

BRUSH WEAR

TECHNICAL NOTE ■ STA BE 16-35 GB

Brush wear is directly dependent upon the mechanical and electrical losses.

The parameters which **directly** affect brush wear are therefore:

Mechanical	Electrical
Friction f	Contact drop ΔU
Applied Pressure p	Current in the brush I
Peripheral speed v	

These parameters are not independent of one another:

f is a function of v and I

ΔU is a function of p and I

In order to reduce wear associated with the losses, an optimum has to be found.

In particular, wear expressed directly as a function of the pressure applied to the brush is given by the curve fig. 1.

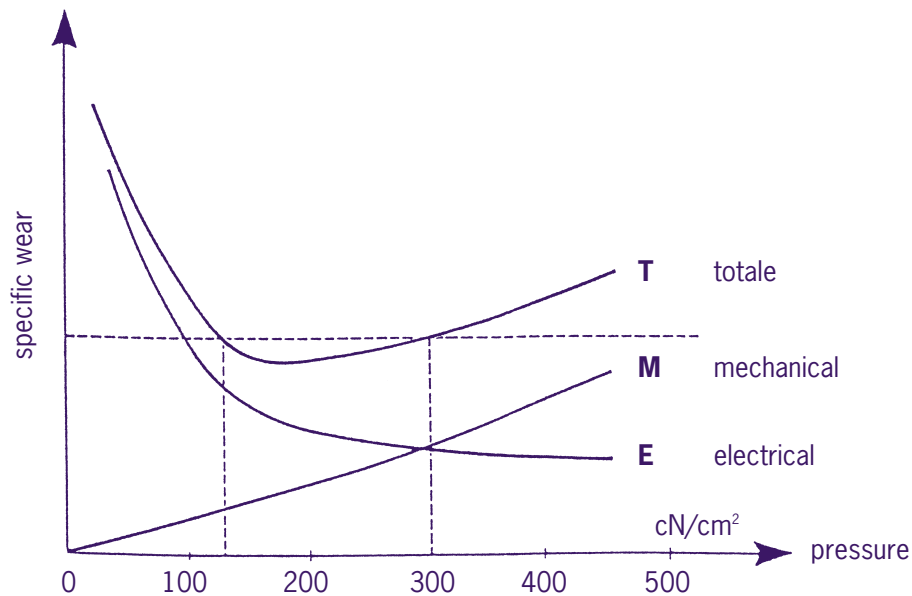


Fig. 1

The curve fig. 1 shows how wear of mechanical and electrical origin intervenes, and indicates clearly the area in which the optimum pressure can be found in order to stabilize the wear of brushes to the lowest possible level.

The ideal area depends upon applications — See Technical Notes STA BE 16-27 (Brush spring pressure) and STA BE 16-46 (On raising brush pressure).

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But brush wear depends largely and indirectly upon many other factors which are difficult to enumerate, because they are associated with each particular case of a machine.

Amongst these, the following may be mentioned:

- variable speed and load capacities of machines,
- shock and vibration due to the machine itself or by the deformation of the commutator or rings,
- polarity in “synchronous machine” applications,
- the quantity and quality of the ventilating air (lack or excess of humidity, aggressive gases, abrasive dust...),
- circulating currents between commutators bars,
- excessive overheating,
- defective commutation,
- condition of brush holders,
- surface condition of tracks.

Amongst these secondary causes, often more important than the direct causes, particular mention should be made of reversing machines.

At each reversal of rotation the brush rocks in the sheath of the brush holder, and its contact face has to re-bed itself with each new direction of commutator rotation. A new contact face is formed, different to the preceding one and the “dihedral” angle brought about by the two contact faces is much more pronounced as the play between the brush and the box increases (fig. 2).

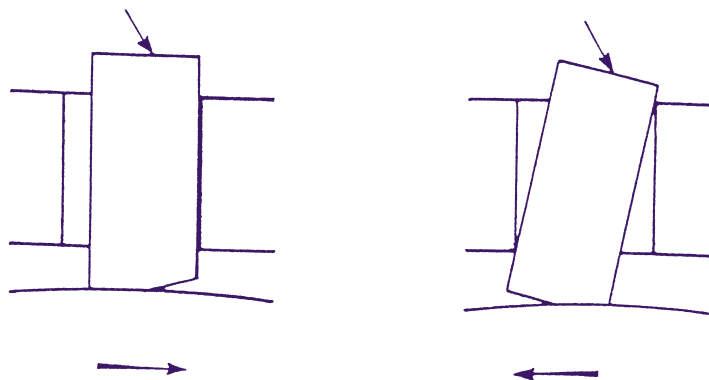


Fig. 2

It follows that if these reversals of direction of rotation are frequent, the brush is practically never in contact, through its total $t \times a$ surface and that the true pressure applied to the brush as well as the current density in the brush are multiplied by the ratio of the theoretical ($t \times a$) area to the true area in contact with the commutator.

This is a very important factor in increased brush wear, and one which should not be neglected when comparing brush life on unidirectional machines to that on reversing machines.

Due to the various causes, which may affect brush wear significantly, it is hard to specify such values. In fact, for the same grade and same brush assembly brush wear can vary to a large extent according to the conditions.

Brush wear is usually expressed as follows:

- for automobile starters : mm/1,000 starts
- for house appliance motors : mm/1,00 hours
- for traction motors : mm/1,000 km (or according to countries : 10,000 km travelled)
- for industrial motors : mm/1,000 hours.

Wear expressed in mm/1,000 h is only comparable therefore with that on commutators or slip rings rotating at the same speed.

Similarly, for traction applications, wear expressed in mm of brush per 1,000 km of vehicle travel is only comparable between them if the ratio of commutator to vehicle travel is taken into account *.

To be compared with one another wear rates have to be referred to the commutator or slip ring travel under the brush.

The wear rate WR_{\star} is the relationship between the amount of wear (Δr) of the brush during a given time period and the total length ($l_{tot.}$) of track (commutator or slip ring) travelled during this very time period. Both lengths hereunder should be expressed in the same units.

$$WR_{\star} = \frac{\Delta r}{l_{tot.}}$$

This wear rate WR_{\star} is also the relationship between the rate of wear of the brushes and the linear speed of the track (commutator or slip ring) expressed in the same unit system.

* This reduction relationship C is:

$$C = p \times \frac{d}{D}$$

Where p is the gear relationship of the locomotive

d : diameter of the commutator

D : diameter of the wheel.

Evaluations:

The average wear rates are evaluated as follows:

a/ Commutator machines

- for couple motors : from 6×10^{-9} to 3.8×10^{-8} m/m
- (window open/close motors, starters)
- for small motors : from 2×10^{-10} to 7×10^{-10} m/m
- (home appliances, hand tools,
- automobile auxiliary motors)
- for traction motors and aircraft : from 2×10^{-10} to 3×10^{-10} m/m
- generators
- for stationary industrial motors : from 0.5×10^{-10} to 1×10^{-10} m/m

b/ Slip ring machines

from 0.5×10^{-10} to 1×10^{-10} m/m

We have noticed that for the same family of machines the relationship WR_{\star} is practically independent of the linear speed of the machine.

However some limits have to be considered under particular operating conditions — see Technical Note STA BE 16-50 (underloaded machines) — or in aggressive atmospheres — see Technical Notes STA BE 16-39 (Humidity of air) and STA BE 16-45 (Silicones).



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