

Brush losses on slip rings or commutators are not always correctly calculated. They represent less than 10% of the total losses of a modern DC machine used within the normal limits of load.

These losses come from 2 different sources:

### 01 - LOSSES OF MECHANICAL ORIGIN $P_f$

Mechanical losses are due to the **friction** between the brushes and commutator or slip ring. They are calculated in watts by the following formula:

$$P_f = 10 \times \mu \times F_r \times v$$

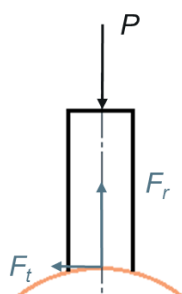


Figure 1 - Forces acting on the brush (radial position)

where:

$\mu$  is the **friction coefficient** of the brush on the commutator or slip ring.

It is defined as the ratio between the tangential force  $F_t$  and the reaction force  $F_r$  acting on the brush:  $\mu = \frac{F_t}{F_r}$ .

Its value depends on the spring pressure, the grade and the peripheral speed\*

$F_r$  is the **normal component of the force** applied on the brush on the commutator or slip ring, in daN.

Its value is equal to the pressure applied on the brush (for more information consult TDS/11),

$v$  is the **peripheral speed** of the commutator or slip ring, in m/s

#### REMARKS

- The pressure  $p$  to be applied on the brush\* is given by the formula:

$$p = \frac{F_r}{S}$$

Therefore the formula for mechanical losses becomes:

$$P_f = 10 \times \mu \times p \times t \times a \times v$$

where:

$S$  is the cross section of the brush, equal to  $t \times a$  (for a radial brush as per figure 1), in  $\text{cm}^2$

$p$  is expressed in  $\text{daN/cm}^2$  when  $F_r$  is in daN (see also TDS-11)

- For a brush with a contact bevel angle  $\alpha$  (see TDS-04),  $p$  is given by the formula:

$$p = \frac{F_r}{S \times \cos \alpha}$$

Therefore the formula for mechanical losses is:

$$P_f = 10 \times \mu \times p \times (t \times a \times \cos \alpha) \times v$$

**02 - LOSSES OF ELECTRICAL ORIGIN  $P_e$**

Electrical losses are mainly due to the **Joule effect**, due to the flow of current through the brush. They are calculated in watts by the following formula:

$$P_e = I \times \Delta U$$

where:

$I$  is the **current intensity**, in ampere

$\Delta U$  is the **brush voltage drop\***, in volt, for the considered current  $I$ .

Remarks:

- For low resistivity grades  $\Delta U$  is considered to be equal to the contact voltage drop.
- The temperature of commutator or slip ring plays a significant role on the contact voltage drop:  $\Delta U$  decreases when temperature increases.

**\* Notes:**

- Recommended pressure and resistivity for each grade, as well as a classification of friction coefficient and voltage drop are indicated in Mersen’s Carbon Brush Technical Guide.
- Indicative values of friction coefficient (as a function of peripheral speed) and brush voltage drop (as a function of current density) are specified in Mersen grades Data Sheets, available upon request. Measurements are performed in our Laboratory according to the standard IEC 60773.

List of references:

Mersen’s “Carbon Brush Technical Guide”

TDS-04: Dimensions of carbon brushes

TDS-11: Pressure on carbon brushes

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

Mersen’s “Carbon brushes for motors and generators” technical guide

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Contact: [info.ptt@mersen.com](mailto:info.ptt@mersen.com)

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