A brake test stand for particles measurement and collection

PmP Meeting
10-02-2016
Outlines

• Introduction
• New design
• Working principle
• Sampling
• Results example
Where were we the last time?

*Mattia Alemani, Ulf Olofsson, Guido Perricone, Jens Wahlström, Anders Söderberg, Alessandro Ciotti, "A proposed dyno bench test cycle to study particle emissions from disc brakes", Eurobrake 2014 proceedings

Dynamic Bench tests helps to understand the particle behavior under real working conditions. Recent updates includes a clean chamber and Isokinetic sampling.
Why to improve?

• To avoid sample contamination due to external sources
• To have a representative sample through iso-kinetic sampling
• To have a controlled volume with well mixed particles
How to improve?

**SAMPLING VOLUME**

**Clean Chamber:** A well defined and controlled volume, with an HEPA H13 filtered air inlet

**Well-mixed airflow:** inside the clean chamber will provide an homogeneous aerosol

**SAMPLING LINE**

**Isokinetik Sampling:** outlet speed equals the sampling probe inlet speed avoiding particle losses

**Sampling efficiency:** to reduce particles settling or sticking along the sampling line

The final target is to have a sampling chain as much representative of the system emissions and reliable, as possible
Final design

Schematic diagram of the test stand. OR: outdoor room; B-I: 0.4m bend tube; F: flow measurement point and filter; BB: bigger box; T: tube; O1: first outlet gap; V: Venturi flow measurement tube; SO: sampling outlet; C: dust-box chamber; A: Air inlet opening; Cy: Cyclone; B-2: 90°, 0.1m bend tube; E: ELPI+® cascade impactor

A photograph of the novel bench design. BB: bigger box (door open); F: inlet tube from which clean air enter; T: outlet tube; R: rotor; C: dust-box chamber

Chamber working principle

Filtered air inlet

Air outlet

Detection

<table>
<thead>
<tr>
<th>Features</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamber dimensions [mm]</td>
<td>1296 x 3793x795 (WxLxH)</td>
</tr>
<tr>
<td>Chamber volume [m³]</td>
<td>0.817</td>
</tr>
<tr>
<td>Airflow [m³/h]</td>
<td>1175 (adj. 500-2500)</td>
</tr>
<tr>
<td>Air-exchange [#/min]</td>
<td>19.5</td>
</tr>
<tr>
<td>Sampling speed [m/s]</td>
<td>3.47</td>
</tr>
</tbody>
</table>

### Controlled parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dyno Bench</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear</td>
<td>Measured after test (weight/thickness)</td>
</tr>
<tr>
<td>Pressure</td>
<td>Applied</td>
</tr>
<tr>
<td>Torque</td>
<td>Torque transducer</td>
</tr>
<tr>
<td>Friction</td>
<td>calculated</td>
</tr>
<tr>
<td>Disc Temperature</td>
<td>1 k-type thermocouple</td>
</tr>
<tr>
<td>Pin Temperature</td>
<td>2 k-type thermocouples (one for each pad)</td>
</tr>
<tr>
<td>Sliding velocity</td>
<td>Imposed/measured</td>
</tr>
<tr>
<td>Flow rate</td>
<td>Imposed</td>
</tr>
<tr>
<td>PM/PN</td>
<td>Elpi+ (with collection)</td>
</tr>
</tbody>
</table>
An Electrical Low Pressure Impactor (ELPI+®) measures and collects particles. A cyclone filters all the particles bigger than 10µm.
A result example

Old Set-up vs. New Set-up

New set-up full test
Towards a test stand for standardized measurements of the brake emissions

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