

MHD – MAHLE HVAC Designer Tool

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Outline

- The company
- Standardization + Automation
- HVAC Wizard: Automated Workflow
- MHD Tool:
 - Motivation & Requirements
 - Functionalities
- Conclusion



Employees: 77,000



More than 170 production locations in 34 countries and on five continents



Sales: EUR 12,3 billion (2016)



15 major development locations with around 6,000 development engineers and technicians in Germany, Great Britain, Luxembourg, Slovenia, the USA, Brazil, Japan, China and India

BUSINESS UNITS

Engine Systems and Components

BU1

Founded 1920



Filtration and Engine Peripherals

BU2



Thermal Management

BU3

MAHLE Behr GmbH
Founded 1905



Aftermarket

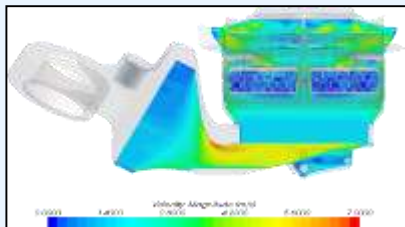
BU4



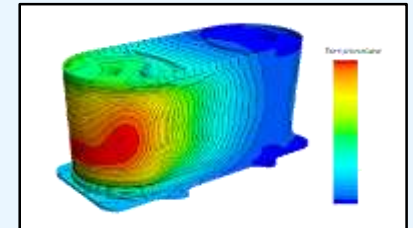
Automation of standardized simulation workflows helps to...

- ... ensure the compliance of the work to the guideline
 - ... reduce manual effort and tedious work
 - ... reduce errors
 - ... reduce lead time
 - ... work collaborative in a global world
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- **Multiple automated workflows for most of the standard products available**

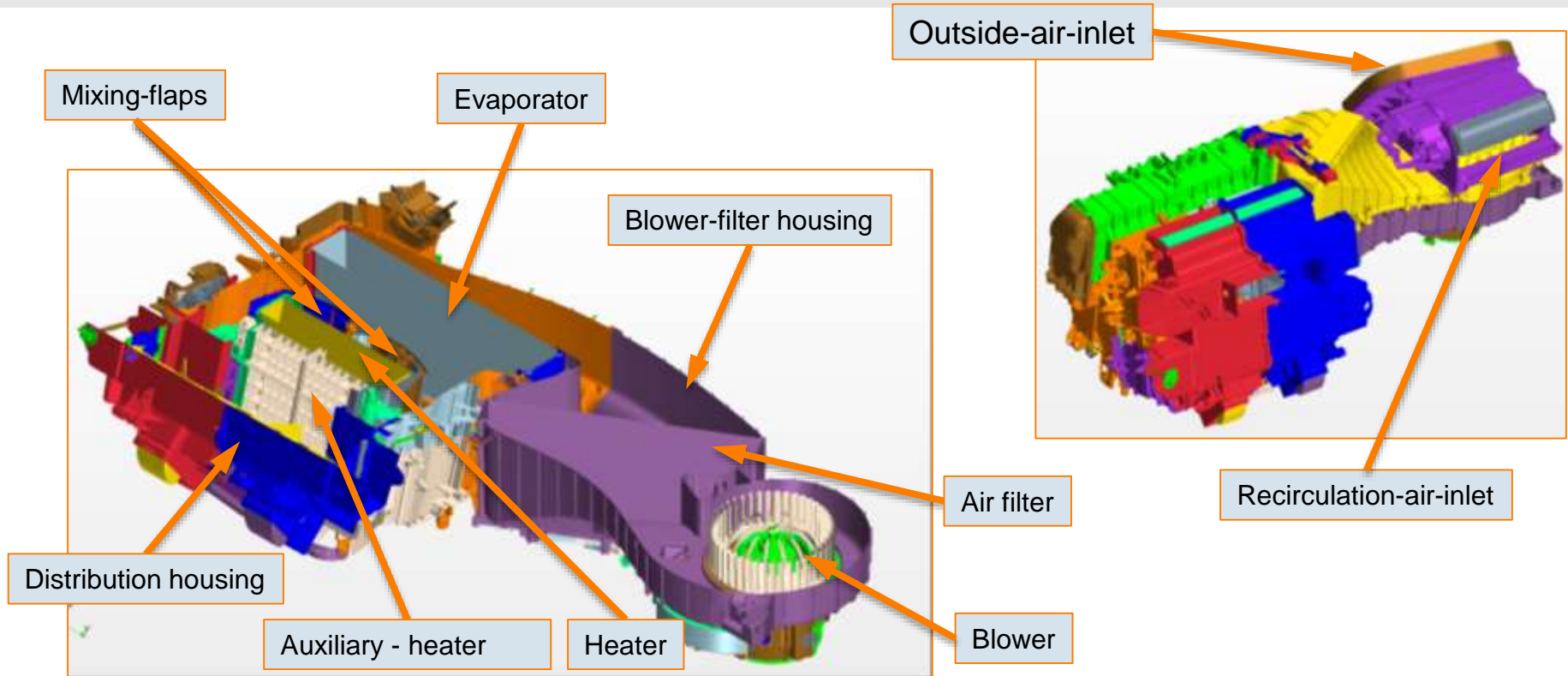
Air Conditioning HVAC Wizard

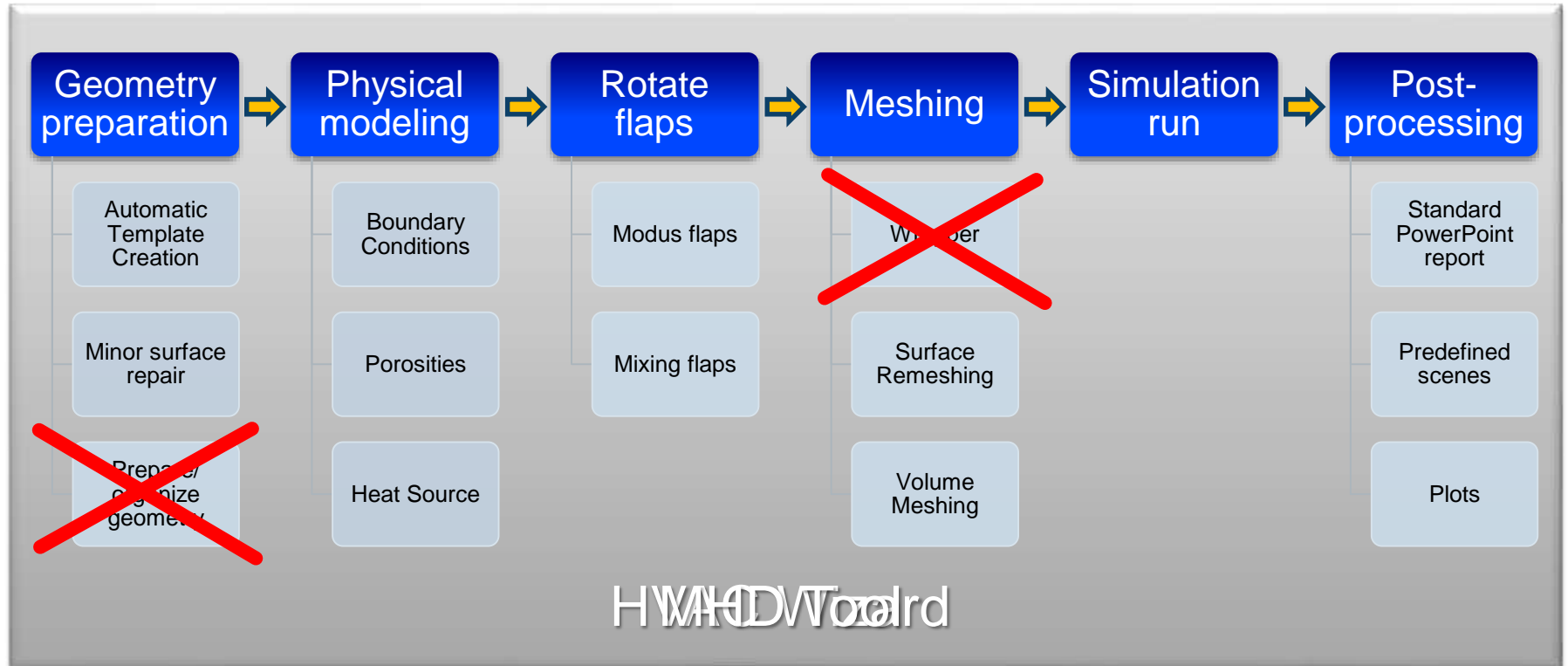


Engine Cooling HEEX Wizard



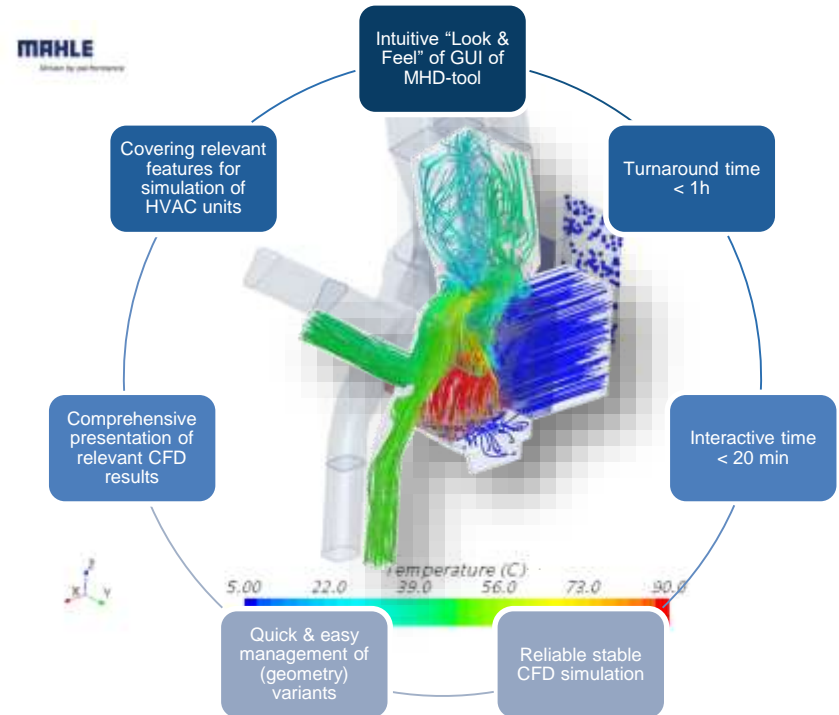
Structure of an HVAC unit





Motivation & Requirements

- Tool for quick HVAC concept evaluation in early development phases – objectives:
 - Mass flow distribution
 - Temperature distribution at outlets
 - Overall pressure drop
 - Flow distribution / homogeneity
- Easy to use for non CFD engineers
- Requirements =>

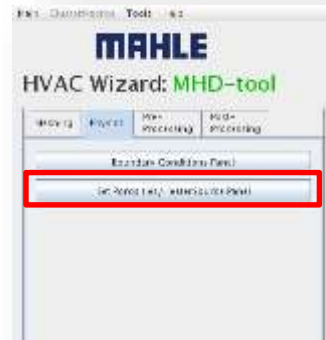


- MHD Tool is part of the HVAC Wizard:
=> customized GUI for three different CFD workflows
- Installed as a STAR-CCM+ plug-in and available as a menu-bar in the STAR-CCM+ toolbar
- Fully developed by MAHLE Behr
 - Compatible with STAR-CCM+ V11.06
 - > 60 Java source files
 - > 700 subversioning revisions
 - > 30 releases



Set-up – Heat Exchanger

- HVAC units contain at least an evaporator and a heater core
=> heat exchanger with complex detailed geometries
=> cannot be modeled for CFD in detail
- Heat exchanger modeled as porous block
- Characteristic of heat exchanger (pressure drop and heat source) are modeled by psi-functions and Nu-functions
- Porosities and Heat Source Panel:
library with parameter of standard MAHLE Behr heat exchanger



Porosities and Heat Source Panel Import Export

Load External HX-Library Reset to Default HX-Library

Default HX-Library: /com/mahle/hvac/utills/resources/hx_lib.xml

HX-Pressure Drop | **HX-Heat Source** | **Outlets-Pressure Drop**

Region:

HX-library:

HX-info:

- manual-input
- HX_MB_STANDARD_Evaporator_SQ9_RB3**
- HX_MB_STANDARD_Evaporator_SQ11_RB3
- HX_MB_STANDARD_Evaporator_SQ7_RB2.5
- HX_38mm_TC_16FPI
- HX_47mm_MT_14FPI
- HX_58mm_MT_14FPI

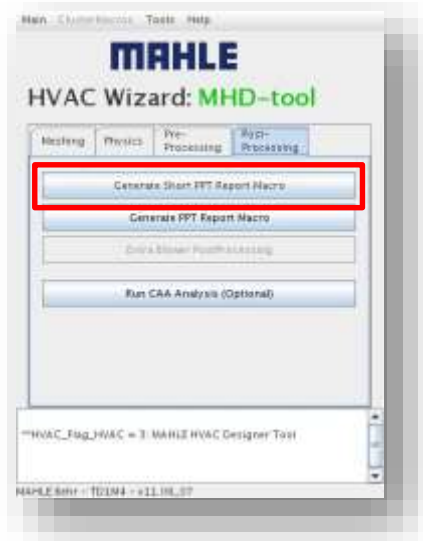
alpha (kg/m⁴) be

x	264.029357	716.223389	0.07	0.65
y	10000.000000	10000.000000		
z	10000.000000	10000.000000		

Export Dimensions Apply

Post-Processing – Short Report

- The Short Report contains at a glance all relevant information and results of the simulation.



Simulation Path Name:
Date/Time of Simulation: Tue Jun 06 17:01:59 CEST 2017
STAR-CCM+ Version: 11.06.010
HVAC Wizard Version: v11.06_07

Inputs

Boundaries

inlet	Mass Flow inlet 41.510 CFM
Duct_Out_panelIn_d_Sout	Pressure Outlet 0.0 Pa / K = 7.38
Duct_Out_detroit_D_Sout	Pressure Outlet 0.0 Pa / K = 1.36
Duct_Out_panelSide_D_Sout	Pressure Outlet 0.0 Pa / K = 15.07
Duct_Out_foortent_D_Sout	Pressure Outlet 0.0 Pa / K = 2.7
Duct_Out_foorear_D_Sout	Pressure Outlet 0.0 Pa / K = 4.00

Heat-Exchangers

Evaporator	HX_MB_
Heater	HX_MB_

Physics/Mesh

Physics: energy
Base size - mm

Outputs

Solution parameters

Number of iterations: 504

Pressure drop

Static pressure at inlet: 141.973 Pa

Outlet conditions

Name	Avg Temp (°C)	Max Temp (°C)	Min Temp (°C)	Mass Flow (%)
Duct_Out_panelIn_d_Sout	27.254	35.046	22.482	12.367
Duct_Out_detroit_D_Sout	40.503	42.757	37.599	10.255
Duct_Out_panelSide_D_Sout	30.584	31.751	29.617	6.992
Duct_Out_foortent_D_Sout	44.923	46.081	42.875	42.322
Duct_Out_foorear_D_Sout	49.545	49.905	49.187	26.063

Homogeneity

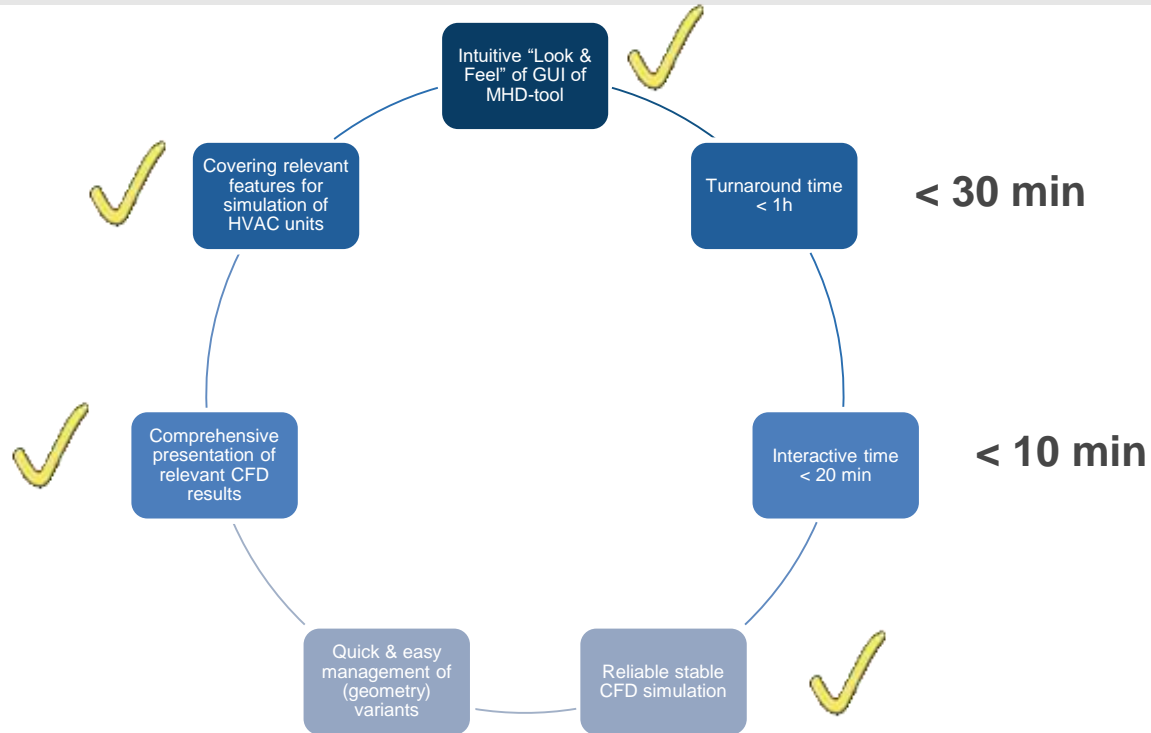
Comp001_Evaporator1_in_vmin	0.616 m/s
Comp001_Evaporator1_in_vmax	0.791 m/s
Comp001_Evaporator1_in_homogeneity	0.982
Comp04_Heater_in_vmin	0.204 m/s
Comp04_Heater_in_vmax	0.752 m/s
Comp04_Heater_in_homogeneity	0.968

Air flow through Heater

Comp04_Heater	45.069 %
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3D Temperature Visualization: 30.000 to 48.125 °C

Requirements – Status of Tool Development



there is always space for improvements...

Conclusion

- The MHD-tool is now an integral part of the HVAC Wizard.
- All requirements are fulfilled.
- It was rolled-out and is used in one R&D location by HVAC Developers.
- Roll-out in further R&D locations in progress.

Further improvements

- Decrease of turnaround time.
- Improvement of applicability.
- Simplification of handling of geometry variants.

Thank you for your attention!