New Features in KULI

ENGINEERING CENTER STEYR
GmbH & Co KG

Josef Hager

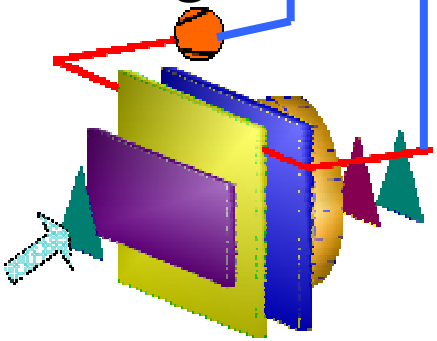
Contents

- **KULI 6.0 New Module Structure**
- **KULI base – Enhancements**
- **KULI advanced – Enhancements**
- **KULI drive – Enhancements**
- **KULI climate control / hvac – Enhancements**

KULI Modules

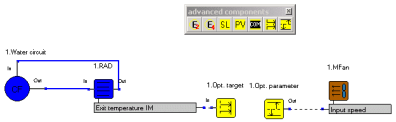
climate control hvac

base light

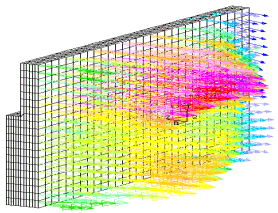


advanced

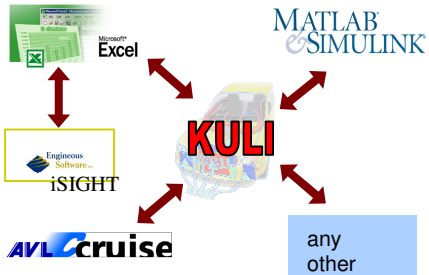
optimize



cfd



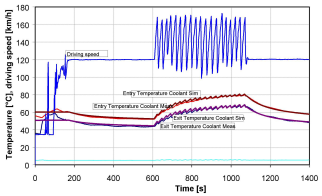
com



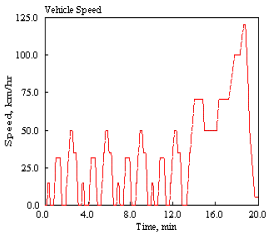
any other program that supports COM

drive

transient



driving simulation



engine model

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KULI 6.0 base

KULI base

- PID Controller
- Calculation object with user definable formula
- N-dimensional maps
- Generic components

KULI base / light

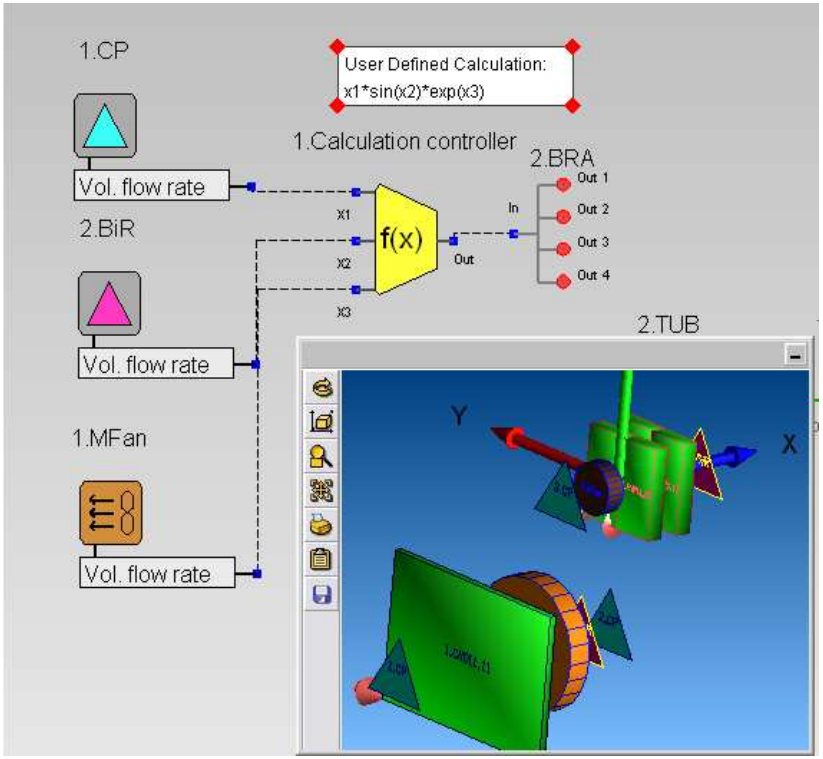
- Plate heat exchanger
- Inlet grid
- New options for cp value
- Enhancements at transition
- Online tutorial

KULI 6.0 base improvements

- Multiple arm signal branch
- Improvements in GUI
- Components from airside visible in inner circuit
- Text box in 2D-window
- New interpolation method (IMSL linear)
- Improved error messages / warnings
- Selection of directory for material properties
- Regression of fan curves
- Unit selection improved
- COM-ID visible in 2D-window

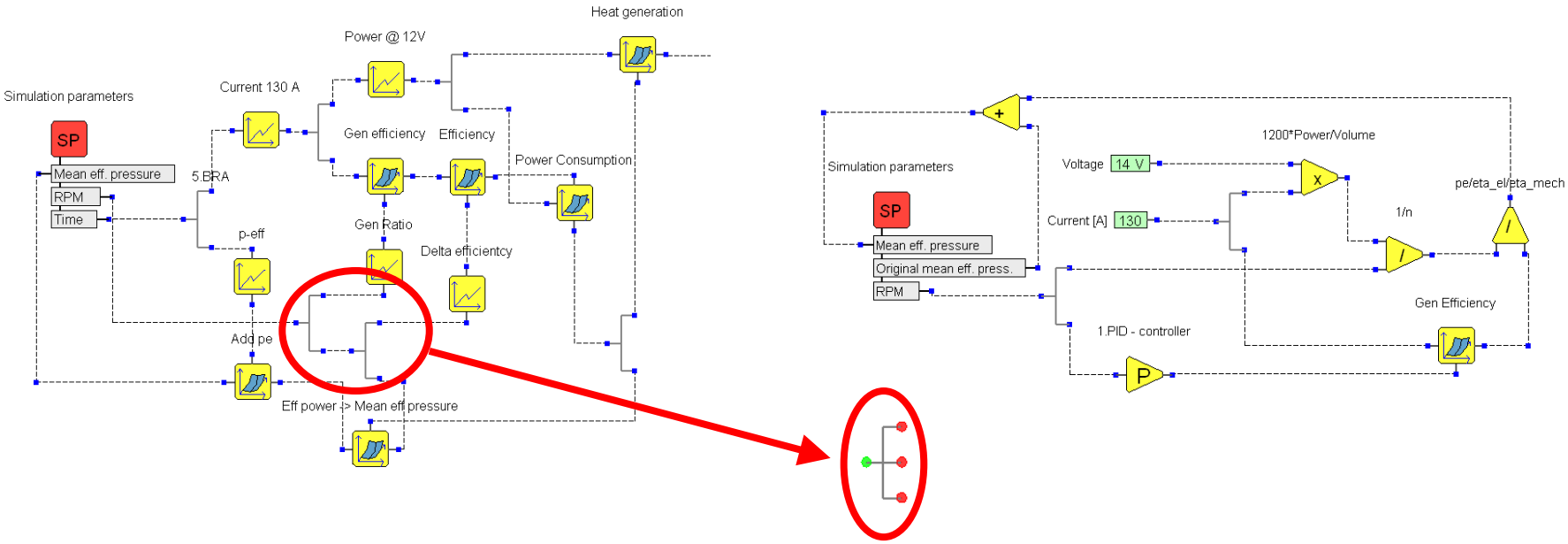
Enhancements in 2D Modeling

- General Design Review
- Multi Signal – Branches
- Comment Fields
- Listing of all available Components



Example – 2d Modeling Object

KULI 5 → **KULI 6**



Simplified modeling due to enhanced 2d features

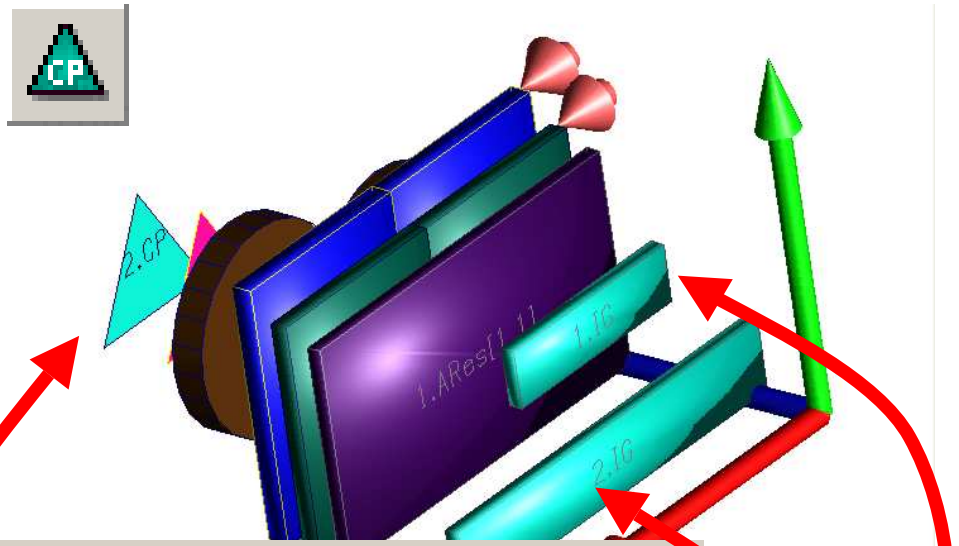
New options for cp value

Absolute Method

Static pressure independent of flow through cooling package

Total Pressure Method

Static + dynamic pressure = constant (at air entry)



Determination of pressure difference

- (•) Relative Method
  Measurement: closed; Analysis: open
- ( ) Absolute Method
  Measurement: open or Values from CFD; Analysis: open
- ( ) Total Pressure Method
  Measurement: closed; Analysis: open

$$\text{rel.}: \quad \Delta p = cp \times \frac{\rho}{2} \times \left(v_\infty - v_{inlet}\right)^2$$

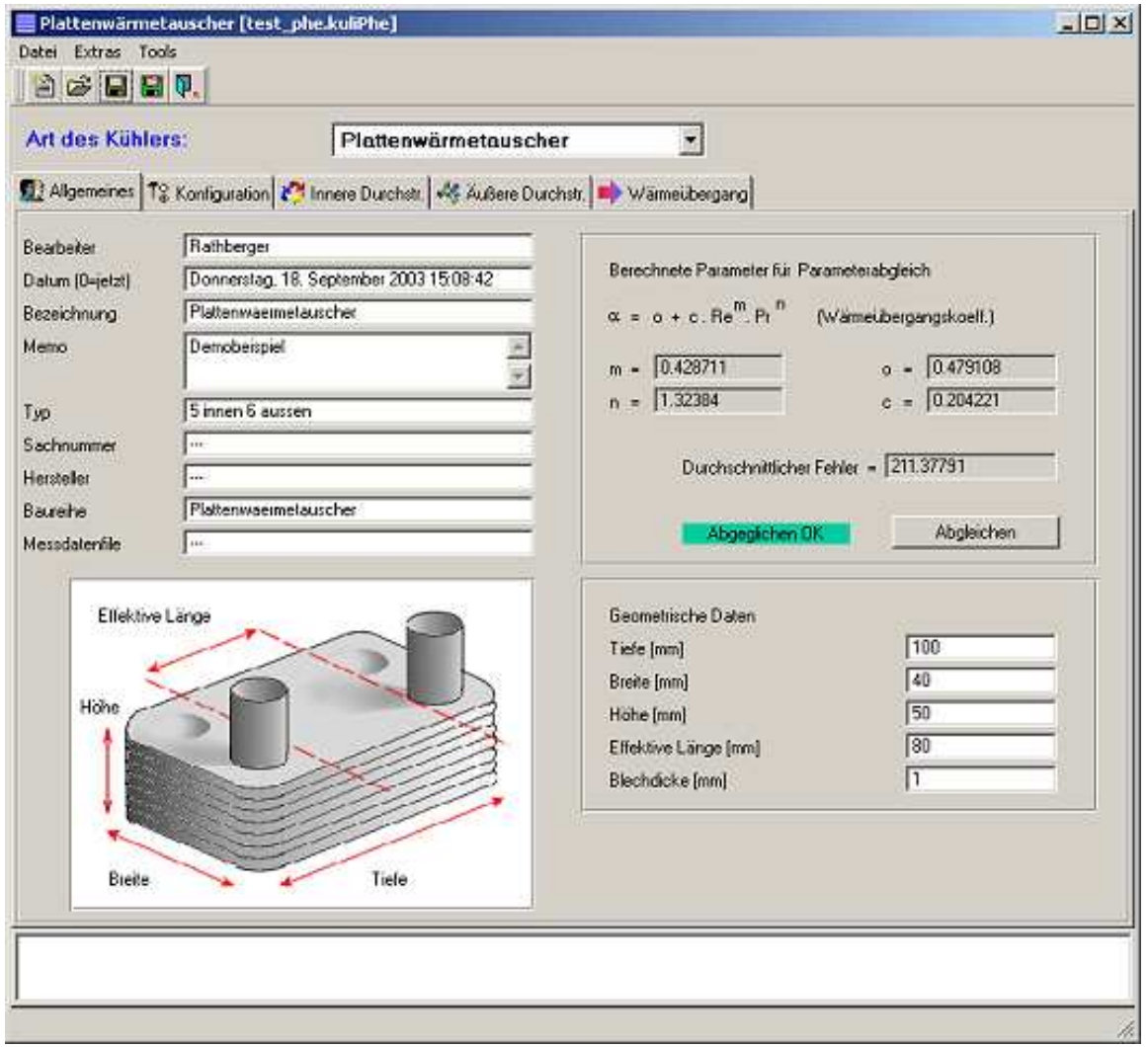
$$\text{abs.}: \quad \Delta p = cp \times \frac{\rho}{2} \times \left(v_\infty\right)^2$$

$$\text{tot.}: \quad \Delta p = \frac{\rho}{2} \times \left(cp \times v_\infty^2 - v_{inlet}^2\right)$$

Plate Heat Exchanger Modeling – Geometrical Data

The input of all geometrical data has graphical support as well.

The characteristic lines for the pressure loss are entered identically to other KULI components.



Generic components

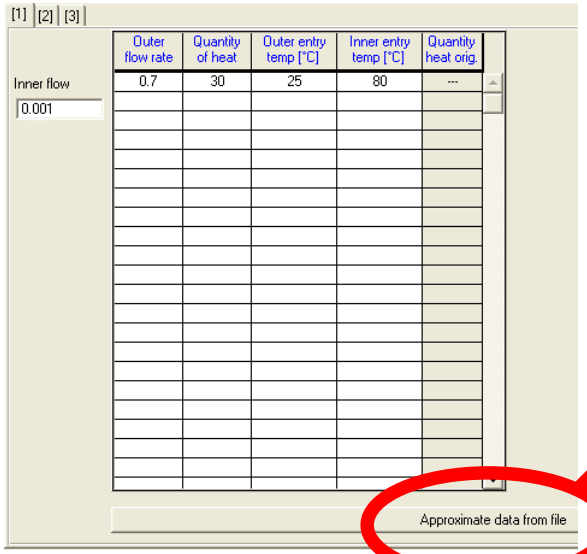
Problem: Lack of data

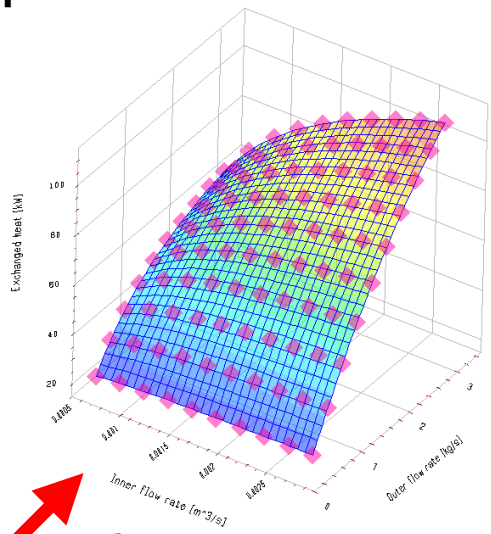
Solution: Use data from an existing (similar) component

Example: Radiator heat transfer map

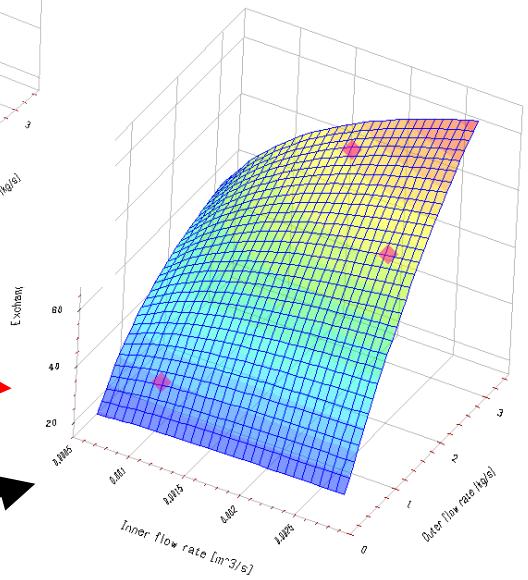
Existing component - 100 measured points

New component generated from 3 measured points





Map of existing component



Map of generated component

Regression of Fan Curves

General data | Charac. curves

Ambient medium: Air
Entry temp. of cooling air [°C]: 20
Entry press. of cooling air [hPa]: 1013
Air humidity [%]: 50

Unit of flow rate: kg/s
Unit of press.loss: N/m²
Unit of power: kW

[1] [Reg]

☑ Calculate with regressed data
☑ Use optional speed input
☑ Regression

Nominal speed [rpm]: 2500

Pressure number regression
Order: 4.
Relative filter range: 0.01
Absolute filter range: 0.01

Efficiency regression
Order: 6.
Absolute filter range: 0.01
Relative filter range: 0.01

Cycling: 6

RPM: 2500

Flow rate	Pressure drop	Power	RPM (option)
0.496	484.59	0.5486	2500
0.515	482.87	0.5546	2500
0.535	481.09	0.5569	2500
0.555	479.21	0.5566	2500
0.575	477.19	0.5546	2500
0.594	474.96	0.5514	2500
0.614	472.51	0.5478	2500
0.634	469.79	0.544	2500
0.654	466.77	0.5405	2500
0.674	463.41	0.5373	2500
0.693	459.69	0.5347	2500
0.713	455.59	0.5327	2500
0.733	451.08	0.5313	2500
0.753	446.13	0.5305	2500
0.773	440.73	0.5304	2500

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KULI 6.0 advanced

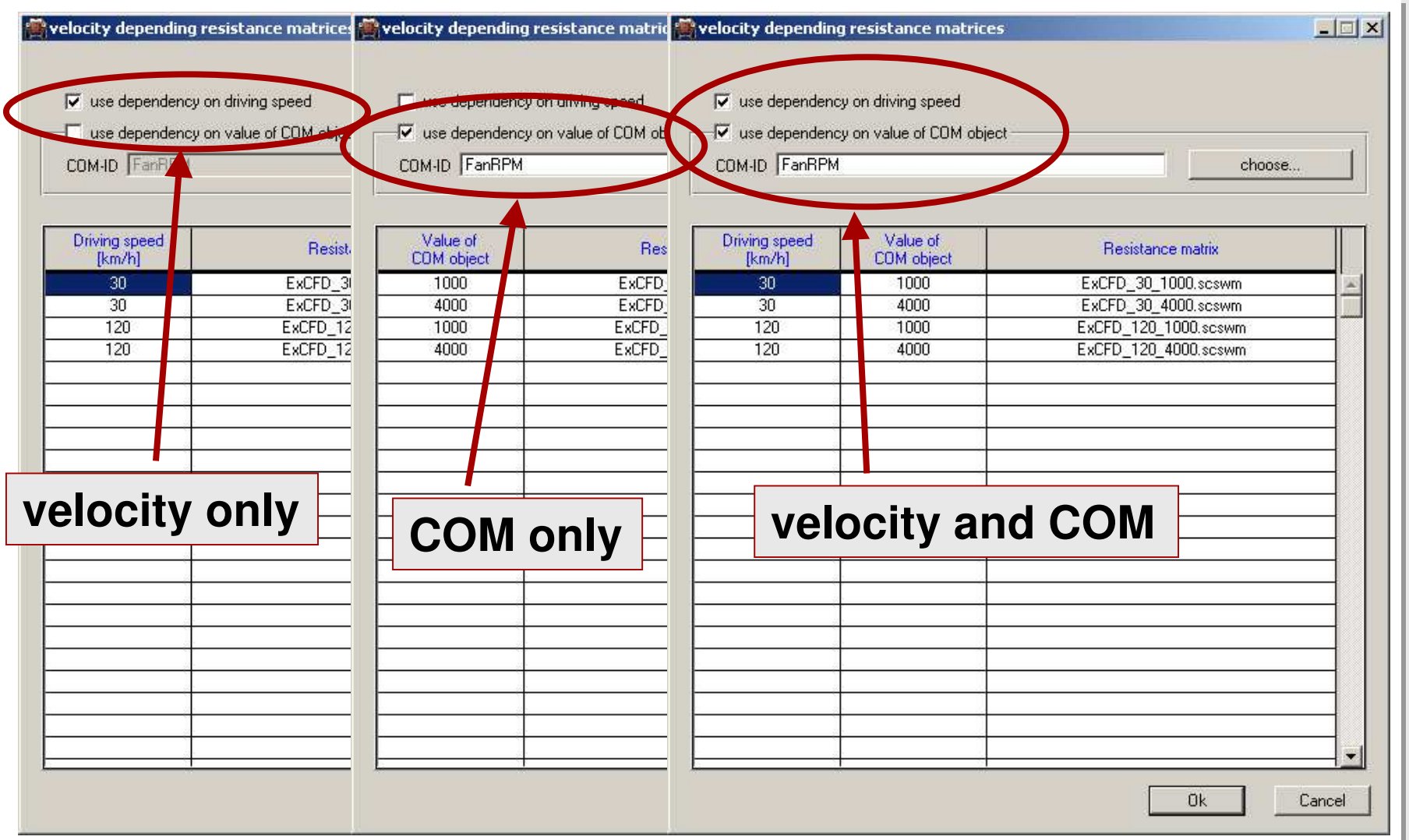
KULI cfd

- Interactive CFD-interface
- Variable resistance matrix
- Import 2d-curve (m-profile) to generate the velocity field of a fan

KULI optimize

- Generate system resistance curve
- Automatic concept studies
- Optimization for more operating points

Variable Resistance Matrix - Dependence on…



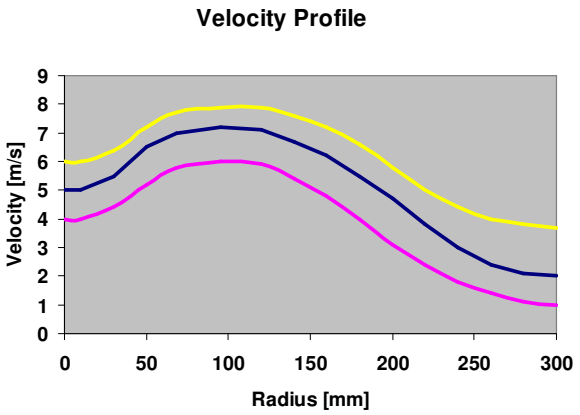
Example: Variable resistance matrix - 2d-velocity curve

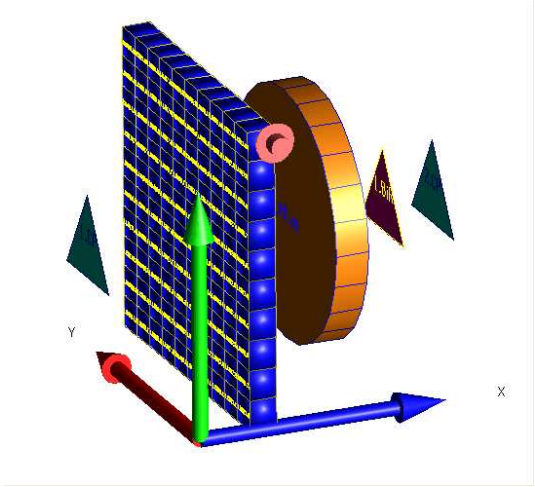
2D characteristic curves (Velocity versus Radius)

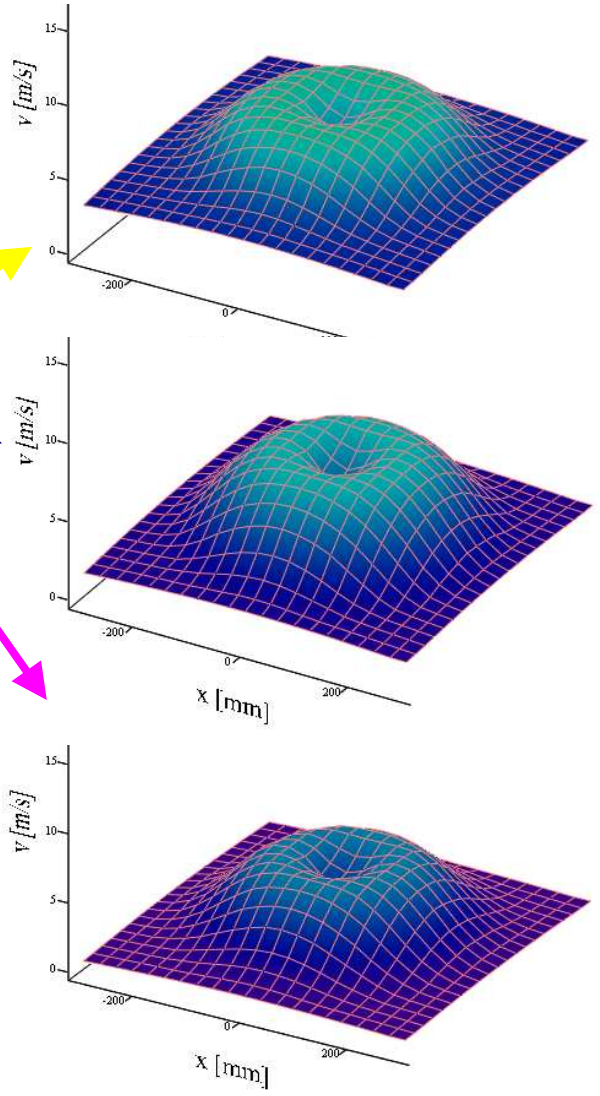
Rotational symmetric velocity profile

Link to operation speed

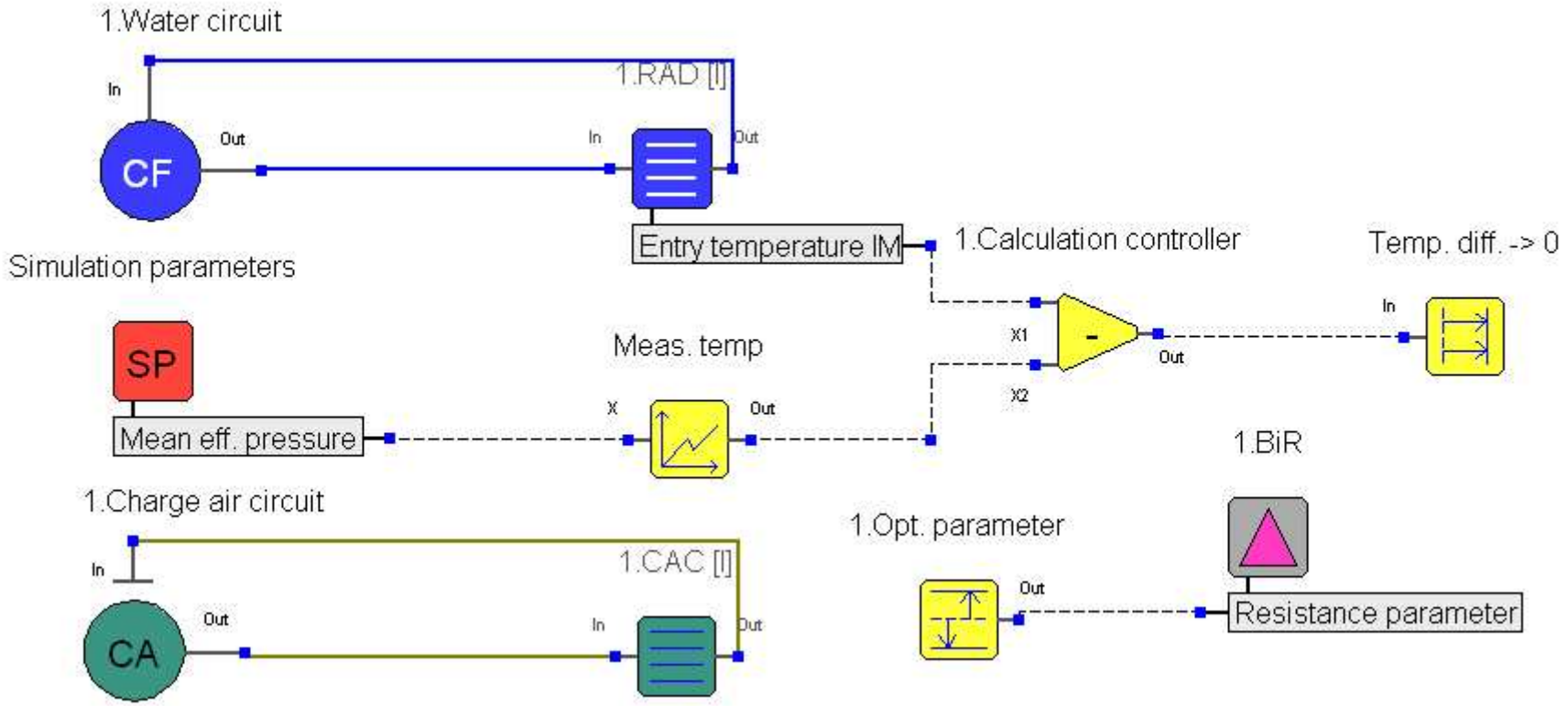
Interpolation between profiles



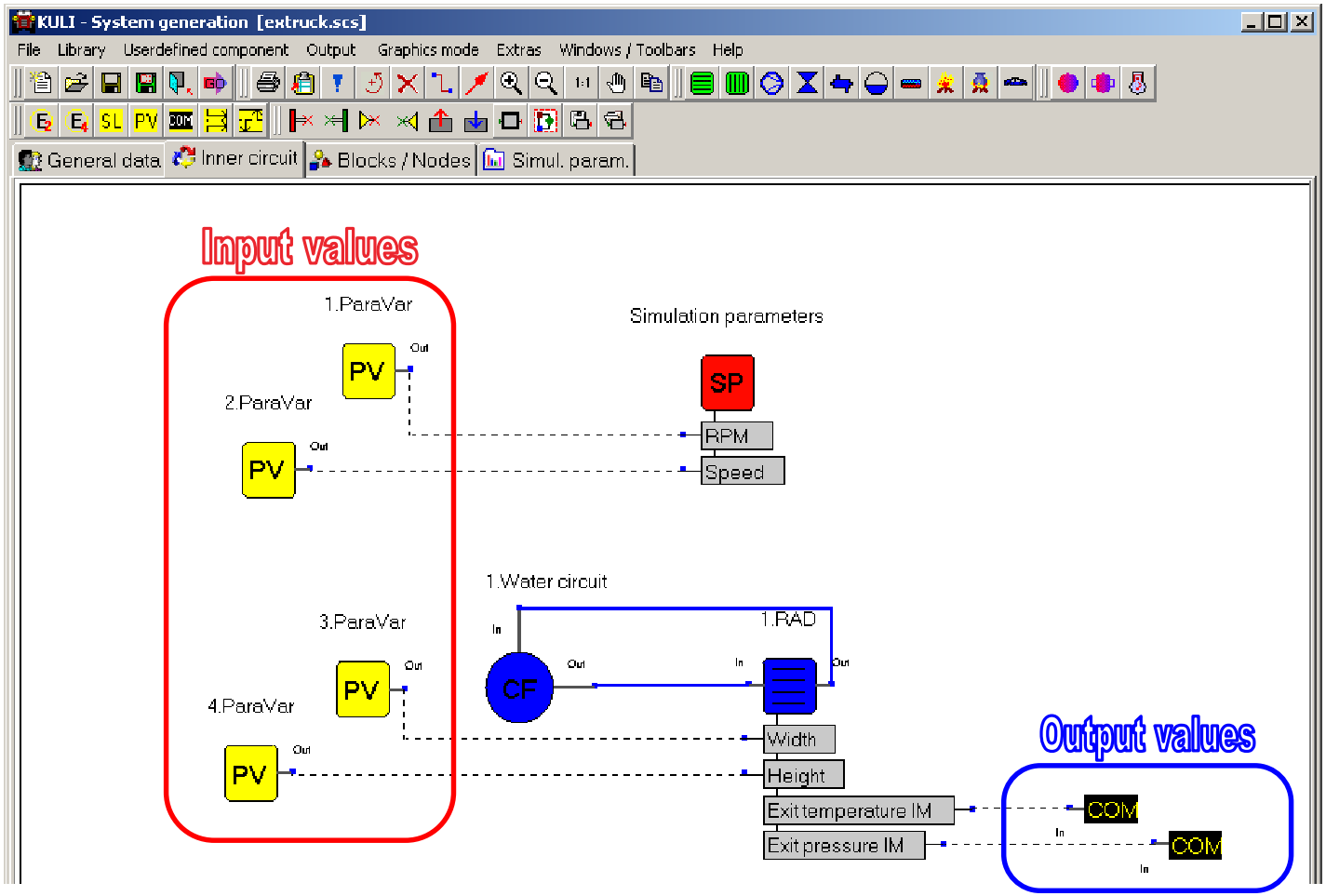




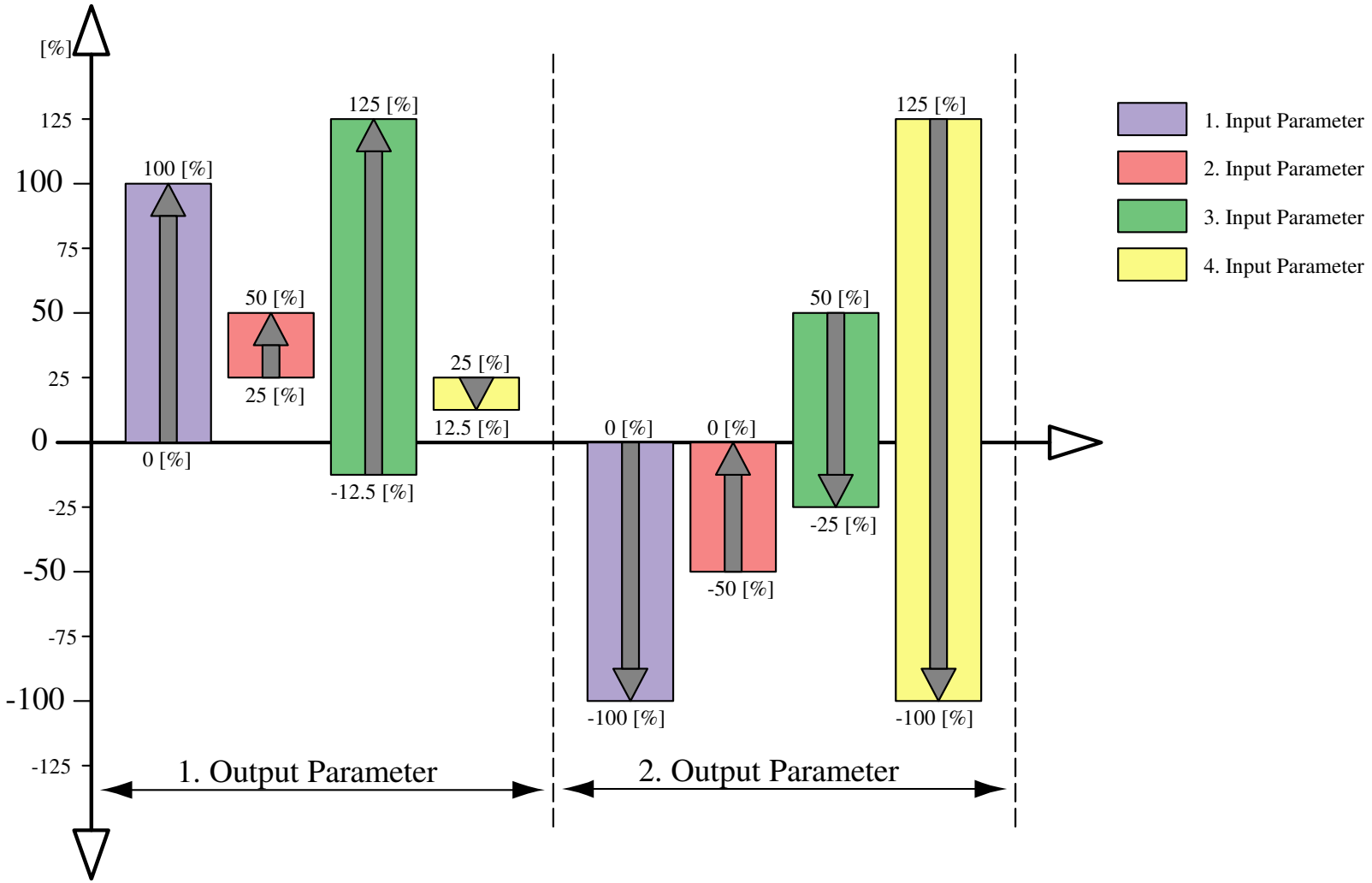
Optimization for more Operating Points



Model for Influences/Effects Analysis



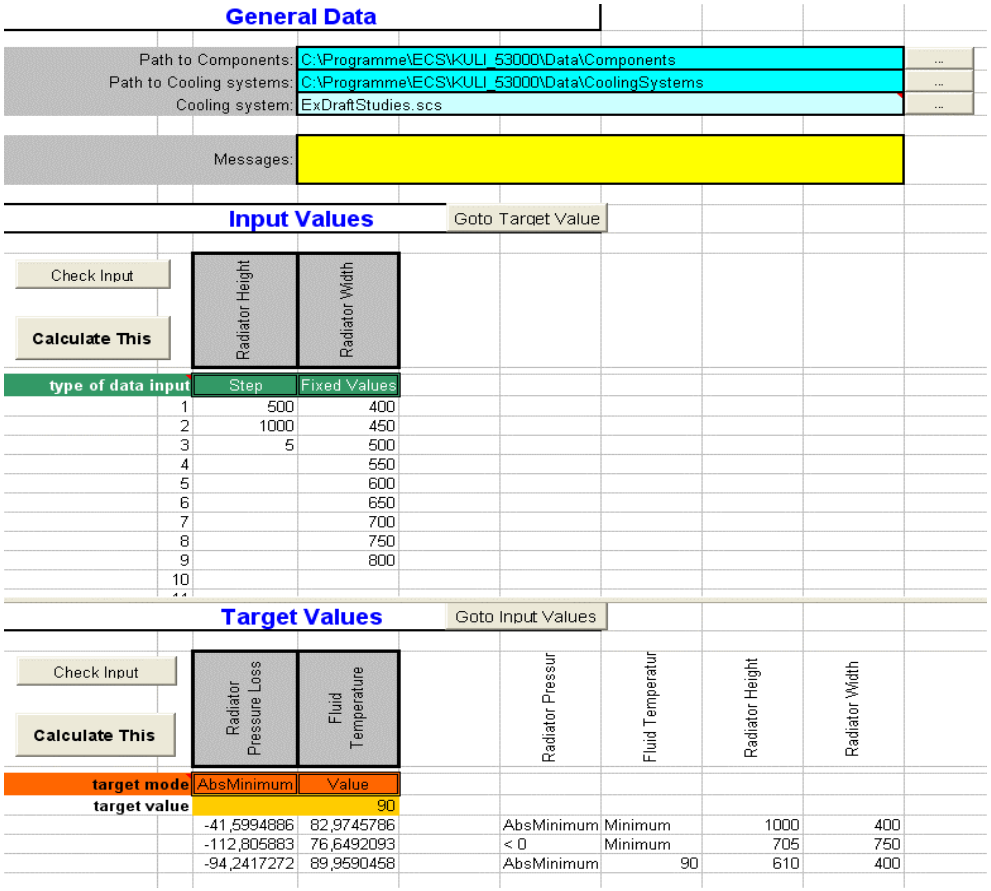
Result: Diagram



Automatic Concept Studies - Features

- Dialog-based specification of parameters, components, configurations among which KULI can choose
- Specification of the target criteria
- Implementation of an optimization method that reduces the necessary computation of variants to a reasonable number
- Representation of how closely the target criteria are matched depending on the input parameters

The Draft Studies Interface



General Data

Path to Components:	C:\Programme\ECS\KULI_53000\Data\Components
Path to Cooling systems:	C:\Programme\ECS\KULI_53000\Data\CoolingSystems
Cooling system:	ExDraftStudies.scs
Messages:	

Input Values — Goto Target Value

Check Input — Calculate This

type of data input	Step	Fixed Values (Radiator Height)	Radiator Width
1	500	400	
2	1000	450	
3	5	500	
4		550	
5		600	
6		650	
7		700	
8		750	
9		800	
10			

Target Values — Goto Input Values

Check Input — Calculate This

target mode	AbsMinimum	Value (Radiator Pressure Loss)	Fluid Temperature	Radiator Pressur	Fluid Temperatur	Radiator Height	Radiator Width
target value		90					
		-41,5994886	82,9745786	AbsMinimum	Minimum	1000	400
		-112,805883	76,6492093	< 0	Minimum	705	750
		-94,2417272	89,9590458	AbsMinimum	90	610	400

Parameter ranges can be defined by:

- A set of possible values
- An Interval with stepwidth
- Filenames

Possible *targets* are:

- Min or AbsMin
- Max or AbsMax
- A target value
- Smaller or larger than a limiting value

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KULI drive

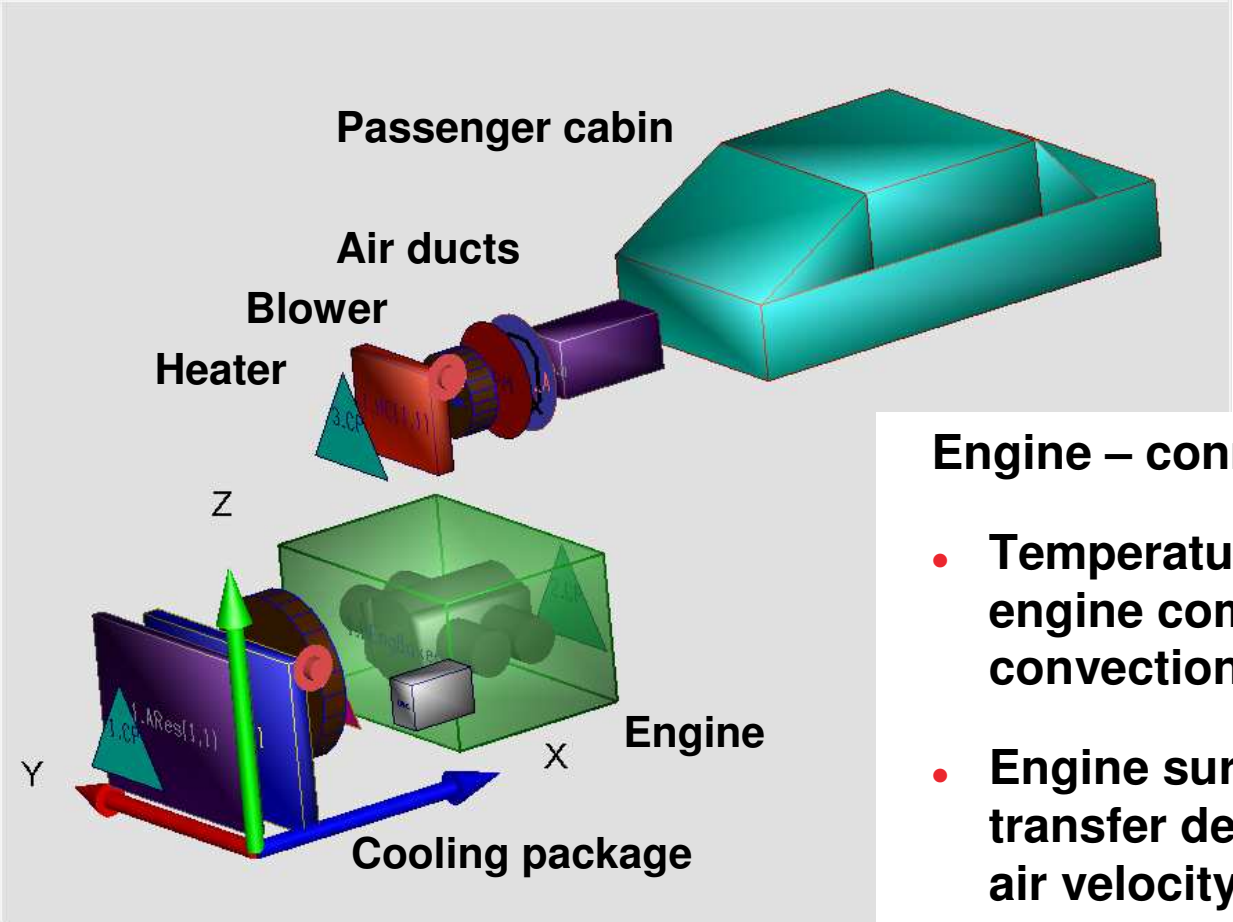
KULI transient

- Thermal network

KULI engine model

- Enhanced features for engine model

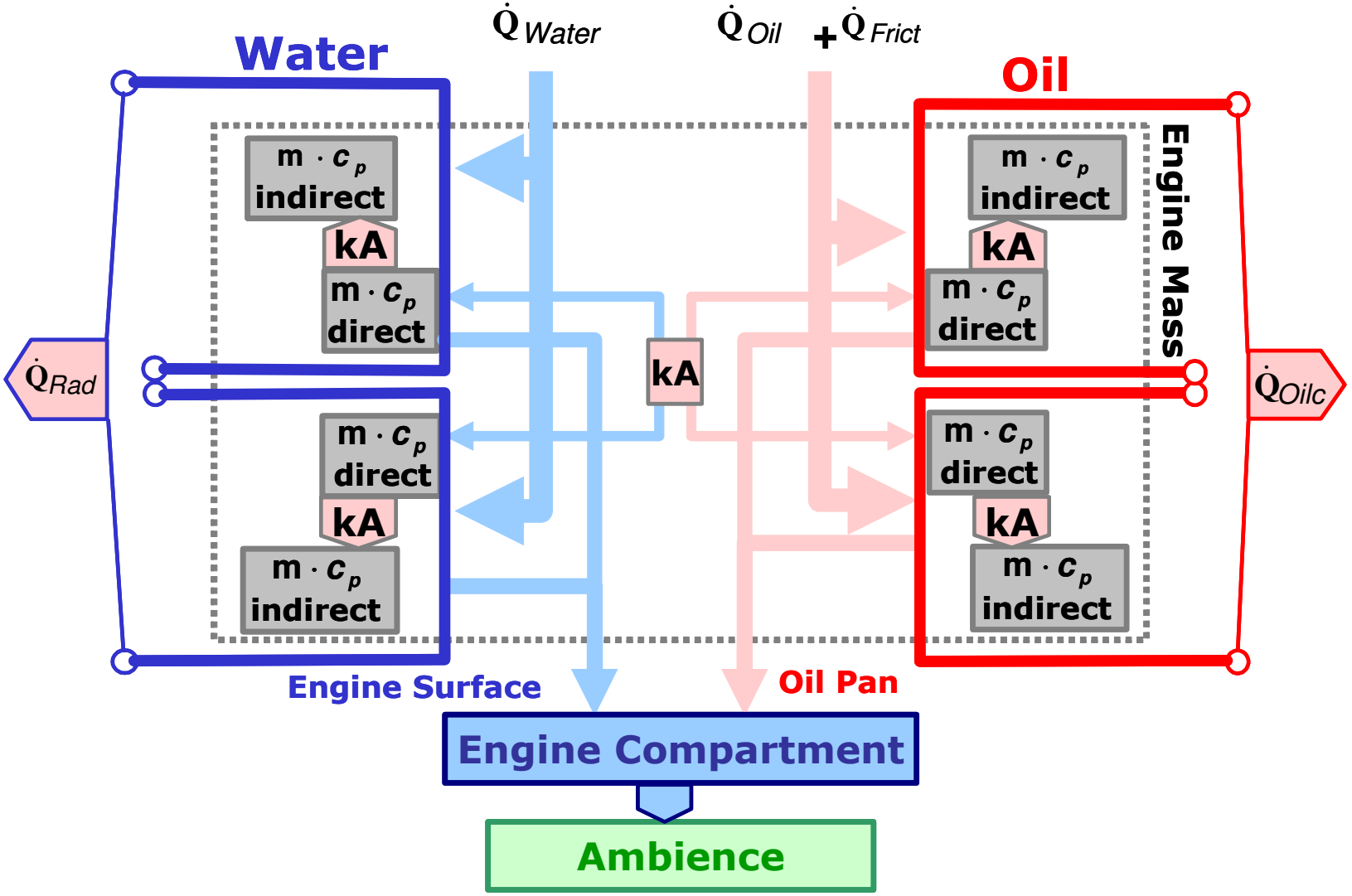
KULI Engine Model – Integration to Airpath



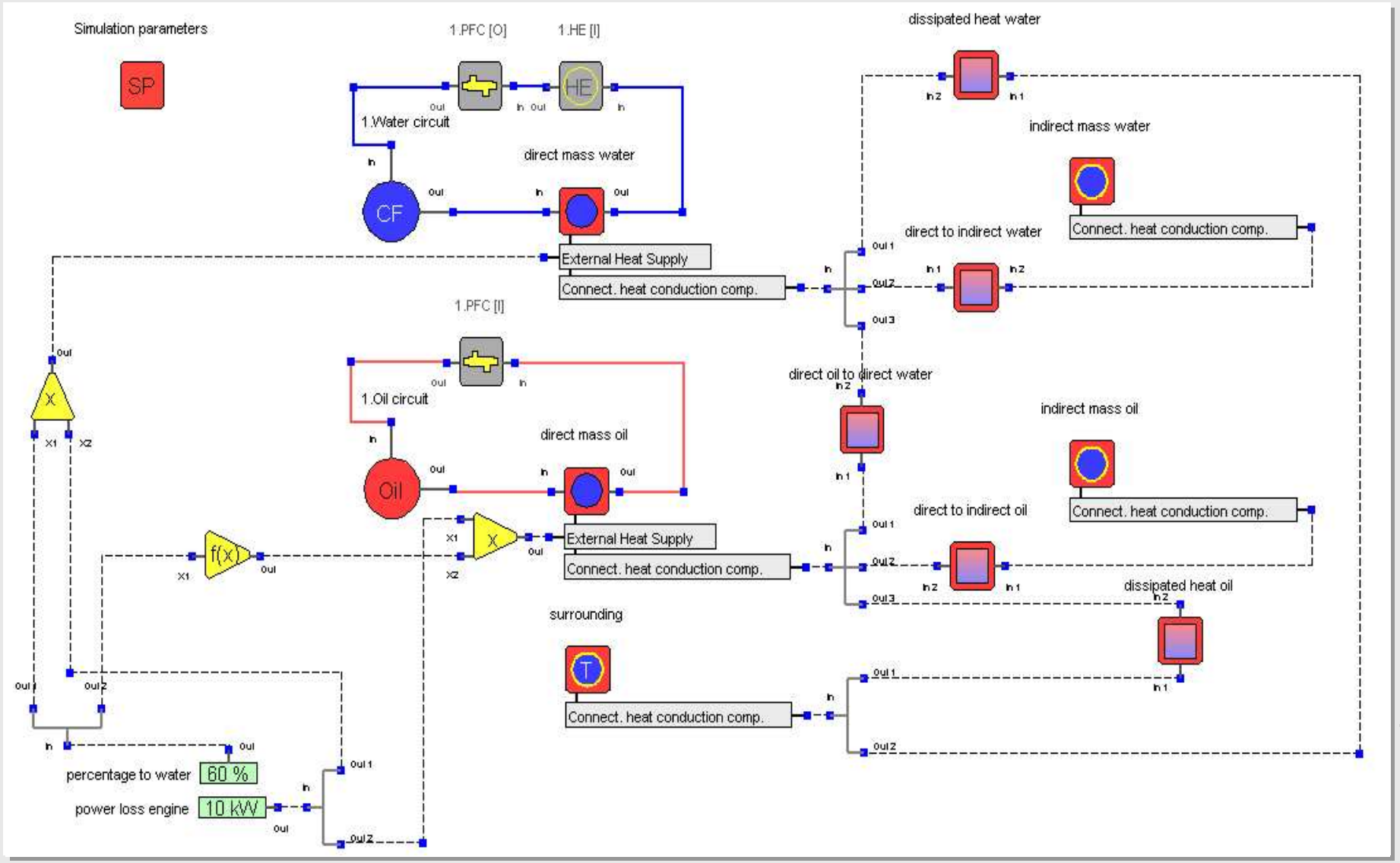
Engine – connected to air path

- **Temperature rise of air in engine compartment due to convection**
- **Engine surface and oil pan heat transfer depending on surface air velocity**

Simulation Model Engine – V-, Boxer Engine



Example: Thermal Network for Engine Model



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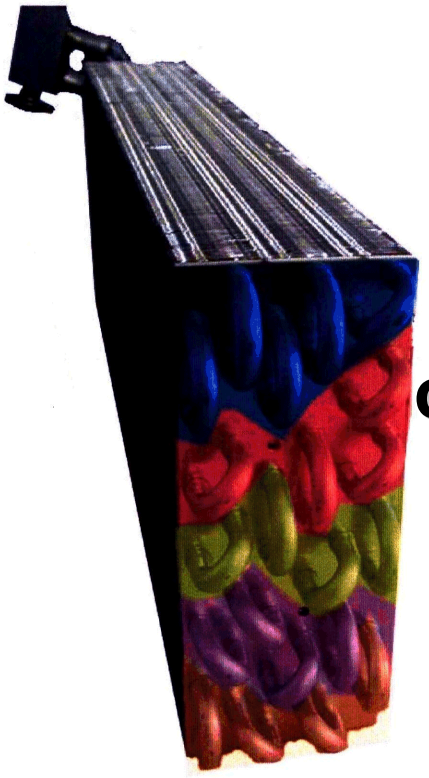
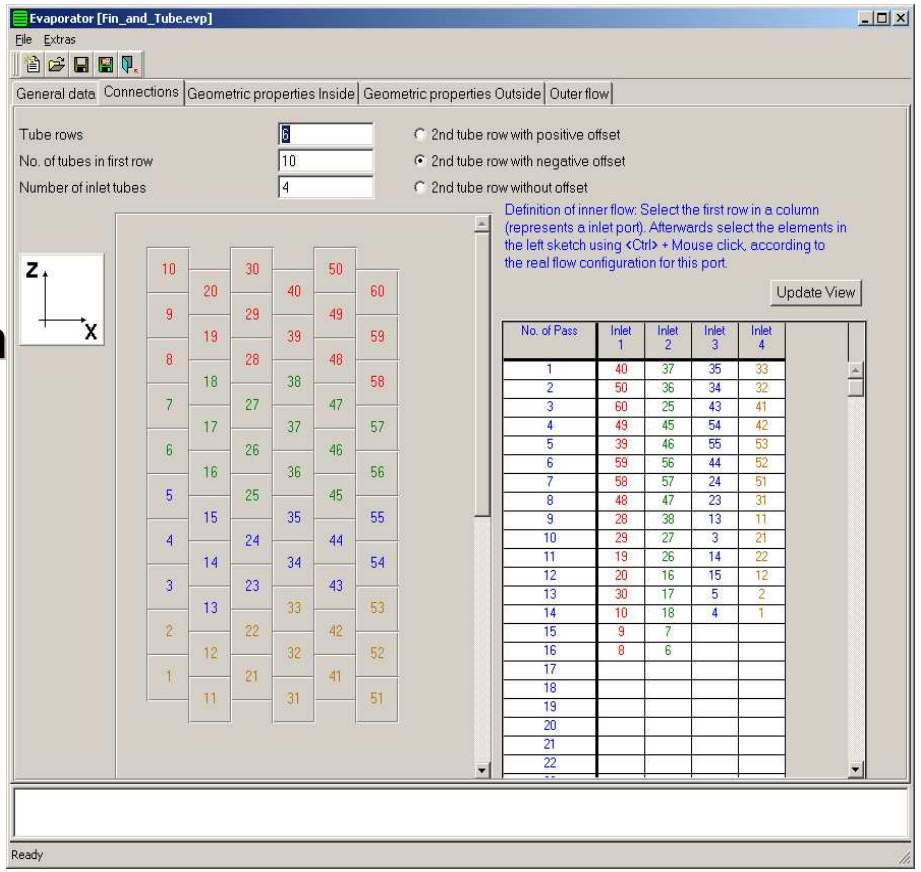
Fin and Tube Evaporator

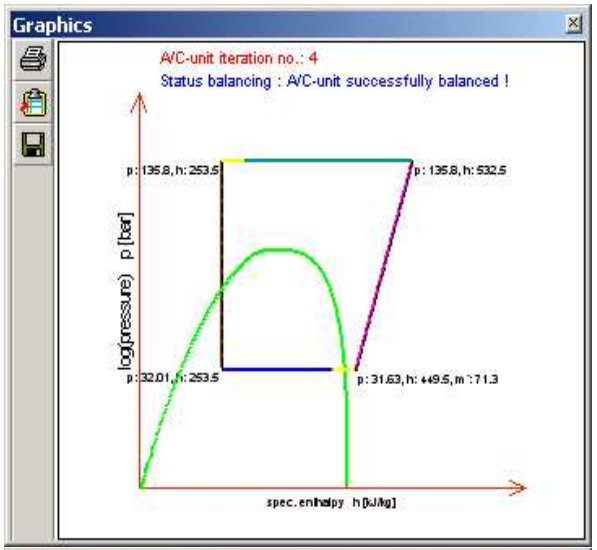


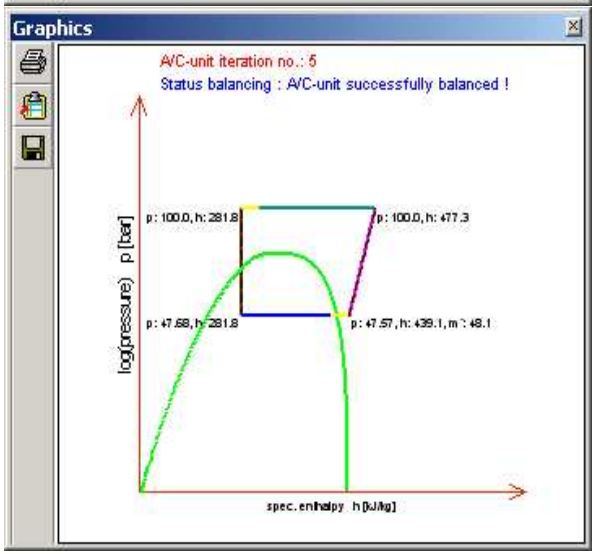
Tube Configuration Table

Simulation Model: Based on Geometric Properties



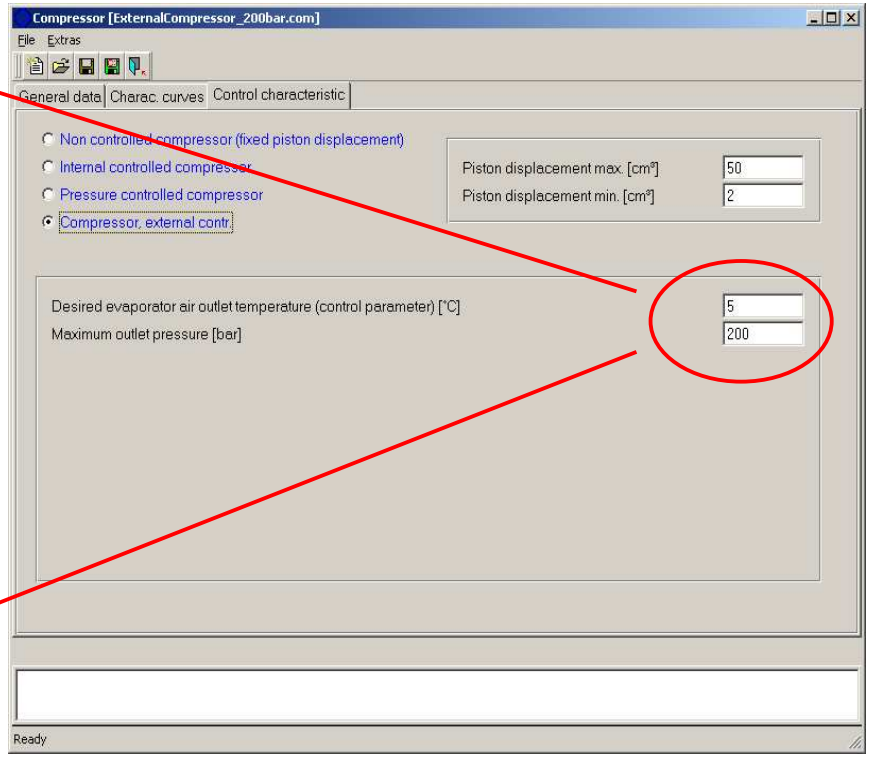
Example: External controlled compressor





Boundary: 200 bar, not achieved

Outlet Air Temperature: 5 °C, desired temp. achieved



Boundary: 100 bar, maximum achieved

Outlet Air Temperature: 16 °C, desired temp. missed

Thank you for your attention!

ENGINEERING CENTER STEYR GmbH & Co KG

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