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Un-conventional Metal Surfacing with Conductive Coating

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Abstract—*As we know that in day-to-day life electricity has become basic need of the people. To produce electricity, stress is directly put over the natural resources like fossil fuels, water, metals by means of either hydraulic power generation or thermal power generation and in this era, we also generate by nuclear power. To achieve the need of power generation, the setup to produce electricity consists of rotor, stator, different types of windings such as stator winding, rotor winding, slip rings, carbon brush holder and different types of connections. Several metals and chemicals are used to electroplate the carbon brush holder such as copper, brass, $CuSO_4$, H_2SO_4. This paper deals with enhancing the life period of the carbon brush holder by doing the electroplating of copper of 0.04 mm over the surface of the carbon brush holder to improve the carbon brush holder surface. The electroplating was done at three different voltages i.e. 270 V, 285 V and 300 V. This enhanced properties like roughness, resistance to corrosion, thermal conductivity, texture, luxture and reduces sparking. The blackening agent was also applied to make copper plated surface oxidant with the help of oxidizing blackening agent. The surface became anti-corrosive, enhances wash ability and the carbon brush holder achieved the close dimensions too. The optimum voltage for electroplating is found to be 300 V in optimum time i.e. 60 seconds.*

Keywords*: Carbon brush holder, Electroplating, Blackening agent, Surface roughness, Thermal conductivity.*

1. INTRODUCTION

Carbon brush holder is a component of generator which is made up of brass by casting process in addition to many other processes. Casted carbon holder is not fit to be used directly because of many reasons such as surface finish, metal to metal wear & tear, sparking problem. The carbon brush is fitted in a brush holder which is designed to hold it in the correct position and allow the brush to run on the surface of the commentator or slip ring (collector) to transfer that current at optimum performance.

So, these are prepared to be used by doing many after processes like electroplating, cutting of casted burs, filing on different surfaces, drilling, reaming, counter boring and then assembling all parts using nuts, bolts and washers.

These types of carbon brush holders are being used in generator based upon rating of the generator and type of slip ring used because width of rings in the slip ring and diameter (outer diameter) of slip ring is the deciding factor for selection of type of carbon brush holder. For example, if the width of ring of slip ring is 10.05 mm then carbon brush of width 10.05 mm can only be used neither lesser nor bigger. Thus, pocket size of carbon holder must be of 10.05 mm which means specification of carbon holder is on the basis of carbon brush being used on ring of the slip rings.

Slip ring is component of the generator which is situated at the end of the rotor shaft at which the output terminals are present. Slip rings are made up of different types of materials such as thermosetting materials such as epoxies. There are many metallic rings present on which the carbon brush holder with the help of graphite is touched from which the generated electric charge is collected. The special arrangement of slip ring and carbon brush holder forms the setup from which the output terminal is connected through output leads.

Also, type of carbon holder depends upon the outer diameter i.e., the length of carbon holder is less between two pockets in which carbon brush is holed which touches the slip ring.

Carbon brush is the component which is hold in the holder of generator to carry the current thus it is called carbon brush holder. Generally, Carbon in graphite form is used since graphite is the best conductor of the electricity. It is because of its sp2 structure due to which one electron is always free to conduct the electric charge with very ease. Different quality of carbon is used basically on basis of conductivity required and power rating of the generator. Since graphite is very soft in nature, so pure graphite is mixed with another conductive material which provides some electrical, mechanical and also physical properties which improve the life of carbon brush. Some such kind of materials are copper, aluminium etc. Carbon and copper are made available in powdered form and these two mixtures are mixed in proper ratio to acquire mechanical, chemical, thermal properties after mixing by the help of the powder metallurgy. These types of carbons are called coppered-carbon brush.

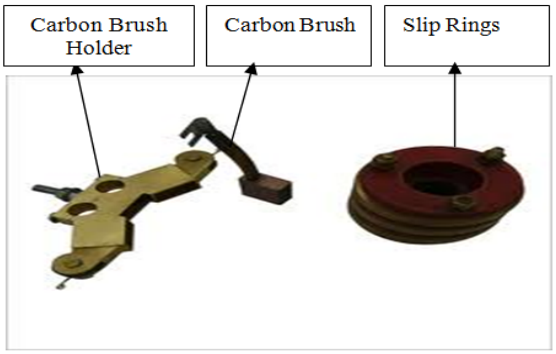

Fig. 1: Dismantled slip ring, carbon holder and carbon brush

The component surface which is exposed to severe conditions is generally coated with a suitable alloy by welding or allied process. Such a coating enables the component to perform satisfactorily. The process providing such coating is called surfacing.

Electro-deposition also called electroplating or simply plating, is an economical technology to protect and enhance the functionality of parts used in many diverse industries including home appliances, automotive, aircraft/aerospace, and electronics in both decorative and engineering applications.

The distinctions between aims of doing electroplating are not, of course, clear-cut and there are many overlapping categories. A deposit applied purely for appearance must be, at least to some extent, protective as well. Some finishes are purely decorative. Many objects meant to be used indoors, in a dry environment and where danger of corrosion is slight, are nevertheless finished with lacquers, paints and electroplated coatings for purely aesthetic reasons. The very thin layer of copper applied to some articles of inexpensive carbon brush holder has little or no protective value; it is there principally to attract a potential buyer. There are many applications of electroplating. Some of them are of increasing importance at present, in which neither corrosion prevention nor decorative appeal is the reason for using finish and improved the wear & tear between carbon & brush holder. Copper is an excellent conductor of electricity and has better corrosion ability.

Main aim of our work is to improve the overall efficiency of the carbon brush holder used to assemble the slip-rings which actually forms an assembly from which electricity is drawn with the help of terminals leads. This is achieved by improving overall (mechanical, chemical and thermal) properties of carbon brush holder. Optimum voltage & time for electroplating of copper is also determined.

2. MATERIALS & METHODS

Work piece used for the experiment is carbon brush holder which was purchased from Perfect Electrical Corporation, Bulandshar, U.P., India. V_2O_5 is used as a catalyst, and H_2So_4, $CuSo_4$ and blacking agent (conductive and anti-corrosion in nature) were the other materials used for experimentation. Silver wire connections, thinner and varnishes were used for extra luxture.

2.1 Working methods

In electroplating the work piece (cathode) is plated with a different metal (anode) while both are suspended in bath containing a water base $CuSo_4$ electrolyte solution. Electroplating is the application of metal coating to a metallic or other conducting surface by an electrochemical process. The article to be plated of an electrolysis cell through which a direct electric current is passed. The article is immersed in an aqueous solution (the bath) containing the required metal in an oxidized form, as a complex ion. The anode is usually a bar of the metal being plated. During electrolysis metal is deposited onto the work and metal from the bar dissolves.

Fig. 2: Work Piece (Carbon Brush Holder)

Fig. 2 shows carbon brush holder which is used to hold the carbon brush and is used in generators, motors.

2.2 Process flow system:

Chemical bath
⇓
Electroplating
⇓
Dip in blacking agent
⇓
Dry well
⇓
Applied coating for texture

Fig. 3: Flow chart of the process

The Cu ions from the anode are discharged using the potential energy from the external source of electricity, the Cu ions continue to move with their ions in the solution and then they are deposited on cathode.

Fig. 4: Setup of electroplating

2.3 Electrolysis:

Supplied in each kit is a set of metal plates which can be either a cathode or an anode. The plates are called anodes when they are used in a plating tank and cathodes when they are used in a de-plating tank. Anodes are always connected to the (+) positive side of a power unit, and cathodes to the (-) negative side. The anodes we supply are of very pure quality. Substituting particularly copper is tempting but can result in low quality copper being introduced into the bath, which can cause contamination of the solution and dish bonding of subsequent layers of plate.

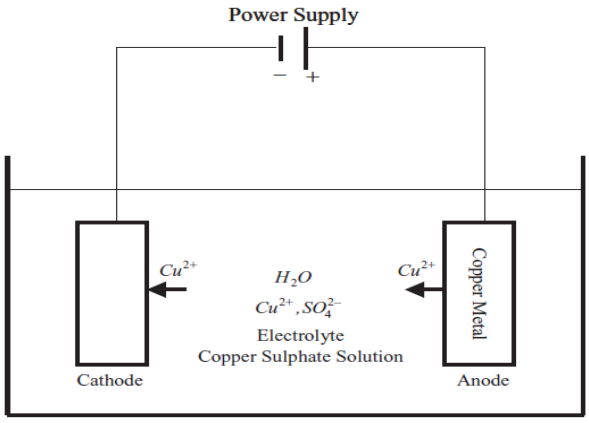

Fig. 5: Principle of electroplating

In a wider sense, all electron-transfer reactions are considered oxidation=reduction. The substance gaining electrons (oxidizing agent, or oxidant) oxidizes the substance that is losing electrons (reducing agent). In the process, the oxidizing agent is itself reduced by the reducing agent. Consequently, the reduction process is sometimes called electro nation and the oxidation process is called de-electro nation. Since a cathode is attached to the negative pole of the electric source, it supplies electrons to the electrolyte. On the contrary, an anode is connected to the positive pole of the electric source; therefore, it accepts electrons from the electrolyte. Various reactions take place at the electrodes during electrolysis. In general, reduction takes place at the cathode, and oxidation takes place at the anode.

Electro-deposition or electrochemical deposition (of metals or alloys) involves the reduction of metal ions from electrolytes. At the cathode, electrons are supplied to cat ions. Which migrate to the anode. In its simplest form, the reaction in aqueous medium at the cathode follows the equation.

At cathode: $Cu^{2+} + 2e- \rightarrow Cu$ (Reduction)

With a corresponding anode reaction at the anode electrons are supplied to the anions, which migrate to the anode. The anode material can be either a sacrificial anode or an inert anode. For the sacrificial anode, the anode reaction is:

At anode: $Cu \rightarrow Cu^{2+} + 2e-$ (Oxidation)

In this case, the electrode reaction is electro-dissolution that continuously supplies the metal ions.

Table 1: Specifications of the set up

Parameter	Quantity
Input voltage (AC)	230V
Output Voltage (DC)	12V
Volume of electrolyte	10L
Volume of catalyst in electrolyte	100g
Volume of potassium in electrolyte	200g
Varnish and thinner solution used	100ml
Length of hollow brass rod at cathode	2.5ml
Stand length hanged on hollow rod	50mm
Surface area of cupper plate used	2×1500mm(2 Plates)
Blackening agent used	100ml

2.4 Different parts of working setup

There are many parts which are assembled together. Each part contributes especial function to give overall result satisfactorily plating of copper on the carbon brush holder such that we can improve the efficiency so the life of the generator will also increase.

2.5 AC-DC convertor: AC-DC convertor is an apparatus which convert AC current into DC current source such that we can achieve interrupted electroplating of copper on carbon brush holder.

2.5b Electrolyte chamber: Electrolyte means metal is present in the ionic solution (liquid) electrolyte is depend upon the type of metal is used for the electroplated on the work piece.

2.5c Hollow bass rod with stands: As we know that current flow in the solid bar or rod is offered some obstruction in the flow of current due to several reasons like solid structure in which current passes internally because of which kernel effect occur and this current passing efficiency is very low. Because of foresaid reason, hollow rod is used as current passing in hollow rod is through surface and due to this, there is no loss

of current. So, most probably or almost current efficiency (current carrying capacity) is up to 99% which is good for working.

2.5d Agitator: Agitator is a pump like apparatus which is only used for making the natural flow of electrolyte while electroplating process is going on. Agitator is used because when the copper ions are released from the sacrificial metal in the electrolyte, they travel to get deposited on the work piece. So, to accelerate the flow of ions to deposit on work piece, electrolyte must be provided with some flow higher than natural flow which accelerates deposition rate of copper metal.

2.5e Water heater: Water heater is electrical heating device which is only used to heat the electrolyte and water.

2.5f Blackening agent: D30 black oxidising salt for copper, D30 black bronze salt for brass features black dyeing at room temperature, and can be used once adding ammonia. It is suitable for brass part with copper content 57%-65%, especially for iron part with copper plated. The copper plated layer on brass part is thin, the copper layer penetrates when water brushing colour by common method is used. However, this does not happen when D30 black bronze salt is used for brass. The dyed film will show copper reddish to dark black with different ratio. The film after drying becomes hard and smooth, not lose colour, but easy for colour brushing.

2.5g Environment implications

In most parts of the world the authorities set acceptance standards for the discharge of industrial effluent into sewers and water courses. It is usually necessary to obtain the approval of the appropriate authority in the form of a 'consent to discharge' before a discharge can be made or alterations are made in the concentration or volume of an existing discharge. There are very few metal finishing plants from which the rinse waters can be discharged directly to the sewers as the contaminant concentrations are outside the limits set by local Authorities with the majority of instillations, therefore, effluent treatment is necessary.

3. RESULTS & DISCUSSIONS

The results have been carried out at three different voltages. That is 270V, 285V, & 300V. The voltage up to 300V was practically possible to be achieved.

Following are the list of properties of brass holder which underwent changes:-

3.1 Roughness: *The percentage change in* decrease in roughness from voltage 270 V to 285 V is about 5% whereas; the percentage change in decrease in roughness from voltage 285 V to 300 V is about 7.5%. Since material removal rate is increased from 270 V to 285 V and then to 300 V, more material is removed from anode and same gets deposited over cathode with increase deposition, the roughness gets increased.

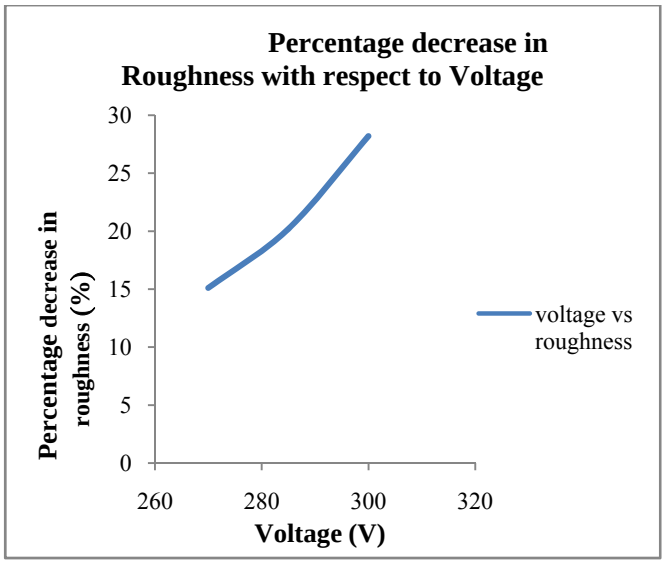

Fig. 6: Percentage decrease in Roughness with respect to Voltage

3.2 Resistance to corrosion*:* After electroplating of copper resistance to corrosion is improved. Carbon brush holder used in India is made of brass. Brass is prone to corrosion as brass is an alloy of copper and zinc with different ratio. Since, copper shows resistance to corrosion. So, Resistance to corrosion of the brush holder is improved after electroplating of copper.

3.3 Surface texture: Surface texture of the brush holder is improved after electroplating because a thin layer of copper is coated on carbon brush holder and plated surface produces to visual impression.

3.4 Surface finish: Good surface finish is achieved by applying coating of varnish on carbon brush holder after electroplating. This will also impart lustrous look to the surface of carbon brush holder.

3.5 Thermal conductivity*:* Copper is used in a wide range of products due to its excellent thermal conductivity. Thermal conductivity test of a copper coated brass sample was performed on Thermal Stabilizer TCT- 426 machine. The outcome value of thermal conductivity of above said sample is **112.1 W/m.K**, where as thermal conductivity of carbon brush holder of brass tested as **105.4 W/m.K**. So, copper is better thermal conductor.

Table 2: Comparison of thermal conductivity of carbon brush holder

Thermal Conductivity of Carbon Brush Holder (W/m.K)	Thermal Conductivity of Copper Coated Brush Holder (W/m.K)	Difference
105.4	112.1	6.3

3.6 Resistance to wear and tear*:* These properties improved after electroplating of copper on carbon brush holder. Earlier, Brush holder was not able to hold the carbon brush properly. This is because manufacturing of brush holder by casting process. Casting process does not provide the better finishing of brush holder. Moreover, without electroplating, there is improper fitting of carbon brush in holder. After electroplating of copper on brush holder, holder can hold carbon brush as jig and fixture. So after electroplating of copper, wear and tear got improved.

3.7 Optimum time for deposition of a Cu layer of 0.04mm on the carbon brush holder is achieved.

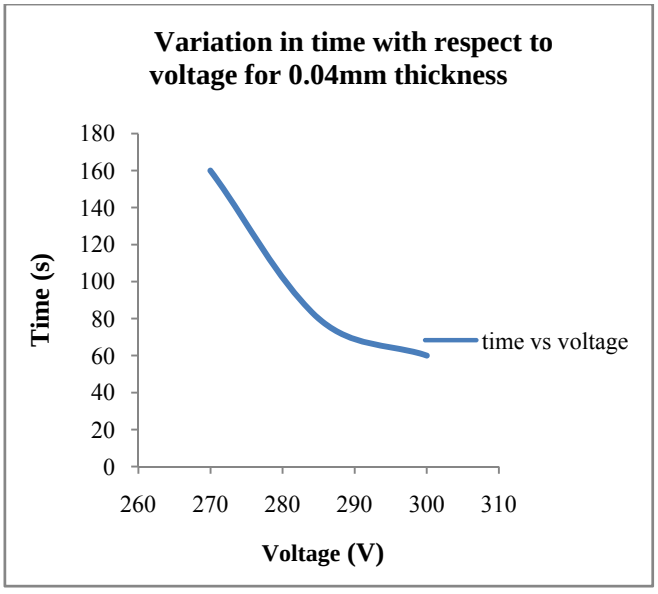

Fig. 7: Variation in voltage & time for 0.04mm thickness

As shown in figure 4.2, Time required to depositing copper layer of 0.04 mm on brush holder decreases with increase in voltage. As voltage increases, material removal rate from anode and material deposition rate on cathode increases. Time required to deposit 0.04 mm at 285 V is decreased by 50% in comparison to 270 V. Moreover, the time required to deposit 0.04 mm at 300 V is decreased by 25% in comparison to 285 V. The optimum time for depositing a layer of 0.04 mm has been found to be 60 seconds at 300 V.

3.8 Overall maintenance cost of carbon brush holder*:* Over all maintenance cost of carbon brush holder reduces because of reduction of spark and wear and tear due to electroplating of copper.

3.9 Reduced Sparking between carbon brush holder and carbon brush*:* As carbon brush holder is made by casting process. So, there is some space between carbon brush holder and carbon brush due to casting process. So, metal surfacing of casted object reduces air spacing between carbon brush and carbon brush holder.

3.10 Increased service life of the brush holder: When wear resistance of brush holder will get improved. Thus, service life of the brush holder also increased.

4. FUTURE SCOPE OF WORK

Since its invention in 1805 by Italian chemist, Luigi Brugnatelli, electroplating has become an extensively used industry coating technology. This standard describes a method for specifying electroplated coatings and post plating treatments on iron, steel, brass, and copper, components for corrosion protection and decorative purpose. Also, its scope is mainly in the following three groups:

4.1 Decoration*:* Coating a more expensive metal onto a base metal surface in order to improve the appearance. Applications are jewellery, furniture fittings, builders' hardware and tableware.

4.2 Protection: Corrosion-resistant coatings such as chromium plating of automobile parts and domestic appliances, zinc and cadmium plating of nuts, screws and electrical components. Wear-resistant coatings such as nickel or chromium plating of bearing surfaces and worn shafts and journals.

4.3 Enhancement*:* coatings with improved electrical and thermal conductivity solder ability.

5. CONCLUSIONS

This deals with enhancing the life period of the carbon brush holder by doing the electroplating of copper over the surface of the carbon brush holder, to increase many mechanical and physical properties and decorativeness which enhance the life of the carbon brush holder properties like thermal conductivity, electricity conductivity, anti-corrosion, texture & luxture.

After electroplating of copper, the blackening agent is applied such that plated copper surface is oxidant by the help of oxidizing blackening agent so that the surface becomes resistance to corrosion and also the carbon brush holder achieves the close dimensions too.

Before copper plating, dimensions of carbon holder pocket are 10.05 mm x 18.05mm. After copper plating, dimension of carbon holder pocket are 10.01mm x 18.01mm. Due to this result of plating, close dimensions are achieved which leads to proper fitting of carbon brush in pocket of carbon holder. There are less chances of sparking which can cause the erosion of side walls of carbon holder.

1) The optimum voltage at the best surface finish is obtained, is 300V because at this voltage, maximum percentage in surface roughness has been achieved.

2) Optimum time at optimum voltage i.e. 300V is 60 seconds, at 300V; 0.04mm layer of copper is plated in 60 seconds.
3) Thermal conductivity of copper coated brush holder is 6.3 percentages more than that of brush holder of brass.
4) By the use of blackening agent D30 post electroplating, weather ability is improved.
5) Blackening agent applied on surfaced copper also provides anti- corrosion layer which ultimately increases the life of the product and by applying the coating of varnish, improved texture and good visual impression to the product is imparted.

Hence, un-conventional electroplating on carbon brush holder with conductive coating improved the efficiency of generator, causes less maintenance cost and increases life of product. Moreover, by putting less stress on the natural resources, which is a good sign for better economy of our nation as well as world.

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