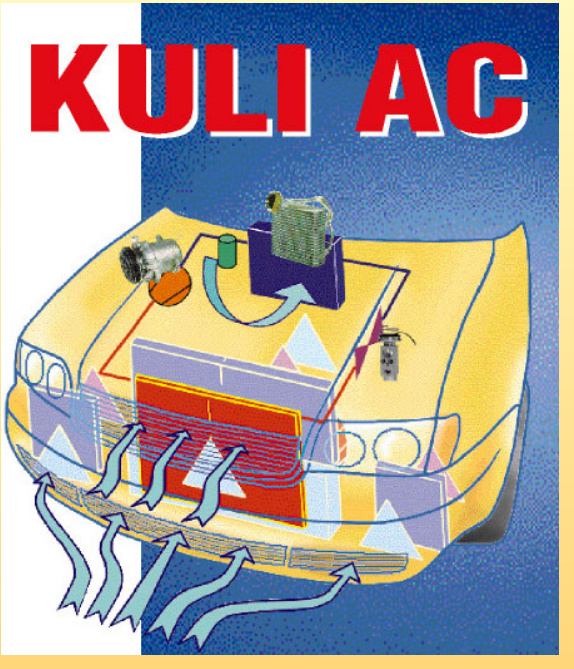
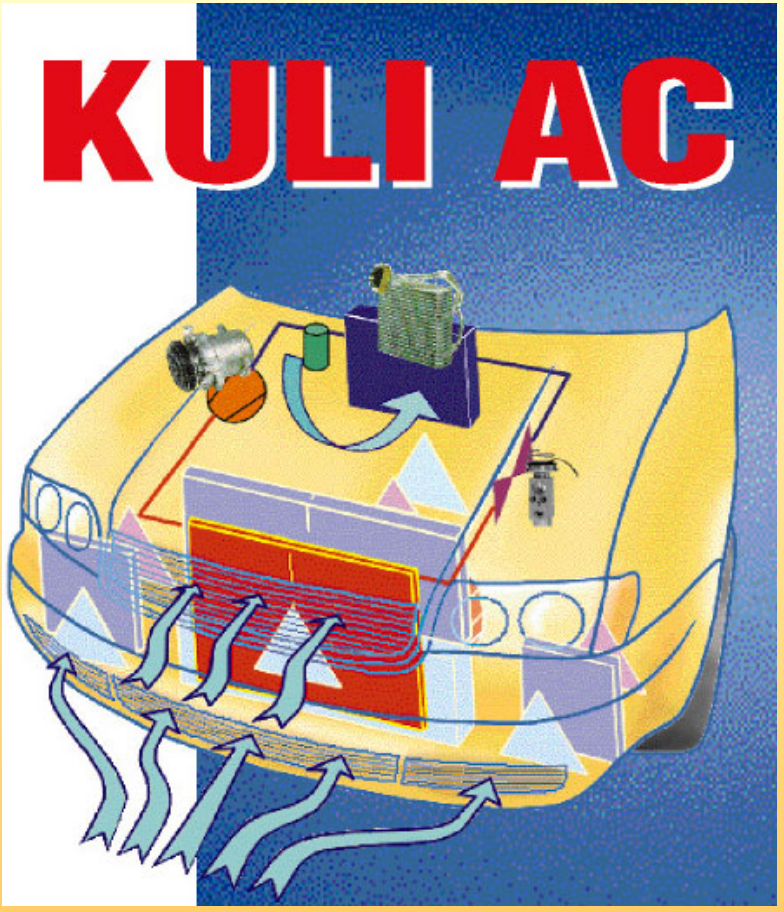
Overview

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

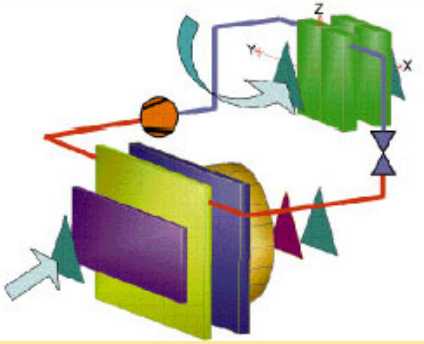


Thomas Anzenberger

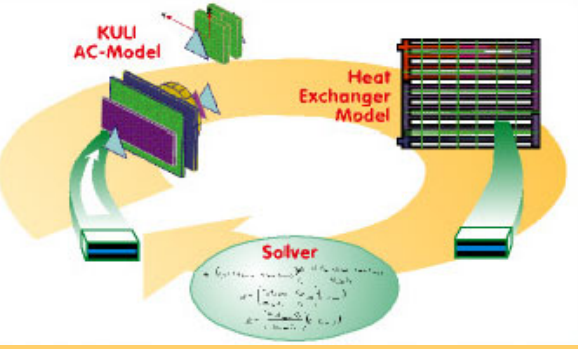
ECS / SDP



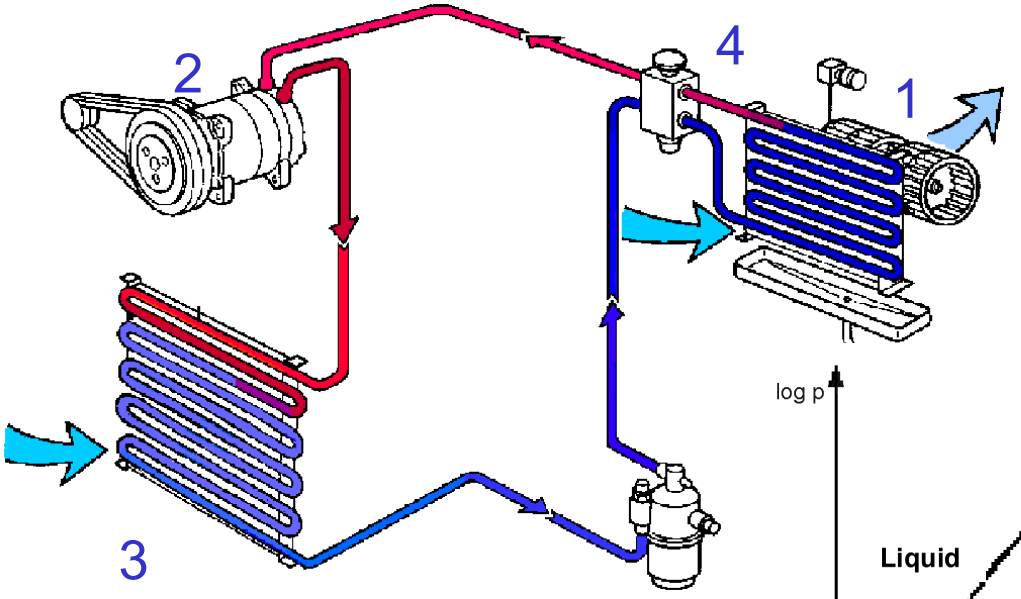
RAPID CONCEPT STUDIES



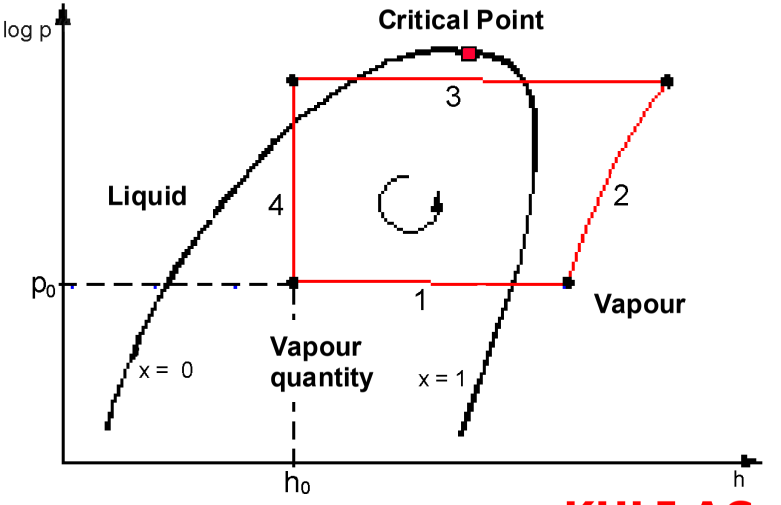
ADVANCED TWO-PHASE MODEL



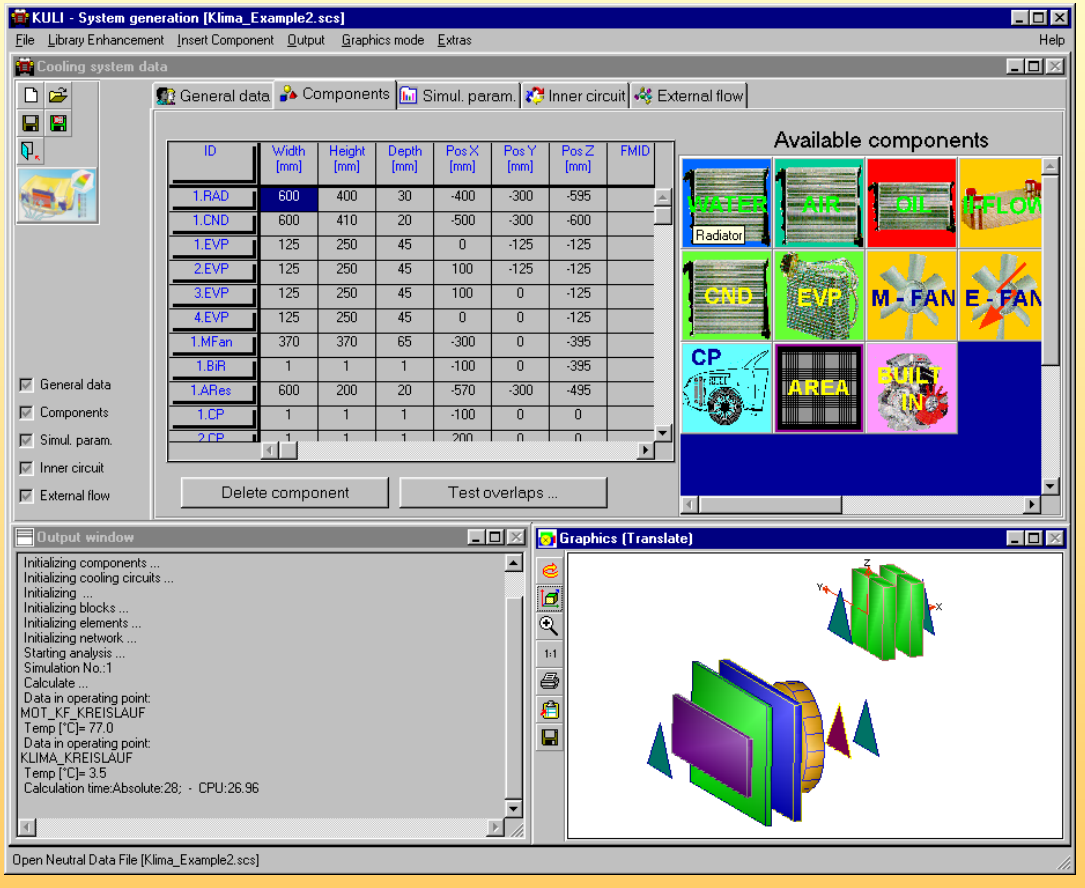
Air Conditioning System (A/C System)



1 ... Evaporator
2 ... Compressor
3 ... Condenser
4 ... Expansion-valve

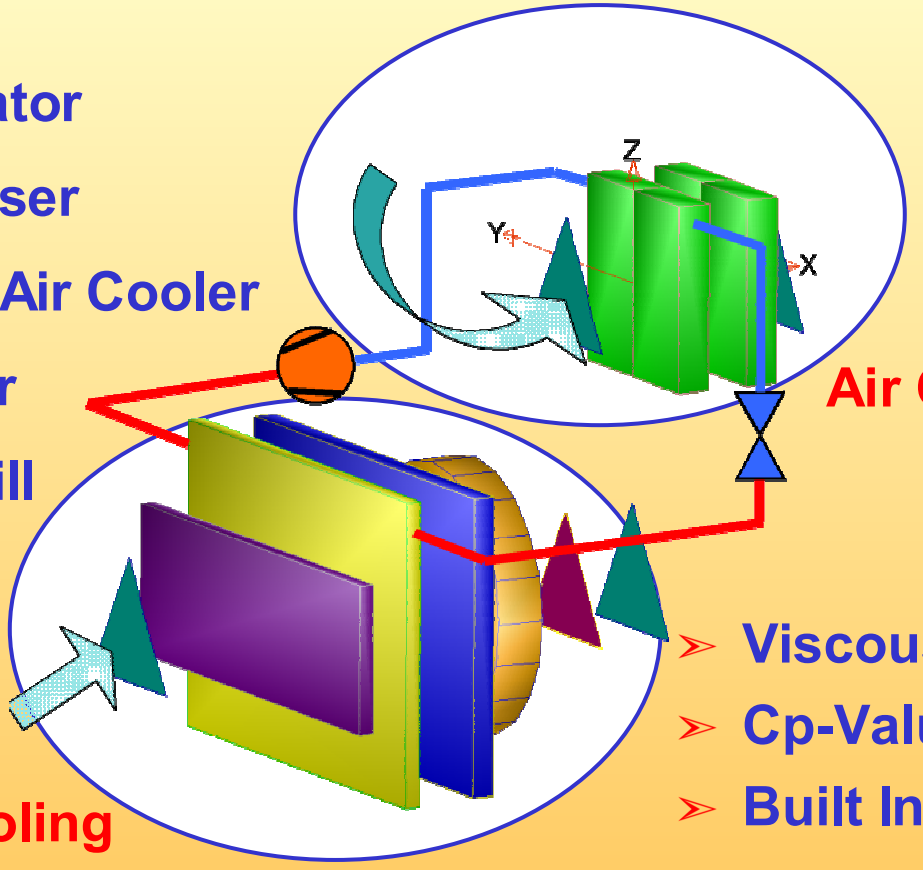


Set up of a KULI A/C Model



KULI AC: Engine Cooling and Air Conditioning

- Evaporator
- Condenser
- Charge Air Cooler
- Radiator
- Trim Grill

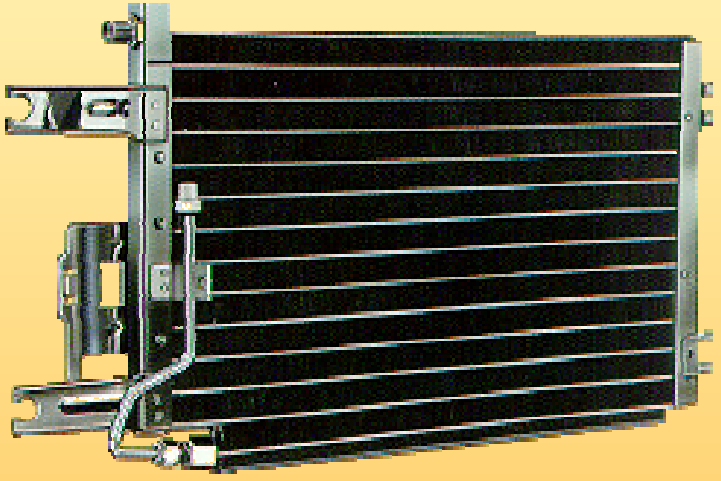


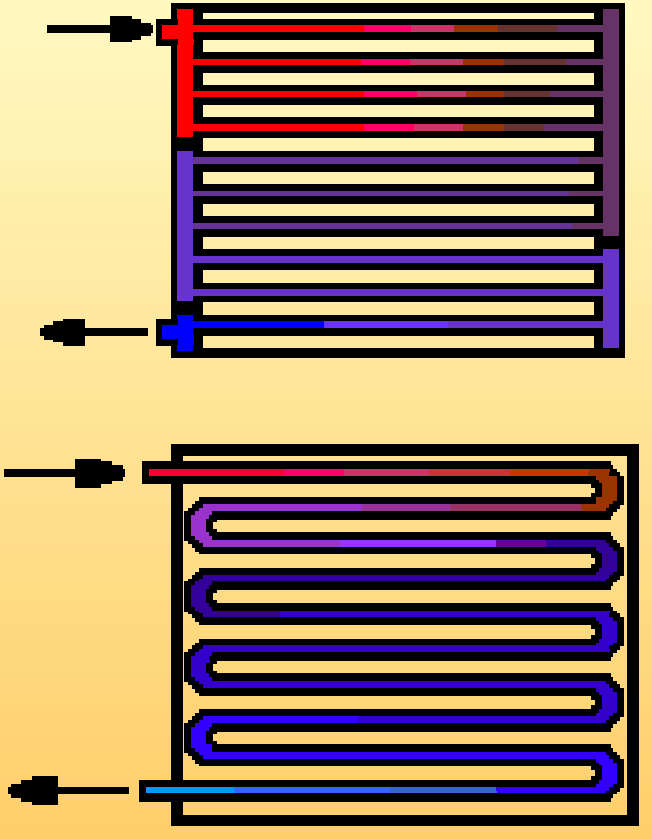
Air Conditioning

- Viscous and E-Fan
- Cp-Values
- Built In Resistance

Engine Cooling

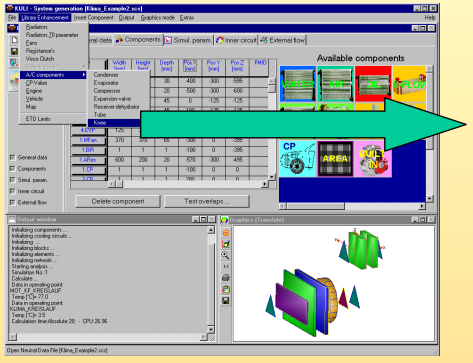
Condenser and Evaporator Model





KULI AC Database

Condenser / Evaporator



A/C condenser [Kondensator.kk]

File

General data | Geometric properties | Charac. curves

Width [mm] 590
Height [mm] 420
Depth [mm] 16
Number of pipe rows 1

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

Inner flow (refrigerant)

Tubular | Non tubular

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

Thickness [mm] 0.35
Roughness height [µm] 0.8
Pipe raughness [mm]

Direction of inner flow: Y (in y direct.)
Input inner heat transfer surface
Inner heat transfer surface [mm²]

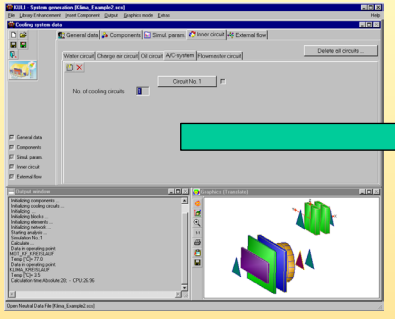
Outer flow (air)

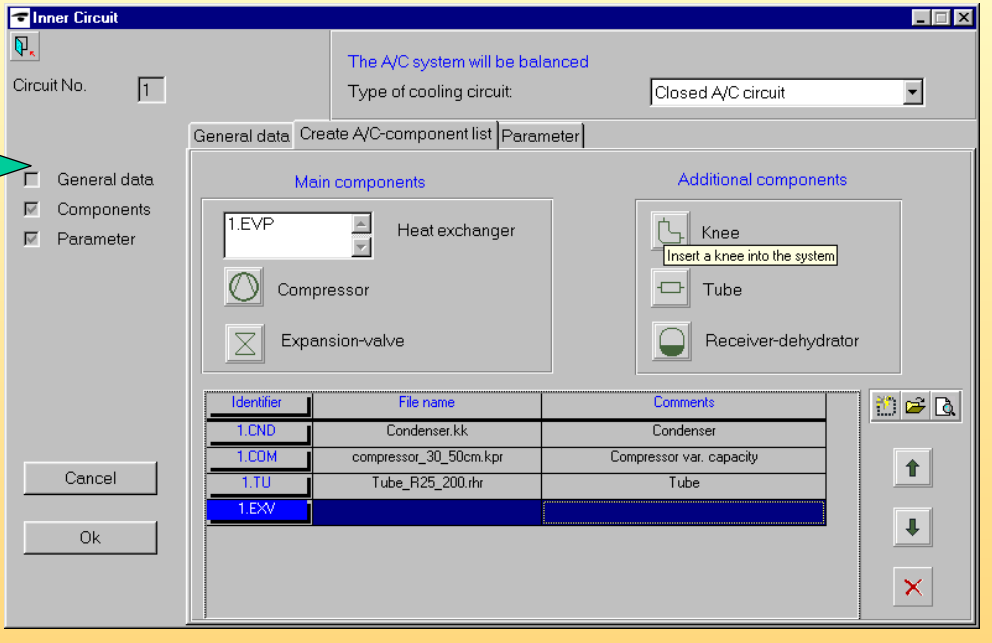
Number of ribs [-] 454
Rib depth [mm] 16
Rib thickness [mm] 0.13

Input outer heat transfer surface
Outer heat transfer surface [mm²]

File successfully saved:C:\entwickl\kulin_0\Komponenten\Kondensator.kk

Set up of the Refrigerant Circuit



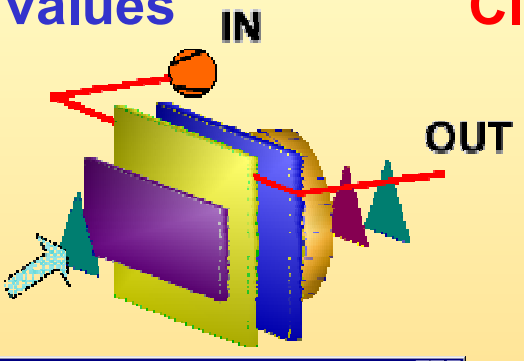


Closed Refrigerant Circuits:
for the whole A/C System

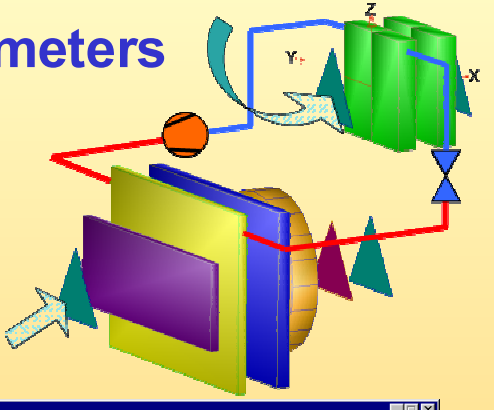
Open Refrigerant Circuits:
for single A/C Component units

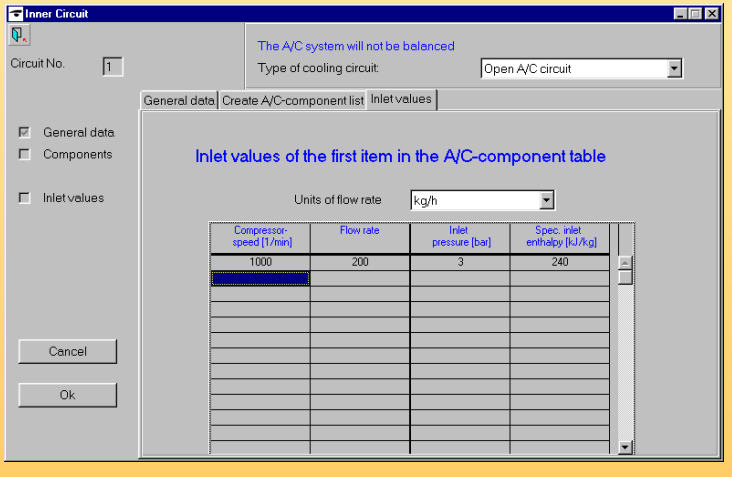
Refrigerant Circuits

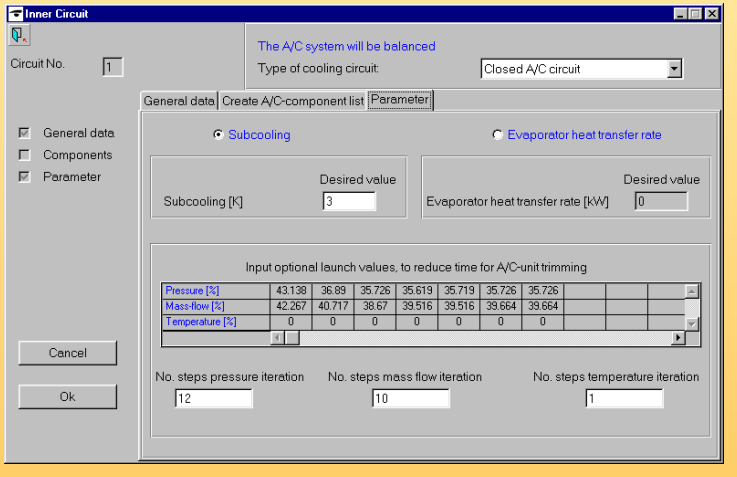
Open: Inlet values



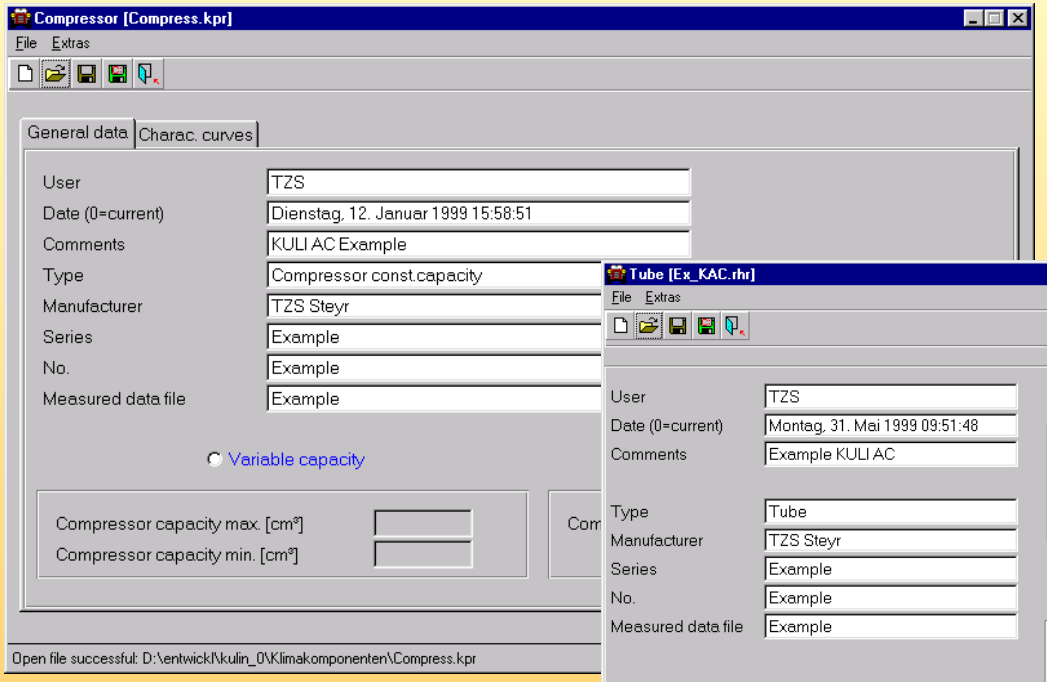
Closed: Parameters



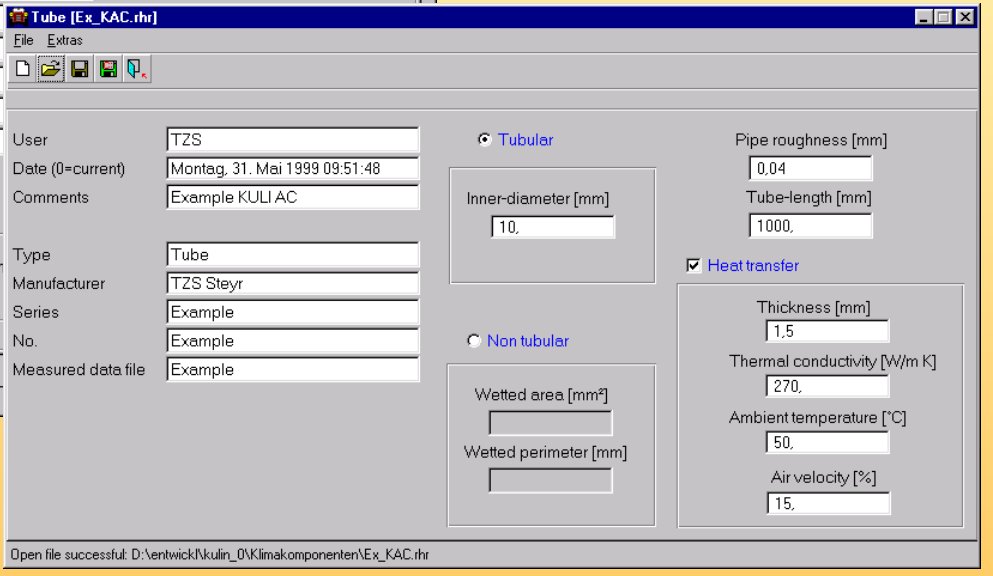




Component Database (Examples)



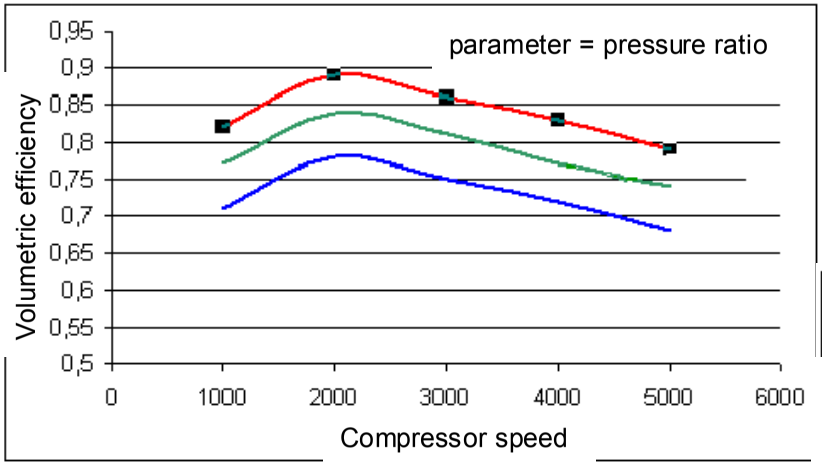
Compressor

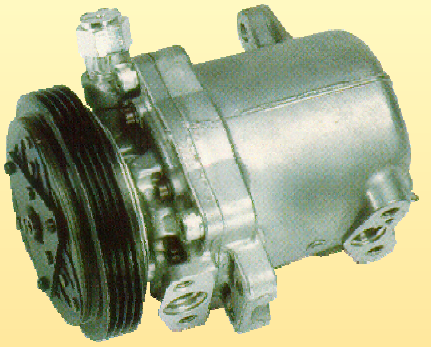


Tube

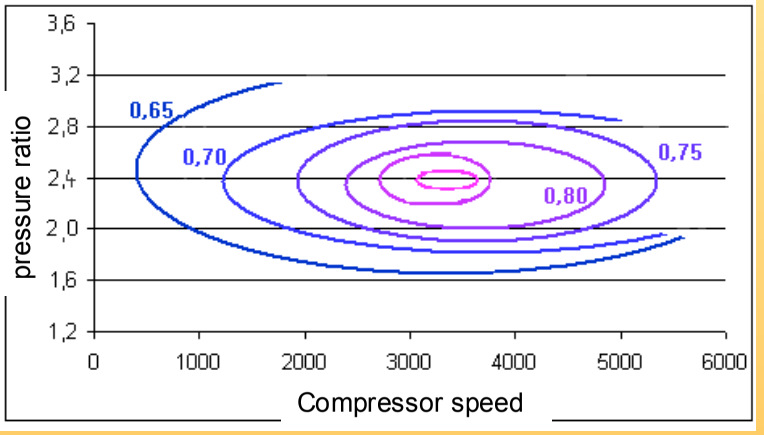
Characteristic Curves of the Compressor

Volumetric efficiency

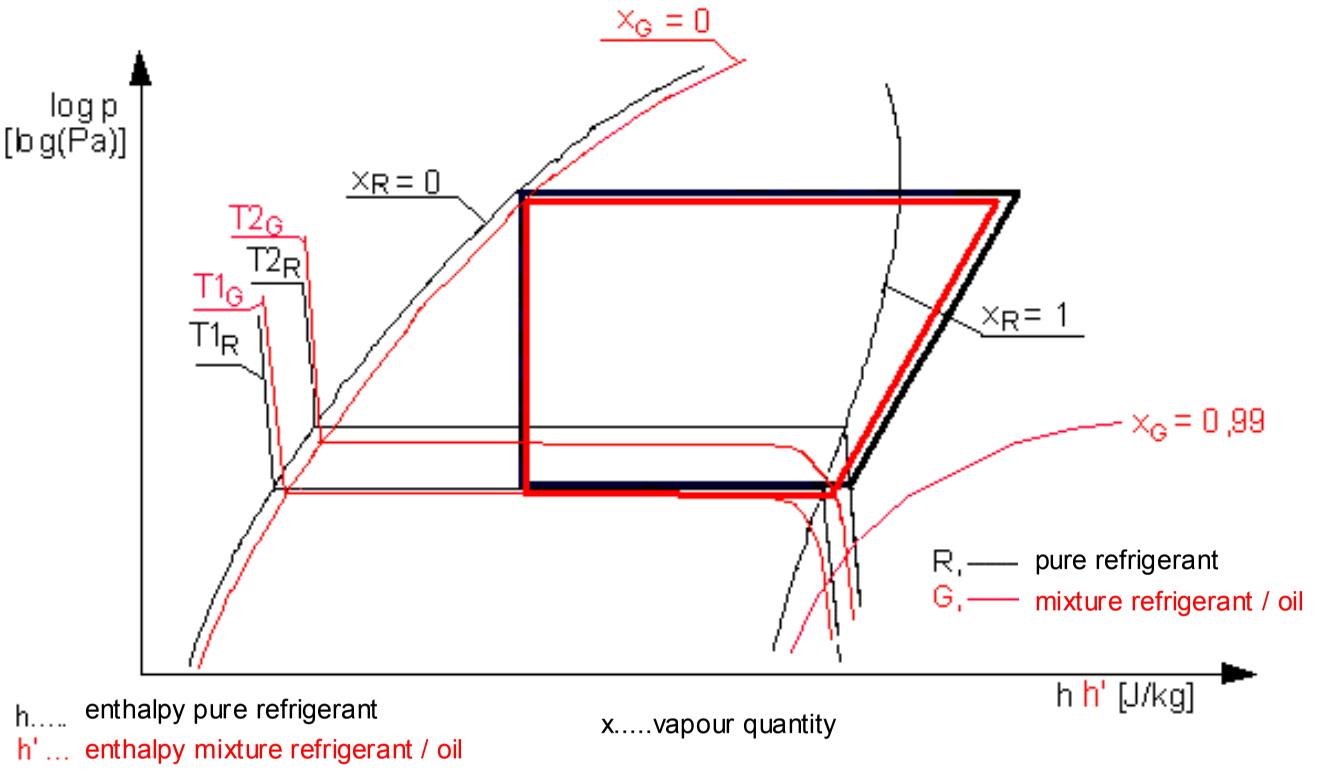




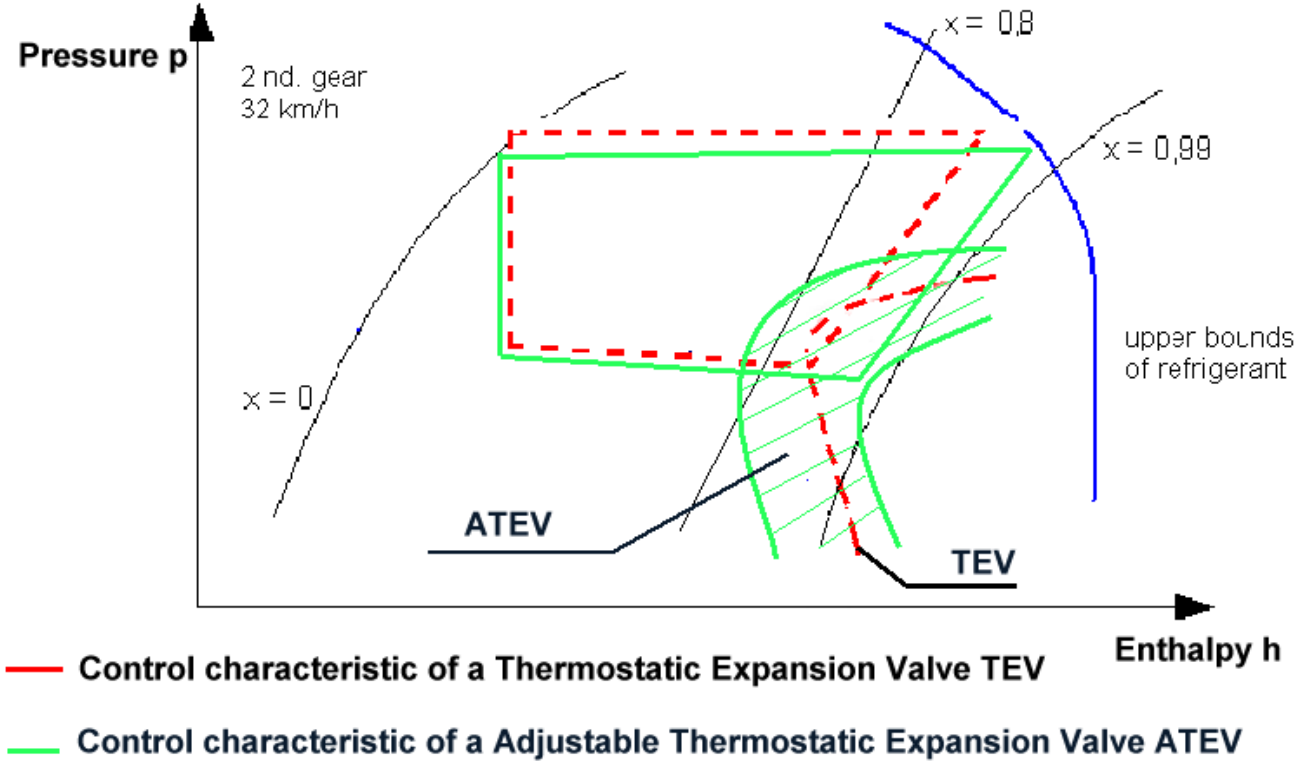
Isentropic efficiency



Oil Ratio Influence

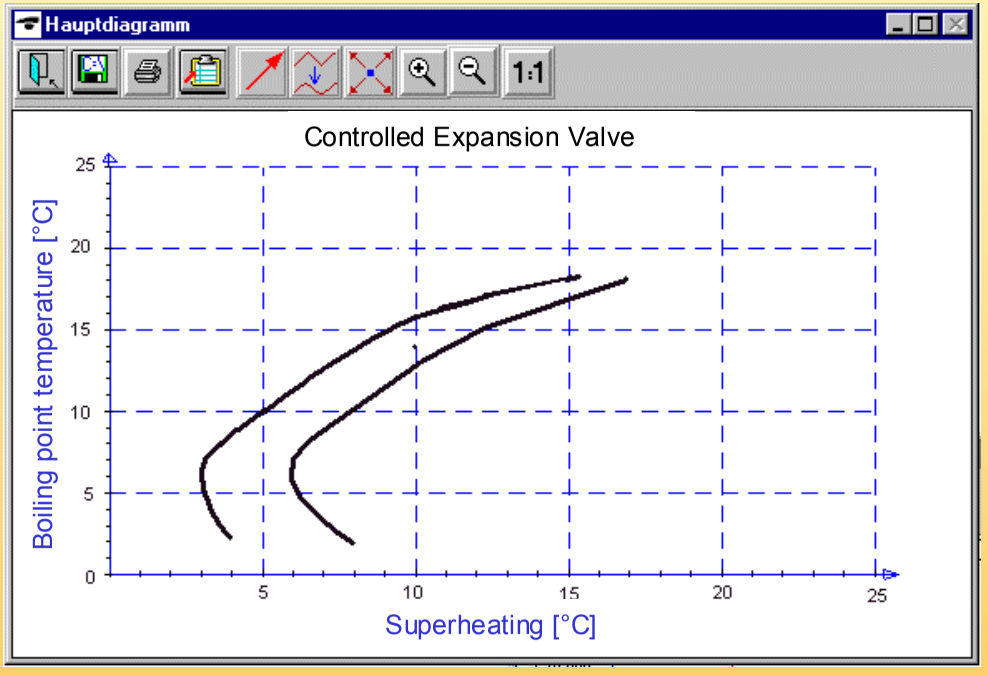


A/C Refrigerant Circuit



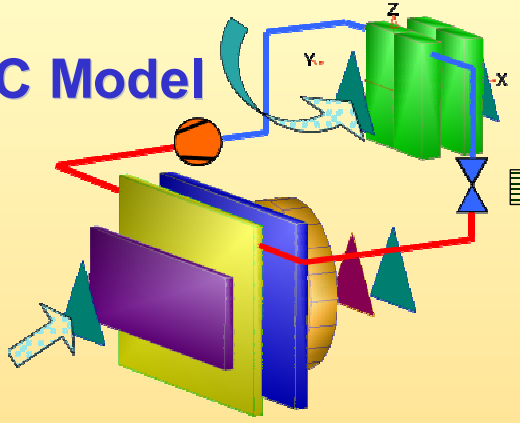
Expansion Valve

Control characteristic

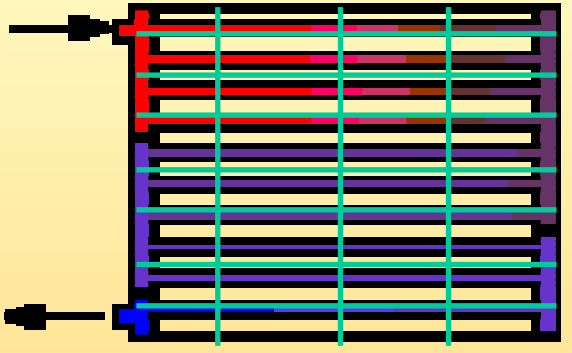


Analysis Model

KULI AC Model



Heat Exchanger Model



Truncation

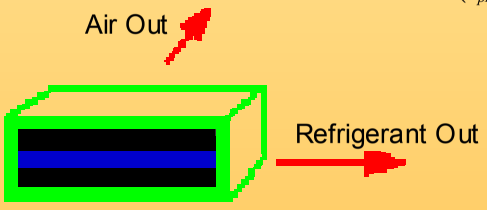
Analysis

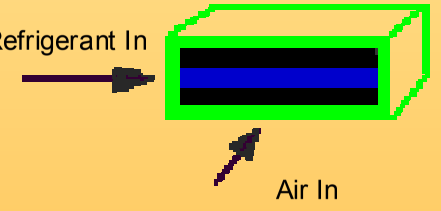
Returns results to KULI AC Model

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

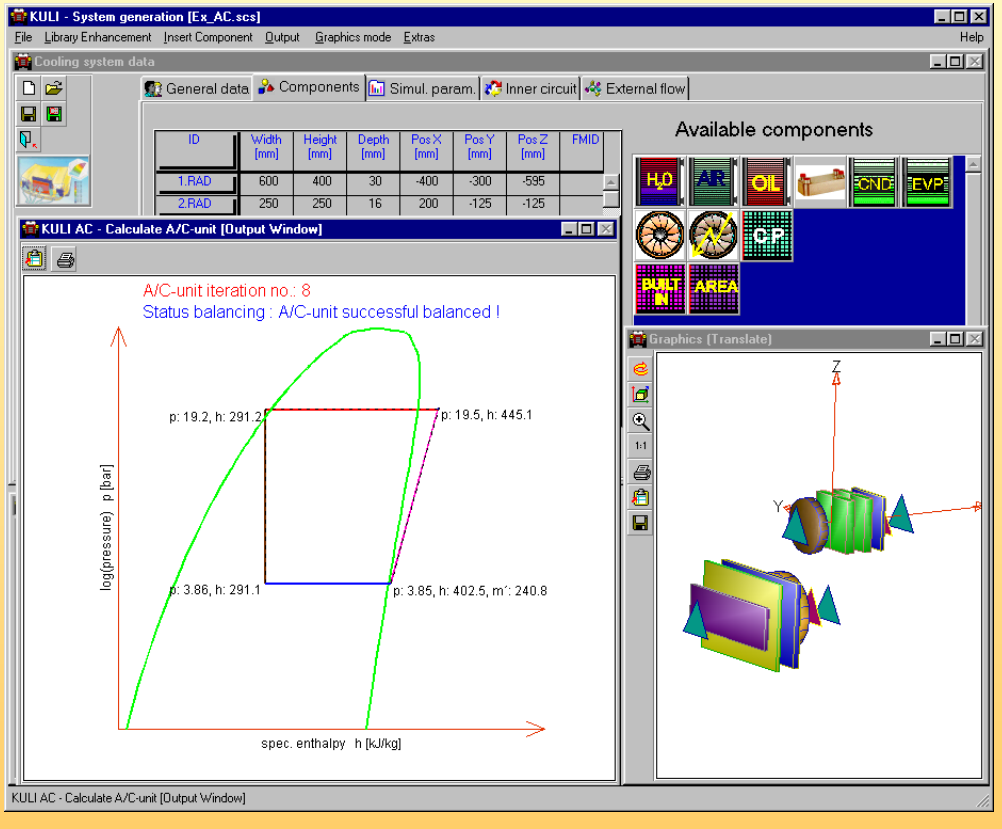
$$dt = -\left(\frac{\alpha_a A_{Außen}}{\dot{m}_{t.Luft} c_p} + \frac{c_{pD}}{c_p} dx\right)\left(t - t_{Oberfl}\right)$$

$$dx = -\left(\frac{\alpha_a A_{Außen}\,\eta_S}{\dot{m}_{t.Luft} c_p}\right)\left(x - x_{S.Oberfl}\right)$$



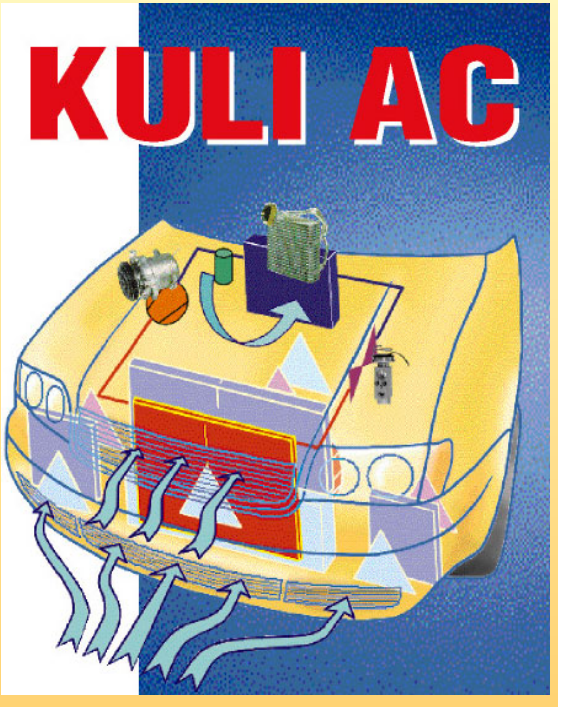


Running Graphical Analysis Output



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