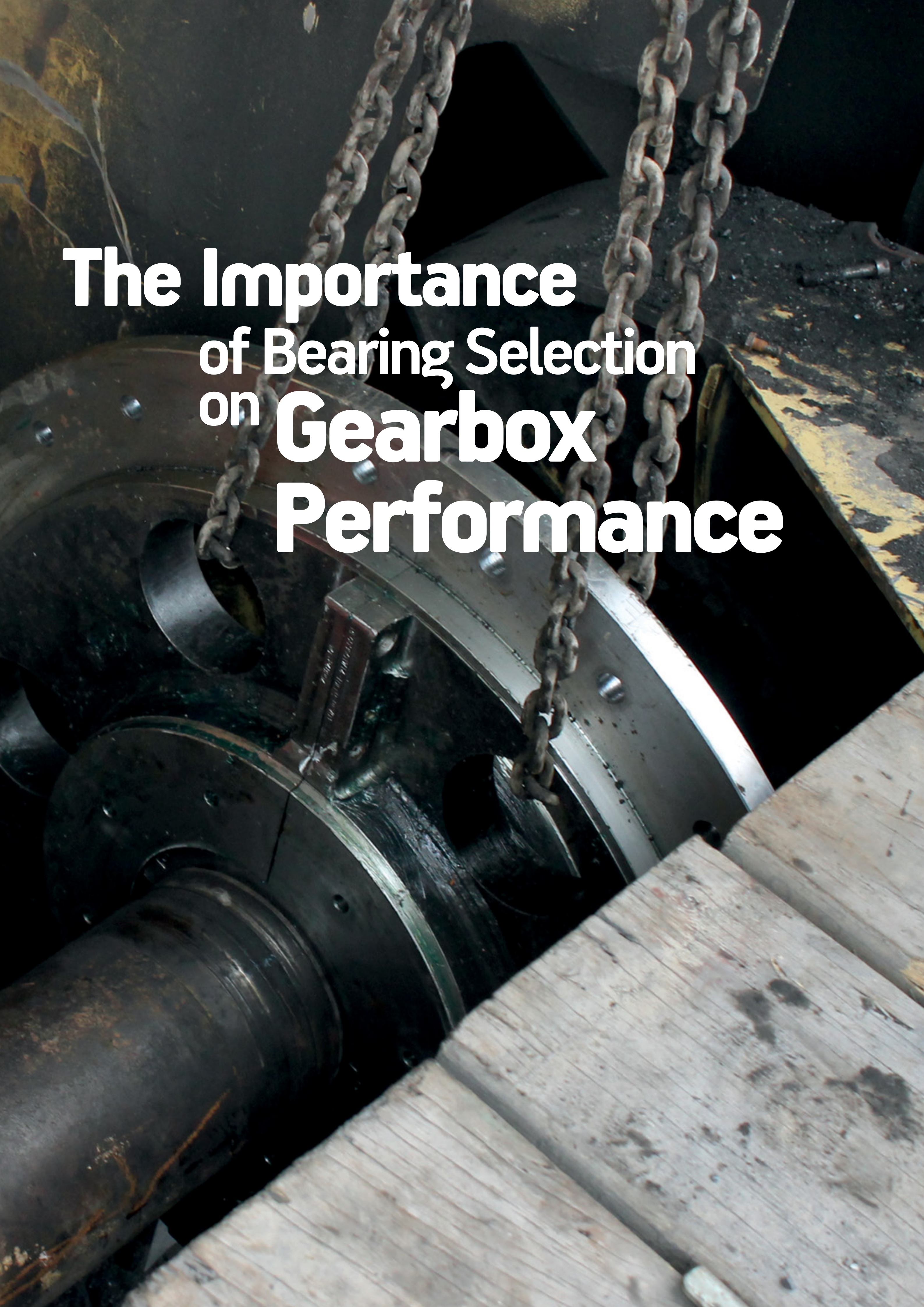
David Beattie
Bearing Consultant
at DASH Engineering

The Importance of Bearing Selection on Gearbox Performance



Large reduction gearboxes are designed to transmit high torque by reducing the high input speed to the desired output speed. This being the reason a gearbox is widely used and a common piece of equipment through heavy industry driving conveyors, mills, crushers and pumps.

The gears throughout a gearbox are precision manufactured with high accuracy that require trained technicians to assemble and install. It is not unusual for a simple reduction gearbox to have many stages that may include bevel and pinion gears for drive/input direction changes, as well as multiple helical gears of differing ratios to achieve the desired output.

The objective is to have the gearbox operate as quietly as possible. To assist with this, helical gears are generally used in preference to spur (or cross-cut) gears to reduce audible gear mesh noise. We all recall the 'whine' of our manual cars when we reversed? In these cases, reverse is a spur gear.

Helical gears are excellent for power transmission, durability and quiet operation, however there is a downside to this design. As these gears are

manufactured with an angle, there is always a resultant axial (thrust) force that requires attention.

In applications where this axial load becomes extremely large, the helical gears are cut in opposing directions, often referred to as 'herringbone gears'. This design requires:

• increasing the gearbox sizing
• more accuracy in assembly and
• adds additional cost in the precision machining.

In operation however, this gear design will not result in axial (thrust) loads. In the more common helical and bevel/pinion gear drives, the resulting axial (thrust) loading must be borne by the supporting bearings. Often, the choice of bearings is based on load carrying capacity and theoretical bearing life, without an essential understanding of the bearing and its fundamental design.

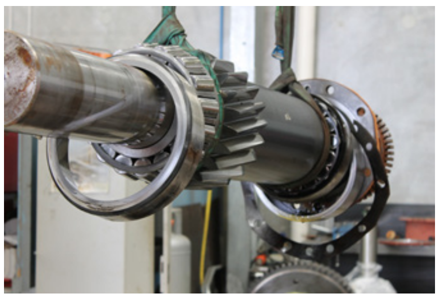
There are many different bearings available, each having a unique set of load-carrying characteristics. These characteristics should be clearly understood along with the application load characteristics prior to installation. In most applications, the shaft requires location as well as the ability to rotate.

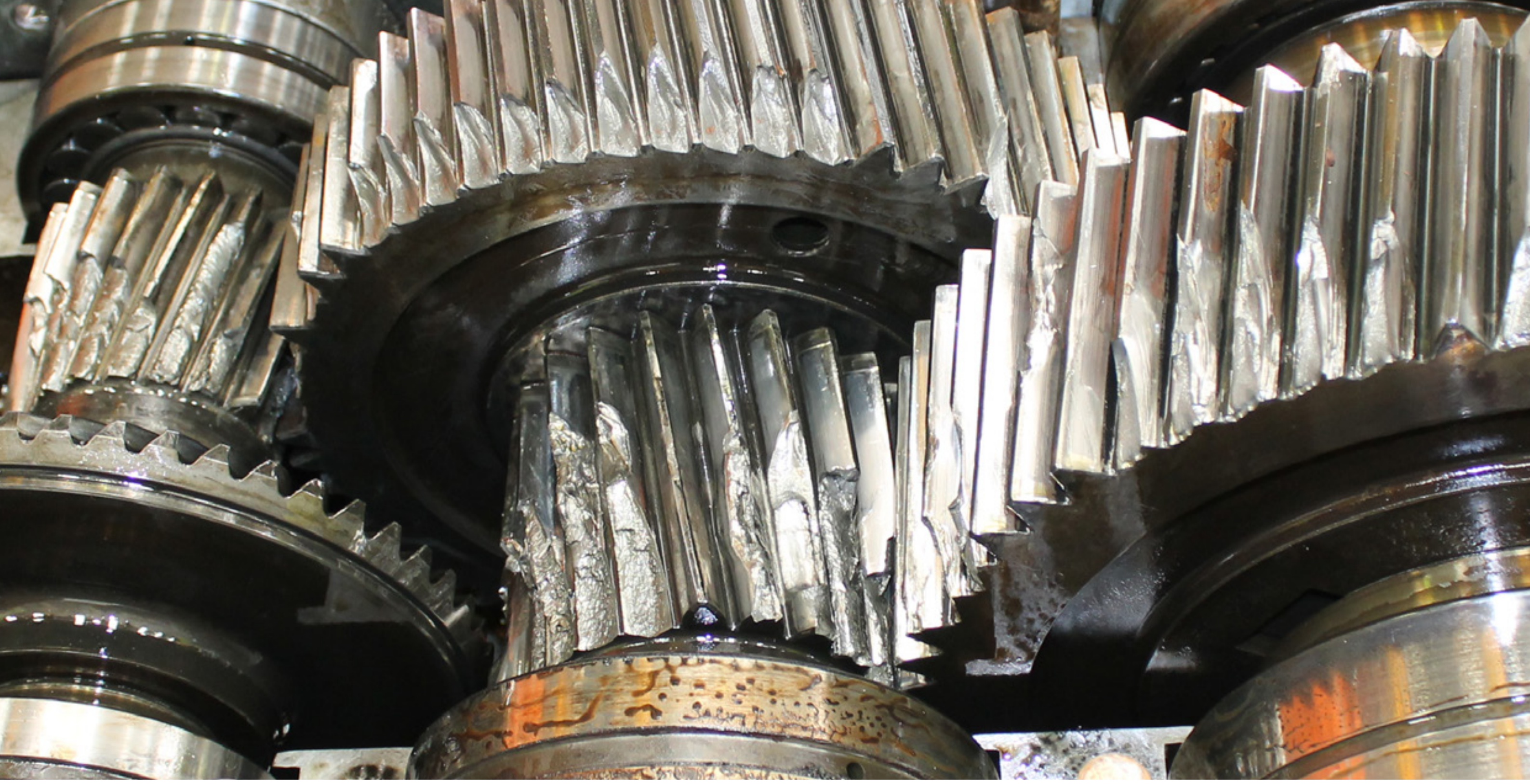
Bearing loads can be pure radial, pure axial or a combination of the two. Generally, most applications have a combination of these two. Bearings are designed to take different loads, with most able to accommodate combinations of loads. A ball bearing, for example, is designed to accommodate radial loads, however, it is able to support some axial (thrust) loading and therefore is excellent to use in an electric motor, as this bearing will positively locate the rotor. In this example there will also be some shaft thermal growth. To eliminate the risk of bearing 'cross-location', a cylindrical roller bearing can be utilised. This

type of bearing is available in many configurations. It can be used as there are configurations that will allow for axial movement within the bearing itself, while still maintaining radial load carrying.

Some bearings are also designed to allow for misalignment. This can be beneficial where there is a possibility of housing to shaft inaccuracy, or a possibility of shaft deflection. Similar to the helical gear design, these bearings have advantages and disadvantages.

In the case of spherical roller bearings, the ability to misalign whilst allowing rotation without compromising load carrying capacity is excellent. These bearings are an excellent design for use





in a conveyor pulley as there is always difficulty in maintaining accurate alignment and the applied radial loading is usually high. Furthermore, these bearings also have the ability to 'locate' the shaft by accommodating small axial (thrust) loads.

The disadvantage, or downside, to a spherical roller bearing is that by nature of its internal design, there is a compromise to rolling efficiency. Imagine trying to roll a wine barrel down a hill – it's not likely roll straight. The same is occurring within the spherical roller bearing – the rolling elements have a tendency to skew and slide, increasing operating temperatures. The critical component that maintains rolling element alignment is the cage. Without the cage, the rolling elements skew easily, resulting in catastrophic failure.

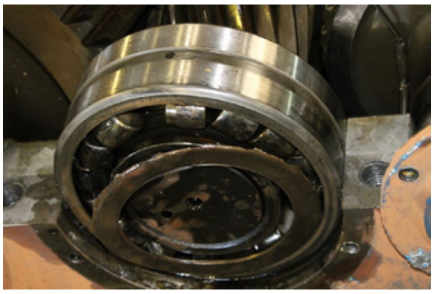
The rolling inefficiencies of a spherical

roller bearing can be easily compared by referring to the speed ratings in any bearing manufacturers catalogue. Review the speeds of bearings of the same overall size – ID, OD and Width. Compare this speed for ball bearings, cylindrical roller bearings, even tapered roller bearings and it is very likely that the speed rating for the spherical roller bearing will be significantly less.

Why? Speed ratings are based on a standard that requires a specific load be applied with the bearing able to maintain a prescribed temperature at this 'limiting' speed. Some manufacturers have 'reference speeds' which differ from the 'limiting speed. The measurement however is fundamentally the same. Gearboxes often have spherical roller bearings installed on slower speed reduction shafts which is interesting from a bearing application perspective.

Gearboxes are accurate by design. Gear mesh, backlash and alignment are critical to gear life and reliable operation. Shaft design must maintain this accuracy without deflection. Housing bore alignment must ensure the shaft maintains the gear accuracy requirements.

Given these accuracy constraints, there appears to be a lack of fundamental bearing engineering knowledge on bearing selection. The application does not require the ability to misalign. There is likely to be resulting axial (thrust) loading and the gear separating forces are insufficient to maintain the minimum bearing load requirement to maintain rolling contact. The internal rolling inefficiencies and insufficient radial loading can combine with axial (thrust) loading to result in premature bearing failure. A bearing that is ideal for a conveyor pulley being used in a gearbox application may not be the best option.



A bearing that is designed specifically to have the ability to accommodate a combination of radial and axial (thrust) loading, along with a load rating that maintains the minimum loading requirements can be considered. The tapered roller bearing is often an excellent alternative if spherical roller bearings are failing prematurely, or not providing adequate service life in gearbox applications.

Author: David Beattie
DASH Engineering –
IMPARTIAL & INDEPENDENT Bearing Consultants