TECHNICAL DATA SHEET **BRUSH WEAR**

1. GENERAL

Brush wear depends mainly on mechanical and electrical losses (see *TDS-05*). The parameters which directly affect brush wear are therefore:

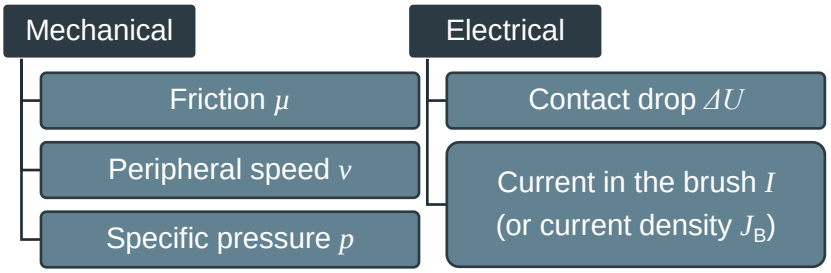


Figure 1 – Main parameters affecting brush wear

These parameters are not independent on one another:

- μ is a function of v, specific pressure p and, to a lesser degree, current I
- ΔU is a function of specific pressure p and current I

It means that, to reduce the wear associated with losses, an optimum has to be found for each parameter.

Brush wear as a function of pressure

As said above, pressure has a direct action on both electrical and mechanical losses. The curve of *Figure 2* shows how brush wear is affected by the pressure and clearly indicates the optimum pressure range where the brush wear is stabilized at the lowest possible level.

For more information, refer to our Technical Note *TDS-11* relative to the pressure on carbon brushes.

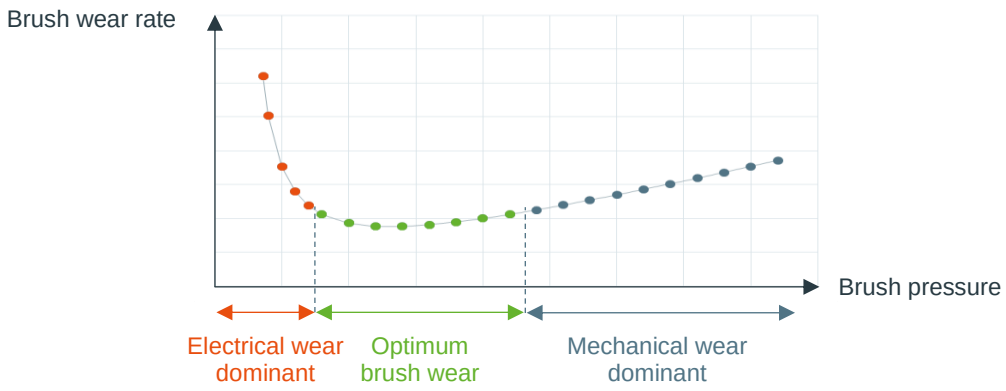


Figure 2 – Influence of pressure on brush wear

NOTE: The optimum pressure range is expected to be different from one grade / application to another. That is why the recommended pressure is specified on each grade technical data sheet.

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Other operational factors

Brush wear, and its uniformity between brushes, depends indirectly on **many other factors** which are associated with each particular **machine (design, application and maintenance condition)**.

Amongst these, the following shall be mentioned:

- **Variable speed and load** duty of the machine in operation.
- **Surface condition** of tracks: roughness (see *TDS-02*), defects (out of round, low/high bars)...
- **Shock and vibration**, due to:
  - machine installation (alignment, shaft),
  - a deformation of the commutator or slip-rings (out of round),
  - a poor stability of the brush (clearance to the brush-holder – see *TDS-04*, brush orientation radial / trailing / reaction versus brush shape, adjustment of brush-holders, non-uniform pressure…).
- The quality of the **environment**:
  - lack or excess of humidity (see *TDS-17*),
  - presence of aggressive gases or abrasive dust… (see *TDS-23* on silicones),
  - poor maintenance of filters (if existing).
- The quantity and quality of the **cooling**: overheating or excess of cooling (see *TDS-12*), in particular for slip-ring units (unbalanced air flow distribution between rings – see *TDS-20*).
- Differential **polarity**, in DC machine or synchronous machine applications.
- Defective **commutation** or **circulating currents** between commutators bars.
- **Reversing machines** (contact surface will be reduced in case of frequent reversals).

Due to these various causes, which can affect brush wear significantly, it is hard to specify values of brush wear. Indeed, for the same grade and same brush assembly, brush wear can vary to a large extent according to the conditions of operation.

NOTE: The skin aspect (see *TDS-13*) gives a clue for the diagnosis. It must be completed by measurements to confirm or exclude each possible cause exposed above. For more information, refer to *TDS-08*.

2. EXPRESSION OF BRUSH WEAR

Brush wear is usually expressed as follows:

- for **industrial motors**: **mm/1 000 hours** (effective running time)
- for **traction motors**: **mm/10 000 km** (effective travelled distance)

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

Similarly, for traction applications, wears expressed in mm of brush per 10 000 km of vehicle travel are only comparable between them if the ratio of commutator to vehicle travel is taken into account (see paragraph on calculation).

Calculation of brush wear

For general application :

The brush wear Δr_i for each brush i, in mm, is the difference between its initial length and its used length.

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It is calculated with the formula (1).

$$\Delta r_i = r_i - r_{i0} \quad (1)$$

Where:
r_i is the length of the brush i, in mm [1]
r_{i0} is the length of the brush i, in mm

Then, the brush mean wear rate $\overline{WR}$ is the average of each brush wear rate, which is the brush wear Δr_i divided by the effective running time (i.e. without machine stoppage). It shall be multiplied by 1000 to be expressed in mm / 1000 hours.

Formula (2) gives the direct calculation of the brush mean wear rate $\overline{WR}$:

$$\overline{WR} = \frac{\sum_i \Delta r_i}{N} \times \frac{1000}{t_{er}} \quad (2)$$

Where:
Δr_i is the wear of each brush i, in mm (formula 1)
N is the number of brushes
t_{er} is the effective running time, in hours
$\overline{WR}$ is expressed in mm/1 000 h

NOTE: $\sum_i \Delta r_i$ means the sum of each brush wear = $\Delta r_1 + \Delta r_2 + \Delta r_3 + \quad + \Delta r_N$.

For traction application:

To obtain a value of the brush wear rate in mm/10 000 km (of railroad travelled), the previous formula shall be adapted, by introducing a reduction factor C, which correlates with the commutator or slip ring travel under the brush.

$$\overline{WR}_{railroad} = \overline{WR} \times \frac{0{,}360}{v_p \times C} \quad (3)$$

Where:
v_p is the peripheral speed, in m/s
$\overline{WR}$ is the mean wear rate (2), in mm/1 000 h
C is the reduction factor, calculated by (4)

$$C = g \times \frac{d}{D} \quad (4)$$

Where:
d is the commutator/slip-ring diameter, in mm
D is the wheel diameter, in mm
g is the gear ratio of the locomotive

NOTE: To be compared with one another, wear rates can be referred to the commutator or slip ring travel under the brush, that is to say in mm per effective running length (for further information consult the standard IEC 60773).

[1] Great care shall be exercised when measuring the length of a brush. Different methods / tools are available, each with different accuracy, and they may not give the same result, especially when they are operator-dependent.

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Cited documents:

– Mersen PTT Technical data sheets:

TDS-02: Roughness

TDS-04: Dimensions of Brushes and brush-holders

TDS-05: Losses in brushes

TDS-08: Preventive maintenance

TDS-11: Pressure on carbon brushes

TDS-12: Ventilation

TDS-13: Aspect of commutator / slip-rings skins

TDS-17: Air humidity

TDS-20: Slip-ring brushes

TDS-23: Silicones

– IEC60773: Test methods and apparatus for the measurement of the operational characteristics of carbon brushes (Norm available at https://webstore.iec.ch/home or at national standardization committees (AFNOR, DIN, ANSI…).

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- Technical advice to help you maximize the efficiency of your equipment and minimize your operating and maintenance costs
- Retrofit solutions



The **MERSEN DustCollector**,
patented carbon dust collection system,
is designed to avoid short circuits
caused by low insulation resistance!

A SMART CONCEPT

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- ✓ Completely integrated and customized with **plug & play concept**
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Contact: info.ptt@mersen.com

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