Hidden Runout?

Question submitted via *The Gear Industry Home Page™*

Robert E. Smith

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Q: I would like to know if too much total composite error on a scissors gear in a diesel engine could contribute to high vibration levels? I'm talking about 0.0015" over the maximum tolerance of 0.0026".

Answer submitted by
Robert E. Smith
R.E. Smith & Co.
Rochester, NY

A: How much is "too much" depends on the application. What is good for one application may not be good for another. Factors such as rpm, structural dynamics, ambient conditions, etc., all must be considered. Also, it depends on the frequency of the noise or vibration. Does it occur at "once per revolution" frequency of the gear set? Or does it cause noise or vibration at sidebands of mesh frequency? All of these questions have to be evaluated.

A total composite error of 0.0041" would not be unusual or detrimental in many automotive and vehicle drive trains. However, you possibly are being deceived by the method of quality control. Double-flank composite testing can find radial runout, which is the major component of double-flank total composite error. It cannot find accumulated pitch error, which is just as bad for once-per-revolution velocity variations. This deception in measurement is a phenomenon called "Hidden Runout." For a complete discussion of this subject, see AGMA technical paper 95FTM1, "Detection of Hidden Runout," by Smith, Laskin and Bailey. You may very well have an accumulated pitch error that is much larger than the runout that you can tolerate, or think you have.

Hidden runout occurs frequently with gears that have been hobbed with excessive runout and then had a subsequent finishing operation such as shaving or some grinding processes. It can even happen with form grinding or hobbing, when the workpiece is properly trued up, if the workspindle drive gear is mounted eccentrically or worn out.

A precision index check of pitch and accumulated pitch

Fig. 1—Precision index check of pitch and accumulated pitch after hobbing.

Robert E. Smith

is the principal in R.E. Smith & Co., gear consultants of Rochester, NY, and one of Gear Technology*'s technical editors. He has more than 50 years of experience in gearing and is the author of numerous papers and articles. He is also very active in AGMA standards development.*

error can find the problem. See Figure 1 for a test of such a gear after hobbing. See Figure 2 for the results of the same gear after shaving. Runout has been removed, but the accumulated pitch error still exists. Figure 3 shows the same gear checked by a single-flank composite gear tester. This is a true meas-ure of transmission error (TE) or variation in angular motion. Double-flank composite testers only measure radial motion. Unfortunately, gears do not operate in a radial mode; they operate tangentially.

Another automotive example is discussed in AGMA technical paper 84FTM2, "What Single Flank Measurement Can Do For You," by Smith. That paper discusses a pair of front-wheel-drive gears that caused excessive vibration in the vehicle, at a frequency of once per revolution of the pinion. The pinion passed the double-flank composite test with 0.0025" total composite error. However, single-flank composite testing (tangential measurement) showed 0.0135" total composite error. (The same test would also show approximately the same amount of total index error or accumulated pitch error.) No wonder it vibrated the vehicle! See Figure 4.

In the final analysis, double-flank composite testing is a poor method of quality control for gears that have had a subsequent finishing operation such as shaving and grinding. Remember that double-flank composite testing measures radially, and gears don't work that way. Single-flank composite testing is much more informative. It measures gears the way they work. Unfortunately, industry has been very reluctant to adopt this method of quality control. ○

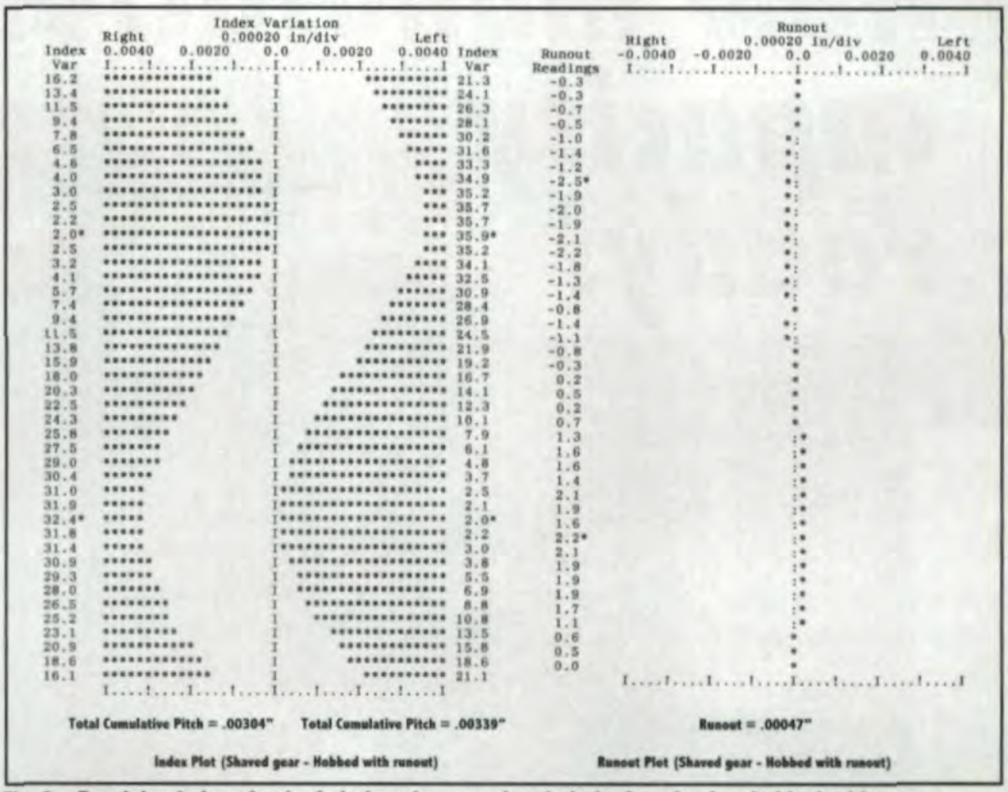

Fig. 2—Precision index check of pitch and accumulated pitch after shaving, hobbed with runout.

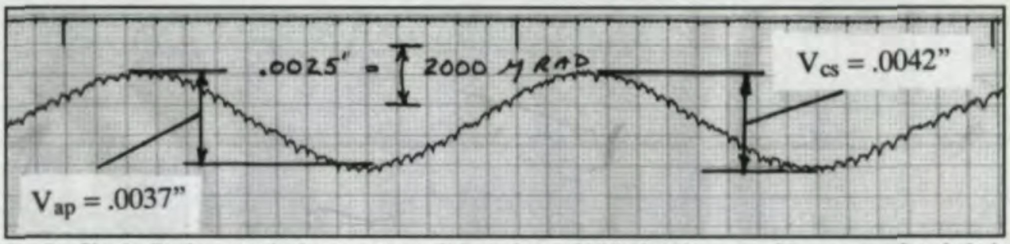

Fig. 3—Single-flank transmission error test of shaved gear, hobbed with runout. (V_{ap}=accumulated pitch variation; V_{cs}=total composite variation, single flank.)

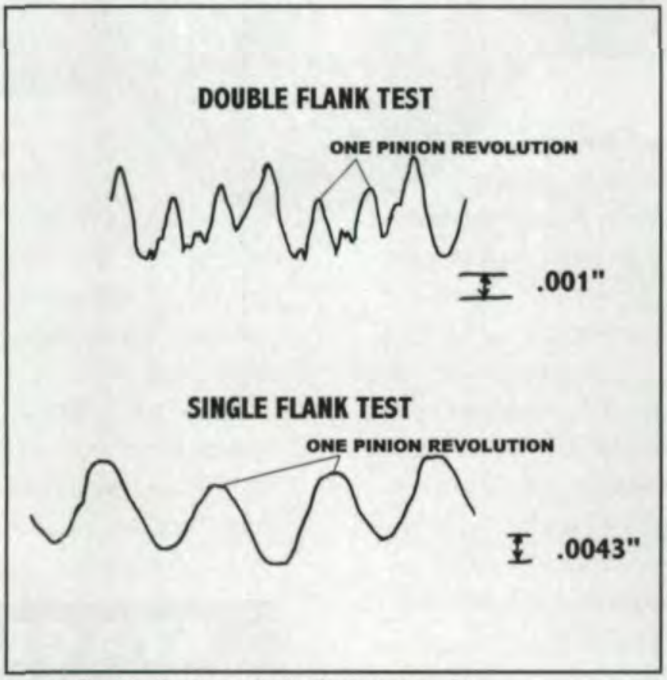

Fig. 4—Double-flank vs. single-flank test results.

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