Our Experts Discuss Electronic Gearboxes, Plus Backlash and What to Do about It

Dennis Richmond
William L. Janninck

Question: In the January/February issue of your magazine, we came across the term "electronic gearbox." We have seen this term used elsewhere as well. We understand that this EGB eliminates the change gear in the transmission line, but not how exactly this is done. Could you explain in more detail?
K. K. Patel, Coburg Powermotive Company, Gujarat, India

Dennis Richmond replies: The term "electronic gearbox" is, perhaps, a misnomer. It refers not to a particular object or collection of parts, but rather to the CNC software that automatically makes necessary adjustments in a machining operation. In a CNC machine, a programmed numerical control activates the machine's servos and spindle drives and controls the various operations.

For example, in a CNC gear grinding machine, the basic ratio between the grinding wheel and the workpiece axis is controlled by an electronic gearbox with an extremely high dynamic response. Modifications to the geometry (crowning, taper or lead) made during the machining sequence are controlled entirely by the CNC control. The advantage of this system is a uniform load condition on the machine's control system. Fluctuations are rapid but consistent. A disturbance simulator module takes advantage of this phenomenon, observing the transient load oscillations that occur through the fluctuations caused by the gear's teeth as they enter and exit the grinding worm's line of contact. The disturbance simulator module evaluates the very fast but uniform errors through a refined electronic circuit, which counteracts the minute deviations by assessing the signals and reducing the deviations by their mean values.

The transition from one load characteristic to another occurs relatively slowly; for example, asymmetric load-related errors take place when a helical gear is being ground. A one-sided load exists as the wheel enters the top face of the gear or exits the bottom face at the end of the pass. Since the disturbance simulator module corrects deviations based on the mean of a number of values received, even one-sided, load-related errors can be detected and offset by adjusting the module or diametral pitch.

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Address your gearing questions to our panel of experts. Write to them care of Shop Floor, Gear Technology, P. O. Box 1426, Elk Grove Village, IL 60009, or call our editorial staff at (708) 437-6604.

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Question: We manufacture electric motor traction drives for locomotives, including the driving pinion and its mating driven gear. We have experienced some problems related to the backlash in the gear set when put into final assembly. Can you examine our gear data and perhaps give us some idea what may be causing the problem? The pinion is 18 teeth and the gear is 64 teeth, 2.11667 DP (12 module), 20° PA, of spur configuration. The pinion and gear are both made of alloy steel, surface-hardened, fully ground on the entire form and operating on a center distance of 19.4094–19.4252" (493.0–493.4 mm). All the geometric gear data are included on the gear prints submitted. Also, how is backlash measured?

N. R. Krishnan, Crompton Greaves Ltd., Bombay, India

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William Janninck replies: The specific details of the backlash problem are not identified, so we will have to give some general answers.

Complaints concerning backlash in a gear set can be divided into two main categories—too little backlash and too much. Too little backlash is the most common complaint. A subcategory of this complaint is negative backlash, which causes a bind or pinch during the rotation of the set. This cannot be allowed, because it could cause severe loading on the gear teeth and the supporting structure, including the case, shafting and bearings. This can occur when the gears have excess runout, and while lash occurs at the low area of runout, a jam may occur when the gears are rotated to the high point of the runout.

In situations with too much backlash in the set, jams or binds do not occur, but noise or clatter may be introduced, and, depending on the application, room may be provided for impacting if loads are reversed. Excess lash can also be the cause of lowering the gear-tooth beam strength and reducing the gear wear life.

In investigating the first backlash problem, a study is made to see what the minimum lash in the set might be. This is done by modeling the set using the lowest allowed center distance based on the tolerance and the highest allowed gear and pinion tooth thicknesses. The resulting minimum backlash in the given set is .009" (.228 mm) by this modeling.

Modeling, however, is based on both gears in the set being perfect in all respects. If some allowance is made for the .003" (.077 mm) gear runout tolerance, plus some mounting errors, it is possible that the actual minimum lash might be reduced nearly to zero. This could only occur if the gear and pinion size were biased totally to the high limit, and the center distance were totally sitting on the low limit. Statistically this seems highly unlikely.

Since the tolerance on center distance of .016" (.40 mm) and the tolerance on tooth thickness of .009" (.228 mm) is liberal, it would be wise to get some inspection data on your production gears and boxes, especially on a set under rejection, to see where the sizes lie in the tolerance ranges and if they are biased as mentioned above,

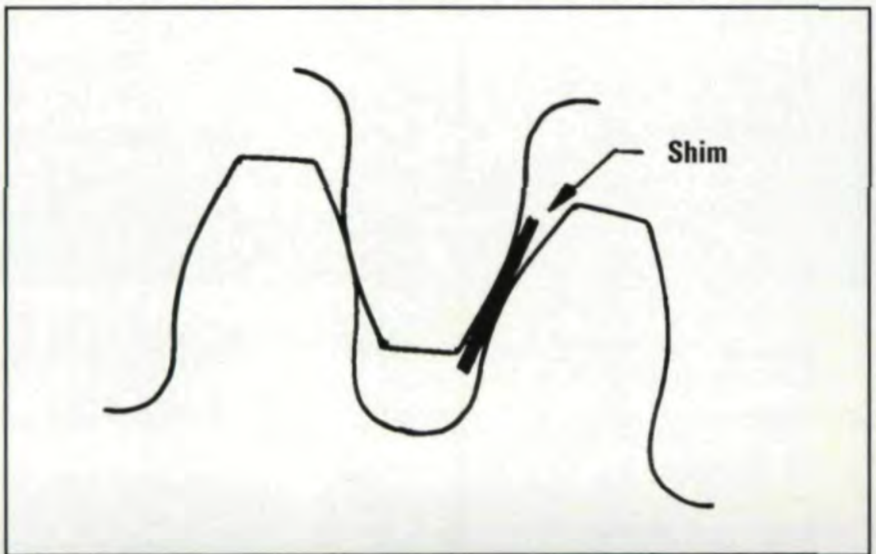

Fig. 1

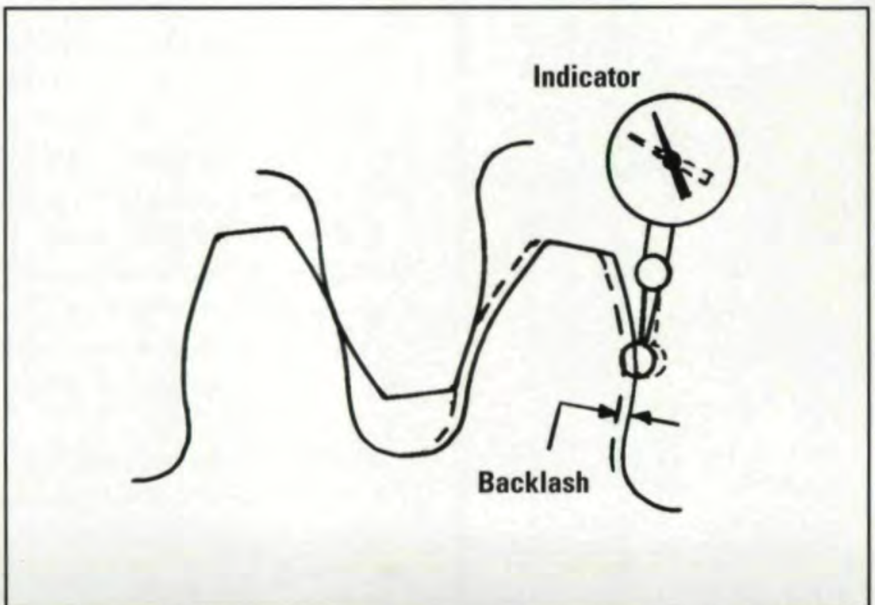

Fig. 2

or even if they are out of limits. This will surely expose the source of the problem. It is difficult to speculate without knowing anything more specific, but one possible solution is to reduce the high tooth thickness by .004–.005" (.102–.127 mm). This would give more lash allowance, and it might eliminate the problem.

By similar model computation, the maximum lash was .041" (1.04 mm). This maximum amount seems reasonable for this particular gear set.

There are several ways to measure backlash. The first and quickest is to mount up the gears and spin them through mesh, turning enough times to assure that all teeth of pinion and gear eventually engage. If they bind somewhere, then there is zero or negative lash, and the set is rejected. If they spin free, then some measure of the actual lash can be obtained by using shims or feeler gages (see Fig. 1). The highest and lowest shims that fit are a measure of the lash.

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LASH CAN BE MEASURED BY SHIMS, FEELER GAGES OR A DIAL INDICATOR.

A small dial indicator can also be used to put a value on the lash. While the indicator is touching against a gear-tooth flank and the mate is locked on rotation, the gear is jogged back and forth, and the indicator is read for the lash with that tooth pair in mesh (see Fig. 2). As with the shims, this has to be done for a number of different mesh positions, and a high and low value will be found.

In establishing the minimum backlash, you must include allowances for the runout to be expected in each gear, as well as some provision for other factors, such as operating temperature and lubricating films. ■