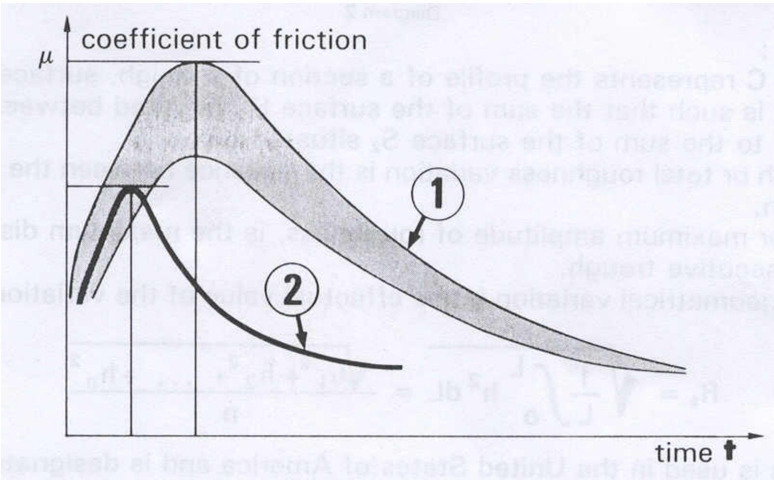
Technical Information

Surface roughness

It is often erroneously thought that the surface of commutators or slip rings should be brilliant and polished to ensure an optimal performance of carbon brushes. *Quite the reverse* !

Apart from low load a low surface roughness is one of the most common reasons for carbon brush problems. Very often the problem is not recognised as such and therefore the wrong remedies are initiated. Following we would like to give some practical hints.

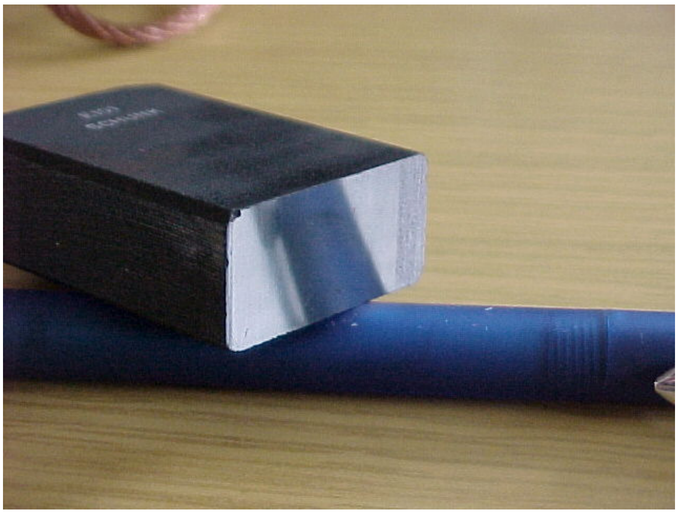
According to experiences from our lab and from the field the friction coefficient on shiny, smooth surfaces is significant higher compared to unpolished surfaces, especially during starting of motors or generators. Stationery conditions and a stable friction coefficient are reached much later, compared to unpolished surfaces (picture 1).



Picture 1: Friction coefficient as a function of surface roughness
Curve 1: Roughness R_z 0,5µm – Curve 2: Roughness R_z 5 µ

There are three reasons:

- On polished surfaces exist more contact points between the contact partners. Therefore the friction coefficient is slightly higher, the mechanical losses and the surface temperature are increased.
- On smooth, polished, moving surfaces the so called „stick-slip“ effect can have much more dramatic consequences. This is a change of static friction and sliding friction. It is easy to imitate this phenomenon, by trying to slide a hand over a smooth glass surface. On moving surfaces this effect creates vibrations with high frequencies but low amplitudes. The results are brush sparking, burn marks, out-of-roundness, high brush wear ... Picture 2 shows the contact surface of a carbon brush conspicuous by brush noise. With those signs the possibility of too smooth surfaces should be kept in mind.
- On commutators or rings which are polished and bright the graphite, one of the essential constituents of the skin, is poorly abraded from the brush or, if it is deposited on the metal at all, fails to adhere firmly. In a long term run this may result in commutator and ring attack.



Picture 2: Smooth contact surface can cause brush chattering

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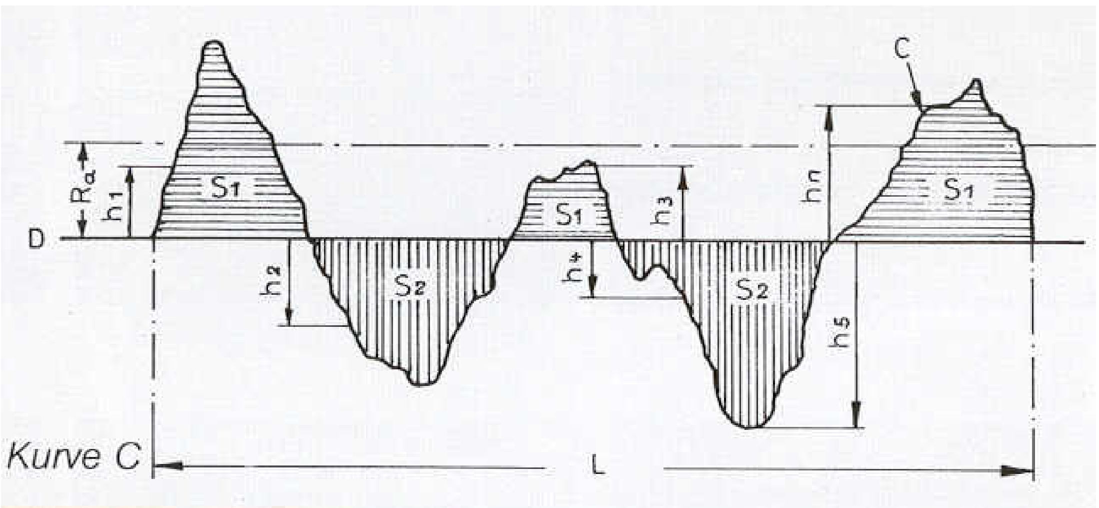
In case of a sufficient surface roughness these problems can be avoided : the skin can be formed normally, the total brush performance becomes much more stable and more uniform.

On the other hand, if the final surface is too rough, the commutator works rather like a grinding wheel and as a result excessive brush wear occurs.

Therefore tolerances for the surface roughness do exist. First of all we would like to explain the differnt definitions of the roughness. Picture 3 gives a heavily magnified detail of a rough surface to explain the various terms.



Picture 3: Magnified detail of a rough surface

Curve C represents the profile of a section of a rough surface on a length L.
Line D is such, that the sum of the surfaces S above and below line D is equal.

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R_a is the average of the distances h of the curve C from line D.

R_z is the average of single roughness of 5 following test sections.

The roughness is given in micro meters (µ).

The optimal values in the two scales are:

R_a 0, 8 to 1,2 µ

R_z 5 to 8 µ

In the US and the UK the R_z value is known as the RMS value (Root Mean Square) . We at SCHUNK prefer the R_z value instead of the R_a value.

We have a handy instrument in our measurement kit, shown in pictures 4 and 5.

Picture 4: Measuring instrument for the determination of roughness

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Picture 5: Measuring sensor

The sensor shown in picture 5 is positioned onto the surface, which should be measured. By pushing a button one is enabled to carry out a simple, fast and reproducable measurement.

The roughening of the surface with a grinding stone is one remedy to solve problems which might be caused by too smooth surfaces. These grinding stones consist of silicone carbide. . SCHUNK offers such grind stones in various sizes and with various grains. By safety reasons all grinding stones have a wooden handle. Picture 6 gives a typical example.

Very often socalled "rubber stones" are found for servicing the surfaces of commutators. These materials force the smoothening of the collector surface and therefore the "stick-slip effect". Also some rubber particles might be transferred into the sliding surfaces. Therefore we strictly recommend to avoid the use of those grinding materials.

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Picture 6: Silicone carbide grinding stone with wooden handle

As a rule a slight grinding of the surface is sufficient to get an improvement. The standard safety regulations for electrical machines must be kept.

Grains of grinding materials are standardised in the German standard DIN 69100.

Grain (DIN)	**Grain No.**	**Grain (Brush manufacturers)**	**Particle size µm**
Medium	46	Coarse	420 – 350
Fine	80	Medium	210 – 177
Very fine	220	Fine	74 – 53
Ultra Fine	600	Very fine	13 - 10

The following empirical values for the processing of surfaces with various grains do exist:.

Material	**Grinding stone**	**R_z µm**
Copper	Coarse Medium Fine	10 5 3
Sttel	Coarse Medium Fine	10 3 1,5

Therefore we recommend the use of grinding stones

- **medium grain for copper collectors or bronze rings.**
- **coarse grain for steel slip rings.**

Summary:

- **A too rough surface is less critical than a too smooth surface. The adaptation of brush and ring radius is made easier, the skin formation goes faster and is more uniform.**
- **The surface should be dull and never mirror like.**
- **So called “rubber stones” should never be used !**