Marc Lässing
Efficient analysis of drivetrain induced vibrations in commercial vehicles using an in-house tool based on Simpack Qt-Script
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Daimler Trucks
Challenge for Commercial vehicles: CO\textsubscript{2} reduction

Many drivetrain based fuel-efficiency measures, such as down speeding or increased cylinder pressure like in 2. generation Daimler OM471 lead to higher driveline excitation of the vehicle.
Driveline excitation interfaces to vehicle and driver

Many interface points to analyze
Relevant excitation orders of vehicles with 6-cylinder engine

The basic load case for drivetrain induced vibrations is a full load engine run up where the driveline excitations interfaces are analyzed with order analysis filters:

- 0.5<sup>th</sup> engine order: fuel injection single cylinder differences (e.g. injector or air in/out-take) differences
- 1<sup>st</sup> engine order: unbalance of crankshaft, flywheel etc., fuel injection asymmetry between cylinder pairs
- 1.5<sup>th</sup> engine order: fuel injection bank differences
- 3<sup>rd</sup> engine order: combustion gas forces / 1<sup>st</sup> order inertial force
- 4.5<sup>th</sup> engine order: crankshaft / crankcase elasticity
- 6<sup>th</sup> engine order: 2<sup>nd</sup> order inertial force
- 1<sup>st</sup> driveline order: unbalance of propshaft
- 2<sup>nd</sup> driveline order: excitation through universal joints

⇒ Many orders to analyze
Result visualization

To get a good impression of the drivetrain excitation several result plots are needed:

100% plot force distribution, sum of orders

⇒ many different visualization types to create
Available gears in commercial vehicles

Usually the engine run up is analyzed for all available gears

Medium duty transmission with 6 gears

Heavy duty transmission with 16 gears

⇒ up to 16 gears to analyze
Analysis of a 4x2 tractor

- 18 dynamic force channels, 3 directions each
- 6 rotational acceleration channels
- various translational acceleration channels
- 8-10 different plot layouts
- 1 - 8 different orders

⇒ already over 400 plots for a 4x2 tractor...

Imagine a 8x8 tipper with 4 driven axles, 5 propshafts and a transfer case...

How to create several hundred plots?

Manually?

Of course not!
An automated process had to be created...
AnSim-PD Analysis and Simulation of Powertrain Dynamics

2004: First automation of interface force export and creation of plots with tcl-scripts and the graphing utility gnuplot

2007: First introduction of qt-script gui.
Export of results with user-filter within pre-defined spf-Files
Script to create pdf-documents using tcl pdf-library

2016: Final version of AnSim-PD including several tool optimizations, new features and adjustments to latest tcl and gnuplot versions

⇒ AnSim-PD uses 4 different script languages, sub-tools and libraries
⇒ Usability within Daimler CAE-Network difficult
2017: The in-house tool AnSim-PD was redeveloped and completely transferred to Simpack_2018 in cooperation with the Simpack Center of Excellence

- Complete process from time integration to pdf creation within Simpack scripting
- Platform independent
- No extra software needed
- Easy to use within the Daimler CAE network

⇒ together with Simpack communicator technology an efficient analysis of drivetrain induced vibrations is now available
Automated model setup

- Interdisciplinary substructure modelling
- Internal modeling guideline defining mandatory communicators
- Standard load case full load engine run up on test-bench
- Interface forces exported via result elements

פשר יזום מהיר של שונים של תצורת אוטומטית של מכונית
Ansim-pd 2.0 gui: configuration

- Define order analysis
- Define order resolution
- Define x-axis
- Define y-axis scaling
- Define Campbell diagrams
- Switch on cab analysis truck/van
Ansim-pd 2.0 gui: documentation

text file for documentation e.g. model history
## Ansim-pd 2.0 gui: exported channels

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</table>

- **general export channels for order analysis**
- **interface forces**
- **translational accelerations**
- **rotational accelerations**
Ansim-pd 2.0 gui: task setup → start process

Start Ansim-pd process:
1. run time integration
2. run measurements
3. create all analysis plots
4. export plots to pdf-document

- Do time integration of model
- Do measurements
- Export results to csv-Files
- Create spf, html and/or pdf-Files
Final PDF document

- pdf document for a 4x2 tractor
- 415 pages including:
  - model documentation
  - Campbell diagrams
  - order analysis plots of all defined orders for interface forces, translational and rotational accelerations
  - 100% plots

⇒ complete engine run up analysis for specific vehicle in one document with a view mouse clicks
Thank you for your attention!