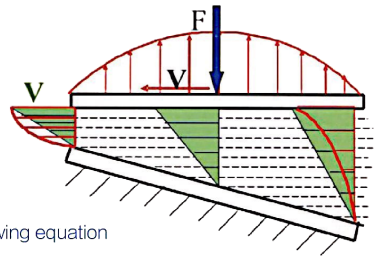
HYDRODYNAMIC BEARING GENERAL INFORMATION

1.HYDRODYNAMIC BEARING BASIC PRINCIPLE

A hydrodynamic bearing is an oil lubricated plain bearing. A plain bearing with hydrodynamic pressure in a pair of friction components to support external load is called a hydrodynamic bearing. One of basic equations of hydrodynamic lubrication is pressure distribution differential equation, also referred to as Reynolds's Equation.

The basic form of the Reynolds's Equation is:

$$\frac{\partial}{\partial x}\left(\frac{h^3}{\eta}\frac{\partial p}{\partial x}\right)+\frac{\partial}{\partial y}\left(\frac{h^3}{\eta}\frac{\partial p}{\partial y}\right)$$
$$=6\left\{\frac{\partial}{\partial x}(U_1+U_2)h+\frac{\partial}{\partial y}(V_1+V_2)h\right.$$
$$\left.-2(W_h-W_o)\right\}$$



The Reynolds's Equation may be expressed as the following equation if the density,etc. is varied with time:

$$\frac{\partial}{\partial x}\left(\frac{\rho h^3}{\eta}\frac{\partial p}{\partial x}\right)+\frac{\partial}{\partial y}\left(\frac{\rho h^3}{\eta}\frac{\partial p}{\partial y}\right)$$
$$=6\left\{\frac{\partial}{\partial x}(U_1+U_2)\rho h+\frac{\partial}{\partial y}(V_1+V_2)\right.$$
$$\left.\times\rho h+2\rho(W_h-W_o)\right\}$$

Where, U, V, W are respectively the velocity component of fluid along coordinate x, y, z directions.

- ρ - Density;
- η - Viscosity;
- t - Time;
- h - Thickness of fluid film;
- p - Pressure;

Necessary conditions for forming hydrodynamic oil film

a. A pair of friction components must be under a pressure;
b. Two surfaces must have a relative speed, so that the oil enters from the large opening and flows out of the small opening;
c. Two surfaces must be continuously and fully filled with lubricating oil;
d. The surfaces of a pair of friction components must form a wedge.

2.HYDRODYNAMIC BEARING CODE KEY

JF 41 / 114 S 6

- 6 — Number of pads
- S — Direction of rotation: S-Reversible; D-Unidirectional rotation
- 114 — Outside diameter
- 41 — Inner diameter
- JF — Model and type: IF-Tilting-pad journal bearing; TF-Tilting- pad thrust bearing; ZF-Tilting- pad thrust journal bearing; TG-Fixed-pad thrust bearing

3. HYDRODYNAMIC BEARING BASIC FORMS AND RECOMMENDED APPLICATIONS

According to different loads, a hydrodynamic bearing may be journal hydrodynamic bearing or thrust hydrodynamic bearing.

A journal hydrodynamic bearing may be designed with various structures, including three-oil wedge bearing, step-face bearing, tilting-pad bearing, etc.

Three-oil wedge bearings and step-face bearings are fixed-pad multi-wedge bearing. During operation, many hydrodynamic oil films are formed, with good rotary accuracy, self-alignment, high rigidity and damping, better high speed stability.They are commonly used for high-speed light-load bearing.

Tilting-pad bearings are tilting multi-oil wedge bearings, of which pads may be automatically adjusted for inclination with varied load and speed. They are one of bearings with the best stability and mainly used for high-speed and light-load bearing.

A thrust dynamic bearing may be designed with various structures, including fixed-pad inclined thrust bearing, fixed-pad inclined-planar thrust bearing, fixed-pad step-face thrust bearing, tilting-pad thrust bearing, etc.

Fixed-pad inclined thrust bearings, fixed-pad inclined-planar thrust bearings, fixed pad step-face thrust bearings are fixed-pad thrust bearing and the main form of thrust plain bearings. They apply to medium and small-scale light-load thrust plain bearings.

Tilting-pad thrust bearings apply to important large and medium scale thrust plain bearings.

4. HYDRODYNAMIC BEARING PAD MATERIALS COMMONLY USED

The common pad materials of hydrodynamic bearing include metal pad materials and non-metal pad materials.

The metal pad materials include cast iron, copper based alloy, Babbitt alloy, aluminum based alloy, copper casting alloy, etc.

The non-metal pad materials include plastic, carbon graphite, ceramics, wood, rubber, etc.

a. Plastic pads can seldom cause damage to shaft diameter, of which vibration absorption is better than metal pad. They feature strong resistance to corrosion, low density and light weight. They are suitable for batch of production.

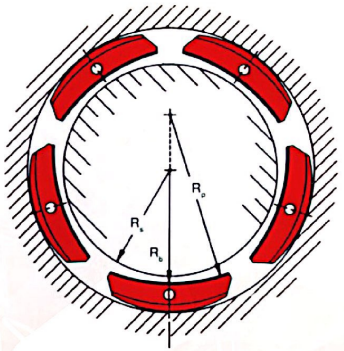
b. Graphite is a kind of self-lubricated pad material resistant to high temperature. It features good stability at high temperature, strong resistance to chemical corrosion, thermal conductivity higher than plastic, coefficient of linear expansion less than plastic.

c. Ceramic materials are hard, resistant to high temperature and to wear, but brittle, difficult to machine, high cost.

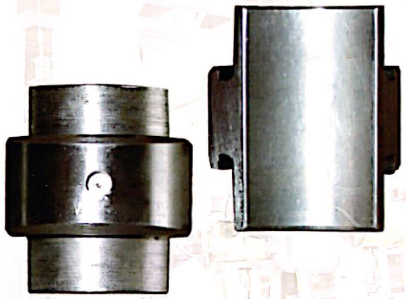
5. LUBRICANT AND LUBRICATION WAY

Lubricating oil and supplying means may be properly selected to improve the service life and bearing capacity of a hydrodynamic bearing. Under normal operating condition, the load of a hydrodynamic bearing is applied onto the lubricating oil film. Therefore, the lubricating oil selected will have direct influence on the bearing capacity of the bearing. In general, the higher the viscosity of the lubricating oil is, the higher the bearing capacity of the oil film is, and the more relatively generated by operating bearing is, causing the faster the temperature of the lubricating oil rises. A hydrodynamic bearing may be oil bath lubricated or pressure supply lubricated. The oil bath lubrication may ensure that the friction face of the lubricating oil are sufficiently contacted, easy to realize dynamic pressure lubrication. The pressure supply lubrication features stable and sufficient oil supply, fast heat dissipation, effective control of lubricating oil temperature, but needing separate hydraulic system.

HYDRODYNAMIC BEARING
TILTING—PAD JOURNAL BEARING

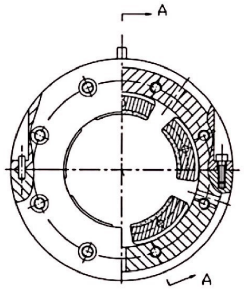


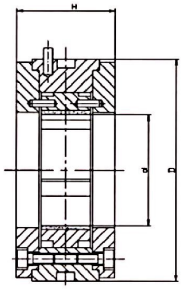
A tilting-pad journal bearing is mainly under radial load and able to bear a certain impact load and unbalanced load. Generally, there are more than 3 pads on a tilting-pad journal bearing, which are evenly distributed on the base. Mostly, it is designed with odd number of pads. The load direction may be either vertical to the pad center or to the space between two pads. The position of the pad supporting point may be adjusted with load and direction of rotation. When the supporting point is at the pad center, the bearing may be bidirectionally rotated but the bearing capacity is lower than that of unidirectionally rotating bearing. If the pad width approaches the shaft diameter, the bearing is under the highest load.



In case of double-layer composite material, the low carbon steel composite layer of the substrate should be Babbitt alloy. Through axial and radial positioning, the bearing makes that the pad is fixed onto the substrate. With proper design of profile and high-accuracy machining, the pad may be free inclined under dual action of revolution and load, forming oil wedge for dynamic lubrication of bearing.

The Babbitt alloy mainly contains tin, lead, copper and antimony. The copper is used to improve the strength and hardness of the alloy of which structural features are that hard phase particles are evenly distributed on the soft phase substrate. The soft phase substrate makes that the alloy features very good inset, adaptability, and resistance to seizure. And, after running-in, the soft substrate is concave and hard particles are convex, so that micro clearance is formed between the sliding faces, as an oil storage space and a lubricating oil channel, good to reduction in friction. The concave hard particles function to support, good to bearing capacity.



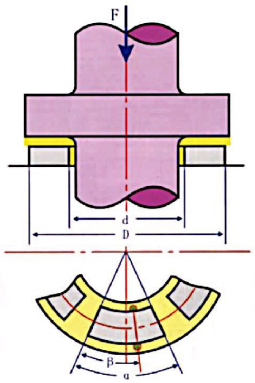


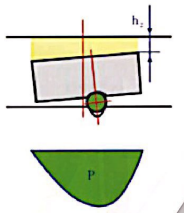
Our tilting-pad journal bearings mainly apply to centrifugal blowers, high-speed centrifugal compressors, steam turbines, steam turbine generator sets and other rotary machinery.

TILTING-PAD JOURNAL BEARING SPECIFICATIONS

d mm	D mm	H mm	Number of pads	Load KN
40	90	45	5	2
50	95	69	5	3.5
60	120	82	5	5.5
75	140	95	5	8.2
90	155	107	5	10.5
100	177	120	5	14.5
115	190	133	5	18.6
125	215	149	5	22
140	228	161	5	25
150	254	174	5	32

Note: The bearings may be customized upon request.



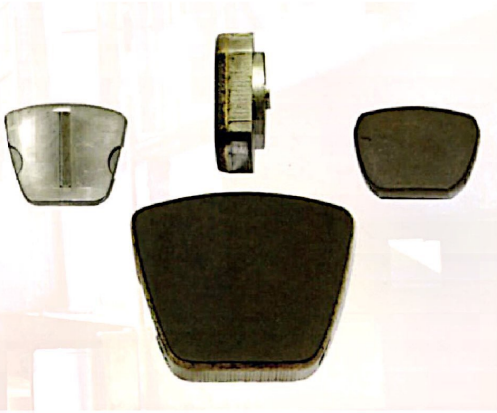


A tilting-pad thrust bearing is mainly under an axial load but may be under a certain impact load. In general, a tilting-pad thrust bearing is designed with even number of pads, which are equally spaced on the base. The pad may be slightly swung about one supporting point. And, the inclination may be automatically adjusted with load and direction of rotation. It may be applicable to a wide range of speed, load and viscosity.

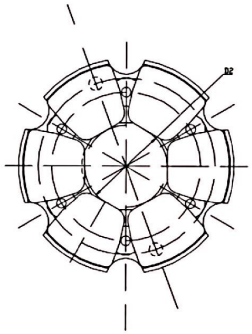
The pad of a tilting-pad thrust bearing is made of three layers of composite material including steel substrate, copper layer and composite material. The substrate material is specially treated steel.

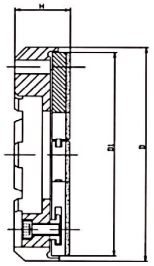
The composite material of the pad surface is improved PTFE to have lower friction coefficient and better heat resistance. The optimal design of pad structure, special machining process, high accuracy of pad dimensions, and proper thickness of oil film allow that the bearing is easy to dynamically forced lubrication.

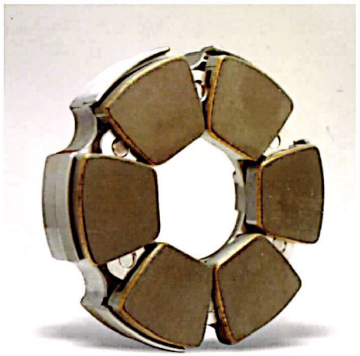
PTFE features a range of excellent performances including very low friction coefficient. It is one of self-lubricating materials with lowest friction coefficient found at present. It has high chemical stability and outstanding resistance to chemical corrosion. The operating temperature ranges from -200 to 250℃. It features good resistance to bonding.



In order to improve the friction performance of PTFE material, the PTFE is filled with some filler for modification. The fillers include Cu powder, MoS2, glass fiber, polystyrene resin, Aramid, etc. The modified PTFE is PTFE based composite material, featuring excellent performance of reduced friction and resistance to wear. Compared to pure PTFE, its resistance to wear is higher by 1000 times, creep resistance at normal temperature higher by 1.5 to 4.5 times, heat resistance higher by 1.5 times, hardness increased by 10 to 30 percent, and thermal conductivity increased by 2 times.





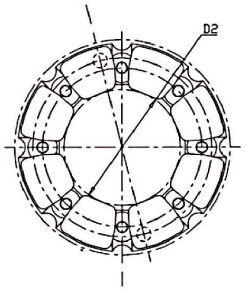


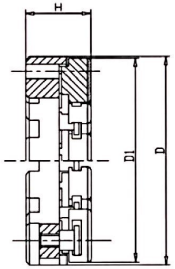
Our tilting-pad thrust bearings are mainly applicable to submersible electric oil pump sets.

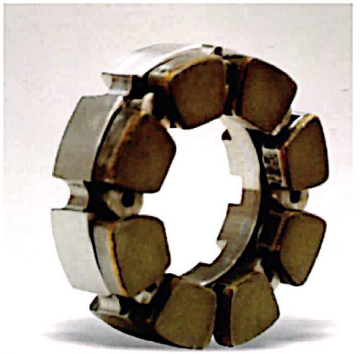
TILTING-PAD THRUST BEARING SPECIFICATIONS

D mm	D1 mm	D2 mm	H mm	Number of pads	Maximum load KN	Maximum revolution r/min
65	60	24	28	6	15	4000
70	65	27	28	6	17.5	4000
75	70	29	28	6	20	4000
80	75	31	28	6	24	4000
85	80	33	28	6	27	4000
90	85	35	28	6	30	3000
95	90	37	28	6	34	3000
100	95	39	28	6	39	3000
105	100	40	28	6	45	3000
110	105	42	28	6	50	3000

Note:The bearings may be customized upon request.





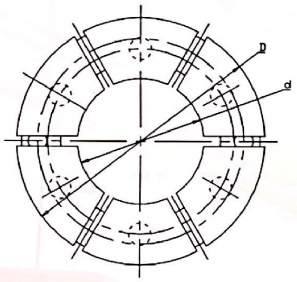


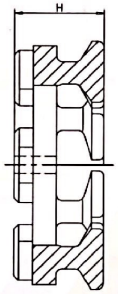
TILTING-PAD THRUST BEARING SPECIFICATIONS

D mm	D1 mm	D2 mm	H mm	Number of pads	Maximum load KN	Maximum revolution r/min
68	65	35	20	8	15	4000
73	70	37	20	8	20	4000
78	75	40	20	8	25	4000
83	80	43	20	8	28	4000
88	85	45	20	8	32	3000
93	90	48	20	8	36	3000
98	95	50	20	8	41	3000
103	100	53	20	8	45	3000
108	105	56	20	8	50	3000

Note:The bearings may be customized upon request.

For a fixed-pad thrust bearing, the pad is fixed onto the substrate. With micro deformation, oil wedge is formed to generate dynamic pressure. To consider the heat dissipation due to friction, a pair of complete friction faces is divided into several pads circumferentially. This structure of fixed pad is integrated with the substrate, made of ZYTCu-10.
Based on QSn10-1, the ZYTCu-10 material may improve the PV value, resistance to bonding and wear, and bearing resistance.
The main alloy elements include Cu, Nu, Sn, Pb, Zn, P, etc. This material features good resistance to wear, long life of fatigue, good speed performance, not easy to be seized.

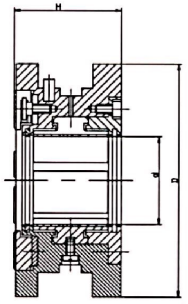


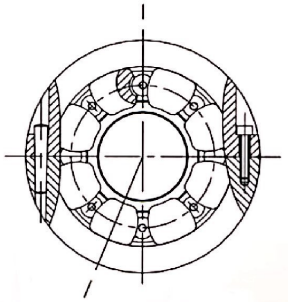


FIXED-PAD THRUST BEARING SPECIFICATIONS

D mm	D1 mm	H mm	Number of pads	Maximum load KN	Maximum revolution r/min
110	42	30	6	40	3000
100	40	23	6	35	3000
95	39	23	6	30	3000
90	37	23	6	26	3000
85	35	23	6	23	4000
80	33	23	6	20	4000
75	31	23	6	18	4000
70	29	18	6	15	4000
65	27	18	6	13	4000
60	24	18	6	11	4000

Note:The bearings may be customized upon request.





A tilting-pad thrust-journal bearing may be under both radial load and axial load and able to axially and radially form a layer of stable hydrodynamic film of lubricating oil. It features comprehensive performance of a tilting-pad journal bearing and a tilting-pad thrust bearing. The material of pad is Babbitt alloy, 3-layer composite material, etc.

TILTING-PAD THRUST-JOURNAL BEARING SPECIFICATIONS

d mm	D mm	H mm	Axial Number of pads	Radial Number of pads	Radial load KN	Axial load r/min
40	106	50	8	5	0.4	0.5
50	120	80	8	5	0.6	1.1
60	130	93	10	5	0.8	1.4
75	150	106	10	5	1	2.2
90	160	118	12	5	1.2	2.7
100	180	131	12	5	1.5	3.3
115	190	144	12	5	1.8	3.8
125	215	160	12	5	2.1	4.2
140	230	172	12	5	2.5	4.6
150	255	185	12	5	2.9	5

Note:The bearings may be customized upon request.