Introduction

A gear coupling serves as a mechanical device which connects shafts of two separate machines and accommodates small amounts of shaft misalignment. Commercial gear couplings transmit more torque for their physical size than other types of couplings. Because of this load transmitting capability, gear couplings have received wide acceptance on the higher speed applications, and on applications requiring high torque capacity combined with low inertia of the drive system.

A gear coupling consists of two shaft hubs with external teeth which are connected by means of a sleeve, generally of two pieces, containing internal teeth. The working action of a gear coupling is that of a flexible spline with the hubs and sleeves rotating together. Adequate lubrication with the proper type is an essential requirement for successful operation of the gear coupling.

The purpose of this paper is to review the areas in which gear couplings have experienced difficulties and to identify the various types and probable causes of failures.

Lubricated Related Failures

The greatest problem in successful operation of gear couplings is to maintain an adequate film of lubricant between the gear teeth. It has been found that a lack of proper lubricant is the principal cause of gear coupling failures. Early stages of lubrication deficiency are shown in Figure 1. The contact area appears scuffed. As a result of the loss of lubricant film between the external and internal teeth, the surfaces rubbed against each other causing small metal particles to break loose. In some cases fretting corrosion, as evidenced by the appearance of a red powder, may be noted. The contacting internal sleeve tooth has a similar scuffed contact area as illustrated in Figure 2.

Figure 1

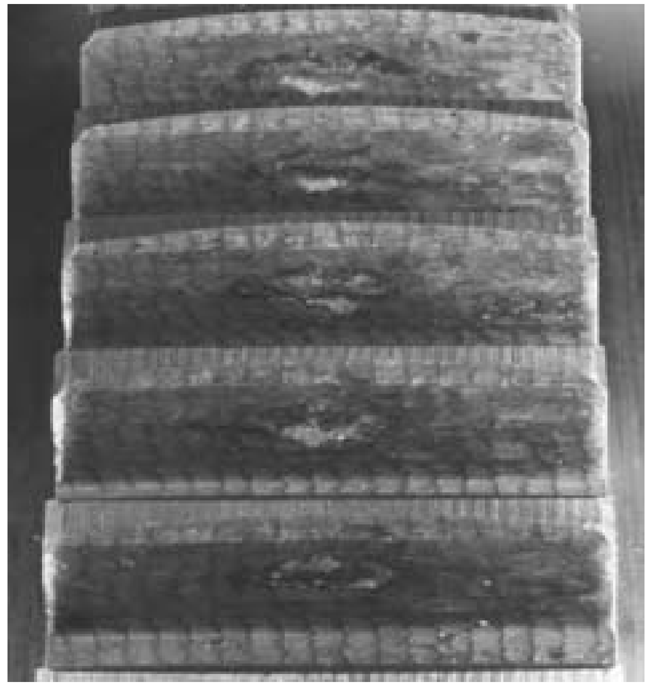

Figure 2

Continued operation of a gear coupling with a lubrication deficiency often produces a badly worn surface, as shown in Figure 3, where 70% of the tooth is worn away. Ultimately, unless the wear can be stopped, the tooth will bend over, as shown in Figure 4, and the mesh will become disengaged. The sleeve or internal teeth may suffer similar wear damage, see Figures 5 and 6, although generally the hub or external teeth will bend or roll over before the sleeve teeth. Proper coupling operation requires both sufficient and correct lubrication.

The lack of lubricant in gear couplings is usually the result of an insufficient lube filling, an omitted lube plug,or a damaged seal or gasket. If oil is used as the lubricant, leakage often occurs through the shaft keyway, unless the keyways are adequately sealed.

Other reasons for lubricant deficiencies in gear couplings may involve the lubricant itself. The lubricant, either grease or oil, may have improper viscosity for the operating speed or temperatures. In the case of grease lubricants, the oil may separate from the soap base because of centrifuging. In all these cases the lubricant either becomes too thin to support the tooth mesh load or is too thick to flow into the tooth mesh contact area. For these reasons an extreme pressure (EP) lubricant of the correct type, as well as speed and temperature limitations must be adhered to. Refer to Manual 458-010.

Figure 3

Figure 4

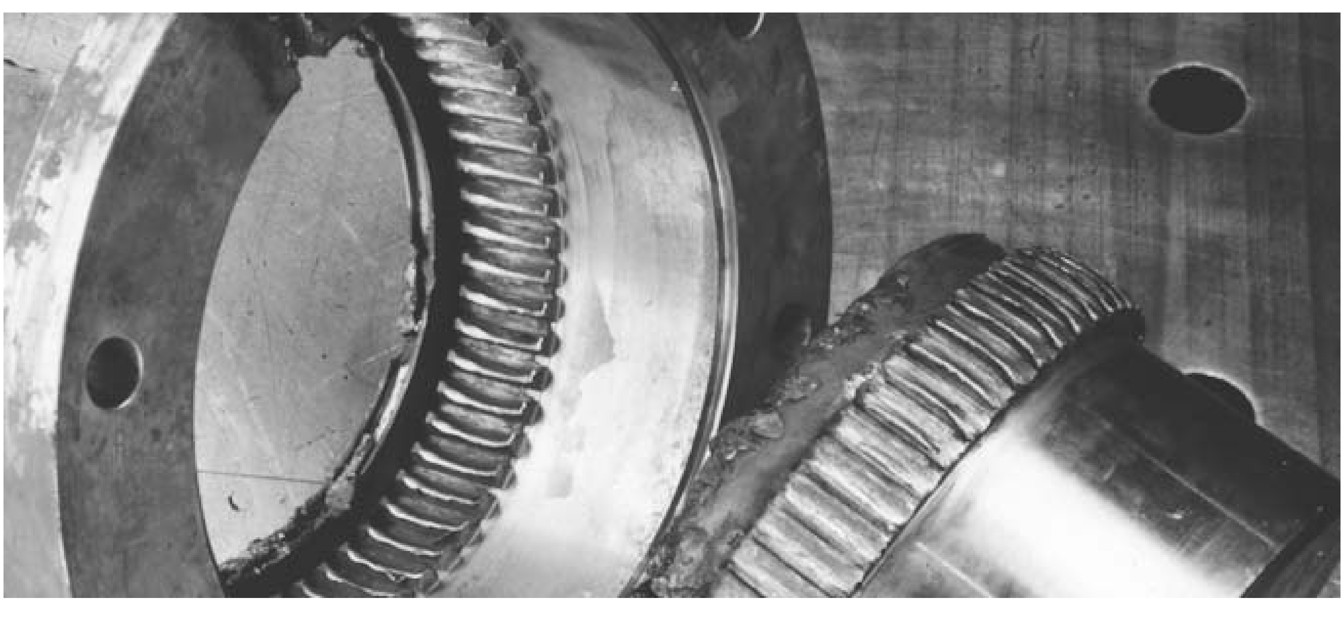

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Figure 5

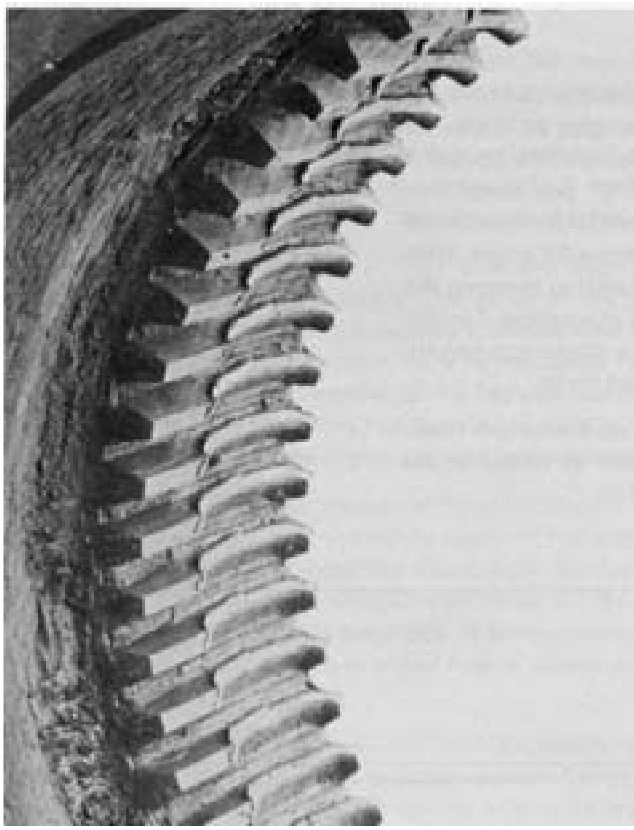
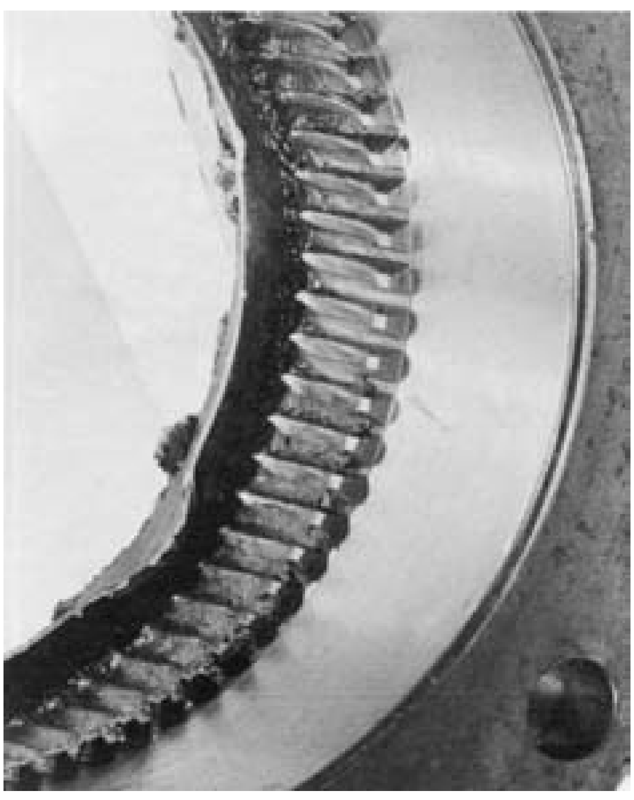


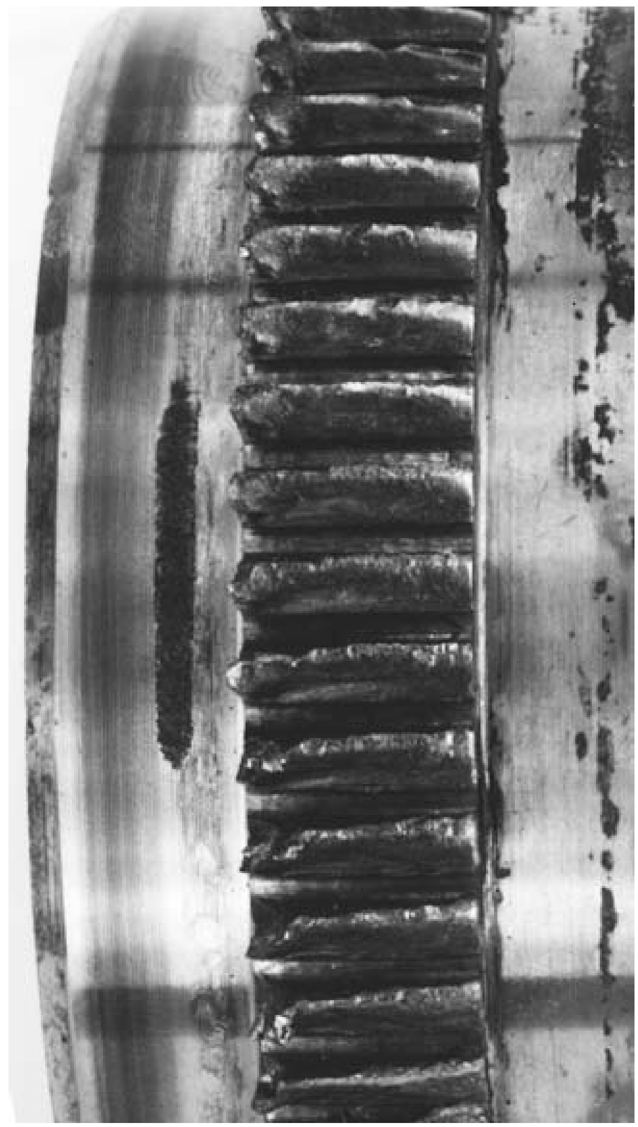
Figure 6



Misalignment Wear

Operating a gear coupling under excessive misalignment will promote wear on the teeth. The gear coupling is designed so that it will accommodate the alignment limits given in the service manual without metal to metal contact in the seal area. If wear is noted in the hub seal area as in Figure 7, it is proof that this coupling was operated with excessive misalignment. The illustrated tooth wear could be attributed to a combination of tooth sliding movement and lack of lubricant because the probability of lube leakage at the seal increases with misalignment.

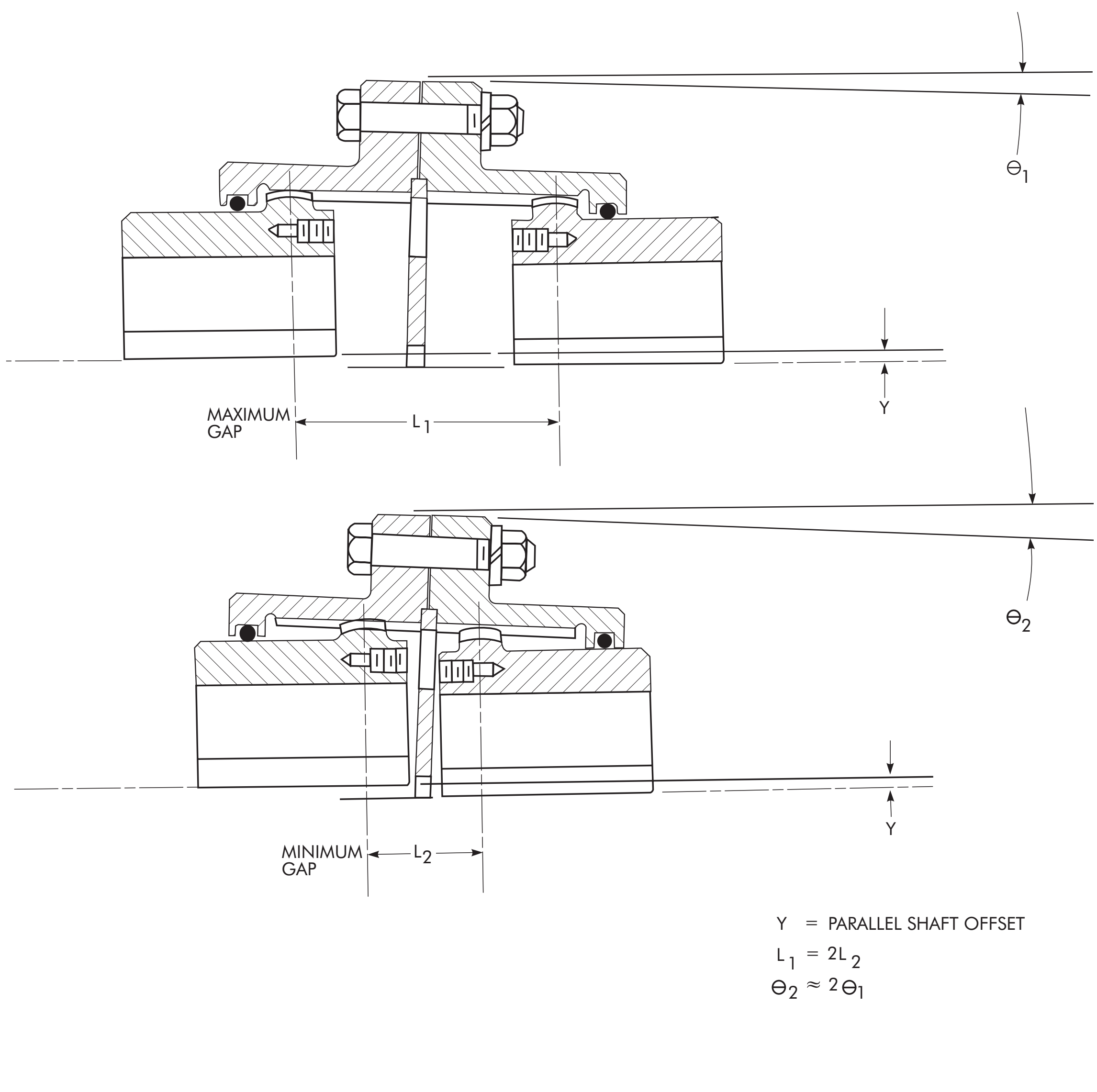
Figure 7



If a Slide type gear coupling operates so that its hub teeth mesh with the sleeve teeth near the gap, as shown in Figure 8, the static misalignment capacity of the coupling will be reduced to a maximum of 1/2° per mesh. For example, reducing the distance between tooth mesh areas by one half will nearly double the sleeve tilt angle. With increased tilt there will be increased sliding between the mating teeth an d a greater possibility of scuffing. For this reason, installations of slide type gear couplings require close attention to alignment and speed limits.

If axial hub movement occurs more than 5 times per hour, add 0.25 to the normal service factor as noted in the selection procedure of Selection Guide 451-110.

Figure 8



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Hub Fractures

It is possible to have gear coupling hubs fail over the keyway from a combination of hoop stress produced by the interference fit and a high tensile stress as a result of excessive torque loads transmitted through the key. Gear coupling hubs are normally made from a .3 to .5 carbon steel having a minimum tensile strength of 65,000 psi.

An example of a hub failure from a single overload application is shown in Figure 9. The break in the hub occurred at one corner of the keyway and extended the full length of the hub. Another view of the same hub, Figure 10, shows a deformation of the keyway from the key. It can be noted that the hub break occurred at the keyway corner away from where the load was applied.

As a result of the hub failure shown in Figures 9 and 10, the mating sleeve had a crack extending nearly its full length, Figure 11. In order to remove the sleeve from the hub, it was necessary to cut the sleeve in the section at the failure crack and 180° away from the crack. It is interesting to note that none of the teeth in either hub or sleeve were broken.

In order to prevent hub fractures, it is necessary that couplings be selected using the proper service factor for the application based on motor capacity or where a brake is involved in the system, the coupling should be selected on the brake capacity.

Figure 10

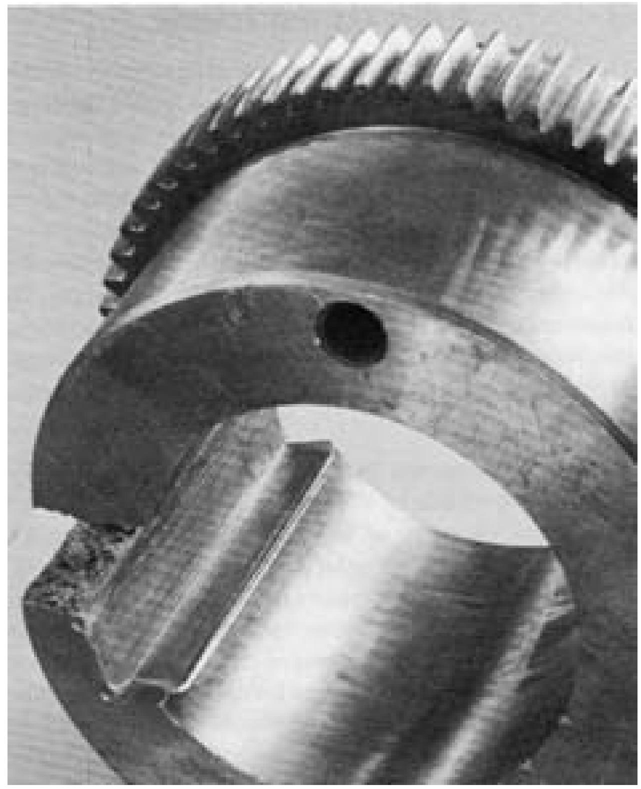
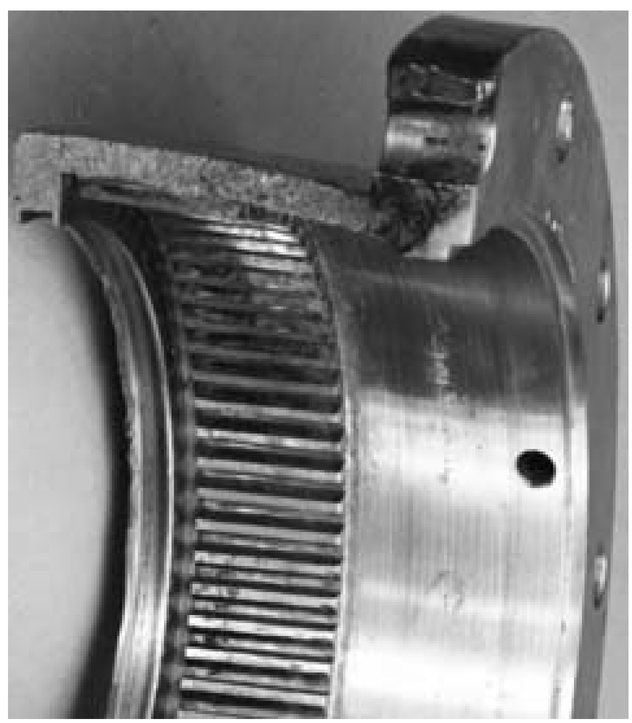


Figure 9

Figure 11

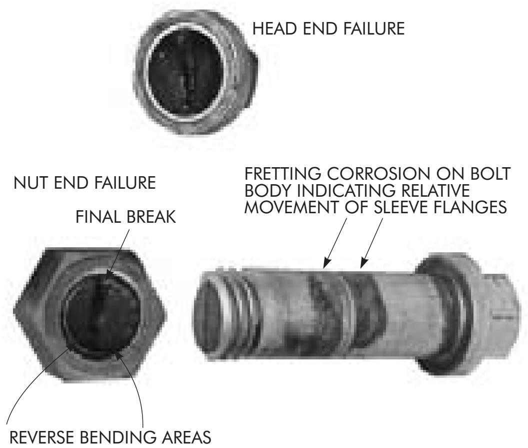


Flange Fastener Failures

The gear coupling sleeve design most commonly used by industry consists of two flanged sleeve halves which are bolted together. Each flanged sleeve has internal teeth which form the spline connection for the external gear teeth of the hubs. Transmitted torque passes from the hub through the gear teeth to one of the flanged sleeve halves. Then the torque load must pass from one flanged sleeve to the other through the bolted and gasketed flange. The fasteners used to connect the sleeves are designed so that the body of the fastener extends into both sleeve flanges. The bolts are SAE grade 5 or 8, depending on coupling size.

In most applications the combination of the frictional transmitting torque of the bolted flanges plus the allowable shear capacity of the bolt body are sufficient to transmit the normal starting and operating loads applied to a properly selected gear coupling. In certain cases, where high starting and impact loads occur in combination with reversing service or severe load fluctuations exist, fasteners have failed in reverse bending fatigue, as shown in Figure 12. This failure shows that the bolt head actually "fatigued off" of the bolt body diameter. It should be noted that the characteristic "beach marks", that often form on the fracture surface of soft material, are not always exhibited to the naked eye in high strength material failures. For this reason the mode of failure, ie; bending fatigue, may not be properly identified.

Figure 12



Bending fatigue loading may also be characterized by: fretting corrosion on the bolt body diameter, imbedding of the bolt washer face diameter into the sleeve, wallowing out of the sleeve flange holes and/or offset of the bolt body diameter.

This type of failure can be the result of insufficient fastener tightening torque, system torsional vibration or reversing loads which exceed the flange joint capacity.

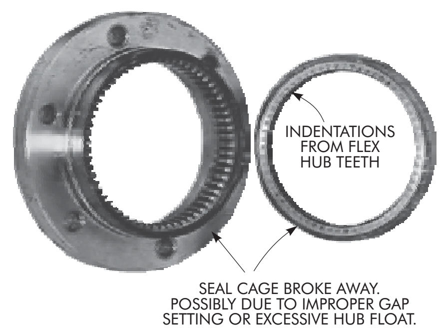
Assuming that the flange fasteners have been installed with the proper tightening torque as specified in the installation manuals, fatigue type fastener failures of a gear coupling are an indication of loads that repeatedly exceed 1.5 to 2.5 times rated torque of the coupling.

One must use care when correcting flange bolt failures. Before substituting higher hardness fasteners or a larger coupling size which would reduce the possibility of further coupling failures, review the loads in the entire system to be sure that other elements will not fail. In some cases, a simple correction of bolt failures has led to extensive damage to other critical connected machinery. In most cases, if the coupling was properly selected for the drive, flange bolt failures would be an indication that the system has been subjected to unexpected overloads.

Sleeve Seal End Ring Failures

Sleeve seal end ring fatigue failures, Figure 13, result from loads imposed on the sleeve seal cage. This type of failure may be the result of radial flexing under excessive misalignment, and/or axial contact due to improper gap setting (too large), or hub axial float. Refer to Manual 428-870, "Axial Movement of Power Transmitting Shaft Coupling". Also note the hub tooth contact pattern on the seal cage face, Figure 13.

Figure 13



Conclusion

The main types of failure encountered with gear couplings are worn teeth. Where tooth wear progresses rapidly, eventual disengagement of the gear coupling can occur when either external or internal teeth roll or bend over. Since gear coupling tooth wear is generally related to the lubricant, it is necessary to determine the reason for lube deficiency and make the required correction.

Gear coupling hub failures can occur from a combination of loads produced by the interference fit and transmitted torque. Adherence to the proper service factor for an application will minimize hub failure problems.

Occasionally the gear coupling flange bolts break. If the correct bolt tightening torque has been used, review the system for high peak loads or severe load fluctuations.

Sleeve seal cage end ring failures may result from high misalignment, improper gap setting, and/or hub axial float.

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design above, furnished as standard.
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available for Sizes 1010 thru 1055
when specified.

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Interchangeability — 1000G couplings are half-for-half interchangeable with ALL standard gear couplings. Rexnord replacement half couplings provide additional hub strength and lower gear mesh loads.

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