Career biography

Presenter's Name	**Dr.-Ing. Wolfgang Reik**	
Company	**LuK GmbH & Co. oHG**	
Professional Career	**1968**	**Studies of physics at the University of Karlsruhe**
	1979	**Engineering degree from the Institut für Werkstoffkunde I (Materials Engineering Institute 1) at the University of Karlsruhe**
	1979	**Dr. Reik joined LuK in Bühl, a supplier to the automotive industry and a specialist for clutches and passenger car drivetrain solutions. Dr. Reik held various entry-level positions at LuK and was later appointed manager of the testing department.**
	1989	**Executive Vice President for Research & Development**
	2004	**Dr. Reik has also been responsible for managing the Automotive Advanced Development department for the Schaeffler Group which consists of INA, LuK and FAG**
Current position; Responsibilities		**Executive Vice President LuK Group Research & Development** **Executive Vice President Advanced Development Schaeffler Group Automotive**

The centrifugal pendulum absorber
Calming down the drivetrain

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Introduction

Rising oil prices, the increasing shortage of crude oil resources and the harmful effects of CO2 on climate warming are forcing vehicle manufacturers to develop drivetrains with significantly better fuel consumption. The conventional drivetrain based on an internal combustion engine is coming under additional pressure by the possibilities of electric-only running that have now come within tangible reach. It is only the fact that battery capacity remains limited that is delaying the introduction of electric cars.
In order to give the internal combustion engine a chance of survival in the long term, the poor efficiency of current drivetrains must be drastically improved.
The fact that barely more than 20% of the inherent fuel energy reaches the wheel and can therefore be used for driving will be unacceptable in future.
Engines and transmissions must therefore be refined to achieve maximum efficiency.
Almost all the measures that are being discussed in this context and are conceivable increase the irregularities in torque and speed affecting the crankshaft.

- Higher power/torque per unit of cylinder capacity
- Higher average pressures
- New, fuel-efficient combustion processes
- Fewer cylinders with identical power
- Generous torque curves, allowing operation at the lowest possible speed

The only way of holding the irregularity at its current level is through considerably greater mass moments of inertia of the flywheel masses. This would, however, come in conflict with the requirements for lightweight construction.
While the greatest potential lies in the engine with its efficiency of barely more than 20%, improvements are also necessary in transmissions, whose efficiency is of the order of 90% depending on the type. The causes of power loss must be optimized or completely removed.

- Low friction in bearings and tooth meshes
- Reduced splashing losses
- Optimized hydraulic components such as pumps
- Replacement of hydraulic actuators by optimum efficiency, electromechanical components

These measures, however, make it more difficult for the drivetrain to damp out the vibrations generated by the engine irregularity and thus avoid rattle and boom noise. Current torsion dampers would no longer appear adequate to this task.
Drivetrain developers are therefore confronted with the situation where urgently required measures to reduce consumption cannot be effectively implemented because the drivetrain vibrations can no longer be overcome.
Many vehicle manufacturers who have clearly recognised this problem have therefore set themselves the task of developing new isolation and damping concepts since the conventional torsion dampers currently used in the dual mass flywheel and converter lockup clutches, are reaching their physical limitations.

Requirements for vibration isolation in modern drivetrains.

Engine development can look back on considerable progress in the last decade [1]. Engine torque relative to engine capacity has significantly increased and the curves have become more generous, i.e. such high torques are available at speeds of barely more than 1000 rpm that fuel-efficient driving is possible and even promoted in these ranges *(Figure 1).*

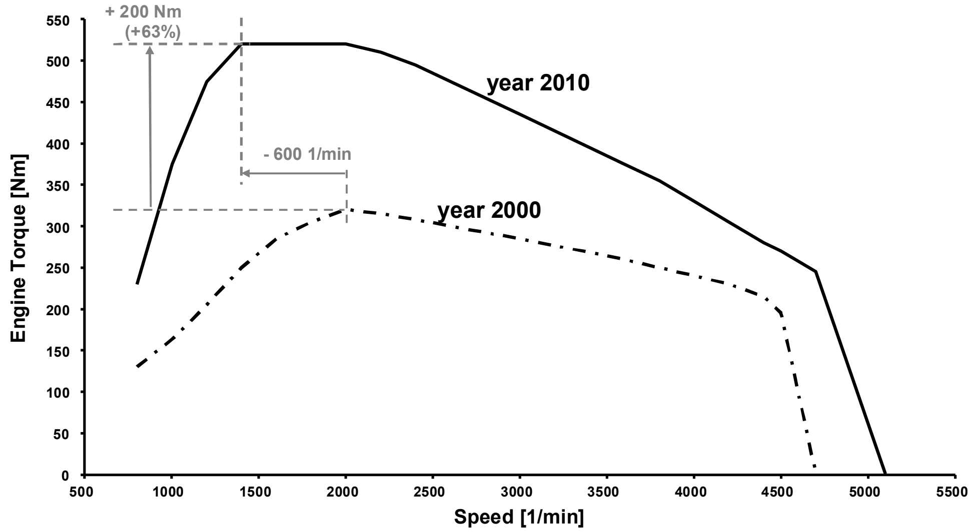

Fig. 1: Increase in Engine Torque from year 2000 to 2010
Based on the Example of a 4 Cylinder, 2.0 litre Diesel Engine

This leads, unfortunately, to correspondingly higher irregularity at the crankshaft *(Figure 2)*.

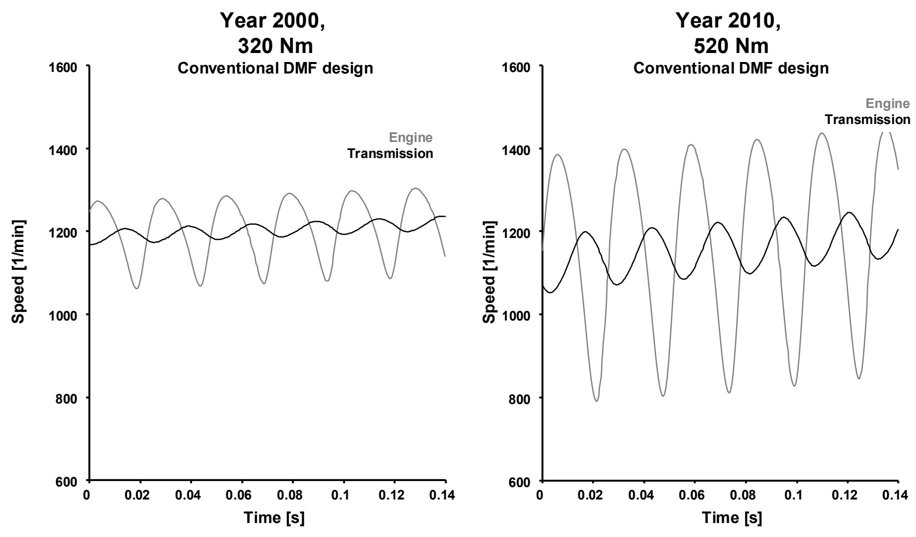

Fig. 2 Increase in Engine Excitation and Resulting Transmission torsional vibrations
Based on the Example of a 4 Cylinder, 2.0 litre Diesel Engine

Since transmissions have been "optimized" over the same period, i.e. designed for lower friction, there is now a situation where even better isolation is required under higher excitation levels in order to fulfil the increased comfort requirements *(Figure 3).*

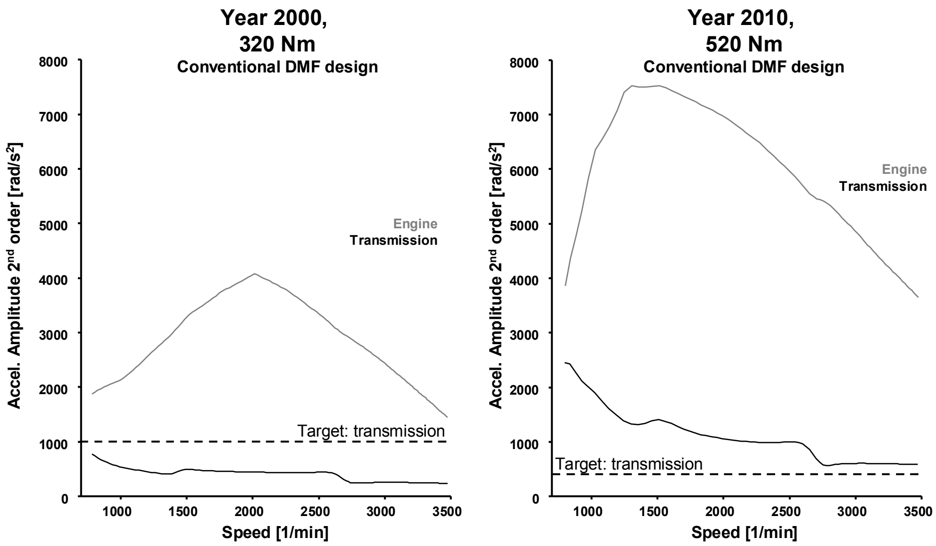

Fig. 3 Increase in Engine Excitation and Resulting Transmission torsional vibrations Based on the Example of a 4 Cylinder, 2.0 litre Diesel Engine

If this is to be solved with the existing damper technology, which uses torsional elasticity to give decoupling, considerably larger torsion angles must be achieved in order to simultaneously give better isolation at lower speeds.

Figure 4 shows in a qualitative manner how the damper capacity must be increased in order to meet these challenges [2]. This would require considerably greater spring volumes, for which no space is available. As a completely separate issue, it would hardly be possible to achieve comfortable driving with such enormously long curves, since the torsional damper would extremely wind up under full load.

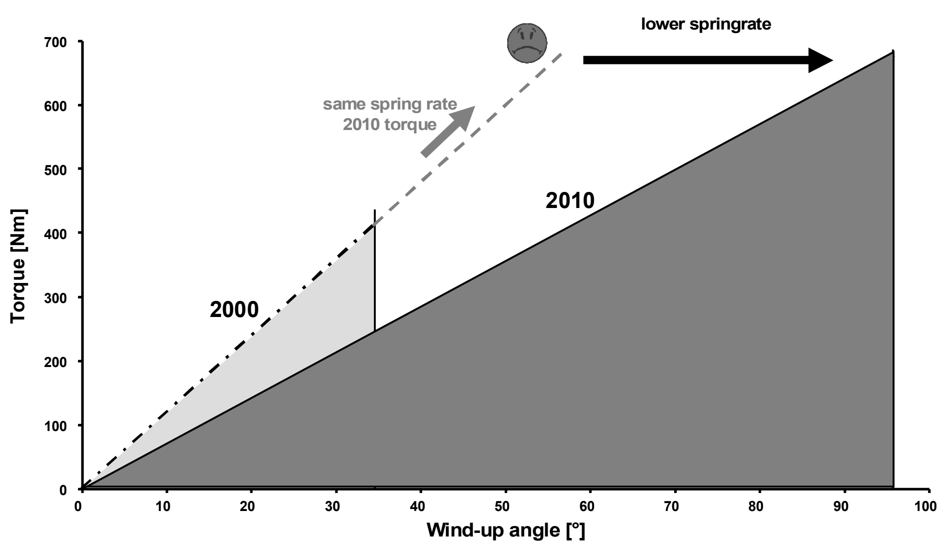

Fig. 4: New Requirements for Damper Design for modern engine

Physical possibilities for vibration isolation

Apart from torsional elasticity-based decoupling using a torsional damper, there are other possibilities for vibration isolation. The fundamental principles are shown in *Figure 5*.

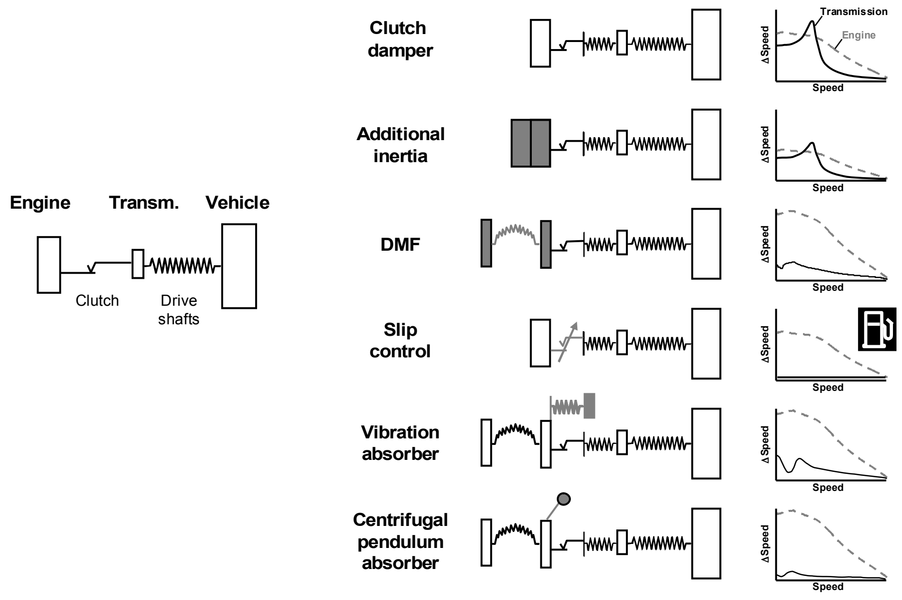

Fig. 5: Different ways to achieve vibration isolation

Prior to the introduction of the dual mass flywheel, only torsional dampers were used in clutch discs and were completely adequate in terms of isolation effect at higher speeds. Since the resonance speed of drivetrain thus equipped is in the range between 1500 and 2000 rpm, isolation cannot be achieved below about 2000 rpm, a speed that is now particularly important for fuel-efficient driving.

Improvements can be achieved by providing an additional mass moment of inertia on the primary side. The irregularity of the engine is reduced in line with this additional mass. In order to fulfill current isolation requirements, however, unrealistically high additional masses would be required.

About 20 years ago, the problem was solved by the dual mass flywheel, in which a well-dimensioned torsional damper was arranged between two masses. As a result, the resonance speed was pushed below the idling speed.

Good isolation of the torsional vibrations was thus possible at lower speeds from approx. 1000 rpm.

Over two decades, the dual mass flywheel was the panacea for vibration problems and drivetrain noise and was successfully implemented in manual transmissions across whole classes of vehicles.

In automated transmissions with converters, in which the dual mass principle cannot be implemented so easily, the specific slip in the lockup clutch was utilised in addition to the conventional torsional dampers in the converter lockup clutches.

According to Coulomb's Law of Friction, the frictional force is not dependent on the slip speed. A slipping transmission element does not transmit any torque variations. The slippage required is directly dependent on the magnitude of the torsional vibrations which lead to relatively high losses at low speeds.

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