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Rotating electrical machinery — Natural graphite brush for slip-ring in wound rotor-type induction motor — Application information

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TECHNICAL REPORT

Rotating electrical machinery – Natural graphite brush for slip-ring in wound rotor-type induction motor – Application information

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ROTATING ELECTRICAL MACHINERY –

Natural graphite brush for slip-ring in wound rotor-type induction motor – Application information

FOREWORD

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IEC TR 63021, which is a Technical Report, has been prepared by IEC technical committee 2: Rotating machinery.

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
2/1794/DTR	2/1823A/RVC

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

This Technical Report has been prepared after considering implications of the withdrawal of IEC PAS 62072:2005 and its potential conversion into an International Standard, and after analysing practical information obtained through the application of natural graphite (NG) brush for slip-ring in wound-rotor type induction motor, compared with copper brush.

Practical values obtained through the application of NG-brushes into slip-rings in various kinds of wound rotor-type induction motor are given in Annex A.

ROTATING ELECTRICAL MACHINERY –

Natural graphite brush for slip-ring in wound rotor-type induction motor – Application information

1 Scope

This document presents technical characteristics, application results and practical information on NG-brush for slip-ring obtained through the application of NG-brush in various kinds of wound rotor-type induction motor (large-size water pump, belt conveyer, lift, winder motor, grinding mill and crusher in coal or ore mine; crane, rolling mill, compressor and winder motor for boring in oil or gas facility).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60413*, Test procedures for determining physical properties of brush materials for electrical machines*

IEC 60773, *Test methods and apparatus for measurement of the operational characteristics of brushes*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
fire-spark
glittering phenomenon observed macroscopically between the brush and slip-ring during the operation of a wound rotor-type induction motor

3.2
life
critical time since the brushes have been installed into the wound rotor-type induction motor and started to operate until the brush and the slip-ring can no longer contribute to the motor's operation

3.3
dust diffusion
phenomenon whereby fine powders, caused by wear of the brush, diffuse in air during the operation of a wound rotor-type induction motor

3.4
noise
acoustic signal of high intensity caused between the brush and slip-ring among the acoustic signals of several wavelengths made during the operation of a wound rotor-type induction motor

3.5
vibration absorbing ability
ability of the brush to absorb or decrease electromagnetic and mechanical vibrations caused during the operation of a wound rotor-type induction motor

4 General remarks

Generally, it is traditional to use the metal grade brush including copper brush for the wound rotor-type induction motor.

The metal grade brush, including copper brushes, can usually damage the slip-ring by the fire-spark during operation. The dust generated by the wear of the copper brush can be the cause of accidents and also contaminates the environment. Compared with the formerly used copper brush, the NG-brush shows high operating characteristics when it is used for the slip-ring of a wound rotor-type induction motor. There is nearly no fire-spark between the NG-brush and slip-ring and no environmental pollution due to reduced wear. It also has sufficient ability of electromotion.

Table 1 shows the size and quantity of typical NG-brushes that are used for wound rotor-type induction motors of various powers.

Table 1 – Typical kinds of brushes

No.	Denomination	Size mm	Quantity (for a motor)	Power kW
1	motor for elevator	25×32×60	36	180
2	motor for compressor	25×32×60	9 to 18	75
3	motor for winder	25×32×60	9 to 18	250
4	motor for boring	25×32×60	6 to 36	1 600 to 3 000
5	motor for grinding mill	25×32×60	18	120 to 250
6	motor for crusher	25×32×60	18	120 to 250

5 General conditions of brush and slip-ring for stability in the operation of a wound rotor-type induction motor

5.1 Fire-spark

Fire-spark causes damage to the surface of the slip-ring. In severe conditions, it bursts out and becomes the cause of accidents or explosions.

5.2 Life

The life of the brush and the slip-ring are the main conditions for the motor’s normal operation. The life of the brush is decided by its wear. The life of the slip-ring is also mutually related to the physical characteristics of the brush.

5.3 Temperature

The proper temperature of the brush is a function of the brush current density, the coefficient of friction and the air flow in the area of the brush and slip-ring.

5.4 Dust diffusion

The dust caused by the wear of the brush lowers the insulation resistance of the motor winding and contaminates the atmosphere around the motor. Dust diffusion can be characterized by the wear of brush.

5.5 Noise

The rotor vibration can be controlled with the vibration absorbing ability of the brush. The vibration absorbing ability is mutually related to the bulk density of brush.

6 Operating characteristics of natural graphite brush for slip-ring in a wound rotor-type induction motor

6.1 Current density

Natural graphite brush for slip-ring in a wound rotor-type induction motor is three to four times lighter than copper brush.

Table 2 – NG-brush's bulk density, electric resistivity and current density compared with the copper brush

Property	NG-brush	Copper brush
Bulk density, g/cm^3	1,35	4,5 to 5,5
Electric resistivity, μΩm	5 to15	0,05 to 3
Current density, A/cm^2	5 to 25	10 to 25

Table 2 shows that the electric resistivity of the NG-brush is 100 times higher than that of the copper brush, but that the current density is nearly equal.

6.2 Vibration absorbing ability

The higher the porosity and the lower the friction coefficient of the brush, the more the vibration caused by the operation of the wound rotor-type induction motor decreases. See Table 3.

Table 3 – Comparison of properties for the assessment of vibration absorbing ability

Property	NG-brush	Copper brush
Porosity, %	43	1 to 2
Friction coefficient	0,12	2

Since the coefficient of friction of the NG-brush is 16 times lower than that of the copper brush and its porosity is 43 times higher than that of the copper brush, the NG-brush has the higher vibration absorbing ability.

6.3 Temperature

Permissible temperature of NG-brush during its operation is 80 ℃.

6.4 Brush's pressure

Copper brush's pressure is usually above 20 kPa to 40 kPa. NG-brush, however, has characteristics sufficient to operate in a range of 9 kPa to 10 kPa.

7 Testing method

The test method on the physical properties and operating characteristics of NG-brush is performed in accordance with IEC 60413 and IEC 60773.

8 Application result

8.1 Fire-spark

There's nearly no fire-spark between brush and slip-ring, because of the lighter weight and current density of NG-brush.

8.2 Wear and life of brush

Table 4 – Wear and life of brush

Brush's weight before testing (g)		**Brush's wear after testing** (g)		**Life** (year)		**Testing period** (h)
copper	NG	copper	NG	copper	NG	
288	64,8	22,5	0,6	0,8	≥ 10	1 000

Based on the consideration of the brush's life (see Table 4 and Annex A) when using the NG-brush in several units, it was evaluated that the life of NG-brush is above 36 months under very unfavourable conditions and about 360 months (when operating for 10 h per day) under normal conditions.

NOTE The unfavourable conditions include relative humidity of more than 80 %, on-off times per hour above 20, vibrating width above 100 µm and ambient temperature above +40 °C.

8.3 Life of slip-ring

The slip-ring's surface using NG-brush is fine and its colour is a bit maroon-copper.

As NG-brush has proper hardness and bending strength and does not show any fire-spark during operation, the slip-ring's surface does not get molten, damaged and scratched. Therefore, it is considered that there's nearly no damage by NG-brush (see Annex A).

8.4 Environmental pollution

8.4.1 Dust diffusion by wear of brush

Table 5 shows dust diffusion evaluated by the wear of NG-brush and copper brush.

Table 5 – Comparison of wear of NG-brush and copper brush

Denomination	**Total wear per 1 000 h** g	
	NG-brush	**Copper brush**
Escalator motor (36 brushes per unit)	21,6	750
NOTE The wear is the same as the other wound rotor-type induction motor.		

As shown in Table 5, copper brush generates up to 34,7 times more dust than NG-brush does. This dust contaminates the environment of the area or causes a short-circuit by entering the gaps in the surrounding assemblies.

The wear of NG-brush is extremely low and this small amount of dust becomes a protection film for the surface of the slip-ring. Therefore there is nearly no dust that flies in the air.

8.4.2 Pollution by noise

In comparing NG-brush with copper brush during operating the wound rotor-type induction motor, there was far less noise in motors using the NG-brush.

As the slip-ring's brush made from NG-material has less fire-spark, noise and dust, it is considered that it satisfies the requirements of IEC 61000-4-2:2001, IEC 61000-6-2:1997 and ISO 14031:1999.

8.5 Economic profit

8.5.1 Brush price

As there are no copper powders used in NG-brush, it is remarkably cheaper than copper brush.

8.5.2 Brush life

Because NG-brush is several times as long as copper brush's life, the operational expense is remarkably lower than copper brush.

8.5.3 No accident due to dust diffusion and slip-ring's life

Because the slip-ring is not damaged and insulation resistance of the winding does not fall, the maintenance cycle of the motor is long.

Annex A
(informative)

Data from practical application

Practical values obtained through the application of NG-brushes into slip-rings in various kinds of wound rotor-type induction motor are given in Table A.1.

Table A.1 shows some results among the results of more than 1 000.

Table A.1 – Data from practical application

Equipment	Introduction period			Properties considered		
	from	to	total operating time h	wear of brush mm	wear of slip-ring mm	fire-spark
Compressor 75 kW	2014/7/24	2014/8/26	324	0,08 to 0,125	no	no
Winder 250 kW	2014/4/10	2014/4/30	480	0,3	no	no
Winder 350 kW	2004/1	2014/5	30 000	12	0,1	no
Pump 125 kW	2009/3	2014/3	15 000	3	0,05	no
Boring machine 1 600 kW	2011/7/7	2012/2/8	2 160	1	no	no
Boring machine 3 000 kW	2012/1/21	2012/4/11	1 920	2	no	no
Boring machine 3 000 kW	2012/5	2012/8	1 700	1	no	no
Boring machine	2012/5	2012/9	1 800	1	no	no
NOTE Table A.1 shows the results tested under the unfavourable conditions indicated in the note in 8.2.						

Bibliography

IEC 61000-4-2:2001, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-6-2:1997, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC PAS 62072:2005, *Natural graphite brush for rotating electrical machinery – Basic characteristics* (withdrawn)

ISO 14031:1999, *Environmental management – Environmental performance evaluation – Guidelines*

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