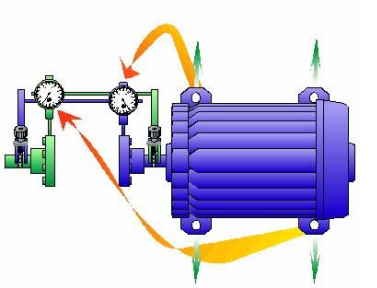

MECH-201: Precision Shaft Alignment… using dial indicators

Abstract

Even with the advent of new computerized dial indicator and laser alignment systems, knowledge of the basics of shaft alignment is a must. Those who purchase new alignment instruments and hand them out to field technicians who lack the knowledge of alignment fundamentals are often disappointed in the returns from their investment.

The fact that shaft misalignment is the largest contributing factor to premature machinery failure has been emphasized in recent years. As a result, alignment tools and alignment training, along with the "precision maintenance movement," have improved significantly. Yet, certain machines continue to either run poorly or fail prematurely due to misalignment. Why?

This activity-based seminar focuses on the fundamental skills required to perform precision alignment tasks. This course starts at the beginning, with the definition of *shaft alignment.* The importance of proper shaft alignment is emphasized, including the adverse effects of misalignment on bearing life and electrical energy consumption. Types and terms of misalignment and other basic concepts are discussed and reinforced through numerous group activities. Graphical and calculation/computer solutions for simple and complex alignment problems are provided. Proper use of rim-face and reverse dial indicator alignment processes are addressed based on client needs.

This seminar provides solutions to simple and complex alignment tasks. Depending on student backgrounds and seminar duration, more advanced alignment subjects can be included in the curriculum. The more advanced subjects include procedures and techniques for efficient alignment of multiple machine trains such as turbine-generator and compressor sets, alignment of machines with vertical shafts, proactive solutions for dealing with bolt-bound and base-bound problems, as well as an advanced look at soft foot, base problems, and the adverse effects of machine frame distortion.

Detailed procedures on each subject, a minimum of 50% hands-on activities, and the how-to's specific to certain alignment methods/instruments make this seminar truly unique.

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Seminar Duration

The duration of this seminar ranges from 24 to 40 hours depending on client preference, worker availability, and shaft alignment background.

Who should attend?

This seminar is designed primarily for maintenance, engineering, technical support and management personnel whose job functions involve alignment of rotating machinery. The scope of content is appropriate for those who align machines, those who detect, investigate and resolve premature machinery failure problems due to misalignment, as well as those who direct activities relative to alignment and machine reliability.

Associated Task(s)

PSADI-1. Align two coupled rotating machinery shafts to specified tolerances using rim-face and reverse dial indicator processes, including proper planning, rough and precision alignment per approved procedure.

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Seminar Objectives

Upon completion of this training the student will be able to properly:

1. Explain common symptoms and causes of misalignment.

2. Explain the adverse effects of misalignment on machinery life, specific failure modes, and energy consumption.

3. Using proper terminology, explain a given set of shaft misalignment conditions.

4. Explain the following three major phases of alignment tasks:
   A. Planning and Pre-alignment
   B. Rough Alignment
   C. Precision Alignment

5. When given a prealignment checklist, explain the effect of each item listed on the overall alignment process and/or the machines' operation.

6. Perform each of the tasks listed on a given pre-alignment checklist.

7. Identify and explain the general types of soft foot.

8. Explain the effects of soft foot conditions on the alignment process and on machine operation.

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9. Explain and demonstrate how to detect and correct soft foot conditions.

10. Define basic terms associated with shaft alignment, including:
    A. Shaft alignment
    B. Offset
    C. Angularity
    D. Power planes
    E. Collinear
    F. Runout
    G. Repeatability
    H. TIR
    I. Bar sag
    J. Validity

11. Explain the general advantages, disadvantages, and sources of error associated with each of the following alignment methods:
    A. Straight Edge/Thickness Gauge Methods
    B. Rim-Face Dial Indicator Methods
    C. Reverse Dial Indicator Methods
    D. Laser Methods: Optalign, Combi, Rotalign, CSI, etc.

12. Demonstrate how dial indicators are properly used for various alignment tasks.

13. Discuss and demonstrate how to properly set up and use dial indicators to obtain reliable alignment data, including the importance of each of the following:
    A. Mounting rim dials/face dials so that the plunger is truly perpendicular to/parallel to the shaft centerline, respectively.
    B. Mounting reverse dials so that the plunger is truly perpendicular to the shaft centerline.
    C. Taking readings with dials at the true clock positions.
    D. Checking readings for repeatability.
    E. Eliminating the adverse affects of coupling backlash on readings.
    F. Checking readings for mathematical validity.
    G. Ensuring values and signs are correctly determined from indicators.

14. Explain and demonstrate how to compensate for dial indicator bar sag, including each of the following:
    A. How to determine how much bar sag exists.
    B. Effects on alignment processes.
    C. Two methods for correcting dial indicator readings for a given amount of bar sag.

15. Explain and demonstrate how the following methods are used to determine the required move(s) for correction of misalignment:
    A. Calculation From Readings and Distance Measurements
    B. Graphical Representation of Machine Dimensions and Shaft Axes

16. Explain and demonstrate how to perform precision alignment of horizontal machine shafts to within specified tolerances using rim & face and reverse dial indicator methods, including:
    A. How to properly set-up alignment hardware.
    B. Obtain and document needed hardware and machine dimensions.
    C. Measure and validate misalignment conditions.

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D. Document key data on a given alignment data sheet.
E. Interpret misalignment data.
F. Determine machine movement needed.
G. Correct misalignment conditions to within specified tolerances.

17. Explain and demonstrate graphical processes that can be used to find the optimum alternate moves when base-bound or bolt-bound conditions are encountered while trying to move a machine.

18. Discuss the purpose for alignment tolerance guidelines.

19. When given data from a completed alignment task, determine offset and angular misalignment that exists in the vertical and horizontal planes.

20. Explain the general effects of thermal growth on alignment processes and machine operation.

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Seminar Outline

1.0 Introduction
- 1.1 Making Precision Maintenance Happen
- 1.2 Seminar Overview, Objectives and Schedule
- 1.3 Universal Technologies Overview

2.0 Importance of Precision Alignment
- 2.1 Comparison to Other Machinery Problems
- 2.2 Common Symptoms and Causes of Misalignment
- 2.3 Effects on Electrical Energy Consumption
- 2.4 Effects on Bearing Life, Shafts, Seals
- 2.5 Effects on Machine Vibration
- 2.6 Alignment Importance Activities & Critique!

NOTE: This section is demonstration-intensive.

3.0 What is Misalignment?
- 3.1 Forms of Misalignment
- 3.2 Alignment Correction Axes
- 3.3 Offset Misalignment
- 3.4 Angular Misalignment
- 3.5 A 3D Perspective
- 3.6 Quantifying Misalignment Activities & Critique!

4.0 Overview of Alignment Processes
- 4.1 Prealignment and Planning Overview
- 4.2 Rough Alignment Overview
- 4.3 Precision Alignment Overview
- 4.4 Alignment Reality: Checks vs. Re-alignment Tasks
- 4.5 Alignment Tolerances
- 4.6 A Generic Alignment Task Procedure!

5.0 Prealignment and Planning
- 5.1 Planning Considerations
- 5.2 Prealignment Checklist Items
- 5.3 Prealignment Checks Demonstration
- 5.4 Prealignment Checks Hands-on Activities & Critique!

6.0 Soft Foot Detection & Correction
- 6.1 Definition of Soft Foot
- 6.2 Types of Soft Foot
- 6.3 How to Detect Soft Foot
- 6.4 Rough-In Soft Foot Procedures
- 6.5 Precision Soft Foot Procedures
- 6.6 Soft Foot Detection and Correction Demonstration
- 6.7 Soft Foot Detection and Correction Hands-on Activities & Critique

7.0 Overview of Alignment Methods
- 7.1 Straight Edges and Thickness Gauges
- 7.2 Rim-Face Dial Indicator Alignment

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7.3 Reverse Dial Indicator Alignment
7.4 Laser Alignment Systems Overview
7.5 Alignment Methods Activities & Critique

NOTE: This section is demonstration-intensive.

8.0 Proper Use of Dial Indicators For Alignment

8.1 Types of Indicators
8.2 Proper Indicator Setup and Use
8.3 General Setup Alternatives
8.4 Validity Checks
8.5 Hardware Sag: Measurement, Effects and Compensation
8.6 Dial Indicator Demonstrations
8.7 Proper Dial Indicator Use Activities & Critique

9.0 Precision Alignment Rim-Face Alignment Procedures: Horizontal

9.1 Rim-Face Indicator Setup Alternatives
9.2 Obtaining Valid Rim-Face Readings
9.3 Interpretation of Rim-Face Readings
9.4 Determination of Required Moves
  A. Calculation/Computer
  B. Rim-Face Graphing
9.5 Making Moves
9.6 Rim-Face Alignment Procedure and Demonstration
9.7 Rim-Face Alignment Hands-on Activities & Critique
9.8 Rim-Face Alignment Troubleshooting

10.0 Precision Alignment Reverse Dial Alignment Procedures: Horizontal

10.1 Reverse Dial Indicator Setup Alternatives
10.2 Obtaining Valid Reverse Dial Readings
10.2 Interpretation of Reverse Dial Readings
10.4 Determination of Required Moves
  A. Calculation/Computer
  B. Rim-Face Graphing
10.5 Making Moves
10.6 Reverse Dial Alignment Procedure and Demonstration
10.7 Reverse Dial Alignment Hands-on Activities & Critique
10.8 Reverse Dial Alignment Troubleshooting

11.0 Overview of Precision Alignment Shaft Alignment...special techniques

11.1 Precision Alignment of Multiple Machine Sets/Trains
11.2 Considerations for Dynamic Movement
11.3 Precision Alignment of Vertical Shafts

12.0 Conclusions

12.1 Tips For Making It Happen In The Workplace
12.2 Course Evaluation

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