CASE STUDY



END-OF-LINE PRODUCTION TESTING AT VOLKSWAGEN, KASSEL

The Volkswagen plant at Kassel, Germany is the Volkswagen Group's largest gear and transmission production facility.





CHALLENGE

Volkswagen continuously tightens the noise, vibration and customer acceptance requirements for their transmissions, all while expecting the percentage of passing completed transmissions to continuously increase.

SOLUTION

Using Brüel & Kjær DISCOM systems in their test beds and establishing a control loop, root causes and potential problems are identified earlier or even predicted and avoided entirely.

RESULTS

Volkswagen is able to eliminate root causes and catch other potential problems early in the process, which minimizes cost, improves final assembly passing percentages and leads to higher quality.

BRÜEL & KJÆR CASE STUDY – END-OF-LINE PRODUCTION TESTING AT VOLKSWAGEN, KASSEL

VOLKSWAGEN, KASSEL

The Volkswagen plant at Kassel, Germany is the Volkswagen Group's largest gear and transmission production facility. They make transmissions, literally from start to finish: from milling the gears to the final transmission assembly. About 17 500 transmissions per day are produced at the plant, and the goal is to produce transmissions that cost-effectively satisfy the customer expectations for durability, ride comfort (including noise) and price.

THE CHALLENGE

Tighter pass-fail limits, improve quality and reduce cost

Customer expectations for the durability and comfort of cars, vans and trucks are ever increasing. Manufacturers must find a balance point for producing quality products that are cost-effective, not only for the manufacturer, but also for the customer. Customers want vehicles that work and are nice to be in, but they will compare prices versus features until

"YOU MAY WANT TO HEAR THE ENGINE, BUT NOBODY WANTS TO HEAR THE TRANSMISSION; IT'S ANNOYING TO THE CUSTOMER."

Dr Nils Krohn, Head of Acoustics Quality Assurance they find the level of performance and quality they are willing to pay for.

In some vehicles, manufacturers may spend a lot of money to ensure a specific sound, and in others, manufacturers will be going for the quietest interior they can get. But as Dr Krohn pointed out: "You may want to hear the engine, but nobody wants to hear the transmission; it's annoying to the customer." That comment sums up transmissions for the vast majority of drivers, but not just for sound, also for durability. The transmission is something that should just work, and with the trend of vehicles becoming increasingly less noisy, they especially do not want to hear it.

Testing to increase productivity

Gears and transmissions are machine made to tolerance limits. But flaws (for example nicks and surface ripples, or weaviness) are unavoidable and tolerance limit exceedance can happen due to tool wear. And with such a high volume over the course of a single day, even a small percentage of substandard gears or completed transmissions is a substantial number that must be reduced to an absolute minimum. This makes testing and finding the causes of defects and predicting tolerance exceedance necessary.

A first reaction might be to assume that as complexity, quality requirements and customer expectations increase, that the rigours of testing would increase and that transmission quality rejections would also increase, but that is only half right. Yes, testing has become much more rigorous and fine-tuned, but the success rate for completed transmissions is better than it used to be, according to Dr Krohn, particularly in the last 5 years. How do they manage to increase the testing strictures and have better end-of-line results?

THE SOLUTION

Identifying root causes reduces failures The answer lies in testing for the right reasons, establishing a control loop and identifying





"A SIGNIFICANT NUMBER OF FEATURES THAT ARE NOW PART OF THE STANDARD DISCOM SYSTEM ORIGINATED FROM DISCUSSIONS WITH AND REQUESTS FROM VW KASSEL PERSONS, INCLUDING DR KROHN."

Holger Behme-Jahns Group Leader of Software Engineering for Brüel & Kjær DISCOM

problems earlier and earlier in the process. Reworking a single gear pulled off the production line is one thing, pulling a gear out of an assembled transmission is costly, but pulling a transmission from a completed vehicle to fix that gear is expensive and unacceptable, and that vehicle reaching a customer, worse yet.

Testing is primarily focused on identifying durability issues and ensuring customer acceptance. Durability issues, such as nicks and surface ripples or weaves in gears can lead to a failure in an assembled transmission. And on top of the expected reliability, there is the ride quality and comfort that consumers have come to expect and associate with quality.

And the outcome needs to be cost effective. According to Dr Krohn, gears and transmissions that function perfectly and produce insignificant noise, are producible, but definitely not cost effective. At the same time, noisy vibration factories jammed into the drivetrain could be available for little more than the cost of materials. But would they even be worth that cost? Somewhere in-between are reliable, unobtrusive and affordable transmissions. There needs to be a way to continuously move that convergence of durability, cost and acceptance further and further to the perfection side of the spectrum.

The control loop and DISCOM

Establishing a control loop with testing for each transmission family is the key element. Volkswagen's basic control loop comprises cycles of testing, comparison and evaluation, refining test parameters and re-testing throughout the developmental stages of the production line. The stages are a preliminary group, a pre-series and the final production line. Testing is the key element, and this is where DISCOM enters the fray.

The DISCOM production testing team has had a close working relationship with Volkswagen for many years. DISCOM NVH Analysis system software is used both to test gears at the end of their production lines and also to test the completed transmissions at the end of their lines. The end-of-line transmission test simulates vehicle conditions and uses order-syn-

DISCOM joins Brüel & Kjær For the past 20 years DISCOM has developed and distributed systems for acoustical quality analysis used in endof-line testing in the automotive industry. These systems are highly respected and used world-wide by companies in and around the automotive industry. Brüel & Kjær acquired DISCOM on July 26, 2016.



chronous resampling, so the noise sources from different rotors inside the transmission can be separated.

The DISCOM system consists of a latest-generation industrial computer that has been enhanced by a unique USB-based data acquisition front end, specially developed by DISCOM. Two of the key elements of DISCOM NVH Analysis software that are particularly beneficial to large production environments are a parameter database and a results database. Due to the order-synchronous resampling process, a root cause-analysis of the production defect is possible. The result database and associated tools in the DISCOM system help develop predictions on tool wear and related tolerance mismatch problems.

Preliminary group – baseline and characteristics

When creating a new production line, the first task is producing the preliminary group of around 20 transmissions. Dr Krohn's team works with the DISCOM team to analyse data and find identifying characteristics. This is where the gears and produced transmissions will be tested on the production line with DISCOM NVH Analysis to form a baseline and begin to identify pertinent characteristics. For example, a seven-gear transmission (six forward and one reverse) would typically have around 700 characteristics (two speed ramps per gear, which works out to 50 characteristics per test step or ramp) identified by the DISCOM production testing team (examples of characteristics include spectral values, energy values and order tracks).

Once the preliminary baseline is established, the completed transmissions are put in vehicles and tested using a mobile test system looking for correlation with the test stand. The data and drive feedback are used to refine the test limits. This is an iterative process that leads to a much more refined set of limits for the next trip through the end-of-line test stand.

Pre-series - refinement and correlation

The next step in the process is the pre-series. In the pre-series, there is continued cooperation with the DISCOM team, where the major goal is to find a subset of those characteristics that are of specific relevance for the current transmission model and where the limits are most important. In the end, out of those 700 characteristics, the Volkswagen team will identify around 200 that are relevant to the particular gear set and transmission. This process is a more refined version of the pre-series end-of-line test and mobile test, where they will continue to adjust parameters and limits, looking for that best-fit for durability, customer acceptance and cost-effectiveness.

Production iine - refinement ever after

The production line is only the final step in that the transmissions produced will end up in production vehicles intended for sale in the market. In practice though, the production line is just one long stage in the test-loop refining process. All of the data for each gear and transmission test, both pass and fail, are stored and available for retrieval for later reference and analysis, within seconds. This aids in developing predictions concerning tool wear (that leads to surface ripples and tolerance exceedance, etc.) and identifying root causes for faults that can be eliminated in the future.

THE RESULTS

When machining and material issues can be found early in the process, they are not so expensive to deal with, but the later issues arise in the production process the more expensive they become. And of course, the worst case scenario is a sub-standard transmission making it into a car. The testing procedures, systems and software developed and used by Volkswagen and the DISCOM team don't just weed out defective transmissions, they improve customer acceptance and cost effectiveness by stopping the vast majority of problems before they can become increasingly expensive and aggravating to the end users.



www.bksv.com/casestudies

Copyright © Brüel & Kjær. All rights reserved.

