

Fan reliability issues explored

Gareth Jones
Managing Director
Phone +44 1635 2811-11
Fax +44 1635 2811-61
Gareth.Jones@uk.ebmpapst.com

Introduction

Since cooling fans are mainly used to increase the reliability of electronic equipment by preventing overheating, any fan failure is potentially serious. We therefore expect fans to operate reliably over a long a period of time. Since most fan failures are due to worn bearings, only high quality, steel ball bearings were once considered reliable enough. This inevitably resulted in higher cost. Recently however, technical improvements in sintered sleeve bearings have led to reliability figures at least as good as ball bearings - but at significantly lower cost.

Reliability specifications

The reliability of fan can be specified in several ways but the most meaningful approach is to take it as the probability that a unit will not fail during a defined period under specified operating and ambient conditions. For example, a good quality fan may have a service life of 80,000 hours under continuous operation at 40degC ambient. The L10 specification states that less than 10% of a statistically significant number of fans should fail during 80,000 hours continuous operation at 40degC. In most equipment, fans operate at well below 40degC for most of their lives, so their actual reliability will normally be much higher. The L10 figure does, however, give a excellent comparative indication of the fan's reliability. They should not be confused with the sometimes much higher lifetime figures based on less stringent criteria which can give a completely different result.

The importance of lubrication - the Achilles heel of bearings

It is an accepted fact that most fan failures are caused by wear of the bearing systems so it is hardly surprising that ball bearings fans, particularly those using modern using grooved ball bearings, have long been the favoured solution. However, even the high apparent reliability of ball beatings can be misleading. They can for example, have a long calculated, modified nominal service life, according to ISO 281 standards, of several hundred thousand hours, but these values are usually not achieved in practice even in the most favourable conditions, mainly because the bearings fail earlier due to failure of their lubricant.

In fact, the single most important factor affecting the reliability of a fan is the composition and reliability of the lubrication system and not the fatigue life of the bearing itself. This equally applies to DC fans where the older brushed commutation, once a common source of fan failure, has now been replaced by all solid-state commutation using Hall-effect sensors with much higher reliability. Although there are various formulae for calculating the life of the lubricating oil, the results rarely agree with practice. It is therefore more useful to carry out life tests with different lubricants and to select the one best suited to the application. In this way, the most appropriate lubricant can be identified to provide the required fan service life, greatly increasing predictable reliability of the fan.

So why sleeve bearings?

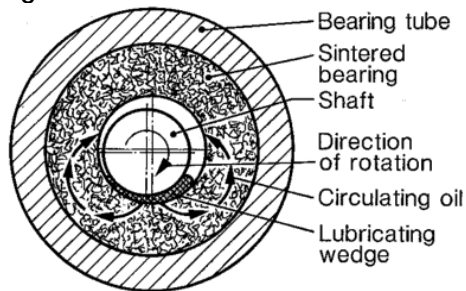
There are many reasons why sleeve bearings have become a very useful alternative to ball bearings. Sleeve bearings (sometimes known as slide bearings) generate less running noise. They are less sensitive to shock and vibration. They cost less and continual technical development means that they can match the reliability of ball bearings.

As a supplier of both ball bearing and sleeve bearings fans, Papst has conducted comparative life tests which show that fans with particular sleeve bearing systems can now achieve similar reliability to those with ball bearings. i.e. an L10 lifetime of 80,000 hours of operation at an ambient temperature of 40degC. As a result, sleeve bearing fans are now more than capable of meeting the long life requirements of demanding computer systems, telecommunication equipment, measurement and medical systems etc., and their lower noise and lower cost makes them even more attractive.

Sintered Sleeve Bearings: the Papst SINTEC bearing

Behind this improvement in sleeve bearings lies significant developments in sintering technology, in particular the unique SINTEC process used by Papst. This process uses a special metal powder that is pressed into the required shape at very high pressure and then sintered at high temperature. The material created in this way is porous, with the pore volume taking up about 15 to 30% of the bearing. The pores are then filled with lubricant using a vacuum soaking process and a re-circulating reservoir is created to ensure continuing operation over long periods.

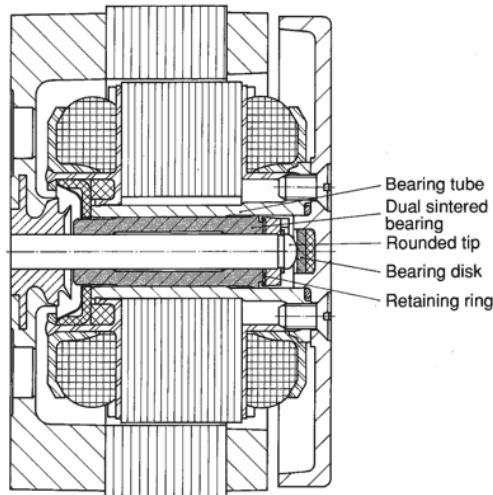
Fig 1: Lubricant circuit in a SINTEC bearing



This unique design of SINTEC bearing ensures that lubrication is maintained even when the fan is at rest, so that the bearing is never dry, even during the crucial start-up phase. At rest the capillary effect forms a film of lubricant between the shaft and bearing so that lubricant never drains away from the bearing. Then when the fan starts to rotate, a slight pressure difference causes a hydrodynamic pressure wave to be set up in the bearing gap as a result of the rotary movement of the shaft causing the lubricant to circulate around the bearing. This hydrodynamic state produces a lubricating bulge at the narrowest part of the bearing gap, exactly where friction should be greatest, ensuring that the shaft and bearing no longer touch and lubricant is always supplied to exactly where it is needed.

To ensure re-circulation, the oil pressure that is greatest at the narrowest place of the bearing gap forces the lubricant into the pores of the sintered bearing. To compensate for this, oil flows out from the sintered metal in areas of lower pressure and circulates to the areas of high pressure where it is needed. This re-circulating circuit creates a stable state as in Fig 1.

Fig 2: The SINTEC compact bearing from Papst guarantees excellent alignment and a large oil reservoir



To allow the SINTEC bearing to take up the radial load of the fans, two bearing positions with sufficient axial spacing are required. The ideal solution is to use double sintered bearings with two separate bearing positions in a single sintered part. The main advantages are improved alignment and a considerably larger oil reservoir due to the larger bearing volume.

The design also features an additional axial bearing disc which ensures that a stable position is reached in both axial directions. By taking up the axial lateral forces in either direction, fans can be mounted with the shaft in a non-horizontal plane. Under this condition a film of lubricant is formed between the rounded end of the shaft and the disc and a state is achieved similar to that normally seen in a radial bearing.

Dimensioning, lubrication and manufacturing quality

The manufacturing of sintered bearing requires extremely careful matching of shaft and bearings. This makes great demands on manufacturing processes. For example, bearing play should be no more than 1% of the shaft diameter. So, for a 4mm shaft it should be no more than 0.04 mm. Not only does this require extremely close tolerances for the bearing bore and the shaft diameter but the steel shafts must meet stringent requirements regarding accuracy of shape and surface quality.

Summary

Fans with SINTEC compact bearings are now suitable for demanding computer systems, telecommunication plants and in measurement and medical technology as quiet, reliable and reasonably priced alternatives.