Industrial Maintenance

Introduction to Mechanical Drive Systems

Courseware Sample

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Safety and Common Symbols

The following safety and common symbols may be used in this manual and on the equipment:

Symbol	Description
⚠ DANGER	**DANGER** indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
⚠ WARNING	**WARNING** indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
⚠ CAUTION	**CAUTION** indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
CAUTION	**CAUTION** used without the *Caution, risk of danger* sign ⚠, indicates a hazard with a potentially hazardous situation which, if not avoided, may result in property damage.
	Caution, risk of electric shock
	Caution, hot surface
	Caution, risk of danger
	Caution, lifting hazard
	Caution, hand entanglement hazard
	Notice, non-ionizing radiation
	Direct current
	Alternating current
	Both direct and alternating current
	Three-phase alternating current

Safety and Common Symbols

Symbol	Description
	Earth (ground) terminal
	Protective conductor terminal
	Frame or chassis terminal
	Equipotentiality
	On (supply)
	Off (supply)
	Equipment protected throughout by double insulation or reinforced insulation
	In position of a bi-stable push control
	Out position of a bi-stable push control

We invite readers of this manual to send us their tips, feedback, and suggestions for improving the book.

Please send these to did@de.festo.com.

The authors and Festo Didactic look forward to your comments.

Table of Contents

Table of Contents

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To the Instructor

- Before a student begins a work order, ensure that the equipment is in good condition and does not represent any risk when used.

- When a student has to complete a setup that is partially already mounted, ensure that the setup corresponds to the job description.

- This guide provides you with the answers to calculations, and measurements. Your evaluation, however, must relate to the quality of the accomplished work. Make sure that the objectives listed in the Work Assessment Table are met.

- When the jobs are performed in teams, ensure that each student has and installs a padlock when performing the lockout/tagout procedure.

- Make sure that the students understand the objectives of the job to do. They should have read the appropriate pages in their textbook.

- Contact the National Center for Construction Education and Research (NCCER), at *www.nccer.org*, to obtain the requirements relative to the NCCER accreditation of this course.

Sample Job Sheet

Extracted from

Introduction to

Mechanical Drive Systems

Shaft Alignment and Rigid Couplings

Rigid shaft couplings are used to join lengths of shaft of equal or different diameter. The main use is to extend the length of a shaft. It is rarely used to connect a prime mover directly to a load. A rigid sleeve coupling is shown in Figure 8-1.

Figure 8-1. Rigid coupling.

Unlike flexible shaft couplings, rigid shaft couplings do not allow errors in alignment, which may cause premature failure of bearings or shafts.

Rigid shaft couplings are installed after the shafts have been aligned. A straightedge and feeler gauge are used to measure and adjust parallel and vertical alignment.

Shaft Alignment and Rigid Couplings

OBJECTIVES

In this job, you will perform a shaft alignment and install a rigid coupling.

EQUIPMENT REQUIRED

- Universal Base Assembly, model 46603
- Motor Package, model 46609
- Couplings – Shafts Panel, model 46610
- Pillow Block Bearings Panel, model 46611
- Test/Measurement Package, model 46630
- Tool Box Component Package, model 46631

SAFETY PROCEDURE

Before proceeding with this job, complete the following check list.

☐ You are wearing safety glasses.

☐ You are wearing safety shoes.

☐ You are not wearing anything that might get caught such as a tie, jewelry, or loose clothes.

☐ If your hair is long, tie it out of the way.

☐ The working area is clean and free of oil.

☐ The floor is not wet.

☐ Your sleeves are rolled up.

PROCEDURE

Lockout/Tagout Procedure

☐ 1. Set the disconnecting switch to OFF.

☐ 2. Write your name on a tag, and install it in the lockout device.

☐ 3. Lock the disconnecting switch with the lockout device.

☐ 4. Lock the lockout device with your padlock.

☐ 5. Ask the instructor and each teammate to install their own padlocks in the lockout device.

Note: *The universal base should be set up from Job Sheet 7. Repeat Job Sheet 7 if necessary.*

Universal Base Setup

☐ 6. Loosen the pillow block bearing setscrews and slide the shaft away from the motor.

☐ 7. Remove the flexible jaw coupling halves, insert, and keys from the two shafts. Keep the rest of the setup intact.

☐ 8. Slide the sleeve coupling on the shaft supported by the pillow block bearings.

Vertical Angular Alignment

☐ 9. Adjust the gap between the ends of the shafts to approximately 0.125 in.

☐ 10. Line up the shaft keyseats and position them at the 9-o'clock position.

☐ 11. Lay a straightedge on the top of the shafts and measure the gap at two points using a feeler gauge as shown in Figure 8-2. Mark the position of the two points with a soapstone marker.

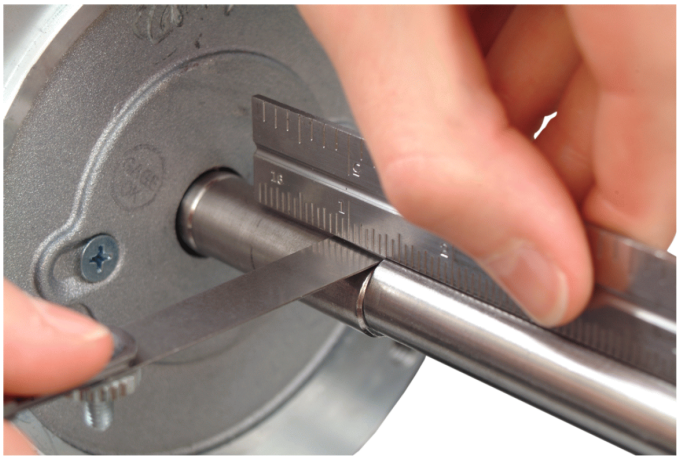

Figure 8-2. Vertical angular alignment.

Gap at point 1: _____

Gap at point 2: _____

☐ 12. Calculate the vertical angular misalignment by subtracting the smaller gap from the larger. Note the position at which the larger gap was measured.

Vertical angular misalignment: _____

Position of the larger gap: _____

☐ 13. Record the distance between the measurement points (soapstone marks) along the shaft.

Distance between measurement points: _____

☐ 14. Calculate the shim ratio using the following formula:

$$S_r = \frac{L_1}{L_2}$$

where S_r is the shim ratio;
L_1 is the distance between the slots of the motor base, in inches;
L_2 is the distance between the measurements points in inches.

Shim ratio: _____

☐ 15. Calculate the required shim thickness using the following formula:

$$S_t = S_r V_{am}$$

where S_t is the shim thickness in inches;
S_r is the shim ratio;
V_{am} is the vertical angular misalignment in inches.

Shim thickness: _____

☐ 16. Determine if the front or the rear of the motor must be shimmed.

Side to be shimmed: _____

☐ 17. Loosen the screws on the determined motor base side and install the shims.

Note: *An equal thickness of shims must be installed under the two front or rear motor screws to raise it evenly.*

☐ 18. Measure the gaps at point 1 and 2, and calculate the vertical angular misalignment.

Gap at point 1: _____

Gap at point 2: _____

Vertical angular misalignment: _____

Vertical Parallel Alignment

☐ 19. Measure the gap at one point between the shafts, using a straightedge and a feeler gauge.

☐ 20. Add shims with a total thickness equivalent to the gap under the four screws of the motor plate.

Horizontal Alignment

☐ 21. Line up the shaft keyseats and position them at the 12-o'clock position.

☐ 22. Lay a straightedge on the side of the shafts at the 3-o'clock position.

☐ 23. Loosen the four motor screws, and adjust the motor position until there is no gap between the straightedge and the shafts.

☐ 24. Tighten the motor screws.

Sleeve Coupling Installation

☐ 25. Install a key on both shafts. Make sure they are in line with the end of each shaft.

☐ 26. Slide the sleeve coupling along both shafts and make sure there is no interference at any point.

☐ 27. Tighten the coupling setscrews on the keys.

☐ 28. Ask the instructor to check your work.

☐ 29. Disassemble the setup and return the components to the storage location.

Name: _____ Date: _____

Instructor's approval: _____

Sample Work Order
Extracted from
Introduction to
Mechanical Drive Systems

Shaft Alignment and Rigid Couplings

Task: To align two shafts. To install a rigid sleeve coupling.

PROCEDURE

☐ 1. Perform the Safety Procedure listed in Appendix I.

☐ 2. Perform the Lockout/Tagout Procedure described in Appendix J.

☐ 3. What is the main function of a rigid coupling such as the one shown in Figure 8-1.

Figure 8-1. Rigid coupling.

☐ 4. Which of rigid or flexible couplings can accomodate the higher degree of misalignment?

☐ 5. Assemble the setup shown in Figure 4-3.

☐ 6. Install the flexible coupling on the driven shaft and use a feeler gauge and a straightedge to measure the parameters required for the alignment as shown in Figure 8-2.

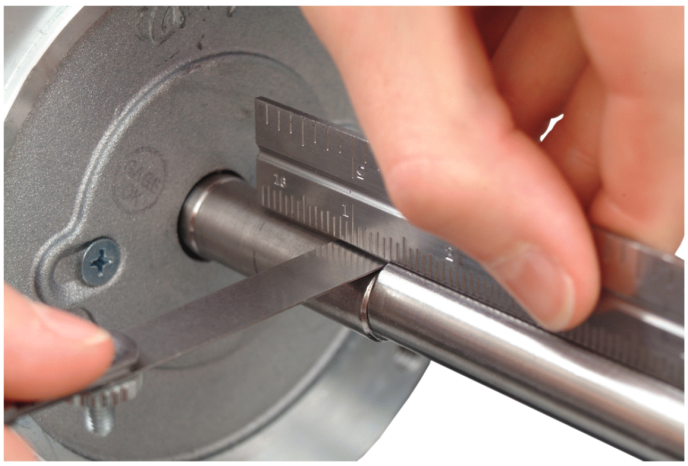

Figure 8-2. Measurement of a parameter.

Vertical Angular Alignment

☐ 7. Record the following parameters:

Gap at point 1: _____

Gap at point 2: _____

Vertical angular misalignment: _____

Position of the larger gap: _____

Distance between measurement points: _____

Shim ratio: _____

Shim thickness: _____

Side to be shimmed: _____

☐ 8. Install the shims.

Vertical Parallel Alignment

☐ 9. Measure the gap between the hubs and record it.

Gap: _____

☐ 10. Install the shims.

Horizontal Alignment

☐ 11. Adjust the motor position.

☐ 12. Complete the sleeve coupling installation.

☐ 13. Ask the instructor to check your work.

☐ 14. Disassemble the setup and return the components to the storage location.

Name: _____ Date: _____

Instructor's approval: _____

Other Sample Extracted

from

Introduction to

Mechanical Drive Systems

Post-Test

1. What does the meter indicate on the control panel?

   a. The voltage at the Motor outlet on the side of the control panel
   b. The voltage at the Motor outlet on the universal base
   c. The current delivered at the Motor outlet on the universal base
   d. The current delivered at the Motor outlet on the side of the control panel

2. To which position should the *Output Voltage* selector be set when using the constant speed motor on the universal base?

   a. Fixed
   b. Variable
   c. Any position is correct
   d. It depends on the use of the motor.

3. What is the use of the emergency button on the Start/Stop station?

   a. Controls the motors mounted on the universal base
   b. Produces an emergency noise
   c. De-energizes the Motor outlet on the universal base
   d. De-energizes the Motor outlet on the side of the control panel

4. Who must install a padlock on the lockout device?

   a. Each person involved in the job
   b. Only one of the person involved in the job
   c. The instructor only
   d. It is never mandatory to install a padlock.

5. When should the safety panels be installed?

   a. When there is an obvious risk of injury
   b. When the constant speed motor is used
   c. When asked by the instructor
   d. Before any setup is powered

6. What does a photo-reflective tachometer measure?

   a. The amount of light reflected by an object
   b. The current in a component
   c. The voltage in a component
   d. The angular velocity of a rotating component

7. What is a prony brake used for?

   a. Measure the input power of a prime mover
   b. Provide a means for applying an adjustable load torque to the output shaft of a prime mover
   c. Brake a motor until it stops completely
   d. Measure the current consumed by a motor when it stops

8. Where should a setscrew be tightened on a shaft?

   a. Only on a key
   b. On the flat surface of the shaft or on a key
   c. Directly on the shaft keyseat
   d. Preferably on the round portion of the shaft

9. What type(s) of coupling(s) can compensate for slight errors in shaft alignment?

   a. Flexible couplings only
   b. Rigid and flexible couplings
   c. Rigid couplings only
   d. Any existing type

10. What are the two basic types of shaft misalignment?

    a. Horizontal angular and parallel
    b. Angular and linear
    c. Parallel and angular
    d. Vertical angular and horizontal angular