9 Design of shaft and housing.

9.1 Roughness and accuracy of shaft and housing.

When in service, if the accuracy of shaft and housing is too low, bearing will not work .For example:
Low or not good enough accuracy of shoulders will cause misalignment of inner rings and outer rings. In this situation ,centralized load will be added to the bearings, and resulting in fatigue life reduction and even cages broken or raceway burn.

The housing demands sufficient rigidity, high rigidity is good for load distribution.

Generally speaking, turning or fine boring can make shaft and housing accurate enough. But high requirement of running accuracy and noise need ground finish for final process.

When arrange two bearings in one-piece housings, the fitting surface should adopt ‘go’ structure.

In general conditions, shaft housing accuracy class and roughness refer to Table 9.1.

Table 9.1 Precision accuracy of shaft and housing

Items	Accuracy class of bearing	Class shaft	Housing bore
Roundness tolerance	class 0 , class 6	IT3—IT4	IT4—IT5
	class 5, class 4	IT2—IT3	IT2—IT3
Clindricity tolerance	class 0 , class 6	IT3—IT4	IT4—IT5
	class 5, class 4	IT2—IT3	IT2—IT3
End face run-out of Shoulders	class 0 , class 6	IT3	IT3—IT4
	class 5, class 4	IT3	IT3
Roughness degree of matching surface (Ra)	Small size bearing	0.8	1.6
	Large bearing	1.6	3.2

Remarks:
IT figures of standard tolerance refer to attached list of reference sample.

9.2 Mounting dimensions.

Shoulder height of shaft or housing should be larger than maximal allowable dimension of bearing chamfer, and contact with flat part of bearing end face. Fillet radius should be smaller than minimal allowable dimension of bearing chamfer in order not to affect mounting. Usually, we describe it in table 9.2.Shoulder height of bearing taking big axial load should be a bit larger than figures in the following table.

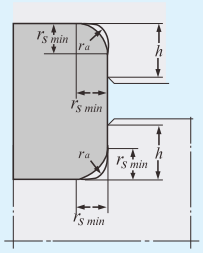

Table 9.2 Shoulder height and fillet radius Unit:mm

Chamfer dimension r_{smin}	Shoulder height h (Min)	Fillet radius R (Max)
0.1	0.4	0.1
0.15	0.6	0.15
0.2	0.8	0.2
0.3	1.25	0.3
0.6	2.5	0.6
1	3	1
1.1	3.5	1
1.5	4.25	1.5
2	5	2
2.1	6	2
2.5	6	2
3	7	2.5
4	9	3
5	11	4
6	14	5
7.5	18	6
9.5	22	8
12	27	10
15	32	12
19	38	15

In order to decrease stress concentration and to increase strength of shaft , when maximum fillet radius should be larger than dimension of bearing chamfer (fig. 9.1 a), or shoulder is too low to get sufficient contact area, a spacer is used between bearing and shaft shoulder. (fig9.1b)

The cutting allowance of ground finish for shaft and housing see Table 9.3

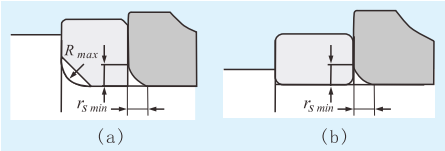

Fig. 9.1 Bearing mounting with spacers

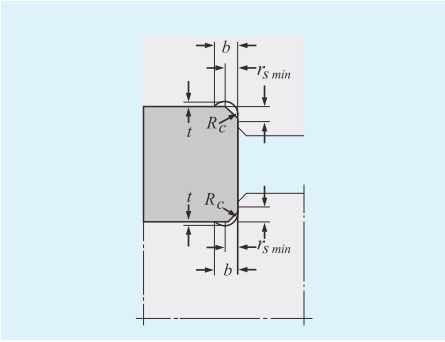

Table 9.3 Grinding cutter relieving dimension Unit:mm

Chamfer dimension r_{smin}	Cutter relieving dimension		
	b	t	R_c
1	2	0.2	1.3
1.1	2.4	0.3	1.5
1.5	3.2	0.4	2
2	4	0.5	2.5
2.1	4	0.5	2.5
3	4.7	0.5	3
4	5.9	0.5	4
5	7.4	0.6	5
6	8.6	0.6	6
7.5	10	0.6	7

9.3 Sealing device

Sealing device of bearing is made to prevent dirt such as dust, moisture, metal powder etc from entering. At the same time, it can prevent internal lubrication of bearing from leaking. So, no matter what running conditions, sealing device must keep its sealing, dust proof functions constantly. It must make bearing easy to dismount, mount and maintain, with no abnormal friction and burn.

Sealing device can be classified into contact type and non-contact type according to its structure.

9.3.1 Non-contact sealing

Non-contact sealing is a kind of sealing with small internal clearance. So, it is zero friction, small temperature rise and no abrasion. Non-contact sealing is suitable for high-speed rotating.

The simplest form of non-contact sealing is to decrease radial internal clearance and form sealing. This kind of sealing is suitable for use in grease lubrication, dry condition with little dust.

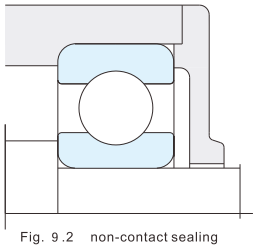

Fig. 9.2 non-contact sealing

To make several concentric circle oil grooves in diameter of bearing housing is a way to improve sealing. Please refer to fig. 9.3.In grease lubrication, these grooves can keep grease, so it can keep dirt out.

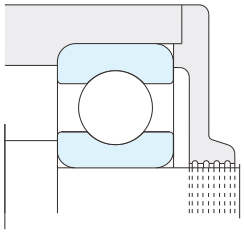

Fig.9.3 Concentric oil groove sealing

When using spiral oil lubrication on the horizontal shaft, if oil grooves are opposite the direction of rotation of bearing, the oil flowing out along shaft will return to bearing housing(Fig.9.4). Of course, spiral grooves on the outer diameter of shaft can take the same effect on sealing.

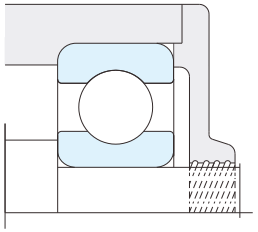

Fig. 9.4 Spiral oil groove sealing

What we called labyrinth sealing is to make multi labyrinth grooves to prolong channels, in that case, the sealing effect is improved. This type of sealing is used for grease lubrication. Filling lubricating grease into labyrinth grooves can prevent bearing from outside dust or moisture.

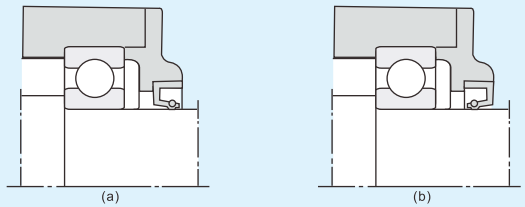

Fig. 9.6 Oil sealing

9.3.2 Contact sealing

The contact sealing is achieved by means of the contact between the shaft and the seal end. Generally speaking, contact sealing takes better effect than non-contact sealing, but its friction moment and temperature rise are higher.

Felt seals is the simplest way of sealing, which is mainly used for grease lubrication (fig. 9.5) to prevent slight dust. But it is very hard to stop oil from soaking and leaking through felt. Please contact C&U group technical center if there is any problem.

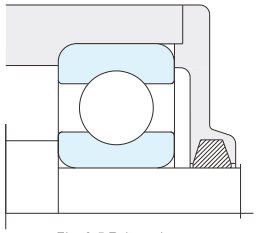

Fig. 9.5 Felt seals

Oil seals is widely used and become the most effective method of sealing, which applied spiral spring to control the contact force of the lips, the directions of lips are different from the purpose of preventing foreign matter entering into bearings(Fig.9.6 a) or lubrications inside flowing out of housings.(Fig.9.6 b)

In point of sealing lip material , stretchy high molecular material is adopted. Table 9.4 shows application temperature Scope of all kinds of material in different working conditions.

Table 9.4 Sealing material and application temperature

Sealing material	Application temperature scope ℃
Nitrile-butadiene rubber	−25～+100
Methacrylate Rubber	−15～+130
Silicone rubber	−70～+150
Fluoro-elastomer	−30～+180
Tetrafluoro ethylene resin	−50～+220
Felt	−40～+120

Allowable speed of contact type seal varies according to smoothness, accuracy class, lubrication, application and temperature etc. reference figure as following table 9.5

Table 9.5 Seal type and allowable velocity

Seal Type	Allowable linear velocity m/s
Felt seals	4
Grease seal	6
Oil-seal (nitrile-butadiene rubber)	15
Oil-seal (fluoro-elastomer)	32

Table 9.6 shows reference figure of contacting section roughness between shaft and sealing lip. In order to improve abrasion resistance, the hardness of shaft surface must reach HRC40.if possible HRC55 or more via heat treatment and solid chroming.

Table 9.6

Linear velocity m/s		Roughness of surface
over	up to	Ra
—	5	0.8
5	10	0.4
10	—	0.2