13. Bearing Material

Rolling bearing is made of ring and rolling elements, which directly receive the load, and the cage for maintaining rolling elements at a uniform distance.

Ring and rolling elements of bearing receive high contact stress repeatedly, and they involve contact rolling movement along with sliding movement. And cage receives both tensile and compressive forces while having a sliding contact with either ring or rolling element. Bearings, which are used for a long time while continuously and repeatedly receiving high stress, eventually show fatigue effect, and the sliding contact area also becomes slowly worn out, which eventually damage the bearing.

Also, when selecting the bearing material, it is important to consider the stress conditions of each part, as well as lubricating condition, reaction with lubricant, operating temperature and environment, etc.

13-1 Material of Ring and Rolling Element

Both ring and rolling element need to have high mechanical strength, rolling-fatigue resistance, hardness, and wear-resistance.

Furthermore, their material should have excellent dimension stability to prevent performance deterioration caused by dimensional changes. Also, it should have good machinability in consideration of economical production.

Most commonly used materials that satisfy all the above conditions are high carbon chrome bearing steel and case hardened steel, and their chemical composition are shown in Table 13-1 and 13-2.

Kinds of bearing steels depending on the characteristics of used location are shown below.

- General locations
  High carbon chrome bearing steel treated with complete hardening process.
- Locations requiring impact load and toughness
  High carbon chrome bearing steel treated with surface induction hardening.
  Chrome steel, Cr-Mo steel, Ni-Cr-Mo steel treated with carburizing heat treatment.

The probability of rolling fatigue life distribution using same material can vary significantly. This is mainly caused by non-metallic inclusions in the bearing material or segregation and unevenness of other chemical elements.

Non-metallic inclusions affect the characteristics and properties of bearing material in different ways depending on different production procedures in raw materials, melting methods, casting methods, and heat treatments, etc.

KBC makes it a standard procedure to use vacuum degassed raw steel materials, and various data including degree of segregation, and defects, are analyzed and maintained continuously to minimize the deviation. And FHBC also applies special heat(HL) treatment on bearings to even further enhance the resistance of rolling fatigue life.

In general, bearings are made to be used under the operating temperature below 120℃. If used above 120℃, these bearings can post some problems, such as softening or dimension changes of the parts, or insufficient lubrication. To overcome the problems generated during high temperature usage, special measures have been developed to insure the hardness and prevent dimension changes of bearing materials, and these bearings can be safely used under the operating temperatures up to 350℃, provided some operating conditions are met.

Some bearing materials to be used under high temperature or corrosive environment are shown below.

- High operating temperature above 350℃:
  Ceramic bearings made of heat resisting steel or Si_3N_4, etc.
- Heat-resisting or anti-corrosion:
  Stainless steel of martensite series.

Also, some special heat treatment processes have been also developed to make it lighter and/or

tougher to overcome the severe operation conditions. By evenly distributing the chemical elements that enhances the surface toughness, cracking propagation caused during lubricating condition such as in the case of foreign materials entered from unclean operating environment can be subdued. And, special heat(RC) treatment which generates fine microstructures, can further increase the rolling fatigue life.

13. Bearing Material

Table 13-1 Chemical Composition of Bearing Steel

Unit %

Specifications	Symbol	C	Si	Mn	P	S	Cr	Ni	Mo
KOREA	**STB2**	0.95...1.1	0.15...0.35	≤ 0.5	≤ 0.025	≤ 0.025	1.3...1.6	≤ 0.25	≤ 0.08
KS D 3525	**STB3**	0.95...1.1	0.4...0.7	0.9~1.15	≤ 0.025	≤ 0.025	0.9...1.2	≤ 0.25	≤ 0.08
	STB4	0.95...1.1	0.15...0.35	≤ 0.5	≤ 0.025	≤ 0.025	1.3...1.6	≤ 0.25	1.1...0.25
GERMANY VDEH	**105Cr2**	1...1.1	0.15...0.35	0.25...0.4	≤ 0.03	≤ 0.025	0.4...0.6	–	–
(German Iron	**105Cr4**	1...1.1	0.15...0.35	0.25...0.4	≤ 0.03	≤ 0.025	1.9...1.15	–	–
&Steel	**105Cr6**	0.9...1.05	0.15...0.35	0.25...0.4	≤ 0.025	≤ 0.02	1.4...1.65	–	–
Association)	**100CrMn6**	0.9~1.05	0.5...0.7	1...1.2	≤ 0.025	≤ 0.02	1.4...1.65	–	–
JAPAN JIS	**SUJ1**	0.95...1.1	0.15...0.35	≤ 0.5	≤ 0.025	≤ 0.025	0.9...1.2	≤ 0.25	≤ 0.08
G 4805	**SUJ2**	0.95...1.1	0.15...0.35	≤ 0.5	≤ 0.025	≤ 0.025	1.3...1.6	≤ 0.25	≤ 0.08
	SUJ3	0.95...1.1	0.4...0.7	0.9...1.15	≤ 0.025	≤ 0.025	0.9...1.2	≤ 0.25	≤ 0.08
	SUJ4	0.95...1.1	0.14...0.35	≤ 0.5	≤ 0.025	≤ 0.025	1.3...1.6	≤ 0.25	1.1...0.25
	SUJ5	0.95...1.1	0.4...0.7	0.9...1.15	≤ 0.025	≤ 0.025	0.9...1.2	≤ 0.25	1.1...0.25
U.S.A AISI	**E51100**	0.98...1.1	0.2...0.35	0.25...0.45	≤ 0.025	≤ 0.025	0.9...1.15	≤ 0.25	≤ 0.08
SAE J405	**E52100**	0.98...1.1	0.2...0.35	0.25...0.45	≤ 0.025	≤ 0.025	1.3...1.6	≤ 0.25	≤ 0.08
FRANCE AFNOR	**100C2**	0.95...1.1	0.15...0.35	0.2...0.4	≤ 0.03	≤ 0.025	0.4...0.6	–	–
	100C6	0.95...1.1	0.15...0.35	0.2...0.4	≤ 0.03	≤ 0.025	1.35...1.6	≤ 0.3	≤ 0.1
	100CD7	0.95...1.05	0.2...0.45	0.2...0.4	≤ 0.03	≤ 0.025	1.65...1.95	–	0.15...0.3
GREAT BRITAIN BS970 PART 2	**535A99**	0.9...1.2	0.1...0.35	0.3~0.75	≤ 0.05	≤ 0.05	1...1.6	–	–
SWEDEN SKF	**SKF 24**	0.92...1.02	0.25...0.4	0.25...0.4	≤ 0.03	≤ 0.025	1.65...1.95	–	0.15...0.3
	SKF 25	0.92...1.02	0.25...0.4	0.25...0.4	≤ 0.03	≤ 0.025	1.65...1.95	–	1.3...0.4

Table 13-2 Chemical Composition of Surface Hardened Steel

Specifications	Symbol	C	Si	Mn	P	S	Ni	Cr	Unit % Mo
KOREA	**SCr420H**	0.17...0.23	0.15...0.35	0.55...0.9	≤ 0.03	≤ 0.03	–	0.85...1.25	–
KS D 3754	**SCM415H**	0.12...0.18	0.15...0.35	0.55...0.9	≤ 0.03	≤ 0.03	–	0.85...1.25	0.15...0.35
	SCM420H	0.17...0.23	0.15...0.35	0.55...0.9	≤ 0.03	≤ 0.03	–	0.85...1.25	0.15...0.35
	SNCM220H	0.17...0.23	0.15...0.35	0.6...0.95	≤ 0.03	≤ 0.03	0.35...0.75	0.35...0.65	0.15...0.3
	SNCM420H	0.17...0.23	0.15...0.35	0.4...0.7	≤ 0.03	≤ 0.03	1.55...2	0.35...0.65	0.15...0.3
GERMANY	**16MnCr5**	0.14...0.19	0.15...0.35	1.0...1.3	≤ 0.035	≤ 0.035	–	0.8...1	–
DIN	**20MnCr5**	0.17...0.22	0.15...0.35	1.1...1.4	≤ 0.035	≤ 0.035	–	1...1.3	–
17210	**15CrNi6**	0.12...0.17	0.15...0.35	0.4...0.6	≤ 0.035	≤ 0.035	1.4...1.7	1.4...1.7	–
	18CrNi8	0.15...0.2	0.15...0.35	0.4...0.6	≤ 0.035	≤ 0.035	1.8...2.1	1.8...2.1	–
JAPAN	**SCr420H**	0.17...0.23	0.15...0.35	0.55...0.9	≤ 0.03	≤ 0.03	–	0.85...1.25	–
JISG	**SCM415H**	0.12...0.18	0.15...0.35	0.55...0.9	≤ 0.03	≤ 0.03	–	0.85...1.25	0.15...0.35
4052	**SCM420H**	0.17...0.23	0.15...0.35	0.55...0.9	≤ 0.03	≤ 0.03	–	0.85...1.25	0.15...0.35
	SNCM220H	0.17...0.23	0.15...0.35	0.6...0.95	≤ 0.03	≤ 0.03	0.35...0.75	0.35...0.65	0.15...0.3
	SNCM420H	0.17...0.23	0.15...0.35	0.4...0.7	≤ 0.03	≤ 0.03	1.55...2	0.35...0.65	0.15...0.3
U.S.A. ASTM	**5120H**	0.17...0.23	0.15...0.3	0.6...1	≤ 0.025	≤ 0.025	–	0.60...1	–
A 304	**4118H**	0.17...0.23	0.15...0.3	0.6...1	≤ 0.025	≤ 0.025	–	0.3...0.7	0.08...0.15
	8620H	0.17...0.23	0.15...0.3	0.6...0.95	≤ 0.025	≤ 0.025	0.35...0.75	0.35...0.65	0.15...0.25
	4320H	0.17...0.23	0.15...0.3	0.4...0.7	≤ 0.025	≤ 0.025	1.55...2	0.35...0.65	0.2...0.3
FRANCE	**20ND8**	0.16...0.23	0.1...0.35	0.2...0.5	≤ 0.03	≤ 0.025	1.8...2.3	–	0.15...0.3
AFNOR	**16MC5**	0.14...0.19	0.1...0.4	1...1.3	≤ 0.03	≤ 0.025	–	0.8...1	–
	20NCD2	0.18...0.23	0.1...0.4	0.7...0.9	≤ 0.03	≤ 0.025	0.4...0.7	0.4...0.6	0.15...0.3
	16NCD4	0.12...0.19	0.1...0.4	0.5...0.9	≤ 0.03	≤ 0.025	1...1.3	0.4...0.7	0.1...0.2
	16NCD13	0.12...0.18	0.1...0.4	0.2...0.5	≤ 0.03	≤ 0.025	3...3.5	0.85...1.15	0.15...0.35
	18NCD4	0.16...0.22	0.2...0.35	0.5...0.8	≤ 0.03	≤ 0.025	0.9...1.2	0.35...0.55	0.15...0.3
	20NCD7	0.16...0.22	0.2...0.35	0.45...0.65	≤ 0.03	≤ 0.025	1.65...2	0.2...0.6	0.2...0.3
GREAT BRITAIN	**665H17**	0.14...0.2	0.1...0.35	0.3...0.6	≤ 0.05	≤ 0.05	1.5...2	–	0.2...0.3
BS970 PART 3	**655H13**	0.1...0.16	0.1...0.35	0.3...0.6	≤ 0.05	≤ 0.05	3...3.75	0.6...1.1	–
	832H13	0.1...0.16	0.1...0.35	0.3...0.6	≤ 0.05	≤ 0.05	3...3.75	0.6...1.1	0.1...0.25
	820H17	0.14...0.2	0.1...0.35	0.6...0.9	≤ 0.05	≤ 0.05	1.5...2	0.8...1.2	0.1...0.2
	805H20	0.18...0.23	0.15...0.35	0.7...1	≤ 0.05	≤ 0.05	0.4...0.7	0.55...0.8	0.15...0.25

13-2 Cage Material

Cage guides rolling elements between the rings, and keeps rolling elements at equal distances, so as to minimize the friction between rolling elements.

So it is essential for cage to have appropriate hardness and abrasive-resistance as well as deformation-resistance against adverse impact.

Although the applied load to cages could be considered to be a lot smaller than those to rolling elements or rings, they comparatively have more chances for sliding contacts, which needs to be considered.

Cages can be divided into two groups, namely, metal(ferrous and non-ferrous) cages and synthetic resin cages. Metal cages can be further divided into press cages and machined cages.

And there are many kinds of cages for different kinds, sizes, revolving speeds, temperature conditions, lubricating methods, machining workability of various bearings.

Cold strip steel sheets, such as shown on Table 13-3, are mainly used for ferrous cages, and they are generally press fabricated and used for most of deep groove ball bearings, cylindrical roller bearings, and tapered roller bearings. In case of general use, they do not usually pose any problems at all even under the temperatures higher than 250 ℃. For larger bearings, some machine-tooled ferrous cages are sometimes used.

On the other hand, non-ferrous cages are mostly made of high-tensile brass and they are usually machine-tooled.

Metal cages are sometimes processed(SL Treatment) for efficient lubrication and high heat-resistance, when required for special use. And, to make efficient lubrication even better, which helps to improve torque and noise-level even further, special solid lubrication thin film is sometimes applied. And, in these days, the quantity of KBC production of light, self-lubricating, synthetic resin cages are increasing more and more.

Glass-fiber reinforced, polyamide is widely used for cage material, because it has an excellent lubricating property, reducing friction between rolling elements and rings, and it is also light, making it easy to obtain high revolving speed. Also, it produces almost no wear debris, which helps, in case of grease lubrication, to increase the grease life span.

And its excellent workability makes it an excellent choice for complex shaped cages made to suit the special bearings. However, its heat resistance quality is not that good, although it poses no problem up to general operating temperature of 120℃.

Sometimes, multi-layer penol resin is used as cage material, and this is usually made of fabric layers on penol resin base. Because of its ability to absorb lubricant, heightening lubrication quality drastically, it is widely used for bearings with ultra high revolving speed.

Table 13-3 Chemical Composition of Cage Materials(Cold Strip Steel Sheet)

Unit %

Standards	Codes	C	Si	Mn	P	S
KOREA	**SCP1**	≤0.1	≤0.04	0.25...0.45	≤0.03	≤0.03
KS D 3512	**SCP2**	0.13...0.2	≤0.04	0.25...0.5	≤0.03	≤0.03
	SCP3	0.45...0.55	0.15...0.35	0.40...0.85	≤0.03	≤0.03
JAPAN BAS 361	**SPB1**	≤0.1	≤0.04	0.25...0.45	≤0.03	≤0.03
	SPB2	0.13...0.2	≤0.04	0.25...0.5	≤0.03	≤0.03
	SPB3	0.45...0.55	0.15...0.35	0.4...0.85	≤0.03	≤0.03
U.S.A SAE J403g	**1008**	≤0.1	≤0.1	0.3...0.5	≤0.04	≤0.05
J118	**1009**	≤0.15	≤0.1	≤0.6	≤0.04	≤0.05
J403g	**1010**	0.08...0.13	≤0.1	0.3...0.6	≤0.04	≤0.05