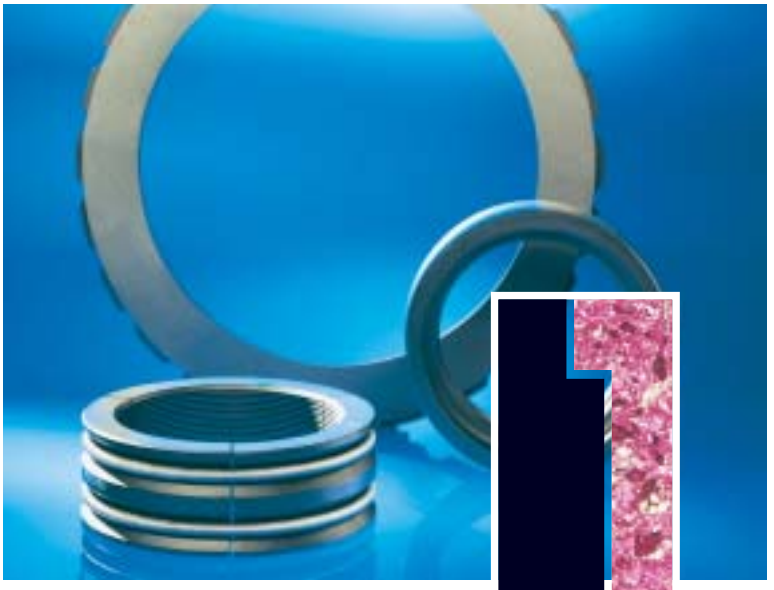
Carbon
and
engineering
ceramics
technology

The tribology of sliding combinations

hard/soft



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Schunk Kohlenstofftechnik GmbH

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When defining sliding processes, a distinction is made between systems with and without liquid lubrication.

Depending on operating conditions, both sliding mechanisms may occur simultaneously (mixed or boundary lubrication).

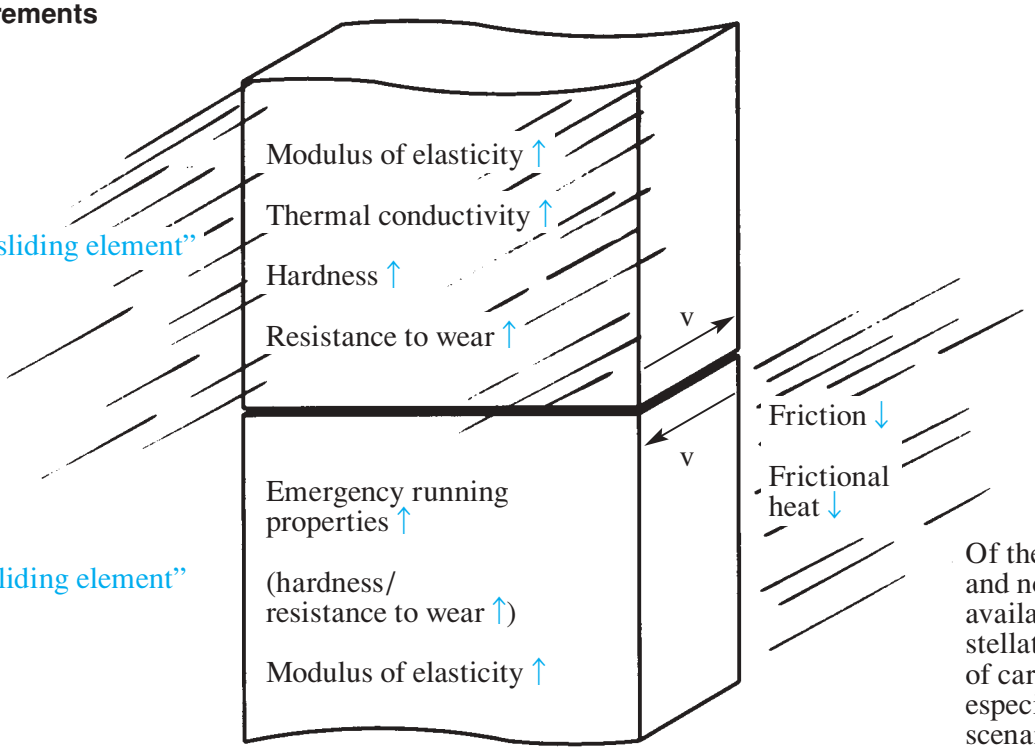
Suitable combinations of materials must therefore exhibit both good dry-running and wet-running characteristics.

Good hydrodynamic properties depend on the defined geometry of the gap between the sliding surfaces, filled with liquid lubricant; a high modulus of elasticity, therefore, is required, to prevent undesirable deformation of the surfaces.

As the lubricating properties of liquids may deteriorate as a result of frictional heat, this heat needs to be dissipated from the gap via at least one of the sliding elements, which should possess good thermal conductivity.

A low coefficient of friction and low wear rates are essential if materials are running dry in direct contact. Where a hard/soft combination of sliding elements is used, the surface roughness of the harder material must be modified in such a way that its abrasive effect on the softer material is minimised. The surface roughness of the hard material is maintained because of its higher hardness. The solid abraded material generated by steady wearing of the softer element should act as a solid lubricant and reducing wear between the surfaces.

Requirements



Of the wide range of metallic and non-metallic materials available for hard/soft constellations, the combination of carbon and SiC has proven especially effective in the scenario described above.

The following diagrams show various properties of particular importance in sliding combinations.

SiC materials:

- CarSIK-ST: pressureless sintered SiC with defined, closed porosity, universal chemical resistance and enhanced tribological properties.
- CarSIK-NT: reaction-bonded SiC exhibiting outstanding tribological properties.
- CarSIK-CT: reaction-bonded SiC with dispersed graphite grains, for unique running characteristics.

Carbon materials:

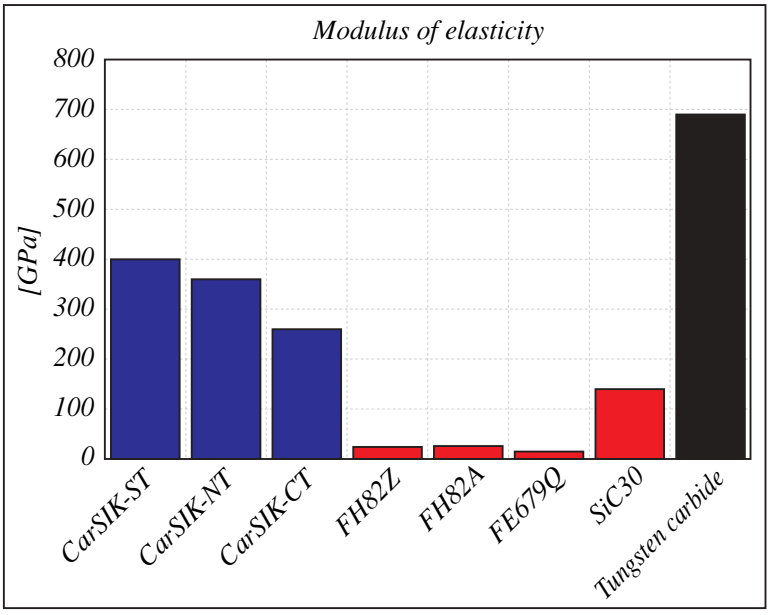
- FH/FS: carbon-graphites, or hard carbons
- FE: electrographite (e. g. FE679QP for dry-running applications only)

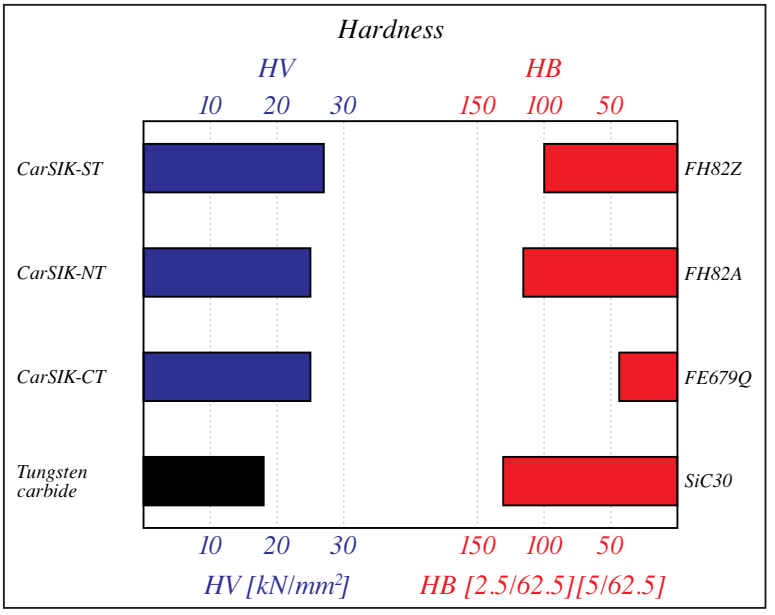
The most important impregnating media, which act as sealants, increase wear resistance and optimise the tribological properties of the carbongraphite, are:

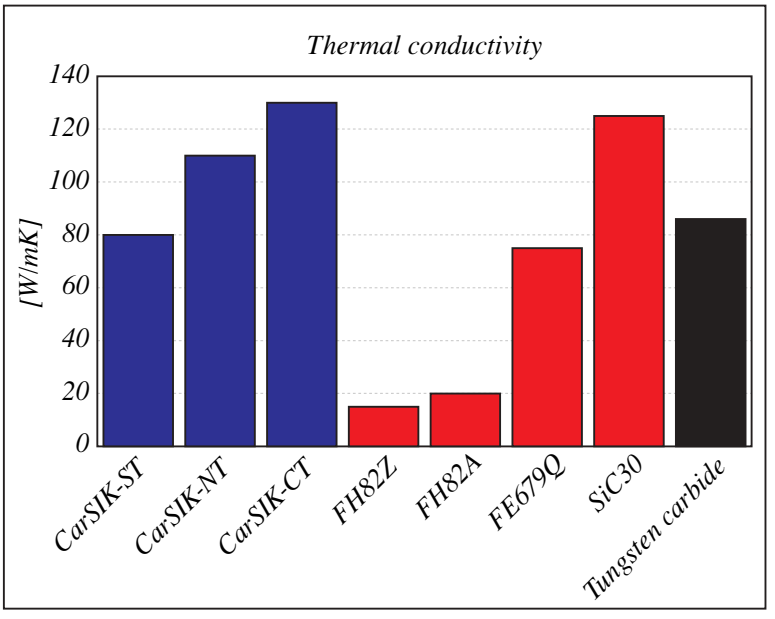
Synthetic resin “Z”
and
Antimony “A”

SiC/Carbon composite

- SiC30 is positioned between SiC and carbon materials containing approx. 43 % vol. electrographite in a silicon carbide matrix.





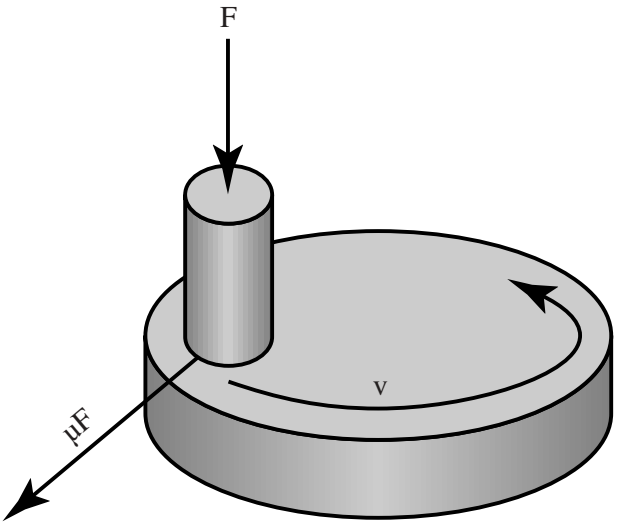


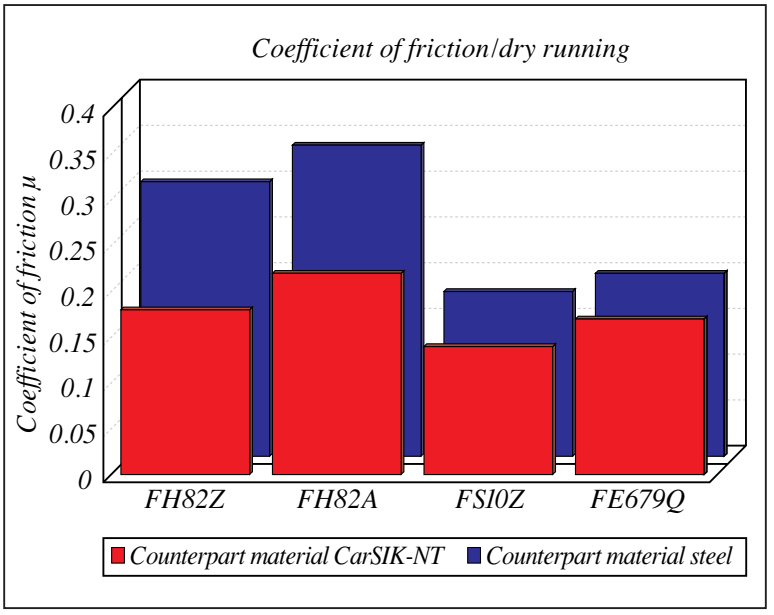
The running properties of a pair of sliding elements can be related to the materials used. The difference in the materials' microstructure and composition affects the way the sliding elements interact and in turn affects the suitability of a given combination. It is not sufficient to consider only the properties of a single material. The materials combination should be optimised for a desired application – such as dry running or running on a liquid film. Useful material combinations most often are determined by actual testing in the application.

Dry running tests

Pin-on-disc test rig

Surface load: 0.1 Mpa
Sliding speed: 6 m/sec
Temperature and relative humidity = constant

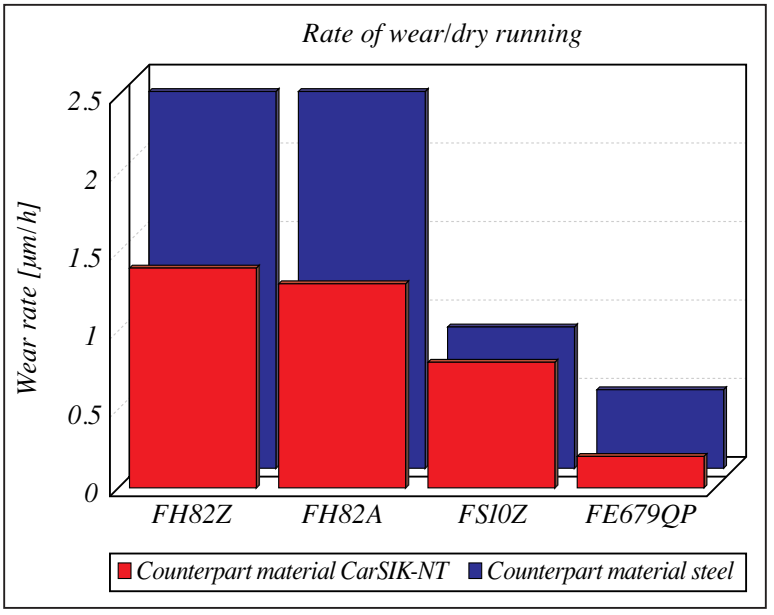




Coefficients of friction against steel are always higher than against silicon carbide.

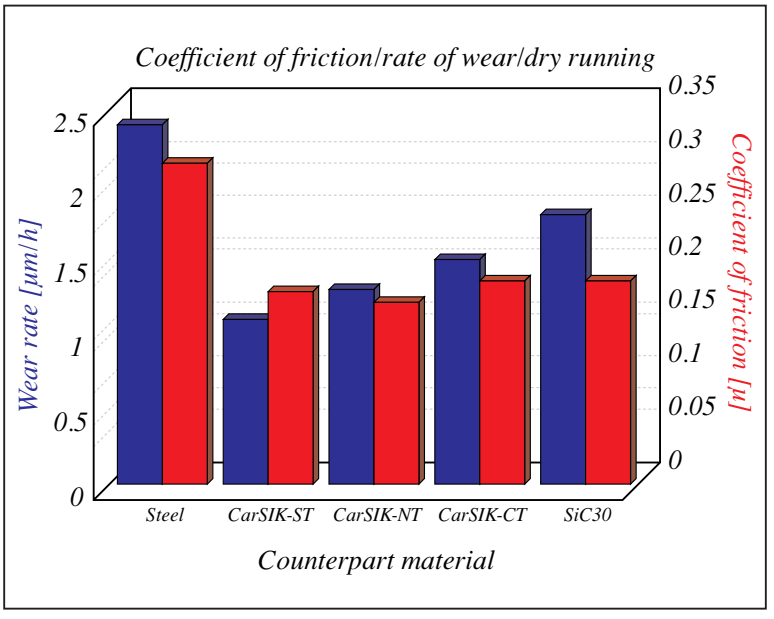
The difference is greatest for material FH82, as it requires the hardest counterpart. The coefficient of friction rises significantly if grooving of soft steel occurs, and the rate of wear increases as a result.

FS10 and electrographite behave in a much less critical way when these are running dry against relatively soft steels.



The hard counterpart materials were compared with FH82Z carbon. Of all carbons tested, this material places the highest demands on the counterpart.

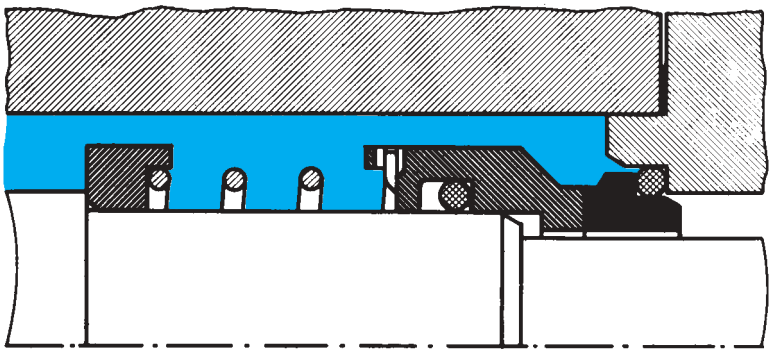
FH82Z gave low wear rates with all SiC materials.



Wet running tests

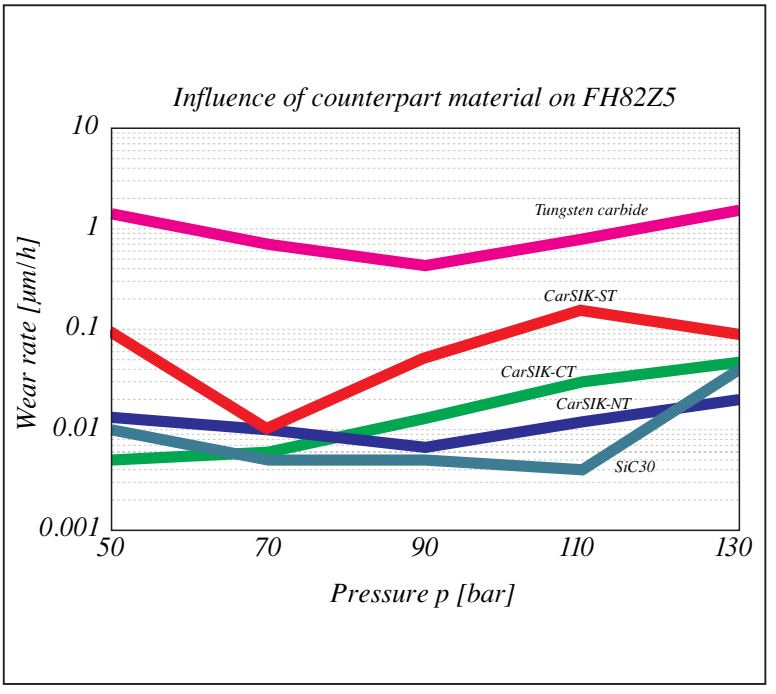
High-pressure test rig for axial face seals

Medium: deionised water
Temperature: 60 °C
Pressure: up to max. 130 bar
Sliding speed: 9 m/sec



Axial face seal, off-load

Test rig for axial face seals



Summary:

Friction and wear of dry-running combinations are lower with SiC counterpart materials than with soft steels. This effect is the greatest with harder carbon-graphite materials, containing abrasive ingredients.

In wet-running conditions in water and depending on pressure, various effects combine to influence carbon wear.

- Direct material contact in marginally lubricated conditions.
- Poor hydrodynamic effects from inadequate microstructure, surface texture and material composition.

At high pressures, deformation particularly of the "soft" carbon rings may occur. The geometry of the sealing gap, and associate the hydrodynamic properties, may be affected.

Experiments have revealed that running properties depend considerably on the choice of material, as is illustrated in this brochure by FH82Z5 in combination with various hard counterpart materials.

In water at 60 °C, the SiC-grades cause significantly less wear to the carbon, than does tungsten carbide, by magnitudes of 10 to 100.

The Schunk materials investigated are outstandingly capable of satisfying the required standards for bearings and seals, even in extreme operating conditions.

Schunk's tried-and-tested quality products are the ideal solution for optimum performance:

- Applications-driven materials and concepts
- Designed to combine the best properties of silicon-carbide and carbon materials
- Quality-assured production methods

As specialists in carbon materials and engineered ceramics, we are the ideal partner for innovative sliding material combinations, efficient service and all aspects of technical and planning support. Make your application our challenge!