RDE-Testmatrix on an engine testbed with virtual components – model based testing in the engine development

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Challenges of RDE-legislation

Vehicle tests on public roads with everyday traffic

› High number of different influences and conditions (driver, traffic, weather, ...)
› Huge effort for vehicle testing
› In case of dataset changes, no repeatability

→ Demand for new RDE-testing methods

Vehicle testing on the engine testbed with virtual components

virtual prototype + driver model + cycle/RDE-route + traffic = Virtual RDE test drive
Testing environment similar to vehicle setup

Coldstart
- Oil and coolant conditioning
- Gearbox warm-up model

Testbed automation
- 24/7 ready for use
- Automatic conditioning of exhaust gas system
- ....

Engine ECU dataset
- No special testbed dataset
- Deactivation of non-existing components (eg. airbag, ...)

Source: AVL, IPG
Integration of real road data and traffic

Road
- Current RDE-route (HRK, „Heilbronner-Rundkurs“)
- Export from ADASRP including
  - Traffic lights
  - Speed limits
  - Grades
  - Curves

Traffic
- Traffic simulation using speed limits with RDx Testgenerator
Testmatrix allows many variations of the reference measurement

<table>
<thead>
<tr>
<th>Route</th>
<th>Driver</th>
<th>Traffic</th>
<th>Payload</th>
<th>Gearbox</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRK</td>
<td>normal</td>
<td>no traffic</td>
<td>0 % payload</td>
<td>“D” drive</td>
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<tr>
<td>Karlsruhe</td>
<td>dynamic</td>
<td>average</td>
<td>90 % max. payload</td>
<td>“S” sport</td>
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<tr>
<td>Nuneaton</td>
<td>nervous</td>
<td>dense</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stuttgart-Feuerbach</td>
<td></td>
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</tbody>
</table>
Good match of v*apos 95% percentile

› Testbed v*apos values close to target

› Simulated Autobahn traffic density is too high

\[ v*apos = \text{product of velocity and positive acceleration} \]

\[ \text{RPA} = \text{relative positive acceleration} \]
Cold start behaviour similar to vehicle

› Small differences in oil temperature and good match for coolant temperature
Similar exhaust-gas temperatures in vehicle and testbed

- Very good match to the reference measurement despite differences in environmental temperature

→ Successful transfer of vehicle measurement to testbed
Driver variation shows influence on \( \nu \)\textsuperscript{apos} values

- All parameters have been fixed except of driver

- Acceptable values for normal and nervous driver
Minor impact on v*apos from traffic variation

› Main impact of the traffic density is on the average velocity

› Minor impact on v*apos

→ Driver causes main impact on v*apos
Summary

RDE-matrix on an engine testbed
› Feasability shown in a pilot project
› Good results for the transfer of a reference measurement
› Variation of different parameters works well

Next steps
› Exact replay of a reference measurement
› Coupling with vECU (gearbox control, etc)
Thank You