Hybrid bearings with ceramic balls

Hybrid ball bearings with steel rings and ceramic balls have today become indispensable for many advanced applications. The advantages have been clearly demonstrated in numerous trials and successful use in the field.

Properties of ceramic

The ceramic material silicon nitride Si_3N_4 is excellent for use in precision ball bearings. A comparison between silicon nitride and conventional bearing steel 100 Cr 6 is shown in diagram 1.

Further advantages of ceramic are:
- Low chemical affinity to 100 Cr 6
- Low friction coefficient
- Little heat transfer
- Corrosion resistant
- Non-magnetic
- Electrically isolating

Properties (at ambient temperature)	Unit	Ceramic Si_3N_4	Ball bearing steel 100 Cr 6
Density	g/cm³	3.2	7.8
Coefficient of expansion	10^{-6}/K	3.2	11.5
Young's modulus	GPa	315	210
Poisson's ratio	–	0.26	0.3
Hardness (Vickers) HV10	–	1600	700
Tensile strength	MPa	700	2500
Fracture toughness	MPa m ^{0,5}	7	20
Thermal conductivity	W/mK	30-35	40-45
Spec. electric resistance	Ωmm²/m	10^{17} - 10^{18}	0,1 - 1

Properties of silicon nitride and ball bearing steel

Advantages for the user

Longer service life

Experience shows that double the service life in comparison to conventional bearings can be reached by using hybrid bearings. Depending on the operating conditions life times rates still higher can be achieved.

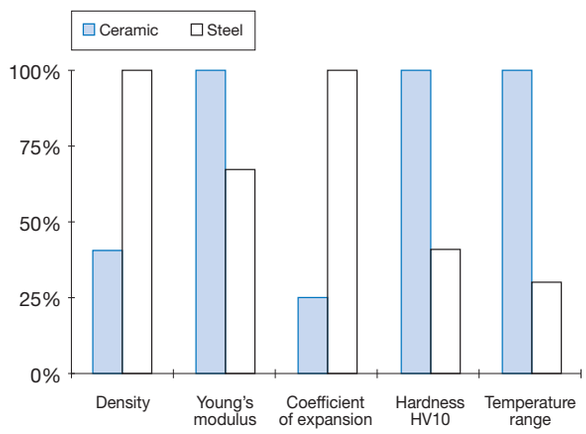

Diagram 1

The reasons for this are:

- **Low surface adhesive wear**
  The lower affinity to steel reduces the adhesive wear, which is caused by the cold welding effect on irregularities in the raceway and ball surface.

- **Low abrasive wear out**
  With steel balls, contaminants and particles from the process of running in are embedded into the surface. With every revolution of the ball, these foreign particles damage the raceway. These particles make little impact on the extremely hard ceramic ball.

- **Insensitivity to poor lubrication**
  Low adhesion and friction allow the hybrid bearing to perform well even under poor lubrication.

- **Longer grease service life**
  Lower operating temperature and favourable tribolic features, extend the service life of the grease.

Higher speeds

The attainable speeds depend above all on the thermal conditions in the bearing. Because of lower friction, the hybrid bearing generates less power loss. Therefore the speed limit is increased dramatically. Depending on the application, speed rises of up to 30 % are possible compared to bearings with steel balls.

- **Low rolling friction**
  The rolling friction is reduced, as the centrifugal force of the lighter ceramic ball is less. The contact ellipse is less because of the higher Young's modulus.

- **Low sliding friction between ball and raceway**
  At high speeds, sliding friction is responsible for most of the total friction.
  One of the criteria for the sliding friction is a low spin/roll ratio.
  The service life is negative affected by values above 0.25.
  Diagram 2 shows the advantages of ceramic balls.

- **Avoid ball skidding**
  The balls skid on the raceway if the preload between the rings is to small. This negative process usually occurs in case of an insufficient preload of the bearing or an excessive acceleration. With hybrid bearings the minimum preload can be reduced as they have a smaller inertia and generate a smaller spinning moment.

Low cost lubrication

- **Grease lubrication** can be used in higher speed ranges.

- The limiting speed for minimum **oil lubrication increases** significantly. In many cases, it can replace the expensive oil jet lubrication.

Higher rigidity

- The radial rigidity of hybrid bearings is approximately 15% higher at low speeds because of the higher Young's modulus.
- With higher speeds, the centrifugal force affects the internal load distribution and the dynamic rigidity is reduced. Diagram 3 shows reduced loss of rigidity for hybrid bearings.
- A high rigidity improves the accuracy and shifts the critical fundamental frequency of the bearing arrangement.

Improved machining accuracy

The following factors lead to an improvement of the surface quality and accuracy of machined parts.

- Higher rigidity of bearing arrangement
- Small thermal expansion
- Low vibration impulse by ceramic balls

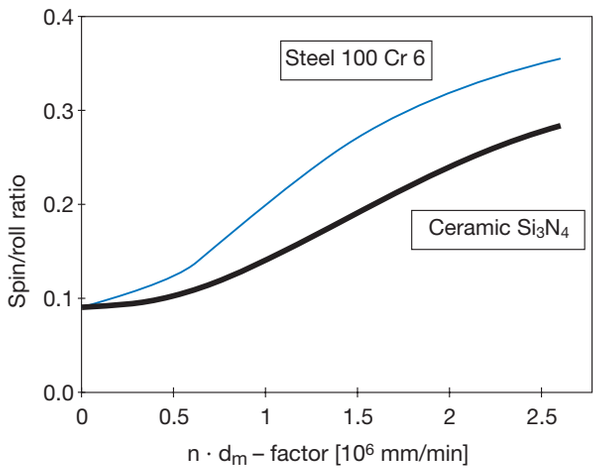

Diagram 2

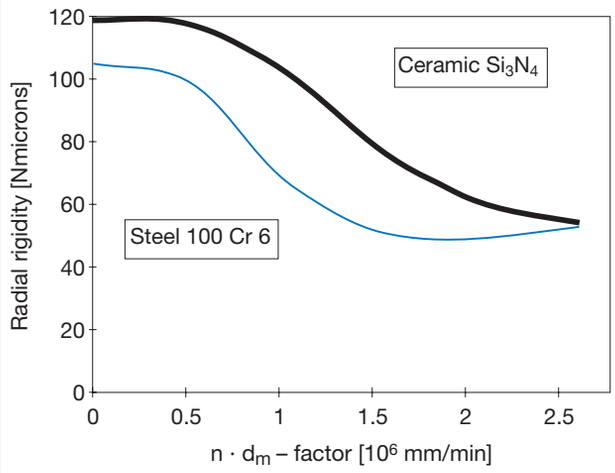

Diagram 3