

A global approach

Cooling system analysis & simulation at Volvo Truck Corporation

Ing. Th.A.J. van der Maarel
Volvo Truck Corporation, Göteborg Sweden

Content

- KULI at Volvo
- Product range
- Kuli application areas
- VHD flow model
- FM flow model
- FH / NH / VN flow model
- KULI simulation results
- Suggestions
- Conclusions

Kuli at Volvo

- Licenses
 - ✓ KULI Base
 - ✓ Modules: Advanced, Drive and AC
- Origin of KULI input data
 - ✓ Component test data: Volvo, global system supplier
 - ✓ Engine heat data: Volvo, vendor
 - ✓ Chassis dynamometer: Volvo
 - ✓ Field tests: Volvo

Product range

- Different Trucks - Cooling system commonality



VN



VHD



FH



FM



NH

Kuli application areas

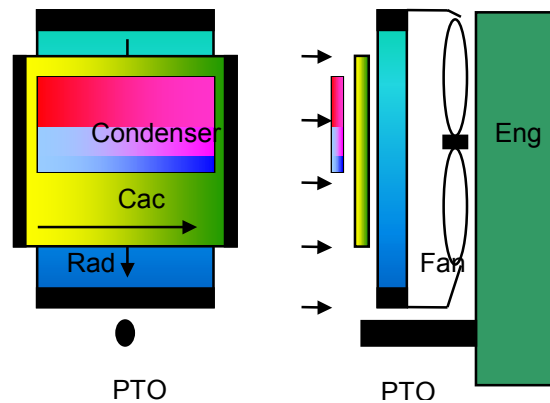
- Early development phase:
 - ✓ Concept studies
 - ✓ Evaluate proposals of different global system suppliers
- Midterm development phase:
 - ✓ Find the best test configurations
 - ✓ Fine-tune simulation model: BIR, flow restrictions, Cp
 - ✓ Parameter variation:
 - fan ratio / fan type / fan diameter
 - fin density / geometry
- Validation phase:
 - ✓ Simulate final concept with proposed engine ratings
 - ✓ Validate cooling system performance demands
 - ✓ Product modification tests

- VHD

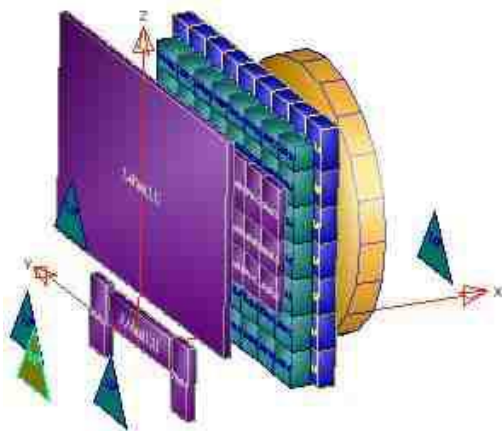


VHD flow model

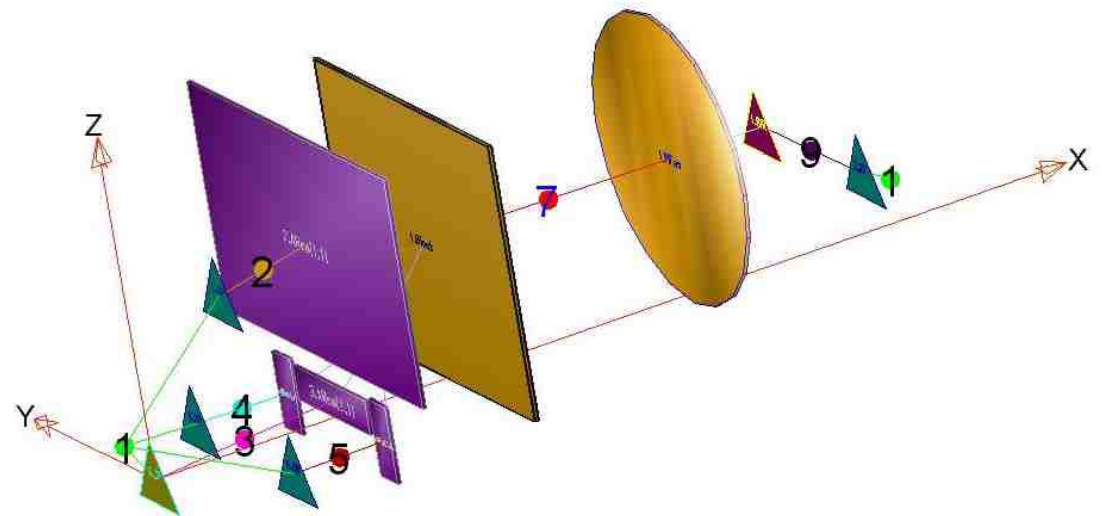
System layout



Kuli model



External flow model

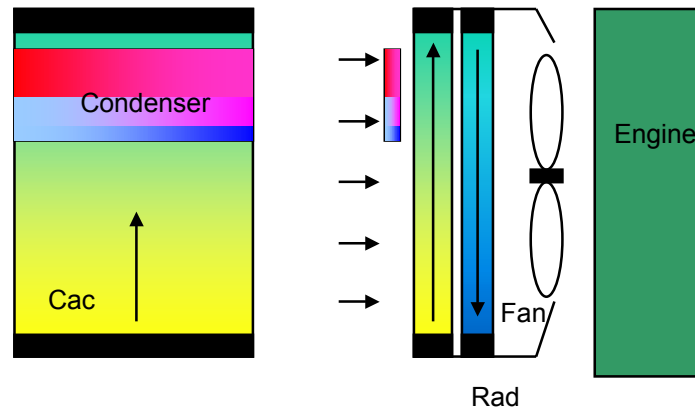


- FM

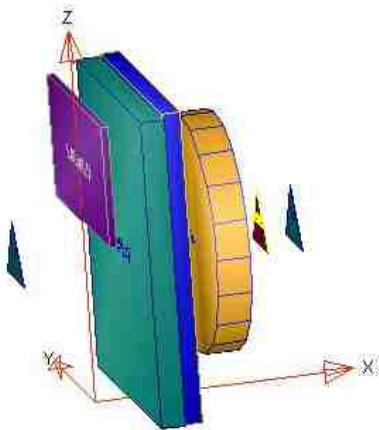


FM flow model

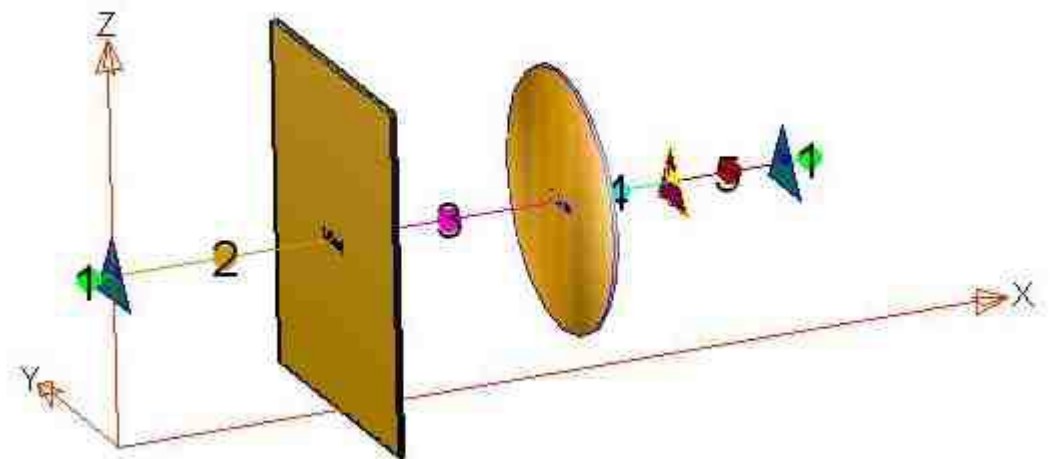
System layout



Kuli model



External flow model

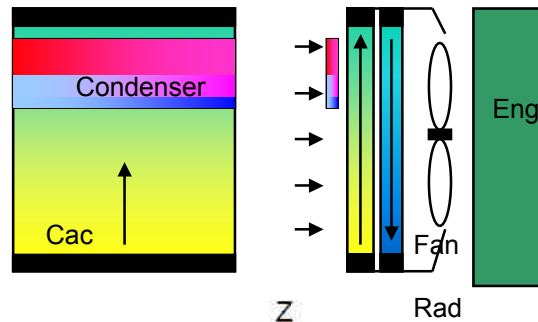


- FH / NH / VN



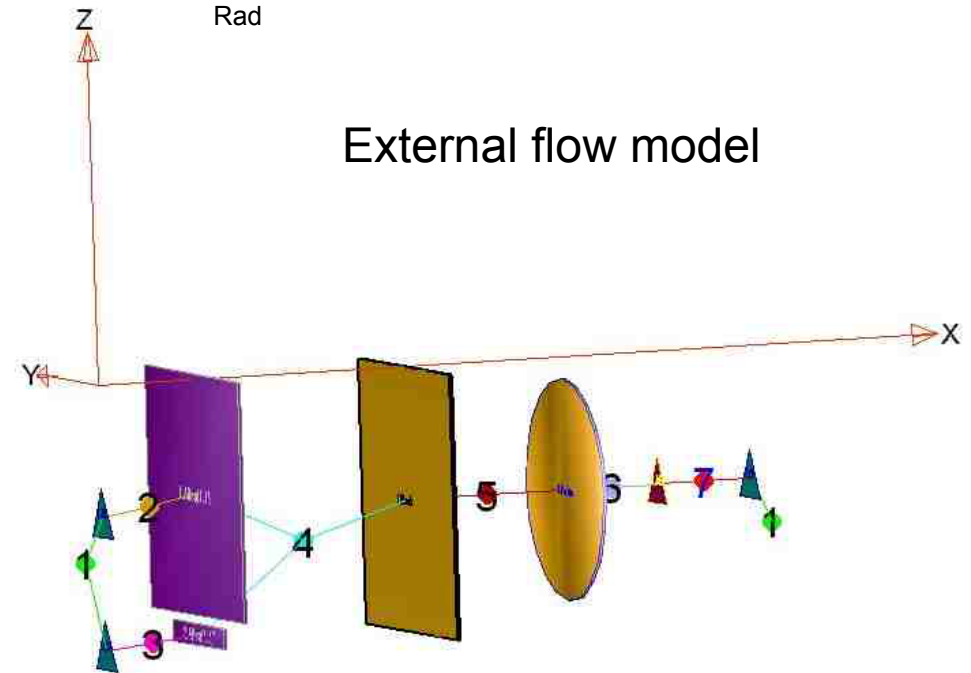
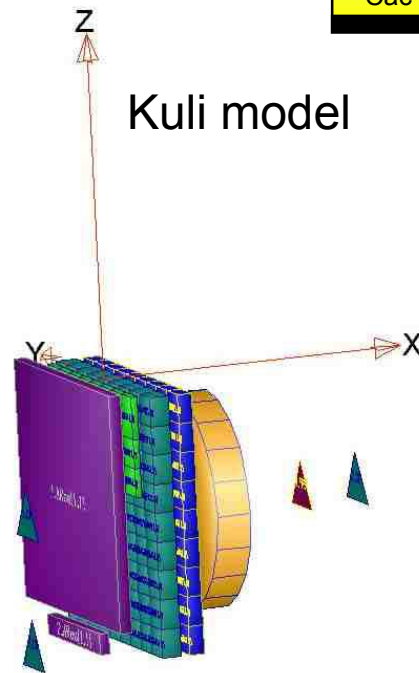
FH / NH / VN flow model

System layout



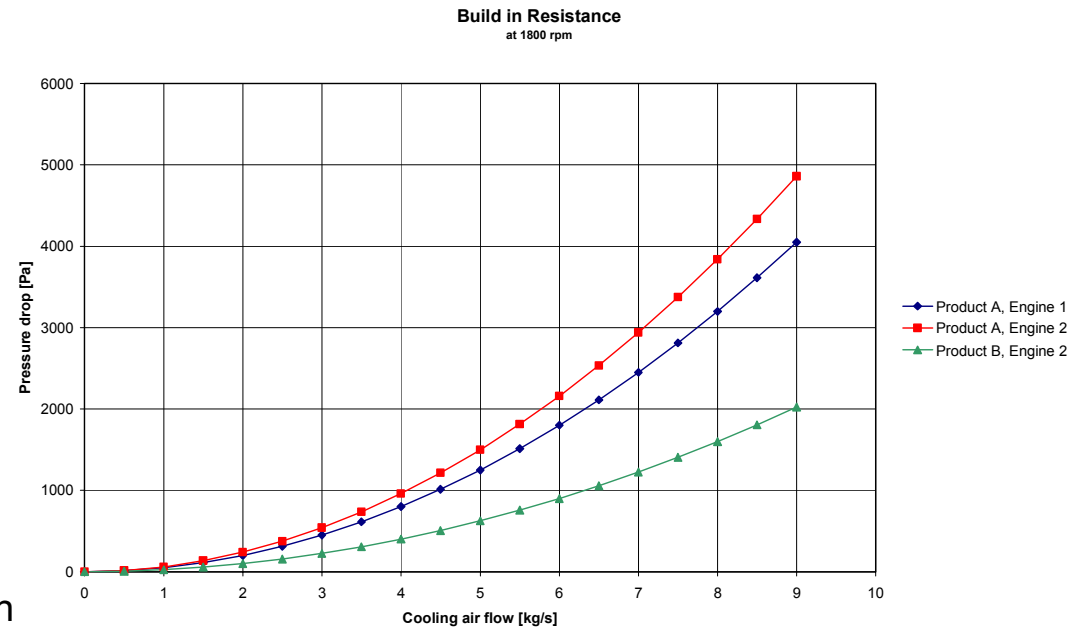
Kuli model

External flow model



KULI Simulation results

- Interesting simulation results
 - ✓ Limiting Ambient Temperature (LAT)
 - ✓ Intake Manifold Temperature Difference (IMTD)
 - ✓ Charge air pressure drop
 - ✓ Operation points
 - ✓ Transient response
 - ✓ Build-in resistance
 - ✓ Fan power consumption
 - ✓ Fan engagement
 - ✓ Fan slip
 - ✓ Needed fan speeds
 - ✓ Temperatures and pressures throughout installation



Suggestions

- **Ideas for improvements in Kuli**

- ✓ Multiple input Controllers for modeling electronically controlled fan clutches
- ✓ BIR-adjustment : the ability to calculate the needed BIR at different operation points (engine speed and mean eff. pressure) in one setting & model
- ✓ Scaling factor for heat & hydraulic characteristics for modeling clogging (default value for heat exchanger should be 100%)
- ✓ downloadable examples from the website
- ✓ more in-depth modeling information in the frequently asked question section of the website

Conclusions

- **Kuli has led to:**
 - ✓ reduced test time in the chassis dynamometer and system test rig
 - ✓ smarter / focused testing: finding the right test configuration
 - ✓ optimized cooling systems: better cooling performance and fuel consumption
 - ✓ shorter development time
 - ✓ more in-dept knowledge of the cooling system
 - ✓ shorter response time for product modifications requests
 - ✓ better presentation material for management (postprocessing)