



SCHAEFFLER GROUP
AUTOMOTIVE

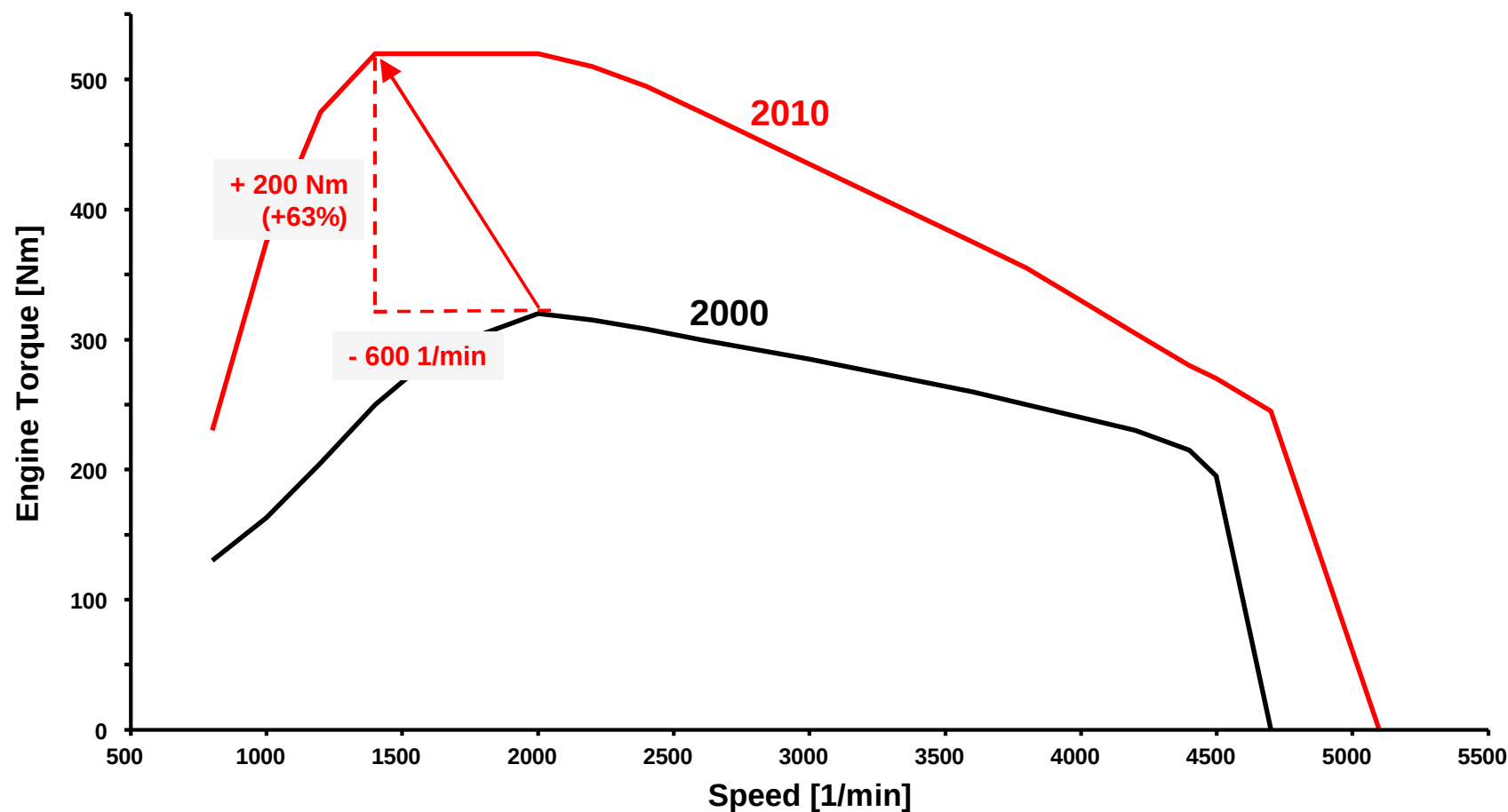
The Centrifugal Pendulum Absorber Calming down the drive train

Wolfgang Reik, Bertrand Pennec, Thorsten Krause



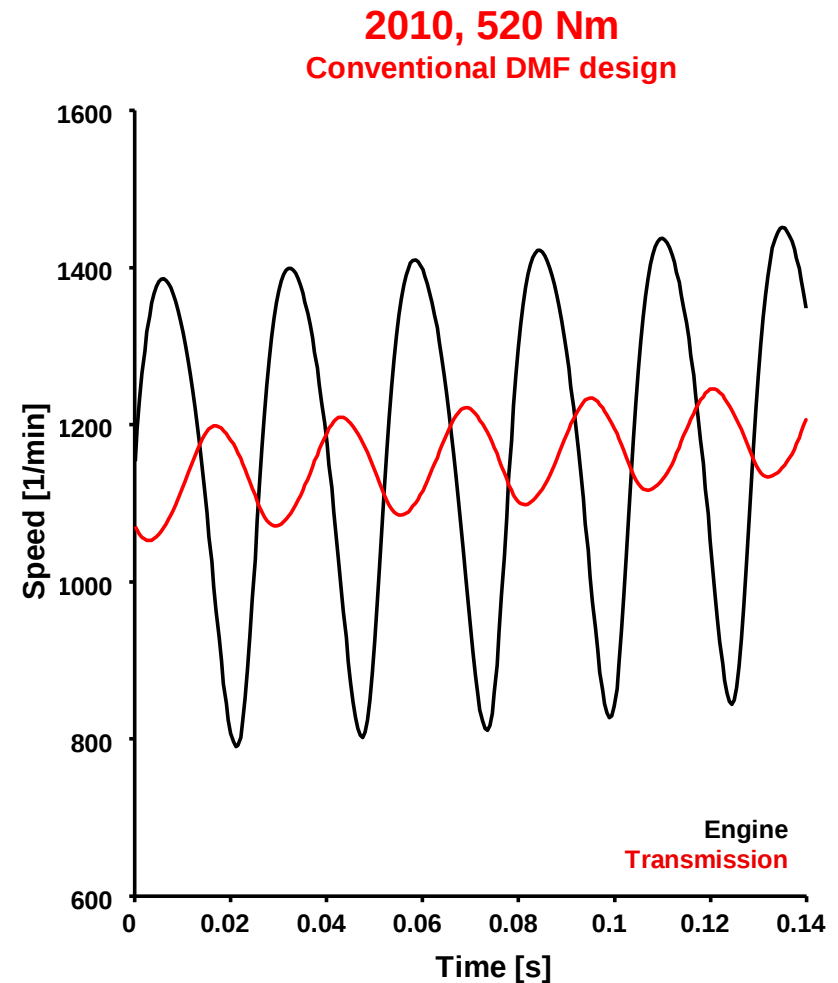
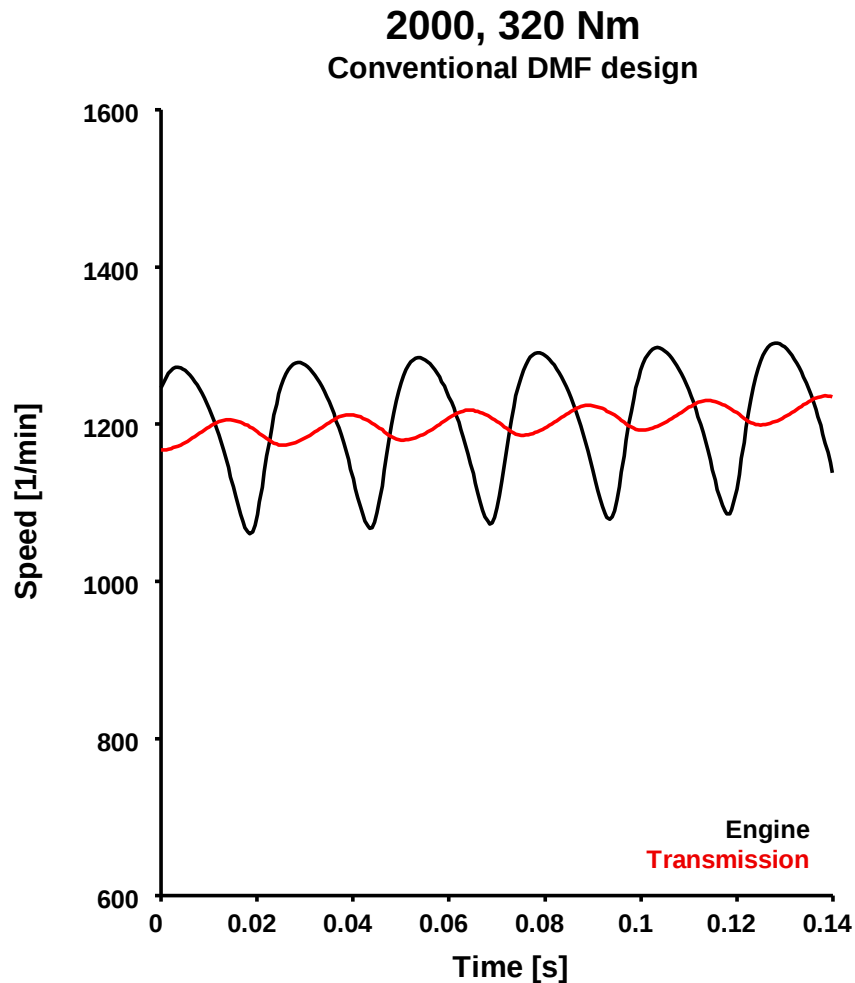
Increase in Engine Torque & Downspeeding

Based on the Example of a 4 Cylinder, 2.0 litre Diesel Engine



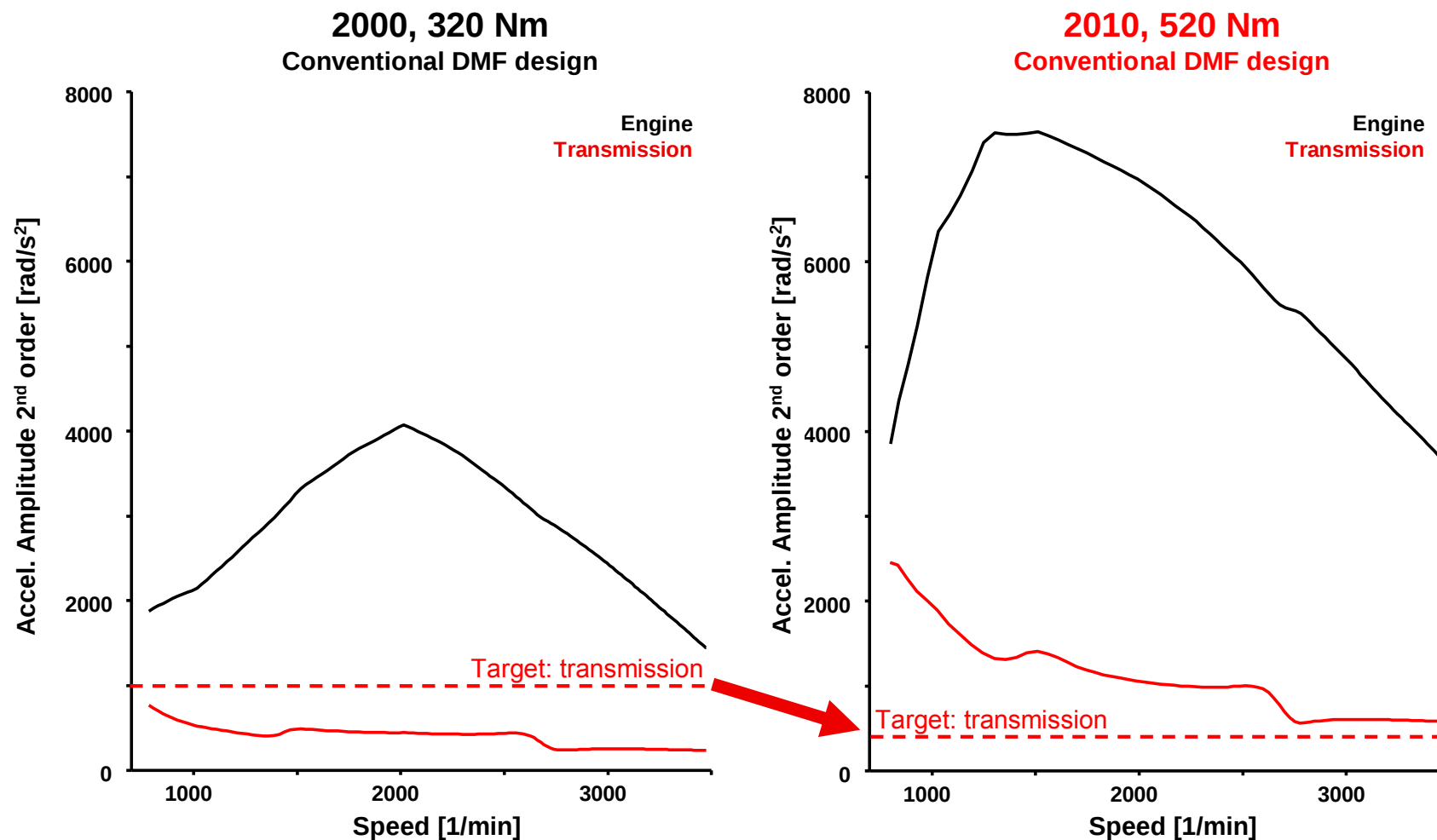
Increase in Engine Excitation & Resulting Transmission vibrations

Based on the Example of a 4 Cylinder, 2.0 litre Diesel Engine

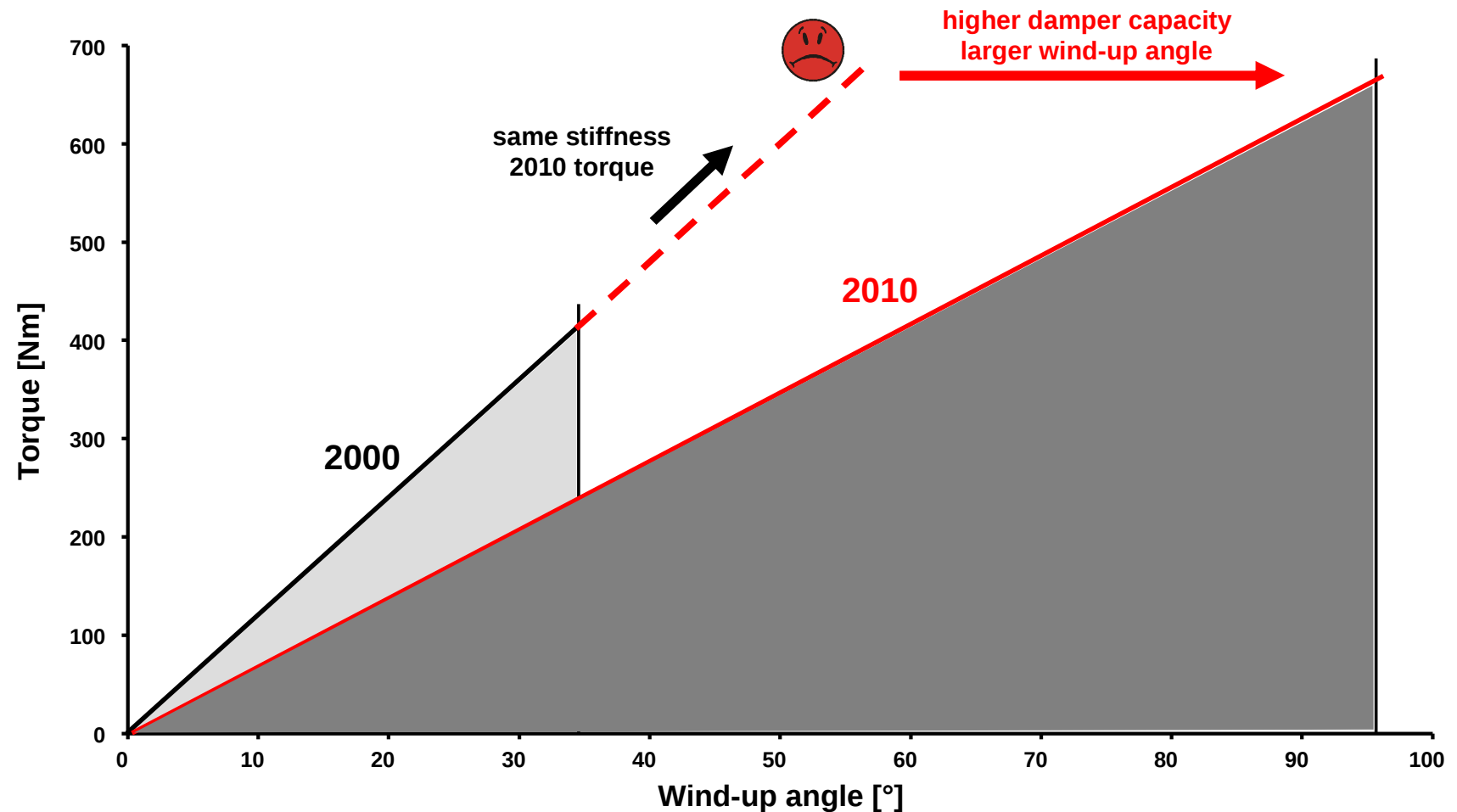


Increase in Engine Excitation & Resulting Transmission vibrations

Based on the Example of a 4 Cylinder, 2.0 litre Diesel Engine



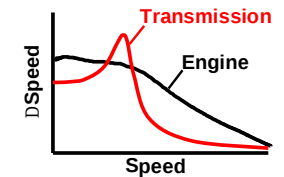
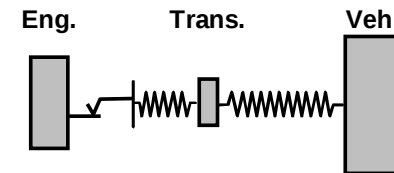
Requirements for Damper Design



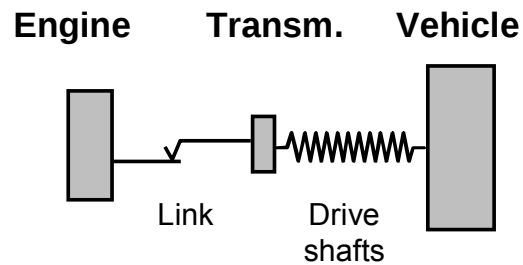
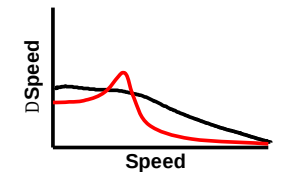
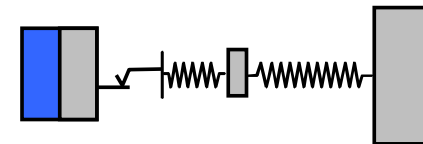
Different ways to achieve vibration isolation



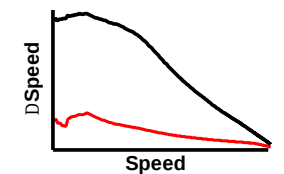
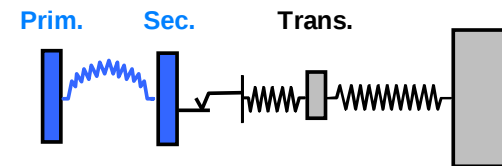
Clutch damper



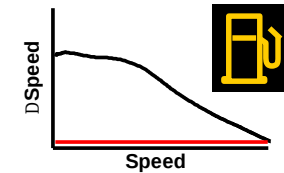
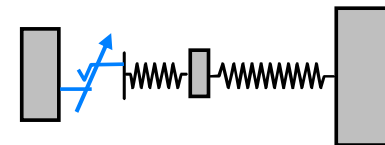
Additional inertia



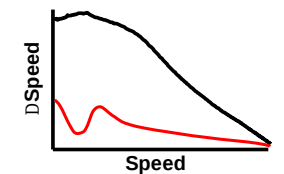
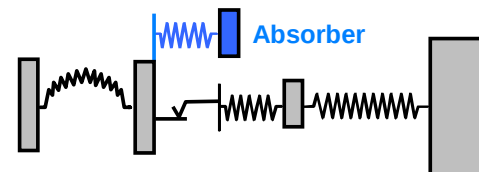
DMF



Slip control

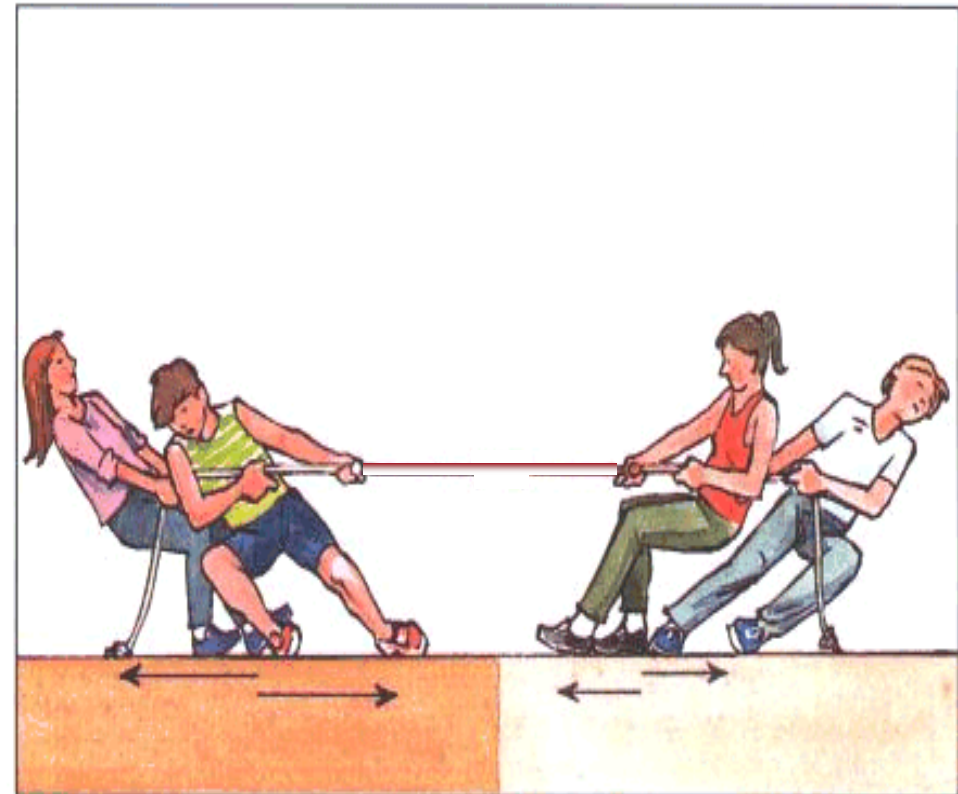
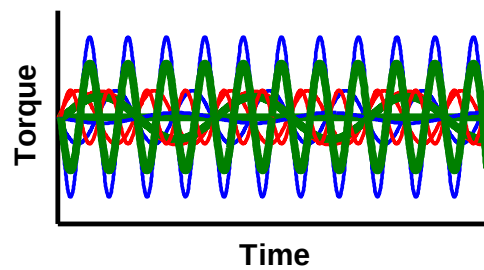
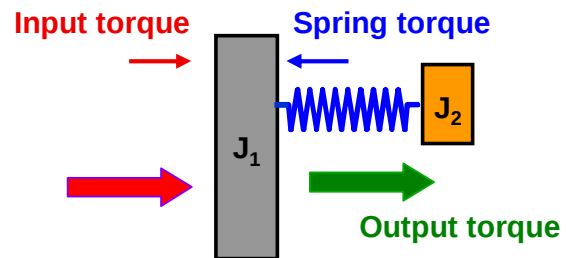


Vibration absorber



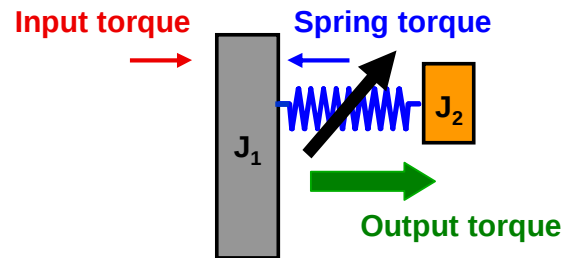
Vibration absorbing effect

Basic concept

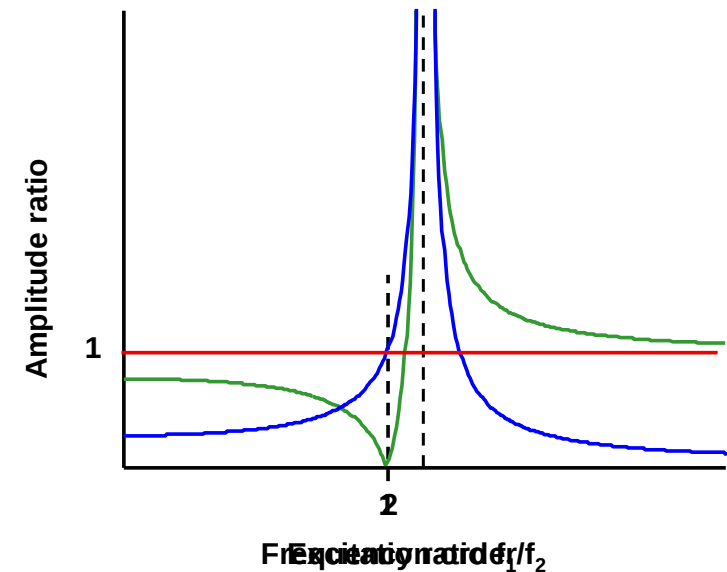
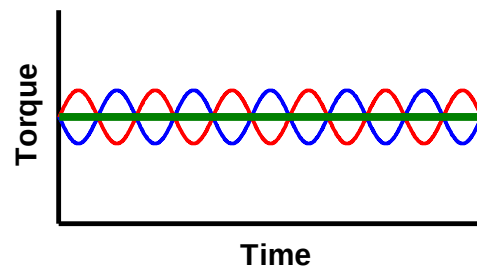


Vibration absorbing effect

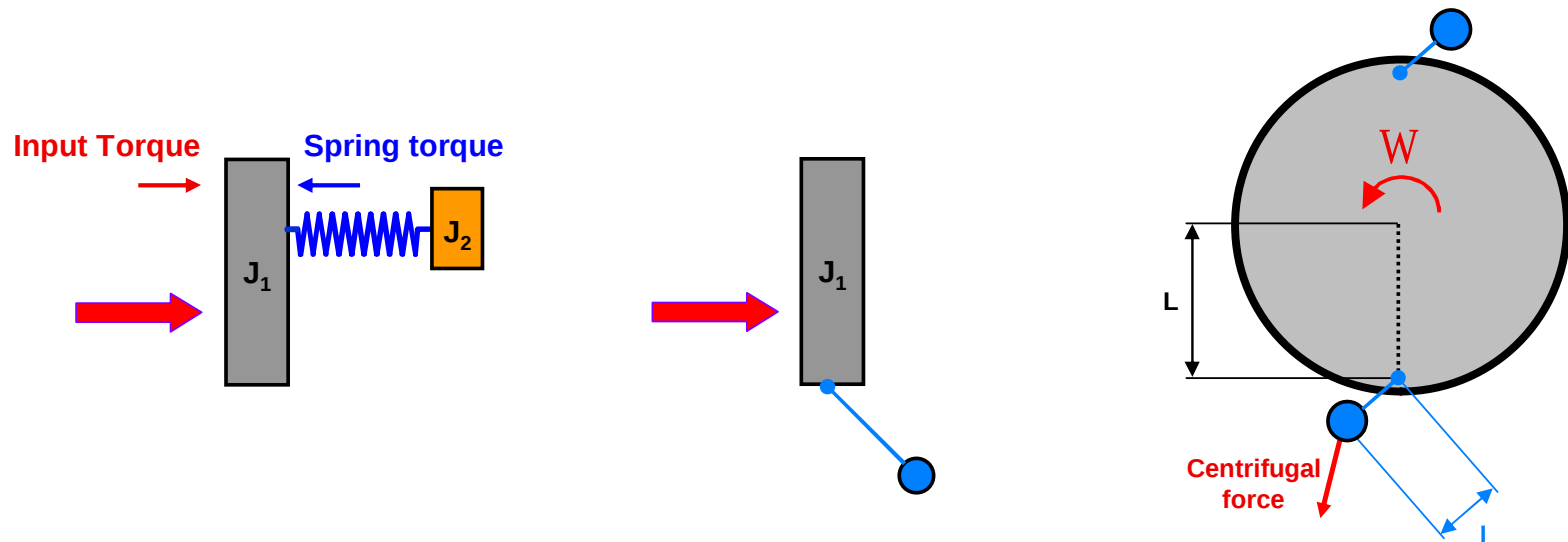
Speed-adaptive behaviour



Solution: speed-adaptive spring stiffness $c \sim n^2$



From Vibration Absorber to Centrifugal Pendulum



$$\omega = \sqrt{\frac{k_{\text{Absorber}}}{J_{\text{Absorber}}}}$$

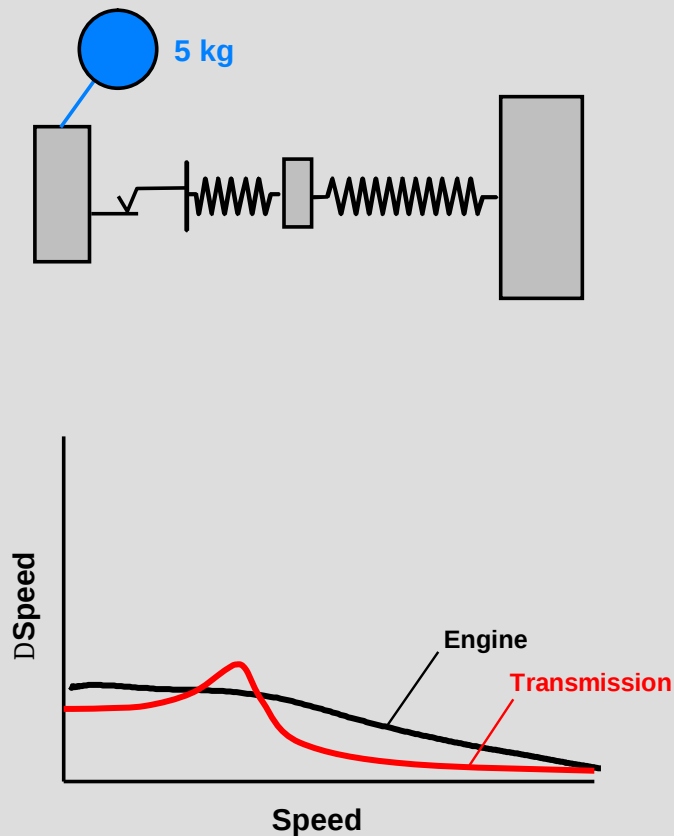
$$\omega = \sqrt{\frac{g}{l}}$$

$$\begin{aligned}\omega &= \sqrt{\frac{L \cdot \Omega^2}{l}} \\ &= \Omega \cdot \sqrt{\frac{L}{l}}\end{aligned}$$

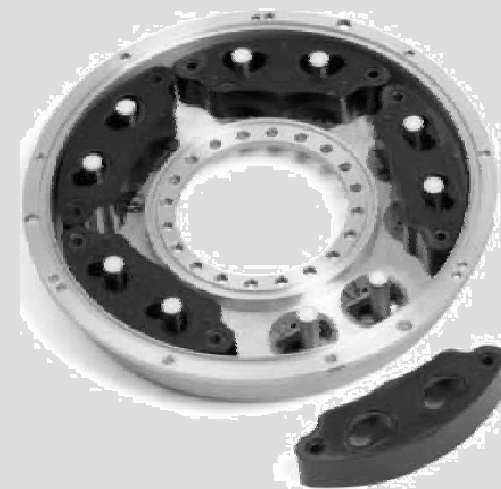
Essential possibilities for locating a centrifugal pendulum absorber



On flywheel



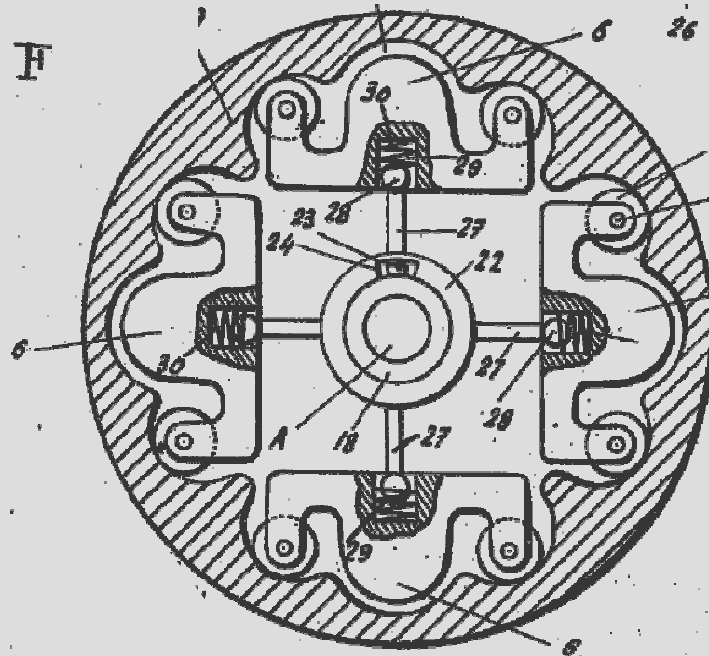
Vibracoustic / Freudenberg
(Bifilar, Sarazin-type)



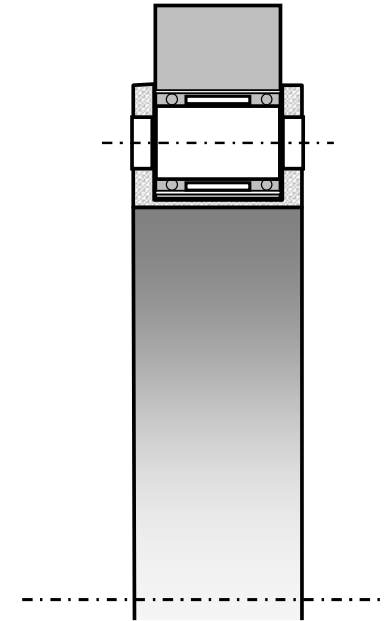
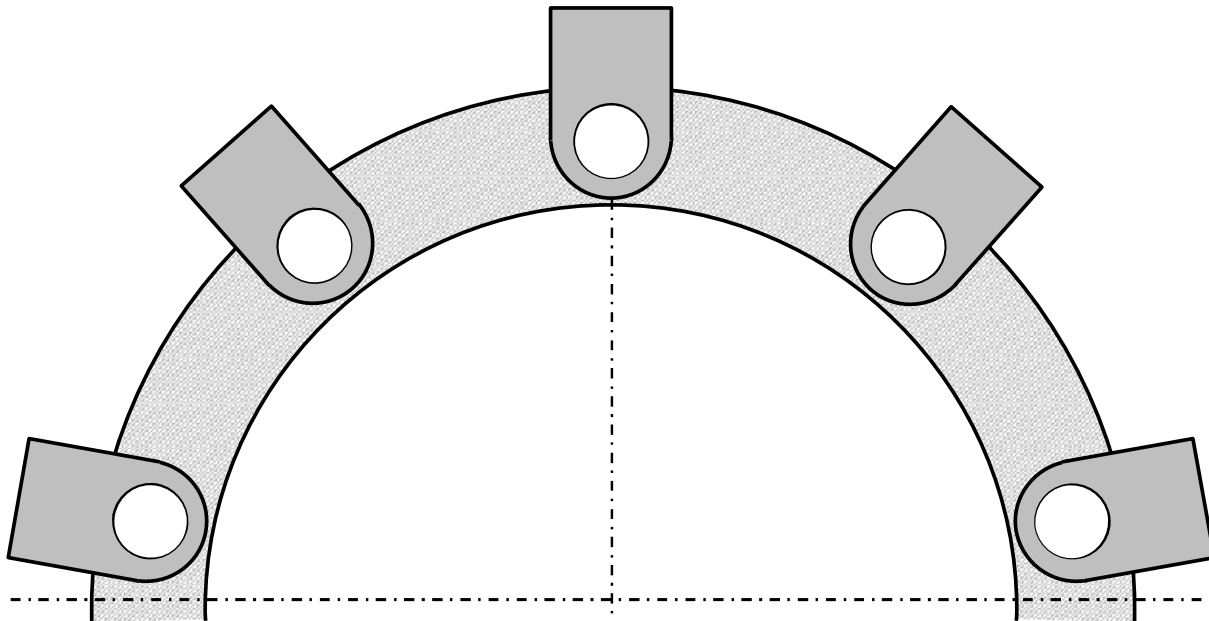
A History of Centrifugal Pendulum Absorbers



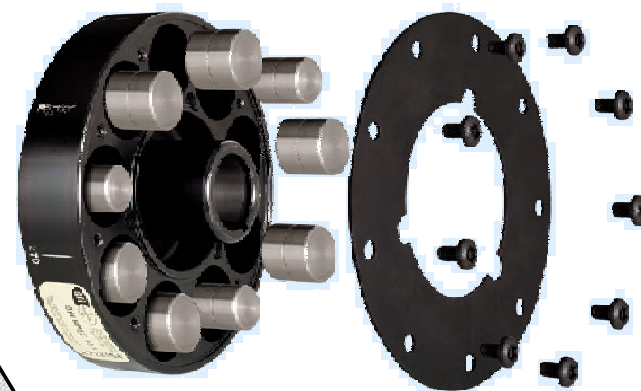
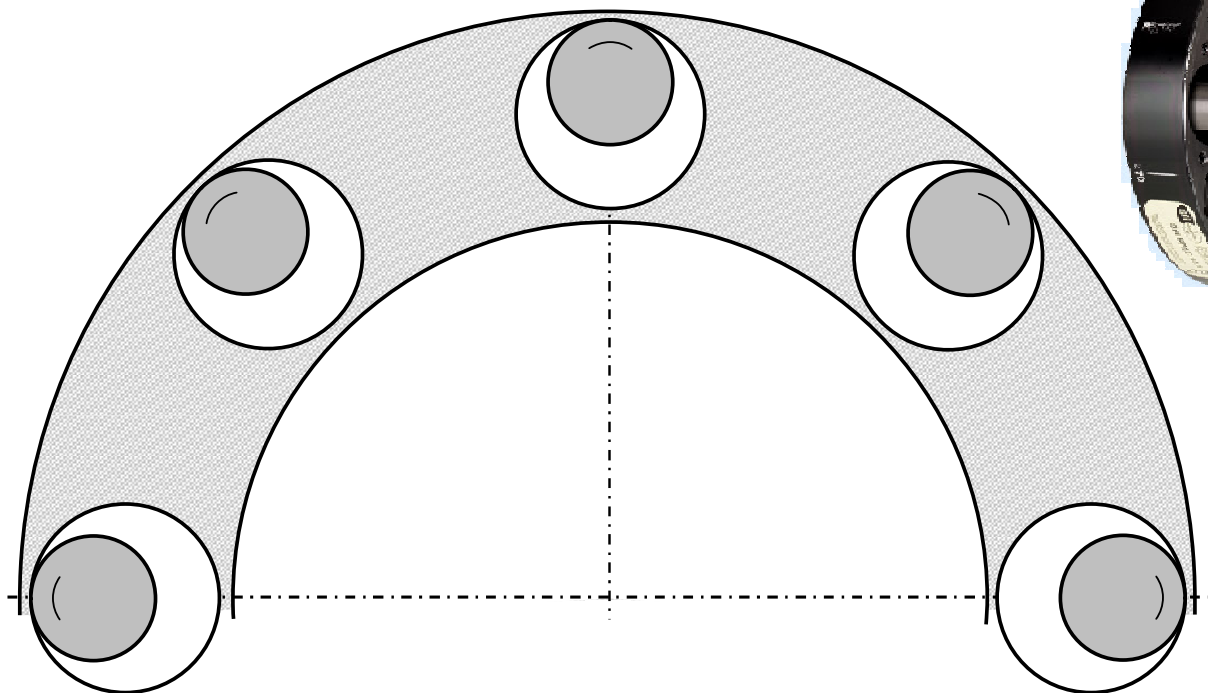
Sarazin-Type: bifilar suspension
(US-Patent 2,079,226 - 1937)



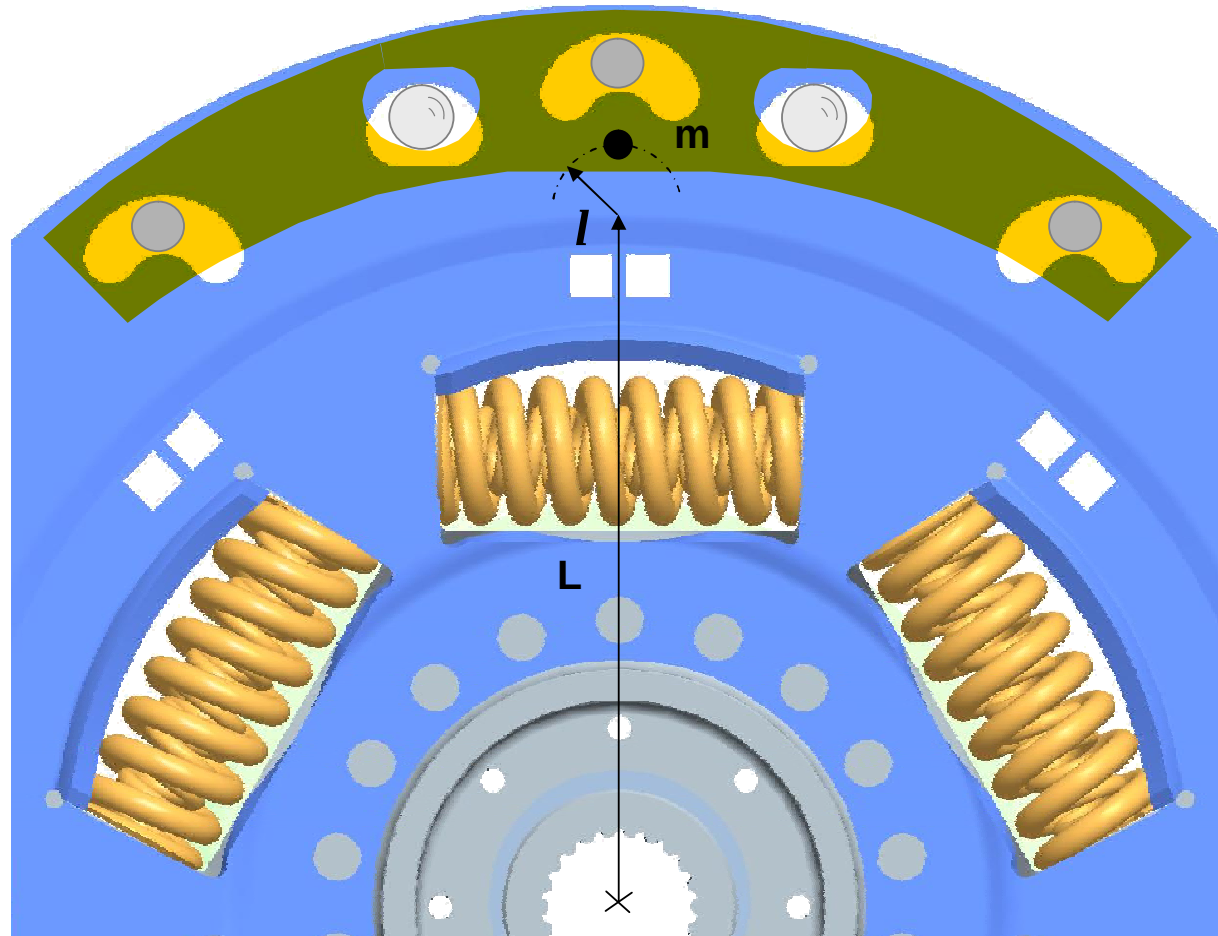
Physical pendulum



Centrifugal Pendulum Absorbers with Salomon Rollers

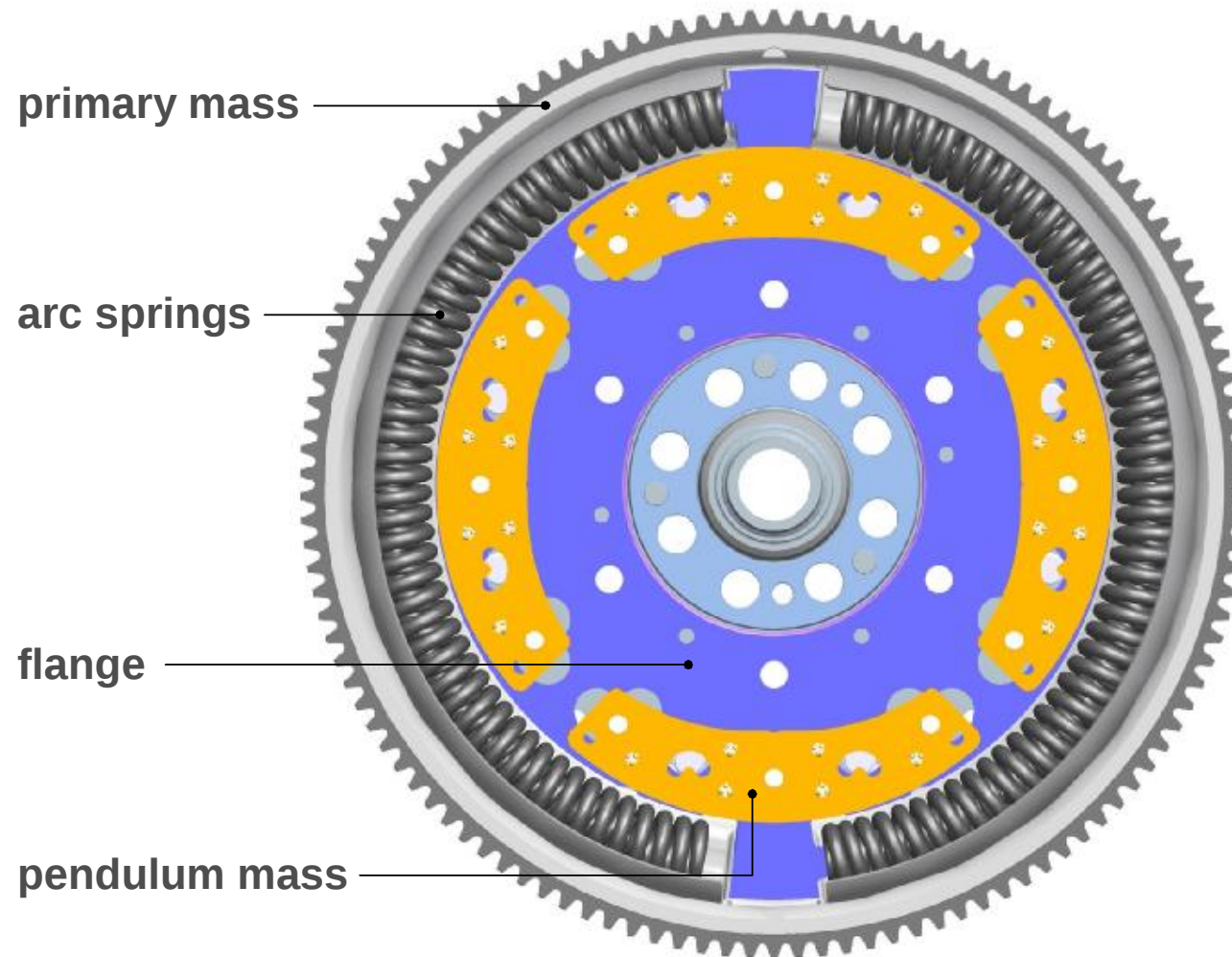


Movement of bifilar pendulum



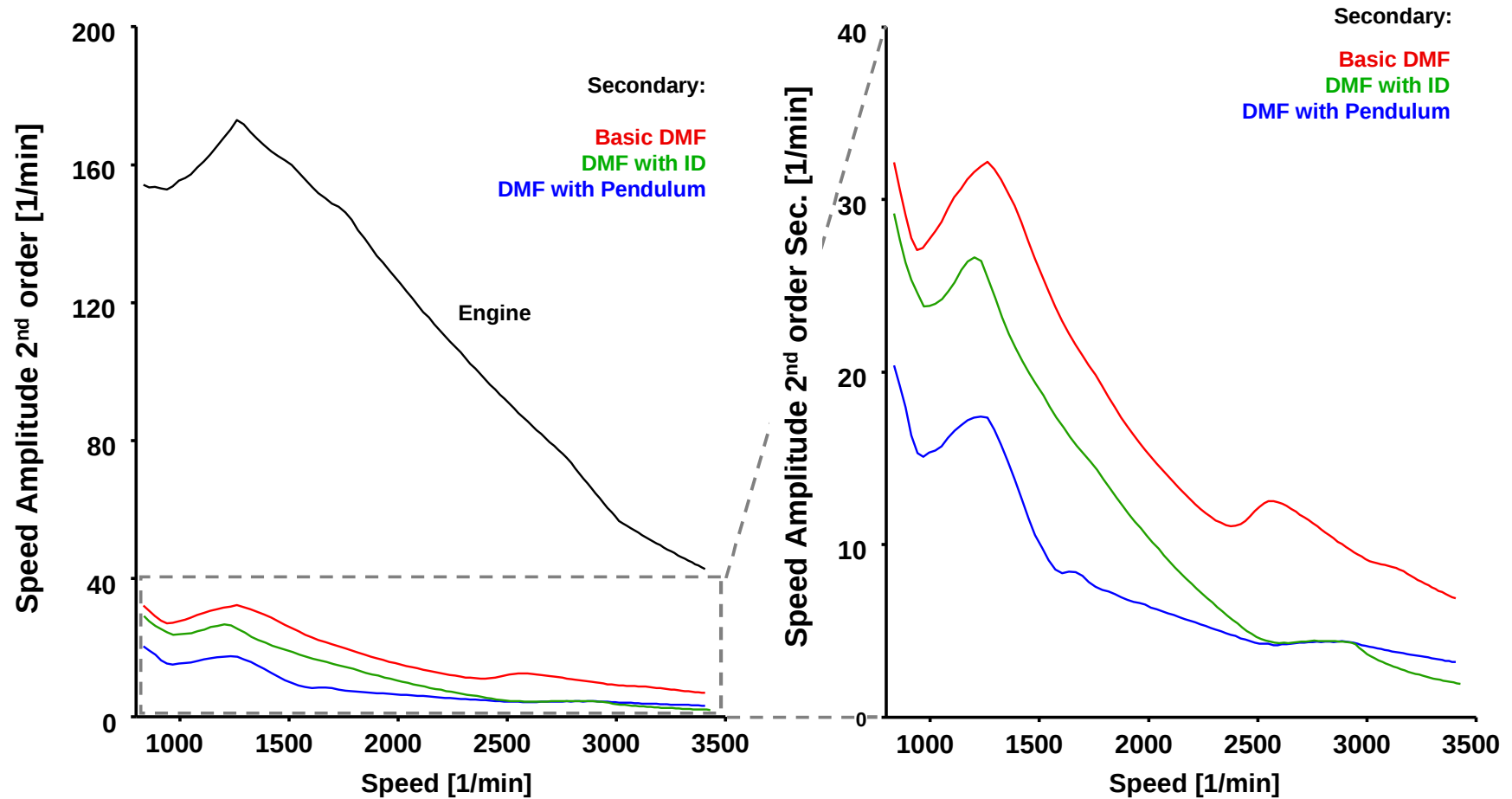
Dual mass flywheel with pendulum absorber

Components and configuration

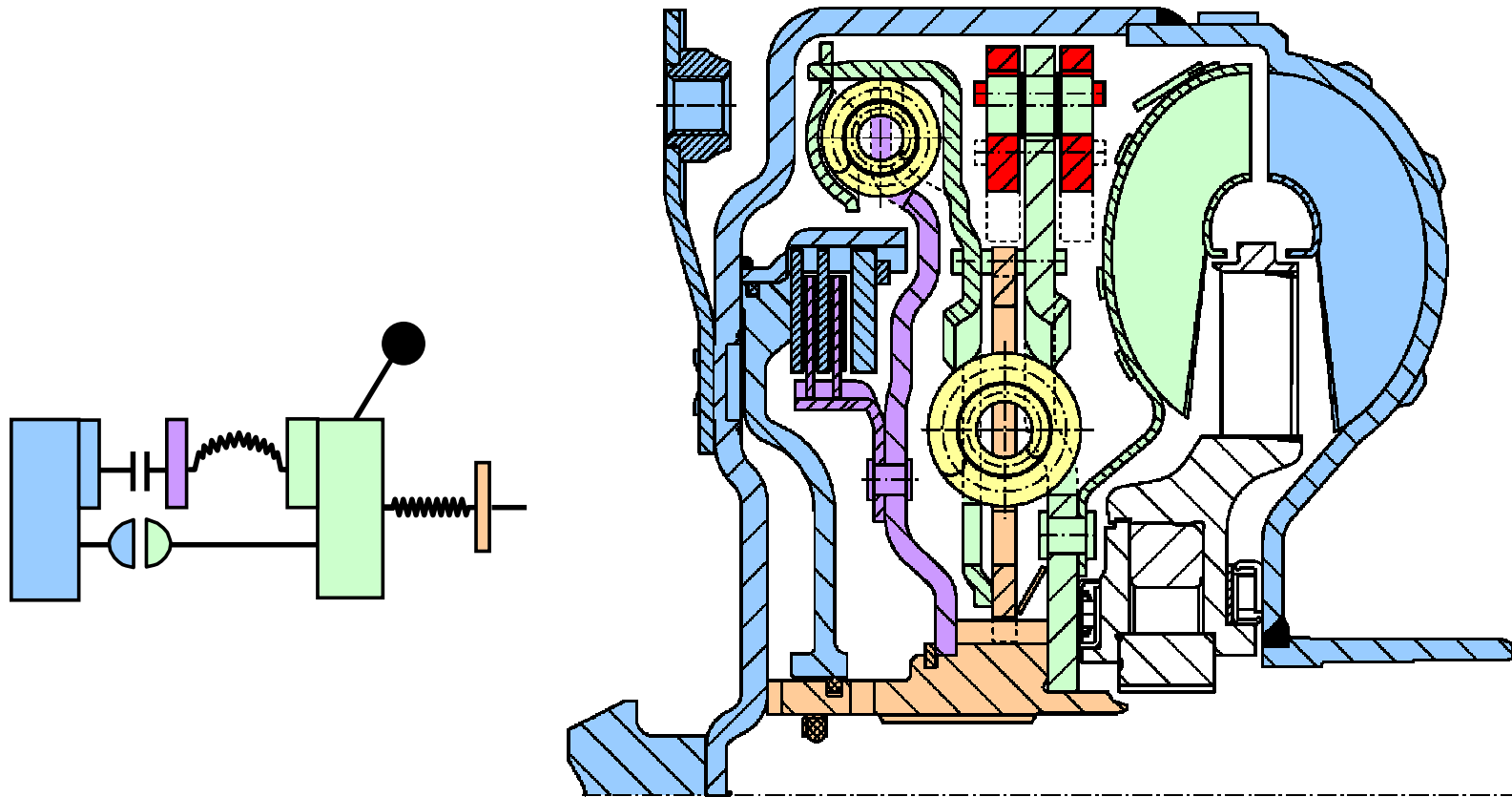


Full Load Simulation – 4 Cyl. Diesel 400Nm

System comparison basic DMF, DMF with ID & with Pendulum

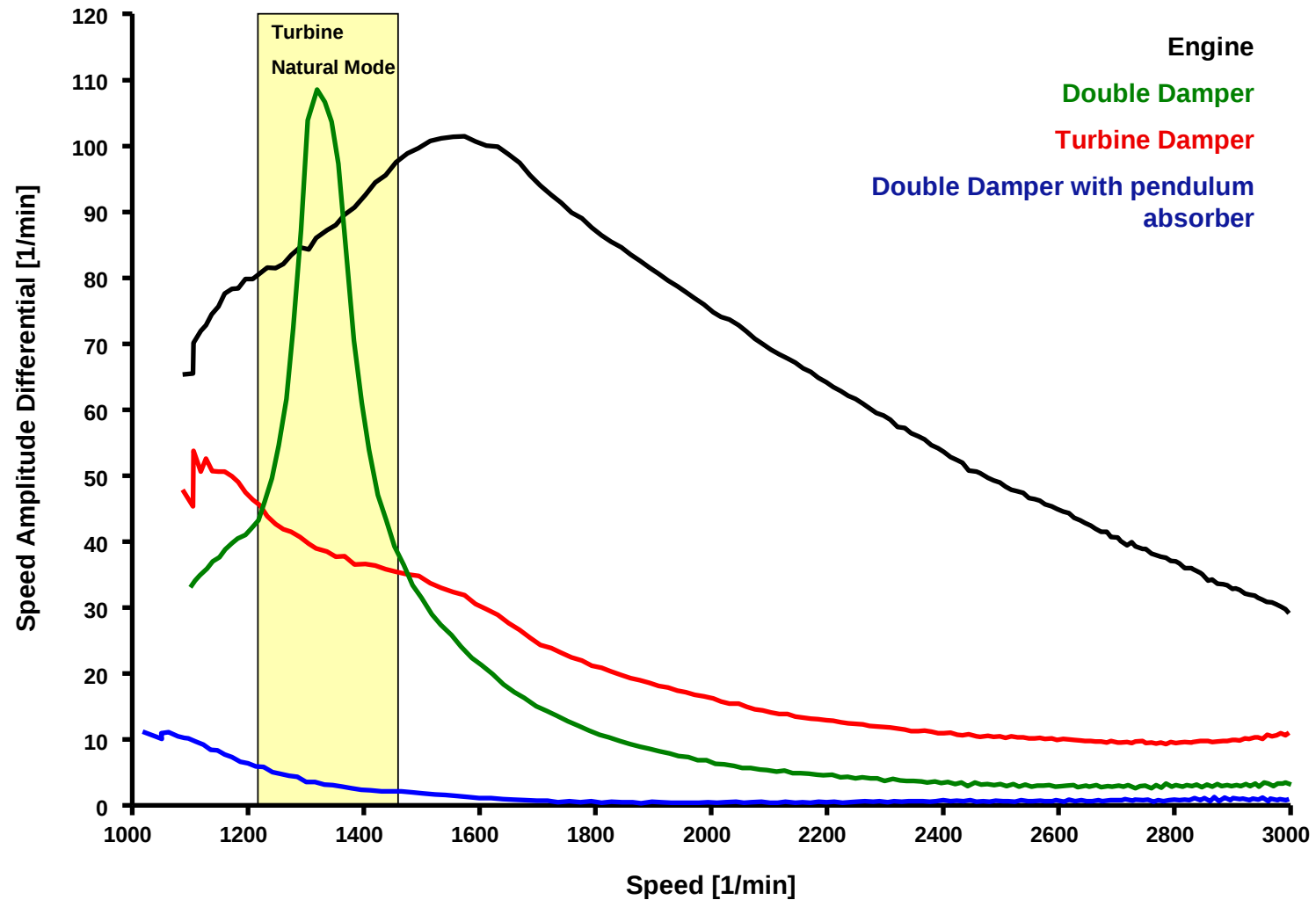


CPA Integrated in TC Design for RWD

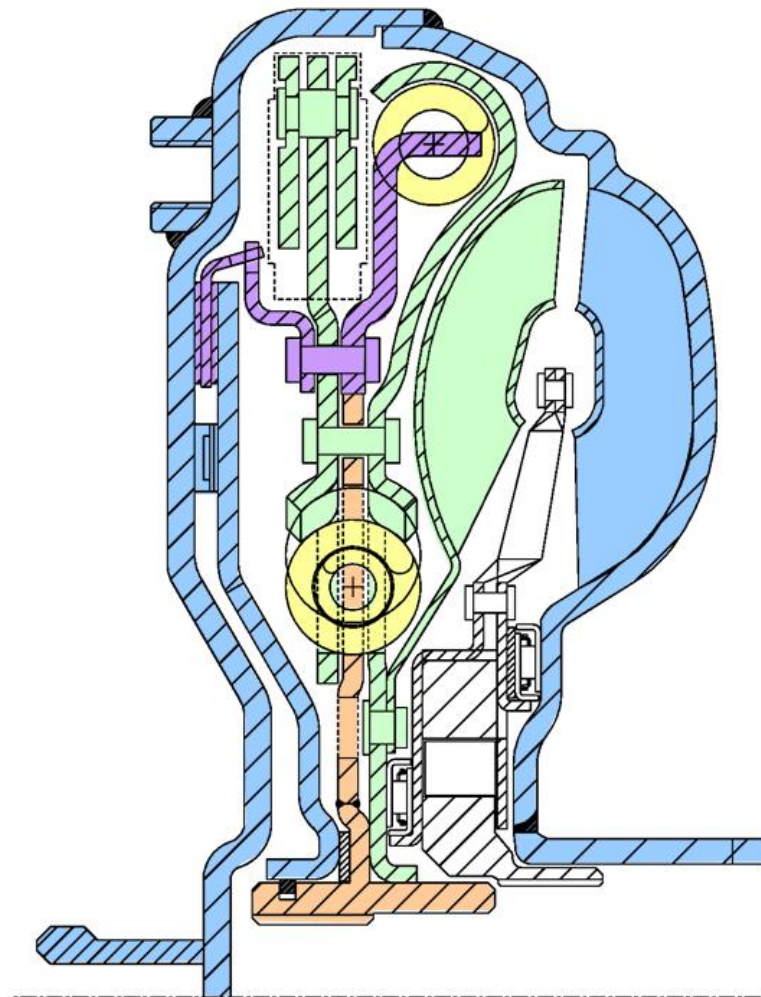
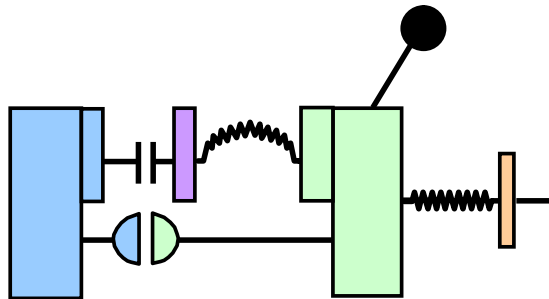


Full load simulation – 4 cyl. diesel 450 Nm

System comparison turbine damper, double damper
vs double damper with pendulum absorber

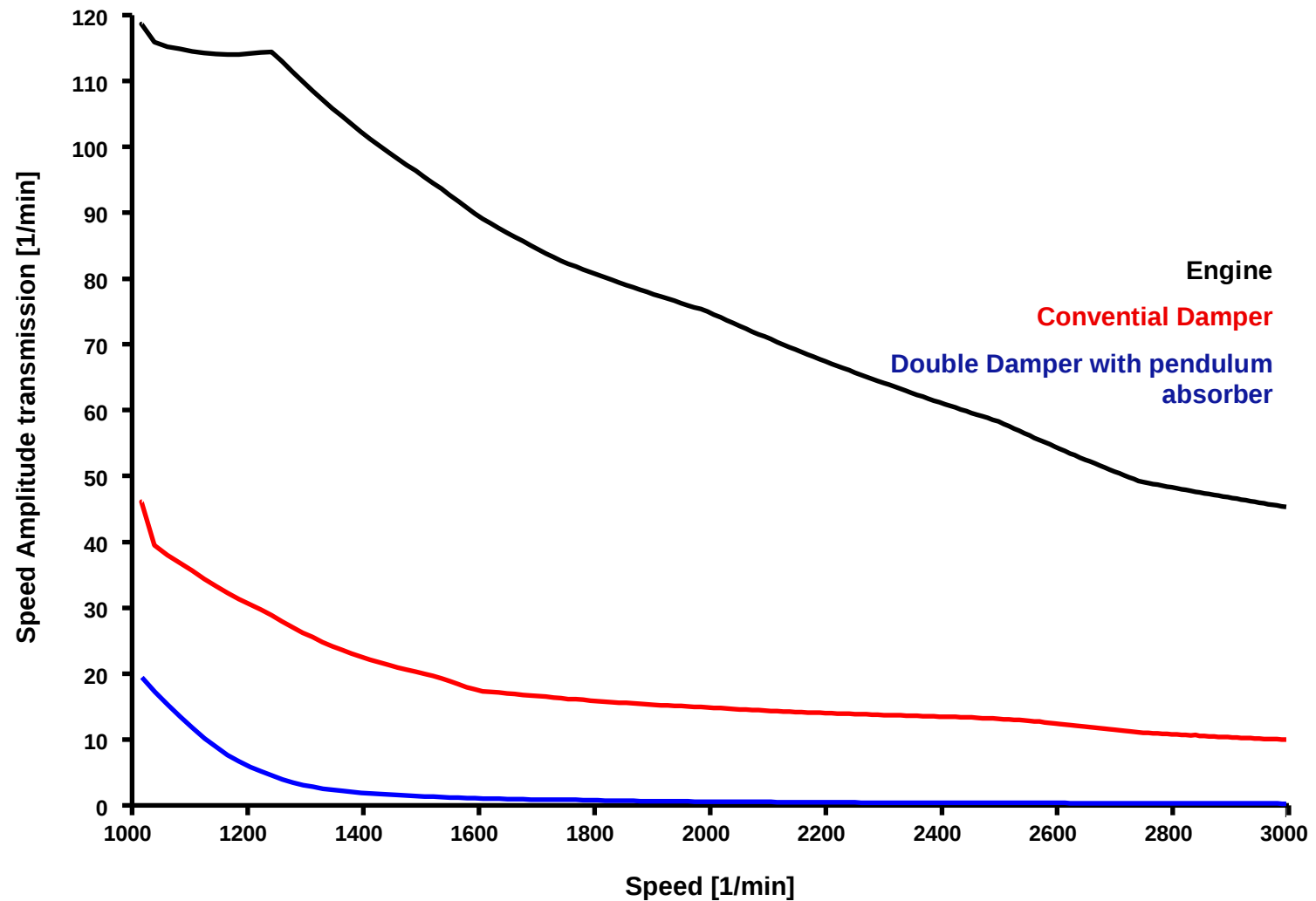


Design for Fwd



Full load simulation – 5 cyl. diesel 400 Nm

System comparison convential damper
vs double damper with pendulum absorber

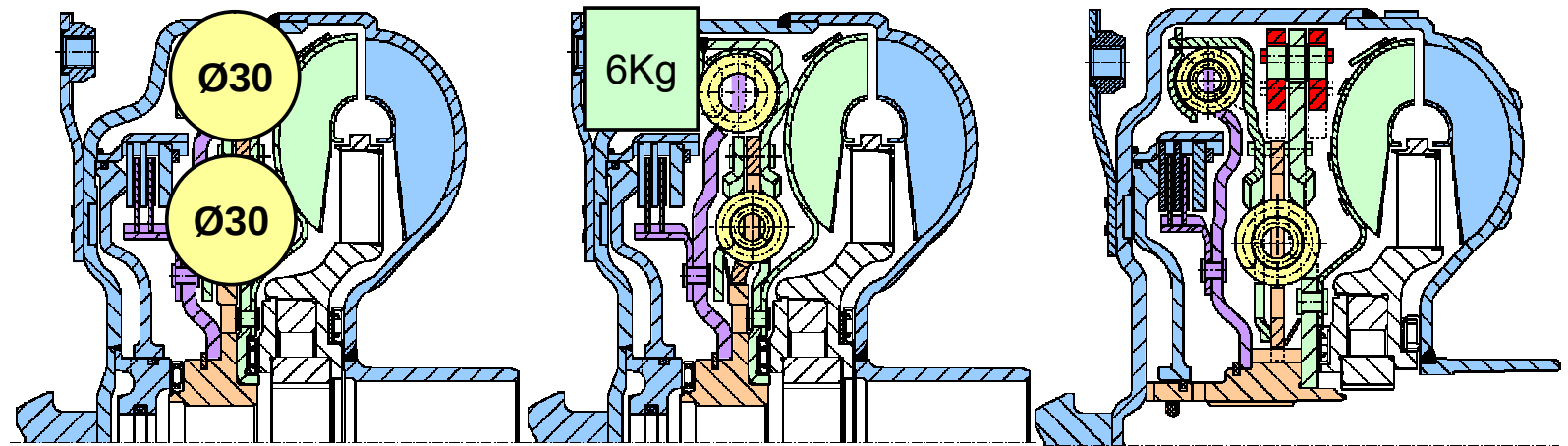


May 2009
Page 20

CTI Symposium - Automotive Transmissions North Amerika

SCHAEFFLER GRUPPE
AUTOMOTIVE

What else could be done to achieve similar isolation?



Spring rate [Nm/°] 10 (without friction)

25

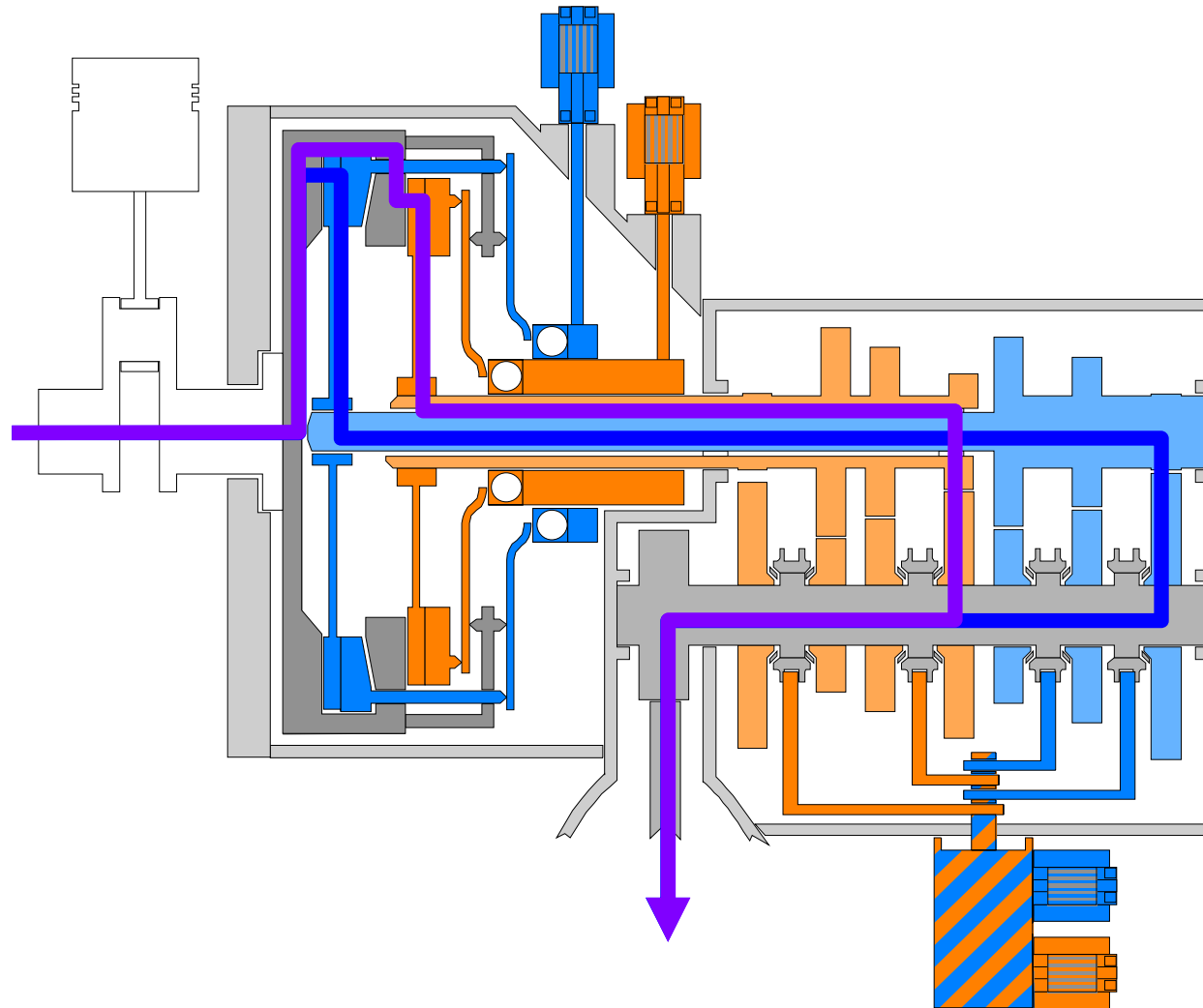
25

Sec. mass [kg] 0.0

+6.0

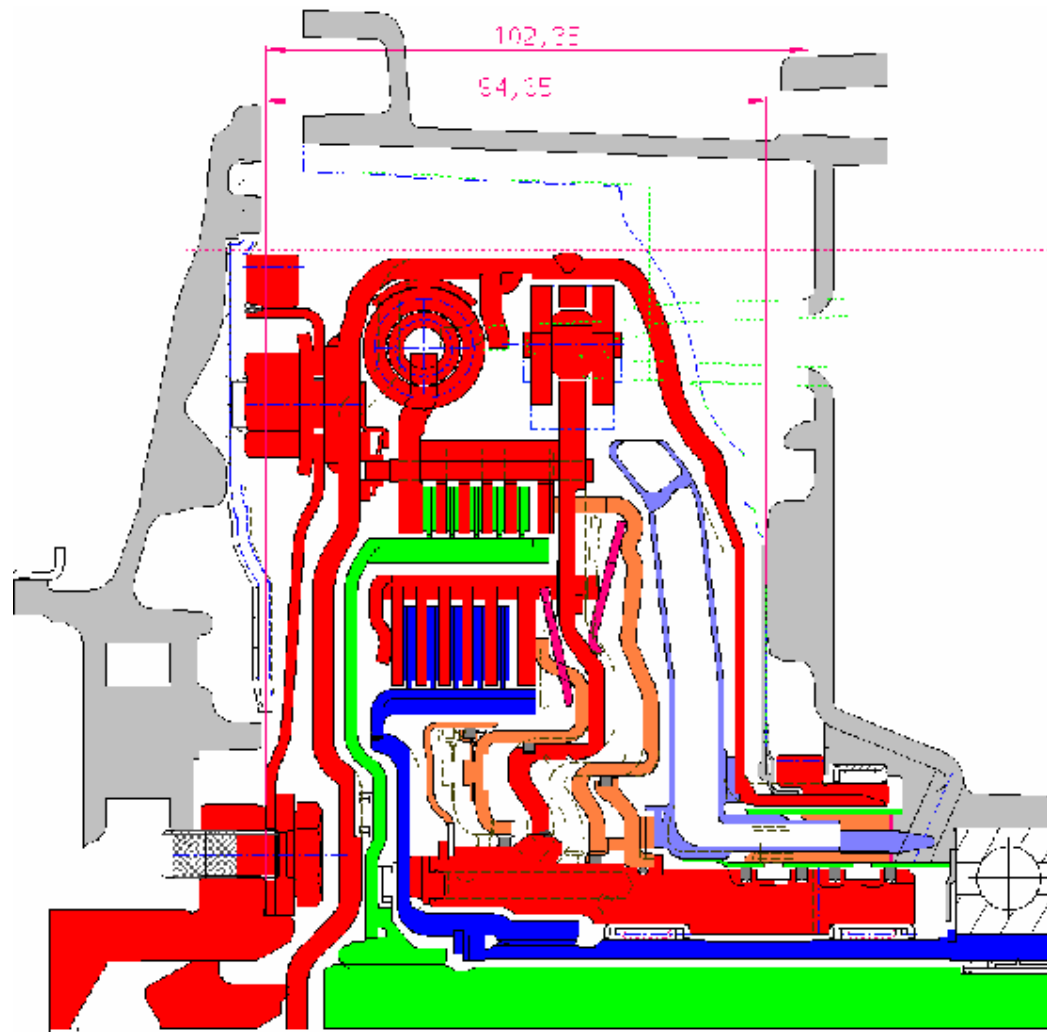
+1,0

Double Clutch Transmission



Encapsulated Wet DCT Clutch

Unit to be assembled similar to a torque converter unit

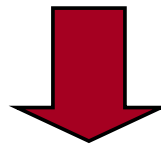


May 2009
Page 23

CTI Symposium - Automotive Transmissions North America

SCHAEFFLER GRUPPE
AUTOMOTIVE

- **Pendulum absorbers can improve torsional isolation significantly**
- **Improvement more than 50% for DMFW and up to 80% for Lockup Clutch Dampers**
- **Tuning order has to match main excitation order of engine**



Allows downspeeding and thus fuel consumption reduction



SCHAEFFLER GROUP
AUTOMOTIVE

Thank you for your attention

Any Questions ?

Wolfgang Reik, Bertrand Pennec, Thorsten Krause

