SECTION 19 FEATURES OF TOOTH SURFACE CONTACT

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Tooth surface contact is critical to noise, vibration, efficiency, strength, wear and life. To obtain good contact, the designer must give proper consideration to the following features:

- **Modifying the Tooth Shape**
  Improve tooth contact by crowning or relieving.
- **Using Higher Precision Gear**
  Specify higher accuracy by design. Also, specify that the manufacturing process is to include grinding or lapping.
- **Controlling the Accuracy of the Gear Assembly**
  Specify adequate shaft parallelism and perpendicularity of the gear housing (box or structure).

Surface contact quality of spur and helical gears can be reasonably controlled and verified through piece part inspection. However, for the most part, bevel and worm gears cannot be equally well inspected. Consequently, final inspection of bevel and worm mesh tooth contact in assembly provides a quality criterion for control. Then, as required, gears can be axially adjusted to achieve desired contact.

JIS B 1741 classifies surface contact into three levels, as presented in **Table 19-1.**

The percentage in **Table 19-1**considers only the effective width and height of teeth.

Table 19-1 Levels of Gear Surface Contact

Level	Types of Gear	Levels of Surface Contact	
		Tooth Width Direction	Tooth Height Direction
A	Cylindrical Gears	More than 70%	More than 40%
	Bevel Gears	More than 50%	
	Worm Gears		
B	Cylindrical Gears	More than 50%	More than 30%
	Bevel Gears	More than 35%	
	Worm Gears		
C	Cylindrical Gears	More than 35%	More than 20%
	Bevel Gears	More than 25%	
	Worm Gears	More than 20%	

19.1 Surface Contact Of Spur And Helical Meshes

A check of contact is, typically, only done to verify the accuracy of the installation, rather than the individual gears. The usual method is to blue dye the gear teeth and operate for a short time. This reveals the contact area for inspection and evaluation.

19.2 Surface Contact Of A Bevel Gear

It is important to check the surface contact of a bevel gear both during manufacturing and again in final assembly. The method is to apply a colored dye and observe the contact area after running. Usually some load is applied, either the actual or applied braking, to realize a realistic contact condition. Ideal contact favors the toe end under no or light load, as shown in **Figure 19-1**; and, as load is increased to full load, contact shifts to the central part of the tooth width.

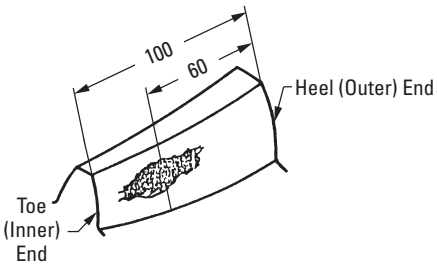

Fig. 19-1 The Contact Trace on Central Front End

Even when a gear is ideally manufactured, it may reveal poor surface contact due to lack of precision in housing or improper mounting position, or both. Usual major faults are:

1. Shafts are not intersecting, but are skew (offset error).
2. Shaft angle error of gear box.
3. Mounting distance error.

Errors 1 and 2 can be corrected only by reprocessing the housing/mounting. Error 3 can be corrected by adjusting the gears in an axial direction. All three errors may be the cause of improper backlash.

19.2.1 The Offset Error of Shaft Alignment

If a gear box has an offset error, then it will produce crossed end contact, as shown in **Figure 19-2**. This error often appears as if error is in the gear tooth orientation.

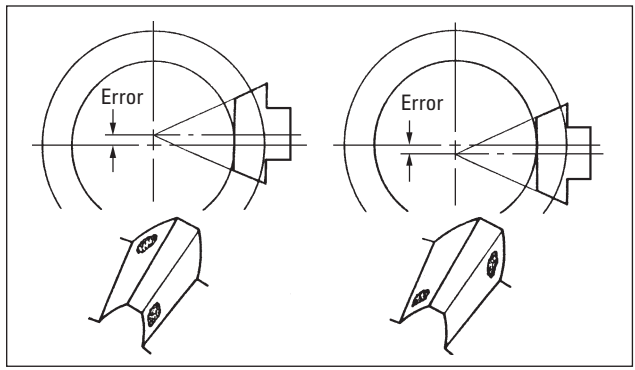

Fig. 19-2 Poor Contact Due to Offset Error of Shafts

19.2.2 The Shaft Angle Error of Gear Box

As **Figure 19-3** shows, the contact trace will move toward the toe end if the shaft angle error is positive; the contact trace will move toward the heel end if the shaft angle error is negative.

19.2.3 Mounting Distance Error

When the mounting distance of the pinion is a positive error, the contact of the pinion will move towards the tooth root, while the contact of the mating gear will move toward the top of the tooth. This is the same situation as if the pressure angle of the pinion is smaller than that of the gear. On the other hand, if the mounting distance of the pinion has a negative error, the contact of the pinion will move toward the top and that of the gear will move toward the root. This is similar to the pressure angle of the pinion being larger than that of the gear. These errors may be diminished by axial adjustment with a backing shim. The various contact patterns due to mounting distance errors are shown in **Figure 19-4.**

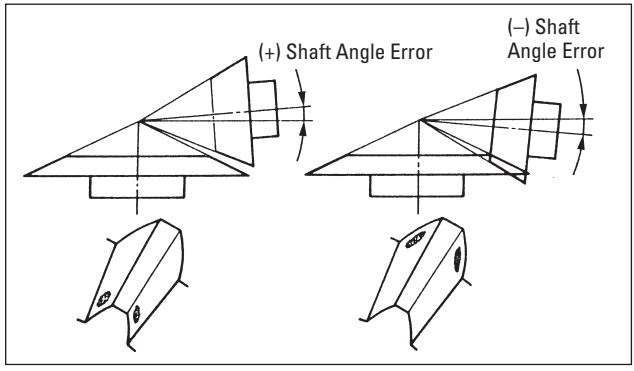

Fig. 19-3 Poor Contact Due to Shaft Angle Error

Mounting distance error will cause a change of backlash; positive error will increase backlash; and negative, decrease. Since the mounting distance error of the pinion affects the surface contact greatly, it is customary to adjust the gear rather than the pinion in its axial direction.

19.3 Surface Contact Of Worm And Worm Gear

There is no specific Japanese standard concerning worm gearing, except for some specifications regarding surface contact in JIS B 1741.

Therefore, it is the general practice to test the tooth contact and backlash with a tester. **Figure 19-5** shows the ideal contact for a worm gear mesh.

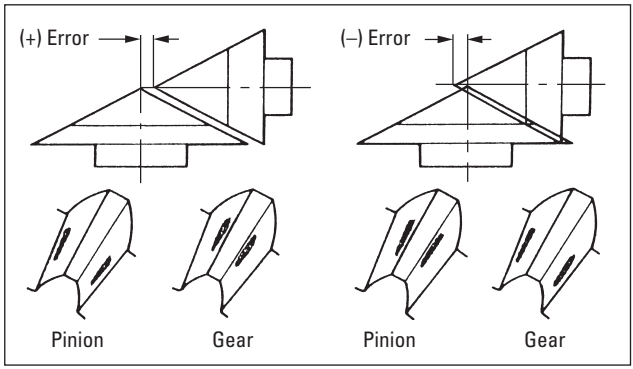

Fig. 19-4 Poor Contact Due to Error in Mounting Distance

From **Figure 19-5**, we realize that the ideal portion of contact inclines to the receding side. The approaching side has a smaller contact trace than the receding side. Because the clearance in the approaching side is larger than in the receding side, the oil film is established much easier in the approaching side. However, an excellent worm gear in conjunction with a defective gear box will decrease the level of tooth contact and the performance.

There are three major factors, besides the gear itself, which may influence the surface contact:

1. Shaft Angle Error.
2. Center Distance Error.
3. Mounting Distance Error of Worm Gear.

Errors number 1 and number 2 can only be corrected by remaking the housing. Error number 3 may be decreased by adjusting the worm gear along the axial direction. These three errors introduce varying degrees of backlash.

19.3.1. Shaft Angle Error

If the gear box has a shaft angle error, then it will produce crossed contact as shown in **Figure 19-6**.

A helix angle error will also produce a similar crossed contact.

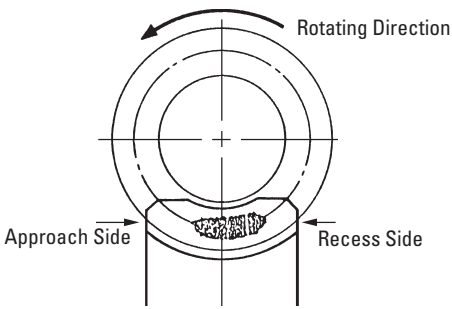

Fig. 19-5 Ideal Surface Contact of Worm Gear

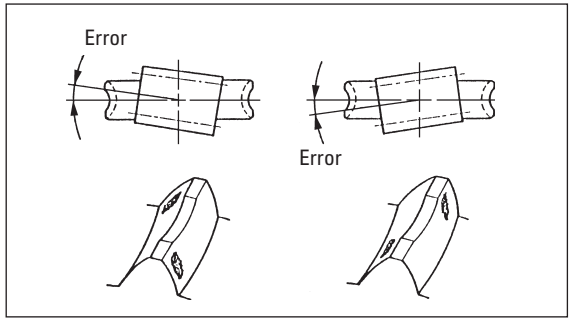

Fig. 19-6 Poor Contact Due to Shaft Angle Error

19.3.2 Center Distance Error

Even when exaggerated center distance errors exist, as shown in **Figure 19-7**, the results are crossed end contacts. Such errors not only cause bad contact but also greatly influence backlash.

A positive center distance error causes increased backlash. A negative error will decrease backlash and may result in a tight mesh, or even make it impossible to assemble.

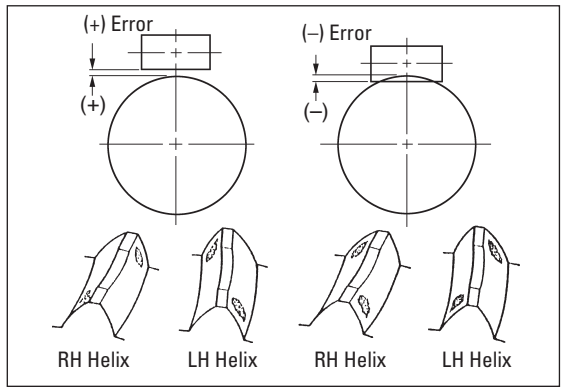

Fig. 19-7 Poor Contact Due to Center Distance Error

19.3.3 Mounting Distance Error

Figure 19-8 shows the resulting poor contact from mounting distance error of the worm gear. From the figure, we can see the contact shifts toward the worm gear tooth's edge. The direction of shift in the contact area matches the direction of worm gear mounting error. This error affects backlash, which tends to decrease as the error increases. The error can be diminished by microadjustment of the worm gear in the axial direction.

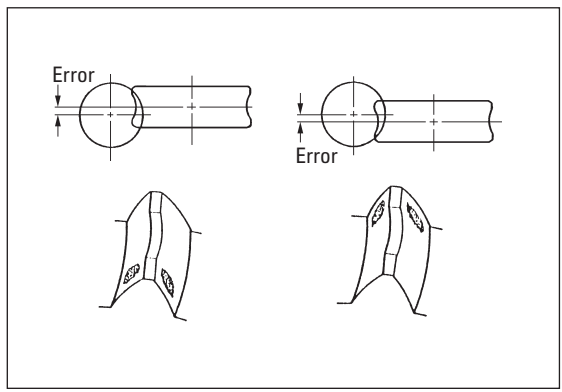

Fig. 19-8 Poor Contact Due to Mounting Distance Error