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CONDUCTOR ROLLField of the Invention

The invention relates to a conductor roll for use in annealing wire, such as copper wire, comprising a substrate having good electrical conductivity and a top coating of tungsten or a tungsten based alloy with a surface roughness of said coating of at least 2 microns Ra.

Background of the Invention

In the annealing of copper wire, copper rolls or hoops are used to heat the wire by the Joule effect. Copper is the preferred material for the conductor roll because it has good conductivity. In a typical or conventional annealing apparatus, the copper wire is fed in contact over two spaced apart conductive rolls connected to a power source. One roll is positive while the other roll is negative. Heat is generated in the copper wire when the rolls are connected to a power source since the copper wire completes the circuit between the conductive rolls. In the annealing of copper wire, the wire is continuously fed over the conductor rolls as a desired speed whereupon the wire is heated and then it is cooled in a conventional manner. The copper wire contacts the conductor rolls and the friction therebetween causes wear in the surface of the conductor rolls. Once the wear of the rolls becomes undesirable for efficient operation of the annealing process, the rolls are replaced. This results in a shut down of the annealing operation and thus loss of productivity. It has been proposed to substitute nickel in place of copper for the roll

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material since nickel has better wear resistance characteristics. However, nickel rolls are much more expensive than copper rolls and are still subject to wear resistance.

It is an object of the present invention to provide a conductor roll with a tungsten or tungsten based alloy coating having a roughness of at least 3 microns Ra and which coating has excellent wear resistance characteristics when used in annealing wire, such as copper wire.

Another object of the present invention is to provide a cost effective and good wear resistance coating for conductor rolls for use in annealing wire, such as copper wire.

The present invention will become more apparent from the following description thereof when considered together with the accompanying drawings which are set forth as being exemplary of embodiments of the present invention and are not intended in any way to be limitative thereof.

Summary of the Invention

The invention relates to a conductive roll for use in annealing wire comprising a conductive substrate coated with a tungsten or tungsten based alloy and wherein the surface of said coating has a surface roughness of at least 2 microns Ra. The substrate of the conductive roll has to have good electrical conductivity and withstand the heat of an annealing process. Although the preferred material for the substrate would be copper, it could also be made of bronze, nickel and steel. The coating for the conductive roll is tungsten or a tungsten based alloy.

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It is not enough to have a tungsten or a tungsten based alloy coating, but the coating must have a surface roughness of at least 2 microns Ra, preferably 5 microns Ra or above. The coating thickness can vary from 50 to 150 microns thick. To produce the necessary roughness in the surface coating, the coating could be grit blasted using a material such as ceramic beads, metallic beads or the like; laser engraved using conventional laser devices; electro-erosion of the coating surface; machining of the surface to get the required roughness; or any other conventional techniques. The substrate could be treated, such as by grit blasting, to produce the necessary roughness prior to or after depositing the coating on its surface. Alternately, an undercoat could be deposited, such as nickel or nickel based alloy, which could have the desired roughness or made to have the desired surface roughness so that the topcoat of tungsten or a tungsten based alloy will conform to the surface contour of the undercoat. An undercoat of nickel with five percent by weight aluminum has been observed to have the natural roughness that would be suitable for this invention. A nickel-aluminum undercoating is a good corrosion resistant layer for many substrates and thus would provide a good duplex coating with the tungsten or tungsten alloy top coating. In the practice of this invention, any good corrosion resistant undercoat could be used such as nickel, nickel-containing coatings and the like. The top coat could also be sealed with a suitable sealer, such as an epoxy sealant. This could also protect the substrate by providing a barrier to prevent penetration of any detrimental elements in the environment of the annealing process.

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Upon testing of the coating of this invention, it was believed that a smooth surface could provide a better surface to reduce friction wear on the conductive roll since the wire could slide over the roll with less friction. However, it was found that to increase the friction wear of the coated roll, it was necessary to roughen the surface to 2 microns Ra or greater.

Drawings

Figure 1 is a schematic diagram of an annealing process for copper wire.

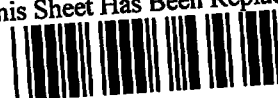
Figure 2 is a perspective view of an arc segment of a conductive roll shown in Figure 1.

Figure 3 is a perspective view of an arc segment of a conductive roll with the coating of this invention and showing copper wires being fed over such coating.

Figure 4 is a cross section of the conductor roll of Figure 3 taken through line 4-4.

Referring to Figure 1, a schematic diagram is shown of an annealing process 2 for copper wire 4 in which the copper wire 4 is fed over conventional rolls 6 to negative conductor rolls 8, positive roll 10 and negative roll 9. The negative conductor rolls 8-9 and the positive conductor roll 10 are connected across a voltage supply (not shown), such as 30 volts, and then the copper wire 4 is fed over these conductor rolls 8-9 and 10 to form a circuit that can develop a high current such as 125 amperes. The resistive heating of the copper wire 4 can increase the temperature of the wire, as for example up to 200°C or higher. As the conductor wire 4 is fed from conductor roll 8 to conductor roll 10, a current flows through the copper

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wire and due to IR losses, the copper wire is heated. The copper wire 4 is then fed from conductor roll 10 to conductor roll 9 in which it is fed into a suitable tank 15 where an inert gas nitrogen 12 is contained over a mixture of water and oil 14. The heated wire 4 is then cooled by the water and oil mixture 14 and is fed over roll 7 where it is then suitably wound for storage and/or shipment to a desired locality. The speed at which the copper wire 4 is fed over the rolls 8-9-10 is generally about 15 meters per second. For different annealing processes, this speed can vary either lower or higher.

Figure 2 shows an arc segment of a conductor roll 16 after it had been used in an annealing process for two parallel spaced apart copper wires. The contact of the copper wire with the conductor roll 16 created friction in which semi-circular grooves 18 were created in the conductor roll. After the grooves 18 are formed to a certain depth and width, the conductor roll has to be removed and replaced by a new conductor roll. Figures 3 and 4 show an arc segment of a conductor roll 20 having a coating 22 and two parallel aligned, spaced apart copper wires 24 being fed over the coating 22. As shown in Figure 4 which is an enlarged view of a segment of the arc segment of Figure 3 taken through lines 4-4, the copper wire 24 contacts the peaks 26 of the coating 22 so that only minimum contact is made between the coating 22 and the copper wires 24. Since the coating 22, which is a tungsten or tungsten based alloy coating, has good wear resistance characteristics, the coated conductor roll 20 will provide a greater service life than an uncoated conductor roll.

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EXAMPLE

A copper wire 0.5 mm thick was annealed in an apparatus as shown in Figure 1. During an annealing process, uncoated conductor rolls were used and in another annealing process, the conductor rolls were coated with tungsten and had a surface roughness of different values. The conductor rolls that were coated were first grit blasted with 20 mesh size aluminum oxide particles at a pressure of about 23 psi. The tungsten coating was then deposited to a thickness of 100 mm. The annealing process used a 30-volt power source that produced a current of 125 amperes. The temperature of the wire between the negative conductor roll and positive conductor roll was about 200°C and the temperature of the water-oil mixture was about 40°C. The copper wire was fed over the conductor rolls at a speed of about 15 meters per second. In the annealing process that used the uncoated conductor rolls, the rolls had to be replaced after 60 hours of use. The coated conductor rolls that were surface finished to 0.05 micron Ra lasted for 175 hours; the coated conductor rolls that were surface finished to about 5.5 microns Ra lasted for 325 hours; and the conductor rolls that were surface finished to 10 microns Ra lasted for about 900 hours. As evidenced from these data, the conductor rolls that have been coated with tungsten and surface finished to several microns Ra in accordance with this invention will provide longer service in annealing copper wire than uncoated conductor rolls or conductor rolls that are coated but have a surface finish of less than 2 microns Ra.

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It will be understood that various changes in the details, materials and arrangement of parts which have been described herein may be made by those skilled in the art within the principle and scope of the invention as expressed in the claims. For example, an undercoat, such as nickel aluminum, may be applied prior to the tungsten or tungsten alloy top coat to provide corrosion protection for the substrate. In addition, a sealant, such as an epoxy, can be applied to the top coat to also provide corrosion protection for the substrate. Thus any material can be used as the substrate as long as it is sufficiently conductive to pass a desired current through the copper wire.

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WHAT IS CLAIMED

1. A conductive roll for use in annealing wire comprising a conductive substrate coated with a tungsten or tungsten based alloy layer and wherein the surface of the coated layer has a roughness of at least 2 microns Ra.
2. The conductor roll of claim 1 wherein the surface of the coated layer has a roughness of at least 5 microns Ra.
3. The conductor roll of claim 1 wherein the substrate is made of a conductive material selected from the group consisting of copper, bronze, nickel and steel.
4. The conductor roll of claim 1 wherein the thickness of the tungsten or tungsten based alloy layer is from 50 to 150 microns thick.
5. The conductor roll of claim 1 wherein an undercoat is disposed between the substrate and the tungsten or tungsten based alloy layer.
6. The conductor roll of claim 5 wherein the undercoat is selected from the group consisting of nickel-aluminum and nickel.
7. The conductor roll of claim 1 wherein a sealant is disposed over the tungsten or tungsten based alloy layer.

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8. The conductor roll of claim 7 wherein the sealant is epoxy.

9. The conductor roll of claim 5 wherein the substrate is bronze, the undercoat is nickel-aluminum and the surface roughness of the tungsten or tungsten based alloy layer is at least 5 microns Ra.

10. The conductor roll of claim 8 wherein the substrate is copper the sealant is epoxy and the surface roughness of the tungsten or tungsten based alloy layer is at least 5 microns Ra.

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