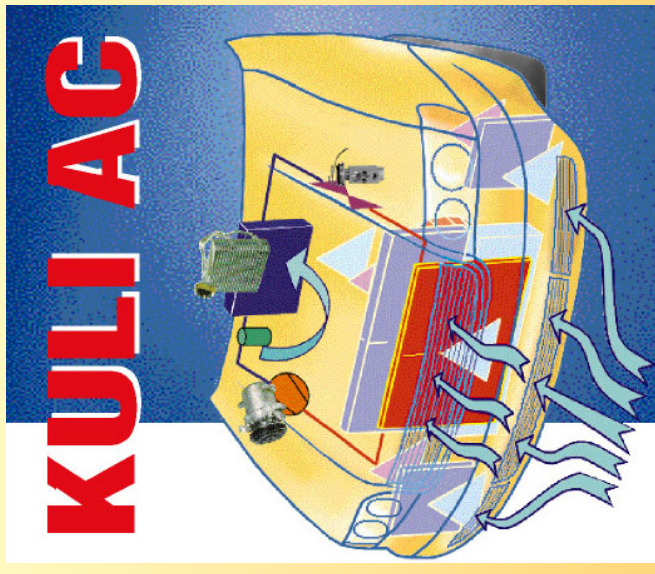


Overview

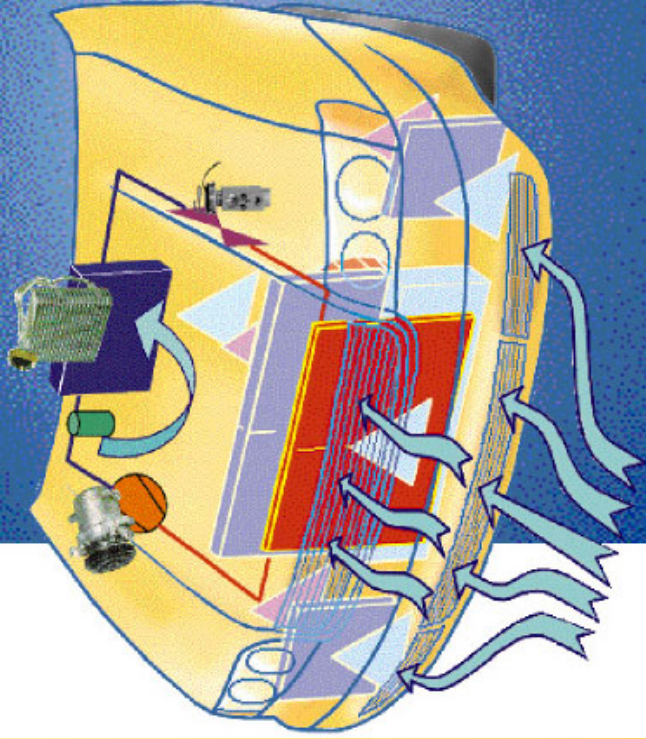
- The Air Conditioning System
- Engine Cooling and Air Conditioning
- **KULI AC** Refrigerant Circuit setup
- **KULI AC** Analysis Model
- **KULI AC** at work
- Summary



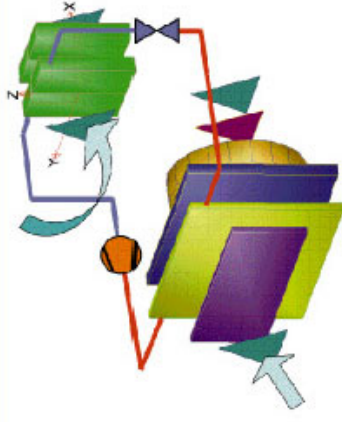
Thomas Anzenberger

ECS / SDP

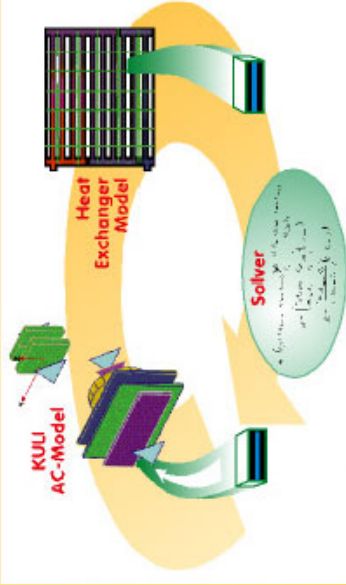
KULI AC



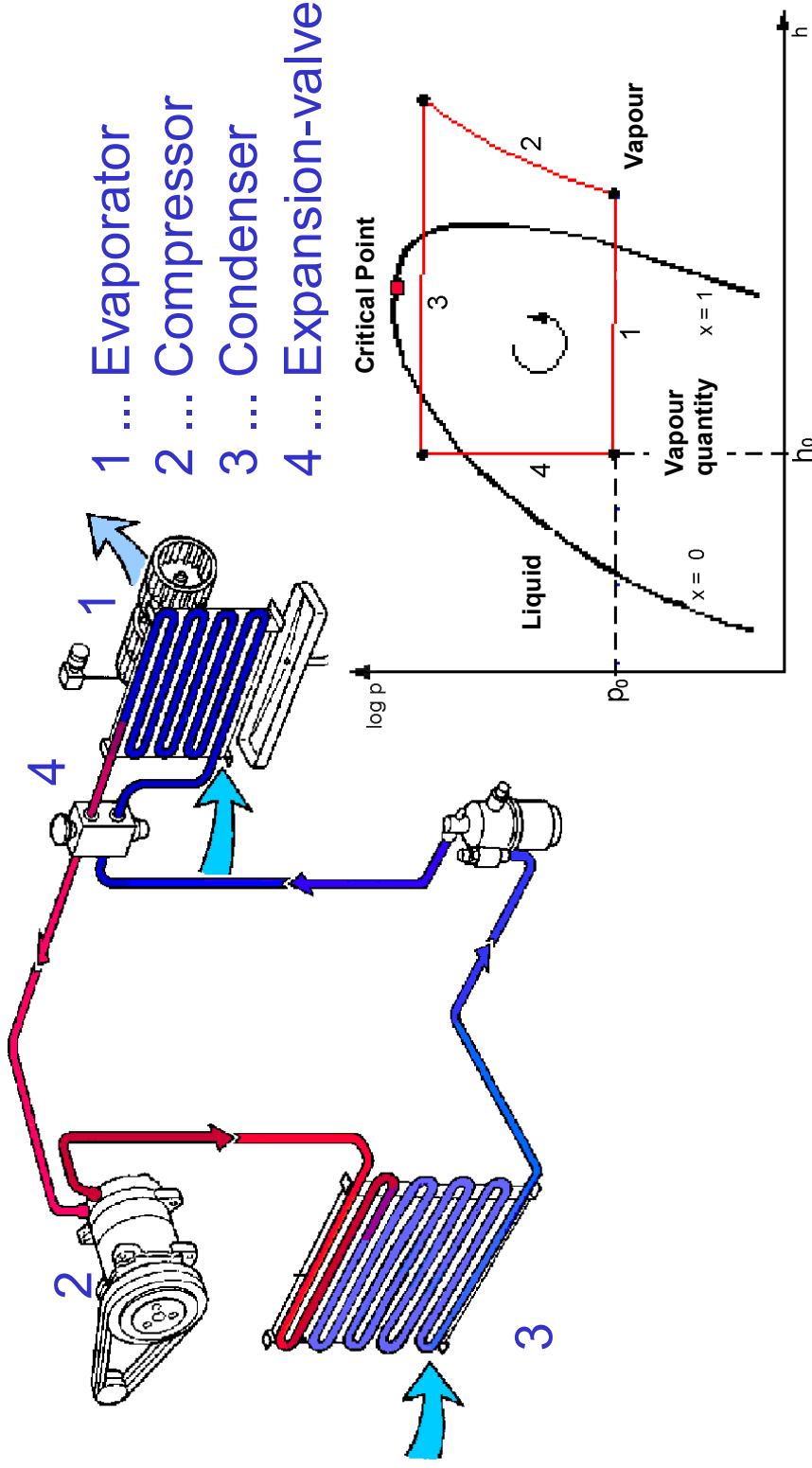
RAPID CONCEPT STUDIES



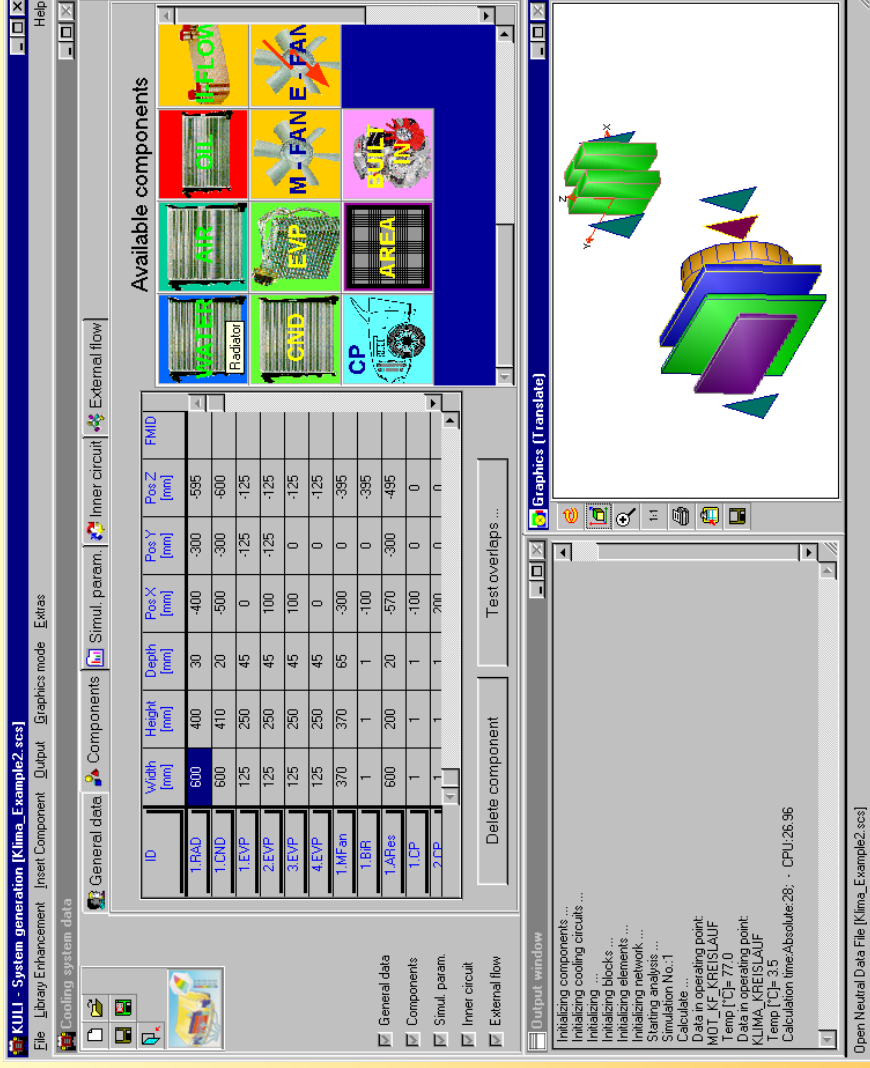
ADVANCED TWO-PHASE MODEL



Air Conditioning System (A/C System)



Set up of a KULI A/C Model



KULI - System generation [Klima_Example2.scs]

File Library Enhancement Insert Component Output Graphics mode Extras

Cooling system data

General data Components Simul. param. Inner circuit External flow

ID	Width [mm]	Height [mm]	Depth [mm]	Pos X [mm]	Pos Y [mm]	Pos Z [mm]	RMID
1RAD	600	400	30	-400	-300	-595	
1CND	600	410	20	-500	-300	-600	
1EVP	125	250	45	0	-125	-125	
2EVP	125	250	45	100	-125	-125	
3EVP	125	250	45	100	0	-125	
4EVP	125	250	45	0	0	-125	
1MFan	370	370	65	-300	0	-395	
1BR	1	1	1	-100	0	-395	
1ARes	600	200	20	-570	-300	-495	
1CP	1	1	1	-100	0	0	
2CP	1	1	1	200	0	0	

Available components

Graphics [Translate]

Output window

Initializing components ...
 Initializing cooling circuits ...
 Initializing ...
 Initializing blocks ...
 Initializing elements ...
 Initializing network ...
 Steady analysis ...
 Calculation No. 1
 Calculate
 Data in operating point:
 MOT_KF_KREISLAUF
 Temp [C]= 77.0
 Data in operating point:
 KLIMA_KREISLAUF
 Temp [C]= 3.5
 Calculation time Absolute 28; - CPU: 26.96

Open Neutral Data File [Klima_Example2.scs]

KULI AC: Engine Cooling and Air Conditioning

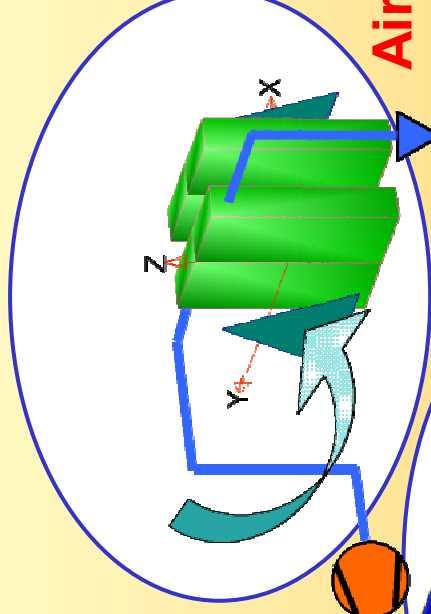
➤ **Evaporator**

➤ **Condenser**

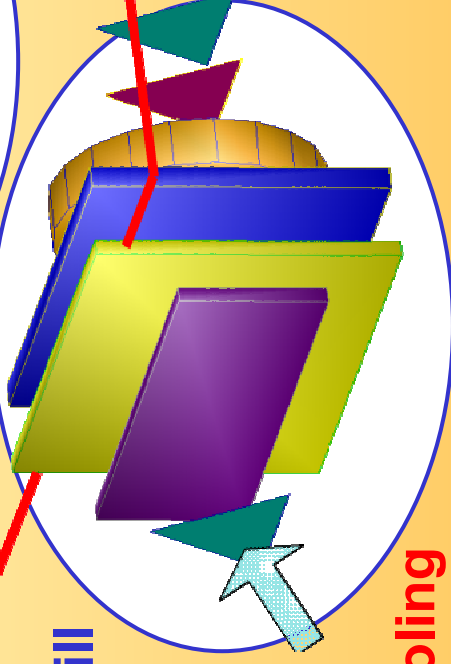
➤ **Charge Air Cooler**

➤ **Radiator**

➤ **Trim Grill**



Air Conditioning



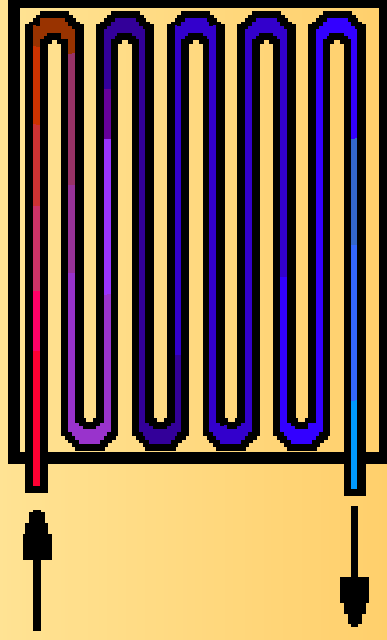
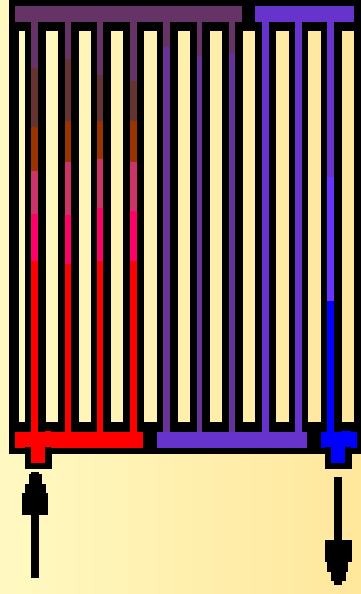
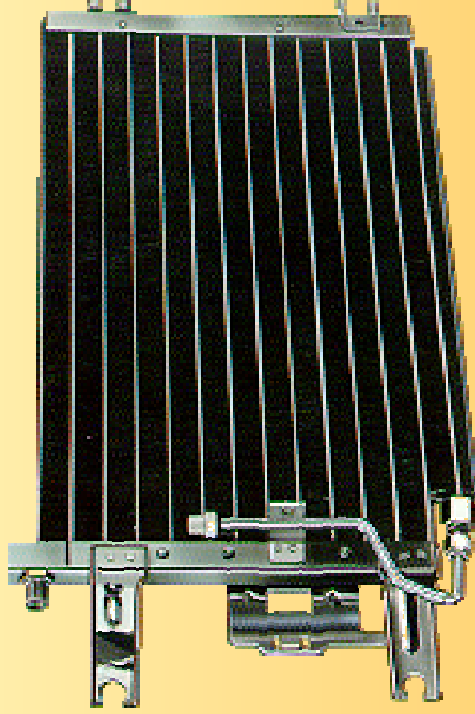
Engine Cooling

Viscous and E-Fan

Cp-Values

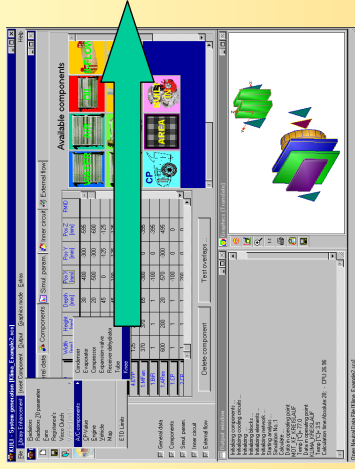
Built In Resistance

Condenser and Evaporator Model



KULI AC Database

Condenser / Evaporator



A/C condenser [Kondensator.kk]

File Edit View Help

Geometric properties Charac. curves

General data

Width [mm] 530
Height [mm] 420
Depth [mm] 16
Number of pipe rows 1

Inner flow (refrigerant)

☒ Tubular ☐ Non tubular

Diameter [mm] 13.21 Wetted area [mm²] 25.74
Wetted perimeter [mm]

Thickness [mm] 0.35 Roughness height [μm] 0.8 Pipe roughness [mm] 0.13
Direction of inner flow Y (in y direct) Input inner heat transfer surface

Outer flow (air)

Number of ribs 454 Rib depth [mm] 16 Rib thickness [mm] 0.13
Input outer heat transfer surface

Conventional heat exchanger

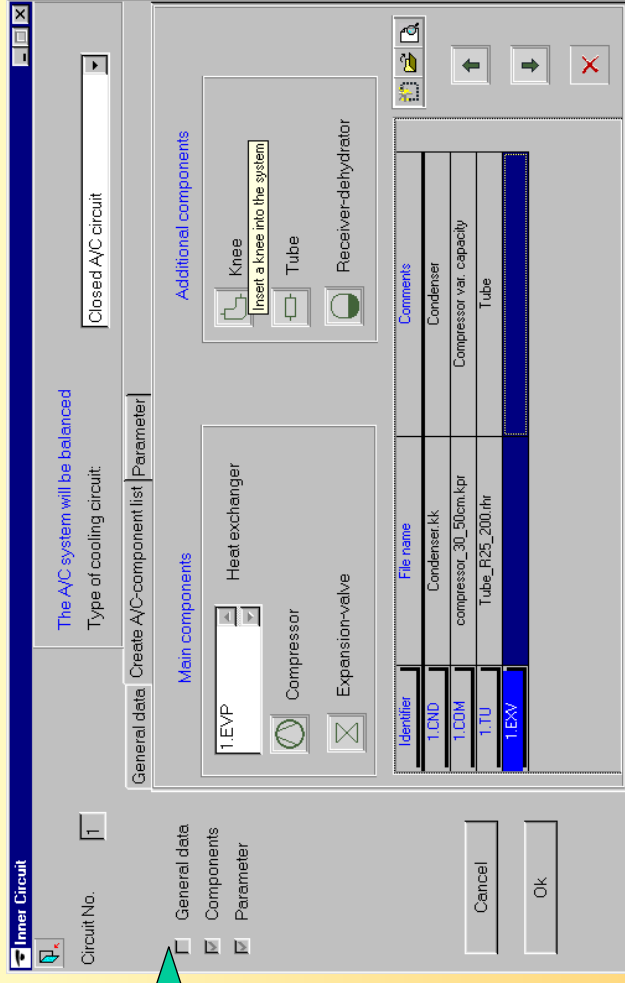
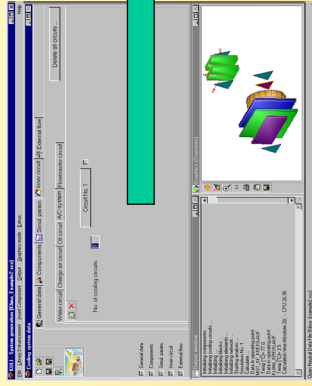
Number of fluid transits

Parallel flow heat exchanger

Block No.	Number of tubes
1	14
2	10
3	6
4	4
5	4
6	4

File successfully saved: C:\entwick\kulin_O\K-Komponenten\Kondensator.kk

Set up of the Refrigerant Circuit

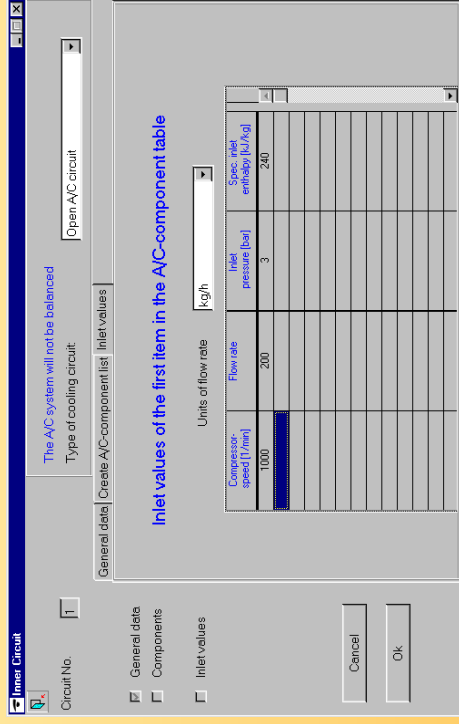
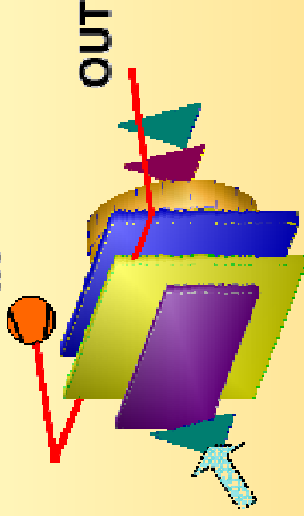


Closed Refrigerant Circuits:
for the whole A/C System

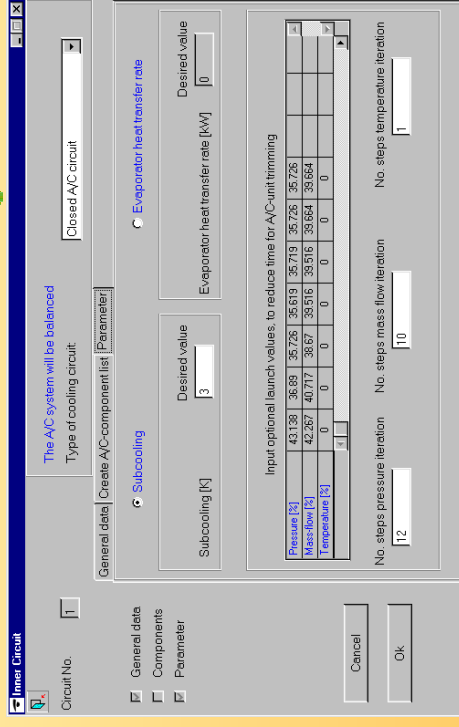
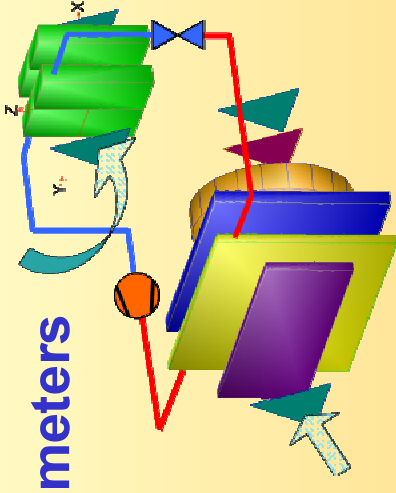
Open Refrigerant Circuits:
for single A/C Component units

Refrigerant Circuits

Open: Inlet values



Closed: Parameters



Component Database (Examples)

Compressor [Compress.kpr]

File Extras

General data

Charac. curves

User

Date (0=current)

Comments

Type

Manufacturer

Series

No.

Measured data file

TZS

Dienstag, 12. Januar 1999 15:58:51

KULI AC Example

Compressor const capacity

TZS Steyr

Example

Example

Example

Compressor capacity max. [cm³]

Compressor capacity min. [cm³]

Variable capacity

Open file successful: D:\vertwick\kulin_DVKlimakomponenten\Compress.kpr

Tube [Ex_kAC.rhr]

File Extras

TZS

Montag, 31. Mai 1999 09:51:48

Example KULI AC

Type

Manufacturer

Series

No.

Measured data file

Tube

TZS Steyr

Example

Example

Example

Compressor capacity max. [cm³]

Compressor capacity min. [cm³]

Tube

Inner-diameter [mm]

Wetted area [mm²]

Wetted perimeter [mm]

Non tubular

Heat transfer

Thickness [mm]

Thermal conductivity [W/m K]

Ambient temperature [°C]

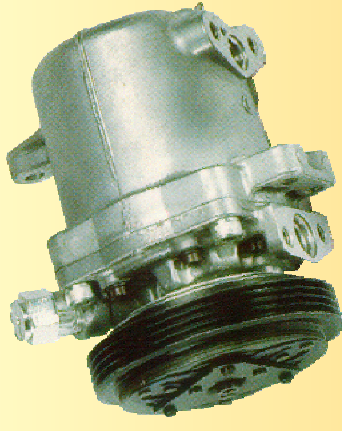
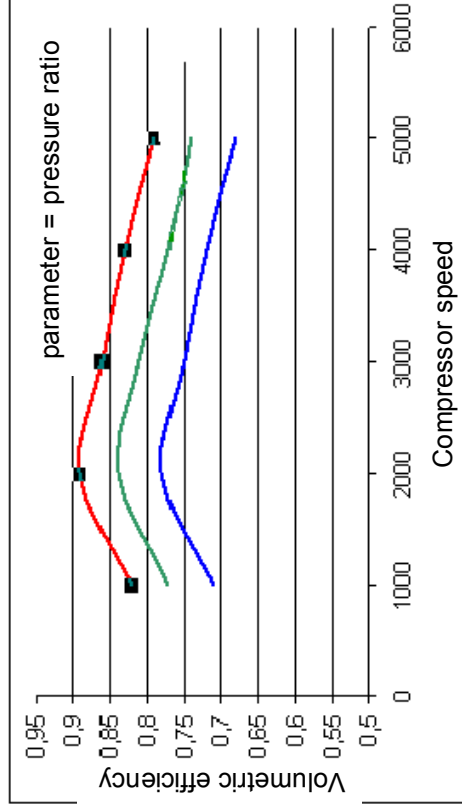
Air velocity [%]

Open file successful: D:\vertwick\kulin_DVKlimakomponenten\Ex_kAC.rhr

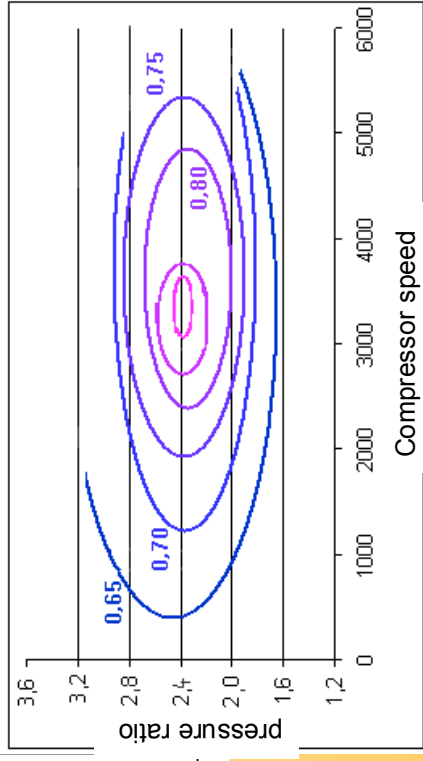
Tube

Characteristic Curves of the Compressor

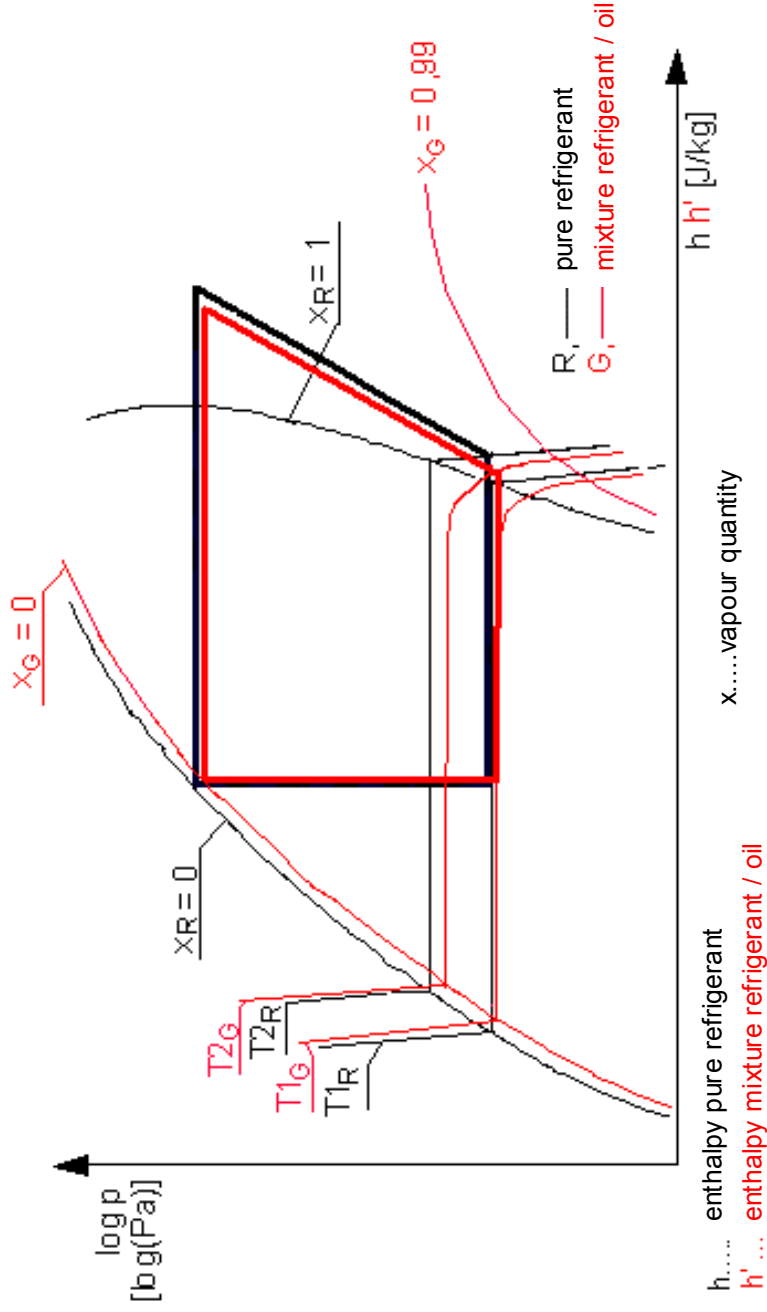
Volumetric efficiency



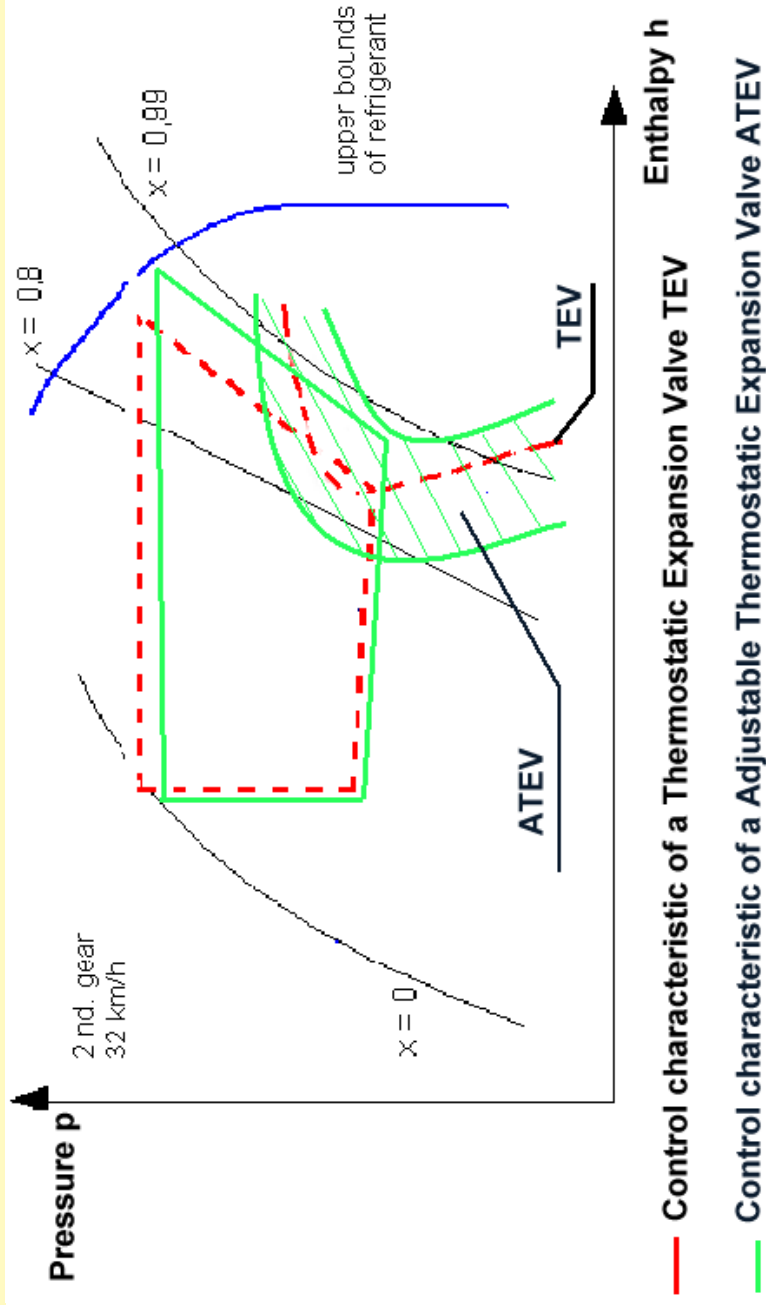
Isentropic efficiency



Oil Ratio Influence

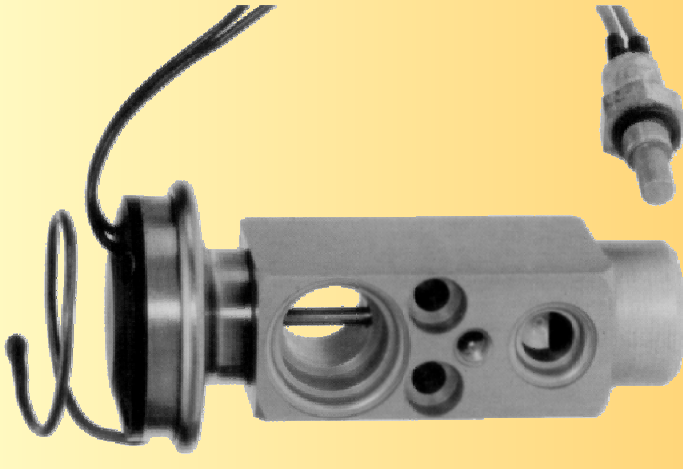
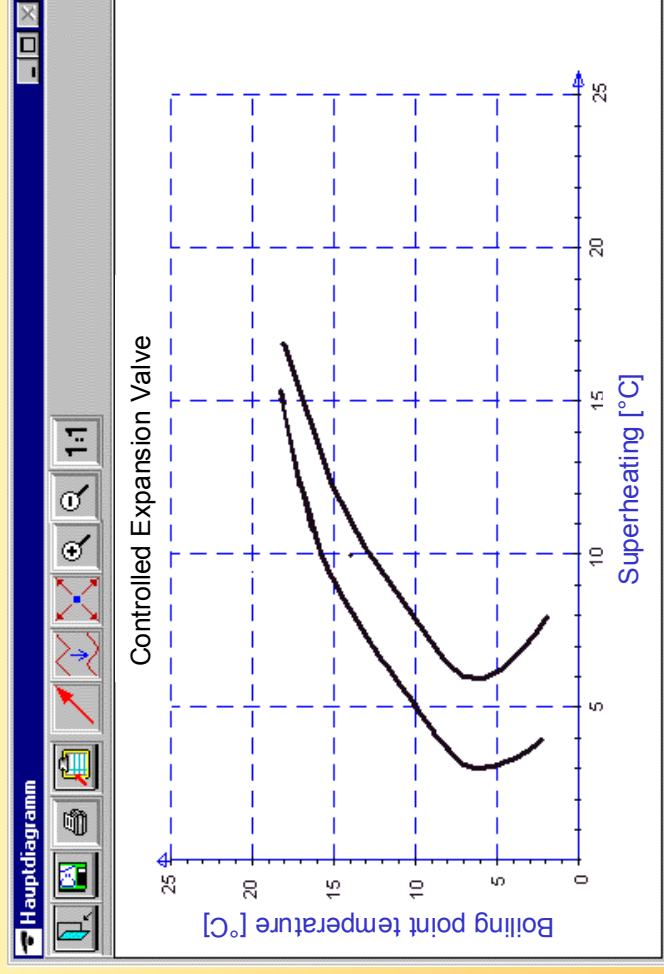


A/C Refrigerant Circuit



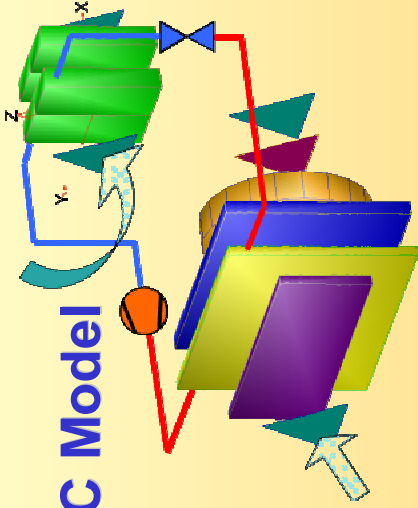
Expansion Valve

Control characteristic

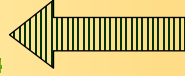


Analysis Model

KULI AC Model



Returns results to KULI AC Model



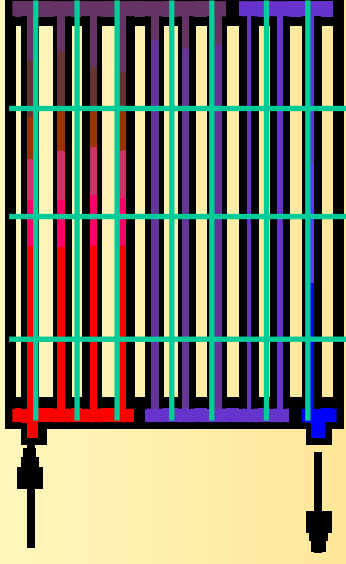
Analysis



Truncation



Heat Exchanger Model

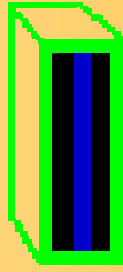


$$dt + (c_{pD} + h_{0Wasser} - c_{Wasser} t_{Oberfl}) \frac{dx}{c_p} + \frac{\alpha_i A_{Innen} (t_{Oberfl} - t_{Innen})}{\dot{m}_{i, Luft} c_p} = 0$$

$$dt = - \left(\frac{\alpha_a A_{Außen}}{\dot{m}_{i, Luft} c_p} + \frac{c_{pD}}{c_p} \right) \frac{dx}{c_p} \left(t - t_{Oberfl} \right)$$

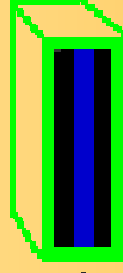
$$dx = - \left(\frac{\alpha_a A_{Außen} \eta_s}{\dot{m}_{i, Luft} c_p} \right) (x - x_{s, Oberfl})$$

Air Out



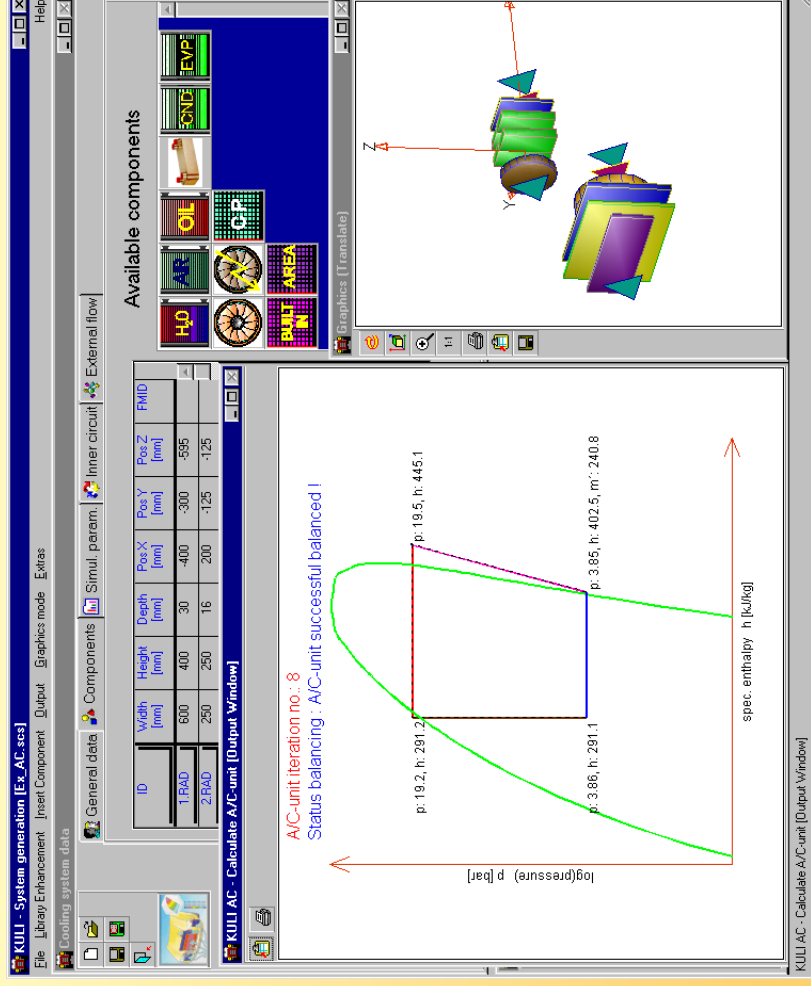
Refrigerant Out

Refrigerant In



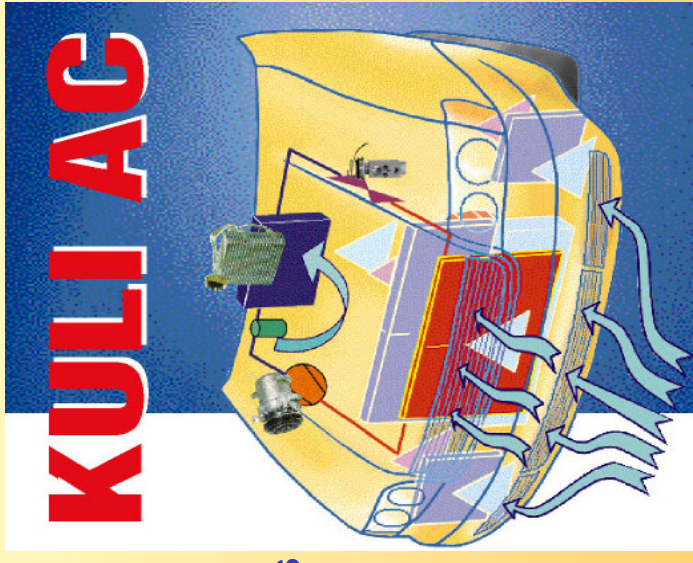
Air In

Running Graphical Analysis Output



Analysis Results

- Pressures, Temperatures (air, refrigerant)
- Refrigerant Enthalpy, Vapour Quantity
- Mass Flows (air, refrigerant)
- Heat Flows for Evaporator, Condenser, Tubes
- Condensate separation at the Evaporator
- Surface Temperature of the Evaporator
- Necessary Refrigerant Quantity
- Required Compressor Power
- Cold Power index and Carnot efficiency



KULI AC Developing Steps

- Orifice-Tube
- Set Refrigerant amount in Circuit
- Controlled Compressor Capacity
- Carbon Dioxide Refrigerant
- Free Component Connections

