

Technical Information

Non-uniform brush wear

Many customers ask : „Why do brushes on a specific machine show a non-uniform brush wear ?“

Fluctuations in the brush grade are often held responsible.

Below we would like to provide you a small suitcase of arguments. By means of these arguments you can show, that a lot of other parameters might be responsible for non-uniform brush wear

1. **Non-uniform out-of-roundness from one brush track to the next**

No commutator-surface is exactly round and it will not become better during operation. Once damaged it will also not heal by itself. Commutators / slip rings can stay in a stable state but become worse over the years if not maintained properly. Admissible values of the out-of-roundness depend amongst others on the peripheral speed; what's good at 500 rpm must not be good at 3000 rpm.

Commutator profiles of large machines can be much different from the inner to the outer tracks. Stability of the commutator, vibrations of the brush holder stud, non-uniform current sharing etc. can be accountable for that.

2. **Non-uniform brush pressure**

The tolerance of the pressure of a pressure spring is $\pm 10\%$. This can be assigned directly to the brush wear. It has to be considered that springs don't last for ever. The pressure drops off continuously, due to a fatigue effect during operation. As larger the out-of-roundness as more the fatigue, due to the permanent up and down movement of the brushes.

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3. Non-uniform total downforce

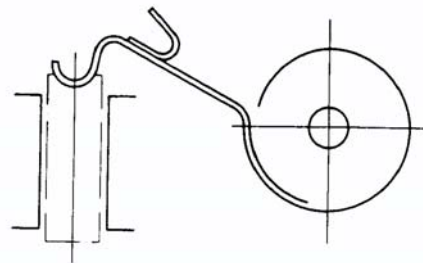
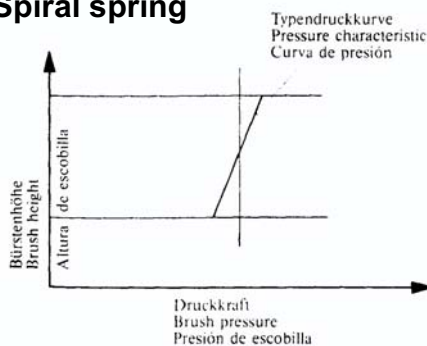
The weight of a carbon brush has an influence on the brush wear, even though it is relatively low. The net force of brushes in 6 o'clock and 12 o'clock position can be different. This naturally becomes more of a factor with heavy metal graphite brushes.

4. Non-uniform characteristics of the spring pressure with the brush wear

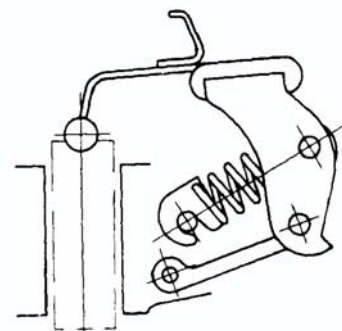
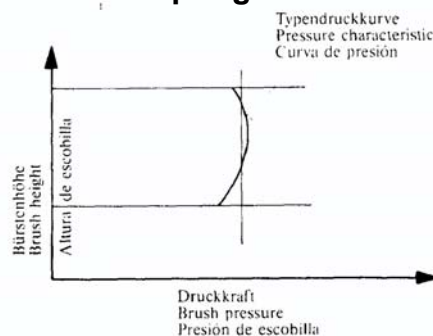
The pressure characteristics of a pressure spring depends on the spring type. The spiral spring, predominantly used in traction, has got a heavily declining characteristic, whereas the pressure gradient of extensions springs and constant coil springs is virtual linear.

With adjustable springs it must be borne in mind, that the pressure differential by means of handling failures.

Spiral spring

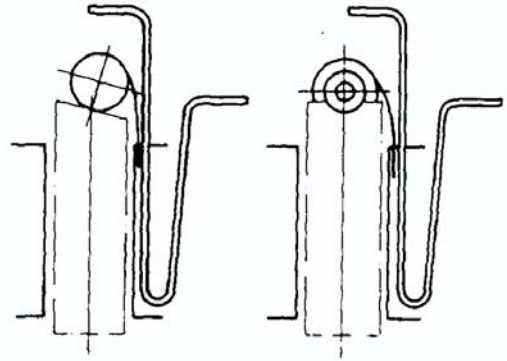
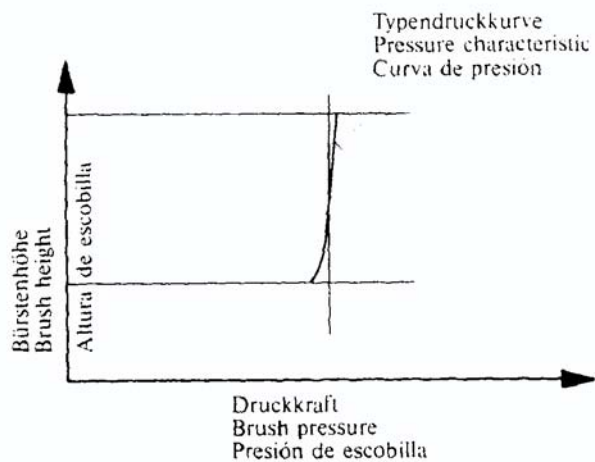


Extension spring



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Constant coil spring

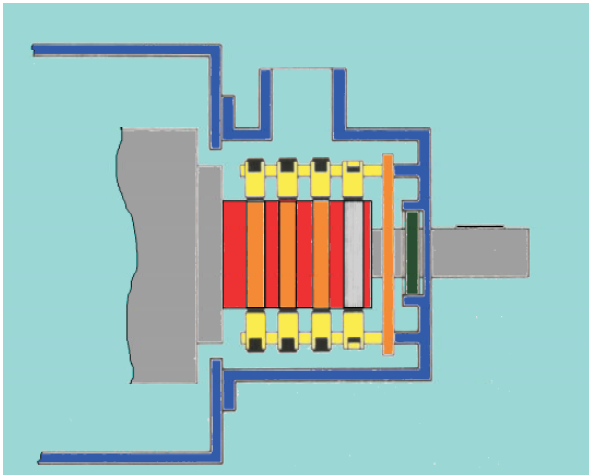


5. Variable friction in the brush box

Brush dust. Oil and other contaminations don't accumulate uniformly in the machine. Whatever origin, contaminations deteriorate the operating conditions by all means. Dirt can cause differences in friction between the carbon brush and the brush holder, between spring and brush and inside the windings of the spring itself. Therefore during maintenance periods one has to pay attention on contaminations nearby the brush holders.

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6. Differences in temperature



Commutator- / slip ring and brush temperature depend on the ventilating air inlet and exhaust locations. The location of air flow obstructing supports, the location of air flow directing baffles or even brushes located near open risers of large machines can have a negative influence. The brush temperature is by no means uniform. .

The difference in temperature of brushes located near the winding and brushes on the bearing side is well known. Therefore there is often a natural gradient in brush length from the winding side to the bearing side. But reverse cases are also known.

Non-uniform current distribution

Specific brush grades are more selective than others. Some grades, resin bonded graphite grades, need to be limited to 4 brushes per stud on order to limit selectivity. Carbon also has the unusual feature that the resistance decreases as the temperature increases. This can cause a snow ball effect, because the brushes with the least resistance will transfer most of the current and will become significantly warmer and so on. By means of burn out of pig tails and malfunction of tamped contacts this situation can very fast escalate in the breakdown of the motor.

The SKT grade family –E46- distinguishes itself by a very uniform current sharing. That is the main reason for the big success of this grade on large DC machines, e.g. in steel works.

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7. Non-uniform commutation

Differences in the air gaps between the inter poles and the winding cause dissymmetry in the magnetic flux and therefore differences in the current sharing.

By the way: One should be careful to equate brush sparking always with “bad commutation” Much more factors can cause brush sparking. This will be the subject of another SKT-Info.

8. Stability of the brush holders and brush stud assembly

A large machine with 8 to 10 brushes per stud has a quite long brush stud. This stud is usually only supported at one end and vibrations at the unsupported end, no matter how small, usually work against keeping the brush in intimate contact with the commutator.

9. Differential polarity

In DC machines, half the number of brushes are positive half are negative. Half are anodes, half are cathodes. As electrons flow in only one direction, current is leaving one brush and going to the commutator, while it's going from the commutator to the other brush.

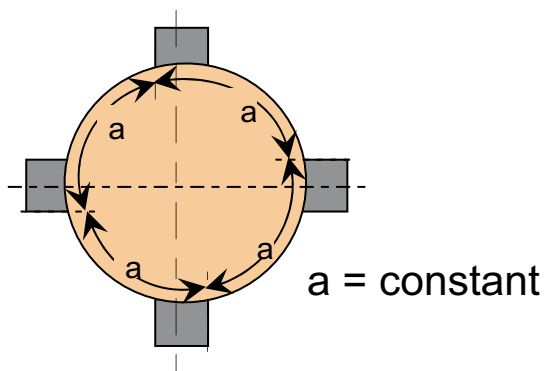
The axial arrangement of the brushes on the commutator is also important to guarantee that no non-brushed tracks appear on it. Since the film formation depends on the polarity of the brushes, the number of plus and minus brushes must be as equal as possible in all tracks. In many cases of course there has to be a compromise (e.g. 6 pole machines)

When a compromise situation has been reached, care must be taken to ensure that no tracks occur which have only cathodic loading. Cathodic brushes (motor(-), generator(+)) alone in one track lead relatively easily to commutator attack.

For DC slip ring service, synchronous machines, this polarity effect is the reason for reversing polarity of the rings occasionally, to force even slip ring and brush wear.

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10. Non-uniform brush spacing (pole pitch)



Brushes need to be equally spaced circumferentially around the commutator where they come in contact with the commutator. Deviations of a half insulation bar should not be exceeded. Fitting the brush holder is facilitated by laying a paper strip around the commutator, which has previously been accurately marked the pitch.

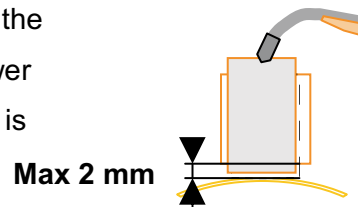
Furthermore the leading and the trailing edge of the brushes must be exactly parallel to the edges of the segments. Long brush studs may appear uniformly spaced where they are supported, but can in fact be tilted toward an adjacent brush stud at the other end.

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11. Non-uniform brush orientation

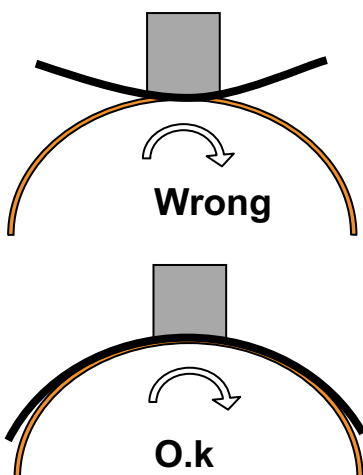
Brush holders can orient brushes for trailing, radial or reaction or a combination of trailing and reaction. Whatever the motor manufacturers' reason for the combination of trailing and reaction, it needs to be recognized that the differing brush orientations will affect the rate at which brushes wear.

In addition it should be noted in connection with the fitting of holders, that the space between the lower edge of the holder box and the collector surface is about 2mm.



12. Non-uniform brush seating

13.



Whether or not brushes were properly seated and the process used can also affect wear life. Initially, new brushes do not intimately contact the commutator surface. Point or line contact quickly changes and finally does approach a full seat. But the amount of time and current passed through the brush before it is fully seated, can cause local damages because of the abnormal high current density. The time to even this failure will surely differ. Therefore non-uniform brush wear will happen..

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14. Non-uniform electrical connections

All connections from the power source to the commutator surface need to be sound. Bolted electrical connections from stator coils to brush studs, from terminals to riveted or tamped shunts finally to the carbon brush, need to be working in unison to promote equal distribution of current.

15. Non-uniform film formation...

... is usually an indicator, that one or more of the above are taking place.