Importance of Coupling Alignment

By Mr. S. J. Mehta, Executive Director, Rathi Transpower Limited, Pune

Studies over the past forty years indicate that 60% of all equipment breakdowns are due to poor alignment.Some surveys indicate that up to 90% of equipments run outside their recommended alignment tolerances.

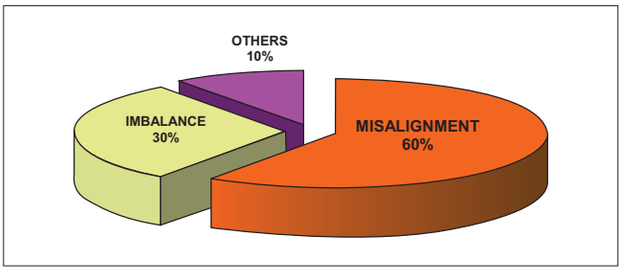


Fig 1 Breakdown analysis

When shafts are misaligned, the loading of shafts increases dramatically because of the reaction forces created within the coupling. These forces are major source of vibration, in addition few causes & effects observed on the equipment are as follows :-

Causes

- Misalignment (50%-70%)
- Imbalance (30% - 40%)
- Others (10%)

Effects

- Wear of mechanical components, seals, bearings, coupling parts etc. & in some cases even premature failure of components.
- Material fatigue namely size and shape, frequency of flexing, ambient temperatures and the ability of the material to absorb and / or transfer heat, affects the material life.
- Seal material, elastomeric coupling element, is forced to flex repeatedly causing heat build-up and results in premature failure.
- 50-70 % reduction of calculated life time of the components.
- Lubrication problems are caused by leakage in the seals, resulting in insufficient lubrication.
- Cavitations in pumps.
- Power consumption increases significantly.

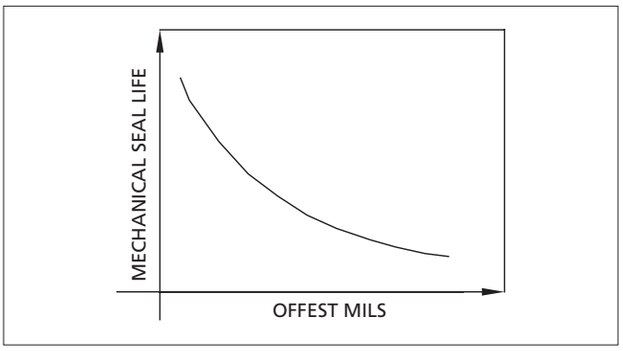
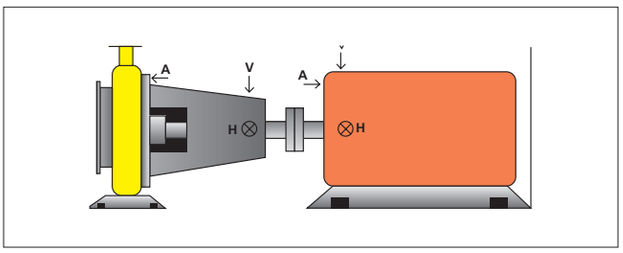


Fig 2 B

Fig 2 B represents the relationship between mechanical-seal life and offset misalignment. It doesn't take much misalignment to reduce the seal life by 90 %.

Measurement of Vibrations and Analysis



Vibrations can be measured in following positions and gives general information(as shown in above figure):

- Horizontal vibrations indicates imbalance (H)
- Vertical Vibrations indicate a weak or loose foundation (V)
- Axial vibrations indicate misalignemnt (A)

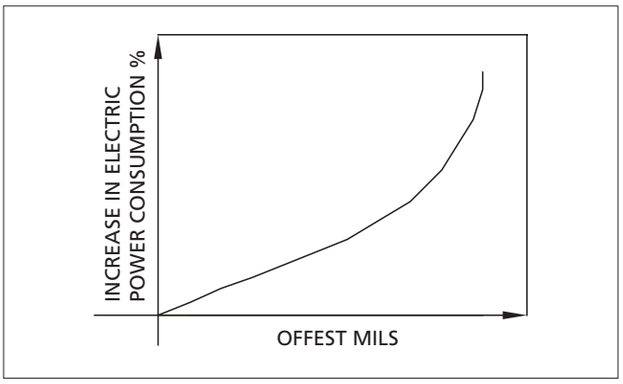


Fig 2 A

To quantify the benefits of alignment ref Fig 2 A. If we add up the power consumption of large pumps (circulating water, boiler feed water, condensate etc.) the cost of alignment and monitoring the same is negligible.

Alignment Methods

There are many alignment methods, but three methods are most common.

1) Straight edge / Feeler gauge method

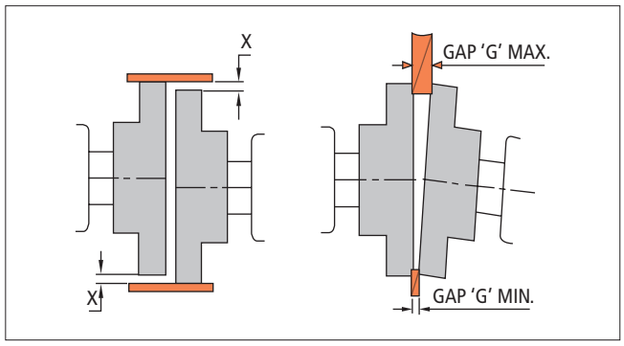


Fig 3 Eye Ball alignment method

It is a method of alignment in which a straight and feeler gauge is used to determine the amount of angular and parallel misalignment. The advantage of this method is that alignment is quick and no special tools & skills are required.

2) Rim and Face Alignemnt Method

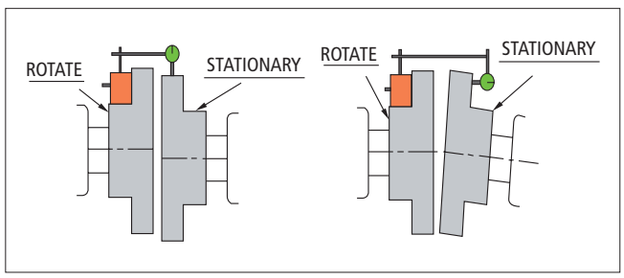


Fig 4 Alignment with dial indicator

In this method of alignment, dial indicators are used to align the two datum axes. The readings are taken and the amount and type of corrections to align the datum axes is calculated using either mathematical formulas or graphical plots.

3) Laser Alignment

Laser optic alignment device uses a laser beam. Information is fed to a microprocessor to indicate adjustments that are needed to be made. The advantage of laser alignment is speed of alignment and precision of alignment. The drawbacks are cost of alignmet equipment and the training required.

By using above alignment methods, (based on the suitability and cost) required alignment can be achieved.

In addition to the above alignment tools shims are required of proper size and thickness. These shims must be clean and made from corrosion and crush-resistant material. Make sure that these are free from burrs, bumps, nicks and dents. If commercial shims are used, verify actual thickness with a micrometer before use.

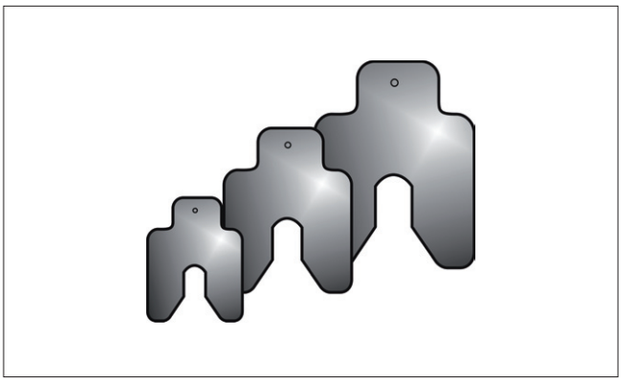


Fig 5 Alignment shims

Coupling Manufacturing and Misalingment

When a coupling is manufactured, each of its components has built-in tolerance which can affect the ease of installation as well as limit the accuracy achievement. The limitations results in forces on connected shafts, heat generation, vibration, overall life of components.

A coupling's permissible misalignment has many defining attributes. These include torque to be transmitted, requirements of connected equipments, rotating speed, duty cycle, heat dissipation and capacity to withstand the same, coupling type and design characteristics.

Based on these parameters coupling manufacturer decides the permissible misalignment capability of the coupling.

Coupling is to be installed within 25% of the permissible misalignment specified by the manufacturer. So, the 75% of the permissible misalignment of a coupling is a available during operating condition.

Coupling allows misalignment in three ways: -

1) Due to clearances between surfaces allowing relative movement between components.
2) Flexing of elements.
3) Combination of both.

The amount of relative motion of flexing of the element ultimately determines the life of components.

Symptoms of Misalignment

Misalignment is not easy to detect on machinery that is running. The radial forces transmitted from shaft to shaft are typically static forces (uni-directional) and are difficult to measure externally.

Consequently what we actually see are the secondary effects of these forces. They will exhibit many of the following symptoms:

- Premature bearing, seal, shaft or coupling failures.
- Excessive radial and axial vibrations.
- High temperatures at or near bearing housing / casing or high discharge oil temperature.
- Excessive amount of oil leakage at the bearing seals.
- Loose foundation bolts.
- Loose or broken coupling bolts.
- Some flexible coupling designs run hot under misalignment conditions. If it is of an elastomeric type, look for powder inside the coupling guard.
- Excessive amounts of grease (or oil) on the inside of the coupling guard.
- The shafts are breaking (or cracking) at or close to the inboard bearings or coupling hubs.
- Unusually high number of coupling failures or faster / increased wear rate .

Note, that the flexible couplings do just what they are designed to do.... they flex to accommodate misalignments. But the shafts are flexible too, and as the forces become more severe, ultimately the misalignment also increases and the shafts also flex.

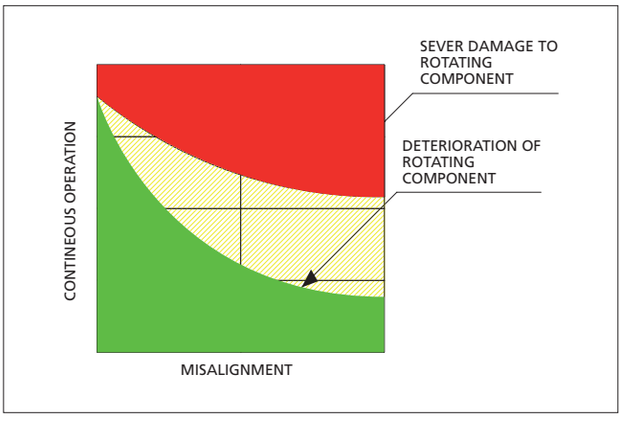


Fig 5 A Coupling life

The fig 5 A shown here illustrates the estimated time to failure of a typical part of rotating equipment based on varying alignment conditions. The term "Failure" here means a degradation of any critical component of the equipment such as seals, bearings, coupling, shaft or rotors. The study revealed that misalignment is the root cause of the failure.

Frequency of Alignment Check

The rotating equipments can move around immediately after it has been started. This is fairly a rapid movement and the shafts eventually take a somewhat premanent position after the thermal and process conditions have stabilized (anywhere from 2 hrs to a week in some cases).

When the rotating equipment starts, the shafts start moving to another postion. The movement is due to temperature changes that are caused by friction in the bearings or by thermal changes that occur in the process liquids and gases. Movement of equipment may also be caused by process reaction moments in connected piping or counter-reactions due to the rotation of the rotor.

However, there are slower, more stubtle changes that occur over longer period of time. Equipment slowly changes its position due to various reasons such as : setting base soils underneath the machinery causes the entire foundation to shift, seasonal temperature changes etc. This also causes concrete, base plates, piping and conduit to expand and contract.

It is recommended that newly installed equipment be cheked for any alignment changes anywhere form 3 to 6 months after operation has begun. Based on the findings during the first or second alignment "checkup", the future check up frequency can be decided.

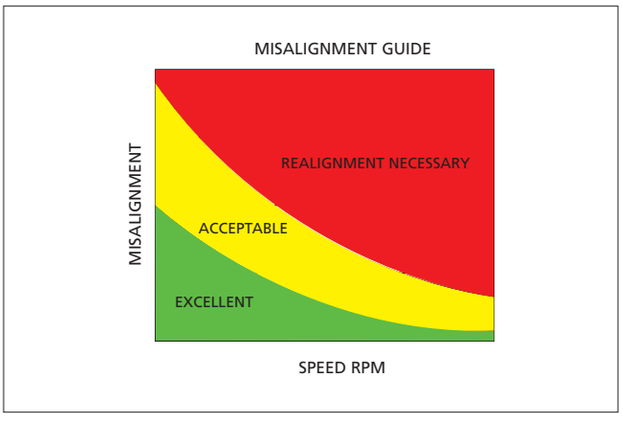


Fig 6 Misalignmnet Guide

The goal of the mechanic doing the alignment is to positon the equipments such that all of these deviations are below tolerance values. A tolerance guide is shown in fig 6 It will serve as a guideline for establishing a goal for the people who are involved in the alignment process. This is representative graph, values will differ for different types of coupling & application.

Alignment Procedure

The "Macro" procedure can be as follows:

- Carry out pre alignment checks
- Rough alignment to "eyeball clean" (with bolts loose.)
- Rough soft-foot correction : Fill any gap if existing.

Note :

SOFT FOOT: A gap between one foot of an equipment and foundation is generally referred as "soft foot". A pump or motor typically has four feet and generally rests on three, leaving a gap under the fourth. This is called soft foot and if left unshimmed, than the equipment frame will distort from its resting position as the bolts are tightened to secure it in place. This distortion bends the shafts and preloads the bearings. The later is one of the leading causes of premature bearing failure.

- Initial alignment: Get to within 5 to 15 mils at the coupling or less than 20 mils at feet.
- Final soft foot: All feet to less than 2 mils.
- Final alignment within tolerances as specified by coupling manufacturer.

Other Check Points

Check deficiencies which could prevent the attainment and retention of good alignment. Good engineering practice suggests concrete foundation to be three times the weight of rotating driver and driven equipment five times, for reciprocating equipment assembly.

Check grout condition, no voids below the base plates. Make sure the same is cured properly prior to starting alignment work.

The base plate must be rigid, so no part of foot moves more than 1 mil out of plane with other feet on the same equipment. Use a straight edge and feeler gauge to verify that mounting pads are in level, flat, parallel, coplanar and clean. Be sure to select hold-down bolts of proper size with enough clearance to permit any corrective movement required.

Piping should be well fitted and supported and sufficiently flexible, so that shaft movement is not more than 2 mils when the last pipe flanges are tightened.

In some cases, pipe expansion or movement, leads to misalignment and increased vibration. Better pipe supports, stabilizers or flexible spool pieces may be needed in such situations.