

Technical information

Out-of-Roundness

With the present information we would like to inform you about the topic collector out-of-roundness and also take the opportunity, to present the "SCHUNK Motorscope" as an equipment for the measurement of collector defects.

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::

- Eccentricity or ovality , known as out-of-roundness,
- flats,
- high and low bars,
- loosening of segments , e.g. after overloading of the motor.

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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 radial holder vibrations,
- 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 reproducible 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 "SCHUNK Motorscope". We will also give some hints for truing collectors by means of grinding and skimming.

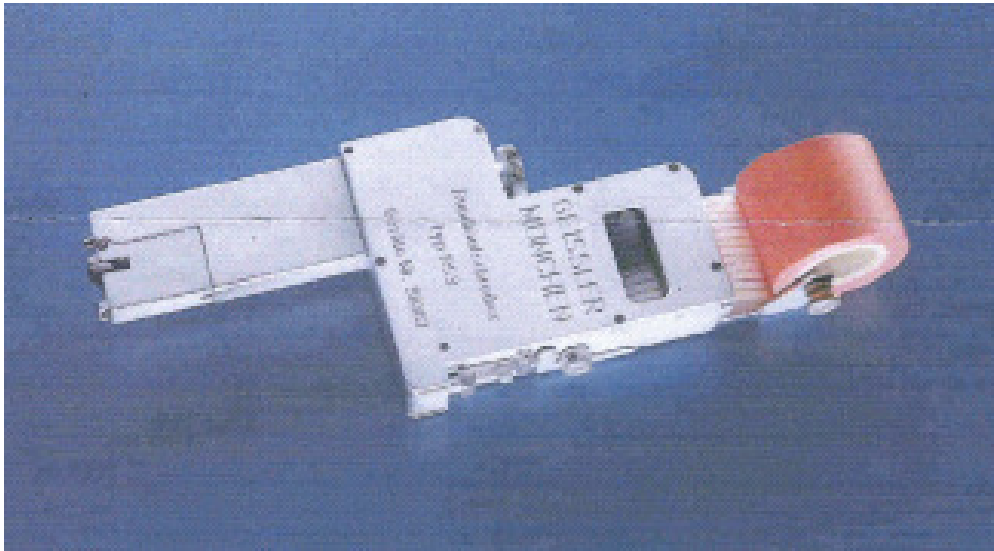
2. Measurement of Collector Deformations

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 of the collector profile. One can therefore not distinguish between long wave and short wave out-of-roundness.



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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.

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



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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.



The mentioned instruments have one common disadvantage, The collector must be turned for the measurement. This means for a potential free measurement, that the motor must be turned by hand. In railway applications the vehicle must be moved by pushing or pulling , sometimes by means of an extra train.

This major disadvantage is prevented with the SCHUNK Motorscope described in the following chapter.

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2.1 The SCHUNK Motorscope ©



In the year 1997 SCHUNK began with the development of its own instrument. Based on the experiences of our application engineers the device was mainly designed for measurement on working and alive machines. Costly preparations like declutching of the gear box can be avoided.

The data are registered by means of an insulated installed, magneto-resistive Hall-effect sensor and put in an intermediate memory. A short protocol can be printed with an internal printer. Afterwards the data can be analysed with a Laptop or a PC and processed for different graphs.

Measurements with the Motorscope are necessary for:

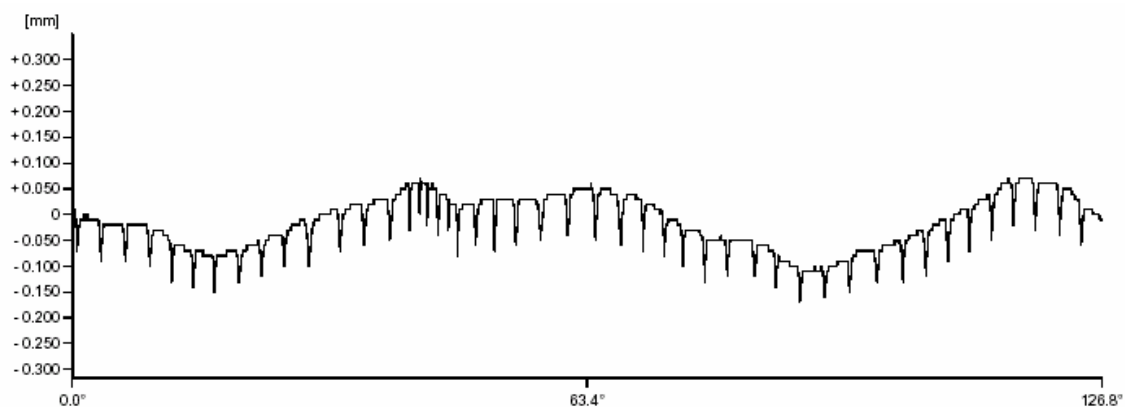
- fault detection ,
- preventive maintenance,
- planning of maintenance,
- quality control,.

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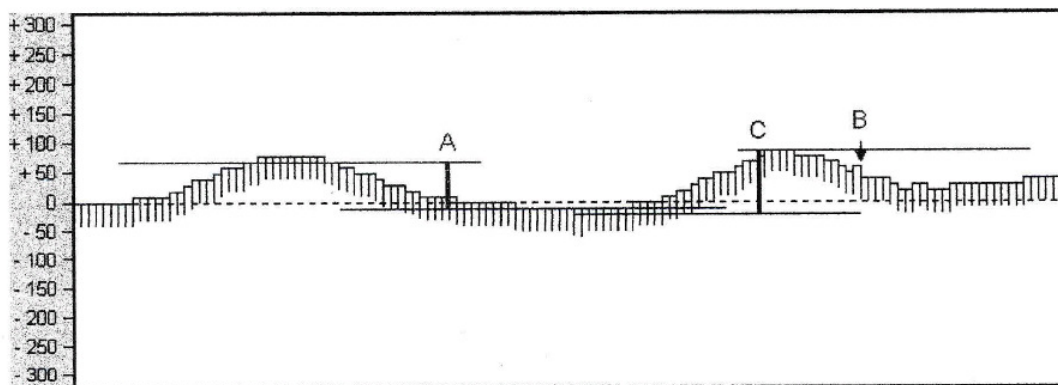
2.1.1. Measured Variables

The resolution of the gauge is shown in $10\mu\text{m}$ intervals ($0,01\text{mm}$, $1/100\text{mm}$). The internal resolution is $5\mu\text{m}$. The data are rounded down if they are lower than $5\mu\text{m}$ and the y are rounded up if more than $5\mu\text{m}$. The rounding up and down of the measured values is necessary, because shocks, contamination of the collector surface, tolerances in the bearing etc. should not influence the result,.

The resolution is good enough to detect damages of the bar edges, burn marks on the bar surface and copper drag. See also picture below.



The measured variables can be explained with the following graph.



A = max. out-of-roundness (e.g. 0,080mm)

B= bar to bar distance (e.g. 0,020mm)

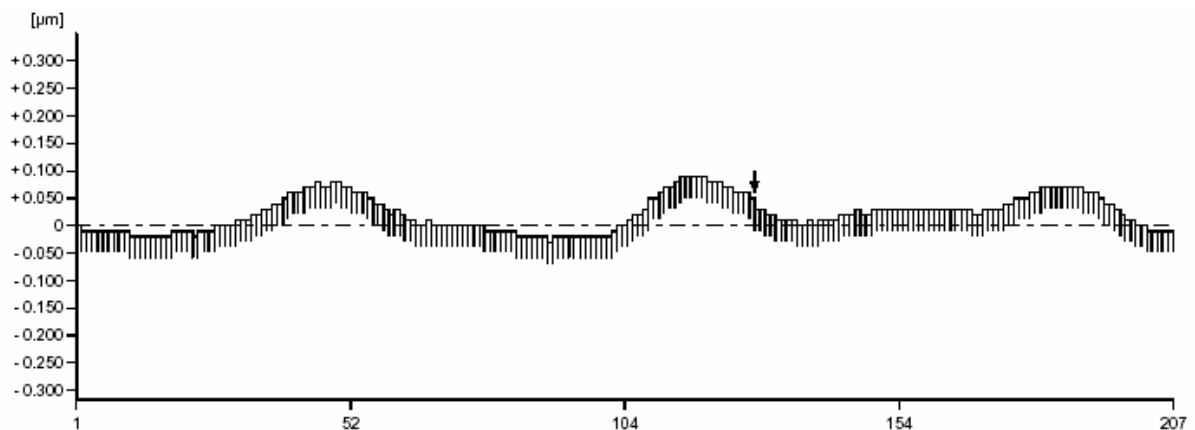
C=max. bar difference TIR (e.g. 0,100mm)

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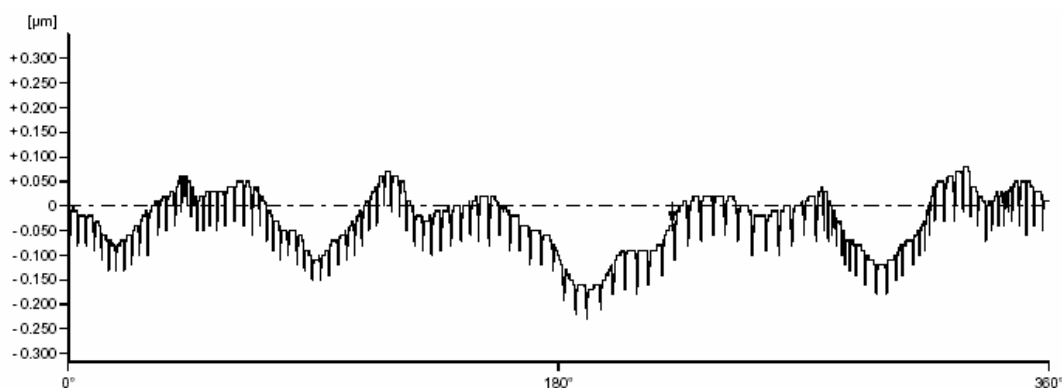
Max. out-of-roundness

The displacement of the commutator or slip ring from the ideal middle is called true running.. Changes in the true running are normally ovalitys. The data given by the Motorscope are average values. The max. 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



Short wave out-of-roundness

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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 devices like the SCHUNK Motorscope. 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

The maximum bar to bar distance is the difference between the highest and lowest point on the measured surface.

2.1.2. 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.

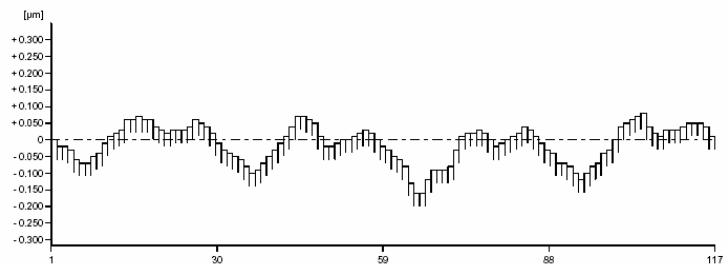
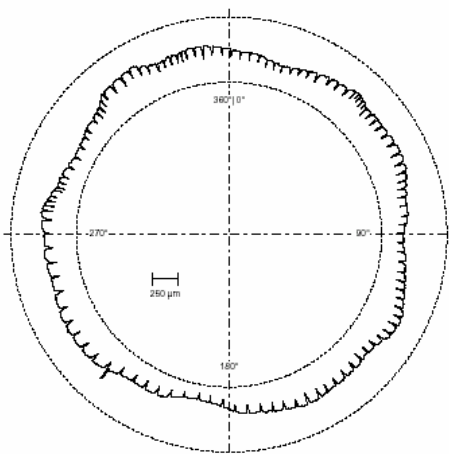
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Value	Bar-to-bar distance	Bar-to-bar distance	Bar-to-bar distance	Out-of-roundness	Out-of-roundness	Out-of-roundness
180μ						Unzulässig
160μ						
140μ					unzulässig	
100μ			unzulässig	unzulässig		
80μ		inadmissible				permissible
70μ					permissible	
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

2.1.3. 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. With the SCHUNK Motorscope 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.

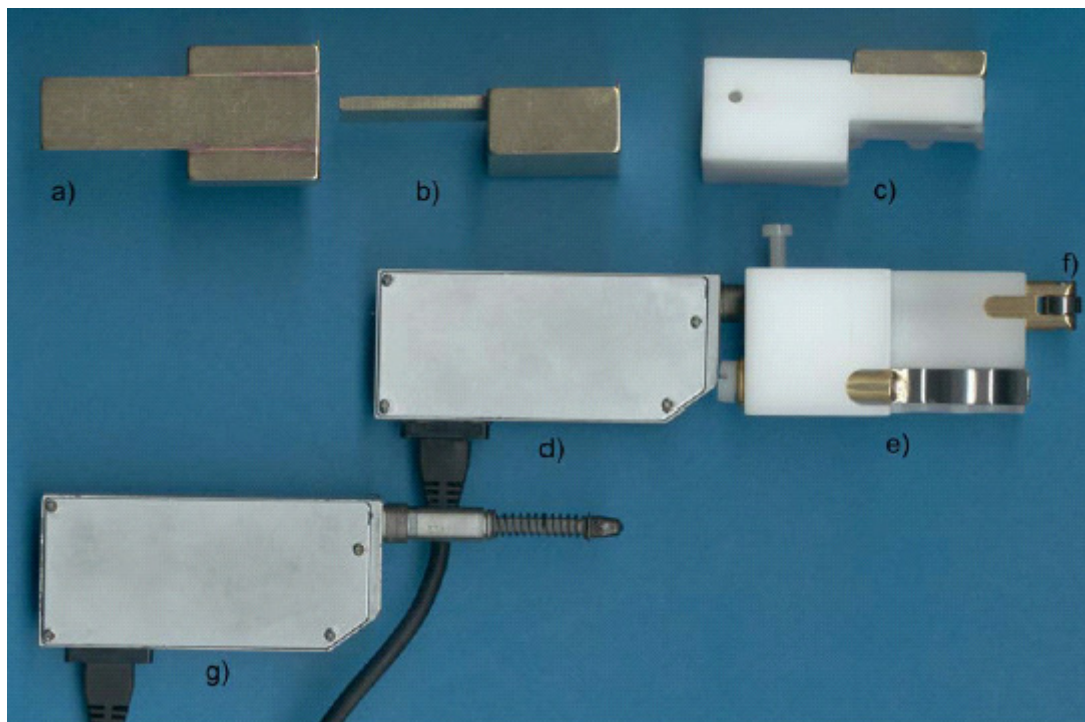
The linear graph shows a small segment of the collector with idealised bars. The total collector can be scrolled from 0° to 360°.



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2.1.4. Operation

The instruments is delivered with the following articles:



A & B	Distance bloc
kC	Adapter with distance block
D	Adapter with clamping fixture
F	Measuring wheel or pin
G	Sensor

The instrument has a capacity for 16 measurements. A differentiation between commutator and slip ring is possible. After the installation of the adapter, which can be fitted to all existent holder dimensions by means of distance blocks, the sensor is locked in the adapter. The start of the measurement should take place preferably with a magnetic speed sensor which also stops the measurement after exactly one turn. Alternatively the measurement can

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also be started and stopped by a hand feeler. For collectors with a known number of segments the number of bars can also be preset

Preferably the measuring wheel should be used. The correct number of bars is only registered on collectors with a clear distance between the bars. In case of problems the measuring pin can be used alternatively.

The machine must be turned slowly during the measurement. The speed should be not more than 5 - 6 m/s. Otherwise the instrument will not detect the correct number of bars.

With larger drives the measurement can be done with tip-operation or during the run-out of the machine. After the measurement is completed the data can be transferred to a PC. All relevant data are also available by means of an integrated printer.

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*****
Schunk MotorScope V2.00
      Kollektorlauf-
      Messprotokoll

Datum       : 23.05.2000
Zeit        : 10:27
Motor ID    : -----
Spur/Speicher: 003
Drehz.-Sensor: ja
Typ         : Kommutator
Aufloesung  : 010um/Imp

      Messwerte

m. Unrundheit: 0.010 mm
Lamellensprg.: 0.120 mm
max Lam Diff : 0.150 mm
erk. Lamellen: 0100
Drehzahl     : 0002 rpm

*****
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The measurement can be controlled with the PC-graph. Wrong measurement can be seen easily,

Due to instabilities of the collector the commutator profiles on each track might be different. Therefore it is advisable to measure each track, especially for large motors and traction drives.

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The Motorscope gives the option to measure the out-of-roundness of collectors and slip rings with motor potential. For that the instrument must be grounded. The relevant safety recommendations for work with running electrical machines must be observed.

2.2 Source of Supply

The Motorscope can be obtained at the following address.

SCHUNK Kohlenstofftechnik GB4
Rodheimerstraße 59
35452 Heuchelheim
Hermany
Phone: +49 641 608 0
Fax: +49 641 608 1748
Email: gb4@schunk-group.com

A demo version with sample measurements and price statements are given on request.

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-runout 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)

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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 expedient 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 (see Info No 36e) Th surface roughness resulting from the machining is influenced

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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	100 – 300	0,05 – 0,1	0,05 – 0,15
	Diamond	300 - 500	0,05 – 0,1	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 chamfered