13. Bearing Materials

13.1 Ring and rolling element materials

While the contact surfaces of the bearing rings and rolling elements are subjected to repeated heavy stress, they still must maintain high precision and rotational accuracy. To accomplish this, the rings and rolling elements must be made of a material that has high hardness, is resistant to rolling fatigue, is wear resistant and has good dimensional stability.

High carbon chromium bearing steel, which can be deep hardened by the so-called through hardening method, and case hardening steel with a hardened carburized outer layer are used for the rings and rolling elements of standard bearings. The hardness of the rings and rolling elements is usually on the order of HRC 58 to HRC 65.

The most widely used and most suitable materials for rolling bearings are high carbon steels. The chemical composition for JIS G 4805 standard high carbon chromium steels is shown in Table 13.1. The most commonly used of these steels, SUJ2, is equivalent to such steels as AISI 52100 (U.S.A.), DIN 100 C_r6 (West Germany), and GS 534A 99 (U.K.). For bearings with large cross section dimensions, SUJ3 or SUJ5 having good hardening properties are used.

For case hardening steel; chrome steel (SC_r), chrome molybdenum steel (SCM) and nickel chrome molybdenum steel (SNCM) are used; their chemical compositions for are shown in Table 13.2. Because of its combination of a hard surface layer which has been carburized and hardened to an appropriate depth, and a relatively pliable inner core, case hardening steel has excellent efficiency against shock load. NTN uses case hardening steel for almost all of tapered roller bearings.

The most common cause of fatigue cracking in bearings is the inclusion of non-metallic impurities in the material. By using clean materials, low in these non-metallic impurities, the rolling fatigue life of the bearing is lengthened. For all its bearings, NTN uses steel low in oxygen content and non-metallic impurities, and refined by a vacuum degassing process as well as outside hearth smelting.

For bearings requiring high reliability and long life, vacuum melted steel (CEVM) and electro-slag melted steel (ESR) which are even higher in purity are used. For information about bearings constructed of these materials, please consult NTN.

Table 13.1 High carbon chromium bearing steel

Specification	Symbol	Chemical composition %						
		C	Si	Mn	P	S	Cr	Mo
JIS G 4805	SUJ 2	0.95~1.10	0.15~0.35	0.50max.	0.025 max.	0.025 max.	1.30~1.60	—
	SUJ 3	0.95~1.10	0.40~0.70	0.90~1.15	0.025max.	0.025max.	0.90~1.20	—
	SUJ 4	0.95~1.10	0.15~0.35	0.50 max.	0.025max.	0.025max.	1.30~1.60	0.10~0.25
	SUJ 5	0.95~1.10	0.40~0.70	0.90~1.15	0.025max.	0.025max.	0.90~1.20	0.10~0.25

Table 13.2 Case hardening steel

Specification	Symbol	Chemical composition %							
		C	Si	Mn	P	S	Ni	Cr	Mo
JIS G 4104	SC_r420	0.18~0.23	0.15~0.35	0.60~0.85	0.030 max.	0.030max.	—	0.90~1.20	—
JIS G 4105	SCM420	0.18~0.23	0.15~0.35	0.60~0.85	0.030max.	0.030max.	—	0.90~1.20	0.15~0.30
JIS G 4103	SNCM420	0.17~0.23	0.15~0.35	0.40~0.70	0.030max.	0.030max.	1.60~2.00	0.40~0.65	0.15~0.30
	SNCM815	0.12~0.18	0.15~0.35	0.30~0.60	0.030max.	0.030max.	4.00~4.50	0.70~1.00	0.15~0.30

Table 13.3 High speed steel

Specification	Symbol	Chemical composition %								
		C	Si	Mn	P	S	Ni	Cr	Mo	V
AMS 6490	M50	0.77~0.85	0.25max.	0.35max.	0.015max.	0.015max.	0.15max.	3.75~4.25	4.00~4.50	0.90~1.10

For bearings operated in high temperatures, high speed steel (M50), is used. For applications requiring high corrosion resistance, stainless steel (SUS 440C) is used. The chemical composition for these steels is shown in Tables 13.3 and 13.4. For bearings whose raceway surfaces are induction hardened, machine structural carbon steel (S48C to S50C), and chrome molybdenum steel (SCM440) which has a relatively high carbon content are used (for chemical composition, see Table 13.5).

Table 13.4 Stainless steel

Specification	Symbol	Chemical composition %							
		C	Si	Mn	P	S	Cr	Ni	Mo
JIS G 4303	SUS440C	0.95~1.20	1.00max.	1.00max.	0.04max.	0.030max.	16.00~18.00	0.6max.	0.75max.

Table 13.5 Induction hardening steel

Specification	Symbol	Chemical composition %						
		C	Si	Mn	P	S	Cr	Mo
JIS G 4051	S48C	0.45~0.51	0.15~0.35	0.60~0.90	0.030max.	0.035max.	—	—
	S50C	0.47~0.51	0.15~0.35	0.60~0.90	0.030max.	0.035max.	—	—
JIS G 4105	SCM440	0.38~0.43	0.15~0.35	0.60~0.85	0.030max.	0.030max.	0.90~1.20	0.15~0.30

13.2 Cage materials

Bearing cage materials must have the strength to withstand rotational vibrations and shock loads. These materials must also have a low friction coefficient, be light weight, and be able to withstand bearing operating temperatures.

For small and medium sized bearings, pressed cages of cold or hot rolled sheet steel are used. However, depending on the application, brass sheet or stainless steel is also available. The chemical compositions are shown in Table 13.6.

For large bearings, machined cages of machine structural carbon steel (S30C) (Table 13.7) or high tensile cast brass (HBsCI) (Table 13.8) are widely used. However, spheroidal graphite cast iron or aluminum alloy cages are also used.

Injection molded plastic cages are now also widely used, and most are made from fiberglass reinforced heat resistant polyamide resin. Plastic cages are light in weight, corrosion resistant, and have excellent damping and sliding properties.

Table 13.6 Materials for pressed cage

Specification	Symbol	Chemical composition %				
		C	Si	Mn	P	S
BAS361	SPB2	0.13~0.20	0.04max.	0.25~0.60	0.030max.	0.030max.
JIS G 3141	SPCC	0.12max.	—	0.50max.	0.040max.	0.045max.
JIS G 3131	SPHC	0.15max.	—	0.60max.	0.050max.	0.050max.

Table 13.7 Materials for machined cage

Specification	Symbol	Chemical composition %				
		C	Si	Mn	P	S
JIS G 4051	S30C	0.27~0.33	0.15~0.35	0.60~0.90	0.030max.	0.035max.

Table 13.8 Materials for machined cage

Specification	Symbol	Chemical composition %								
		C	Si	Mn	P	S	Ni	Cr	Mo	V
JIS H 5102	HBsCI	55.0max.	Remains	1.5max.	0.5~1.5	0.5~1.5	1.0max.	1.0max.	0.4max.	0.1max.