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Study of Hardness and Electrical Properties of Prepared Metal Graphite Composite Brushes

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Abstract

In electric motors, electrical energy is transformed to mechanical energy or vice versa. Electrical energy has to be transformed from a stationary component into moving one, which is done by copper commentator in sliding contact with graphite brushes.

This study includes a technical method to prepare metal – graphite composite brushes. The prepared brushes are tested and found to have mechanical and electrical properties agree with standards.

Key wards : Metal- graphite composite , Brushes , Copper .

دراسة الصلادة والخواص الكهربائية للفحمات المصنعة من المعدن والكرافيت

الخلاصة

تتحول الطاقة الكهربائية الى طاقة ميكانيكية وبالعكس في محركات الطاقة الكهربائية . تتحول الطاقة الكهربائية من مركبة ثابتة الى مركبة متحركة ويتم هذا التحول باستخدام مبدل (عاكس التيار) ينزلق بتماس مع الفحمات الكرافيتية. تتضمن هذه الدراسة المسلك التقني لتحضير الفحمات الكرافيتية المصنعة من المعدن والكرافيت. تم انجاز سلسلة من التجارب والفحوصات التي تجرى على النماذج المحضرة والتي بينت انها تمتلك خواص ميكانيكية وكهربائية متوافقة مع المواصفات القياسية .

Introduction

Electrical brushes are invented a century ago in England and the development of them is accompanied with that of motors[1]. The earliest brush is made of clusters of copper wires, but modified motors with higher power and higher performance made primitive brushes, so carbon brushes (which are mainly made of carbon materials) are invented[2]. Carbon brushes are generally composed of carbon material, solid lubricant, resin binder and additive. Graphite has a lamellar structure and anisotropic properties that induce good friction and wear behavior, so it constitutes the main component of the carbon material of brushes[3]. Molybdenum disulfide is often chosed as a solid lubricant due to its good lubricant properties[4]. Metal- graphite brush is one type of carbon brushes containing a metal such as a copper with various percentage depending on the certain application of brushes, It’s a sliding contacts used for transfer of the actuating electric current in the electric synchronic and synchronic motors and generators[5]. They must posses high conductivity and stability of transfer of electric current and low specific electric resistance. A part from this they must have good mechanical characteristics and resistance to the influence of the surroundings (vibration, damp, acid, etc). Material of the brushes should posses low friction coefficient in order to prevent wear and tear of the material of

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the element along which the brush is sliding [5].

Developed countries such as Japan and England have developed such brushes with high performance [6,7] , but for commercial and secret reasons it is difficult to find related literatures expect a few patent.

The main objective of present work is to study the effect of copper on mechanical and electrical properties of composite metallographic brushes and studying the variables affecting the properties of the prepared metal-graphite brushes.

Experimental Procedure

Materials

The materials used in this study are: Commercial grade graphite supplied by degoza German company, high purity copper and MSO_2, supplied by BDH Limited, which are used as additives material, and Phenolic resin type novolac supplied by Flukia company which is used as a binder material.

Sample Preparation

Graphite powder is heated in an oven for a period of 2 hours under a temperature of 110-120 ^{O}C in order to remove the moisture and sieved to get a grain size of 100 micron. Copper and MSO_2 are sieved separately to get powder of 75 micron particle size. Weighted amount of metal and graphite is mechanically mixed. Various composition of copper-graphite are prepared which are: 10/90, 20/80), 30/70, 40/60, 50/50, 60/40, 70/30, and 80/20%wt, then 1% wt of MSO_2 and 10% of novolac powder (60μm) are added with continuous mixing to ensure maximum homogeneity throughout the binding material.

The mixture is poured in steel cylindrical mould and then pressed with 3Tons/cm^2. The molded specimens are cured in an oven under 150˚C for 1 hour and then the metal – graphite specimens are heated from room temperature to 800˚C at a rate of 10 ˚C/minute using tube furnace for 4 hours. During sintering process, the samples are also maintained in an argon atmosphere to avoid oxidation.

Properties measurements

Prepared samples are subjected to the following tests:

Hardness Test

Shore(A) hardness is measured using optical hardness machine type7091. The test is carried out according to DIN 53505, ASTM (D 1706-61) and ISO (DR988) .

Density Measurement

This test is carried out according to ASTM.

Resistivity Measurement

A known current (I) is passed through the cylindrical sample, and the potential difference (V) between the electrodes is measured, then the resistivity (ohm-cm) of the sample is :
Obtained from the following relation:

$$S=VA/IL = RA/I$$

Where:
R: is the resistance in ohm.
A: cross sectional area of the sample,cm^2
L: length of the sample, cm

Current density measurement

In the present work, voltage difference across a known section of the sample is applied and a direct measurement of the current is carried out using Keilhley 6Li Electrometer, U.K.
Results and discussion

The results of this work are listed on Table(1). Optical microscopy is used to examine the surface of the prepared samples. The appearance of different phase structure of the carbon brushes with copper contents is shown on Figure(2,A, B & C). The appearance of phase is clearly shown in photographs (B and C). The pores apparent in our samples are due to the released gasses produced by the pyrolysis of the resin morphology of surface of brushes. Figure (2) shows optical Micrograoh for microstructure of metal-graphite of 80/70wt%. The structure shows a uniform distribution of metal in graphite with little pores. This homogeneity increases the electrical conductivity as well as improving the mechanical properties.

Hardness gives an indication of the ability of material to resist scratching abrasion. Figure (3) shows the effect of copper addition on shore hardness. It is obviously seen that increasing weight fraction of copper will increase hardness which reached maximum at 30% Cu, and then decreases sharply when copper fraction is increased. This is due to the softness of copper.
But at the same time, the resistively decreases very sharp when the weight fraction of copper metal increase as shown in figure (4) , this is due to the high electrical conductivity of copper.

Interesting result obtained when current density of the samples showed sharp decrease at the point when the hardness is at its highest value at 30 wt %Cu content. However, It may be very necessary to give the hardness property while specifying the metal–graphite brushes. At certain hardness value, the material may give a lower current density as shown in Figure (5).

Conclusions

1. Metal – graphite brushes are prepared successfully in this work.
2. Prepared brushes give satisfy the requirements of commercial grade.
3. The sintering temperature up to 800 ºC convert novolac polymer completely into carbon .

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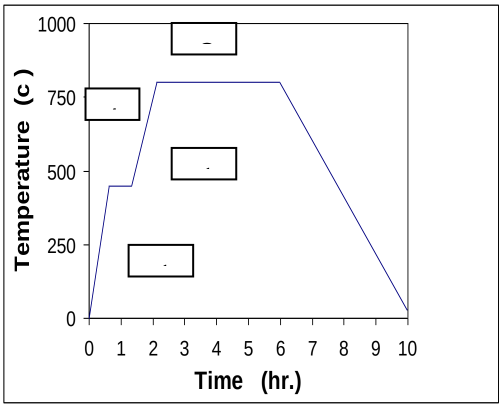


Fig . (1) Time – Temperature Diagram

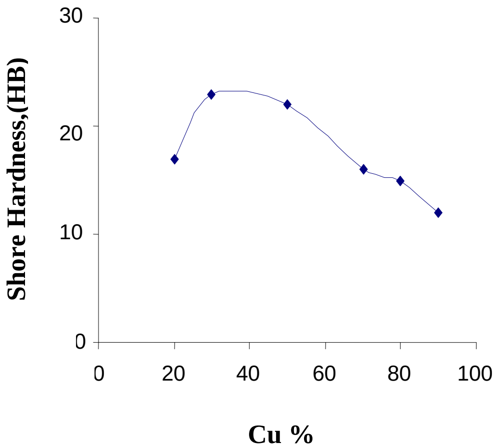


Fig. (3) Effect of copper on hardness

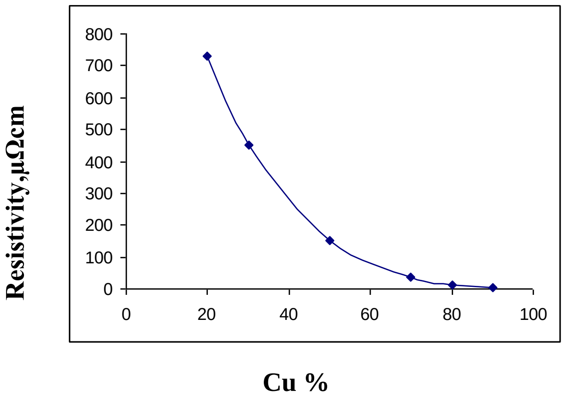
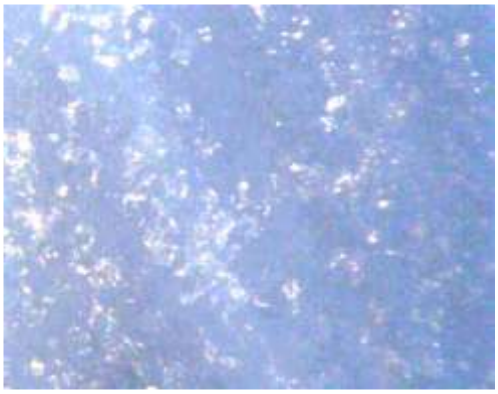


Fig . (4) Effect of copper on resistivity



(A) Photo-micrograph (Cx300) of sample of carbon brushes contain no metal

(B)–Photo- micrograph (Cx300) of sample of carbon brushes contain 35 % Cu

(C)– Photo- micrograph (Cx300) of sample of carbon brushes contain 65 % Cu

Fig. (2) Photo- micrograph of carbon brushe samples

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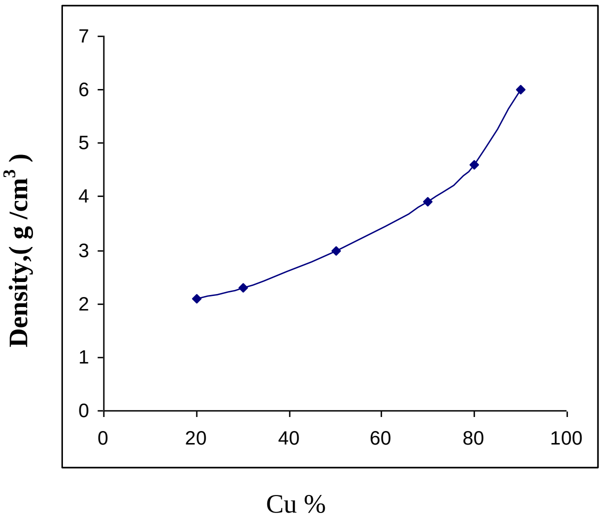

Fig . (5) Effect of copper on apparent density

Table (1) Results of produced sample properties

Metal content Cu %	**Shore hardness** (HB)	**Apparent density** (g/ cm^3)	**Resistivity** ($\mu\Omega cm$)
20	17	2.10	730
30	23	2.30	450
50	22	3.00	150
70	16	3.90	38
80	15	4.10	11
90	12	6.00	5