Maintaining gearbox centre distance minimises acoustic noise in micro motion applications

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Simulation shows that the problem of acoustic noise in micro motion gearbox design can be reduced by removing transmission error. Optimised gearbox design ensuring close manufacturing tolerances can achieve this. As wider factors surrounding gearbox integration can also impact noise levels, it's useful to partner with a motion solution manufacturer that takes a holistic approach to application design.

Subhash Jadhav, Application Engineer, and Pradeep Deshmane, Principal Engineer, Portescap, discuss the importance of gearbox centre distance.

Excessive acoustic sound generation, or noise, is undesirable for a variety of micro motion applications. Many medical applications demand low noise to enable patient comfort and recuperation, while various military devices need to operate with low acoustic sound for tactical importance. Within a motion system, the gearbox can be a cause of acoustic noise, so to design transmission with a low sound output, it's crucial to understand the factors that impact it.

An important cause of acoustic noise is misalignment of the shafts within the gearbox, on which the gear sprockets are mounted. This misalignment can be traced back to the challenge of maintaining centre distance. Centre distance is the measurement between the centre of two intermeshing gears, and it should be maintained to a predetermined tolerance.

However, due to mounting inaccuracies, and misalignment occurring during operation, centre distance can increase above its predetermined position. In turn, this can displace housing bore positions, as well as the bearings supporting the shafts within the housing. This misalignment causes issues in gear teeth engagement, and these dynamic behaviour changes can result in transmission errors and acoustic noise.

To design a gearbox with the desired low noise properties, a simulation can test the critical factors involved. To vary the centre distance, the housing bore connected to the bearings is displaced at set distances. This simulates the variation that can occur in manufacturing tolerances, where housing bore position might vary between 30 and 80 microns depending on the production accuracy achieved by the motion system designer.

To test and contrast operating conditions of a compound gearbox comprising three spur gear pairs, analysis should include both load-free and load conditions at 0.5Nm torque. A speed range extending up to 5,200rpm for the gearbox input shaft should also be applied. To replicate the operation of non-linear loads, gear mesh harmonics (distorted voltage waveforms) from first to third order will cover the maximum frequency of 4,000Hz. Misalignment should also be arranged in the skew condition, where the output gear is displaced in the skew direction from the mating gear. This way, noise levels are more sensitive compared to an alternative out of parallel misalignment.

Ultimately, the simulation of the displacement of the shaft-supporting bearings shows that the change in centre distance significantly impacts transmission error and noise levels. The more extreme the misalignment of the shafts, the higher the maximum peak to peak transmission error, as measured in microns. This factor is increased the higher the applied Nm torque load. The more precisely manufactured the gearbox, and the more reliably it can maintain centre distance over time, the lower the transmission error.

To understand the corresponding acoustic noise as a result of the transmission error, a specially set up microphone can capture the output. This is measured in the Decibel A-scale (dBA) as the human ear would hear it, whether on a hospital ward or a military zone. With a no misalignment centre distance condition, the maximum amplitude is 38dBA, measured at 3,200rpm. However, as misalignment skews to 30 microns, noise increases to 50dBA, and at a misalignment of 80 microns, it reaches 52dBA.

How the gearbox is mounted within the overall system, and how the gearbox interacts with it, are also factors impacting transmission error and noise. The simulation can be used to provide analysis on the deflection, considering factors such as alignment and bending, of the system as a whole. Deflection measurement at a system's maximum load can be identified, as well as understanding if any improvements are required to control deflections by altering the mountings on gearbox, material combinations, or load conditions used in the application.

Considering the impact of centre distance on acoustic noise, if a low output is required, it's imperative to partner with a motion designer such as Portescap that can achieve the closest tolerances in gearbox production. As wider factors outside of the gearbox design can also impact an application's overall noise level, a motion designer like Portescap that takes a holistic approach to system design can help achieve an improved result overall.

Image captions:

Image 1: Maintaining gearbox centre distance minimises acoustic noise in micro motion applications (Stock_210575912)

About Portescap

Portescap offers the broadest miniature and specialty motor products in the industry, encompassing coreless brush DC, brushless DC, stepper can stack, gearheads, digital linear actuators, and disc magnet technologies. Portescap products have been serving diverse motion control needs in wide spectrum of medical and industrial applications, lifescience, instrumentation, automation, aerospace and commercial applications, for more than 70 years.

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