TOTAL ALIGNMENT CAN REDUCE MAINTENANCE AND INCREASE RELIABILITY

by

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INTRODUCTION

There are several acceptable alignment methods presently available. Despite their diversity, one common thread of agreement is noted. That is, maximum machine life and optimum runs will not be attained unless the machines' shafts are essentially collinear at service conditions.

Contrary to popular beliefs, flexible couplings do not reduce the need for accurate alignment. Actually, the primary purpose of flexible couplings is to absorb minimum angular misalignment and end thrust, not large angular forces resulting from slipshod alignment techniques.

The accuracy with which ambient-condition misalignment can be measured has increased significantly in recent years. Unfortunately, knowing the exact cold position offers little help toward the primary goal of attaining precisely-aligned equipment at equilibrium conditions.

True alignment (exactly collinear axes) can seldom, if ever, be achieved at running conditions without knowing the thermal relationship of the shafts to be aligned. Calculating the differential thermal movement between operating machines has not proven satisfactory due to outside influences (foundation settlement, piping strain, etc.).

In order to guarantee that the service condition alignment is within acceptable tolerances, it is necessary to:

- Measure shaft relationship accurately at ambient conditions and establish base alignment data.
- Monitor relative shaft position from ambient to normal operating conditions.
- Offset alignment of the shafts to compensate for the known thermal movement.

There are several acceptable methods available to accurately measure ambient to service condition movement of rotating machinery. The user should determine which method is best suited to his application. Quoting Al Campbell, "It's not as important which method you use, as it is that you use one". In some cases it has been helpful to use a combination of these techniques.

The method covered in this paper is the DynAlign Bars (Dodd Bars). These bars are manufactured and marketed under a license granted by Chevron Research Company, U.S. Patent No. 3,783,522. The bars provide a direct method for attaining accurate shaft alignment at equilibrium (normal running) conditions and for continuous tracking to ensure that alignment is maintained during actual operation. The bars make it possible to measure and compensate for the thermal "growth" that occurs in equipment from the cold state to normal operating conditions.

COLD ALIGNMENT

The primary goal of any alignment program should be to strive for near shaft collinearity at the operating conditions. Near collinear alignment is possible using the DynAlign method. However, for this or any other alignment technique to work, certain prerequisites are vitally necessary:

- The foundation must be properly installed and the base should be parallel with respect to the machine's shaft.
- The machines must be free of piping strain. This is accomplished with the use of proper supports, hangers, expansion joints, etc.
- The machines must be resting firmly on the mounting bases, with equal loading on each support. Sufficient clearance must be provided in the hold-down bolt-holes to permit adequate movement for future adjustments.
- The machines' supports and baseplate pads must be square with respect to each other. They must be free of burrs and other obstructions.
- The shim-pack must provide a firm, solid, adjustable link between machine and baseplate. The best arrangement is one thick laminated shim with peel-off segments. Starting-point shim-pack thickness is normally ¼ inch.
- Indicator mounting brackets must be fabricated and securely fastened to the coupling hub or shaft in such a manner that the indicator bracket "sag" will be minimal. If the indicator bar "sag" cannot be eliminated, it must be accounted for in the indicator's readings.

If the DynAlign bar method of continuous alignment monitoring is to be successful, precise cold alignment data must be available. For this reason, reverse dial-indicator readings are recommended.

The accurate, static shaft relationship is determined by affixing a dial indicator to one shaft and measuring the periphery of the second shaft. The indicator simply represents
the projected center line of the shaft to which it is attached and establishes its position relative to the second shaft.

Figure 1 shows the reverse dial indicator method of making static alignment measurements. Reverse dial readings are the most effective way to establish the index or reference point required to take full advantage of the DynAlign capabilities. The DynAlign bars electronically indicate dynamic shaft movement relative to the static positions initially established by dial readings (Figure 2).

ALIGNMENT METHOD

Basically, the method is simple. Alignment bars, representing the projected offset center lines of two machines, are attached to the inboard bearing housing of each unit. Noncontacting transducer probes are used to measure the relative movement between the bars, indicating the thermally induced travel of the two shafts.

The alignment bar attached to the driver holds two pairs of noncontacting proximity sensors; the second bar attached to the driven equipment holds two pairs of corresponding targets. One pair of sensors monitors the horizontal and vertical alignment at the driving shaft; the second pair performs the same functions for the driven shaft. Any change in the distance between the rotating shaft centerlines causes a corresponding change in the sensor outputs, indicating the amount and direction of movement (Figure 3).

The alignment bars are the most critical part of the system, and they are designed to be as insensitive as possible to either mechanical disturbances or temperature change. Each bar is constructed from three parallel sections of stainless steel airframe tubing, arranged in a triangular configuration and reinforced by braces placed at regular intervals. The resulting structure combines the low mass and extreme rigidity necessary to resist wind currents generated by high speed couplings. The bars are made of stainless steel to resist corrosion and, therefore, are especially suited for permanent installation for continuous alignment monitoring. They can be located inside the shaft coupling guard.

The bars are designed for internal air or liquid coolant circulation to maintain thermal stability in high temperature environments. To insure accuracy and repeatability, the bars are mounted on special plates made from an alloy of 36% nickel-steel, especially chosen for its excellent temperature stability (INVAR 36).

The sensor system consists of four eddy probes mounted on one bar with corresponding targets mounted on the other. The eddy probe is a distance-to-voltage transducer designed to measure either dynamic motion or, as in this case, static gap. A probe and target are shown in Figure 4. The probe consists of a flat coil of wire molded into a plastic case that protects it from shock or vibration. It receives a radio-frequency signal that is generated by an eddy probe driver and transmitted over singlewire shielded cable. The signal develops a small electromagnetic field around the coil, part of which is absorbed by eddy currents flowing in the target surface. The amount of absorption is proportional to the distance between the eddy probe and the target, increasing or decreasing as they move closer together or farther apart.

Figure 3. Eddy Probe and Block Utilized in the DynAlign System.
The eddy probe driver detects the degree of field absorption by the target and produces a DC voltage directly proportional to the distance between the shafts. The displacement range of the eddy probe driver output is from 1 to 100 mils with 40 micro-inch resolution. Outputs from the eddy probe drivers are displayed on an alignment monitor, shown in Figure 5. It is portable and may be carried from one location to another, serving as the monitor for a number of installations. It displays the signals from each of four eddy probe driver units on individual vertical scale meters which are calibrated directly in mils of deflection, as were the dial indicators used for static alignment measurements. The readings, therefore, indicate mils of deviation of the shaft centerlines from their collinear positions.

Utilizing the tool outlined, the following alignment procedures are effective in eliminating misalignment as a source of machinery problems:

1. Obtain cold alignment data by the reverse dialing method.
2. When previous thermal expansion measurements are not available, the equipment should be offset-aligned for expected thermal movement using the calculated or other "best guess" methods.
3. Install the bars and reference them to the cold alignment base data. The bar installation should be made with the machine at the same ambient conditions as when the cold data was taken.
4. Monitor the alignment of the machines and record from cold to normal running conditions.

5. Plot a graphical explanation of the relationship of the machine for both cold and hot alignment. This method is helpful in determining the amount of offset alignment at ambient conditions necessary to achieve a satisfactory shaft relationship at normal running conditions.

6. With the machine down, compute shim adjustments and side-to-side movements mathematically. In most cases, both vertical and horizontal alignment corrections can be accomplished in one move (by the use of several strategically located indicators on the machine to be moved). Although the corrective adjustment may be plotted on suitable graph paper, mathematical computations probably offer greater accuracy.

7. Record the final alignment data at the normal operating conditions. Periodic alignment checks will reveal any changes induced through foundation settlement, piping strain, temperature change, etc.

Once the alignment bars have been properly installed and referenced to the cold dial-indicator reading, they can be used for aligning the machines. If alignment changes are necessary, the bar reading will serve as a dial indication. Alignment adjustment time is greatly reduced since the coupling guard need not be removed nor the coupling parted. Successful on-the-line adjustments have been made using this method.

CONCLUSION

Is there a better way? This was the question that inspired the development of the alignment techniques covered in this
paper. The main objectives were: (1) to reduce the cost of maintenance and down time caused by running equipment misaligned, (2) to continuously monitor the alignment of in-service equipment, (3) to minimize the time required to align machines, and (4) to simplify the entire alignment program and to train mechanics and millwrights to perform the complete sequence (tracking of movement, determine desired offset, and align machine). All these objectives have been accomplished. Hopefully the information presented will aid the reader to similar achievement.

BIBLIOGRAPHY