Reducing Gear Rattle

The professionals at Muncie Power Products help you to address—and eliminate—gear noise/rattle one step at a time.

By Mikel Janitz
Creating a Baseline

The first step in the process was to create a baseline. Baseline noise testing was conducted on a diesel-powered Class 3 cab with an automatic transmission (refer to the graph accompanying this article for details). Before the gear set was mounted measurements for external backlash, gear quality, internal backlash, and endplay were recorded. All improvements are based on these measurements. The gear set was run at idle—approximately 700 rpm—the noise level recorded, and a baseline established. The red line on the graph represents the unacceptable sound level from that test. From this point the team started working on particular features to improve or reduce noise and rattle one step at a time.

Now let’s look at the graph, which depicts the impact on noise level as each feature is addressed. As you can see the baseline is well above the acceptable level. The noise was unacceptable to customers due to many factors, including excessive backlash between the transmission output gear and the input gear, reduced gear quality, smaller gear pitch, high internal backlash between gears, gear centerlines at top of tolerance, and high bearing endplay. One additional feature affecting noise is the presence of drag, or the lack of sufficient drag, which impacts noise and rattle in any form. Drag will be discussed last.

It is also noted here that the graph indicates that the features are additive. Each feature can therefore reduce noise by some amount. Noise can also be reduced proportionally to the number of features improved. It was discovered that one can change features, but the backlash between the transmission gear and gear set must be addressed first or the other steps have minimal impact. The design of backlash has its limitations. Consequently, backlash is controlled at installation and during gasket selection. Care must be taken to properly mount, install the gear set, and torque the fasteners to achieve optimal noise levels. This is in the control of the installer at this point.

After reducing the backlash between the transmission and gear set, the next feature worked on was gear quality. Improving gear quality can be costly. It is important to understand the relationship of manufacturing cost vs. reduced noise. It was demonstrated that higher gear quality and gear pitch reduced noise. The reduction was not only measurable, but also detectible to the human ear. Note that the gear quality went from a baseline of AGMA 8 to AGMA 10. Gear quality was the second-highest contributor to reduce noise, and therefore the second feature on the graph.

Controlling Backlash

The next step taken to reduce noise focused on internal backlash and centerline control. These are combined since they are so closely...
related. This is a cost-effective means to reduce noise. Accurate CNC equipment, programming, and tooling must be used in manufacturing to hold and repeat tight centerline tolerances. Testing indicated that it is necessary to control internal backlash before moving to the next step. It is important to specify and control internal backlash, but the results show that this had little effect in reducing rattle and noise that is detectible to the human ear. This was an important finding, but this step had the smallest impact on reducing noise of all those we addressed.

Rattle and noise create sound waves that we feel and hear. The waves of sound come from vibration between the gear, shaft, and bearing set. If the bearing set is loose—excessive endplay >.003, for example—the vibrations are more pronounced, and the noise is noticeably louder. Rattle is a huge customer dissatisfaction issue. If the endplay is reduced, the noise is reduced proportionally. The baseline endplay was excessive, and consequently the noise was unacceptable. When the endplay was reduced by 25 percent, the noise was reduced as well. Endplay cannot be completely eliminated, however, therefore rattle cannot be completely eliminated. If it were, bearings would burn up, and then you have a completely different issue to

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**Fig. 1:** Baseline noise testing was conducted on a diesel-powered Class 3 cab with an automatic transmission.
contend with. Bearings need to be sized properly, lubricated appropriately, and allowed to expand while in use. Endplay is last on the list to address, but there are other issues impacting rattle including gear size, inertia, weight, material, and geometry, just to name a few. These features were not addressed at present, as it would require significant time with simulation and 3D modeling to go down that path.

INTRODUCING DRAG

The last feature studied was the effect of drag on the noise in a gear train. In the graph the orange line represents the baseline gear set with the addition of drag only. A drag element by itself will reduce noise if the drag force is significant enough. A drag element in series with other features discussed will reduce noise, as well. The downside of introducing a drag element is the inefficiency it creates. It creates heat and requires power (uses fuel) to overcome resistance forces. The graph also indicates that noise was at an acceptable level with only a drag element without other features improved.

The question then becomes whether the inefficacies can be tolerated, and can operating costs justify the reduction in noise? Drag can come in many forms; for example, tight bearings, excessive hydraulic fluid levels, friction between clutch plates, and shaft loads. Other designed parts can be introduced to create drag, as well. Drag was last on the list to work on because of the negative aspects associated with it. The graph shows noise can be reduced to acceptable levels without drag, but it also shows that noise can be reduced by doing nothing other than adding drag.

CONCLUSION

Noise and rattle are big customer concerns today. Gear manufacturers and users of gear sets are working together to balance noise, rattle, and efficiency, as well as cost. Product design engineers are working with manufacturing engineers to produce the most-quiet gear set economically available. And test engineers and lab technicians will keep testing and reporting results so that we can continually improve customer satisfaction.

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