# nBRUSH ON THE MACHINE

## FUNCTION

The Brush has an essential function in the operation of an electrical machine. Its primary function is to deliver or to collect electrical current from a rotating part of an Electrical Machine such as a Slipring Induction motor or a D. C. machine. The brush has a yet harder duty to perform in case of a D. C. machine, that of commutation or changing the direction of current in the conductors with every rotation and several times during one rotation of the machine. A third and most difficult task the brush has to do is to keep the commutator or slipring surface clean, smooth and protected by a film of carbon so as to maintain intimate contact throughout the operation of the machine without wearing itself and also the commutator too quickly. All these duties of a brush make it necessary that it should be made of a material having all the physical, mechanical and electrical properties required to make it suitable for the machine. Carbon is the only such material which not only has all the properties but also can be had in different combinations to suit particular requirements of special machines.

In order to accurately fulfill its purpose it must have a certain mechanical "behaviour", adequate current capacity and shock-absorbency characteristics.

In the short study which follows, we examine the main "sensitive points" of a brush, which may be grouped under three headings: Mechanical, Electrical and Chemical aspects.

## A. MECHANICAL ASPECTS

### A1. CONDITIONS OF THE RING AND COMMUTATOR SURFACES

Commutators and rings should have a surface which is neither too smooth nor too rugged, and when necessary should be rectified so that the degree of error is confined to accepted limits.

For commutators, faulty mica recessing is often responsible for serious disturbances, and this should be carefully verified to ensure sufficient depth of milling, and no slivers along the bar edges. The edges of the bars should be chamfered at 45 degrees.

On rings, especially those with a high peripheral speed, there is generally a helical grove to improve the stability of the brush and to prevent the phenomenon of "glazing" in order to prevent rapid wear of the brush, it is important to chamfer the edges of this groove.

### A2. VIBRATIONS

- All vibrations impair the contact between brush and commutator. It may have as its origin: Bad balance, defective running, bad alignment and exterior to the machine itself, gearing coupling and driven or driving equipment.

- A commutator in a bad or deformed condition gives rise to faults which should be attenuated if not suppressed.

- The vibratory system constituted by the brush, the spring and the brush holder with its support, can enter into resonance, this is generally followed by serious deterioration of the brush and even also of the brush holder.

A3. PRESSURE

- Low pressure, advisable in order to diminish the friction losses, but it can cause a higher electrical wear as a result of sparking.

- High pressure, which tend to diminish the contact drop of the brush, thus reducing electrical losses, but provoke wear by higher mechanical erosion.

A4. BRUSH SUPPORT

The brushes should be supported throughout a sufficient length, with a definite clearance to prevent wedging, but not so great a clearance that might allow hammering by the brush between the brush box walls. The allowed clearance for various brush sizes are defined by the International Electrotechnical Committee (IEC) and their standards are gradually substituting the older national standards. In certain cases anti-dust grooves are arranged on the faces of the brushes.

In order to diminish frequent brush replacement, brushes with considerable length have been created, that is to say, with their wear length augmented. These adapt themselves particularly well to constant pressure brush holders. This type of Brush holder ensures good brush support and exercises a constant force throughout the whole brush wearable length.

As a general rule, the brush holders should be well aligned and adjusted to a distance of 2 to 3 mm from the ring or commutator. Such holders should be inspected and cleaned at regular intervals.

B. ELECTRICAL ASPECTS

B1. CONTACT DROP

This is an important characteristic of sliding contact and is less an electrical property of the brush or of the machine than a property of the complex film deposited on the ring and the commutator (skin) and the interface layer. The skin is a mixture of metallic oxide, carbon and water.

The interface layer is composed of a gaseous film, ionised with particles of carbon in suspension and some times of fine dust.

It is, therefore, to be expected that the contact drop should be influenced by all the factors which may modify the skin or the interface layer, for example, the temperature, the pressure and the ambient humidity, the atmospheric impurities, the

speed of the commutator, the pressure applied on the brushes, the transverse currents and the nature of the brush itself.

Contact drop gives rise to electrical losses and heating of the commutator or ring occasioned thereby and influences commutation and the distribution of current between brushes.

### B2. COMMUTATION

In reality, the phenomena of commutation which are often responsible for sparking at the brushes are the consequences of current reversal in those sections of the armature which momentarily under-go short circuit by the brushes.

One should not confuse, commutation sparking with sparking which is a result of mechanical causes (vibrations) or the bad adjustment of the neutral, or of faulty interarm adjustment or of insulation faults in the winding or faults in the construction of the commutator etc.

THERE ARE A CERTAIN NUMBER OF ARTIFICES BY WHICH THE COMMUTATION OF A MACHINE CAN BE IMPROVED:

- Sandwich brushes which limit circulating currents and control the skin well.
- The introduction of circumferential stagger.
- Split or dual grade brushes where the elements of each are in a different grade.

### B3. CURRENT DENSITY

This is the average current distributed over the whole contact surface.
The density of the current has a great influence on all conditions which affect the performance of brush operation, wear, friction, temperature etc.

## C. CHEMICAL ASPECTS

### C1. HUMIDITY

Water, which is an essential constituent of the skin is supplied by the ambient air. When the air is very dry, the skin obtained is predominantly metallic oxides. As a result, high friction develops, which together with sparking result in brush wear which can be very rapid and some times quite spectacular.

Even though this may be in low proportions in the atmosphere and especially, if associated with humid conditions, it attacks the skin and destroys it. The commutator becomes marked and the brushes spark considerably. Such vapours are chlorine and its compositions (chlorine solvents) Ammonia, Hydrogen Sulphide, Anhydrous Sulphuric acid etc.

## C2. OILS AND HYDROCARBONS

The contamination of commutators, rings and brushes by oils, oil vapour, fuel oils etc. is caused by:

- Projection of tiny drops of mist carried by the ventilating air.
- Condensation of vapours developed at hot points.
- Migrations from a bearing which is not properly sealed.

These oily contaminations always considerably disturb the other wise satisfactory operation of a machine. Two incidents are frequent:

- The wedging of brushes in their holders as a result of the formation of thick grease when carbon dust makes contact with oil.
- Deterioration of the rings and commutators as a result of the deposition of a thick insulating grease of the brush tracks resulting in the formation of a skin having burrs and grooves.

## C3. DUST

Dust is always harmful; it causes:

- Wear and grooving of commutator or ring
- Rapid wear of brushes
- Furrowing of the brushes faces and sides
- Sticking of the brush in its holder

Antidust grooves in particular will assist in curing these difficulties but the best remedy is to prevent such occurrence.