Overview of Thermal and Fluid System Simulation

Sadek Rahman
Kanwerdip Singh
Richard Sun
Aero/Thermal Center of Competency and Core CFD
DaimlerChrysler, Auburn Hills, USA

Agenda

- Chrysler Group and KULI
- Application Areas
- Chrysler Group CFD Simulation Process
- KULI Simulation Examples
- Suggestions
- Conclusions

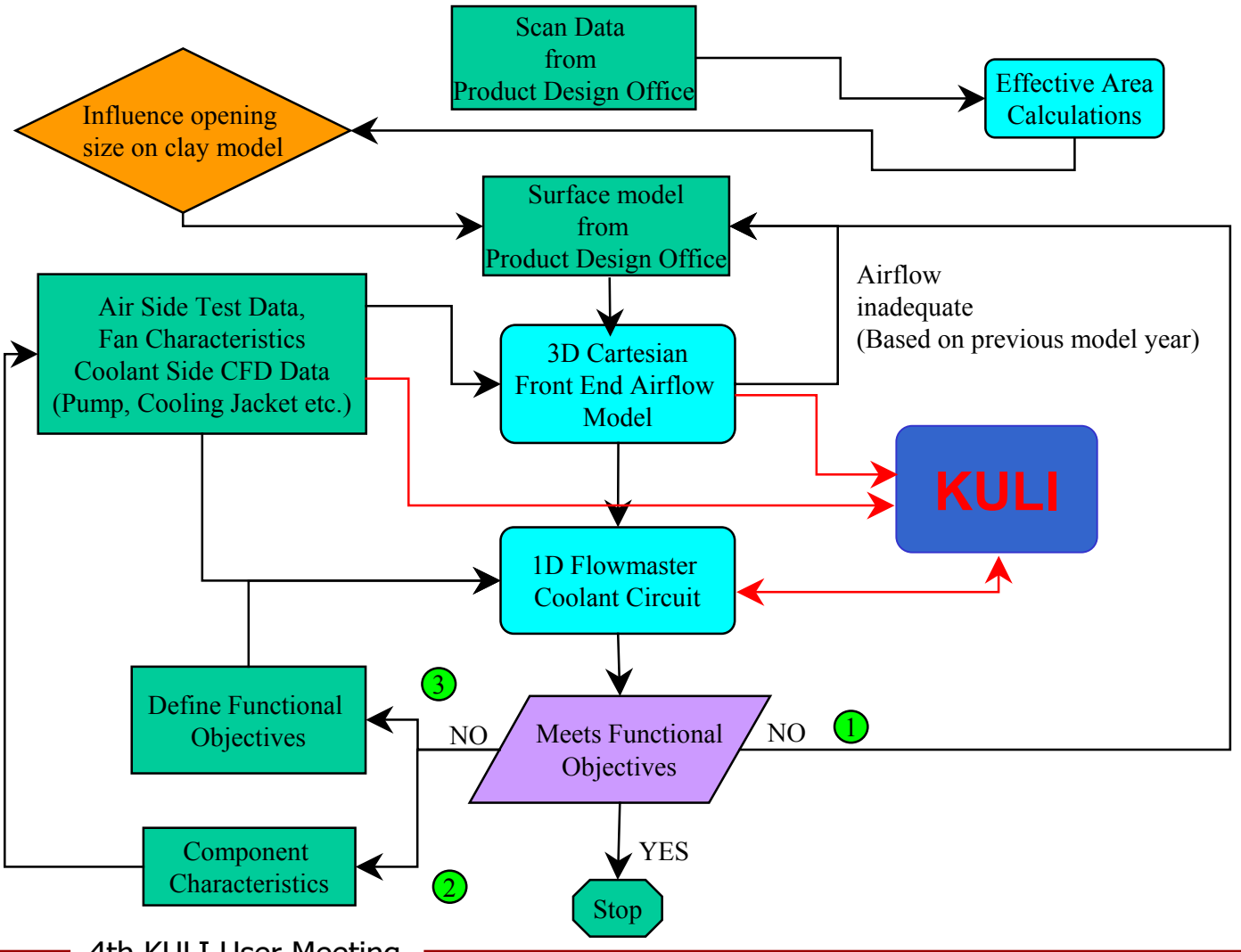
Chrysler Group and KULI

- Introduction: KULI was introduced to Chrysler Group in 2000
- Users : Two Full-time (2) users
- Licenses : Renting following licenses
  - KULI Base : Two (2) Licenses
  - KULI Advanced : Two (2) Licenses
  - KULI HVAC : One (1) License
  - KULI Drive : One (1) License
- Additional Support: Onsite Support for Special Projects
- Future : Increase KULI use

Application Areas

- Engine Cooling System Simulation and Analysis
- Vehicle HVAC System Simulation and Analysis
- Thermal and Fluid System Optimization and Sensitivity Study

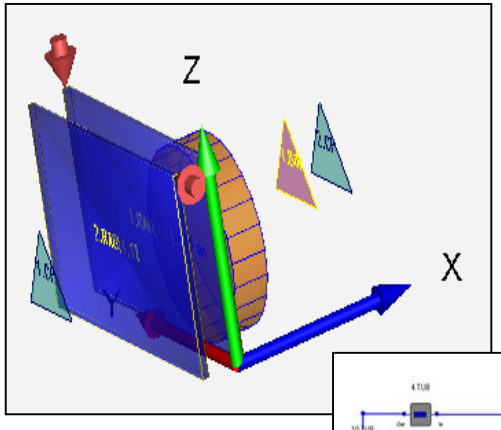
Chrysler Group CFD Simulation Process

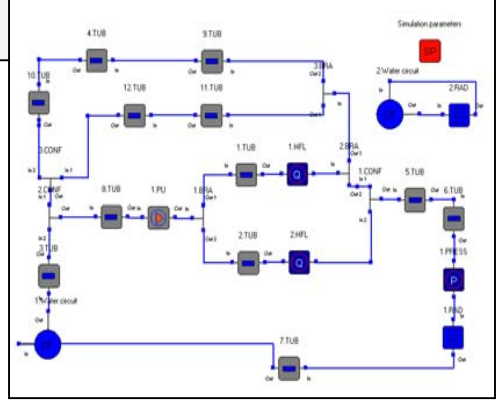


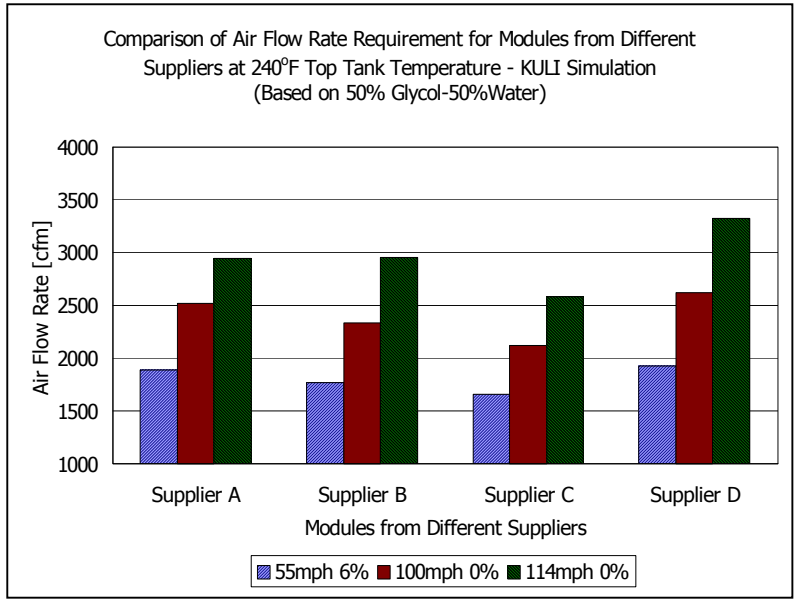
KULI Simulation Examples

Engine Cooling System : Cooling Module Selection

- Comparison of Air Flow Rate Requirement for Modules from Different Suppliers at 240°F Top Tank Temperature



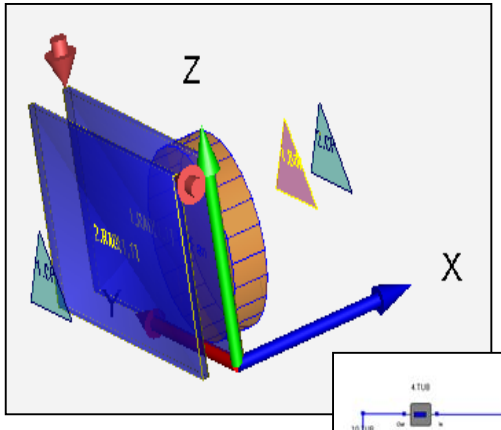


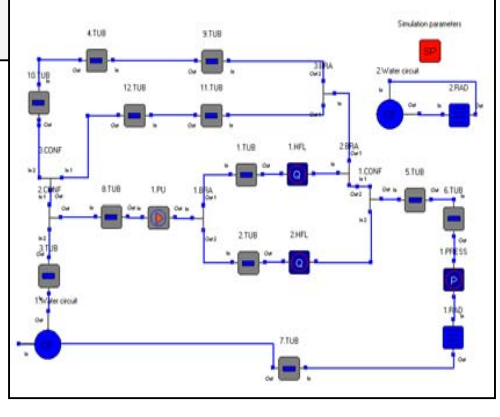


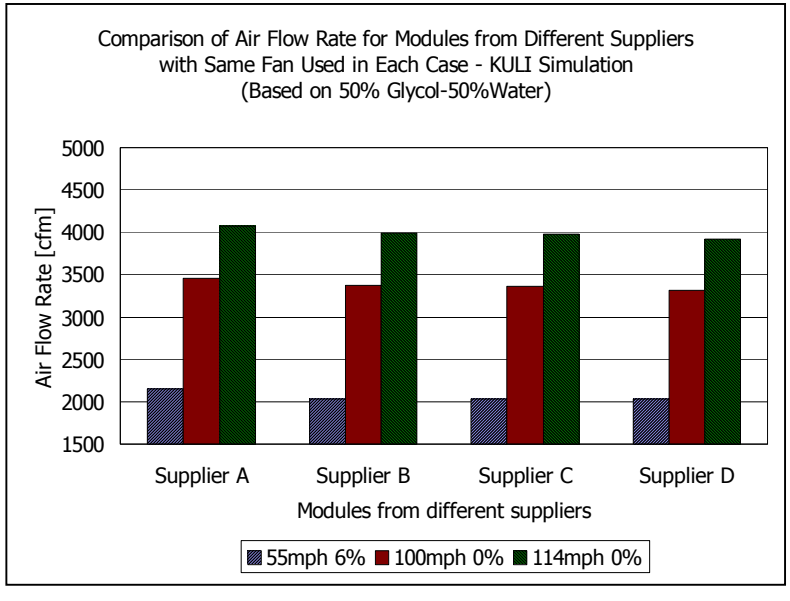
KULI Simulation Examples

Engine Cooling System : Cooling Module Selection

- Comparison of Air Flow Rate Available for Each Modules from Different Suppliers with Same Fan Used in Each Case



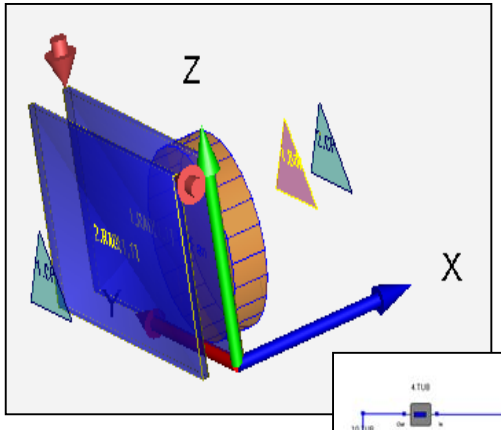


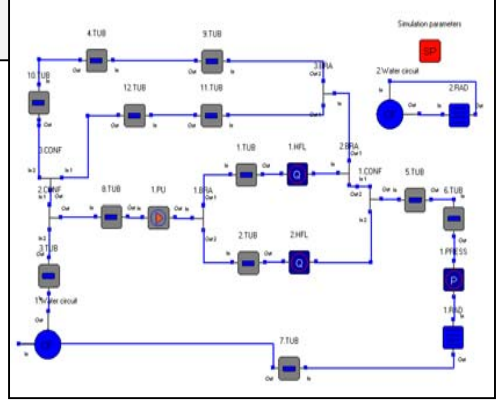


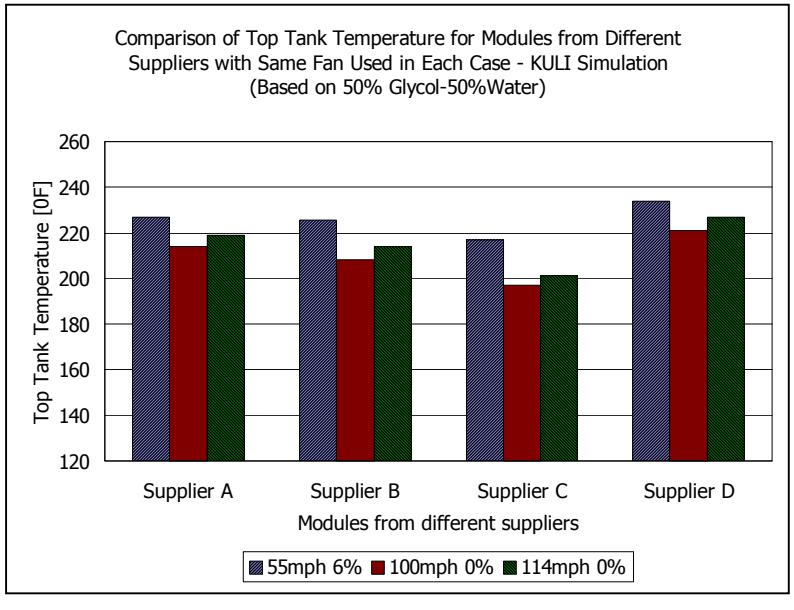
KULI Simulation Examples

Engine Cooling System : Cooling Module Selection

- Comparison of Top Tank Temperature for Modules from Different Suppliers with Same Fan Used in Each Case



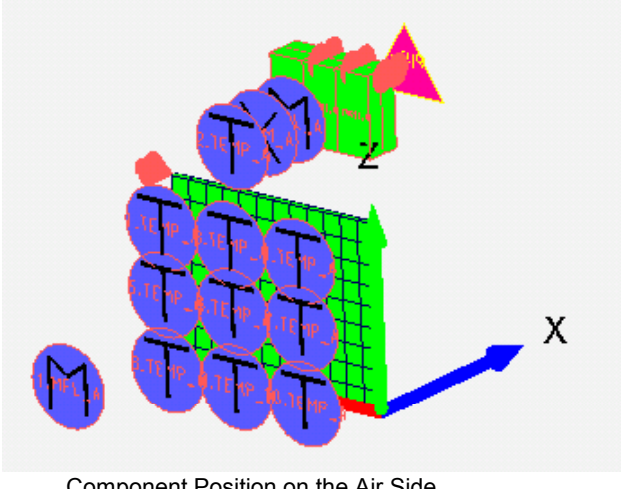




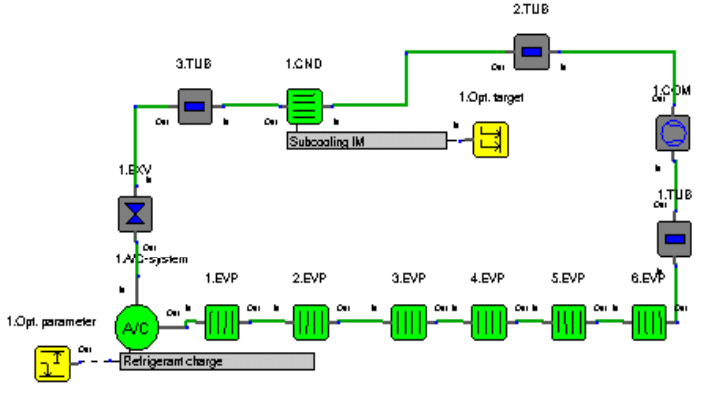
KULI Simulation Examples

HVAC System : HVAC System Performance Prediction at Idle Condition

- Effect of Condenser Refrigerant Flow Direction and Number of Passes on Evaporator Air Out Temperature, Head Pressure and Suction Pressure



Component Position on the Air Side



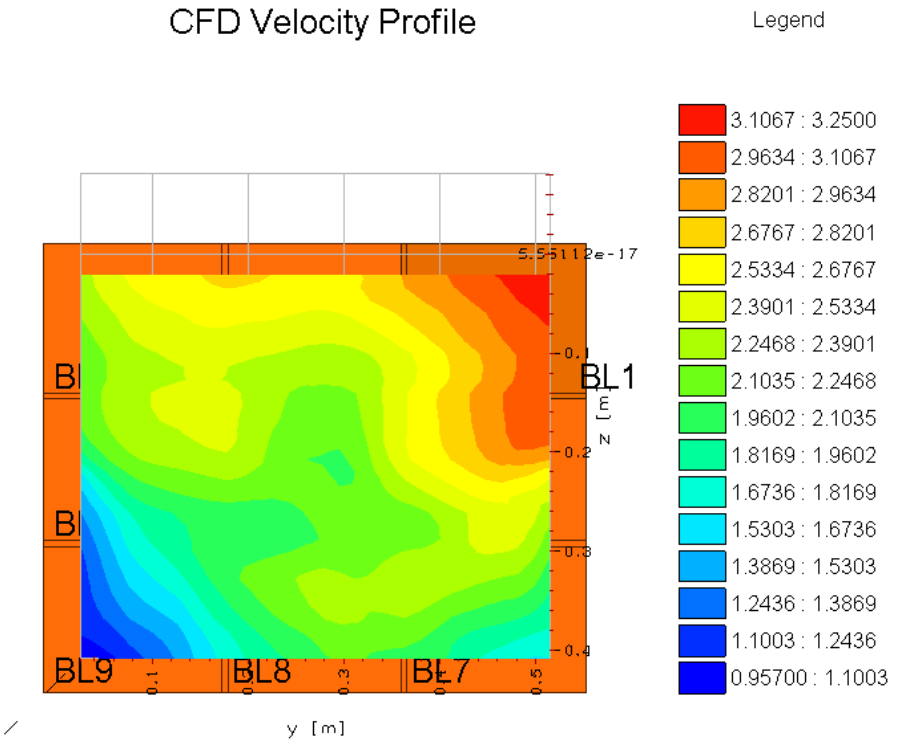
Component Position on the Refrigerant Side

Report made by Markus Kovac, MAGNA STEYR ECS; 2003

KULI Simulation Examples

HVAC System : HVAC System Performance Prediction at Idle Condition

- Condenser Was Subdivided Into Nine Segments Based on Measured Inlet Air Temperature
- Velocity Profile Predicted From CFD Simulation Was Used to Generate Resistance Matrix



128.6 °F	187.6 °F	134.1 °F
151.3 °F	154.2 °F	154.5 °F
161.1 °F	142.8 °F	145.6 °F

120 °F	120 °F	120 °F
140 °F	140 °F	140 °F
160 °F	160 °F	160 °F

100 °F	100 °F	100 °F
140 °F	140 °F	140 °F
180 °F	180 °F	180 °F

KULI Simulation Examples

HVAC System : HVAC System Performance Prediction at Idle Condition

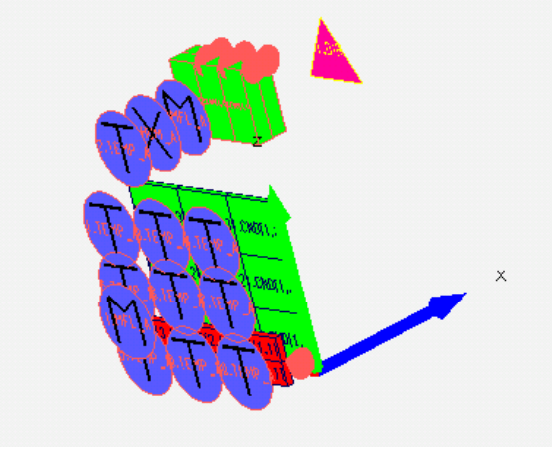
- Summary

		Evaporator Air Outlet Temp. °F	Compressor Head Pressure psi	Compressor Suction Pressure psi
4 Pass Condenser	TopDown	61.0	422.1	60.9
	BottomUp	60.8	417.7	60.9
2 Pass Condenser 3:1	TopDown	62.2	436.6	62.4
	BottomUp	62.1	433.7	62.4
2 Pass Condenser 1:1	TopDown	62.1	433.7	62.4
	BottomUp	61.7	430.8	62.4
4 Pass Condenser Temp.Distribution 1	TopDown	59.4	372.7	58.0
	BottomUp	58.8	362.6	58.0
4 Pass Condenser Temp.Distribution 2	TopDown	60.8	410.5	60.9
	BottomUp	57.9	343.7	56.6

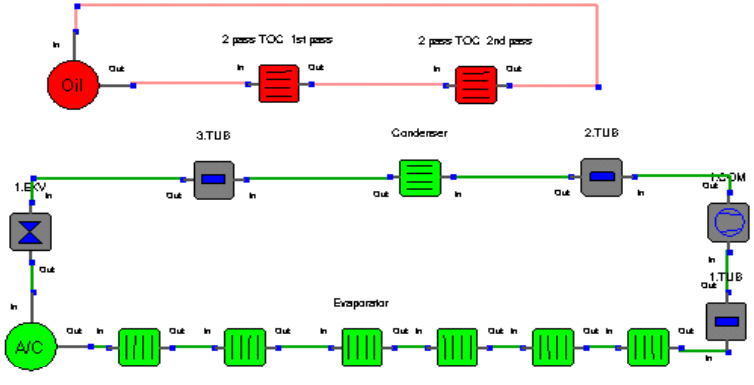
KULI Simulation Examples

HVAC System : HVAC System Performance Prediction at Idle Condition

- Effect of the Addition of a Transmission Oil Cooler in Front of Condenser on HVAC System Performance



Component Position on the Air Side



Refrigerant and Oil Circuit

Report made by Markus Kovac, MAGNA STEYR ECS; 2003

KULI Simulation Examples

HVAC System : HVAC System Performance Prediction at Idle Condition

- Summary

CND Refrigerant Flow Inside	Compressor					Condenser	HVAC		TOC	
	Speed	Head Pressure		Suction Pressure		Air Volume Flow CND	Pannel Outlet Temp.		Oil Inlet Temp.	
	rpm	psi	bar	psi	bar	cfm	°F	°C	°F	°C
TopDown	879.0	472.8	32.6	71.1	4.9	1167.0	68.0	20.0	305.6	152.0
BottomUp	879.0	433.7	29.9	66.7	4.6	1167.0	65.3	18.5	305.6	152.0
TopDown	1055.0	464.1	32.0	65.3	4.5	1400.0	64.2	17.9	301.6	149.8
BottomUp	1055.0	435.1	30.0	62.4	4.3	1400.0	61.7	16.5	301.6	149.8
TopDown	1230.0	458.3	31.6	60.9	4.2	1624.0	61.7	16.5	298.4	148.0
BottomUp	1230.0	435.1	30.0	59.5	4.1	1624.0	60.1	15.6	298.4	148.0
TopDown	1406.0	454.0	31.3	58.0	4.0	1862.0	60.1	15.6	294.8	146.0
BottomUp	1406.0	435.1	30.0	56.6	3.9	1862.0	59.0	15.0	294.8	146.0

KULI Simulation Examples

Robust Engineering : HVAC System Sensitivity (Work in Progress)

iSIGHT software

iSIGHT is a generic software shell that improves productivity in the design process

Why iSIGHT

Design Of Experiment (DOE)

Monte Carlo Simulation

Optimization

Multi-criteria Tradeoff Analysis

SixSigma Robust Design

Reliability Optimization

Taguchi Robust Design

Reliability analysis

KULI Simulation Examples

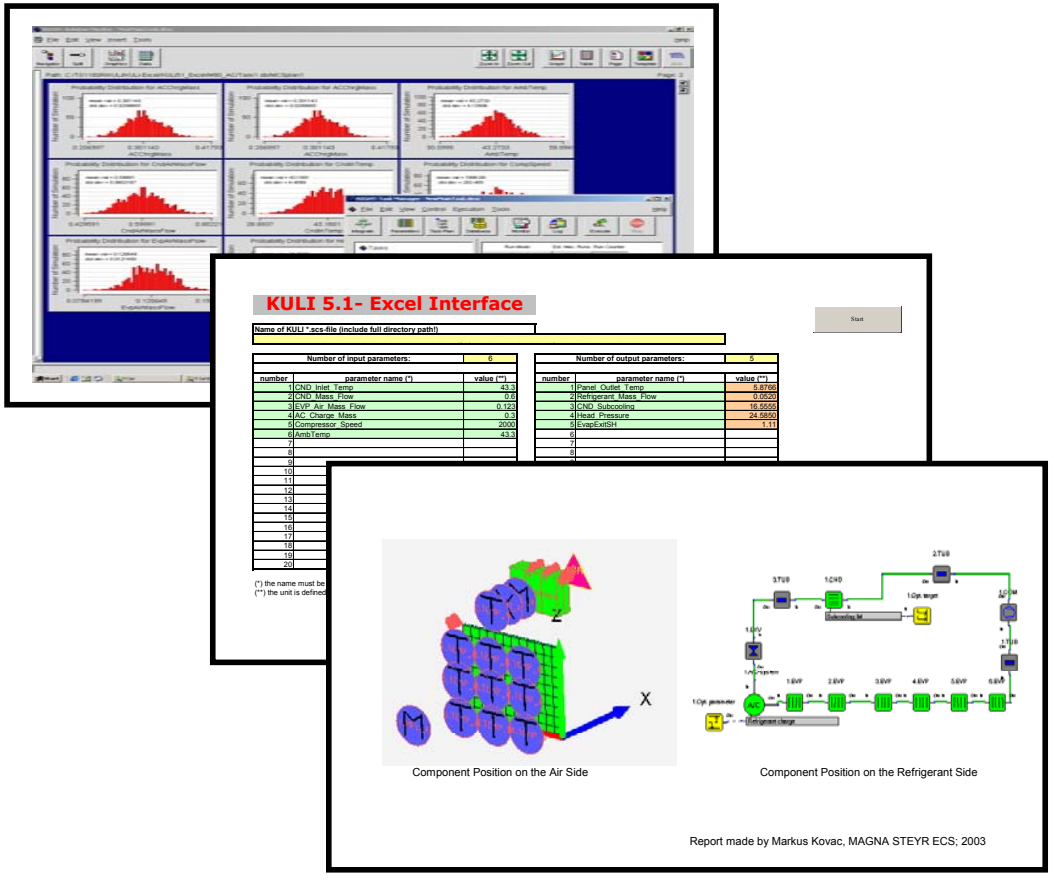
Robust Engineering : HVAC System Sensitivity (Work in Progress)

iSIGHT-Excel-KULI Co-simulation

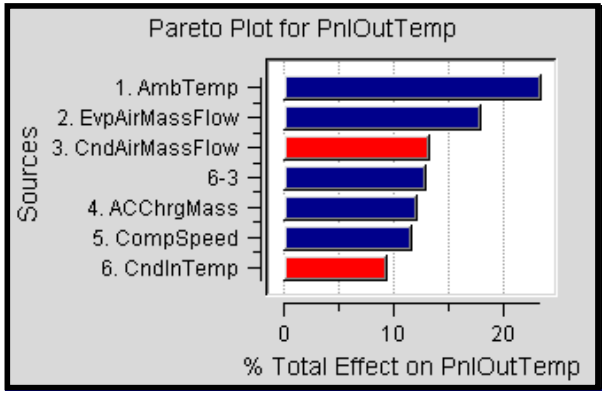
- Computer Model Based Sensitivity Analysis
- Component Sizing and Optimization
- Robust Engineering of HVAC System

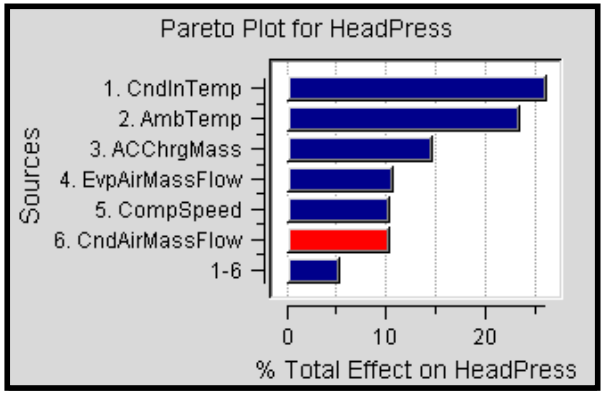
KULI Simulation Examples

Robust Engineering : HVAC System Sensitivity (Work in Progress)



Pareto Analysis





Suggestions

- Scope to Improve Inner Circuit - More Built-in Components
- Customization of Post-processing
- Help Establish KULI As the Media of Data Transfer Between OEMs and Its Component Manufacturers

Conclusions

- KULI Has Already Become an Integral Part of Chrysler Group Thermal and Fluid System Design Process
- More KULI Functionality Will Be Utilized in Future
- Chrysler Group Is Planning to Continue Close Working Relationship With KULI Development Team for the Enhancement of the Software