Technical information - Out-of-roundness

With the present information we would like to inform you about the topic collector out-of-roundness.

1. Carbon Brush Problems by Collector Defects

Each deformation of a commutator or slip ring of rotating, electrical machines will lead to problems during operation. These difficulties sometimes appear suddenly and in various ways:

- Brush sparking,
- damage of the brushes by high bars,
- high brush wear,
- damage of pig tails and brush tops,
- noise,
- damage of springs of brush holders.

As higher the peripheral speed of the machine, as more serious these defects become. For this reason immediate action is always to be desired.

The following deformations and damages of commutators can trigger the a.m. problems::

- out-of-roundness,
- flats,
- high and low bars,
- loose segments , e.g. after overloading of the motor.

The following items can be mentioned as possible reasons for out-of-roundness and flats::

- Imbalance of the rotor,
- Vibrations and mechanical shocks,
- Start-up burn marks,
- Burn marks by commutation problems or failures of the winding,
- Burn marks by local lifting of particular brushes by formation of air-cushions,
- Brush sparking by a high friction coefficient.

Which measure should be taken, depends on the kind and size of the out-of-roundness. An exact and reproducable measurement is a mandatory basis.
Therefore we would like to highlight the measurement of commutator and slip ring out-of-roundness, and direct your special attention to the various instruments. We will also give some hints for truing collectors by means of grinding and skimming.

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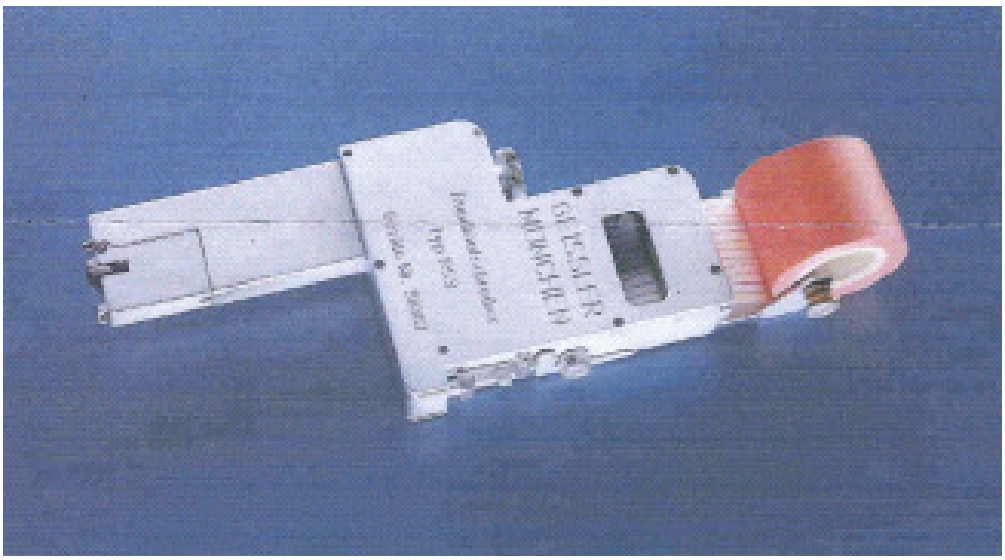
2. Measurement of Collector Deformations

The most simple method is the determining with a clock gauge. The disadvantage is, that only the maximum out-of-roundness can be determined, but not the collector profile. One can therefore not distinguish between long wave and short wave out-of-roundness.

The next step is a mechanical instrument from the company Geissler, Germany, which enables the registration of a collector profile on a paper strip.



Despite a low resolution even the recording of copper drag is possible with this instrument. The small size, the low weight, the easy handling and the universal use made this instrument to the favourite for the measurement of out-of-roundness during the last decades. Unfortunately the production of this device is stopped since approx. 10 years. Repairs can only be carried out by precision mechanics.

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A device with a bit higher resolution working with the same principle is offered by the company Feinprueef. The collector profiles can be printed on thermal paper.

Since the beginning of the 90s a first electronic device was introduced. This allows a very accurate measurement of collector deformations, but only without motor potential. Different types of graphs make the analysis easier.

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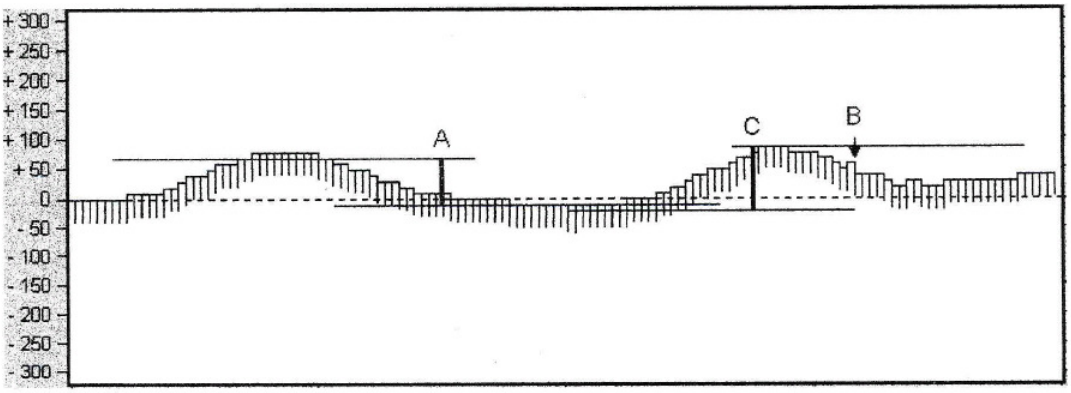
Unfortunately the demand for these instruments was only very little. Therefore the production of the SCHUNK Motorscope and of a Morganite instrument was stopped in 2010. Up to now there are no appropriate devices in the market.

2.1. Measured Variables

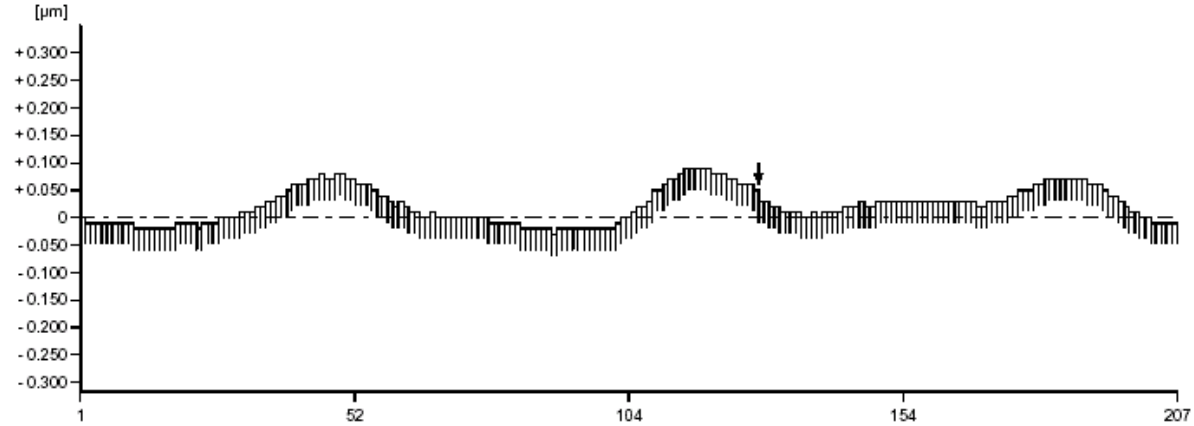


A = max. out-of-roundness (e.g. 0,080mm)
B= bar to bar distance (e.g. 0,020mm)
C= max. bar difference TIR (e.g. 0,100mm)

Max. out-of-roundness

The displacement of the commutator or slip ring from the ideal middle is called true running.
A change in the true running is normally an ovality. The data given by the instruments normally are average values. The maximal out-of-roundness can therefore be different from the max. bar-to-bar difference (see above drawing). This sometimes leads to misunderstandings.

One can distinguish between long wave and short wave out-of-roundness.



Long wave out-of-roundness

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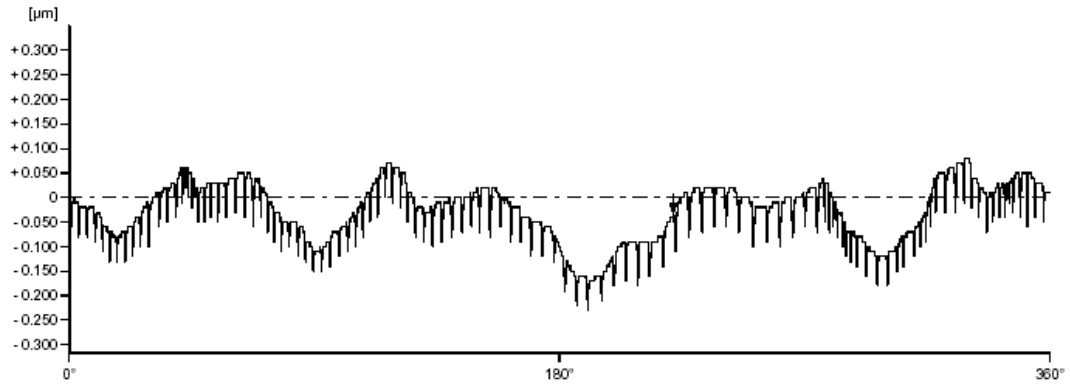

Short wave out-of-roundness

A carbon brush can normally follow an ovality regular spread over the perimeter. Short wave out-of-roundness e.g. by means of high and low bars or segments is the reason for separation of brush and collector. Brush sparking will arise, the commutator surface will be burned and the out-of-roundness will even be enlarged.
Those short wave out-of-roundness occurs mainly, but not exclusively, in traction applications.

The value of the maximum out-of-roundness is not enough to judge the state of the collector. Most important is the *shape of the collector profile* which can be displayed very clear with the common devices. Values measured only by a mechanical gauge should therefore be considered very carefully only.

Bar to Bar Distance

The bar to bar distance is the difference between two neighbouring bars. The change can be a high or a low segment. The maximum difference i.e. is displayed and indicated by an arrow. Even copper drag is shown as such a change.

Maximum Bar to Bar Distance (TIR, Total indicated reading)
The maximum bar to bar distance is the difference between the highest and lowest point on the measured surface.

2.2. Limiting Values

Exact figures for the out-of-roundness can not be given, because the value depends very strong on the peripheral speed of the collector. While for smaller motors with higher peripheral speeds only an out-of-roundness of 0,02 – 0,04mm can be tolerated, values of some tenth are allowed for slow running motors with speeds up to 10m/s..

Our recommendations for out-of-roundness and bar to bar distances are given in the following graph.

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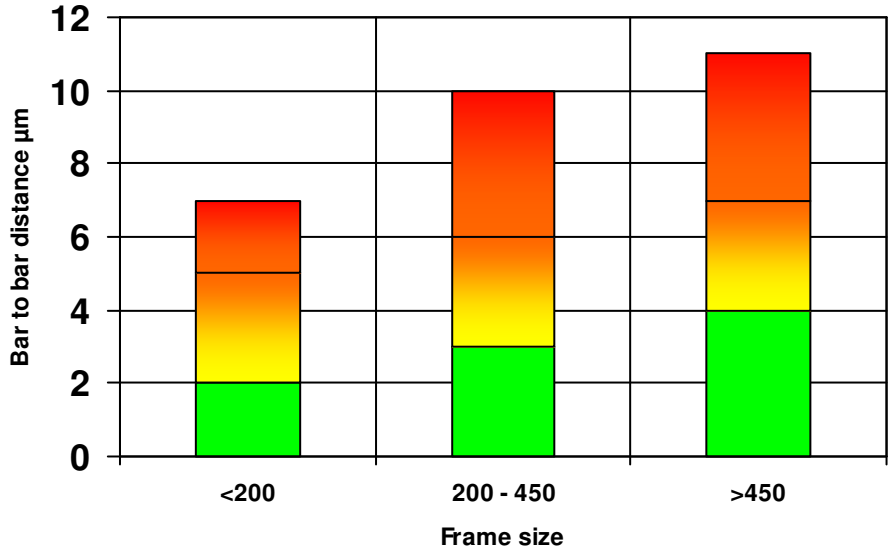
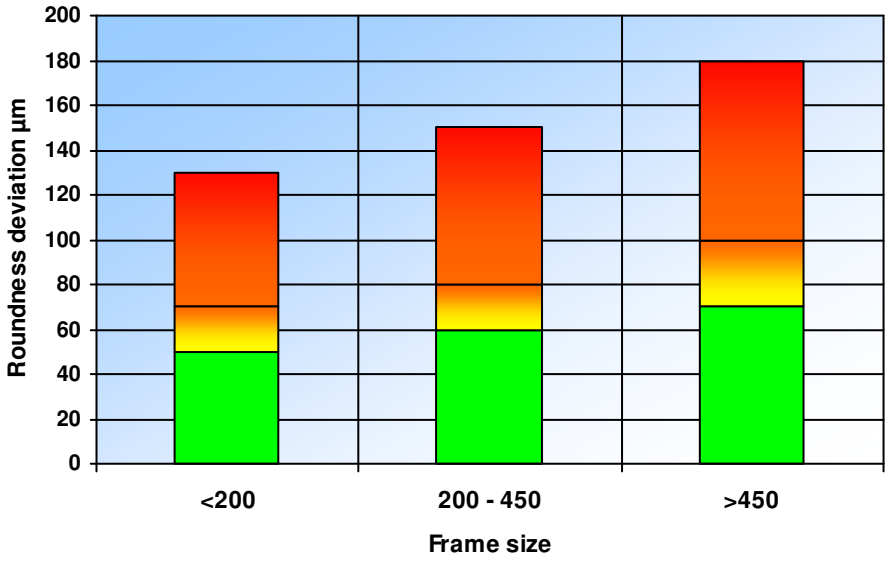
Bar to bar distance



Out-of-roundness



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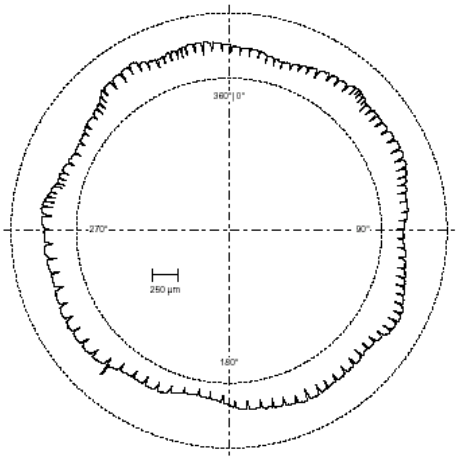
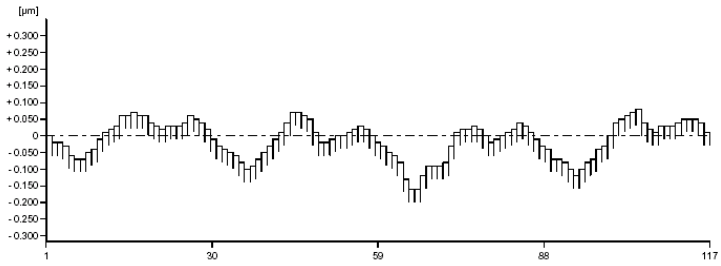
2.3. Graphs

The above shown stretched graph allows the view on the total profile as well as on a smaller segment. The bar to bar difference is indicated by an arrow. The high resolution enables the detection of smallest damages on the lamellas. A circle diagram is also possible, which is specially suitable to detect flats and deviations from the circularity. The bar to bar difference is also indicated by an arrow.
The linear graph shows a small segment of the collector with idealised bars. The total collector can be scrolled from 0° to 360°.





3. Truing of Collectors

Out-of roundness of a small degree can be removed by grinding with a silicone carbide grinding stone If the out-of-roundness or collector-run-out is very great the collector should be skimmed.

3.1 Grinding of Collectors

It may be necessary to carry out a preliminary grinding operation with a coarse grinding stone and then to carry out the final operation with a stone of finer grain (see table below)

We recommend generally to use a coarse grinding stone for the preliminary grinding. For the final grinding of steel rings a stone with a medium grain should be used. With non-ferrous rings the use of a “fine” stone is recommended for the final operation.,

Class (DIN 69100)	**Grain**	**Grain (brush manufacturer)**	**Particle sie µm**
Medium - SC46K5BA	46	Coarse	420 – 350
Fine – SC80K4BA	80	Medium	210 – 177
Very fine – SC220 K3BA	220	Fine	74 – 53

In order to avoid an increasing of the out-of-roundness during grinding, the tangential dimension of the grinding stone should be twice as large as the defective place to be removed on the rotor. It is expe-

dient to move the stone along a guiding aid. If the defective place is very wide or severe out-of-roundness the grinding should be carried out with a tone fixed in a support.
Subsequent polishing (smoothing) of the ground rotors should be omitted. For the same reason the use of emery paper should also be dispensed with since in our experience this can easily produce a too smooth surface.
The relevant safety recommendations for work with running electrical machines must be observed. With running machine the grinding operation should be carried out with a rubber plate to stand on, and with rubber gloves,

3.2 Skimming of Collectors

If the out-of-roundness or collector-runout is very great, it is recommended to skim the collectors. Depending on the size of the machine this can be done in situ (mainly in case of medium size or large machines) or on a lathe. Both diamond and carbide tipped lathe tools can be used. Diamond is used in metal cutting predominantly to give a super-finish.
In addition to ensure true running, skimming is intended to achieve the correct surface roughness. The surface roughness resulting from the machining is influenced by the lathe parameters as cutting angle, cutting rate and feed. Therefore no general recommendations can be given, The following table contains only guide line values

Recommended conditions for truing commutators and slip rings

	Tool	**Cutting speed (m/min)**	**Feed (m / revolution)**	**Depth of cut (mm)**
Collectors	Carbide tipped Diamond	100 – 300 300 - 500	0,05 – 0,1 0,05 – 0,1	0,05 – 0,15 0,03 – 0,10
Rings bronze & steel	Carbide tipped	100 – 150	0,05 – 0,10	0,10 – 0,15

Generally cut angles of 13° to 25° are suitable. After completion of the skimming procedure the collector can be ground to remove adhering copper particles. After that the collector must be thoroughly cleaned. If necessary the edges of the bars must be re-chamfered