal mounted to the tank for retaining the electroplating fluid solution in contact with the anode and the surface of the workpiece;

moving means mounted to the tank for moving the tank, anode, centralizer, and seal along the workpiece at a controlled rate; and

an electrical power supply electrically connected to the anode and the workpiece for supplying a voltage to the anode, through the electroplating fluid solution, and to the workpiece to plate the surface with the electroplating fluid solution.

8. A system according to Claim 7, wherein the surface is cylindrical, the centralizer comprises a non-conductive circular guide disk located adjacent an axial center of the tank for radially aligning the anode within the tank with respect to the cylindrical surface, and the anode is cylindrical.

9. A system according to Claim 7, wherein the seal comprises a set of non-conductive flanged seal plates with lip seals located at respective axial ends of the tank, the lip seals forming low pressure seals between the tank and the workpiece to retain the electroplating fluid solution in the tank.

10. A system according to Claim 9, wherein the set of flanged seal plates comprise a plurality of flanged seal plates of various sizes that are used to accommodate workpieces having different diameters.

11. A system according to Claim 7, wherein the moving means comprises a set of support wheels rigidly secured to the tank but allowed to freely rotate, a drive motor coupled to at least one of the support wheels to control a rate of movement of the tank and anode along an axial length of the workpiece for continuously plating the workpiece.

12. A system according to Claim 7, wherein the electrical power supply comprises DC power for supplying a positive charge to the anode via a cable lead, and a negative charge to the workpiece via another cable lead, such that material is plated onto the surface at a rate that is dependent on the DC power, a concentration of the electroplating fluid solution, and a rate of movement of the anode relative to the workpiece.

13. A system according to Claim 7, wherein the tank has a fill port on an upper end thereof for adding additional electroplating fluid solution and monitoring a fluid level of the electroplating fluid solution inside the tank.

14. A system according to Claim 7, further comprising extensions installed on each axial end of the workpiece for plater run out, such that the tank is allowed to smoothly travel beyond the axial ends of the workpiece to plate an entirety of the surface of the workpiece.

15. A system according to Claim 7, wherein the anode is continuously moved along the workpiece at a controlled, predetermined rate so that a uniform plating thickness is obtained on the surface over an entire length of the workpiece.