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Parallelism, perpendicularity, and misalignment

The proper alignment of gears in mesh is critical for their proper operation.

Sometime around your 12th birthday, the trip to the dentist resulted in a discussion about the misalignment of your teeth and the need to see an orthodontist for braces. Although traumatic for the average teenager, braces were not the end of the world for the teeth themselves. When speaking about gear teeth, there aren't any braces to correct misalignments that lead to premature wear and eventual failure.

The gears most vulnerable to misalignment failure are worm gear pairs. The first misalignment to review is the perpendicularity of the worm axis to the worm wheel axis. When they are properly aligned, the wear on the worm wheel tooth occurs in the center of the tooth. If the worm is not properly aligned, there will be wear on the opposite ends of the tooth flank as shown in Figure 1.

The second alignment to consider is that the worm axis is centered with the worm wheel axis. When properly centered, the tooth engagement will occur in the center of the tooth flank on both sides of the worm wheel tooth. If the worm is not properly centered, then the worm wheel will wear on the outer edge of the tooth on both flanks as shown in Figure 2.

Center distance is another consideration for not only worm gear pairs but also for spur and helical gear mesh. In order for the gear teeth to properly interact, there needs to be a minimal amount of clearance to permit the smooth engagement and disengagement of the teeth as they come in and out of mesh. Additionally, there needs to be sufficient clearance to permit lubricant to enter the tooth mesh. This clearance is known as backlash. When gears are spaced too close together, the backlash becomes too small, leading to binding of the mesh. If the gears are spaced too far apart, they will not engage at the proper point on the tooth flank. An example of the tooth engagement when setting gears at the proper center distance and at the improper center distances are shown in Figure 3.

One final mesh consideration for worm gear pairs is centering the worm over the worm wheel such that the proper engagement occurs. An example of this is shown in Figure 4.

Other types of gears also have alignment issues. One important tolerance for gear racks is the face width tolerance. This, along with

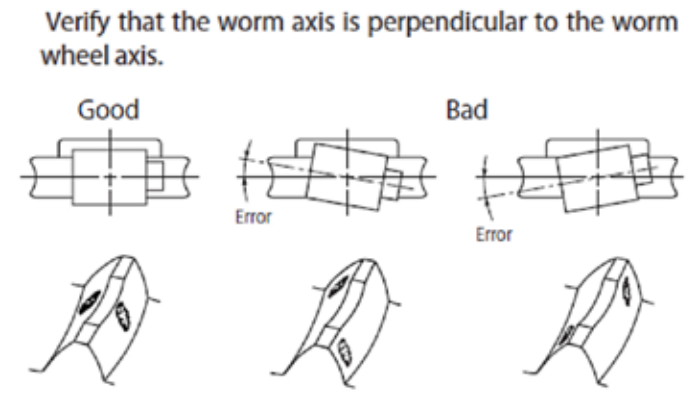

Figure 1

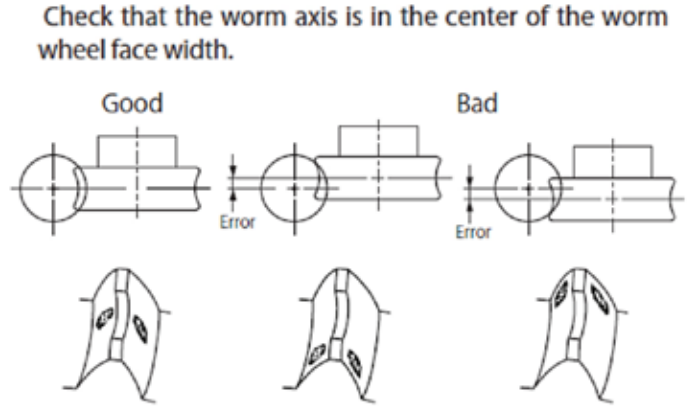

Figure 2

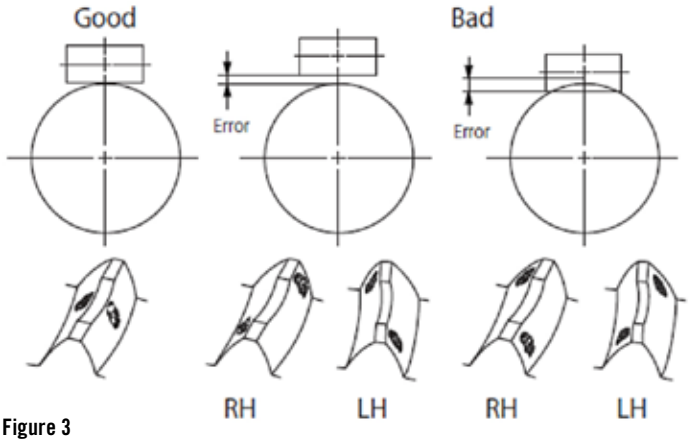

Figure 3

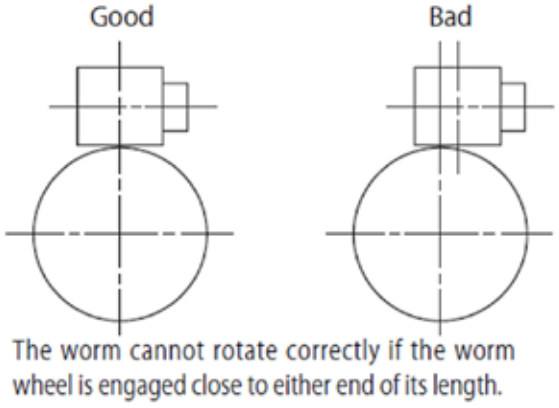

Figure 4

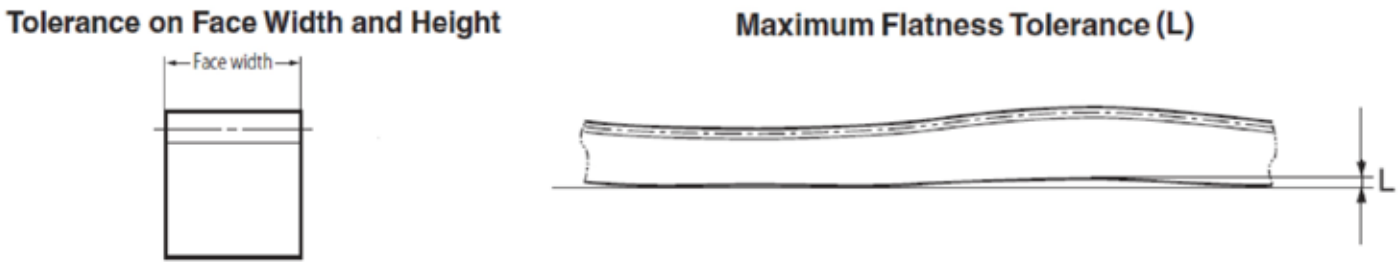

Figure 5

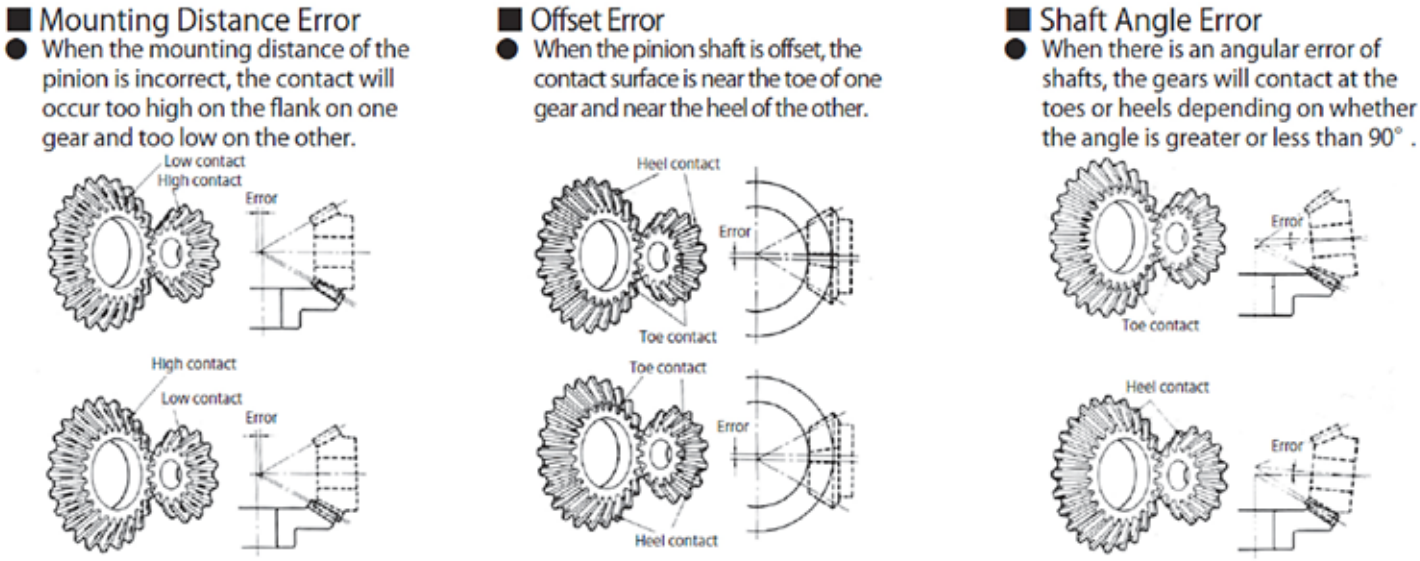

Figure 6

the total rack height tolerance and the flatness of the rack, are critical during assembly (Figure 5).

The pinion will not operate as desired and can prematurely wear if the face width of the pinion and rack are not exact. Additionally, there will be positioning errors if the rack straightness is not maintained during assembly.

For miter and bevel gears, there are three alignments errors to consider (Figure 6). These are mounting distance error, offset error, and shaft angle error. Similar to the errors of worm gear pairs, each of these errors will result in premature failure of the gears and a large increase in noise.

All of these misalignment errors can be corrected if you know how to interpret the wear patterns of the gear mesh. Unlike the braces you wore in high school, there are no worries about losing a rubber band in the middle of fifth period Spanish class nor of having to wear your night guard headgear or retainer.

ABOUT THE AUTHOR

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