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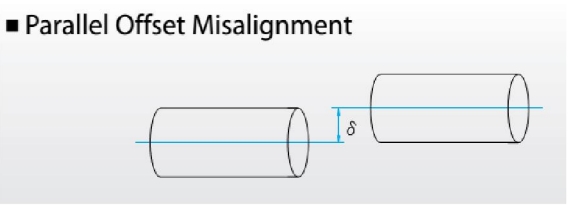
Couplings for Linear Motion Applications

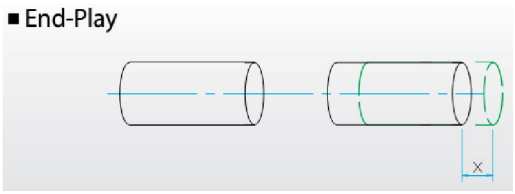
With the huge variety of couplings available on the market selecting the best coupling for any application can seem a daunting exercise. This document is an aid to the optimal selection of couplings for linear applications.

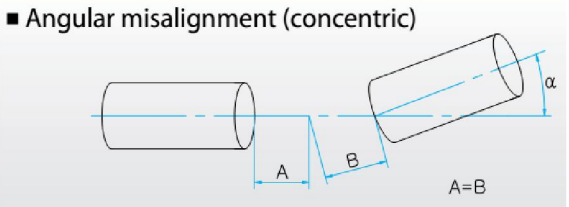
Shaft misalignment

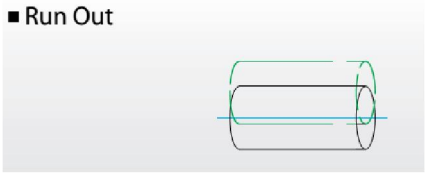
The basic purpose of a coupling is to connect two shafts and transmit rotation. Sounds simple enough but why not just rigidly clamp or even weld the two shafts together? As any experienced engineer will tell you every measurement has a tolerance and when considering a connection between two shafts this means the two ends of the shaft will not be perfectly aligned. It doesn't matter if the geometry has been CNC machined or laser aligned, some inaccuracy will always be present.

The misalignment of the shafts can be characterised as Parallel, Angular, End play and run out as shown below.









If there is no misalignment ability in the coupling then moment loads will be generated between the two shafts and this load will cycle with every rotation of the shaft. When shafts are in constant motion or at high speeds then what we end up with is a perfect configuration to create fatigue failure of the shaft itself. In cases of high misalignment inaccuracy of motion and vibration of the mechanism can occur.

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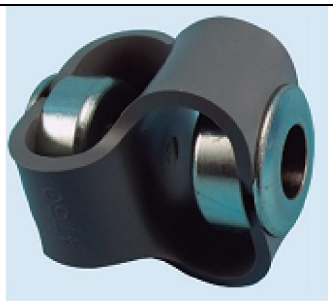
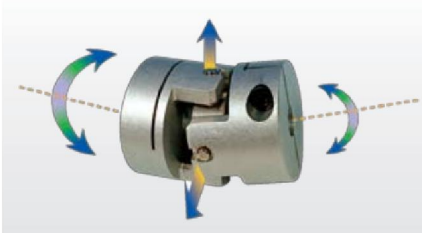
Couplings for power transmission

The majority of couplings are used for power transmission in mechanisms such as pumps, generators conveyors, fans and mixers. As these applications do not require much accuracy of the payload or reversing of motion then the simplest way of allowing for misalignment is to introduce a flexible compliant element between the two shafts. Some common types of couplings used for power transmission are shown below.

 Flexible coupling	 Tire coupling
 Jaw or Lovejoy coupling	 Gear coupling

For extremely high misalignments a universal or cross joint coupling will be required.



Precision requirements

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For many applications flexibility in all directions is desirable to simplify alignment. Highly flexible couplings also help to reduce impacts and shock loading through the drive system. For single direction applications such as fans and pumps rotation is only in one direction so play or backlash in the coupling is also not a factor.

For linear applications lack of rotational stiffness will mean at any given time the carriage and payload has not travelled as far as commanded. If the application is linear point to point this may not be a factor as the payload will still get to position when the thrust load is removed. Highly flexible systems may however cause problems with oscillations about the set point causing an increase in settling times.

Lack of stiffness is a significant factor in CNC machining producing inaccuracy where contouring of one axis relative to another is required. In cutting applications backlash and lack of system rigidity can allow the tooling to vibrate, known as chatter, which reduces precision and compromises surface finish.

In cyclical applications backlash results in what's known as lost motion. When the drive shaft changes direction the shaft rotate slightly before the load is taken up. In applications where changes of direction are frequent there is a cumulative effect at every reversal and the positioning error grows.

The perfect coupling for linear applications will have no backlash, be torsionally stiff possible and still be tolerant of as much misalignment as possible. Couplings designed for this sort of condition are known as anti-backlash or precision couplings.

Sizing a coupling

The following factors need to be specified and or considered in selecting a coupling.

Torque: Most couplings have a rated and peak torque. Rated torque is the torque the coupling can transmit on a continuous basis. Torque above peak for the coupling will see the coupling immediate fail and any torque between rated and peak will reduce the service life of the coupling.

Speed: Couplings have a maximum rated speed due to balance constraints. This speed reduces with size.

Shaft size: The size of the two shafts is an important consideration. Each end of a couple can be different sizes but there is a minimum and maximum each size coupling can accommodate.

Rigidity: Mostly discussed above but consider higher rigidity will add cost.

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Misalignment: The amount of misalignment present may determine which coupling can be used. Keeping the misalignment below 30% of maximum will greatly extend the service life of the coupling.

Environment: Elevated temperature and some chemicals can reduce the couplings service life. Corrosion resistance with nickel plating or full stainless is available in some types of couplings.

Inertia: Low inertia is desirable to reduce inertia which increases machine response.

Shaft clamping

The method of clamping the shaft to the coupling can have a major impact on ease of assembly and the fatigue life of the overall system.

A set screw is a common way to clamp but really only suitable for low torque applications. The set screw can easily damage the shaft, causes fatigue and is sensitive to vibrations.

A key way is also widely used and can be effective in many applications. Best practice is to use additional set screws to hold the key and shaft. Keyways require additional machining to reasonable tolerances. The keyway can also create stress raisers and hence fatigue.

Clamp type couplings have better torque carrying than set screws and do not cause damage to shafts. They require little shaft machining do not create stress raisers and are simple to install. Care must be taken in the torque carrying capability and tightening torque.

Taper types have perfect symmetry, the highest torque carrying capability and shaft machining is simple. This type is generally only available on larger couplings.

Note the shaft insertion length can also have an impact on application. If the shaft does not extend long enough into the coupling it may not carry the rated torque. If it is inserted too far then in may interfere with the other side of the coupling, reduce the misalignment capability and reduce service life.

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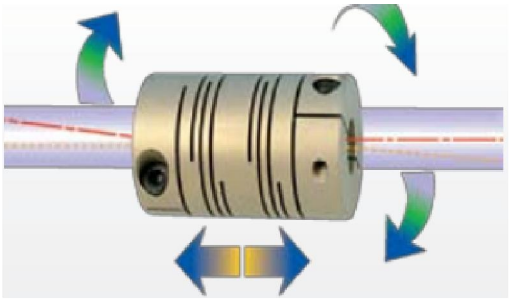
Commonly available precision couplings

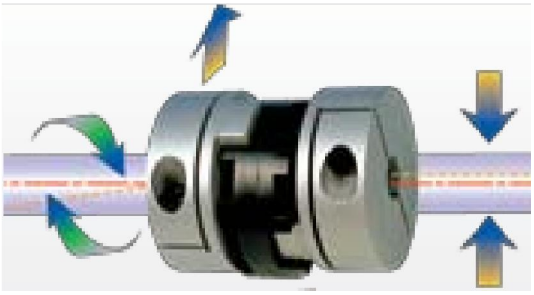
Beam coupling:

Beam couplings offer high durability, low inertia with excellent concentricity and speed range. Stainless steel types are available and there are different options of length and beam pattern which has an effect on speed and torque ratings. They have relatively stiff and zero backlash and popular in small CNC machines. Due to their complex structure they can be more expensive than some other types.



Oldham coupling:

Oldham couplings offer good misalignment and torque capability. These couplings also act as a mechanical fuse with failure being limited to the centre element and the two hubs can rotate freely to disconnect the load. The centre element can be replaced on its own independently of the two hubs. Their simple and robust construction also makes them more economical than other types. They are popular in general industrial applications.



Precision jaw coupling:

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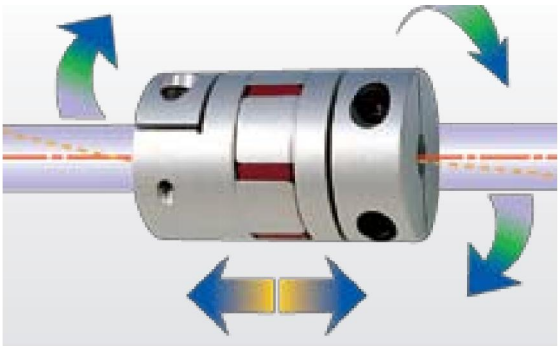
These are of similar design to the commonly available jaw couplings used in industrial applications. Unlike industrial types they have aluminium hubs, precision construction and preloaded inserts. For ant backlash operation the transmitted torque needs to be less than rated. Different inserts are available to modify shock absorbing and stiffness attributes. The interference of the jaws means they are fail-safe in event of insert failure.



Disc coupling:

Disc couplings have excellent torsional stiffness, high torque ratings and low inertia but lower misalignment ability. Due to the larger number of parts and assembly requirement they are more expensive than other types and often used in commercial CNC applications.