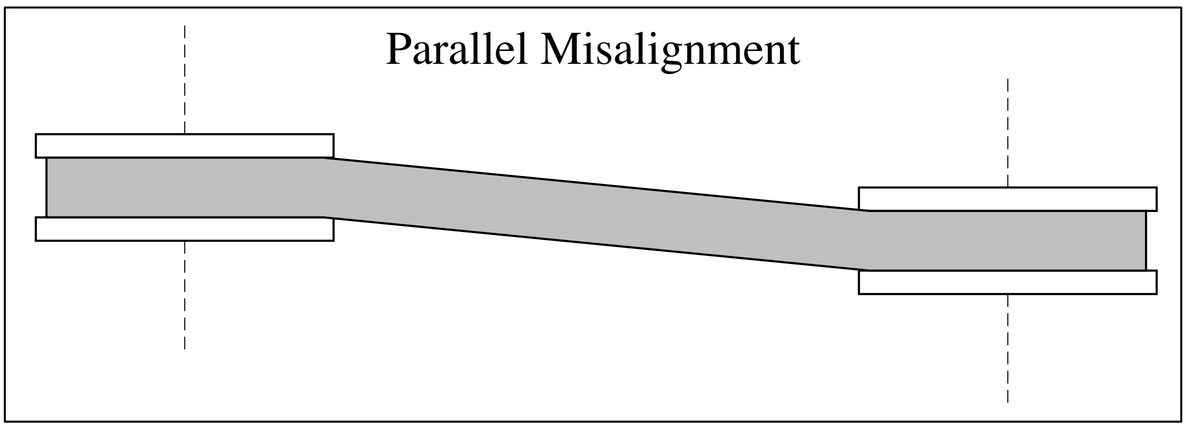
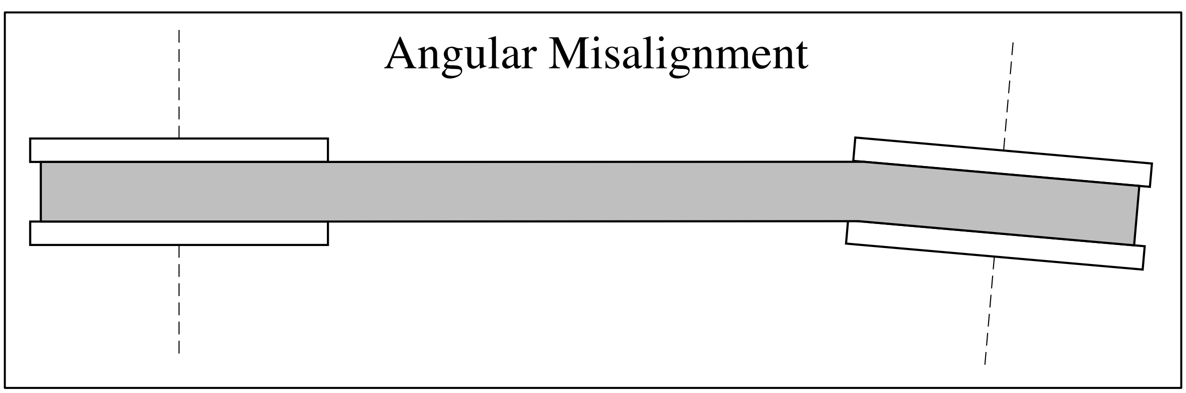
Pulley Alignment

There are many different factors that contribute to machine downtime when considering Sheave/Pulley, Belt and Bearing wear. The single biggest factor that can impact the reliability of belt driven equipment is pulley alignment. Just a few minutes of intentional pulley alignment can lead to extended service life. Depending on its severity, misalignment can gradually reduce belt performance by increasing wear, slip and fatigue. Or, it can destroy a belt in a matter of hours or days.





Any degree of misalignment, angular or parallel, will decrease the normal service life of a belt drive. The goal in sheave alignment is to position the plane created by the rotation of the moveable sheave to be "co-planar" with the plane created by the stationary sheave.

A generally accepted alignment tolerance for belt drives recommends the following:

"As a general rule, sheave misalignment on V-belt drives should be less than $^1/_2$ degree or 1/10″ per foot of drive center distance. Misalignment for synchronous, Polyflex and Micro-V belts should be within $^1/_4$ degree or 1/16″ per foot of drive center distance."

Rules of Thumb

It may not be practical or possible to accurately calculate misalignment in a total system while determining if it is in acceptable alignment. It is also difficult to visualize small fractions of an angle such as 1/4 or 1/2 deg. These angles are illustrated with the following rule of thumb:

- For V-belt drives: 1/2 deg. = approximately 1/10 in. offset per foot.
- For synchronous, 60 deg angle, and V-ribbed drives: 14 deg = approximately 1/16-in. offset per foot.

It is also understood, however, that ***"The greater the misalignment, the greater the chance of belt instability, increased belt wear and V-belt turnover."***

This tolerance is designed to provide acceptable life for the belts and sheaves, not necessarily the rest of the machine components.

As with all transmission systems, better alignment typically results in better performance with fewer failures and higher efficiency. With the current laser based measurement technology available today, these recommended tolerances are easy to improve upon.

Degree Conversion:
$^1/_2$ degree sound like a pretty small number, but keep this conversion in mind:
1 degree = 17 mils/1″
$^1/_2$ degree = 8.5 mils/1″
$^1/_4$ degree = 4.25 mils/1″

For a drive with a 36″ distance between drive centers, the Gates Tolerance would be as follows: 8.5 mils/1″ multiplied by 36″ = 306 mils, allowable offset! This also works for the 1/10th inch per foot of center distance. 1/10th inch = 0.100″. 36″ = 3', therefore the allowable misalignment would be 0.300″.

There are several methods currently employed to align sheaves.

- "Eye-Ball" Alignment
- Straight-Edge Alignment
- Face Mounted Laser System

Eye-Ball Alignment is when the alignment of the sheaves is evaluated by visual inspection of the belt grooves and possibly the "straightness" of the belt when the tension is adjusted. Obviously there are severe drawbacks to this method. This method depends greatly on the ability of maintenance personnel, distance between the sheaves, quality of the belts, etc. This method is also not very repeatable from operator to operator.

Straightedge alignment is just what it sounds like. A straight edge is placed on the outer faces of the sheaves. Any deviation in the alignment will present itself as a gap between the sheave face and the straightedge. While this is an improvement in the alignment of the sheaves, this still leaves several areas for improvement. First, while this method addresses the amount of "pigeon-toe" and "offset" it does not address the "twist" or vertical angle measurement. Alignment is completed when the sheaves touch the straight edge at all edges of the sheaves.

This method also has a drawback with very long span drives. Precision straight edges are bulky, expensive and hard to manipulate. They often require great care when transporting and storing and require at least two people to measure.

Another drawback of this measurement method is the quality of the sheave, or whether the sheaves on the driving and driven machine are made by the same manufacturer. As far as sheave quality is concerned, the manufacturing drawings have a very large tolerance for the distance from the sheave face to the center of the first belt groove. This value is not critical to the sheave manufacturers. This distance on some sheaves deviates by as much as $1/16^{th}$ inch. For two sheaves, the deviation has the potential to be doubled. That deviation could cause an offset error of $1/8^{th}$ inch. The factors above will cause the distance from the face of the sheave to the belt groove to vary from sheave to sheave. Remember the goal above, to align the planes of power transmission, i.e. the belt grooves. Aligning the faces of the sheaves is counter productive if the distance from the face of the sheave to the belt grooves is inconsistent. Another quality issue is the surface finish of the face.

Typically, these are not precision-machined surfaces. A "bump" or high spot on the sheave face will force an angular error into the measurement. An error as small as 0.010″ on a 6-inch diameter sheave will result in a fairly significant error.

Laser Based Measurements

Face Mounted Laser Systems were the first real attempt to address the Vertical Angle or "twist" misalignment as well as the pigeon-toe and offset. This method uses a line laser transmitter magnetically mounted to the face of one of the sheaves. Three targets are mounted on the face of the other sheave. The amount of misalignment is interpreted by noting the difference height of the laser as it strikes the targets.

Again, great care must be taken to measure the distance from the sheave face to the belt groove. Recent changes in this method are the addition of "adjustable targets" in an attempt to improve the accuracy of the face mounted laser based sheave alignment tools.

Most of the face-mounted systems also offer a "low-cost" or "compact" version of their systems. Alignment is completed with this type of system when the line laser strikes the monuments at their "target center". The farther the monuments are apart, the better the results of the alignment.

1. Pre Alignment Checks
    A. Inspect sheaves and belts for wear/deterioration. If excessive wear is noted, the component should be replaced. If a belt is worn, all the belts should be replaced.
    B. Generally speaking when using a Belt/Sheave gage, if wear in excess of 1/32″ is noted, the component should be replaced.

2. Measure sheave groove in the axial direction for TIR.
    A. By mounting a dial indicator with the plunger directed toward one side of the belt groove, you will be able to accurately measure how much the sheave is cocked on the shaft.
    B. Excessive axial runout can also be caused by excessive sheave wear. Often, this axial TIR can be corrected by adjusting the take-up bolts on the tapered bushing. Axial TIR should not exceed 0.5 mils/1″ of sheave diameter. For sheaves larger than 10 inches in diameter, Axial TIR should not exceed 5 mils.

3. If excessive axial TIR is noted, measure the runout of the machine shaft. Shaft TIR should be less than 0.002″.

4. Measure the sheave radial TIR. Sheave eccentricity will cause large values of radial TIR. Tolerances for radial TIR are similar to those for Axial TIR. Large amounts of radial TIR are often the result of a defect during manufacturing.
    A. Radial TIR, if excessive, will cause high 1X sheave rpm vibration in the direction of the belts, sometimes mistaken for unbalance of the sheave or fan rotor.

5. Check and correct motor soft foot.

6. Mount the measurement system and evaluate the results.

7. Alignment corrections should be made in the following order:
    A. Correct Vertical Angle or "Twist".
    B. Correct Horizontal Angle or "Pigeon-Toe".
    C. Reposition sheaves axially on the shaft to correct offset.

If you are using a face mounted system relying on monuments, it is very important to reverse the fixture setup and verify the alignment looking the other direction. The reason is simple; small amounts of Horizontal Angularity may not be seen until the distance traveled by the laser beam is increased. Let's consider the following example:

Sheave A is 10″ diameter
Sheave B is 20″ diameter
Distance between sheave centers is 36″

With the monuments mounted on sheave A and the Transmitter mounted on sheave B a difference in laser position on the monuments of 0.020″ may be undetectable to the naked eye. That is 2 mils/1″ of Horizontal Angularity. By reversing the setup, that 2 mils/1″ angularity is projected over 46″ (center distance + Sheave B radius). Now the laser line will appear 0.086″ (over 1/16″) from the center of the monument, very easy to identify with the naked eye. Following the proper alignment of the sheaves, it is important to properly tension the belts. Over-tensioning of the belts significantly increases the loading on the bearings of the machines.

Conclusion

Misalignment can be an obstacle for satisfactory synchronous and V-belt drive performance. In many cases, it is not easily detectable in complex drive applications. Maintenance technicians should also check related components, such as brackets, braces and platforms, for proper design and placement. These components must be strong enough to withstand the peak forces exerted by the belt drive without bending or flexing. When making belt changes please be sure to change all of the belts in the power transmission plane to get the longest run from the equipment.

With a few simple alignment steps, you will increase the run time of your machinery.

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