Materials for Rolling Bearings

The performance and reliability of rolling bearings are determined to a large degree by the materials from which the bearing components are made.

Steels for Bearing Rings and Rolling Elements

Steels used for bearing rings and rolling elements must be capable of high fatigue strength and wear resistance. The structural and dimensional stability of the bearing components must be satisfactory at the operating temperatures which can be expected. In most cases the choice of a particular steel is dictated by the application requirements.

Through-Hardening Steels

The most common through-hardening steel used for rolling bearings is a carbon chromium steel containing approximately 1% carbon and 1.5% chromium. For bearing components having large cross sections steels alloyed with manganese and molybdenum are used because of their superior through-hardening properties.

Much development has been accomplished in the area of through hardened steels. Particular attention has been paid to cleanliness and modern bearing steels have such small contents of inclusions that it is now recognized that under ideal conditions bearings should no longer fail from fatigue.

Case-Hardening Steels

Chromium-nickel and manganese-chromium alloyed steels with a carbon content of approximately 0.15% are those case-hardening steels most commonly used for rolling bearings.

Steels for MRC Rolling Bearings

In the majority of applications there is virtually no difference in behavior between bearings made of through-hardened or case-hardened steels. This fact has been acknowledged by ISO in that no distinction is made between steel types in the life calculation. In fact, steel cleanliness and proper manufacturing methods as well as bearing design are the decisive factors. However, there are applications where a particular type of steel has certain advantages.

Because MRC has both the competence and the facilities for through hardening, case hardening and induction hardening, attention is paid to the main application fields for each particular bearing and the steel and method of heat treatment are chosen to give the best performance in these applications.

Steels for Temperature-Resistant Bearings

MRC rolling bearings can generally be used at operating temperatures up to 250˚F (121˚C). If the operating temperatures are higher than this, the bearings must be subjected to a special heat treatment (stabilization) so that inadmissible changes in dimensions do not occur as a result of microstructural changes. However, the bearings should not be stabilized for a higher temperature than the expected operating temperature.

For bearings which are required to operate at temperatures in excess of 450˚F (232˚C) special steels with high hot hardness are required. In such cases it is advisable to contact MRC Bearing Services Engineering.

Steels for Corrosion-Resistant Bearings

For bearings which come into contact with corrosive media during operation chromium or chromium/molybdenum stainless steels are used. Because of the reduced hardness of these steels, the bearings do not have the same high load carrying capacity as bearings made of conventional steels. The corrosion resistance is only available when the whole surface is perfectly polished and if it is not roughened or damaged during mounting. It is recommended to seek advice from MRC regarding the selection and application of stainless steel bearings.

Hybrid Bearings with Ceramic Balls

MRC hybrid bearings use steel inner and outer rings with ceramic balls. This combination provides a bearing that has greater stiffness, is able to handle higher speeds and higher temperatures.

The lower density of the silicon nitride ceramic balls creates less centrifugal force than steel balls. Lower density combined with the reduced friction due to the ball's smooth surface, allows the bearing to run at much higher speeds. The low thermal expansion of the ceramic balls makes them less sensitive to differences in temperature between the inner and outer rings. The higher modulus of elasticity makes the bearings much stiffer.

Materials for Cages

The main purpose of the cage is to keep the rolling elements at an appropriate distance from each other and to prevent immediate contact between two neighboring rolling elements in order to keep friction and thus heat generation in the bearing at a minimum.

In grease lubricated bearings some of the grease inside the bearing will adhere to the cage forming a lubricant reservoir and ensuring good lubrication of the operating surfaces of the bearing.

The cage is guided either on the rolling elements or on one of the bearing rings and is thus radially centered. Pressed steel or brass cages are generally guided on the rolling elements. Inner or outer ring land guided machined cages generally permit operation at higher speeds and are necessary when movements additional

to the pure rotational are superimposed, particularly when conditions of high acceleration prevail. Suitable steps must be taken (e.g. oil lubrication) to ensure that there is a sufficient supply of lubricant to the guiding surfaces of the cage and to the inside of the bearing.

Rolling bearing cages are mechanically stressed by frictional, strain and inertia forces. They may also be subjected to the chemical action of certain lubricants, lubricant additives or products of their aging, organic solvents, coolants (halogenated hydrocarbons, ammonia) etc. Thus the design and choice of material are of paramount importance for the performance of the cage as well as for the operational reliability of the bearing as a whole.

Standard Cages

As rolling bearings have been developed various cage types and designs for the different bearing types and sizes have emerged; the cages differ as to form, material, manufacturing methods, cost of production and operational limits.

In the text preceding each section, information is provided regarding the standard cages with which the bearings are fitted and also the possible alternatives. The standard cage is always well proven in service and is the design considered most suitable for the majority of applications. With reference to the viability of production, the costs and the different application areas of the bearings, the standard cage for the larger bearings may be different from that for the smaller bearings in one and the same series. If a bearing with a non-standard cage is required it is always advisable to check availability before ordering.

Molded Polyamide Cages

For some bearing types, e.g. double row deep groove ball bearings, and angular contact ball bearings, the small and medium-sized bearings are available with molded cages of heat stabilized, glass fiber reinforced polyamide 6,6. Heat stabilized, unfilled polyamide cages are available for a limited number of sizes. This material is characterized by a favorable combination of strength and elasticity. The good sliding properties of polyamide on lubricated steel surfaces and the smoothness of the cage surfaces in contact with the rolling elements mean that little friction is generated by the cage so that heat generation and wear in the bearing are at a minimum. The low density of the material means that the inertia of the cage is small. All these factors plus inherently superior dynamic balance result in smoother and quieter running bearings.

The injection molding process used to produce the cages allows functionally suitable designs to be made. The excellent running properties of polyamide cages under lubricant starvation conditions permit continued operation of the bearing for a time reducing the risk of seizure and secondary damage.

When using bearings with polyamide cages the permissible operating temperatures for the material and its resistance to the lubricant used must be observed. At operating temperatures up to the values given in the adjacent table for the various oils and greases which are used as bearing lubricants, cage properties are unaffected. If the permissible temperature is exceeded, the cage material will age, this process being accelerated the longer the cage is exposed to the excessive temperature. Brief periods at up to 70˚F (21˚C) above the recommended maximum temperatures can be tolerated provided they are interspersed with longer periods at operating temperatures below the recommended values, and provided the maximum operating temperature for the lubricant is not exceeded. When operating temperatures are constantly above 250˚F (121˚C) bearings fitted with metallic cages are recommended. Molded polyamide cages are also unsuitable for operating temperatures below -40˚F (-40˚C) as they lose their elasticity.

The organic solvents normally used to clean rolling bearings such as white mineral spirits or trichloroethane do not affect cage properties, nor do dilute alkaline cleaners (e.g. soda) if they are at room temperature and the period during which they are in contact is short. The chlorofluorocarbons or ammonia used in refrigeration do not attack polyamide. In vacuum, polyamide cages become brittle because they become dehydrated.

Permissible operating temperatures for cages of glass fibre reinforced polyamide 6,6 with various bearing lubricants

Lubricant	Permissible operating temperature[1]	
	˚C	˚F
Mineral oils		
Oils without EP additives e.g. machine oils, hydraulic oils	120	248
EP oils e.g. industrial and automotive gearbox oils	110	230
EP oils e.g. rear axle and differential gear oils (automotive), hypoid gear oils	100	212
Synthetic oils		
Polyglycols, poly-a-olefins	120	248
Diesters, silicones	110	230
Phosphate esters	80	176
Greases		
Lithium base,[2] polyurea, bentonite, calcium complex	120	248

[1] Measured on the outside surface of the outer ring.
[2] For sodium and calcium base greases and other bearing greases with a maximum operating temperature below 120˚C, the maximum temperature for the polyamide cage is the same as the maximum temperature for the grease, otherwise the permissible operating temperature is 120˚C.

Steel Cages

Pressed cages of steel sheet are standard for many deep groove ball bearings. These cages have relatively

high strength and weigh little. To reduce friction and wear they may be hardened and surface treated. High strength, machined steel cages, often silver plated are also available for critical and extra heavy duty applications.

Machined Bronze

Machined bronze cages are used for heavy duty applications and larger size bearings. Machined bronze cages can be used at operating temperatures up to 450˚F (232˚C). They are not affected by the mineral or synthetic oil based lubricants normally used for rolling bearings nor by the organic solvents used to clean bearings. They are very resistant to corrosive attack.

Brass Cages

Pressed brass cages are used for some small and medium-sized bearings, but most brass cages are machined from cast or wrought material.Brass cages should not be used at temperatures in excess of 450˚F (232˚C). They are unaffected by most of the commonly used bearing lubricants, including synthetic oils and greases, and can be cleaned using normal organic solvents. The use of alkaline cleaning agents is not recommended. Ammonia (e.g. in refrigeration) causes embrittlement in brass so that brass cages are unsuitable and other alternatives should be considered.

Phenolic (Bakelite) Cages

Phenolic cages are used primarily for angular contact ball bearings. These cages are composed of machined, cotton fabric impregnated with phenolic resin. The light weight construction of the phenolic cage makes it ideal for high speed applicatons. Phenolic cages should not be used in temperatures in excess of 225˚F (107˚C).