Improving Your Productivity with KULI 7.0 – New Features

Rolf Salomon

MAGNA POWERTRAIN

drivetrain components and systems

engines and engine components

axle and chassis modules

Engineering Center Steyr Gmbh & Co KG

driven by passion

KULI 7.0

base / light
climate control / hvac
advanced
- com
- optimize
- cfd

drive
- transient
- engine model
- driving simulation

components

What's New?

Detailed information available in the KULI user manual

Please download latest version from

www.kuli.at

and use online help

Examples available on our website www.kuli.at -> support -> examples

New module KULI components

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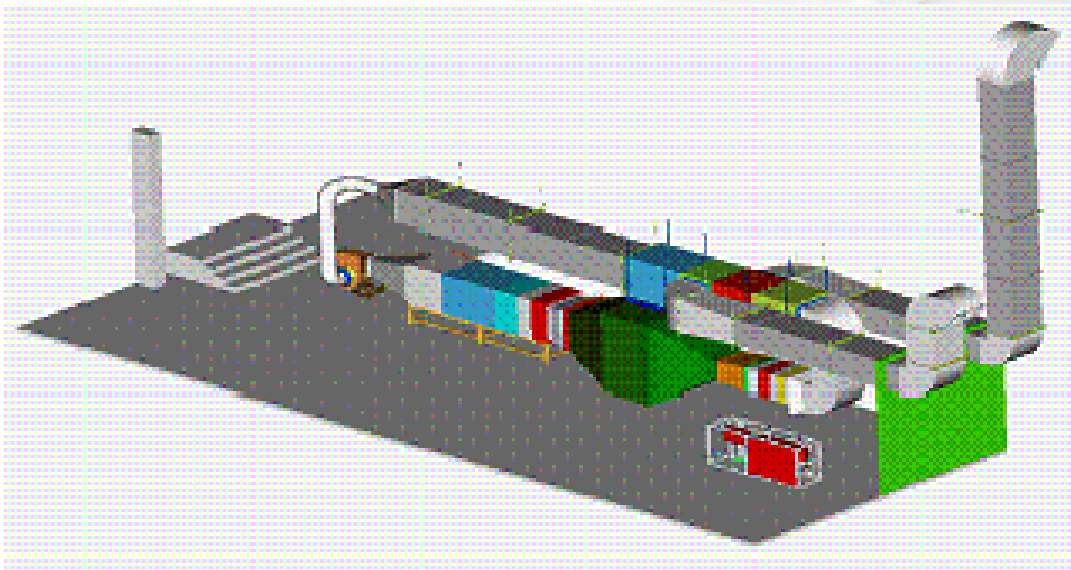
- The virtual test bench

- Available as standalone version and additional module to KULI base



Improvements KULI base

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- Project organization
- Built-in resistance (BiR), definition of loss coefficient
- Medium controller
- Results of COM-objects visible in 2D-inner circuit window
- Information about calculation objects in the postprocessor
- File history implemented
- Additional sensors and actuators available

Settings reorganized

- Global KULI settings (Extras -> Settings)
  - Local user directory (ini-files)
  - Graphic settings
  - KULI media path
  - Output units
  - Component info box
  - License information
  - Activated KULI modules
- Project settings
  - Working directory
- Project / file settings
  - Analysis options

Data handling - projects

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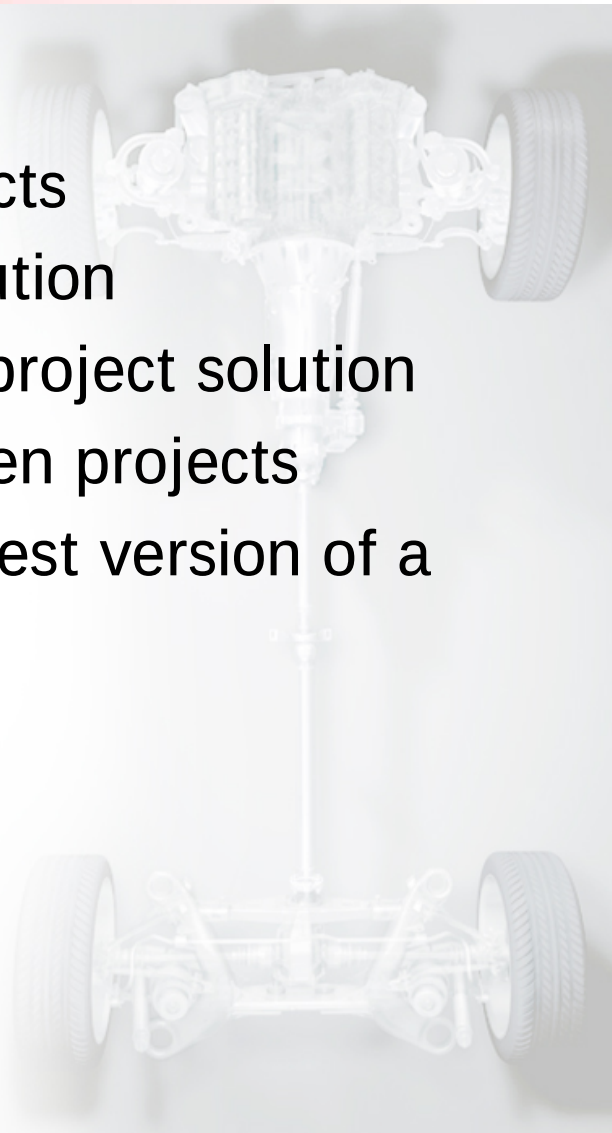
Features

- Dialog based management of KULI projects
- Projects will be collected to a project solution
- Existing projects can be imported into a project solution
- Moving or copying of components between projects
- Detect whether a project contains the latest version of a component



Data handling - projects

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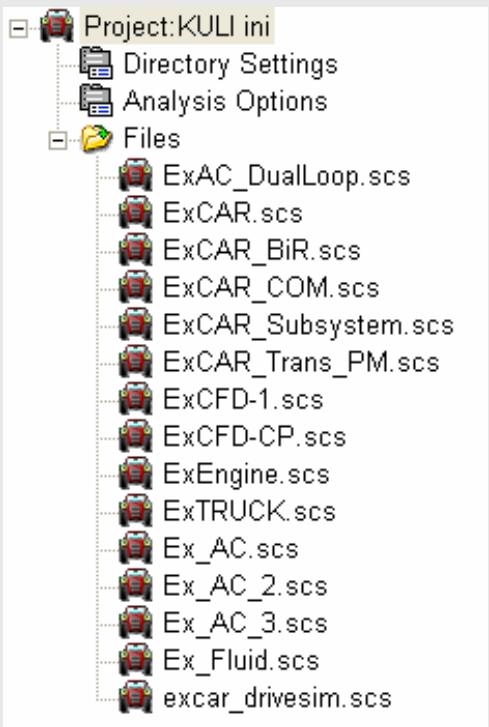
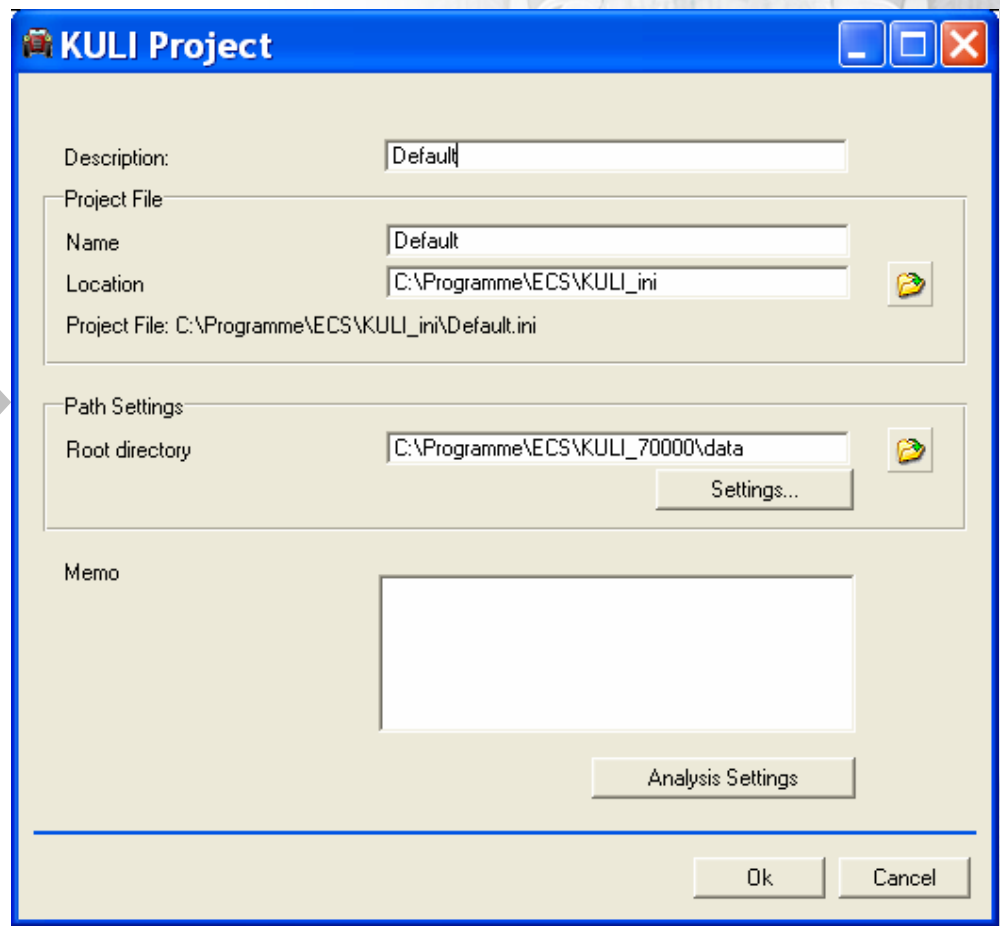
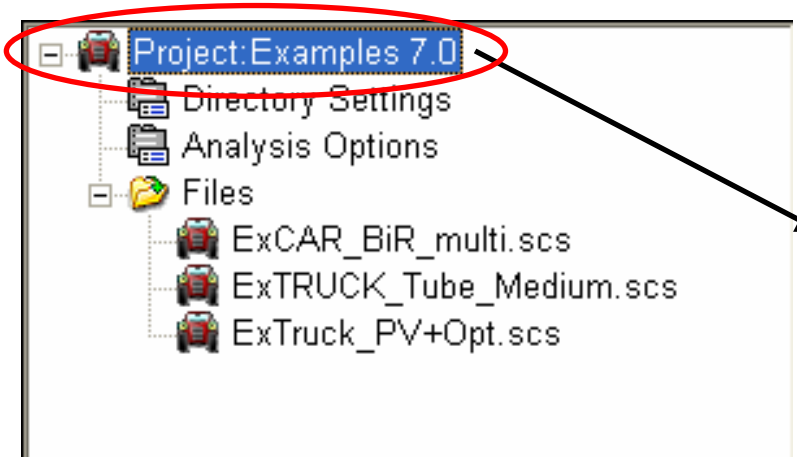
Project management implemented in KULI

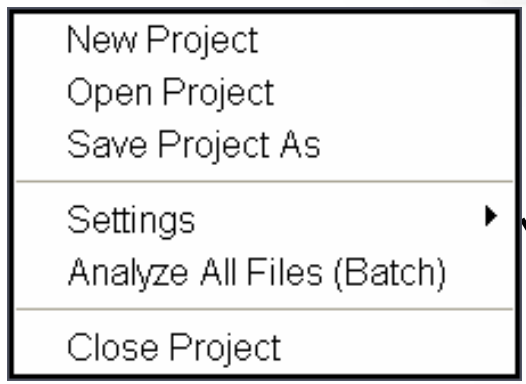
KULI project solution

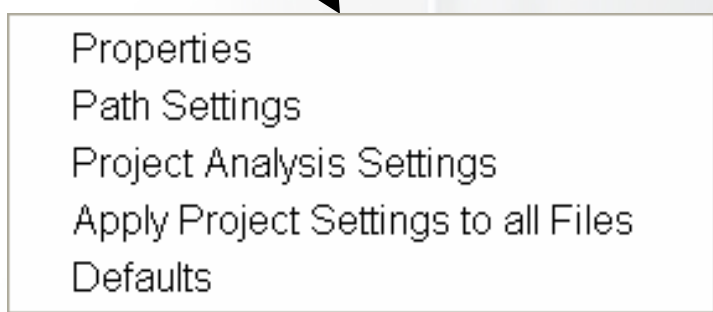




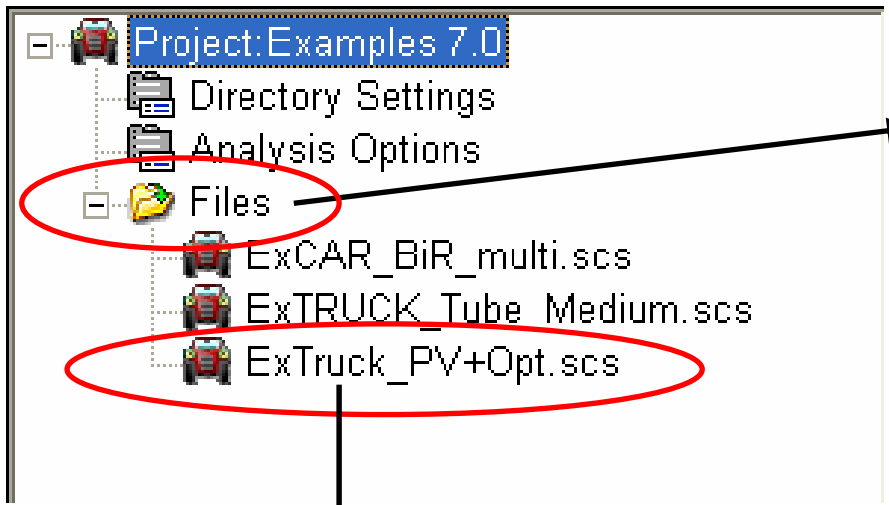
Context menu for project







Context menu for files



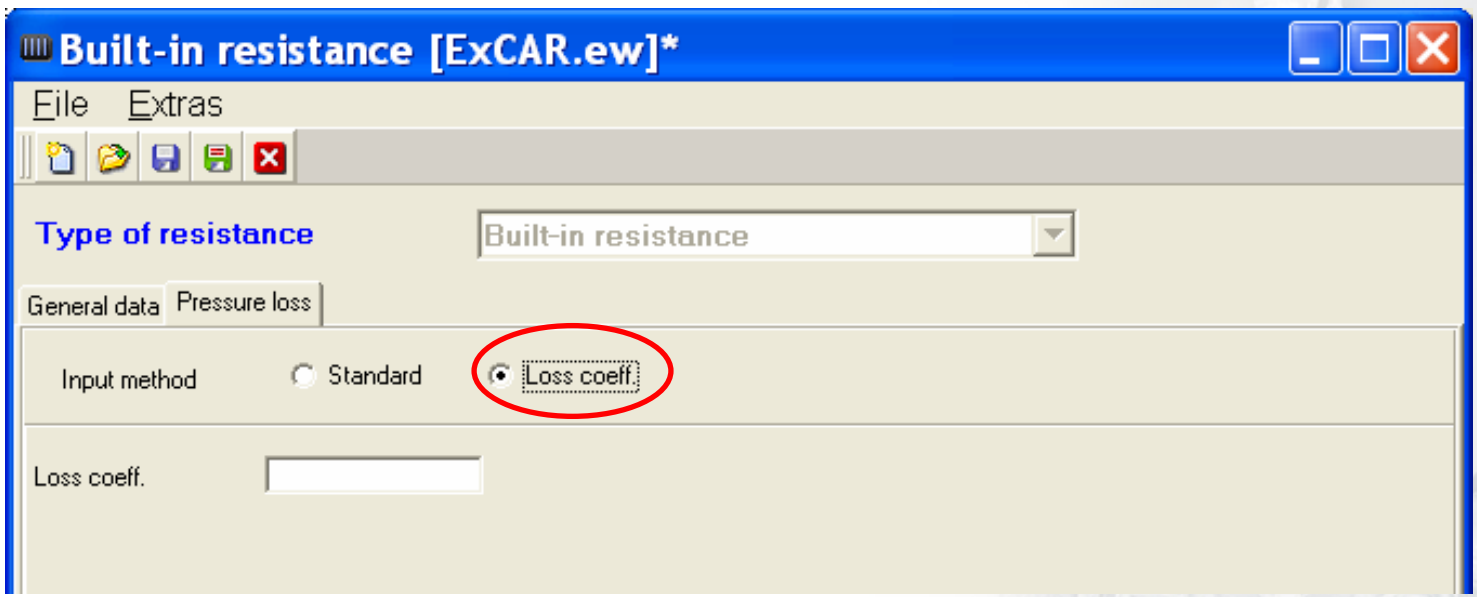
- Add New File...
- Add Existing File(s)...
- Import File(s) to project (Copy Unpack)
- Open File at other Path

- Open KULI File
- Unpack and open KULI File
- Remove File from Project
- Delete File from Disk
- Settings ▸
- Analysis ▸
- Verify used Components

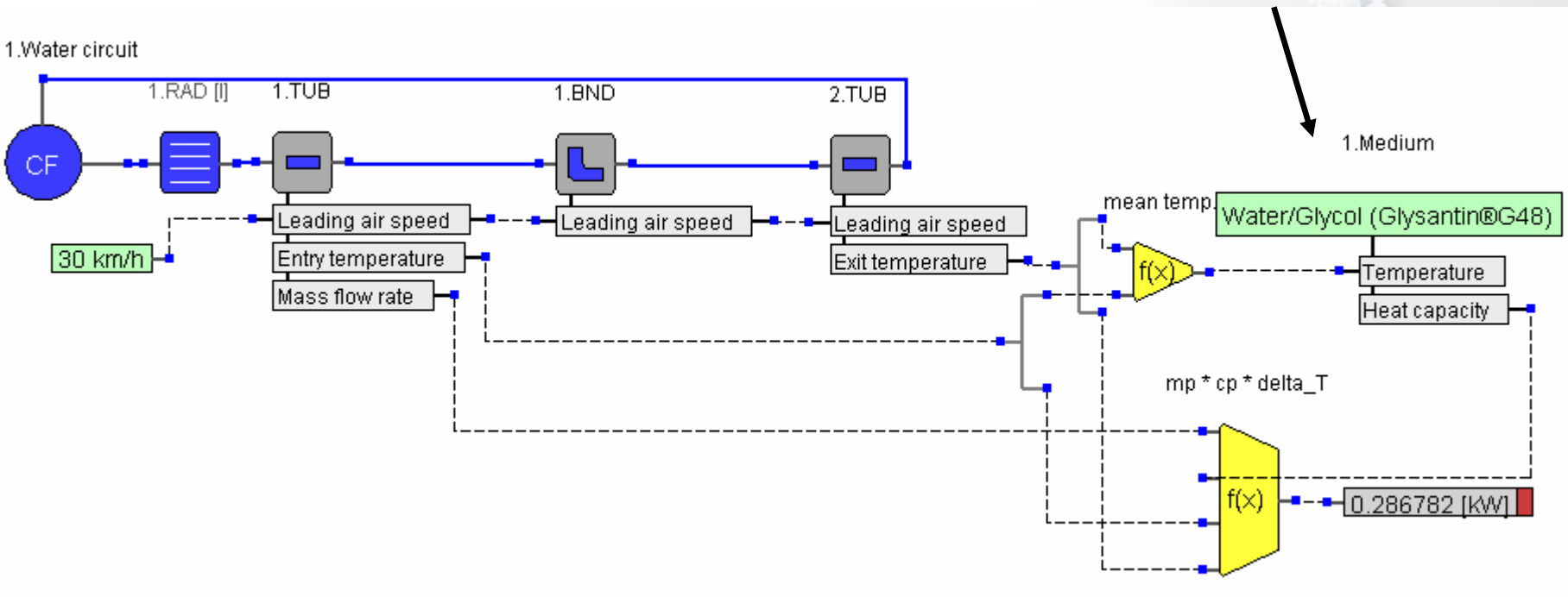
- Apply Project Settings to selected File
- Apply Project Settings to all Files
- File Analysis Settings
- Compare Analysis Settings

- Open and Analyze File
- Analyze Files (Batch)
- Analyze All Files (Batch)

- Additional definition of pressure loss with pressure loss coefficient (zeta-value)
- Sensor and actuator available



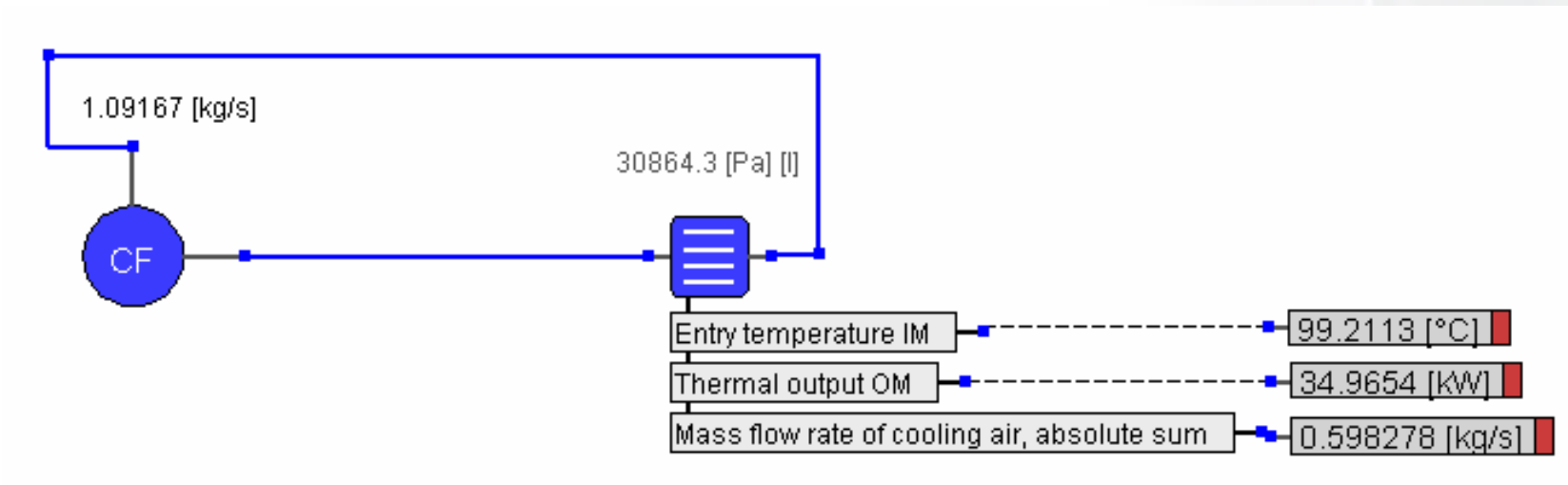
Medium controller



Results of COM-objects visible

Results shown from

- Last active operating point
- Last time step



Calculation objects

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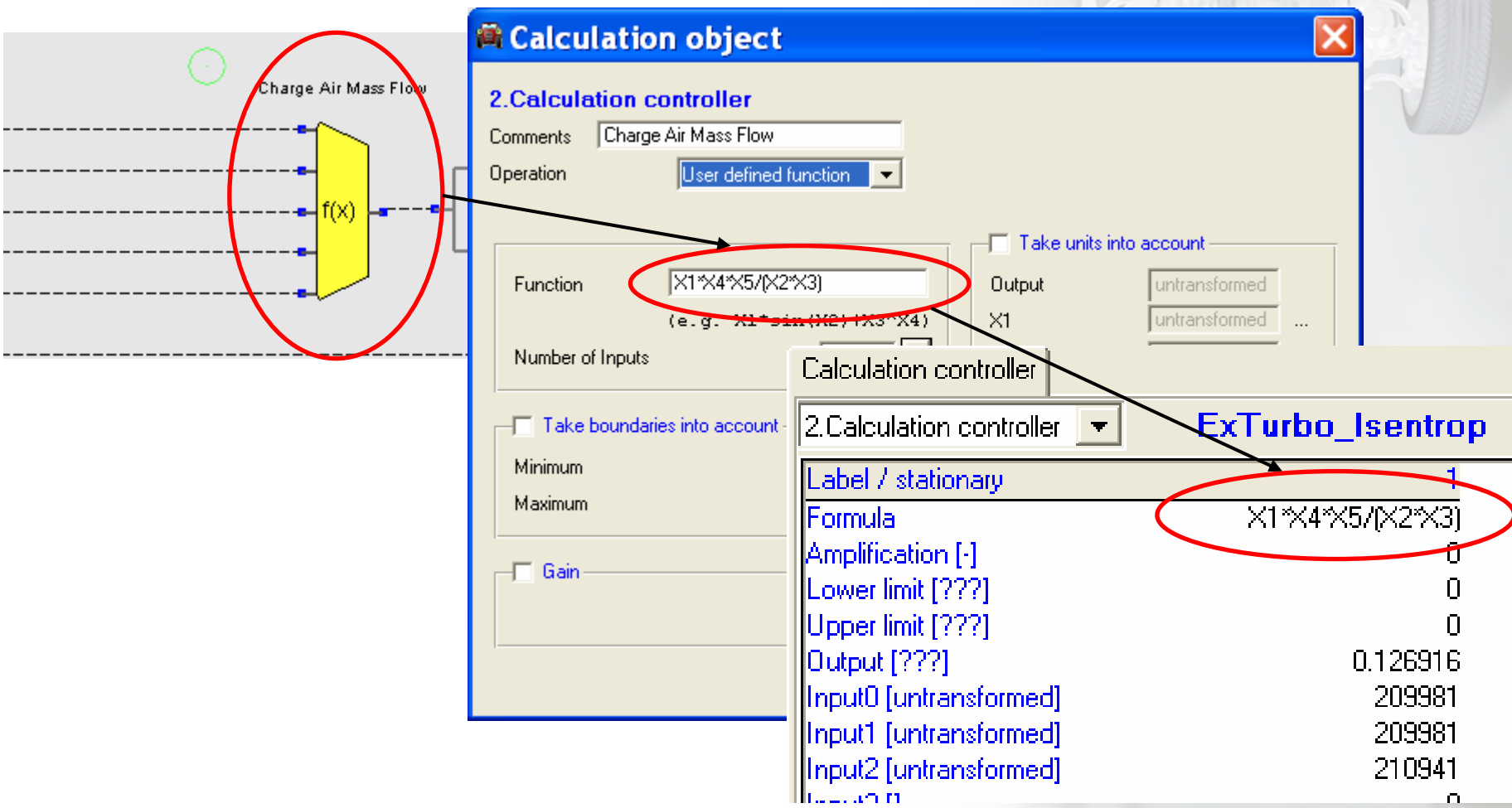
- Information available in the postprocessor

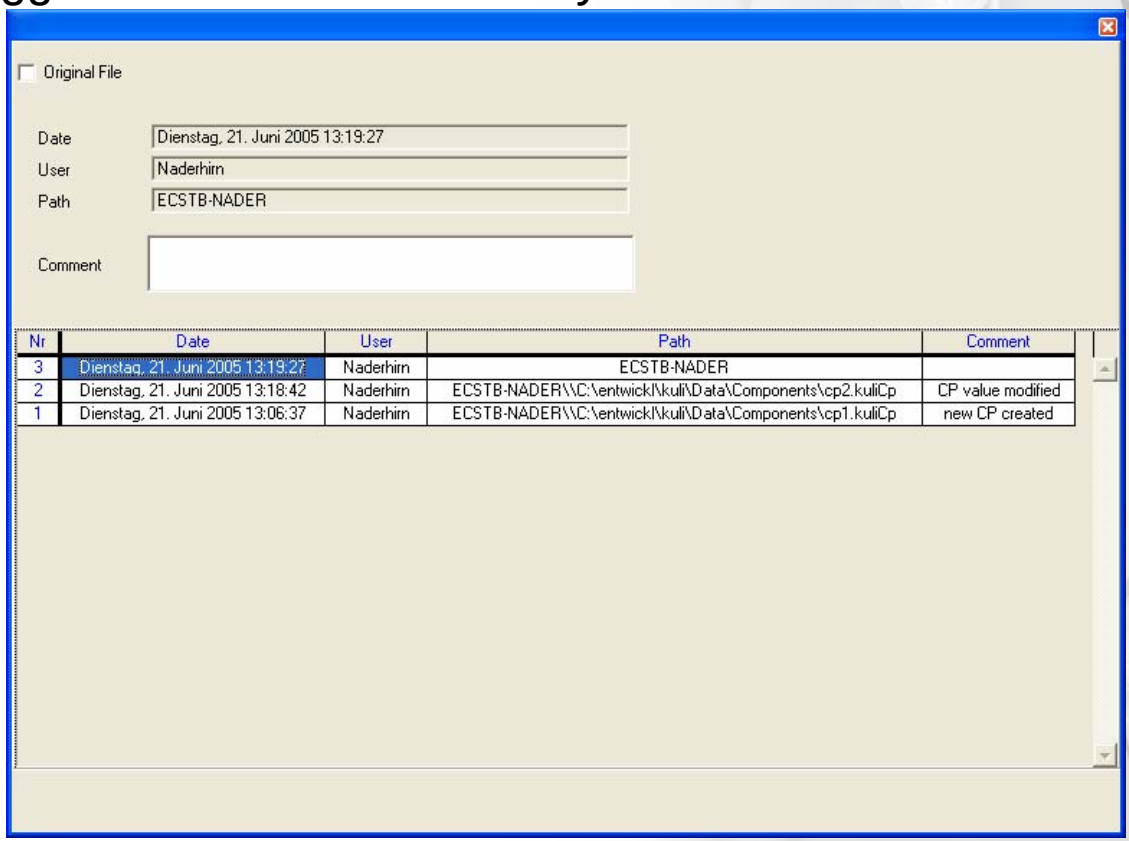


Data handling – File version history

- File can be stored as „Original File“ which is write protected
- Modified „Original File“ cannot be overwritten and MUST be stored under another file name
- File modifications are logged in a file version history table

If this option is enabled the file will be stored with the write protection attribute enabled

File modifications are logged in this table. The date, user and path are filled automatically. A comment can be set by the user.



Nr	Date	User	Path	Comment
3	Dienstag, 21. Juni 2005 13:19:27	Naderhirn	ECSTB-NADER	
2	Dienstag, 21. Juni 2005 13:18:42	Naderhirn	ECSTB-NADER\\C:\entwickl\kuli\Data\Components\cp2.kuliCp	CP value modified
1	Dienstag, 21. Juni 2005 13:06:37	Naderhirn	ECSTB-NADER\\C:\entwickl\kuli\Data\Components\cp1.kuliCp	new CP created

Improvements KULI drive

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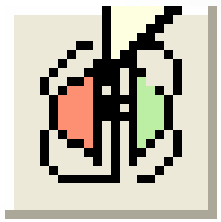
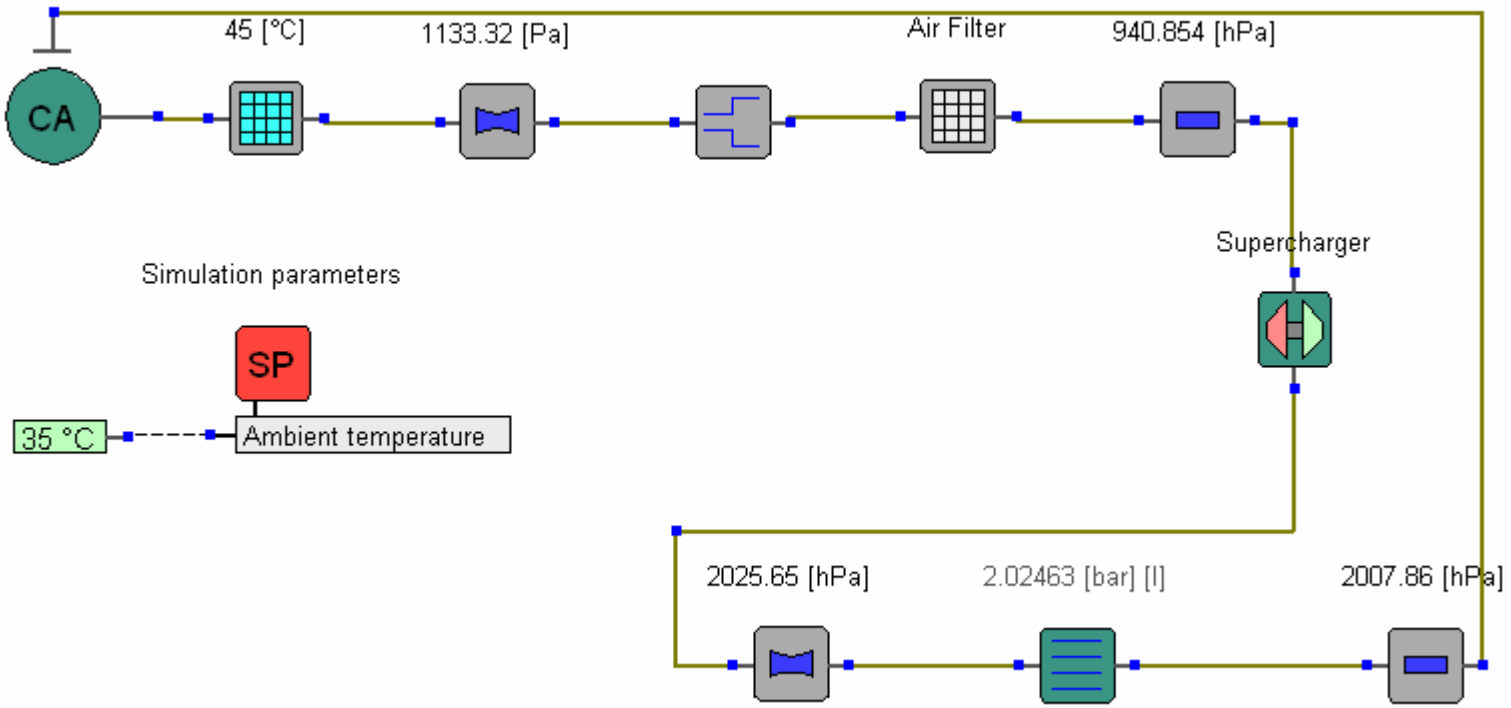
- New component turbocharger
- Improved engine model

Supercharger

- Consideration of ambient conditions





Improved engine model

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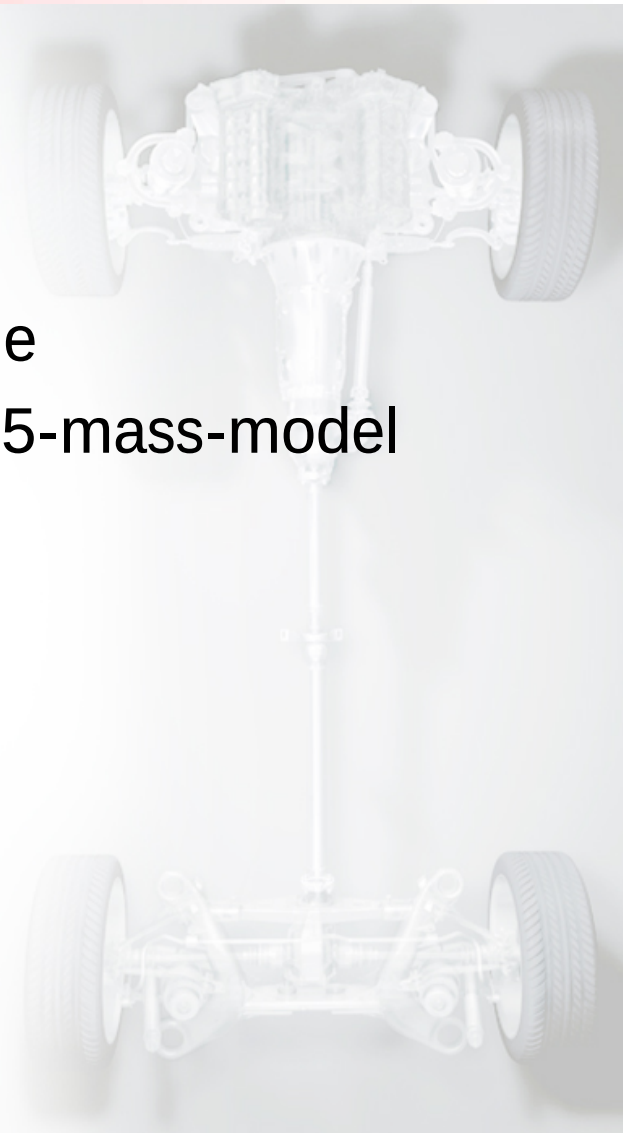
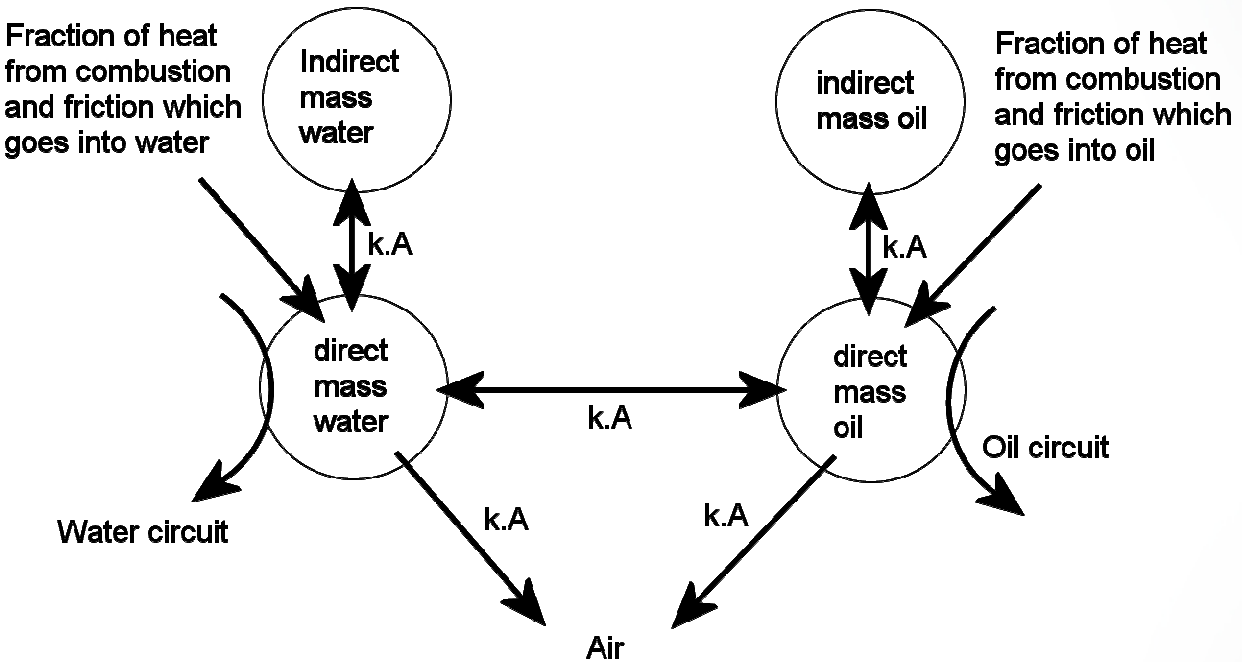
- More flexiblitiy for modelling
  - 4-mass-model
  - 5-mass-model
- Automatically adjustment easier to handle
- Hot-soak phase simulation possible with 5-mass-model
- Extrapolation
  - Increase of engine speed or engine load
  - Increase of displacement



KULI 6 - the 4-mass model



The engine is described by directly and indirectly heated masses.

Oil and water side of the engine are modeled separately.

Between the masses there is heat conduction.

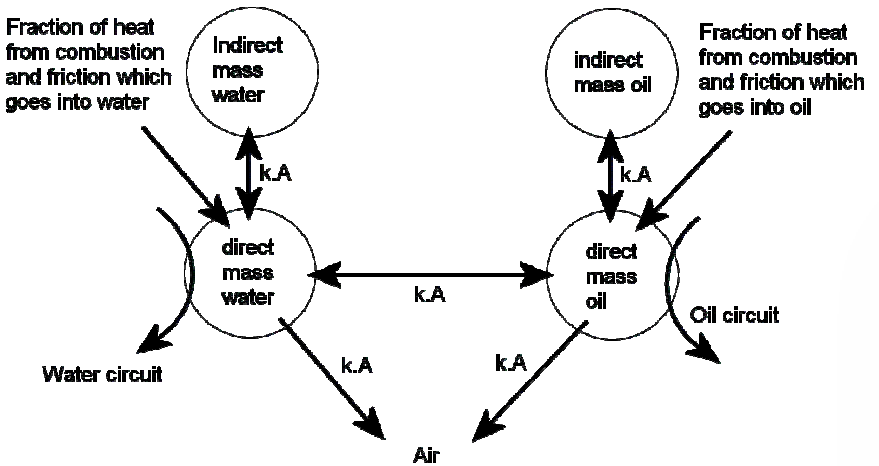
The direct masses are heated by the combustion and by friction loss.

The system dissipates heat to oil- and water circuit and to the air.

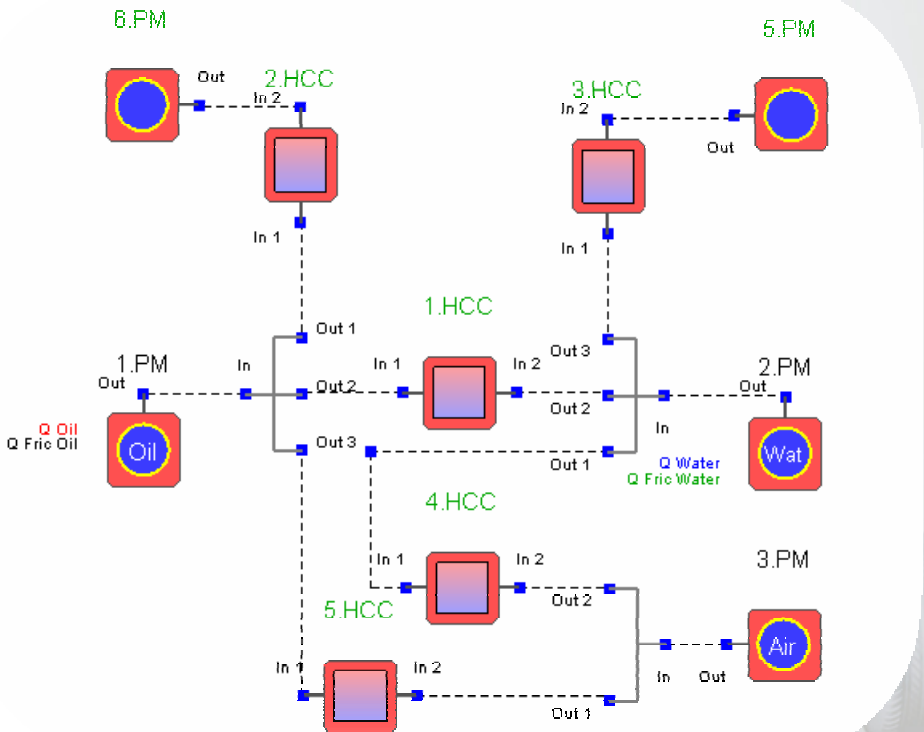
This 4-mass model is relatively simple, but it still manages to describe the main properties of an engine.

Modelling the 4-mass engine model

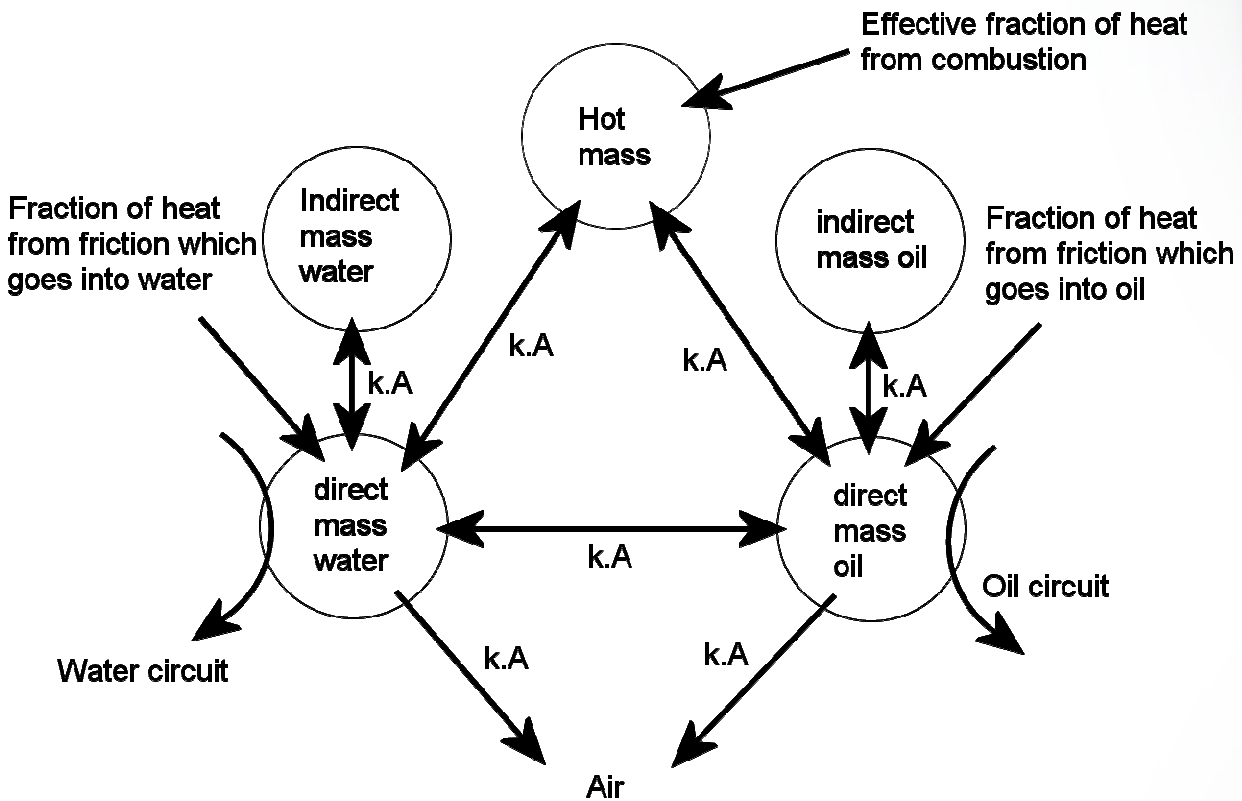
Schematic display



KULI engine model



Improved models – the 5-mass model



In the 5-mass model the hot pistons are included as an additional mass.

Now the direct masses are only affected by the friction-induced heat, the heat from the combustion process is added to the piston mass.

This model offers better possibilities to distribute the heat to the system, thus the user has more flexibility when adjusting the system to measured data.

Modelling the 5-mass engine model

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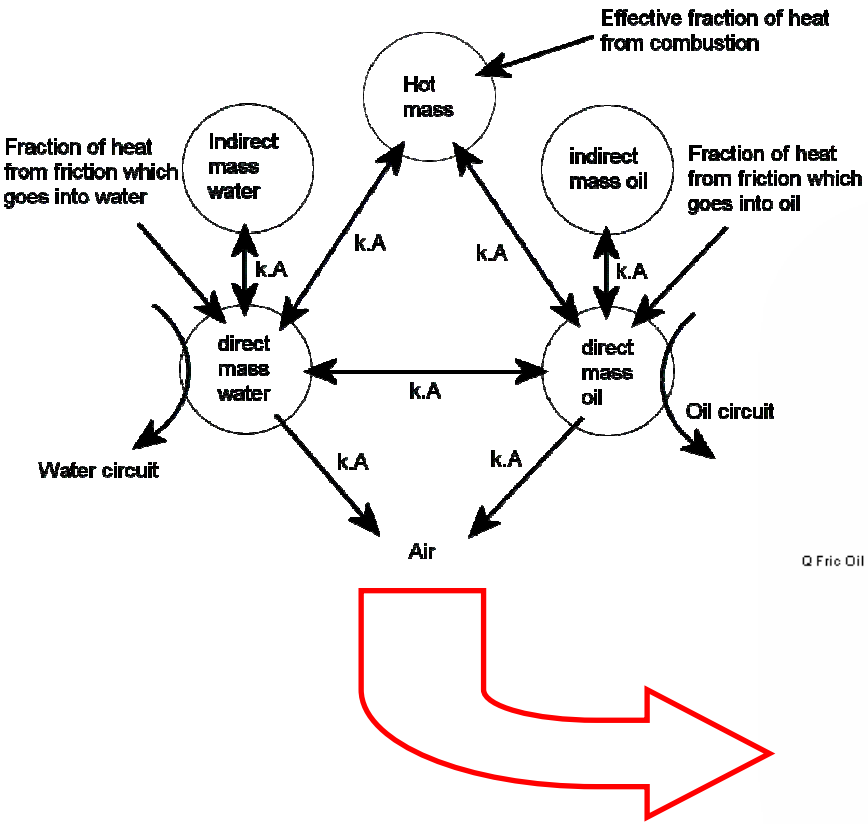
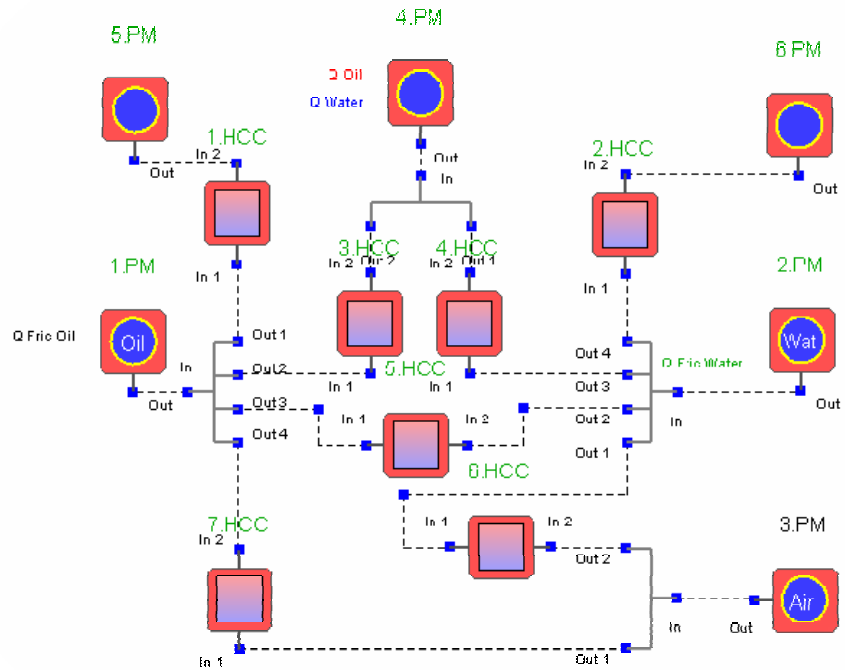
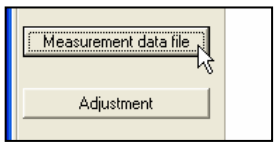
Schematic display



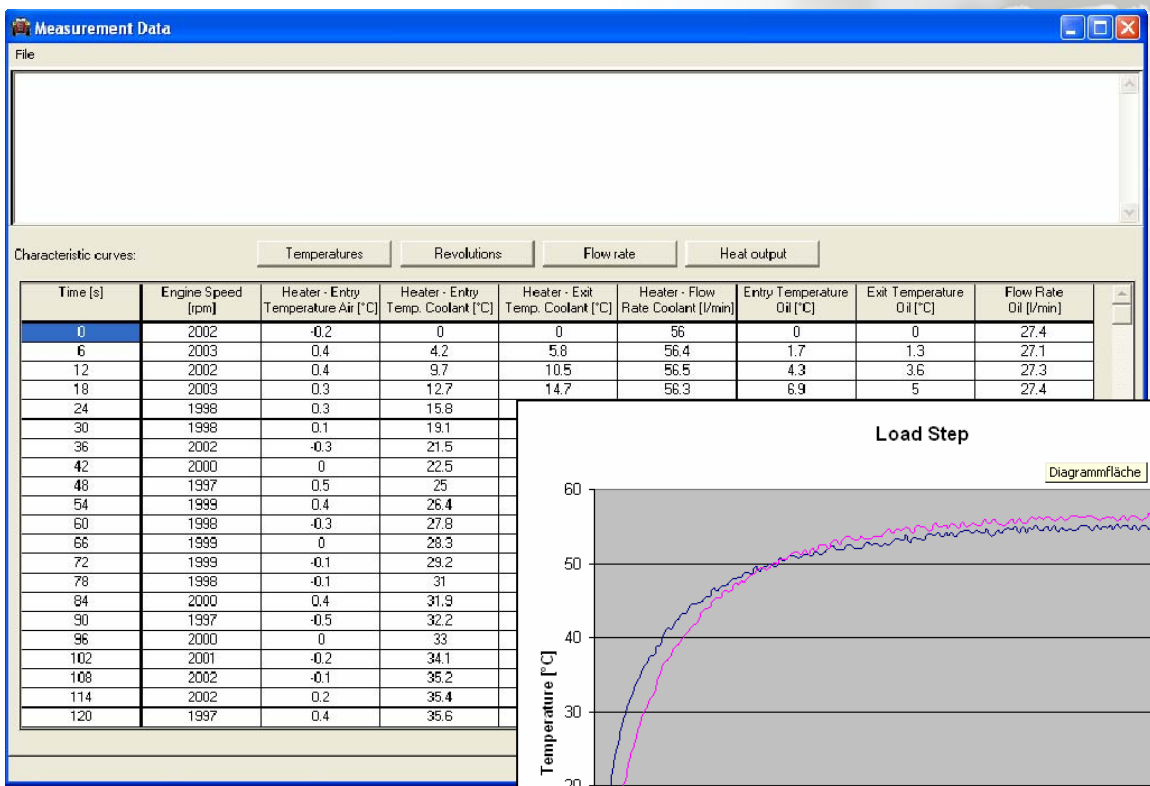
KULI engine model



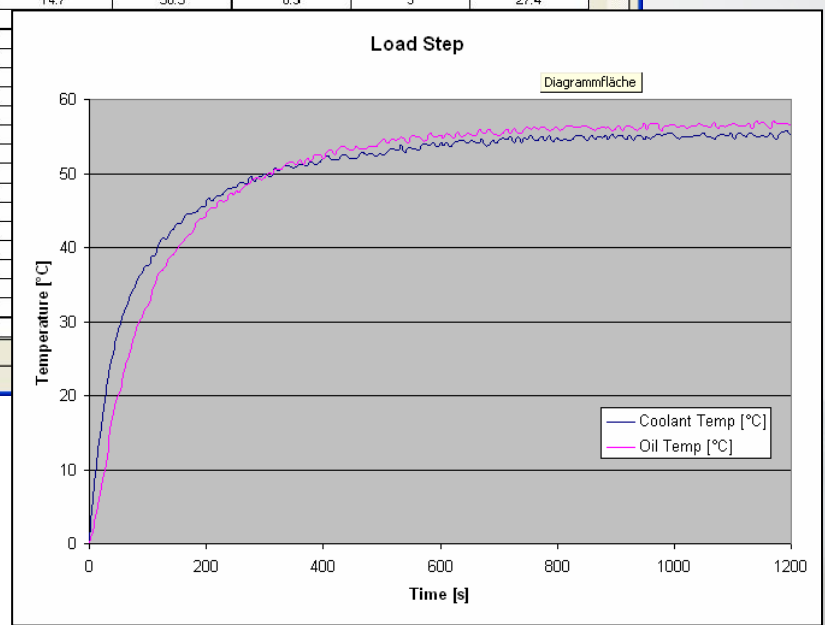
Defining the auto adjustment data



Clicking the ***Measurement data file*** button opens a table where the data of a load step measurement has to be inserted.



Time [s]	Engine Speed [rpm]	Heater - Entry Temperature Air [°C]	Heater - Entry Temp. Coolant [°C]	Heater - Exit Temp. Coolant [°C]	Heater - Flow Rate Coolant [l/min]	Entry Temperature Oil [°C]	Exit Temperature Oil [°C]	Flow Rate Oil [l/min]
0	2002	-0.2	0	0	56	0	0	27.4
6	2003	0.4	4.2	5.8	56.4	1.7	1.3	27.1
12	2002	0.4	9.7	10.5	56.5	4.3	3.6	27.3
18	2003	0.3	12.7	14.7	56.3	6.9	5	27.4
24	1998	0.3	15.8					
30	1998	0.1	19.1					
36	2002	-0.3	21.5					
42	2000	0	22.5					
48	1997	0.5	25					
54	1999	0.4	26.4					
60	1998	-0.3	27.8					
66	1999	0	28.3					
72	1999	-0.1	29.2					
78	1998	-0.1	31					
84	2000	0.4	31.9					
90	1997	-0.5	32.2					
96	2000	0	33					
102	2001	-0.2	34.1					
108	2002	-0.1	35.2					
114	2002	0.2	35.4					
120	1997	0.4	35.6					



Afterwards, clicking the button ***Adjustment*** starts the automatic adjustment process…

Summary auto adjustment

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After successful adjustment…

- The **stationary adjustment** guarantees that the engine model correctly reproduces the stationary values defined in the **heat table** of the engine model.
- The **transient adjustment** sets the heat capacities so that **warming-up and cooling-down** curves are reproduced correctly.
- The engine model is **ready to be used in KULI** (transient and stationary). From the outside there is no difference between the old and the new KULI engine model.
  But simulation of **hot-soak phase** is possible with 5-mass-model.

Improvements KULI advanced

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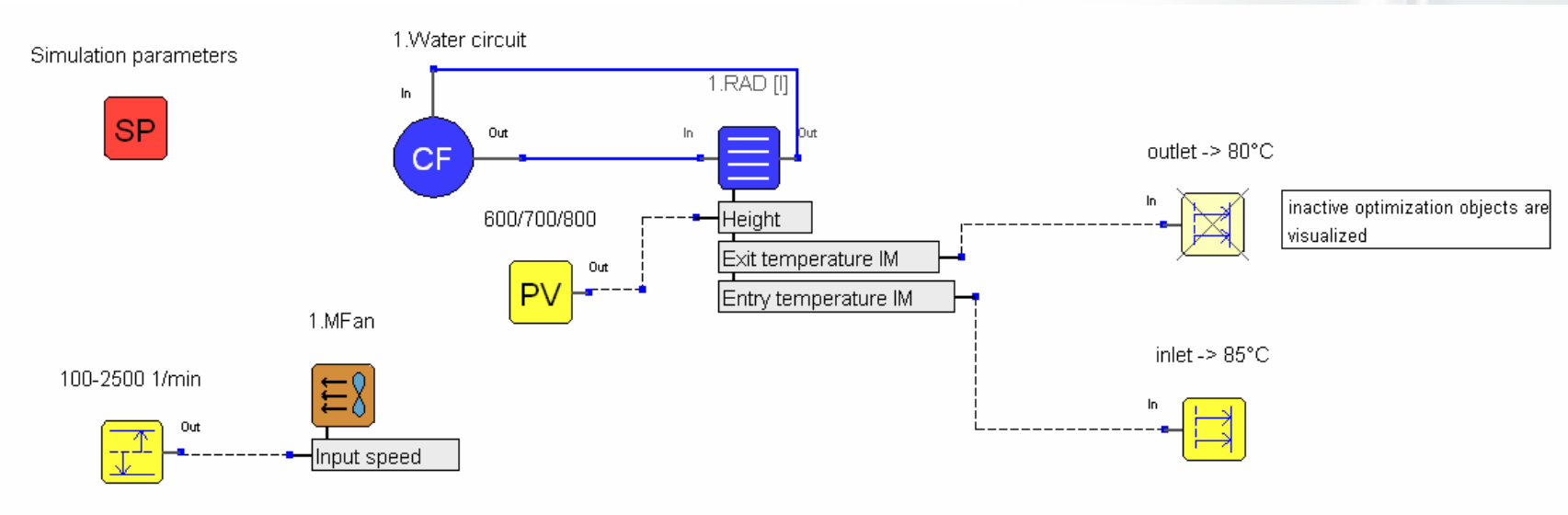
- Combination of automatic optimization and parameter variation implemented
- Identification of a specific operating point for optimization of more operating points

Combined automatic optimization and parameter variation

- for each value of the parameter variation ("outer loop") the optimization will be performed ("inner loop")



Optimization of more operating points

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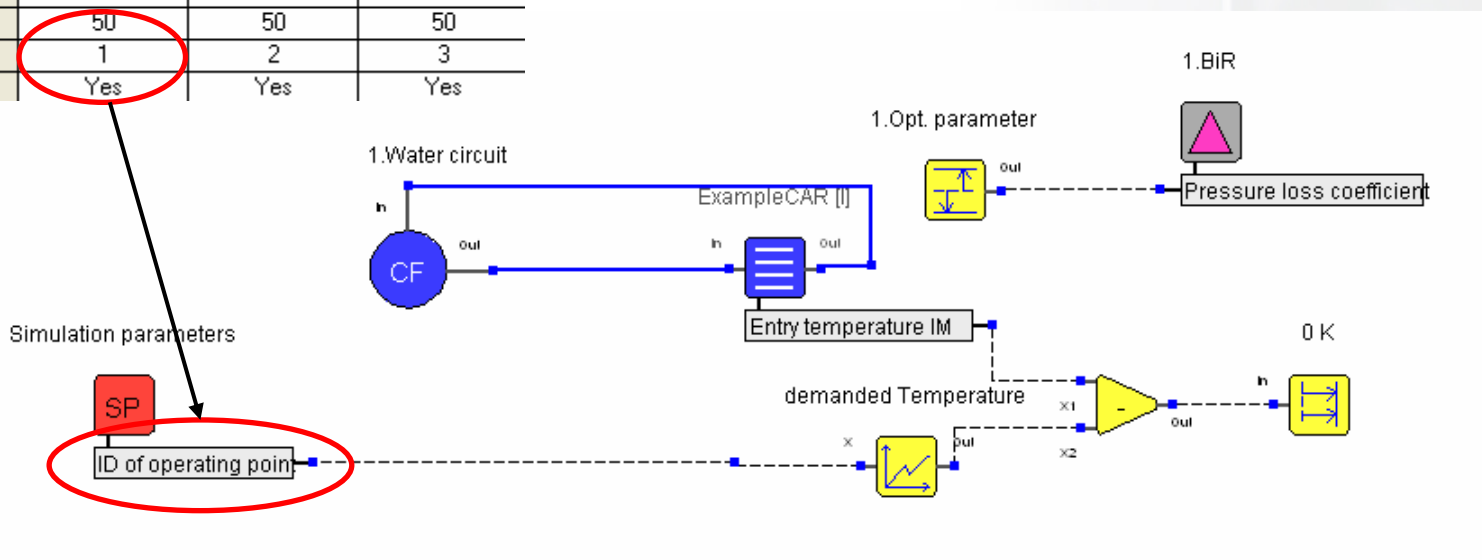
- If the "comment" in the simulation parameters is a number, then "ID of operating point" gives this number; so it can be used to identify the operating point.

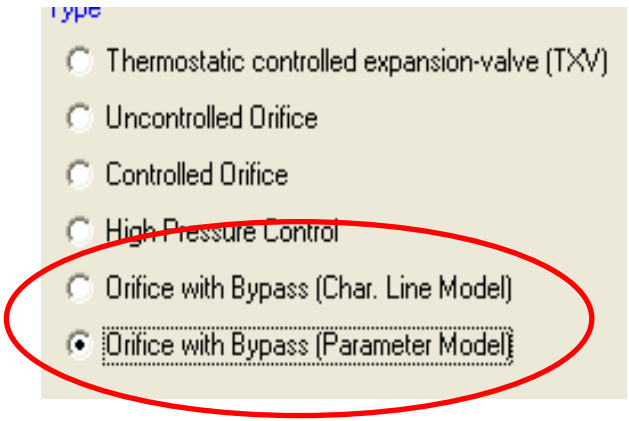
	1	2	3
EngineRPM [rpm]	2650	2480	3970
Mean eff. pressure [bar]	5.9	8.3	9.1
Driving speed	40	105	200
Warm-up temperature [K]	2	0	0
Ambient air pressure	1013	1013	1013
Ambient temperature	20	20	35
Air humidity [%]	50	50	50
Comments	1	2	3
Calculate Operating Point	Yes	Yes	Yes

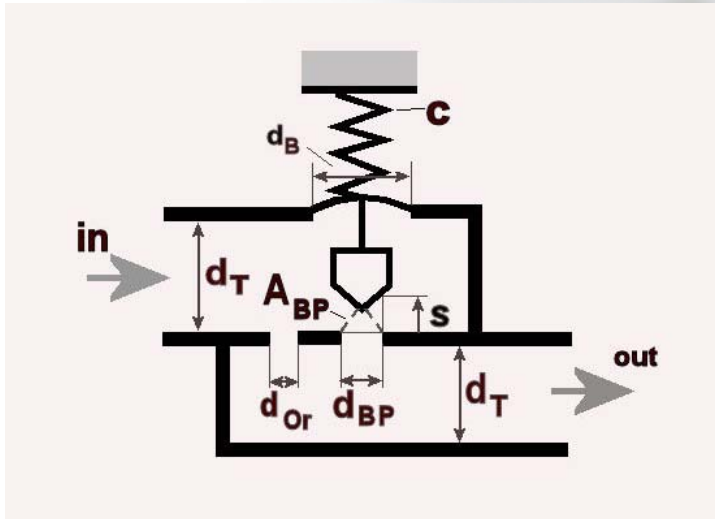


Improvements KULI hvac

- New component: Orifice valve with bypass
- Additional refrigerants implemented
  - R152a, R12, R404a
  - Still existing R134a, R744, interface to Refprop®-database
- New hvac-solver

Orifice valve with bypass





d_{Or}	Orifice diameter
d_T	Tube diameter
d_{BP}	Bypass diameter
d_B	Bellows diameter
s	Valve lift
s_{max}	Maximum valve lift
c	Spring rate (bellows + spring)
A_{BP}	Bypass opening Area
	Opening pressure (high pressure)
	Opening pressure (low pressure)

New module KULI components

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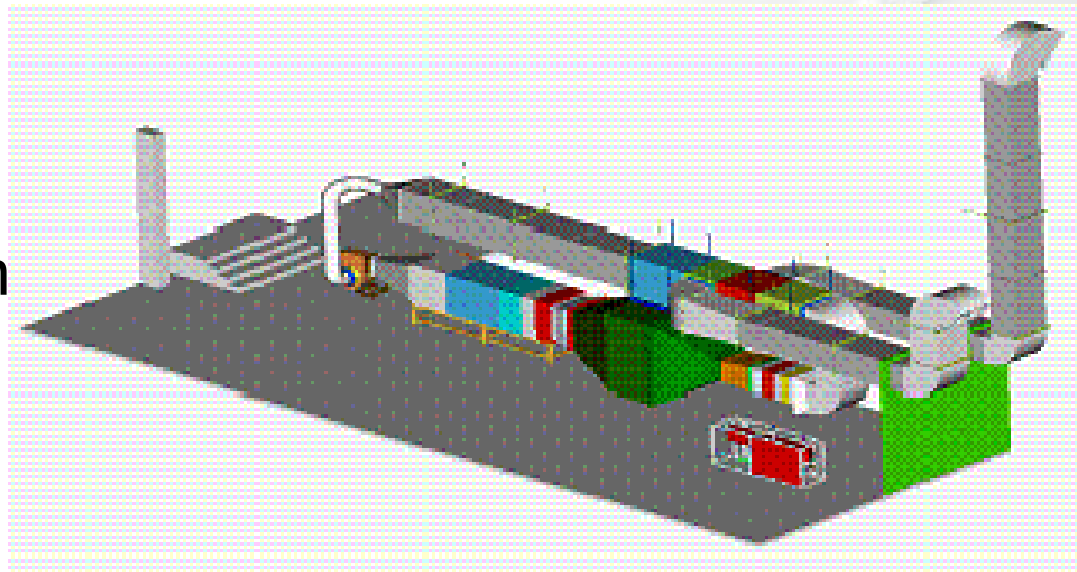
- The virtual test bench
- Available as standalone version and additional module to KULI base
- Online demonstration



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Thank you for your attention!

drivetrain components and systems

engines and engine components

axle and chassis modules

Engineering Center Steyr Gmbh & Co KG

driven by passion