Mechanical Equipment - Course 230.1

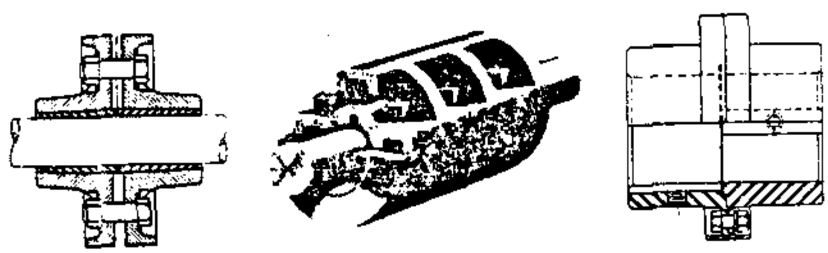
SHAFT COUPLINGS

Couplings

Couplings are used to join two shafts together and to provide some means of transmitting power from a driving source to a driven member. There are two main classifications of couplings, rigid or flexible.

Rigid Couplings

Three types of couplings are shown in Figure 1. Figure 1(a) shows a compression type. These couplings are used for light to medium loads. They consist of taper bored flanges and slotted, tapered sleeves bored to the shaft diameter. As the flanges are drawn together they squeeze the sleeves onto the shafts. The ribbed coupling in Figure 1(b) is used for heavy duty work and to connect two shafts of the same diameter. A single long key is fitted to both shafts and the two halves, which are bored and keyed to suit, are bolted together. The key rather than friction, provides a positive drive. Figure 1(c) illustrates a flanged-faced coupling which can be used to connect shafts of the same or different diameters. Each half of the coupling is bored and keyed to fit the shaft. Set screws secure the hubs to the shafts.

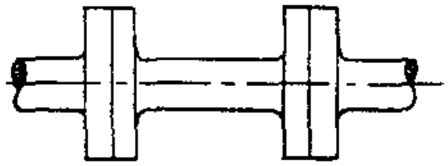


(a) (b) (c)

Couplings

Figure 1

The couplings on the turbo-generator sets at Pickering G.S. are short shafts with flanges forged on each end which mate with forged flanges on the rotor shafts as shown in the diagram below. The flanges are bolted together.



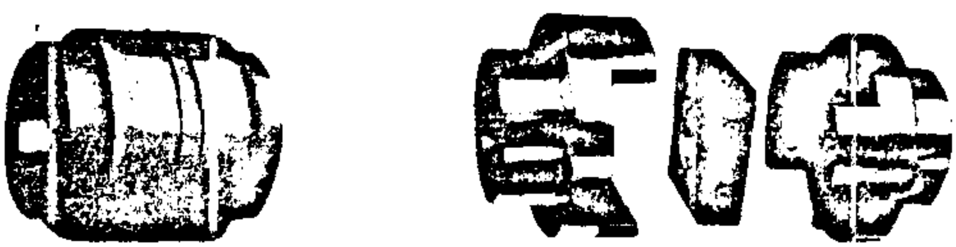
The main disadvantage of rigid couplings is that the alignment must be absolutely correct. If not then stresses can be created which fluctuate due to rotation and lead to fatigue problems.

Flexible Couplings

It is not possible to list all of the various flexible couplings, however they all have one characteristic in common. They will accommodate some misalignment such as may occur through temperature changes or settling of foundations. They are not a means of covering up poor initial alignment - they must still be done very carefully.

Flexible couplings use one of the three basic methods to achieve flexibility. One method is to use tightly fitted rigid parts with a sliding separator. A second method is to use loosely fitted rigid parts and the third method is the use of resilent or flexible parts.

Figure 2 shows two types of couplings employing a sliding separator. The one in Figure 2(a) consists of two flanges with slots milled in these faces. The separator is a disc with a rectangular ridge across each face. The ridge on one face being 90° from the ridge on the other. When assembled the ridges fit into the slots in the flanges and permit some sliding to take place. The exploded view in Figure 2(b) shows a square sliding centre member which engages the flanges. The block may be of self lubricating material or may be oiled.



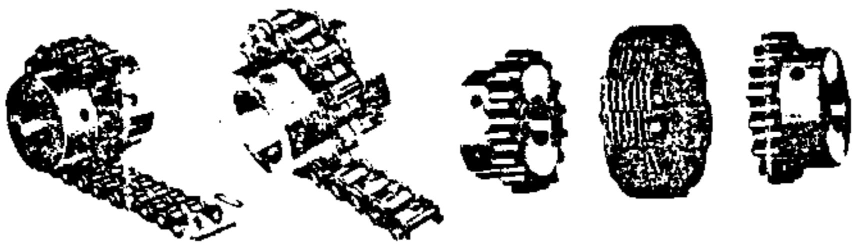
(a) (b)

Figure 2

The slider type of coupling will accept angular misalignment of up to 3°, parallel misalignment of 10% of nominal shaft diameter and end float of 1/32 to 1/4 of an inch. These terms will be explained later under the discussion of alignment. It should be noted that these tolerance do not apply to the initial alignment but are conditions brought on during operation. A flexible coupling does not eliminate the need for careful alignment.

Considering couplings which employ rigid parts loosely connected, Figure 3 illustrated three varieties of one type and Figure 4 shows another type.

The couplings in Figure 3 are called chain couplings. A hardened steel sprocket is fitted to the end of each shaft and then a length of chain is wrapped around engaging both sprockets and is connected at the ends. In Figure 3(a) the cain is a double roller one whereas in Figure 3(b) the chain is a wide single roller chain. Silent chain and sprockets with wide teeth are used in Figure 3(c).



(a) (b) (c)

Figure 3

The tolerances on the roller chain couplings are 1/2° to 1 1/2° angular misalignment, 0.01 to 2% chain pitch parallel misalignment, and .020 to 0.070 inch end play. For the silent chain the tolerances are 1° to 2° angular misalignment, parallel misalignment of 2% of chain pitch and end float of 1/8 to 1 inch. With proper installation, alignment, and maintenance they should have a long service life.

Figure 4 shows a gear coupling which consists of two identical hubs with external gear teeth and a covering sleeve with machined internal gear teeth. The teeth of the hubs mesh with the teeth of the sleeve. The working action is like a spline rather than gears since the parts do not rotate relative to each other. The sleeve may be one piece but for ease of installation it is often in two halves which are bolted together (as in illustration). Gear couplings will permit up to 2° angular misalignment or up to 7° with specially cut teeth. Parallel offset limit can be between .023 to .314 inches depending on the size of the coupling. The end float tolerance will need to be found in the manufacturer's handbook or specification.

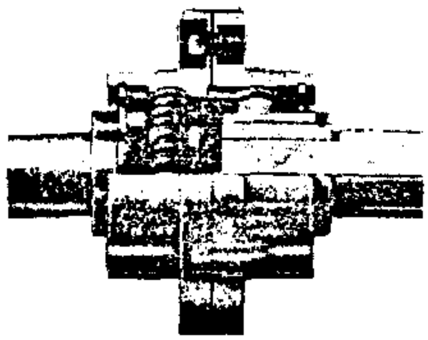


Figure 4

The final class of shaft couplings are those which use a flexible or resilient element in them. The resilient member can be metallic or non-metallic, the choice being dependent of the working environment and the loads involved.

Figure 5 shows a selection of couplings which use metallic elements. Thin metallic discs are used in Figure 5(a), in 5(b) laminated pins. Laminated metal spokes provide the flexibility in 5(c) and a corrugated metal strip fitted into slots in the two halves of the coupling is the flexing element in 5(d). The coupling in 5(e) uses springs and that in 5(f) uses metal bellows. These all come in a variety of sizes, the last two have a particular use in instrumentation.

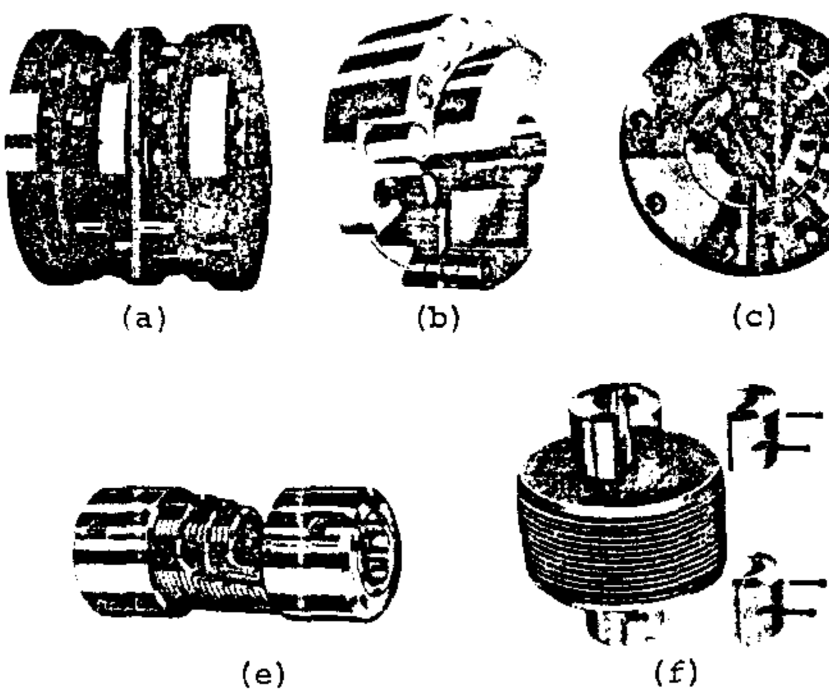


Figure 5

Figure 6 shows how one of the above couplings accommodates misalignment.

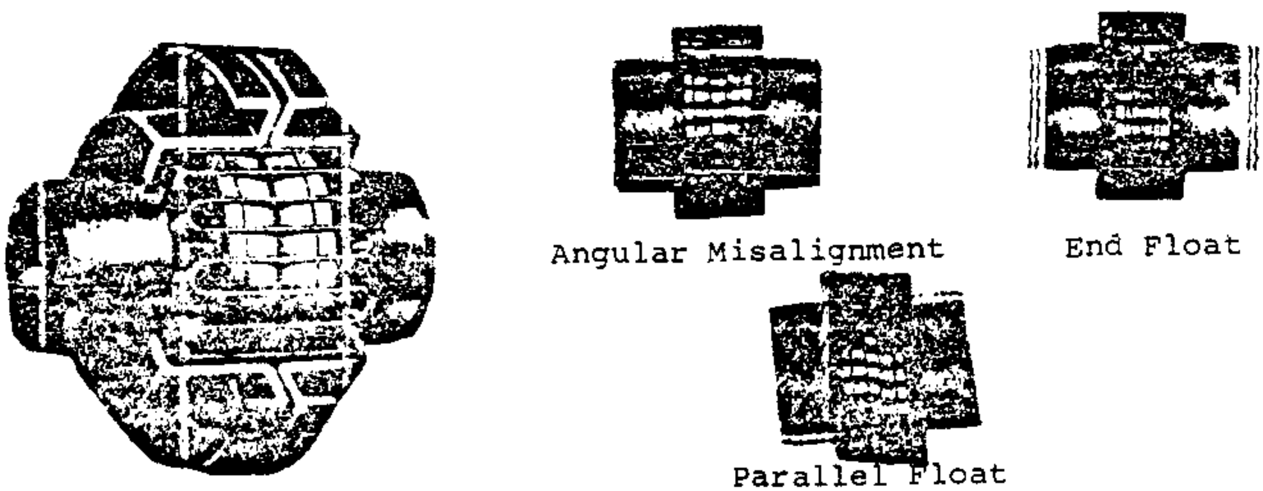
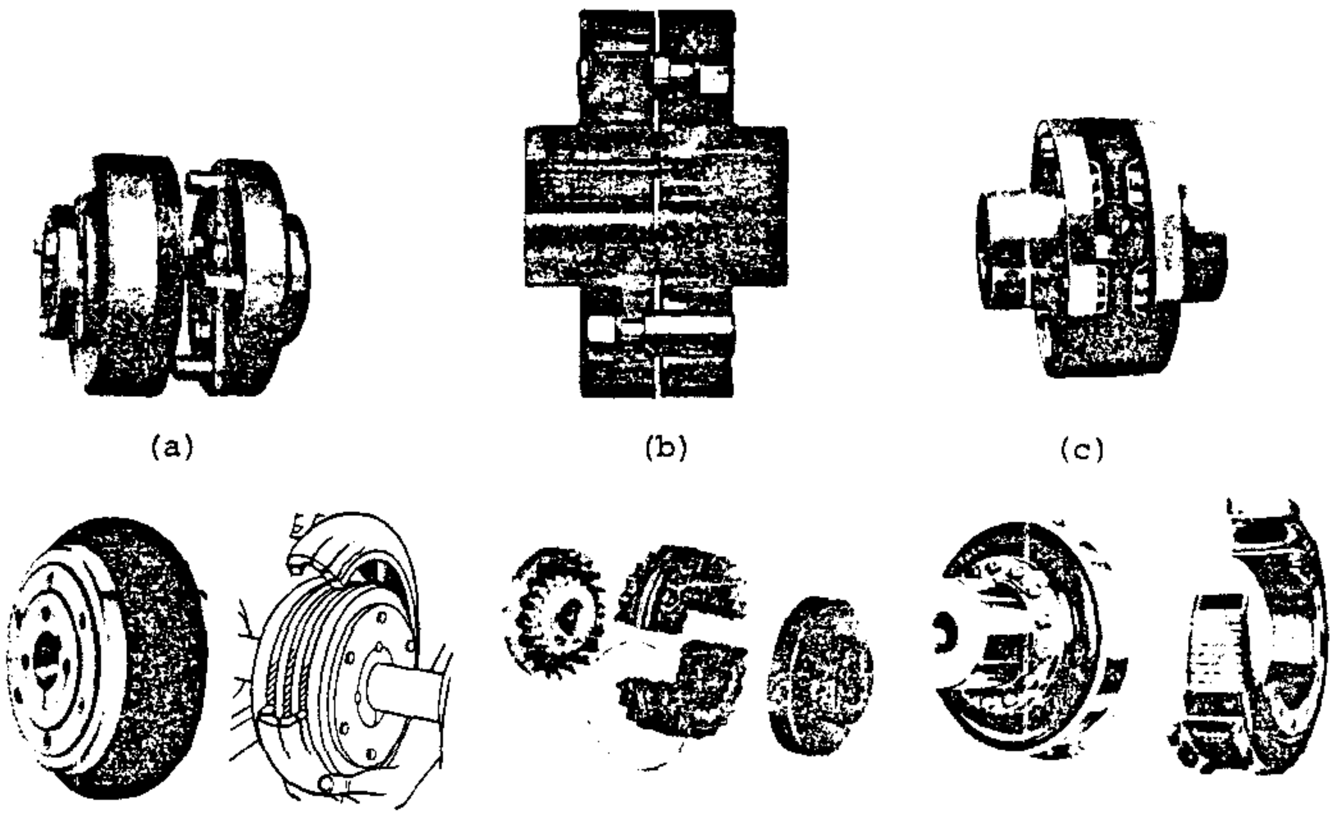


Figure 6

Examples of couplings using non-metallic flexible elements are shown in Figure 7. The coupling shown in Figure 7(a) consists of a non-metallic disc placed between two hubs. Pins in each flange engage alternate holes in the elastic disc. Figure 7(b) shows poins in each flange engaging holes bushed with flexible material in the opposite flange. Flexible spools are bolted between the two flanges in the coupling in Figure 7(c) and these absorb the energy of shock loading. In Figure 7(d) the coupling uses a split flexible element which looks like a top, bolted to the two flanges. The flexible element in the coupling in Figure 7(e) resembles a split internal-external gear. It fits into recesses in the flanges. Figure 7(f) illustrates a coupling with a hollow reinforced rubber torus bonded to an inner and an outer rim.



(a) (b) (c)

(d) (e) (f)

Figure 7

Before leaving this general description of couplings it is necessary to repeat that flexible couplings are not intended to compensate for poor alignment techniques. Misalignment shortens their life.

Alignment

Three terms have been used in connection with the tolerance of a coupling for misalignment. They are angular offset, parallel offset and end float. Each of these terms are illustrated in Figure 8.

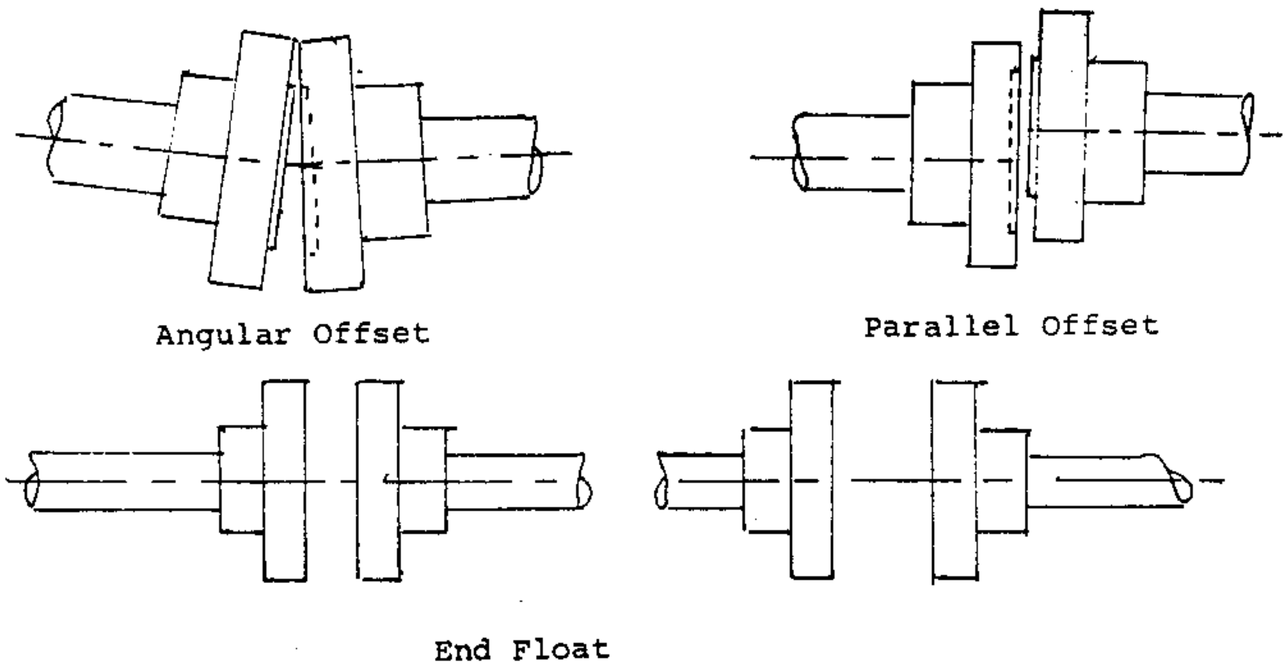


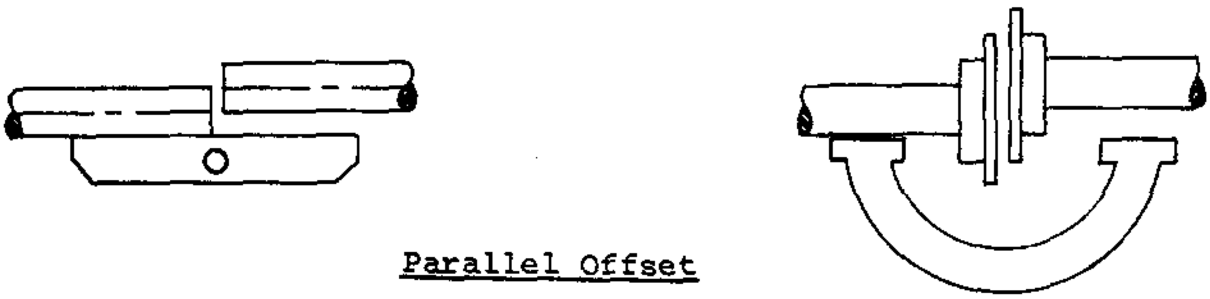
Figure 8

These terms also apply to shafts of course, as does the whole of the following discussion on alignment.

As an example consider the alignment of the shaft of a pump-motor set. First check that neither of the shafts are running-out. It will be impossible to align if one or the other of the shafts are bent or not running true. Make sure that all belt drives or chain drives are slackened off before making this check.

The preliminary alignment both angular and parallel can be done with a straight edge or a special gauge in the case where couplings are installed (Figure 9).

Angular Offset



Parallel Offset

Figure 9

Usually the adjustments are made to the motor and generally it will require shimming to the correct position.

Dial indicators are used to align shafts and couplings to obtain the precise alignment needed in high speed drives.

To check for angular misalignment the dial indicator should be set up in one of the following ways which are illustrated in Figure 10.

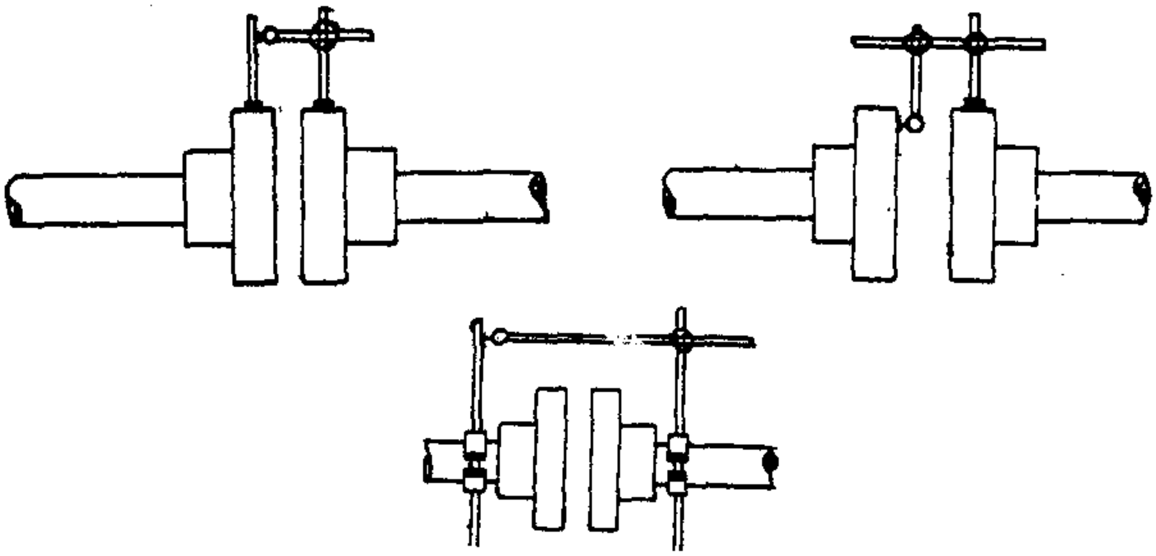


Figure 10

When this set-up is used BOTH SHAFTS MUST BE ROTATED TOGETHER and readings taken every 90°. If all of the readings are the same then the shafts have no angular offset. Under no circumstances should the coupling faces be assumed to be at right angles to the shaft. This is what would be assumed in the second case in Figure 10 if they were not rotated together.

The set-up for parallel offset is shown in Figure 11.

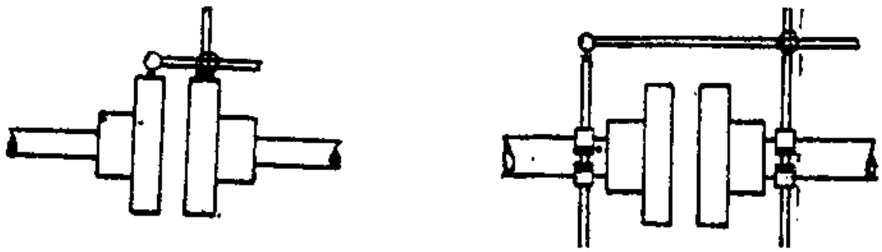


Figure 11

Again the shafts must be rotated together and readings taken every 90°. Corrections will be made by appropriate shimming in the vertical direction or by moving the motor assembly horizontally. The amount of offset will be equal to half the indicated reading for either the vertical or horizontal directions. For example, if the difference between the readings at the top and bottom is 0.016 inches; then the amount of offset is 0.008 inches.

The final check should be made with the components firmly bolted to the base.

Where the pump or motor operates at a high temperature the alignment will need to account for the differences in dimension caused by the change in temperature. Of course it might be possible to align the unit in the hot condition.

If there is insufficient clearance in the bolt holes, they may require to be enlarged.

Alignment requires patience and perserverance. There are no shortcuts.

H. Timmins
L. Laplante

ASSIGNMENT

1. What are the differences between the three main types of shaft couplings?

2. What are the three basic types of misalignment?

3. What type of misalignment will the slides type of coupling accept?

4. Why should both shafts be rotated together when aligning them?