Measurement of Piston Friction with a Floating Liner Engine for HD Applications
用于重卡的浮动缸套发动机的活塞摩擦测量

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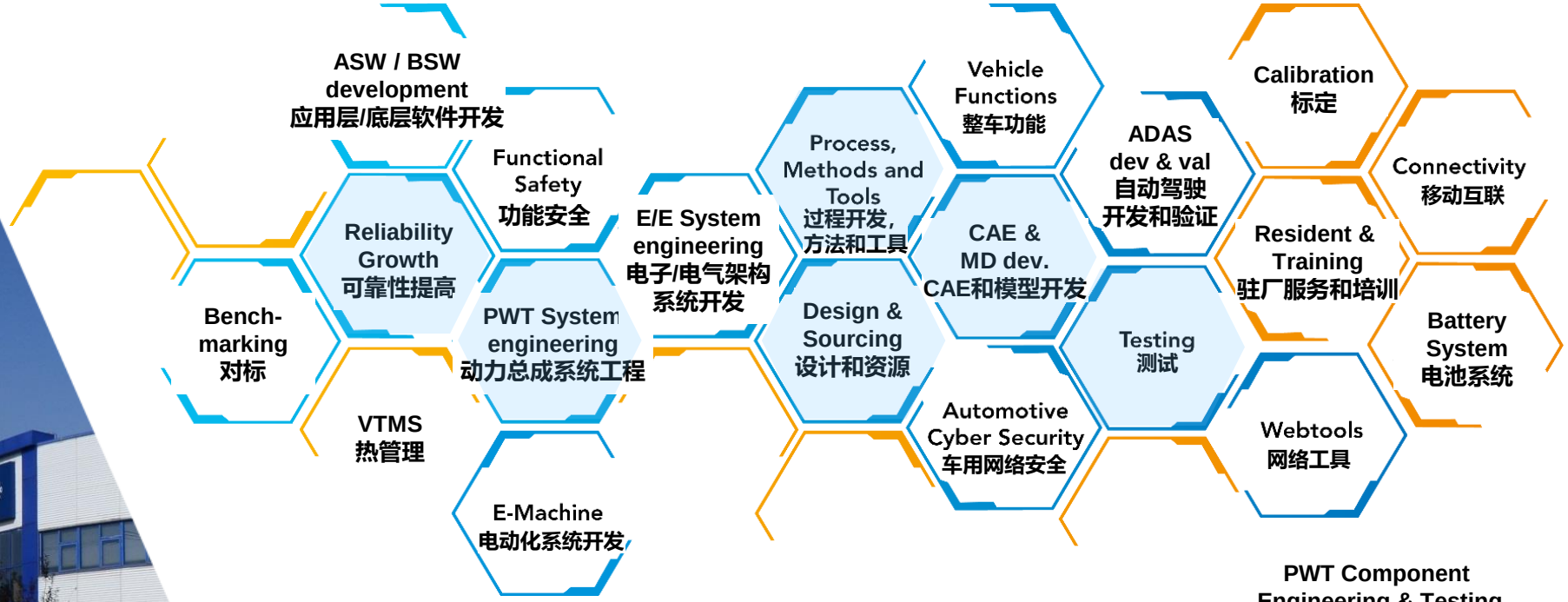
AVL China 中国
Introduction CV Engineering 商用车工程能力介绍

AVL China Footprint
AVL中国发展历程

40Year China Commitment
在中国投入40余年

3 Business Units 3个业务板块
- AVL Instrum. & Test System
  设备测试服务
- AVL Powertrain Engineering
  汽车动力总成工程研发
- AVL Adv. Simulation Techn.
  先进模拟技术

Represented in 9 locations
在9个城市设代表处
approx. 720 staff 约720名员工
3 Technical Dev. Centers
3个技术中心
28 Test Facilities 28台测试设备



AVL Fuel Cell Demo Truck
燃料电池整车

E/E & SW services
电子/电气架构和软件服务

PWT Component Engineering & Testing
动力总成部件工程研发和测试

Motivation 动机
Demand for Friction Optimization 摩擦优化需求

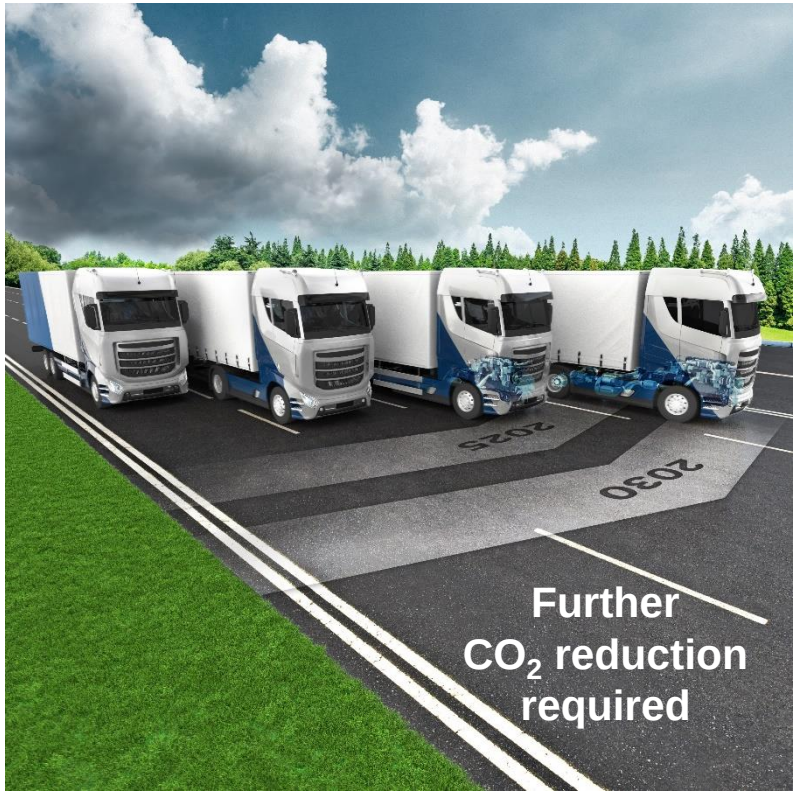
37 % of transport CO_2 emissions are from heavy-duty applications
37%的交通运输二氧化碳排放来自重卡应用

Duty cycles & environmental conditions restrict BEV and FCEV concept
占空比和环境条件限制了BEV和FCEV的概念

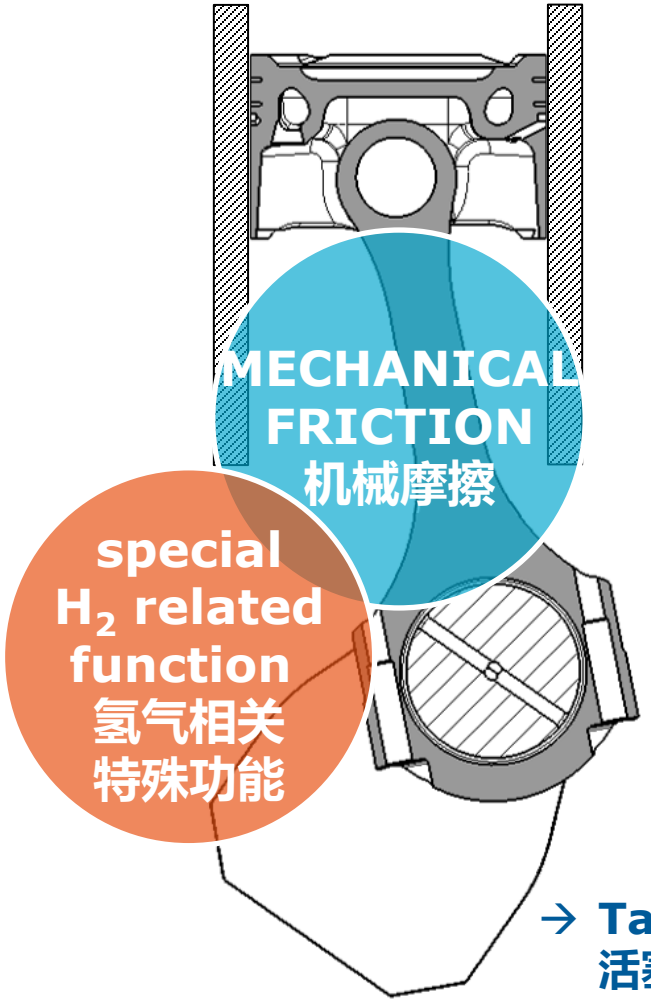
Hydrogen and e-fuels potentially CO_2-neutral
氢和电子燃料拥有碳中和潜力

50 % BTE target is demanding all measures – especially mechanical (friction) optimization
50%的制动热效率目标要求采取一切措施，尤其是机械（摩擦）优化

Friction at PBI very complex and depending on load conditions → Advanced measurement methods required (e.g. floating liner engine)
PBI处的摩擦非常复杂，取决于负载条件→ 需要先进的测量方法（如浮动缸套发动机）



Technologies to reduce PBI friction losses
降低PBI磨损的技术



Initial初始 PBI

- Optimized liner shape 缸套形状优化 *
- Liner & Piston material 缸套与活塞材料 (*)
- Optimized liner surface 缸套表面优化 *
- Reduced piston ring tension 降低活塞环张力 *
- Optimized piston design 活塞设计优化 *
- Crankshaft offset 曲轴偏置 *
- ** H2 slip into crankcase 氢气蹿入曲轴箱
- Coatings: liner, piston & rings 涂层：缸套、活塞和活塞环 *
- Low viscosity oil 低粘度机油 *
- ** Oil input into combustion 机油进入燃烧室
- Oil friction modifi8ers 机油摩擦优化 *
- ** Friction and wear behavior 摩擦磨损性能
- Temperature field & structural stiffness 温度场和结构刚度 (*)

Optimized优化后 PBI

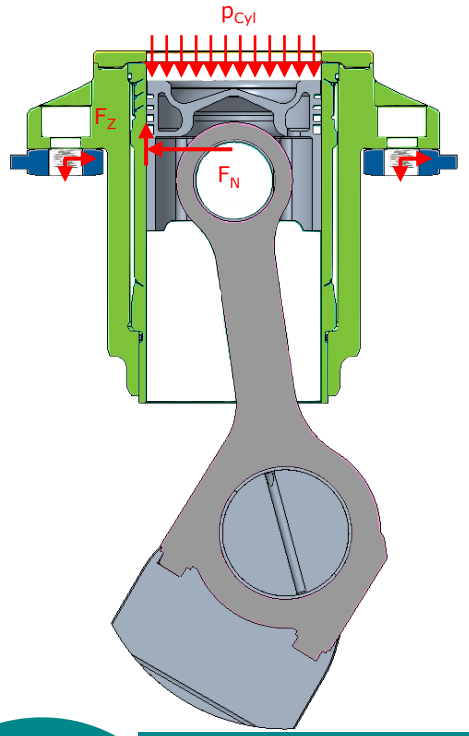
→ **Target for optimization of Piston Bore Interface**
活塞缸筒接面优化目标

* Can be approached with Floating Liner 可使用浮动缸套实现

** future potential 未来潜力

Analysis of piston assembly friction 活塞总成摩擦分析
Heavy-**D**uty **FRI**ction **S**ingle **C**ylinder 浮动缸套

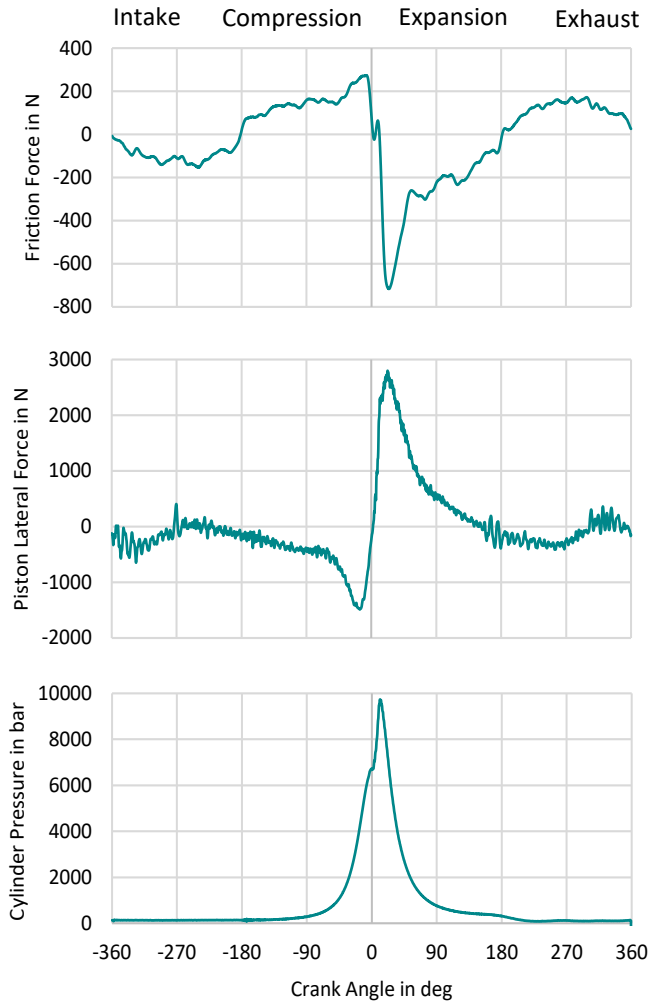
AVL HD FRISC



- Measures crank-angle based friction between piston & liner 测量活塞和缸套之间基于曲柄角的摩擦
- Cycle averaged friction power 平均摩擦功率循环

Typical investigations & variant comparisons under fired condition 燃烧条件下的典型调查和变体比较

- Liner shapes and surfaces (coatings)
  缸套形状和表面（涂层）
- Piston geometries & coatings (skirt, pin, …)
  活塞几何结构和涂层（活塞裙、活塞销等）
- Piston ring tensions and surfaces 活塞环张力和表面
- Oil viscosities & additives 机油粘度和添加剂
- lube oil consumption and component wear
  润滑油消耗和部件磨损
- validate friction and wear simulation models
  验证摩擦和磨损仿真模型



HD FRISC

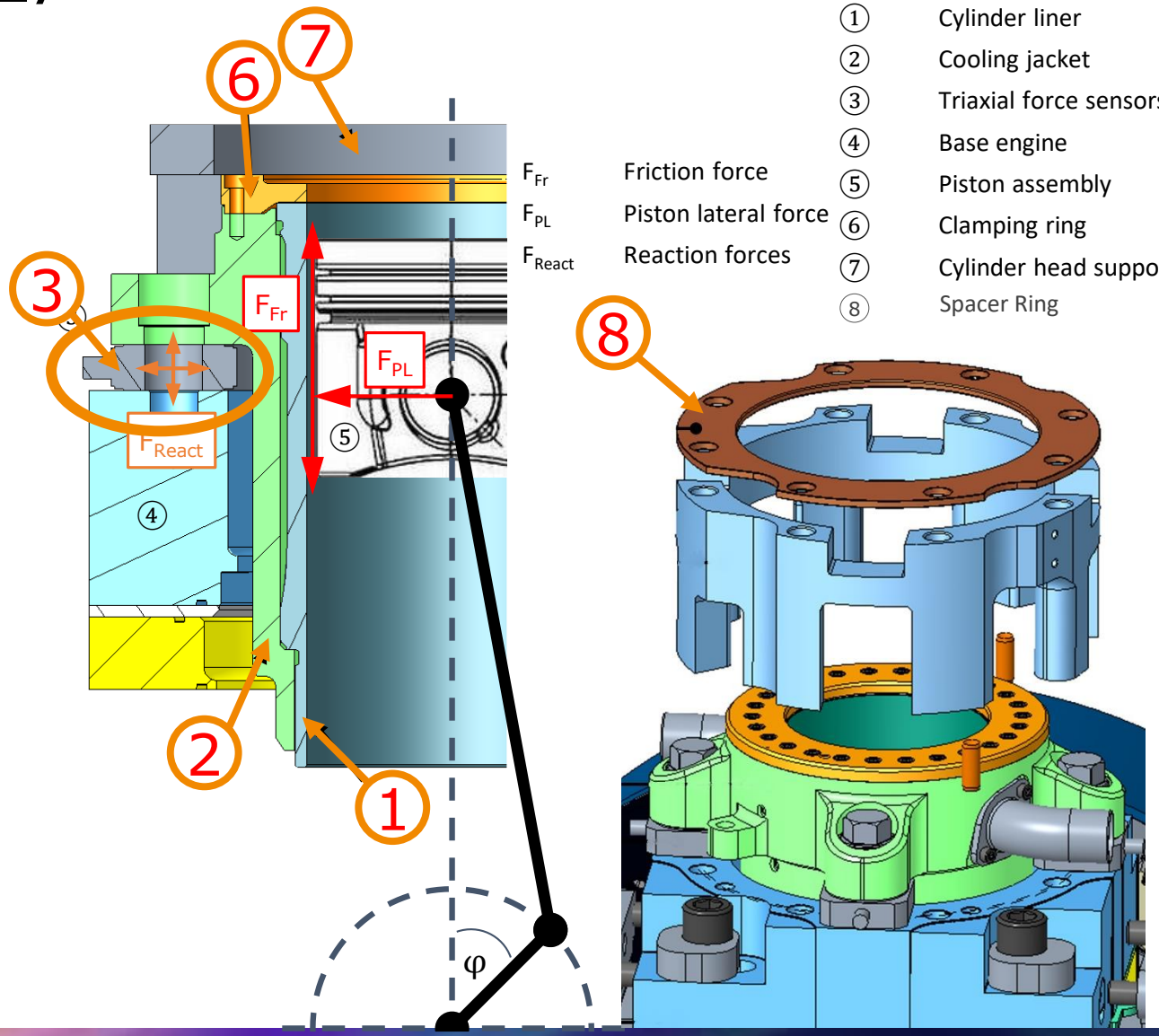
AVLs long time experience with the **floating liner method** ensures highly accurate results of **crank angle resolved piston group friction** at fired engine operation.
AVL在浮动缸套方法上拥有长久经验，能够确保发动机运行时利用曲轴角解决活塞组摩擦，效果精而佳

Floating Liner Engine Concept 浮动缸套发动机概念
Heavy-**D**uty **FRI**ction **S**ingle **C**ylinder 浮动缸套

Liner assembly connected via four pre-stressed triaxial force sensors to crankcase → enable measurements of tensile and pressure forces in cylinder axis as well as lateral forces
衬套组件通过四个预应力三轴力传感器连接到曲轴箱 → 能够测量气缸轴上的拉力和压力以及侧向力

Liner realized as a bottom stop concept and inserted to cooling jacket → easy exchange
衬里作为底部止动装置概念实现，并插入冷却套→ 轻松交换

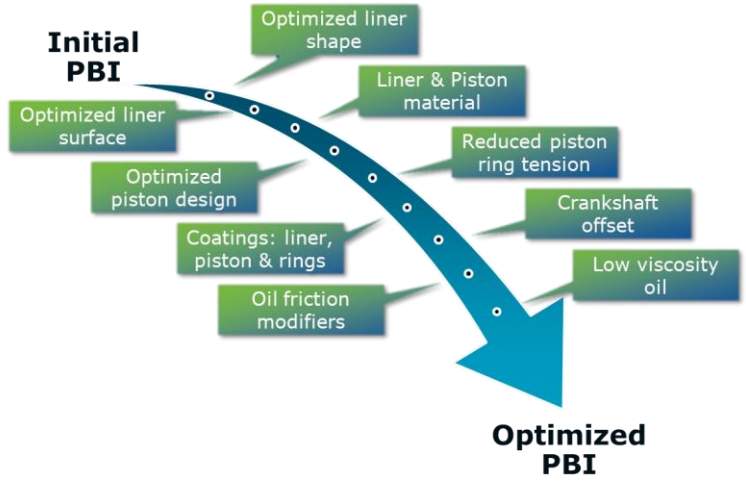
Cylinder liner and cylinder head decoupled by using a special high temperature sealing ring known from the proven system for passenger car/light commercial applications → further compensation of gas forces by geometric design elements or piston modifications not required
气缸套和气缸盖通过使用一种特殊的高温密封圈来解耦，该密封圈来自于成熟的乘用车/轻型商用系统→不需要通过几何设计元素或活塞修改来进一步补偿气体力

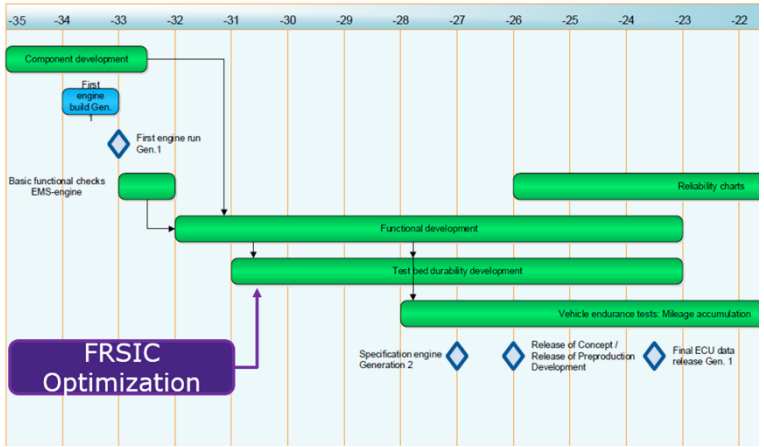


F_{Fr}	Friction force
F_{PL}	Piston lateral force
F_{React}	Reaction forces

①	Cylinder liner
②	Cooling jacket
③	Triaxial force sensors
④	Base engine
⑤	Piston assembly
⑥	Clamping ring
⑦	Cylinder head support
⑧	Spacer Ring

Summary
总结





Why HD FRISC is an important development tool?
为什么HD FRISC是一个重要的开发工具_

- Optimization of piston bore interface in a very early phase of powertrain development process or in case of field issues (troubleshooting)
  在动力总成开发过程的早期阶段或出现实际问题（故障排除，优化活塞缸筒接面
- Detailed simulation model validation to improve prediction accuracy
  详细验证仿真模型，以提高仿真中的预测精度
- Detail assessment of 评估:
  - Friction 摩擦
  - Lube Oil Consumption 润滑油消耗
  - Wear 磨损
  - Blow-By behavior 漏气表现
- **„FRI**ction **S**ingle **C**ylinder (FRISC)" measurement allows
  "单缸摩擦"测量能够实现
  - Efficient component development & optimization 组件开发和优化
  - during engine concept design phase or for troubleshooting
    在发动机概念设计阶段或故障排除期间使用

Contact information
联系人信息

Thank you

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