

Press News

Bearing Systems for Fans: Ball bearings or Sleeve bearings?

Like all rotating machine parts, the rotors of equipment fans need to be provided with bearings. Popular solutions today are either ball bearings or, increasingly, sleeve bearings. However it is not just technical laypersons that are sceptical about sleeve bearings. Many people remember sleeve bearings, admittedly of an old-fashioned design, from wheelbarrows with their squeaking and grinding! Modern sleeve bearings, now manufactured in high-precision processes, have nothing in common with the old type. They are at least on a par with ball bearings and in many cases are actually superior.

The quality of the bearing system plays a vital role in the service life and quiet running of equipment fans. Undemanding, maintenance-free ball bearings thus find wide use in this field of application. Primarily grooved ball bearings are used with side plates, normally arranged as a pair and preloaded by a spring (Fig. 1). The service life of such a construction has been calculated according to ISO 281 at several hundred thousand operating hours. That however is just the theory; in practice the service life is determined almost exclusively by the type of lubricant selected and can be established by means of continuous running tests. Typical values for a DC fan equipped with ball bearings at an ambient temperature of 40 °C would be approx. 100,000 operating hours (L10 to DIN 622). As the temperature rises, then the life expectancy declines noticeably. For example at 70 °C it is then only 50,000 hours, as the service life of the lubricants diminishes due to the faster ageing at high temperatures. The ball bearings potential for long service life cannot therefore really be fully exploited in fan applications. They also have other disadvantages: Ball bearings are relatively sensitive to shocks and have a higher noise factor, not only when first put into operation but even more so towards the end of their life. In contrast sleeve bearings, which for example the ebm-papst company of St. Georgen, Germany use as an alternative to ball bearings, are characterised by their very quiet running, maintained over the whole service life (Fig. 2). This can be a crucial advantage with slow-running, quiet equipment fans. Furthermore sleeve bearings are much less sensitive to shock and vibration, as well as costing less than half to manufacture, which of course has a positive effect on the final price of the equipment to the user. The life expectancy of these fans is high and

easily comparable with models having ball bearings. During long-term trials under onerous test conditions the service life expectancy was shown to be up to 60,000 hours with fewer than 10% failures over a seven year continuous running period. The test samples were installed in a variety of different locations and in part subjected to very high ambient temperatures.

Sleeve bearing systems: construction and function

The type of sleeve bearings installed as alternatives to ball bearings in fans are so-called sintered bearings (Fig. 3). They are manufactured from metal powder that is cast under very high pressure into the desired shape and subsequently sintered at high temperatures. In contrast to “normal” solid sleeve bearings, this material has one main advantage – it is porous and the widely branched system of pores makes up around 15% to 30% of the bearing block. It is then impregnated under vacuum with a lubricant. This additional oil reservoir considerably improves the properties of the bearings:

Differences in pressure arise due to the rotational movement of the shaft in the bearing, which sets in motion the lubricant in the bearing gap (Fig. 4). This creates a wedge-shaped film of oil at the narrowest part of the bearing gap that at higher rotating speeds eventually leads to a hydrodynamic state, where the shaft and the bearing no longer come into contact with each other. This process is the same for all sleeve bearings. However with Sintec compact bearings lubricant is also forced into the pores at the tightest gap, where the highest oil pressure occurs. To balance this, oil flows out of the pores of the sintered metal, in the areas with a lower oil-pressure, into the bearing gap. This helps the film of lubricant to be created more quickly and the stable hydrodynamic state to be reached earlier; the intermediate mixed friction phase, when bearing and shaft still come into contact to a certain extent and where frictional wear is heavy, is substantially shorter than with solid bearings. Measurements have shown that with Sintec bearings a film of lubricant is built up only 20 milliseconds after start-up compared with 100 milliseconds for solid bearings.

Double sintered bearings with thrust bearing

In order for sintered bearings to be able to take up the radial load of fans in a stable manner, then it is recommended to fit two bearings placed at sufficient radial distance. For this purpose two short sintered bearings can be used, which should carefully aligned with each other. In production however this requirement is hard to master. Therefore it is more practical to use so-called double sintered bearings, such as the Sintec compact bearings, which ebm-papst prefers for its fans. They consist of a single sintered component and two separate

bearings. This bearing construction offers further advantages: excellent alignment as well as a larger oil reservoir thanks to the increased bearing volume. Furthermore, thanks to the special mould, the bearing block can be cast so that the geometry of the running areas is not impaired.

So that stability can be guaranteed in both directions, a thrust bearing is also provided: this means that in one axial direction the revolving end of the shaft runs against a non-moving surface. The shaft is therefore fitted with a cup washer, which runs against a special synthetic material. For this spot bearing arrangement to be effective even when the shaft is horizontal, then a magnetic pull of the rotor in this direction should be provided. In the other axial direction a disc, turning with the shaft, butts up against the front of the sintered bearing. Capillary action causes a film of lubricating oil to be created in the gap between the disc and the bearing.

Dimensioning and Lubrication

For full advantage to be taken of sintered bearings, the expected load and operating temperatures have to be taken into account and the individual elements then dimensioned and aligned to each other accordingly. That makes great demands on production engineering. Bearing clearance for fans is for example in the range of only 4 μm ., which in turn means there are very tight tolerances for the bore of the bearing and the shaft diameter.

Furthermore the steel shafts must meet high demands with respect to the surface quality. The film of lubricating oil in sintered bearings is only a few μm thick, so that even small degrees of surface roughness can penetrate the film of oil. The surface roughness of the shaft should not therefore exceed 0.8 μm .

The quality of the lubricants used also plays a pivotal role in the service life of the sintered bearings. A sintered bearing will fail, if the lubricating effect of the oil is diminished due to ageing or if the oil is used up. This leads to an increase in friction and noise, and the fan will run more slowly. This is why ebm-papst uses a special high-performance impregnating fluid to lengthen the service life and ensure low wear during mixed friction conditions. Sintered bearings are thus suitable for applications involving relatively high ambient temperatures and are in this respect also on a par with ball bearings. To avoid loss of lubricant under adverse operating conditions, such as high temperatures or with a vertical shaft, the bearing tubes are sealed at the shaft cup. With certain AC voltage fans, the heavy rotors and the associated high heating of the motors place a heavy load on the bearings; in these cases an additional return path for the oil is provided on the side of the rotor base. If the supply of oil runs low, then lubricant is fed back from the overflow reservoir.

In order for fans fitted with sleeved bearings to run reliably over long periods of time, the rotors and the fan impellers must be carefully balanced. If not balanced correctly then with a horizontal shaft the rotor can wobble. The hydrodynamic state is not reached and the bearings will wear quickly. The rotors are therefore balanced in two planes, using precision robots.

PAP052_fig1.jpg



Fig 1: Ball bearings are widely found in equipment fans, but are not always the perfect solution

PAP052_fig2.jpg



Fig 2: When used at the speed ranges that apply for cooling modern equipment, fans with Sintec compact bearings are audibly quieter than fans fitted with ball bearings

PAP052_fig3.wmf

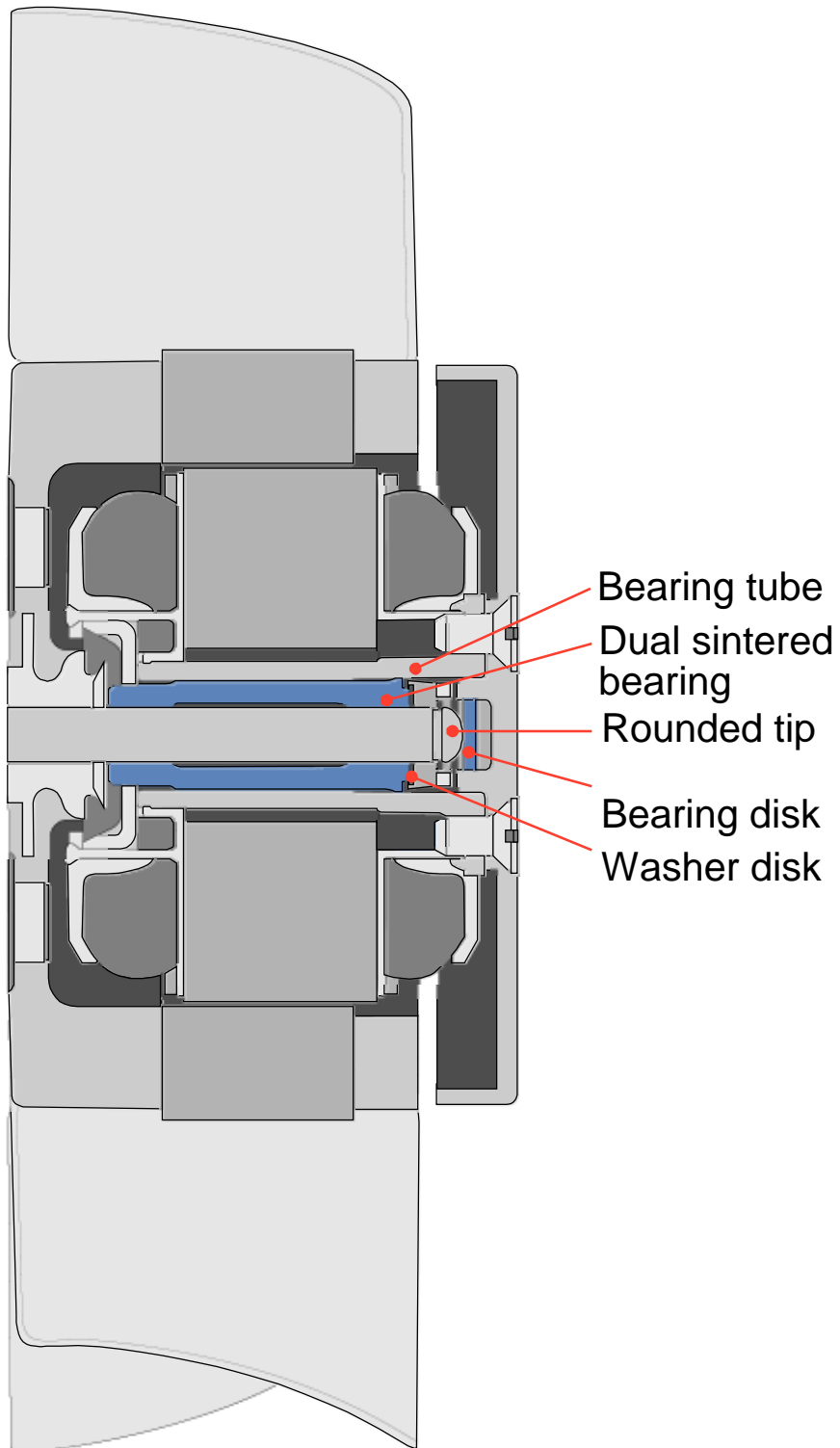


Fig 3: Double sintered bearing with axial spot bearing positioning

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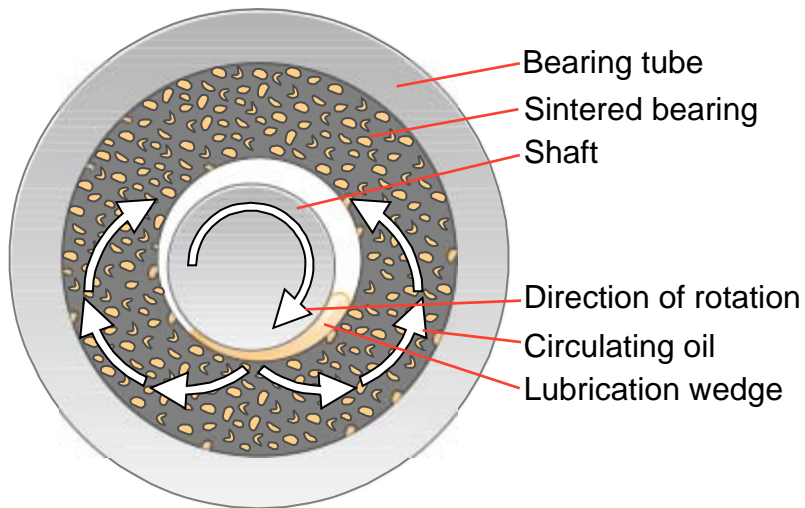


Fig 4: Bearing gap conditions as found in sintered sleeve bearings