Friction, Lubrication and Bearings

Introduction

Mechanical systems have moving parts that transmit motion and force. The system may also convert one type of motion into another type of motion, e.g. rotary motion into reciprocating motion. In the ideal mechanical system all the input motion and force is converted into output motion and force. However, friction between various parts of the mechanism results in heat being generated, wearing of surfaces in contact and loss of efficiency of the mechanical system. Lubricants and bearings are used to counteract the effects of friction in mechanisms.

Friction

Friction is the force that opposes one object sliding over another. Various factors effect friction between two surfaces including:

- the type of materials in contact
- the amount of pressure being applied that forces them together
- the texture of the surfaces in contact
- the area of the surfaces in contact
- whether lubricated or dry.

The amount of resistance to sliding of one object over another is called the coefficient of friction. A high resistance to sliding results in a high coefficient of friction.

The effects of friction

The effects of friction are that surfaces in contact:

- are prevented from slipping freely, (therefore more energy is required to move the part)
- heat up
- expand from the heat and may seize up
- wear.

Certain materials like rubber resist sliding over materials so well that that they are used as erasers, motor vehicle tyres and bicycle brake pads.

Reducing the effects of friction

The effects of friction are reduced by:

- using a lubricant on the surfaces that are in contact;
- using a "bearing"

Friction in use

Friction is the force that opposes one surface sliding over another.

Certain materials like rubber grip a surface so well that they are used as erasers, motor vehicle tyres and bicycle brake pads.

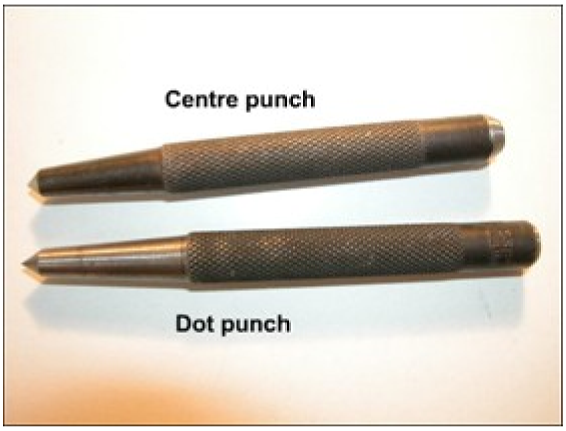
The effects of friction are increased by pressing the two surfaces together harder, (e.g. the bicycle brake opposite) and by increasing the area in contact.

Forcing parts together using a screw

The photograph opposite shows protractor. A screw forces the parts of the protractor together and friction prevents the parts from moving.

To adjust the protractor, the screw must be loosened a little to reduce the effects of friction and then tightened again when the correct angle has been set.

Friction and surface texture



The photograph opposite shows a centre punch and dot punch that have been "knurled" to give a textured surface to the section that will be held.

Textured surfaces increase friction. A textured surface helps us to grip an object firmly and makes it less likely that it will slip from our fingers.

Friction utilised in gripping tools

Most gripping tools have textured jaws that are designed to increase friction and so grip better.

Teeth are cut into the hardened steel jaws of gripping tools that “bite” as the jaws are forced together.

Lubrication

Moving parts of mechanisms should always be lubricated in order to reduce the effects of friction. A lubricant covers moving parts with a thin film that prevents the parts from touching. Because parts are not in contact, friction and wear are reduced.

Lubricants used on machinery consist of base oils, either mineral (made from crude oil), synthetic oils, or a mixture of both, and additives. Additives improve the characteristics of the base oils and make them suitable for specific uses, e.g. for machinery working at high speeds in cold conditions.

Other lubricants include grease, (a semi-solid oil based lubricant), graphite, and teflon.

Oils are classified by SAE numbers. The higher the number, the thicker the oil. SAE 10 is an extra light oil, SAE 75, 140 and 250 are heavy, thick oils.

Multigrade oils change viscosity with temperature. The oil is thin and flows freely when cold and thickens and flows less freely at high temperatures.

The purpose of lubrication is:

- to separate moving parts with a film of "slippery" material, e.g. oil or grease
- to reduce friction
- to reduce wear.

Additional benefits of lubrication:

- lubricants move dirt and debris away from moving parts
- lubrication cools by transferring heat away from moving parts
- lubrication prevents corrosion.

Bearings

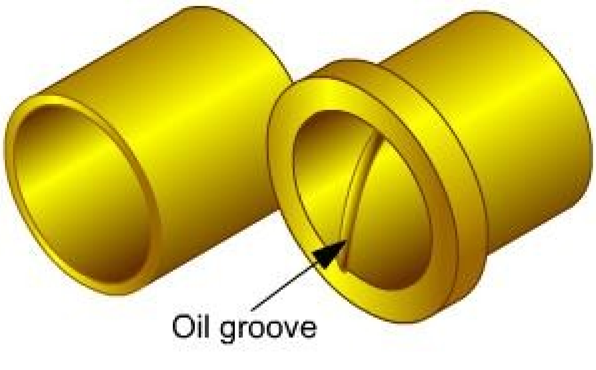
Bearings are used to reduce the effects of friction. There are two main categories

1. Plain bearing (also called a bush) with no rolling elements.
2. Bearings with rolling elements.

Plain bearings

Plain bearings, also called bushes, consist of a tube-like sleeve.

Some plain bearings have a flange at one end.



Plain bearings are made from materials that have a low coefficient of friction. The bearing material may be a bi material such as steel backed PTFE coated bronze or alumium backed frelon. Other bearing materials include, bronze, copper/graphite alloy, nylon, PTFE and cast iron.

Bearings with rolling elements

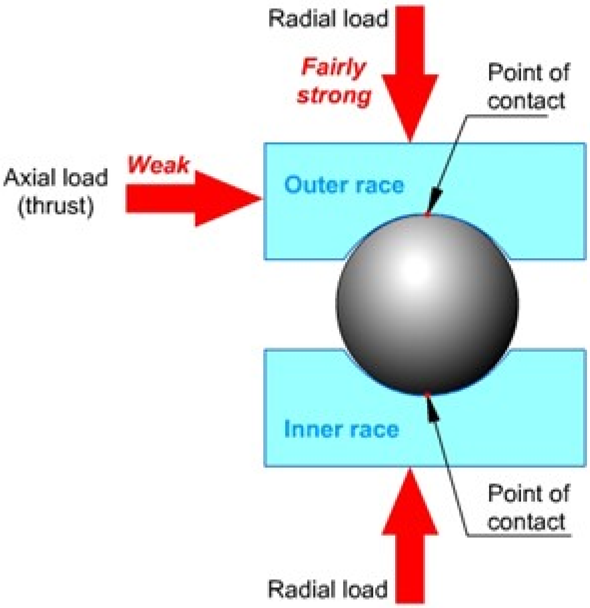
Bearings with rolling elements include:

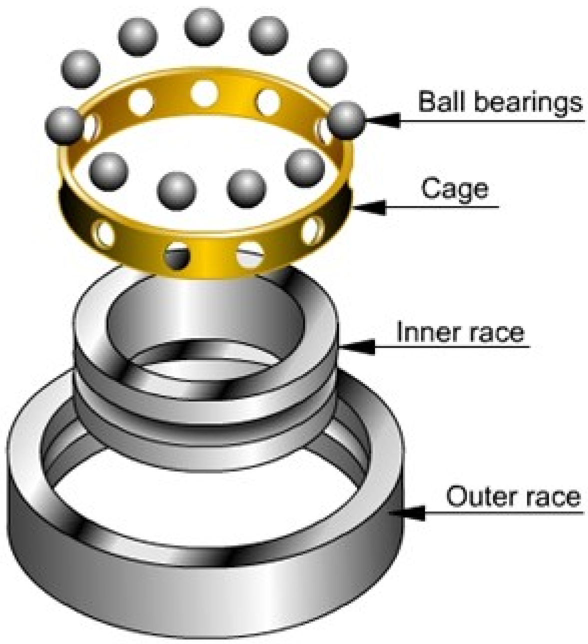
- ball bearings
- cylindrical roller bearings
- needle roller bearings
- spherical roller bearings
- taper roller bearings.

Ball Bearings

Ball bearings are the simplest and most common type of bearing with rolling elements. The rolling elements consist of a number of hardened steel balls that roll in grooves in the outer and inner races. The ball bearings are often held in position by a cage. The cage may be made from a different material than the inner and outer races.

Because of the small point of contact between the polished ball bearings and the ball races, there is minimal friction. This makes them suitable for high speed applications.

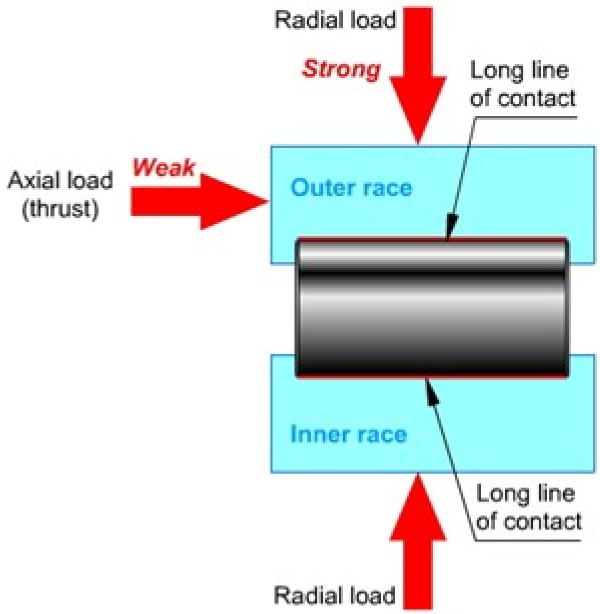




Cylindrical Roller Bearings

Cylindrical roller bearings have a similar design to ball bearings but instead of hardened steel balls, hardened steel cylinders are used as the rolling elements. The steel cylinders have a narrow line of contact with the inner and outer races. This makes them almost as friction free as ball bearings but the long line of contact between the cylinder roller bearing and the inner and outer races enables these bearings to withstand very heavy radial loads.


Cylindrical roller bearing



Needle Roller Bearings

Needle roller bearings are similar to cylindrical roller bearings but the cylindrical rolling elements are much smaller in diameter, i.e. more like needles.

Because the rolling elements have a small diameter, a larger number of them are used than in a similar sized cylindrical roller bearing. This enables needle roller bearings to carry greater loads than cylindrical roller and ball bearings.

Spherical Roller bearings

Spherical roller bearings consist of two rows of spherical rollers that match the curvature of the inner and outer races. Due to the curvature of the inner and outer race profiles, this bearing can take a small amount of misalignment between the bearing and the shaft.

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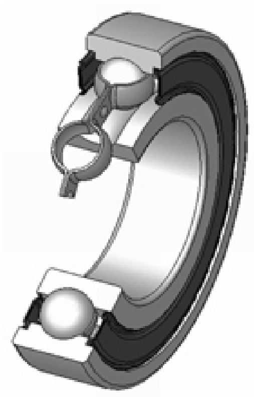
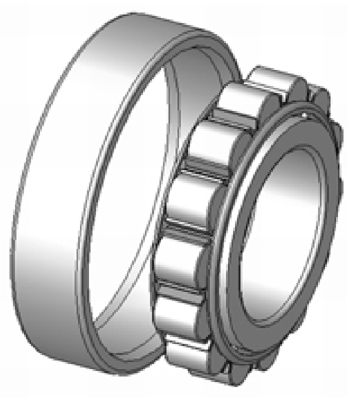
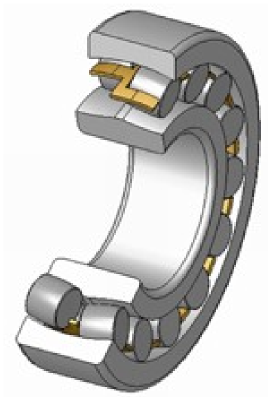


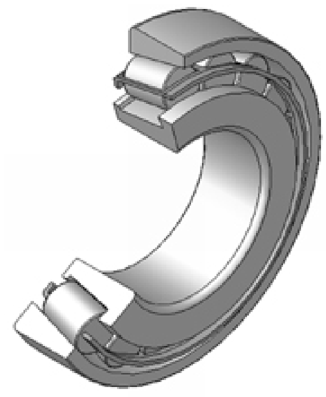
Deep groove roller bearing



Cylindrical roller bearings



Spherical roller bearing



Taper roller bearing

Taper Roller bearings

Taper roller bearings consist of a number of truncated conical rolling elements held in a cage between the inner and outer races.

Taper roller bearings have a high load bearing capacity due to the line contact between each of the roller bearings and the inner and outer races. Taper roller bearings can support radial and axial loads.

Thrust bearings

Thrust bearings consist of either ball or cylindrical rolling elements held between two plates. Thrust bearings are designed to take compression loads.