

New Features in KULI



**ENGINEERING CENTER STEYR
GmbH & Co KG**

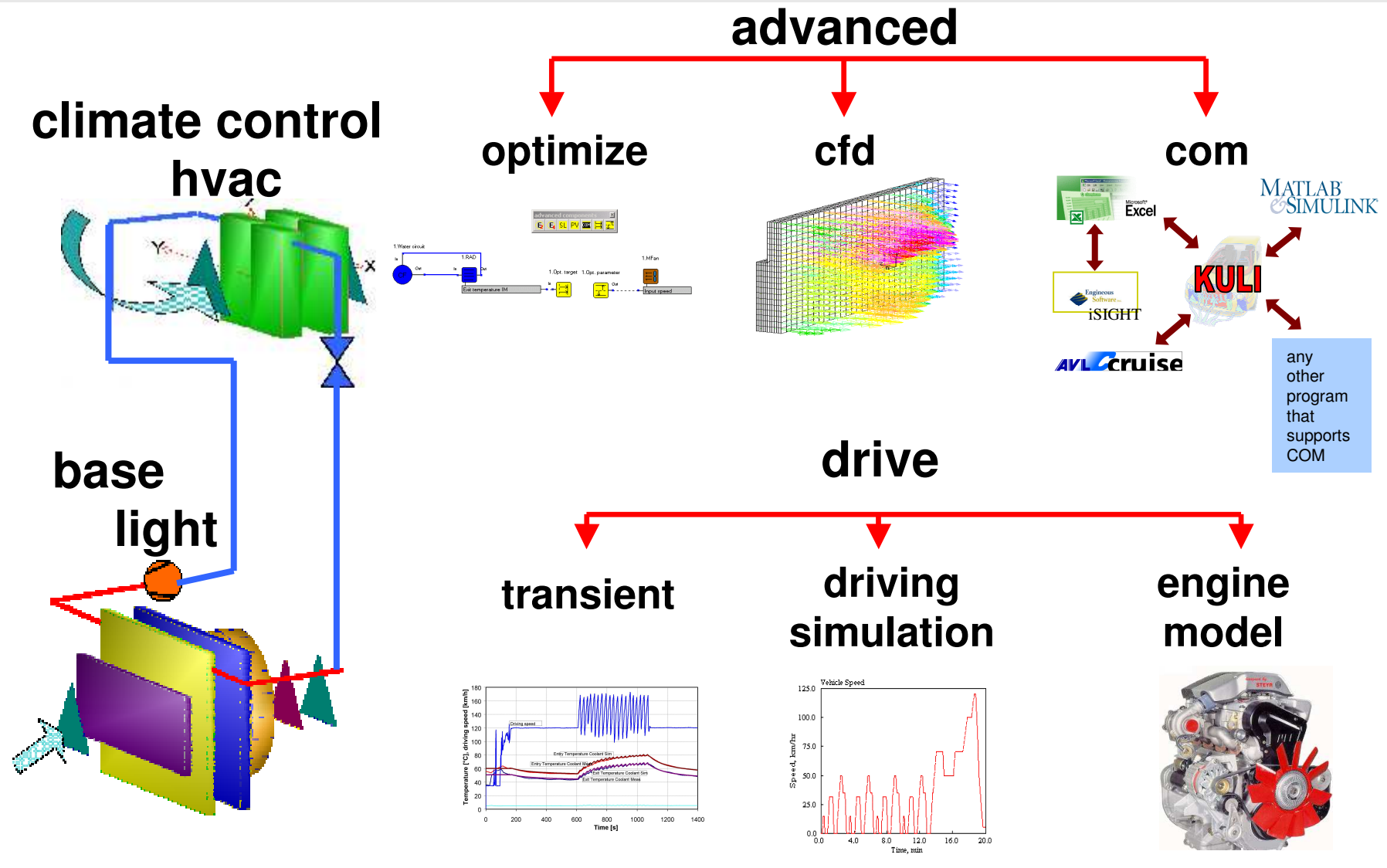
Josef Hager

www.magnasteyr.com

Contents

- **KULI 6.0 New Module Structure**
- **KULI base – Enhancements**
- **KULI advanced – Enhancements**
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KULI Modules



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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

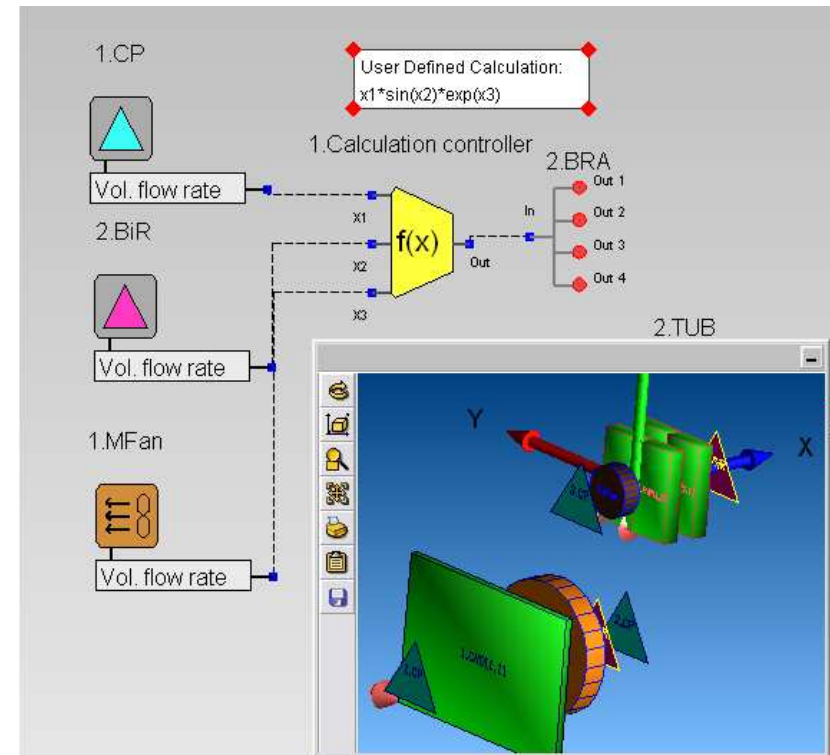
- **Plate heat exchanger**
- **Inlet grid**
- **New options for cp value**
- **Enhancements at transition**
- **Online tutorial**

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

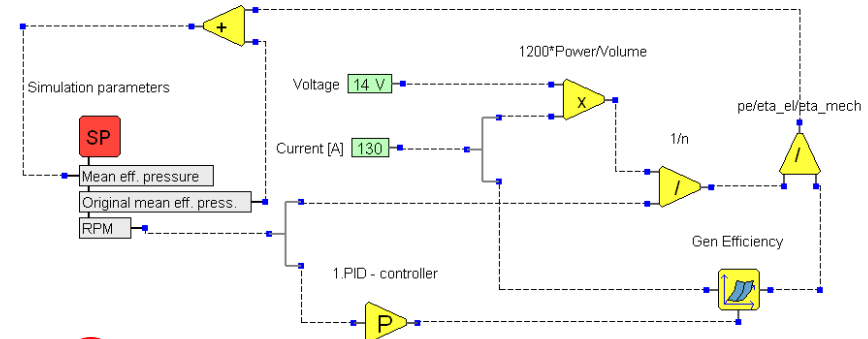
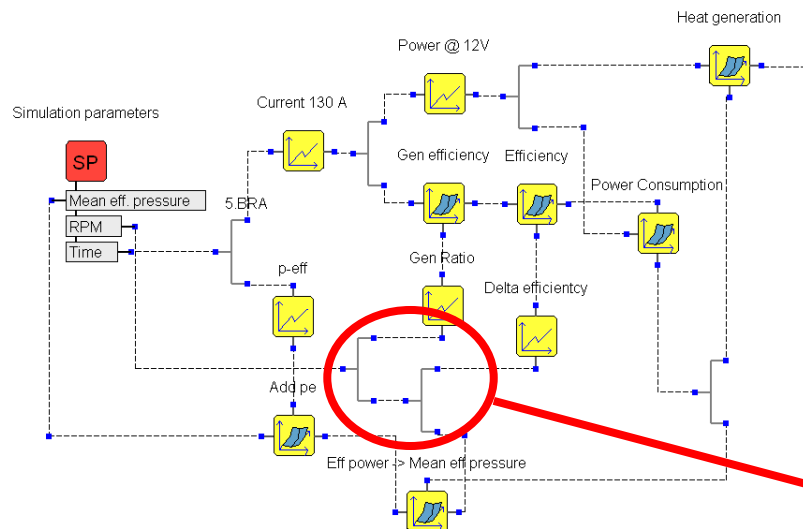


Example – 2d Modeling Object

KULI 5



KULI 6



**Simplified modeling due to
enhanced 2d features**

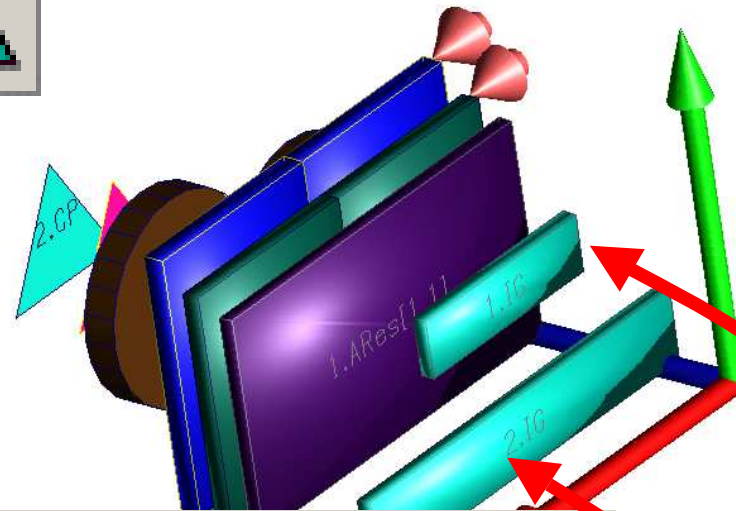
New options for cp value

Absolute Method

Static pressure independent of flow through cooling package

Total Pressure Method

Static + dynamic pressure = constant (at air entry)



Determination of pressure difference

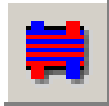
- ☒ Relative Method
Measurement: closed; Analysis: open
- ☐ Absolute Method
Measurement: open or Values from CFD; Analysis: open
- ☐ Total Pressure Method
Measurement: closed; Analysis: open

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

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

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

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.

Plattenwärmetauscher [test_phe.kuliPhe]

Datei Extras Tools

Art des Kühlers: Plattenwärmetauscher

Allgemeines Konfiguration Innere Durchstr. Äußere Durchstr. Wärmeübergang

Bearbeiter: Rathberger
 Datum (Jetzt): Donnerstag, 18. September 2003 15:08:42
 Bezeichnung: Plattenwärmetauscher
 Memo: Demobeispiel
 Typ: 5 innen 6 aussen
 Sachnummer: ...
 Hersteller: ...
 Baureihe: Plattenwärmetauscher
 Messdatenfile: ...

Berechnete Parameter für Parameterabgleich

$$\alpha = a + c \cdot Re^m \cdot Pr^n \quad (\text{Wärmeübergangskoeff.})$$

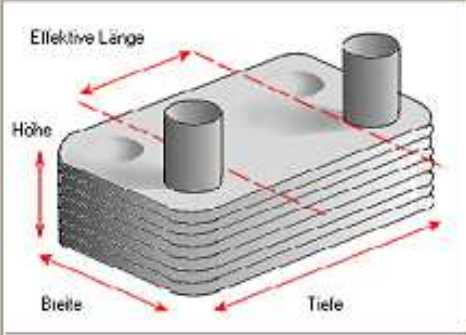
m = 0.428711 a = 0.479108
 n = 1.32384 c = 0.204221

Durchschnittlicher Fehler = 211.37791

Abgeglichen OK Abgleichen

Geometrische Daten

Tiefe [mm]: 100
 Breite [mm]: 40
 Höhe [mm]: 50
 Effektive Länge [mm]: 80
 Blechdicke [mm]: 1



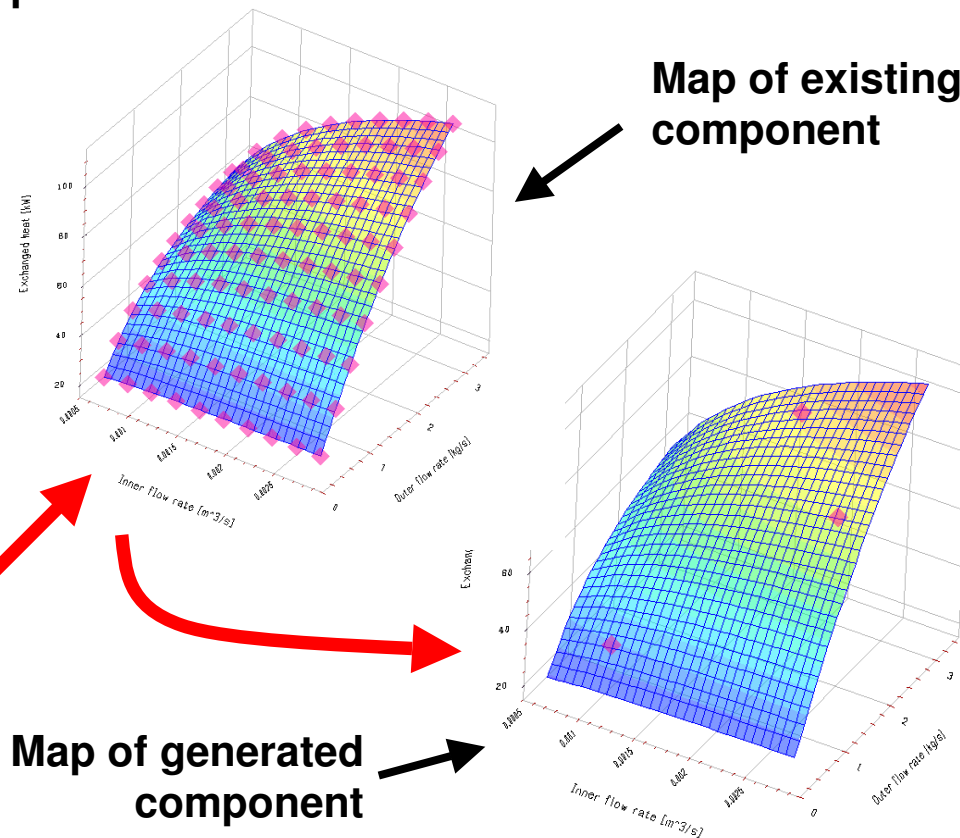
Generic components

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

[illegible]

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

☒ 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

[1] [Reg]

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

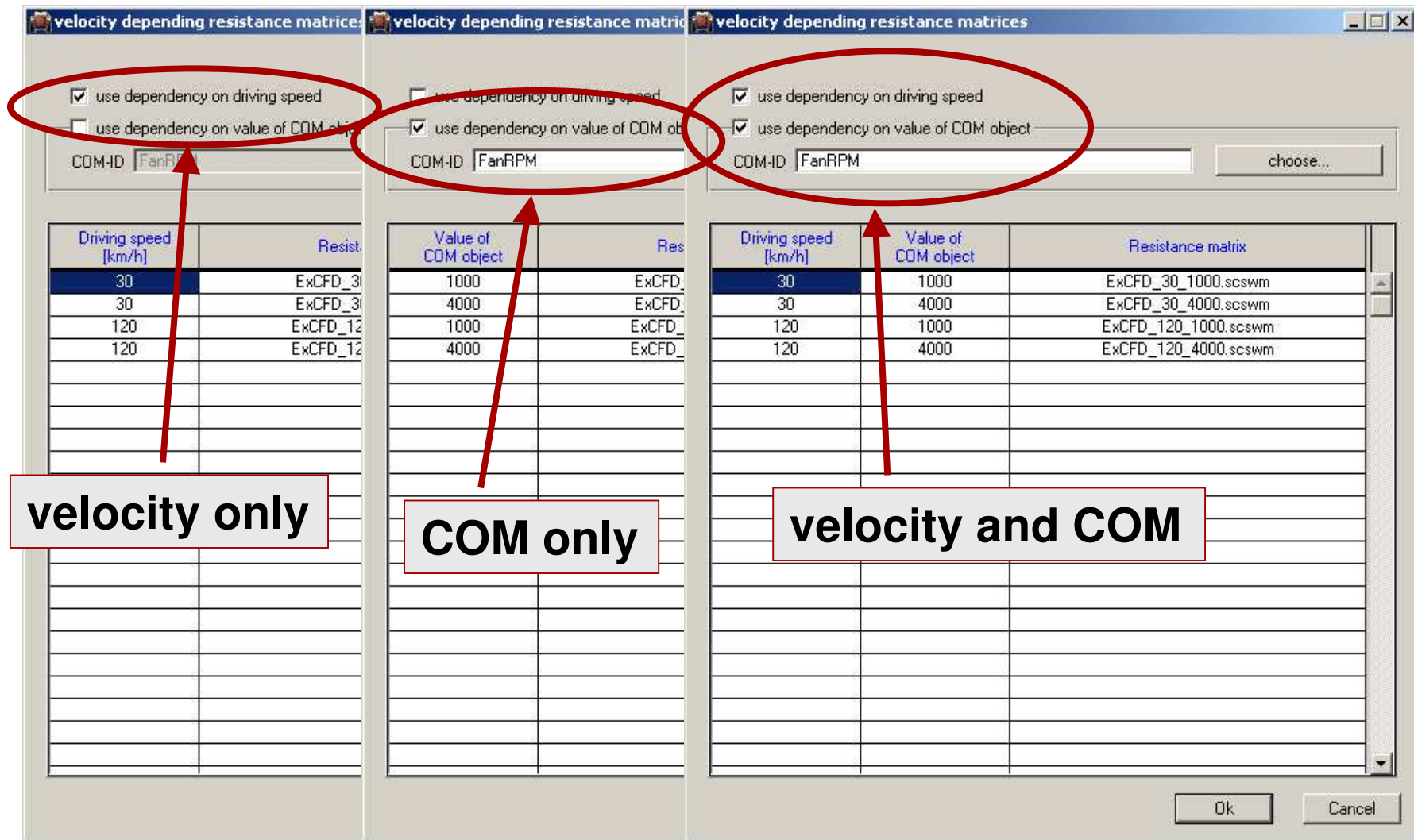
KULI cfd

- **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...



The image displays three screenshots of the 'velocity depending resistance matrices' dialog box, illustrating different dependency settings for the resistance matrix. Red circles and arrows highlight the specific settings and the resulting data tables.

velocity only

Settings: ☒ use dependency on driving speed, ☐ use dependency on value of COM object. COM-ID: FanRPM.

Driving speed [km/h]	Resistance matrix
30	ExCFD_30
30	ExCFD_30
120	ExCFD_120
120	ExCFD_120

COM only

Settings: ☐ use dependency on driving speed, ☒ use dependency on value of COM object. COM-ID: FanRPM.

Value of COM object	Resistance matrix
1000	ExCFD_1000
4000	ExCFD_4000
1000	ExCFD_1000
4000	ExCFD_4000

velocity and COM

Settings: ☒ use dependency on driving speed, ☒ use dependency on value of COM object. COM-ID: FanRPM.

Driving speed [km/h]	Value of COM object	Resistance matrix
30	1000	ExCFD_30_1000.scswm
30	4000	ExCFD_30_4000.scswm
120	1000	ExCFD_120_1000.scswm
120	4000	ExCFD_120_4000.scswm

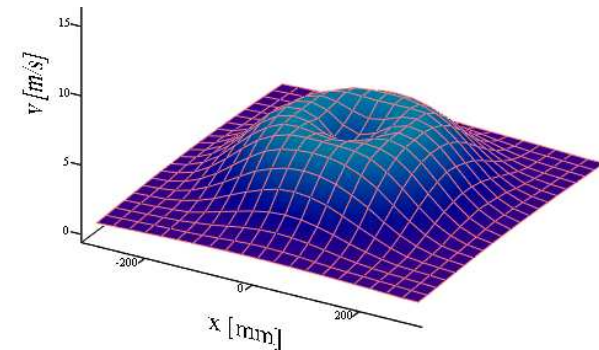
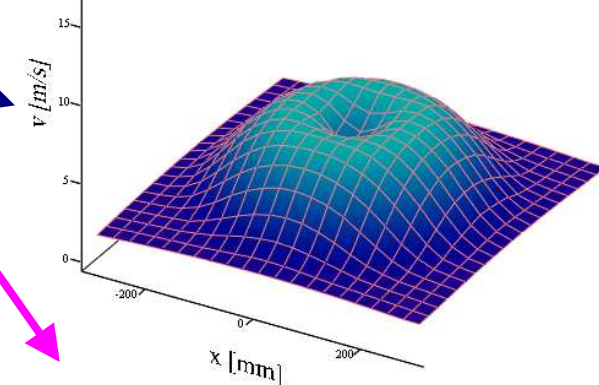
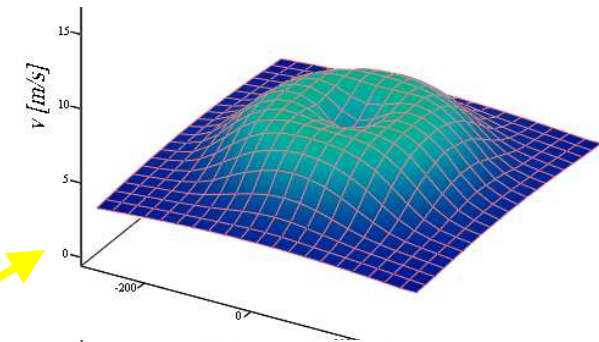
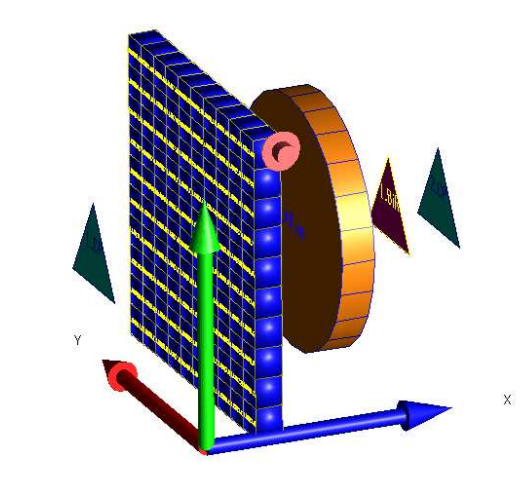
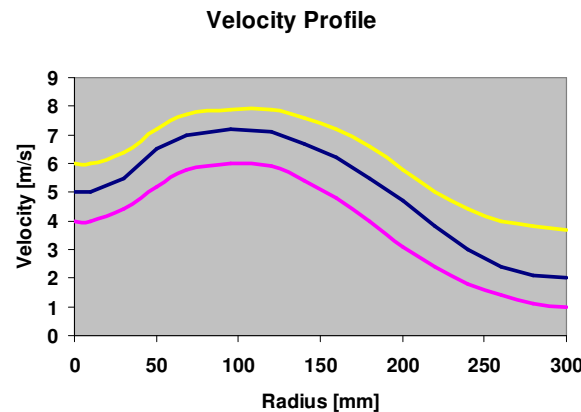
Example: Variable resistance matrix - 2d-velocity curve

2D characteristic curves (Velocity versus Radius)

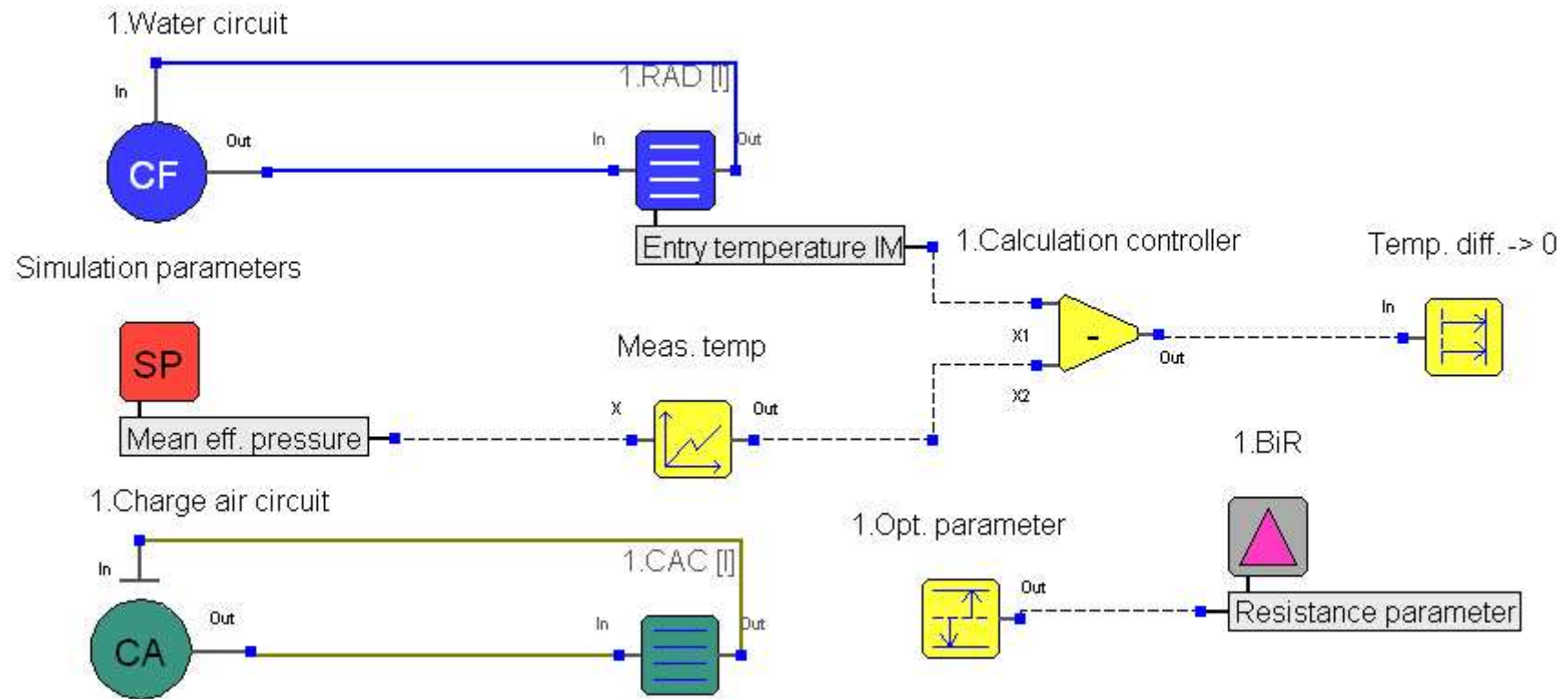
Rotational symmetric velocity profile

Link to operation speed

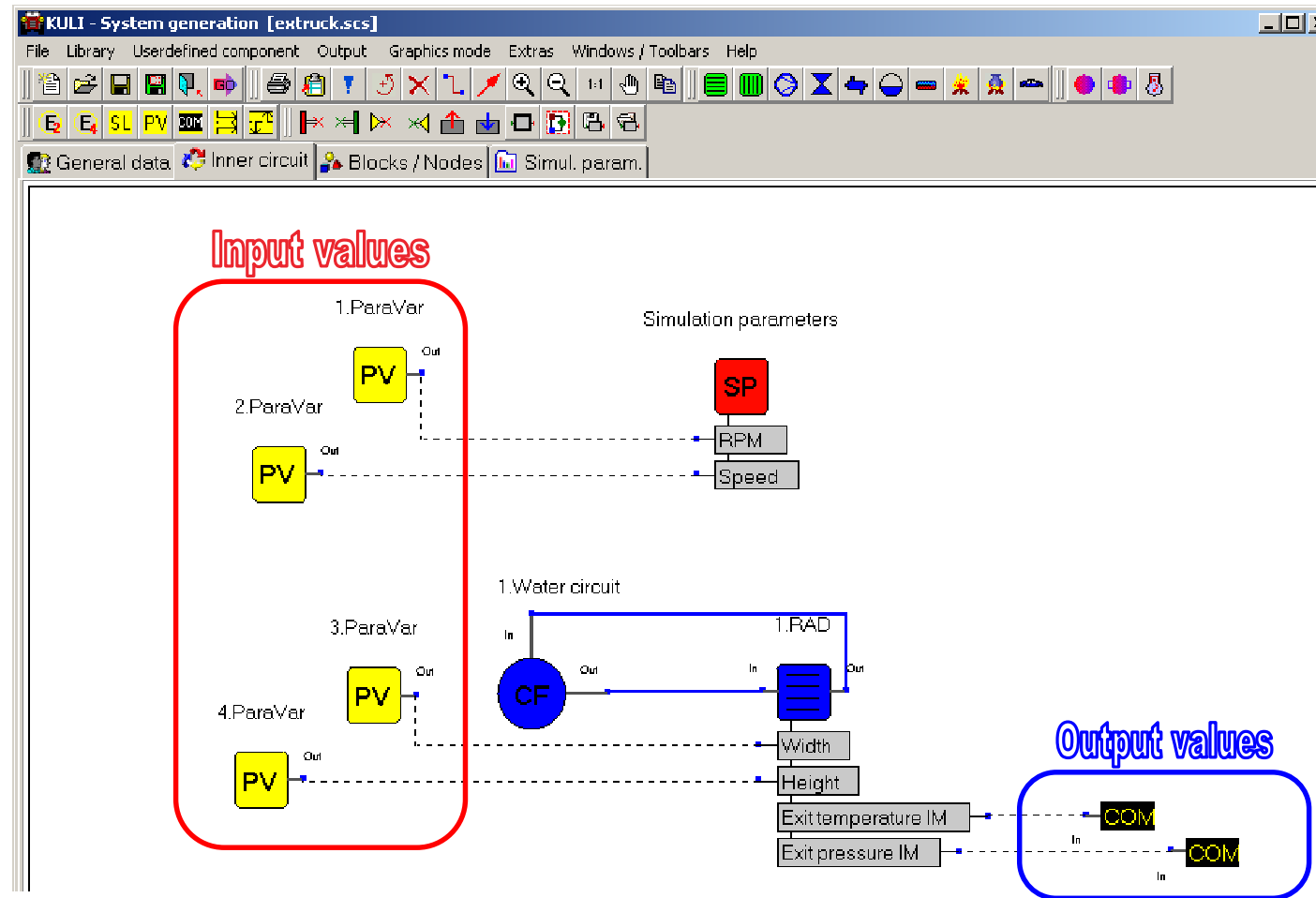
Interpolation between profiles



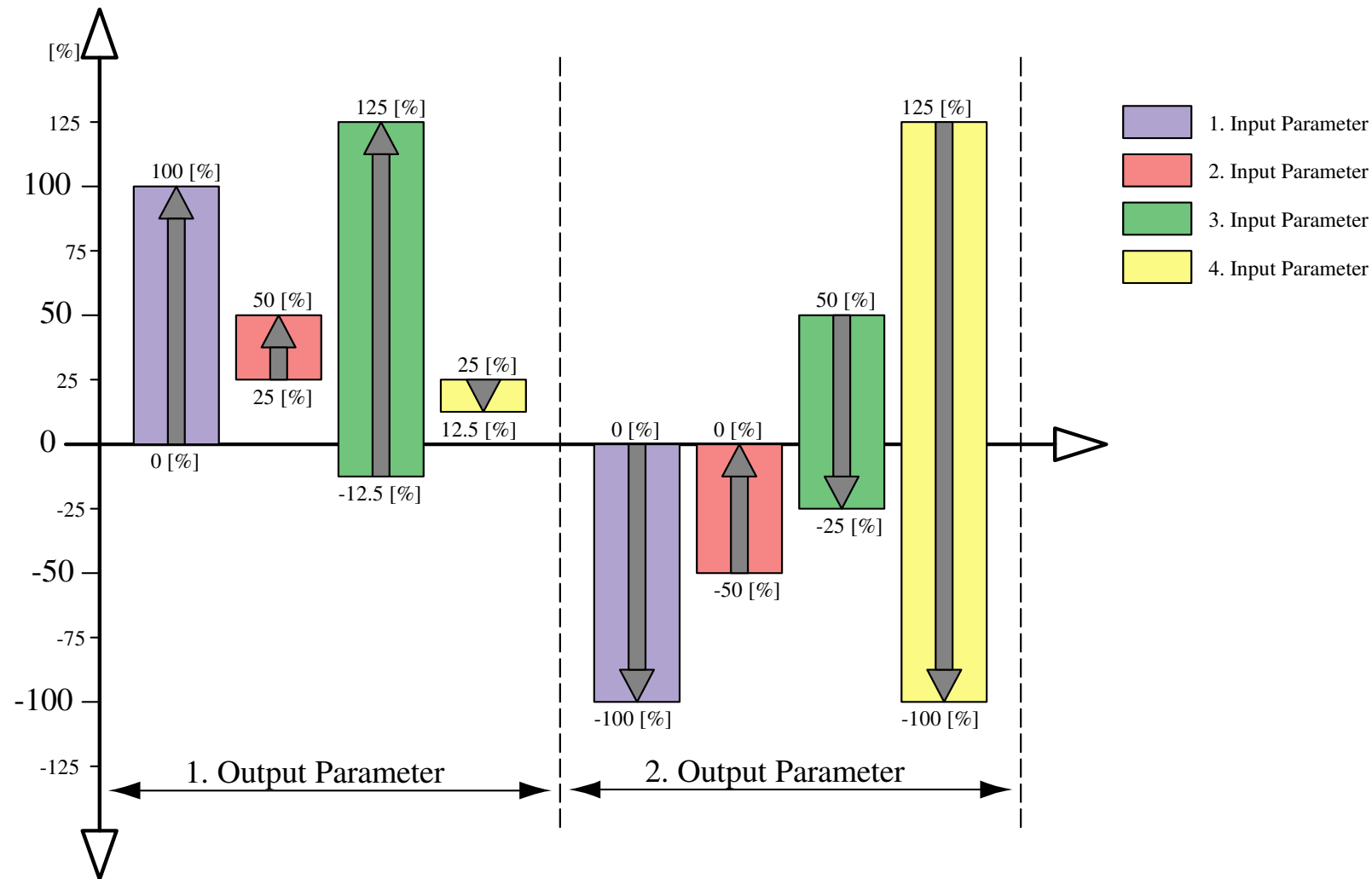
Optimization for more Operating Points



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
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	Fluid Temperature	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

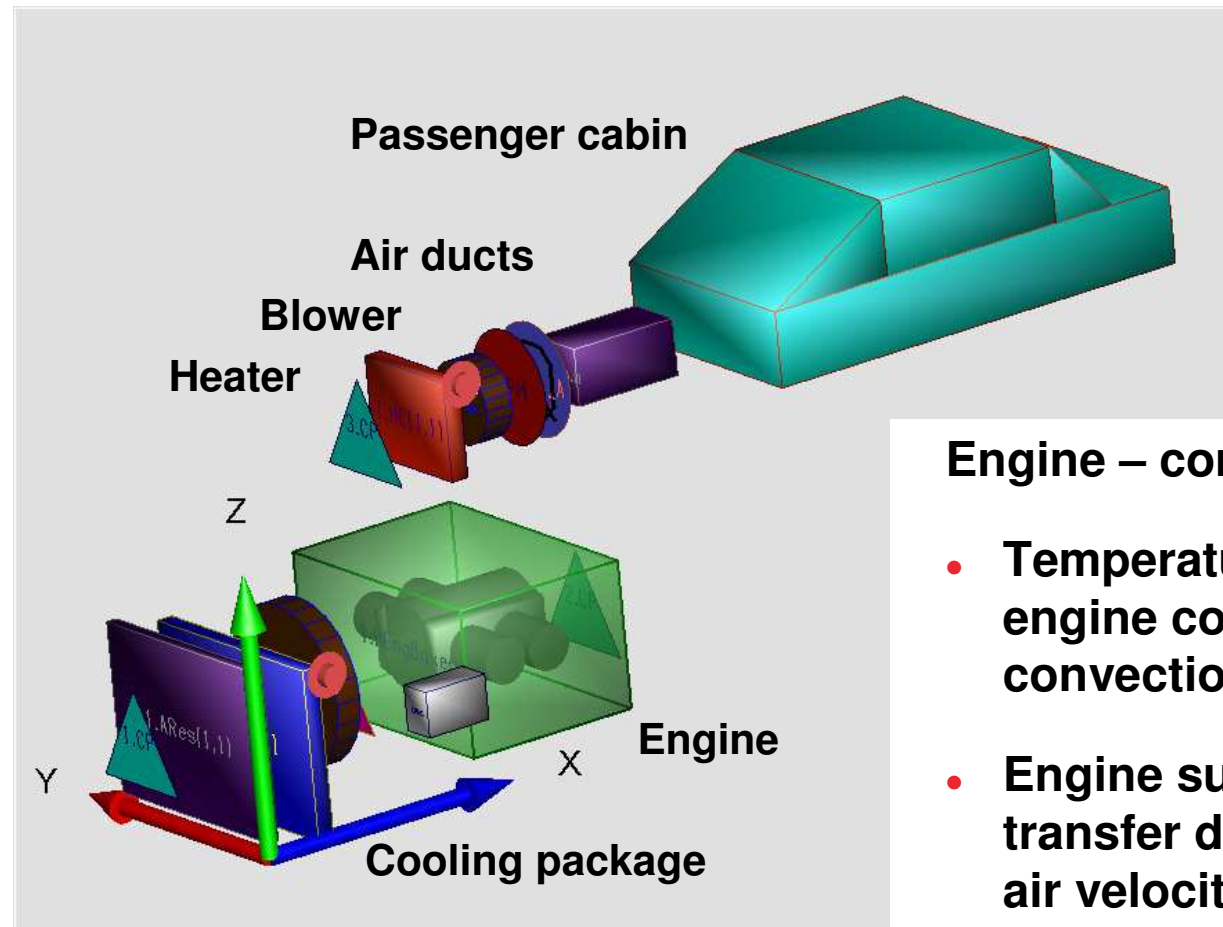
KULI transient

- Thermal network

KULI engine model

- Enhanced features for engine model

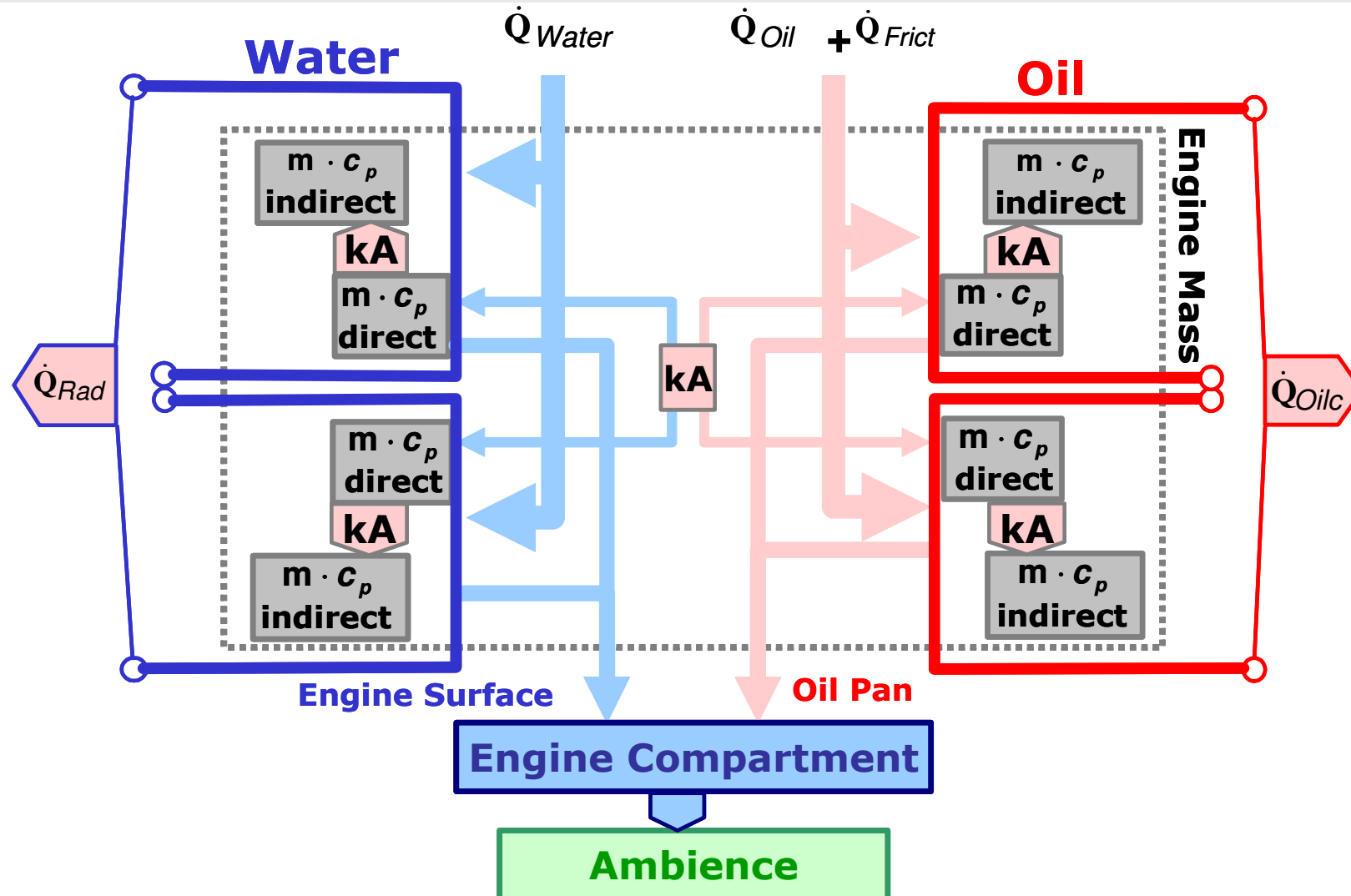
KULI Engine Model – Integration to Airpath



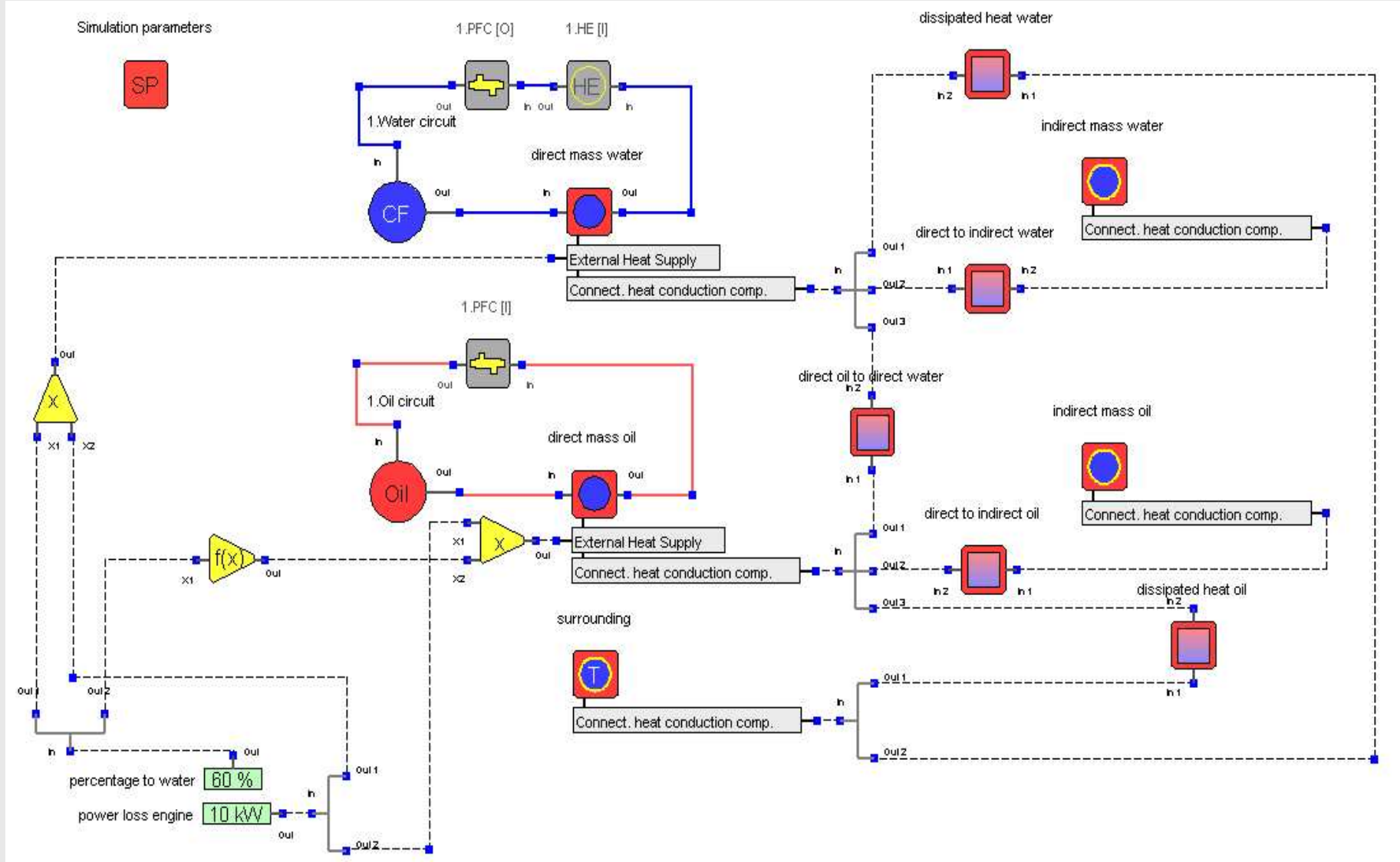
Engine – connected to air path

- 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



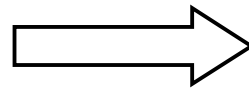
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Fin and Tube Evaporator



**Tube
Configuration
Table**



Simulation Model: Based on Geometric Properties

Evaporator [Fin_and_Tube.evp]

File Extras

General data Connections Geometric properties Inside Geometric properties Outside Outer flow

Tube rows: 6
No. of tubes in first row: 10
Number of inlet tubes: 4

☐ 2nd tube row with positive offset
☒ 2nd tube row with negative offset
☐ 2nd tube row without offset

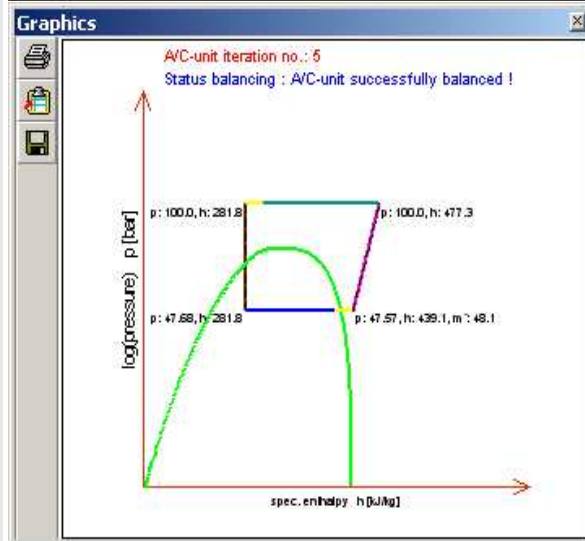
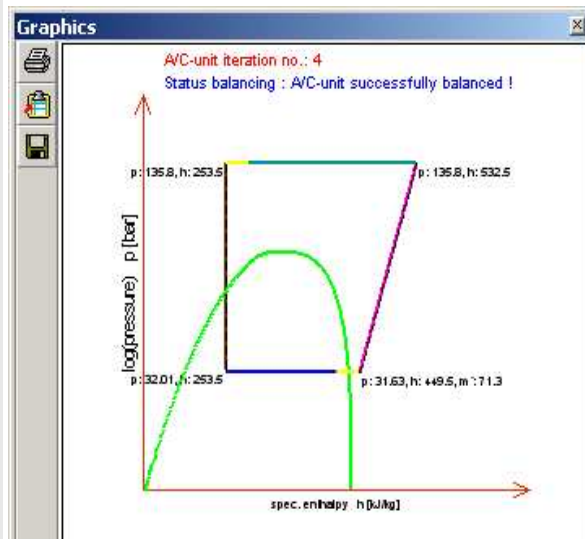
Definition of inner flow: Select the first row in a column (represents a inlet port). Afterwards select the elements in the left sketch using <Ctrl> + Mouse click, according to the real flow configuration for this port.

Update View

No. of Pass	Inlet 1	Inlet 2	Inlet 3	Inlet 4
1	40	37	35	33
2	50	36	34	32
3	60	25	43	41
4	49	45	54	42
5	39	46	55	53
6	59	56	44	52
7	58	57	24	51
8	48	47	23	31
9	28	38	13	11
10	29	27	3	21
11	19	26	14	22
12	20	16	15	12
13	30	17	5	2
14	10	18	4	1
15	9	7		
16	8	6		
17				
18				
19				
20				
21				
22				

Ready

Example: External controlled compressor



Boundary: 200 bar, not achieved

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

Compressor [ExternalCompressor_200bar.com]

File Extras

General data Charac. curves Control characteristic

☐ Non controlled compressor (fixed piston displacement)
☐ Internal controlled compressor
☐ Pressure controlled compressor
☒ Compressor, external contr.

Piston displacement max. [cm³] 50
 Piston displacement min. [cm³] 2

Desired evaporator air outlet temperature (control parameter) [°C] 5
 Maximum outlet pressure [bar] 200

Ready

Boundary: 100 bar, maximum achieved

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

Thank you for your attention!



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