轴承的寿命 The Life The Bushing

JDB(500#)固体润滑轴承的寿命，除急剧的烧焦外，通常由轴承内径的磨损量来决定，磨损量主要受摩擦条件的影响，而摩擦又受承载、速度、杂质、材质、表面粗糙度、工作温度、不同运行方式、所使用润滑剂等条件影响，因此，磨损量只能是一个理论估计值，轴承的寿命取决于各种复杂的条件。

The life of JDB(500#) Solid-lubricant-inlaid depends on the wear depth of the inside diameter of the bushing except such condition as acute Singe, etc. The wear depth is influenced by the load speed, foreign matter, material, surface roughness, working temperature, different operating methods and the lubricant used. So the wear depth is only a theoretical estimate value and the life of the bushing depends on all kinds of the complex conditions.

若因供油不良，杂质渗入而使磨损急剧变化时，就很难预测磨损情形。下式为正常情况下由实验得出的磨损量计算式。

If the oil is not provided well, it is hard to estimat the abrasion state when the foreign matters intermingling. the following formula is the computing method.

$$W = K \times P \times V \times T$$

K:摩擦系数 Coefficient of Friction [mm/(N/mm² ㎜/min. hr]

W:磨损量 Wear Depth (mm)

P:承载压力 Load Pressure (N/mm²)

V:线速度 Linear speed (m/min)

T:磨损时间 Wear Time (hr)

从上式中可以看出，若摩擦系数(K)已知，便可根据承载压力(P)、线速度(V)和磨损时间(T)计算出轴承实际磨损量。但是，在各种实际条件下准确计算出摩擦系数K是件非常困难的事情。在理想条件下，摩擦系数K由影响其值的因素因子Ci来决定。

From the above formula you can see that if the coefficient of the friction "K" is known the real wear depth can be computed according to the pressure "P". linear speed "V" and wear time "T". But it is very difficult to calculate "K" under various actual conditions. Under ideal conditions. "K" depends on the factor "Ci" which influences it.

即i. e. $K = Ci \times k$

Ci: 影响磨损量的因素因子$Ci = C1 \times C2 \times C3 \times \cdots\cdots$

Ci: $Ci = C1 \times C2 \times C3 \times \cdots\cdots$Factor genes that influence the wear depth.

K: 理想条件下的摩擦系数 And k is the coefficient of friction under ideal conditions.

$K = (1\text{-}5) \times 10^{-8}$[mm/(N/mm² ㎜/min. hr)]

C_0：滑动条件系数 Coefficient of sliding conditions

C_0		线速度 Linear speed V(m/min)		
		≤1	1~ 10	10~ 30
承载压力 Loading pressure P(N/mm²)	≤5	8~ 10	10~ 12	12~ 18
	5~ 25	12~ 18	18~ 25	25~ 30
	25~ 50	18~ 25	25~ 30	30~ 40

C_1：温度条件系数 Coefficient of temperature conditions

工作温度 Working temperature(℃)	≤100	100 ~ 200	200 ~ 400
C_1	1~ 2	3~ 5	5~ 10

C2：环境条件系数 Coefficient of surrounding temperature

环境 Surrounding	一般场所 general place	室外 outside	粉尘较多场合 Places with much powder
C_2	1~ 2	5~ 10	10~ 30

C3：使用场所系数 Coefficient of places used

使用场所 Places used	大气中 Atmosphere	水中 Water	海水中 Sea
C_3	1.9	0.8	1.2

工况条件 Working Conditions

1. 承载压力 Loading pressure

通常所谓承载压力是指轴承承受载荷时，轴承支持的最大载荷除以受压面积。所谓受压面积，当轴承为圆柱时，取与轴承接触部分的载荷方向的投影面积。

The so-called loading pressure generally means that when the bushing is loading, the max load it bears divides the pressed area. And the loading pressed area means the projection area of the connecting parts when the bushing is cylindrical.

2. 线速度 Linear speed

轴承的发热量，主要是由轴承的摩擦作用引起的，根据经验可知，对摩擦面温度的上升，滑动速度V的影响远大于承载压力P的影响。轴承若使用同一PV值，速度V愈大，轴承面温度上升愈快，因此在高温使用时，最好能供给润滑油，增大冷却效果和流体润滑；以求降低摩擦系数，以防高磨损和烧焦现象的发生。

The heat radiated by the bushing is mainly caused by the friction of the bushing. According to the experience we know that the sliding speed "V" affects more than load pressure "P" to the surface temperature. If the bushing uses the same PV value, the higher speed the more quickly temperature ascends. So it would be better to provide lubricant to enlarge the cooling effect and liquid lubricant by using high temperature in order to reduce the coefficient of the friction and to prevent the high abrasion and burning.

固体镶嵌型自润滑轴承 Cylindrical Oilless Bushing

3. PV值 PV value

PV值是衡量轴承磨损极限和使用寿命的重要指标。以承载压力P(N/mm²)和线速度V(m/s)的乘积PV值(N/mm² ㎜/s)来表示。

PV value is an important guideline to weigh the abrasion limit and the service life of the bushing. It is shown by the load pressure P multiplying the line speed V.

轴承在单位时间，单位面积所产生的摩擦热量Q，以下式表示：

In the unit time the friction heat q caused by the unit area of the bushing can be shown by the following formula.

$$Q = \frac{\mu \cdot p \cdot v}{J} \text{ kcal/min}$$

J: 热功当量Heat equivalent of work≈ 4270(N/mm²・Kcal)

P: 承载压力 Load Pressure (N/mm²)

V: 线速度 Linear speed (m/s)

μ: 摩擦系数 coefficient of the friction

如果摩擦系数μ略大一些，轴承所产生的摩擦热量跟PV值成正比，这时所产生的热量Q，在经验上就可被认为固体润滑轴承设计时的重要依据。

当轴承运转时，轴承温度受摩擦发生的热量及热量散发情况影响，通常会在一定的温度上稳定下来．若运转持续进行中有杂质渗入，润滑油的性能就会降低，同时由于摩擦粉末的影响，材料的疲劳，此时摩擦面的形态即发生变化，摩擦系数提高，轴承的温度上升，致使摩擦面损伤，而导致烧焦，基于此种情况，轴承的运转温度越低，亦即使用低PV值时，轴承的负荷性较好，寿命延长。所以在设计时，尽可能使用较低的PV值较安全，反之，在详细分析冷却方法，轴的材质，表面粗糙度，配合间隙等因素情况下，欲超越最大PV值使用，也是可能的。

If the coefficient of the friction "μ " is a little bigger, the friction heat and the PV value are in the direct ratio. Then the caused heat Q is commonly considered as the important principle in the solid lubricant bushing design.

When the bushing is running the heat and the heat radiation can be fixed at a certain temperature. If there are foreign matters in the running process, the lubricant property may be reduced and the friction shape may be changed because of the effect of the friction powder and the fatigue of the material. The enhancement of the coefficient of the friction and the ascending of the bushing temperature cause the damage of the friction surface and it will burn at last. Considering such cases, the load property of the bushing will be better and the service life will be longer if the operating temperature of the bushing is lower i.e.using lower PV value. So when designing, use lower PV value to ensure it is safe. Otherwise, it is also possible to use max PV value by carefully analyzing cooling methods, material of the shaft and the roughness of the surface,etc.

PV 值计算方法 The calculating method of the PV value:

	承载压力 Load pressure P(N/mm²)	线速度 Linear speed
轴承 bushing	$\frac{F}{dl}$	$\frac{\pi dn}{10^3}$ $\frac{\pi d \theta c}{1.8 \times 10^3}$
垫片 washer	$\frac{4F}{\pi (D^2-d^2)}$	$\frac{\pi n \sqrt{2(D^2+d^2)}}{2 \times 10^3}$ $\frac{\pi \theta \sqrt{2(D^2+d^2)}}{3.6 \times 10^3}$
滑块 sliding plate	$\frac{F}{BL}$	$\frac{60S}{T \times 10^3}$

F: 垂直承载 uprightness load (N)

d: 轴承内径 inside diameter of the bushing (mm)

D: 轴承外径 outside diameter of the bushing (mm)

B: 滑块宽度 the width of the sliding plate (mm)

L: 滑块长度 the length of the sliding plate (mm)

N: 回转数 the rotation times (rpm)

C: 往复次数 reciprocating times (cpm)

θ: 摇摆角 the rocking angle (℃)

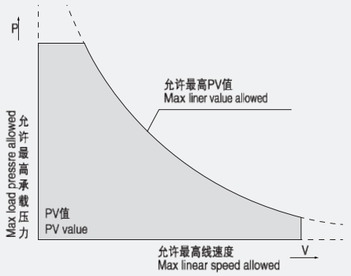
S: 往复长度 the length of the reciprocation (mm)

T: 往复一次需要的时间 (sec) time spenging in each reciprocation

4. 最大PV值 Max PV value

所谓最大PV值是在轴承设计时，在轴承的单位投影面积内所承受的载荷及线速度乘积之最大值，使用时请勿超越此值，在设计时应在图1实线范围内.

The so-called max PV value means the max value of the load in the unit projection of the bushing multiplying the linear speed. Do not exceed the value when using it. When designing please be in the range of Fig 1.



图Fig 1：轴承PV值图