LOSSES IN BRUSHES

TECHNICAL NOTE ■ STA BE 16-8 GB

The importance of brush losses on slip ring or commutator is not always well assessed.

They represent less than 10% of the total losses of a modern continuous current machine used within the normal limits of charge.

These losses come from 2 different sources:

- Losses of mechanical origin W_m due to friction forces. They are given in watts by the formula:

$$W_m = 10\, \mu.\, F.V.$$

where:

μ: is the friction coefficient of the brush on the commutator,
F: is the normal component of the bearing force of the brush on the commutator in daN,
V: is the peripheral speed of the commutator in m/s.

Remark: The pressure to be applied is given by the formula:

$$P = \frac{F_R}{S}$$

where:

F_R is the force transmitted by the spring of the brush-holder
and S the right section of the brush $t \times a$.

For a brush with a contact bevel angle α

$$P = \frac{F}{S \cos \alpha}$$ and the formula becomes

$$W_m = 10\, \mu.\, p.\, V.S.\cos \alpha$$

p expressed in daN/cm^2 and S in cm^2

- Losses of electrical origin W_e which are expressed in watts by the formula:

$$W_e = I \times \Delta U$$

where:

I is the current intensity in amperes
and ΔU the brush contact drop in volts for the considered intensity.

Remark: if the current density in A/cm^2 is added to this formula, it becomes:

$$W_e = S.d.\ \Delta U$$

where:

S is the right section of the brush in cm^2.

To these electrical losses under the brush, it would be advisable to add the losses W_{ch} in the brush, that is to say the losses in the carbon itself, the losses in the connection W_s - tamped or rivetted - (and as well the losses in the flexible W_k which will not be considered).

If h is the height of the brush (in cm), ρ the resistivity of the material (in Ω × cm), r the resistance of the flexible connection (in Ω) it may be written:

$$W_{ch} + W_S = I^2 \left(\rho \frac{h}{S} + r\right)$$

We recall hereafter some value orders for μ, d, ΔU, ρ and r for electrographite, graphite, metal and bakelite graphite brushes:

Brush grade	EG	LFC	CG	BG
μ	0.1 - 0.25	0.1 - 0.2	0.10	0.1 - 0.30
d (A/cm²)	10	6	15	10
ΔU (V)	1.25	1	0.25	1.75
ρ (Ω × cm)	3×10^{-3}	2×10^{-3}	5×10^{-5}	12×10^{-3}
r (Ω)	2×10^{-4}	3×10^{-4}	10^{-4}	6×10^{-4}

You will find below partial and total losses for some typical cases:

Brush grade	1 EG	2 LFC	3 CG	4 BG
t × a (mm)	25 × 32	32 × 32	40 × 20	6.3 × 32
h (cm)	3.2	6.5	4	5.5
d (A/cm²)	10	6	15	10
I in the brush	80	60	120	20
pression cN/cm²	180	150	180	180
application	CC motor 1500 t/mn	Turbo 3000 t/mn	Asynch. motor 1500 t/mn	Schrage motor 1200 t/mn
speed (m/s)	25	75	15	15
W_m (W)	70	175	20	10
W_e (W)	100	60	30	35
W_{ch} (W)	8	5	1	15
W_S (W)	1	0.5	1.5	0.5
Total losses rounded off to	180	240	50	60

In some special cases, when there are important tension differences between the bars of the commutator short-circuited by the brush, the circulation currents under the brushes involve quite important losses which cannot be calculated, as the exact value of these derived currents are usually unknown.

The general formula is:

$$W\,\Phi = \Sigma \left[\frac{\Sigma\, \Delta e_n^{\,2}}{f\,(Rt)} \right]$$

where:

Δe_n is the tension drop between consecutive bars
and R_t the transversal resistance of the brush material.

MERSEN France Amiens S.A.S.
10 avenue Roger Dumoulin
80084 AMIENS CEDEX 2
France
Tel : +33 (0)3 22 54 45 00
Fax : +33 (0)3 22 54 46 08
Email : infos.amiens@mersen.com

Imprimé en France - S.I.C. - CHATEAUNEUF sur LOIRE - 02 38 58 63 63

BE 16-8 GB 7020