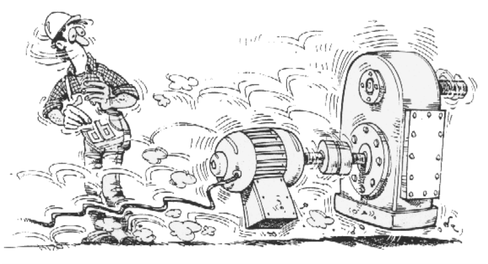
Technical Information

Vibrations

Low electrical load conditions and vibrations are the first items on a list of reasons, which may have a negative influence on the brush performance on DC-drives and slipring machines.
With this actual SKT-Info we would like to deal with the topic „Vibrations- Detection,, Reasons, Remedies" and will also mention some figures, to give you a reasonable background for discussions with users and customers.
It can not be avoided to mention some physical and mathematical basics.



Vibrations

In every machine one part of the drive energy is transformed into vibration energy. No aggregate is built really stiff. Therefore the machine will be moved forward and backward.
A certain degree of vibrations can not be avoided and must be tolerated.

Each machine is constructed for a certain vibration level. Only if this standard vibration level is exceeded one can talk about a deteriorated operation state. The normal vibration level depends on two parameters:

- the mode of operation
- the stiffness of the construction and the foundation.

A large Diesel engine will vibrate more, than a small electric motor – the mode of operation and the forces are totally different.

A drive mounted on an elastic metal frame will be forced to vibrations much easier than a machine on a stiff, heavy concrete foundation.
Slow or sudden changes in the construction or the mode of operation of a machine will also change the vibration behaviour. Loose screws, large movement in the bearings etc. will decrease the stiffness of the aggregate and vibrations will increase. Once started the damages will be intensified. More vibrations will give more mechanical load on the bearings, shaft or foundations, the carbon brushes will show more and intensified sparking, the burn marks will be increased.

Values

A machine with a certain out-of-roundness vibrates dependent on the revolutions per minute rpm). With each turn it makes one movement there and back. The number of vibrations per time unit is called vibration **frequency**, measured in Hertz (Hz).
The division of the rpm of a machine (e.g. 1500 rpm) by 60 results in the turning frequency (here 25Hz) of the vibration, created by the turning out-of-roundness..
Cyclical, i.e. repeating movements can be described by three values.

- distance,
- acceleration,
- velocity.

The distance an object covers during each vibrations is called **vibration distance**. The unit is millimeter.
An object which is moved from rest, braked and moved in the other direction must permanently accelerated positively or negatively. This **acceleration** is measured in m/s^2 or g (1g = 9,81 m/s^2).
The third value is the velocity of the movement of the object. The **vibration velocity** is given in mm/s.
Velocity and acceleration are always changing figures. The peak value can be measured, but much better conclusions of the existing forces can be drawn by looking into the average

value. Therefore most instruments measure the effective value (root of the quadratic average), called RMS-value.
The RMS value between 10 to 1000Hz is called **vibration strength**, measured in mm/s..
With the Vibrameter VIB-10 by the company Status Pro SCHUNK Kohlenstofftechnik has a simple instrument in its equipment to measure the vibration strength.

The vibrations at the selected measuring spot should be as representative as possible. The existing forces are normally transferred via the bearing or the bearing housing. Therefore measurements should be done nearby these points.

As more points are selected, as easier mechanical problems can be detected. The example shows a fan, driven by an electric motor via a belt. The readings at the bearing (3) give information about possible out-of-roundness of the fan. For information about the state of the entire system, one has to make additional measurements at the drive bearing and at the motor itself.

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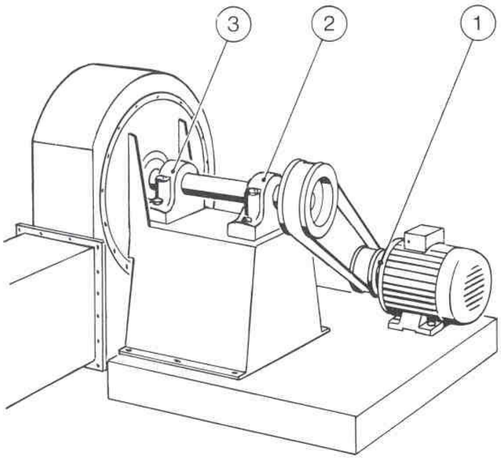

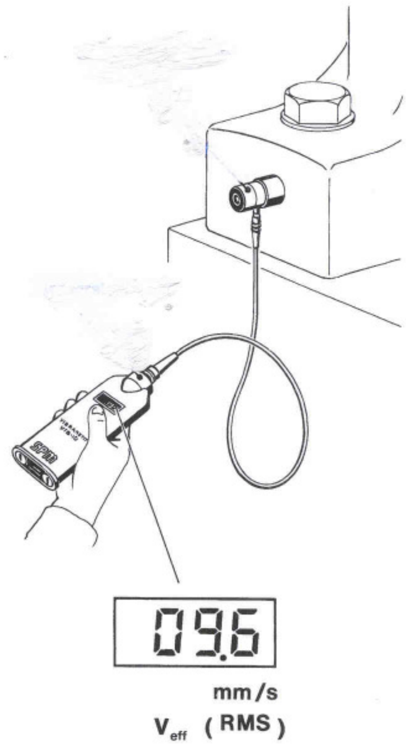

With respect for a perfect commutation the following values should not be exceeded.

Vibration distance ≤ 0,25mm
Vibration strength V_{eff} ≤ 4,5mm/s
Acceleration a ≤ 4 m/s²

Vibrations on brushes and brush holders

One can distinguish self created vibrations and external vibrations. Both influence the perfect contact between carbon brush and commutator or slip ring, and therefore also the commutation.

Self created vibrations can be differentiated by the location where they take place.

On the commutator / slipring

- Out-of-roundness, ovality,
- protruding bars,
- defective bearings,
- bad centre,
- external influences (cogwheel gear box, couplings, belt drives, attached aggregates etc.)

The topic out-of-roundness will be discussed in another Technical Information. Therefore we will give here only some guide line values. The SCHUNK-Motorscope enables a simple, fast, reproducable measurement of the out-of-roundness even with motor potential.

The permissible values for out-of-roundness and bar-to-bar distance depend on the speed and the mode of operation.

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Value	Bar-to-bar distance	Bar-to-bar distance	Bar-to-bar distance	Out-of-roundness	Out-of-roundness	Out-of-roundness
180µ						Unzulässig
160µ						
140µ					unzulässig	
100µ			unzulässig	unzulässig		
80µ		inadmissible				permissible
70µ					permissible	
60µ	inadmissible		permissible	permissible		good
50µ		permissible			good	
40µ	permissible			good		
30µ			good			
20µ		good				
10µ	good					
0µ						
Size	< 200	200 - 450	> 900	< 200	200 - 450	> 900

In case of resonance between the stimulating frequency and the self-frequency of the holder apparatus, even with low peripheral speed heavy vibrations problems may arise. Tests in our electrical laboratory have shown, that on out-of-round collectors forces can be created by means of resonance vibrations, which can neutralise the forces of the springs. Therefore at times the brush pressure might be zero. The current transfer will be heavily disturbed, brush sparking, burn marks and high brush wear will follow..

- defective bearings,
- bad centre,
- external influences (cogwheel gear box, couplings, belt drives, attached aggregates etc.)

At the brush holder

- Wrong holder type,
- wrong holder assembly,
- wrong tolerances of the brush box,
- too low brush pressure,
- wrong distance brush box / commutator surface (max. 2mm),
- defective bearing of the pressure finger bearing,
- wrong position of the pressure finger..

Brush oscillations respectively brush chattering are intensified, if the pressure finger is not positioned in the middle of the pressure pad. Sometimes the brush chattering can be removed by moving or bending of the pressure finger.

At the carbon brush

- Wrong brush tolerances,
- high and heavy changing friction coefficient by atmospheric influences or long low load periods.

Particularly the last mentioned low load problem is one of the most discussed issues in discussions with customers and users. Low electrical load means low electrical losses in the contact surface carbon brush and counter material and therefore low surface temperatures. The oxidation speed of the surface of the ring or commutator will be slowed down, the surface roughness is decreased, and the commutator or slip ring becomes smooth. This will lead to the so called stick-slip effect, a change of adhesion and movement. The carbon brushes are forced to oscillations with high frequencies and low amplitudes. The concomitant of this phenomenon is heavy brush noise, called rattling. Roughening the surface with a me-

dium grained silicone carbide grinding stone is a simple remedy. The usual safety measures for the work with electrical machines must be kept.
We recommend a value **of 5 – 8 µm in the R_z** scale, respectively **0,8 – 1,2 µm in the R_a scale**, as a suitable surface roughness value after grinding and skimming.

If the collector is running perfectly round and the surface has a suitable roughness brush chattering is caused by an unacceptable friction coefficient. Friction coefficients higher than 0,4 can lead to brush chattering. A further trigger for high friction coefficients is low humidity (< $2g/m^3$).

If the temperature exceeds a value of 100 – 120°C electrograpite grades will rattle on steel rings..

The following reasons might be responsible for **external vibrations:**

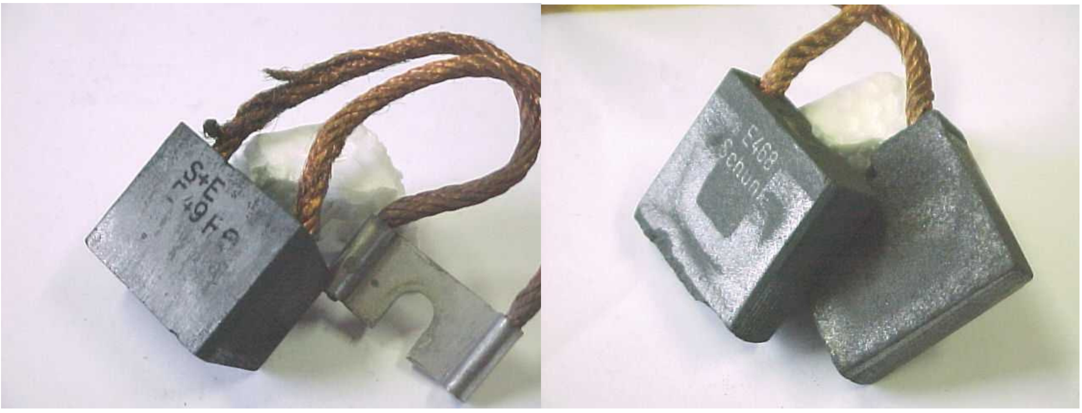
- Drives, nearby the working machine, mounted on the same base frame, e.g. tool drives, fan drives etc.,
- direct mechanical transfer via belt etc.,
- direct coupling of the motor with a fan, mill etc.
- insufficient foundation,
- resonance phenomena by Thyristor rectifiers (harmonics of the DC current),
- shocks by fast current changes dI/dt.

Carbon brushes are "indicating instruments for the machine status"

For none problem else this thesis does have more importance then for the topic vibrations. Brush chattering and rattling are phenomena which are normally combined with brush sparking and noise,

The following four observations at the carbon brushes are clear indicators for the existence of vibrations:

- polished, shiny side surfaces of the brush wafers,
- perceptible markings of the pressure finger on the brush top,
- broken or frayed pig tails,
- loose tamped contacts.



Uneven distributed burn marks on the bars respectively on the slip ring are further indicators for existing vibrations. Vibrations do further increase the out-of-roundness of rings or collectors.

Counter measures for weakening the influence of vibrations

If the cause for the vibrations is recognised, the counter measures for the remove should begin. If it is known, that the machine will have vibration due to the mode of operation or if the machine can not be changed or repaired in a short term, there are some more possibilities to make the carbon brush less sensitive against vibrations, beside the already mentioned grinding of the collector surface.

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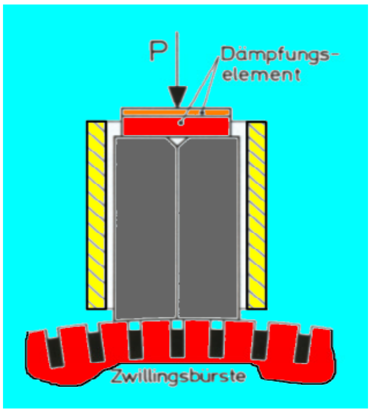
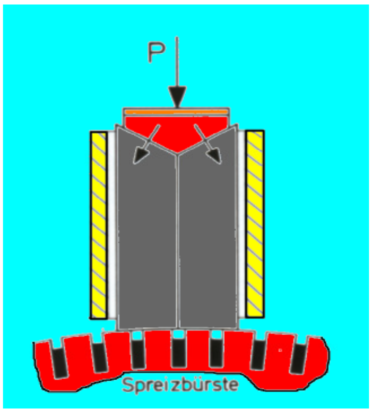
- Use of bevelled brush holders, e.g. with an 8 – 10° angle,
- increase of the brush pressure,
- use of a more elastic brush grade,
- use of carbon brushes with rubber top for better damping,
- use of a thicker rubber top,
- use of twin brushes with loose brush top,
- use of split brushes. The brush wafers are pressed to the wall of the brush box by means of the angle of the brush top. This gives a stabilisation effect to the entire brush performance..





A particularly sensitive part of the carbon brush is the tamped contact. SCHUNK has developed special. Sophisticated designs of these tamped contacts to avoid failures of the contacts due to vibrations.