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While different versions of the internal combustion engine were being used more than 200 years ago, commercial vehicle use began in the mid 19th century when the widespread production of petroleum began. Countless engineering advances have occurred since. Yet one constant has never changed:

VIBRATION.

"All of these engines create different firing pulses in order to operate and it is those pulses that cause oscillations and subsequent vibration," explains Prashant Kulkarni, engineering manager – clutch division, Eaton Corporation. "That same vibration then travels through the entire driveline, through the clutch, the transmission, down the driveshaft, and to the axles.

"When the vibration gets to be too excessive, it can break components like synchronizer pins, gears in the transmission and universal joints. It could even be gears down in the axle, or any other component that is directly in the torque path of the driveline."

Kulkarni goes on to note that the clutch is, in fact, the only component along the driveline that can affect vibration. That's because it is the only soft component and the only component with 'air.' Everything else on the driveline is metal-to-metal – or a match-up that does not dampen vibration, but simply passes it along to the next component.

Meanwhile, today's high-torque, low-speed engines are compounding the problem. As engine speed goes down, the amount of vibration that needs to be dampened increases.

"The engines of today are churning out vibrations that can damage high-value driveline components," he notes.

Thankfully solutions do exist, and damper technology is the key.

"The damper in the clutch has to be precisely designed," believes Kulkarni. "The damper is the most critical part of a clutch. If you design the stiffness of the damper appropriately, it will positively impact the entire driveline."

In explaining the role of a damper, Kulkarni likes to use the analogy of a broomstick and a Slinky®.

"If I'm holding a broomstick on one end and someone else is holding it on to the other end and I shake my end, the other person will feel every oscillation," he adds. "Conversely if we do the same with a Slinky®, the other person will not feel a thing because of the soft spring.

"But a clutch damper cannot be as soft as a Slinky®. It has to have enough travel designed into it to soften or dampen torsional vibration yet be strong enough to absorb the torque required to power the driveline."

No One Clutch Fits All Engines

Several factors come into play in order to reach that precise cushioning balance, says Kulkarni, including:

- The amount of torque from the engine that the driveline needs to support.
- The appropriate stiffness/softness of the damper to isolate vibration energy coming from the engine.
- Determining the correct size of the damper to accommodate the number of springs needed.
- The amount of friction material needed to maximize wear life.



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“With a one-size-fits-all clutch, there will have to be compromises made with one or all of those items,” adds Kulkarni. “The damper will not be optimized in either its stiffness, its size, the amount of friction material or in its torque capacity.”

And even though a clutch may appear to not fail itself in a vehicle, excessive torsional vibration can result in other driveline component failures. “A truck built prior to 1996 used one of our stiffer rate 10-Spring model clutches. Vehicles purchased after 1996 are now standard with soft rate damper such as the 7-Spring or VCT dampers to avoid excessive vibrations.”

“It is important to have various configurations of springs because there is only a certain amount of available space,” says Kulkarni. “So it comes down to a design effort where we make the damper this soft or stiff to transmit this much torque with this number of springs.”

That is also why, he adds, over the last 20 years a plethora of different dampers – and subsequent clutch models – have been developed.

Design Evolution

Beginning in the late 90’s, engine makers opened the flywheel bore from 8.5 inches to 10 inches. This gave clutch designers valuable extra real estate to dampen vibration produced by new engines. Eaton capitalized on this with the introduction of 7-Spring and VCT models. The damper springs in these models grew larger and heavier to provide more travel.

Kulkarni states, “The soft rate 7-Spring and VCT dampers were developed, and designed to take full advantage of the 10-inch flywheel bore. All major North American truck makers have since 100 percent standardized on these soft rate dampers for their large bore engines.”

“Trucks built prior to 1996 have a 8.5-inch flywheel bore that cannot accommodate the larger, soft rate dampers so Eaton still offers 10-Spring product in the aftermarket. Fortunately, Eaton can offer the soft rate dampers to owners of large bore engines across all torque ratings. And we highly recommend taking advantage of this critical damper evolution.”

Eaton has invested heavily over those same 20 years, says Kulkarni, into developing an analytical model of commercial vehicle driveline systems.

“Today we can model an engine connected to any driveline,” he says. “And we can calculate the amount of torque required for that driveline and the associated natural frequencies that is required to have all of those parts that are connected to each other functioning properly.”



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The natural frequency of the driveline is determined by the stiffness and the mass of the components. A given driveline, sized for torque and other criteria, will have its own natural frequency. A change to any of the components in the torque path will change the frequency. The only way to control the frequency of the driveline is to alter the clutch damper.

“Because of the calculations that we have, we can determine how soft the damper needs to be so that the truck is never in a situation where it will be operating at the natural frequency, a condition called driveline resonance, which will cause a lot of damage to the driveline parts and may result in sudden component failure,” adds Kulkarni. “You do not just put in an arbitrary stiffness. It is highly engineered and designed to ensure you get the appropriate durability of your driveline.”

Eaton engineering has worked closely with all major truck manufacturers to develop the baseline for these extensive calculations.”

The damped clutch is right after the engine, and right before all the components that might fail due to vibrations, such as transmission input shafts, synchronizers, u-joints, axles, and more.

“Designing a clutch damper in such a fashion that you reduce driveline resonance, you can eliminate a lot of reliability risks for the entire driveline,” summarizes Kulkarni.

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