ASM Diesel Exhaust Light

Reference

For ASM Diesel Exhaust Light Blockset 2.1.12

Release 2021-A – May 2021

dSPACE

How to Contact dSPACE

Mail:	dSPACE GmbH Rathenaustraße 26 33102 Paderborn Germany
Tel.:	+49 5251 1638-0
Fax:	+49 5251 16198-0
E-mail:	info@dspace.de
Web:	http://www.dspace.com

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Important Notice

Contents

About This Reference

Content

This reference introduces you to the features provided by the ASM Diesel Exhaust Light model. It describes the structure and parts of the model, its physical background, and the data required for parameterization.

Symbols

dSPACE user documentation uses the following symbols:

Symbol	Description
DANGER	Indicates a hazardous situation that, if not avoided, will result in death or serious injury.
WARNING	Indicates a hazardous situation that, if not avoided, could result in death or serious injury.
CAUTION	Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.
NOTICE	Indicates a hazard that, if not avoided, could result in property damage.
Note	Indicates important information that you should take into account to avoid malfunctions.
Tip	Indicates tips that can make your work easier.
	Indicates a link that refers to a definition in the glossary, which you can find at the end of the document unless stated otherwise.
	Precedes the document title in a link that refers to another document.

Naming conventions

dSPACE user documentation uses the following naming conventions:

%name% Names enclosed in percent signs refer to environment variables for file and path names.

< > Angle brackets contain wildcard characters or placeholders for variable file and path names, etc.

Special folders

Some software products use the following special folders:

Common Program Data folder A standard folder for application-specific configuration data that is used by all users.

`%PROGRAMDATA%\dSPACE\<InstallationGUID>\<ProductName>`

or

`%PROGRAMDATA%\dSPACE\<ProductName>\<VersionNumber>`

Documents folder A standard folder for user-specific documents.

`%USERPROFILE%\Documents\dSPACE\<ProductName>\<VersionNumber>`

Local Program Data folder A standard folder for application-specific configuration data that is used by the current, non-roaming user.

`%USERPROFILE%\AppData\Local\dSPACE\<InstallationGUID>\<ProductName>`

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dSPACE Help (local) You can open your local installation of dSPACE Help:

- On its home page via Windows Start Menu
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PDF files You can access PDF files via the icon in dSPACE Help. The PDF opens on the first page.

Overview of the Diesel Exhaust Library

Where to go from here

Information in this section

Diesel Exhaust Library

Introduction

Exhaust systems that contain a diesel oxidation catalyst (DOC) and a diesel particulate filter (DPF) are popular forms of aftertreatment in diesel engines. A DOC reduces CO and unburned hydrocarbons, and a DPF reduces the particulates (soot).

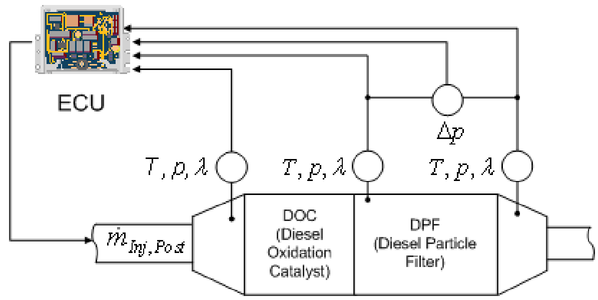
The simulated DPF is what is called a wall-flow filter, also known as a closed system. A wall-flow filter needs the burning of the soot (regeneration) to reduce exhaust back pressure and maintain correct DPF function. The regeneration of the DPF depends on the temperature in it. Good soot oxidation takes place at temperatures higher than 650 °C. Diesel engines usually have low exhaust temperatures, so regeneration has to be forced.

This can be achieved by:

- Increasing the temperature. To increase the temperature, post-injection fuel is usually burnt in the DOC, which also increases the temperature in the DPF.

- Reducing the optimum temperature for regeneration. This can be done by using a chemical catalyst in the DPF or by introducing an additive that is fed into the diesel fuel from a separate tank.

The following illustration shows a simplified schematic for a combination of DOC and DPF including sensors and an ECU.

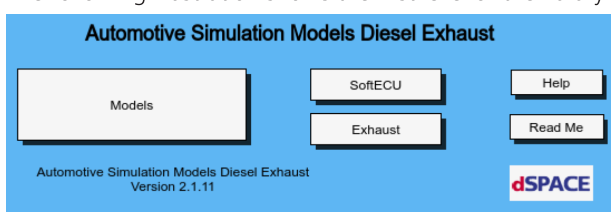


Opening the library

You can open the library in MATLAB/Simulink. Refer to How to Open an ASM Library (ASM Diesel Engine Model Description 📖) or How to Open an ASM Library (ASM Diesel Engine InCylinder Model Description 📖).

Contents

The following illustration shows the first level of the library.



SoftECU The SoftECU subsystem contains blocks that are empty frames without functionality because the light library only offers limited functionality.

Exhaust The Exhaust subsystem contains all the Simulink blocks necessary to model the Diesel exhaust system. Refer to Exhaust on page 11.

Models The Models subsystem contains ready-to-use demo models that you can use to start modelling. Refer to Models on page 31.

Light Version

Introduction

The currently installed *light* version of the ASM DieselExhaust Library only offers a limited functionality.

Blocks

The following blocks are only empty frames without functionality.

- SCR_CATALYST_5_0
- UREA_DECOMPOSITION_4_0
- SCR_CATALYST
- UREA_DECOMPOSITION
- SCR_INJECTION_VALVE_CONTROL_1_0
- SCR_PUMP_HOSE_CONTROL_1_0
- SCR_AIR_PATH_CONTROL
- SCR_HEATER_CONTROL
- SCR_INJECTION_VALVE_CONTROL
- SCR_PUMP_HOSE_CONTROL

Exhaust

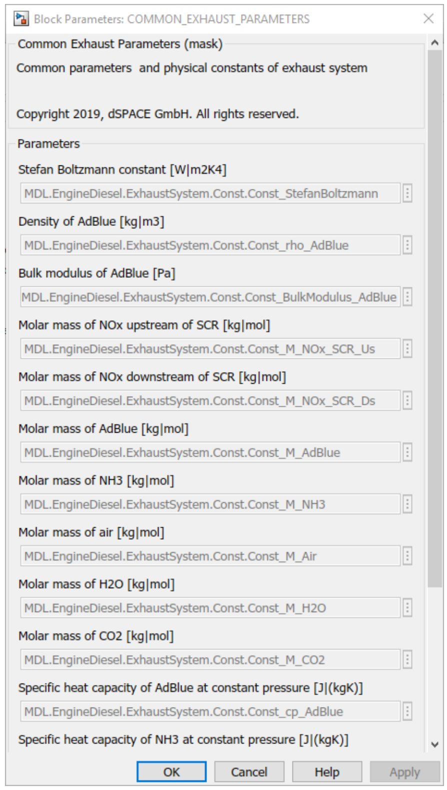
Where to go from here

Information in this section

Common Exhaust Parameters

Description

Parameters that are used several times in the exhaust model are collected in the COMMON_EXHAUST_PARAMETERS subsystem. This provides central online access to all the parameters. If one of these parameters is modified, this affects all the parts of the model that use it online and offline. These parameters are set via masked subsystems (see illustration below) using MATLAB structures.



The COMMON_EXHAUST_PARAMETERS block also uses some parameters from the COMMON_ENGINE_PARAMETERS block when necessary (calculation of dependent parameters or unit conversion, for instance).

To modify the value of a common parameter, change <Structure>.v using the MATLAB Command Window.

Tip

If you want to save the modification for the next start, you should revise the initialization file providing the parameter you want to change (asm_enginediesel_ini.m in our case). It is recommended that you use ModelDesk to modify your parameters and regenerate your initialization files.

For detailed information on parameterization using ModelDesk, refer to ModelDesk Parameterizing 🕮.

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_BulkModulus_AdBlue	[Pa]	Bulk modulus of AdBlue
Const_cp_AdBlue	[J/(kg K)]	Specific heat capacity of AdBlue at constant pressure
Const_cp_Exh	[J/(kg K)]	Specific heat capacity of exhaust gas at constant pressure
Const_cp_NH3	[J/(kg K)]	Specific heat capacity of ammonia (NH_3) at constant pressure
Const_M_AdBlue	[kg/mol]	Molar mass of AdBlue [(NH_2)2 * CO * 7H_2O]
Const_M_Air	[kg/mol]	Molar mass of air
Const_M_CO2	[kg/mol]	Molar mass of carbon dioxide (CO_2)
Const_M_H2O	[kg/mol]	Molar mass of water (H_2O)
Const_M_NH3	[kg/mol]	Molar mass of ammonia (NH_3)
Const_M_NOx_SCR_Ds	[kg/mol]	Mean molar mass of NOx downstream of SCR catalyst
Const_M_NOx_SCR_Us	[kg/mol]	Mean molar mass of NOx upstream of SCR catalyst
Const_cp_CO2	[J/(kg K)]	Specific heat capacity of CO_2 at constant pressure
Const_cp_Exh	[J/(kg K)]	Specific heat capacity of exhaust gas at constant pressure
Const_cp_H2O	[J/(kg K)]	Specific heat capacity of water steam at constant pressure
Const_rho_AdBlue	[J/(kg K)]	AdBlue heat capacity
Const_StefanBoltzmann	[W/(m^2 K^4)]	Stefan Boltzmann constant

Related topics

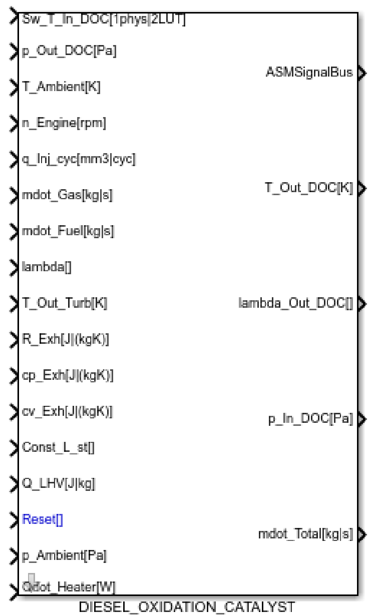
References

Common Exhaust Parameters (ModelDesk Parameterizing 📖)
Exhaust Parameters Diesel (ModelDesk Parameterizing 📖)
History of the COMMON_EXHAUST_PARAMETERS Block (ASM Diesel Exhaust Reference 📖)

Diesel Oxidation Catalyst

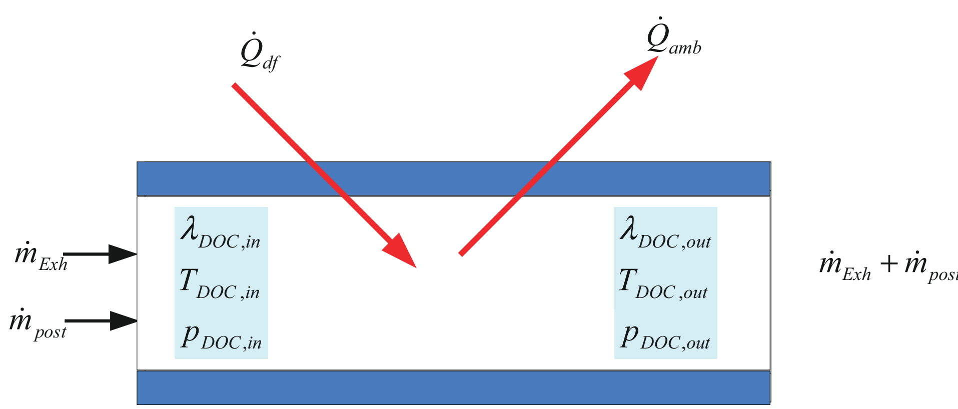
Description

The diesel oxidation catalyst is used to oxidize carbon monoxide and hydrocarbon. Also, it can be used as a catalytic heater to increase the temperature of exhaust gas by oxidation of CO and hydrocarbons. To increase the temperature of exhaust gas, a fuel injection downstream of the engine can be introduced. This fuel quantity does not contribute to torque balance. Thus, two heat sources are considered in the energy balance around DOC: Enthalpy change of exhaust gas between inlet and outlet with the respective mass flow (engine leaving mass flow – EGR mass flow) and energy release from the combustion of post-injected fuel (or the fuel mass flow bypassing the exhaust valves). Several sensors measure the lambda values, pressures, and temperatures before and after the DOC for exhaust gas treatment.



The DIESEL_OXIDATION_CATALYST block simulates the lambda values, temperatures and pressures of the DOC according to energy balance and ideal gas equation.

The following schematic shows the physical structure represented by the model.



The DOC model is based on the following assumptions:

1. Fuel entering the DOC is fully vaporized in the exhaust pipe.
2. The temperature of the DOC is equal to the exhaust gas temperature exiting the DOC.
3. The exhaust gas density is the density at the entrance of DOC.

If the map-based turbocharger model is used, the temperature at the DOC entrance comes from a map function of the engine operating point and is filtered using a first order transfer function:

$$T_{DOC,in} = f\left(n_{Eng}, q_{inj}\right)$$

If the physical turbocharger model is used, the temperature is the turbine outlet temperature.

The DOC outlet pressure is provided as input for the model and the inlet pressure is obtained using the following equation:

$$P_{DOC,in} = P_{DOC,out} + \Delta p_{Exh,DOC}$$

The pressure drop across the DOC was simplified as a function of the inlet temperature and volumetric flow at the input of the DOC:

$$\Delta p_{Exh,DOC} = f\left(T_{In,DOC}, \dot{V}_{In,DOC}\right)$$

The exhaust gas temperature exiting the DOC and the DOC temperature itself can be calculated from the energy balance equation:

[energy change of DOC] = [energy release from the combustion of post-injection quantity] - [Enthalpy change of exhaust between inlet and outlet] - [heat loss to the surrounding]

$$\left(p_{DOC}\, c_{DOC}\, V_{DOC} + p_{exh,DOC}\, c_{v,exh}\, V_{exh,DOC}\right)\frac{dT}{dt} = \dot{Q}_{post} - \dot{m}_{exh}\, c_{p,exh}\left(T - T_{DOC,in}\right) - \dot{Q}_{amb,DOC}$$

$p_{DOC}\, c_{DOC}\, V_{DOC}$ can be simplified as the internal heat capacity of the DOC.

The total energy released from the combustion of the post-injection quantity $\dot{Q}_{post}$ can be calculated from the fuel post-injection mass flow and the heat of combustion of the fuel.

$$\dot{Q}_{post} = \dot{m}_{post}(LHV)\,\eta_{con}/100$$

where LHV is the lower heating value (43949.4 kJ/kg) of the fuel and η_{con} the hydrocarbon conversion efficiency as a function of temperature at the inlet of DOC.

The calculation of heat loss to surroundings $\dot{Q}_{amb,DOC}$ is defined as follows:

$$\dot{Q}_{amb,DOC} = \frac{T - T_{amb}}{R_{th,DOC}}$$

where $R_{th,DOC}$ is the thermal resistance of the DOC.

The fuel and intake air mass flows are calculated from the exhaust gas mass flow and lambda value.

$$\lambda_{DOC,in} = \frac{\dot{m}_{air}}{14.6\left(\dot{m}_{fuel} - \dot{m}_{post}\right)}$$

$$\dot{m}_{Exh} = \dot{m}_{air} + \dot{m}_{fuel} = \frac{\dot{m}_{air}}{14.6\,\lambda_{DOC,in}} + \dot{m}_{post} + \dot{m}_{air}$$

$$\dot{m}_{air} = \frac{\dot{m}_{Exh} - \dot{m}_{post}}{\frac{1}{14.6\,\lambda_{DOC,in}} + 1}$$

$$\dot{m}_{fuel} = \dot{m}_{Exh} - \dot{m}_{air}$$

The lambda calculation is given by:

$$\lambda_{DOC,out} = \frac{\dot{m}_{air}}{14.6\,\dot{m}_{fuel}}$$

The exhaust density is calculated in the outlet state.

$$\rho_{exh,DOC} = \frac{p_{DOC,out}}{R_g\,T_{DOC,out}}$$

Inports

The following table shows the inports.

Name	Unit	Description
Const_L_st	[]	Stoichiometric ratio
cp_Exh	[J/(kg K)]	Specific heat capacity at constant pressure of exhaust gas
cv_Exh	[J/(kg K)]	Specific heat capacity at constant volume of exhaust gas
lambda	[]	Lambda value after combustion process
mdot_Fuel	[kg/s]	Post-injection mass flow
mdot_Gas	[kg/s]	Exhaust mass flow, excluding post-injection (exhaust gas flow)
n_Engine	[rpm]	Engine speed
p_Ambient	[Pa]	Ambient pressure
p_Out_DOC	[Pa]	Pressure at DOC outlet
q_Inj_cyc	[mm^3/cyc]	Mean fuel injection quantity per cylinder, excluding post-injection
Q_LHV	[J/kg]	Lower heat value of fuel
Qdot_Heater	[W]	Heat flow of the external heat source
Reset	[]	Reset all integrators to their initial conditions
R_Exh	[J/(kg K)]	Gas constant of exhaust gas
Sw_T_In_DOC	[1|2]	Switch for mode: ▪ 1: Temperature calculated from physical properties ▪ 2: Temperature from look-up table
T_Ambient	[K]	Ambient temperature
T_Out_Turb	[K]	Turbine outlet temperature

Outports

The following table shows the outports.

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 🕮).

Name	Unit	Description
lambda_Out_DOC	[]	Lambda value at DOC outlet
mdot_Total	[kg/s]	Total exhaust gas mass flow out of DOC
p_In_DOC	[Pa]	Pressure at DOC inlet
T_Out_DOC	[K]	Outlet temperature of DOC

Parameters

The following table shows the parameters.

Name	Unit	Description
Const_Cap_IntHeat_DOC	[J/K]	Internal heat capacity of DOC
Const_Conduct	[W/K]	Thermal conductivity coefficient to the environment in volume before DOC
Const_lambda_UpLim	[]	Upper limit of lambda value
Const_m_Heater	[kg]	Heating mass before DOC
Const_num_ExhSys	[]	Number of diesel oxidation catalysts
Const_Res_Thermal_DOC	[K/W]	Thermal resistance of DOC
Const_T_Out_DOC_Init	[K]	Initial temperature at outlet of DOC
Const_T_Out_DOC_LowLim	[K]	Lower limit of the temperature at DOC outlet
Const_T_Out_DOC_UpLim	[K]	Upper limit of the temperature at DOC outlet
Const_t_PT1_p_In_DOC	[s]	First order time constant for DOC pressure drop
Const_t_PT1_Qdot_Post_DOC	[s]	First order time constant for post-injection heat release
Const_t_PT1_T_In_DOC	[s]	First order time constant for delay of temperature before DOC
Const_t1_PT2_lambda_In_DOC	[]	Time constant 1 of the lambda sensor before DOC
Const_t2_PT2_lambda_In_DOC	[]	Time constant 2 of the lambda sensor before DOC
Const_V_Exhaust_DOC	[m^3]	Exhaust volume in DOC
Map_eta_Oxidation	[%]	Oxidation efficiency of post-injection in DOC as a function of temperature
Map_p_Drop_DOC	[Pa]	Pressure drop map of DOC as a function of inlet temperature and volumetric flow at the inport
Map_T_In_DOC	[°C]	Temperature map before DOC = f(n_Engine, q_Inj_1cyl)

Related topics

References

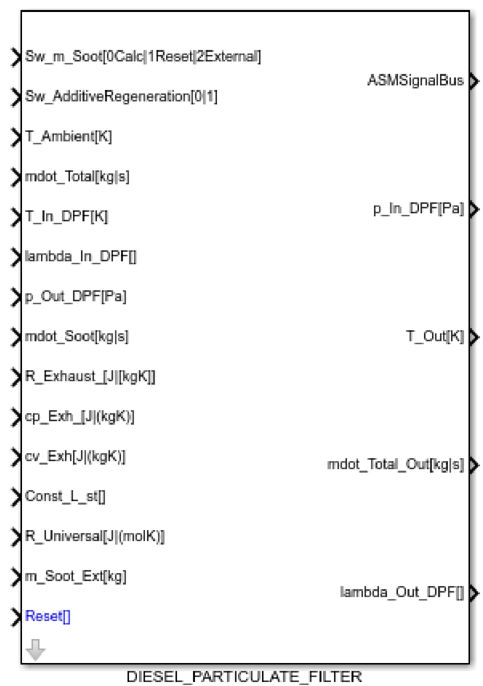
Diesel Oxidation Catalyst (ModelDesk Parameterizing 🕮)
Diesel Oxidation Catalyst V10 (ModelDesk Parameterizing 🕮)
Diesel Oxidation Catalyst V4 (ModelDesk Parameterizing 🕮)
History of the DIESEL_OXIDATION_CATALYST Block........ 39

Diesel Particulate Filter

Description

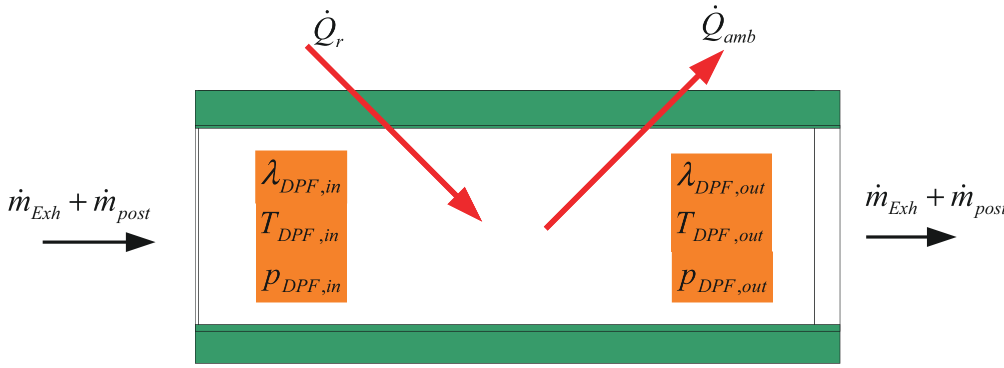
The simulated diesel particulate filter (DPF) is a wall-flow filter, also called a closed system. The soot in the exhaust is trapped in the DPF by filtering. To reduce exhaust back pressure and to maintain correct DPF operation, the soot has to be burned (regeneration).

The regeneration of the DPF depends on the temperature in the DPF. Basically, good oxidation of soot takes place at temperatures higher than 650 °C. There are several ways of reducing this temperature, such as incorporating a catalyst material directly into the filter system or adding a fuel-borne catalyst to the fuel. Due to the usually low exhaust temperatures in diesel engines, a temperature increase is sometimes necessary to activate regeneration. This is usually done by burning injected additional fuel in the DOC (by late post-injection or an extra injector in the exhaust pipe). This increases the temperature in the DPF.



The DIESEL_PARTICULATE_FILTER block simulates the lambda values, temperatures and pressures of the DPF according to energy balance, ideal gas equation, and Arrhenius equations.

The following schematic shows the physical structure represented by the model.



The following assumptions are made for the DPF model:

- The oxidation of particulate material in the filter wall is negligible.
- There is no mass transfer from the cake layer into the filter wall once the wall is filled with particulate matter.
- There is no ash accumulation in the DPF.
- The soot layer undergoes only thermal oxidation, not catalytic oxidation.
- Layer thickness is uniform along the length of the trap.
- The temperature and pressure values at the DOC outlet are used as inlet values of the DPF.

$$p_{DOC,\,out} = p_{DPF,\,in}, T_{DOC,\,out} = T_{DPF,\,in}$$

$$p_{DPF,\,in} = p_{DPF,\,out} + |\Delta p_{DPF}|$$

The calculations are based on the energy balance.

$$(m_{soot}\, c_{soot} + p_{DPF}\, c_{DPF}\, V_{DPF} + p_{exh,\,DPF}\, c_{v,\,exh}\, V_{exh,\,DPF})\frac{dT}{dt} = \dot{Q}_r$$
$$- \dot{m}_{exh}\, c_{p,\,exh}(T - T_{DPF,\,in}) - \dot{Q}_{amb,\,DPF}$$

$p_{DPF}\, c_{DPF}\, V_{DPF}$ can be simplified as the internal heat capacity of the DPF.

The calculation of heat loss to surroundings $\dot{Q}_{amb,\,DPF}$ is defined as follows:

$$\dot{Q}_{amb,\,DPF} = \frac{T - T_{amb}}{R_{th,\,DPF}}$$

where $R_{th,\,DPF}$ is the thermal resistance of DPF.

$\dot{Q}_r$ is the heat release from soot oxidation and is calculated in the following way:

$$\dot{Q}_r = RR_{th}\, \Delta H_{th}\, m_{soot}$$

$$\Delta H_{th} = f_{CO}\, \Delta H_{CO} + (1 - f_{CO})\, \Delta H_{CO_2}$$

where ΔH_{th} is the soot enthalpy.

RR_{th} is the soot oxidation rate, which is determined using oxygen concentration and temperature.

$$RR_{th} = A_p \, y_{O_2} \, e^{-\left(\frac{E_p}{RT}\right)}$$

Oxygen concentration is related to the air/fuel ratio.

$$y_{O_2} = \frac{14.6{*}1.198950\,\lambda - 18}{14.6{*}5.8\,\lambda + 6}$$

The soot mass is calculated by mass balance.

$$\frac{dm_{soot}}{dt} = -RR_{th} \cdot m_{soot} + \dot{m}_{deposit}$$

$$\dot{m}_{deposit} = MAP\left(n_{Eng}, q_{inj}\right)$$

The pressure drop over the DPF is a function of the soot mass present in the DPF and the volume flow at the inlet of the DPF:

$$\Delta\, p_{DPF} = f\left(m_{soot}, \dot{V}_{In,\,DPF}\right)$$

Note

Simulating with the DIESEL_PARTICULATE_FILTER block requires some initialization time. To avoid the real-time process being stopped by this singular task overrun, it is recommended to allow a number of queued task calls before the simulation is stopped. Refer to Model Preparation for Real-Time Simulation (PHS-Bus-Based Platforms) (ASM Diesel Engine Model Description 📖).

Inports

The following table shows the inports:

Name	Unit	Description
Const_L_st	[]	Stoichiometric ratio
cp_Exh	[J/(kg K)]	Specific heat capacity at constant pressure of exhaust gas
cv_Exh	[J/(kg K)]	Specific heat capacity at constant volume of exhaust gas
lambda_In_DPF	[]	Lambda value at DPF inlet
m_Soot_Ext	[kg]	External soot mass input
mdot_Total	[kg/s]	Total exhaust gas mass flow into DPF
mdot_Soot	[kg/s]	Soot mass flow (raw emission)
p_Out_DPF	[Pa]	Outlet pressure of DPF
Reset	[]	Reset all integrators to their initial conditions
R_Exhaust	[J/(kg K)]	Gas constant of exhaust gas
R_Universal	[J/(mol K)]	Universal gas constant
Sw_AdditiveRegeneration	[]	Switch for mode: ▪ 0: DPF regeneration without additive ▪ 1: DPF regeneration with additive
Sw_m_Soot	[]	Switch for soot mass state: ▪ 0: Enable soot accumulation in DPF

Name	Unit	Description
		▪ 1: No soot accumulation in DPF (set to initial soot mass) ▪ 2: No soot accumulation in DPF (set to external soot mass m_Soot_Ext)
T_Ambient	[K]	Ambient temperature
T_In_DPF	[K]	Temperature at DPF inlet

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
lambda_Out_DPF	[]	Lambda downstream of DPF
mdot_Exh_Out	[kg/s]	Exhaust mass flow
p_In_DPF	[Pa]	Pressure at DPF inlet
T_Out	[K]	Temperature at DPF outlet

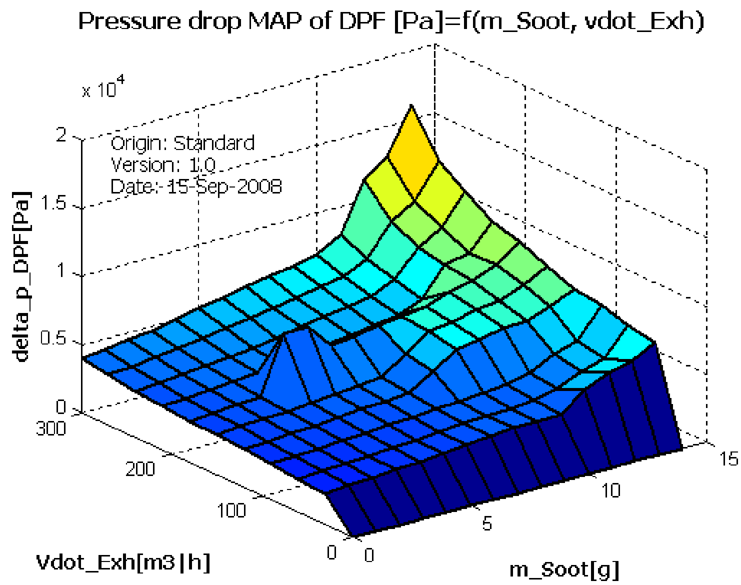
Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Ap_Catalytic_Offs	[1/s]	Offset of soot oxidation frequency_Factor (Ap) for catalytic DPF
Const_Ap_Soot	[1/s]	Thermal frequency factor of soot oxidation
Const_Cap_IntHeat_DPF	[J/K]	Internal heat capacity of DPF
Const_Cap_SootHeat	[J/(kg K)]	Soot heat capacity
Const_Ep_Soot	[J/mol]	Thermal activation energy of soot oxidation
Const_H_Soot	[kJ/kg]	Soot enthalpy
Const_m_Soot_DPF_Init	[g]	Initial soot mass in DPF
Const_num_ExhSys	[]	Number of diesel particulate filters
Const_Res_Thermal_DPF	[K/W]	Thermal resistance of DPF
Const_T_Out_DPF_Additive_Offs	[°C]	Temperature of DPF offset for additive regeneration
Const_T_Out_DPF_UpLim	[K]	Upper limit of the temperature at outlet of DPF
Const_T_Out_DPF_LowLim	[K]	Lower limit of the temperature at outlet of DPF
Const_t_PT1_p_In_DPF	[s]	First-order time constant for DPF pressure drop
Const_t_PT1_p_In_DPF	[s]	PT1 constant for DPF pressure drop
Const_t_PT1_SootOxidation	[s]	First-order time constant for soot oxidation in DPF
Const_t1_PT2_lambda_Out_DPF	[]	Time constant 1 of the lambda sensor after DPF
Const_t2_PT2_lambda_Out_DPF	[]	Time constant 2 of the lambda sensor after DPF
Const_V_Exhaust_DPF	[m^3]	Exhaust volume in DPF
Map_p_Drop_DPF	[Pa]	Pressure drop map of DPF

Processing Information

The pressure drop over the DPF is defined by the following map that is determined by the soot mass in the DPF and the exhaust volume flow. You must provide the map yourself.



Related topics

Basics

Generating a Real-Time Application for PHS-Bus Based Platforms (ASM Diesel Engine InCylinder Model Description 📖)
Model Preparation for Real-Time Simulation (PHS-Bus-Based Platforms) (ASM Diesel Engine Model Description 📖)

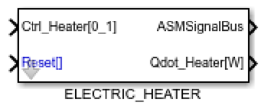
References

Diesel Particulate Filter (ModelDesk Parameterizing 📖)
Diesel Particulate Filter Engine (ModelDesk Parameterizing 📖)
Diesel Particulate Filter V3 (ModelDesk Parameterizing 📖)

Electric Heater

Description

The ELECTRIC HEATER block calculates the heating power of the heating element. One application is heating the DOC during the cold start phase.



The maximum heating power is calculated with a ModelDesk processing function on the block's Parameter page in ModelDesk as in the following:

$$\dot{Q}_{Heater, Max} = \frac{U_{Max}^2 \cdot \eta_{Heater}}{R}$$

The heating power of the block is calculated as:

$$\dot{Q}_{Heater} = \dot{Q}_{Heater, Max} \cdot Ctrl_{Heater}$$

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_Heater	[0_1]	Control signal of electrical heater.
Reset	[]	Resets integrators to their initial conditions.

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 🕮).
Qdot_Heater	[W]	Heating power.

Parameters

The following tables shows the parameters:

Name	Unit	Description
Const_Qdot_Max	[W]	Maximum effective heat output.
Const_t_PT1	[s]	PT1 constant for dynamic behavior.

Related topics

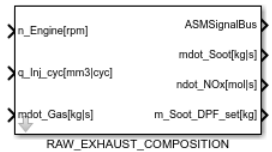
References

Electric Heater (ModelDesk Parameterizing 🕮)
Electric Heater (ModelDesk Parameterizing 🕮)
History of the ELECTRIC_HEATER Block 42

Exhaust Composition

Description

This block calculates the raw exhaust gas composition as a function of the engine operating point. These values are used by the exhaust system. The soot mass can be utilized in the DPF, for example, for test bench simulations.



Note

The NOx and soot emissions output by this block do not include dynamic effects on the combustion process. They are static values from maps that depend only on the engine operating point.

The concentration of NOx in the required table is based on mass fraction. If the concentration is given in molar fraction, it must be converted into mass fraction. The conversion can be carried out as follows:

$$\psi_{NOx} = c_{NOx} \cdot \frac{M_{NOx}}{M_{Exhaust}} = \frac{\dot{m}_{NOx}}{\dot{m}_{Exhaust}} \cdot 1e^{6}$$

where:

c_{NOx} is the molar mass of NOx in the exhaust gas in ppm

M_{NOx} is the molar mass of NOx

$M_{Exhaust}$ is the molar mass of exhaust gas

Therefore, the molar mass flow of NOx is:

$$\dot{n}_{NOx} = \frac{\dot{m}_{NOx}}{M_{NOx}} = \frac{\psi_{NOx} \cdot \dot{m}_{Exhaust} \cdot 1e^{-6}}{M_{NOx}}$$

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Gas	[kg/s]	Exhaust gas mass flow through the exhaust system
n_Engine	[rpm]	Engine speed
q_Inj_cyc	[mm^3/cyc]	Injection quantity per cylinder

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
m_Soot_DPF_set	[kg]	Soot mass in DPF
mdot_Soot	[kg/s]	Soot mass flow
ndot_NOx	[mol/s]	Nitrogen oxide molar flow

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_mdot_Soot_Raw	[g/h]	Mass flow of soot raw emissions
Map_Psi_NOx_Raw	[ppm]	Mass fraction of NOx raw emissions
Map_m_Soot_DPF_set	[g]	Static soot mass setpoint map for DPF

Related topics

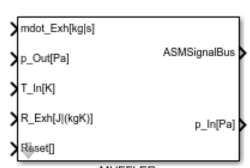
References

History of the RAW_EXHAUST_COMPOSITION Block..42
Raw Exhaust Composition (ModelDesk Parameterizing 📖)
Raw Exhaust Composition Diesel (ModelDesk Parameterizing 📖)

Muffler

Description

The muffler is connected at the end of the exhaust pipe. The MUFFLER block calculates the pressure upstream of the muffler as a function of the pressure downstream and the internal pressure drop.



The pressure drop in the muffler depends on the intake temperature and the volumetric flow at the inlet of the muffler.

$$p_{In} = p_{Out} + f\left(T_{In,Muffler}, \dot{V}_{In,Muffler}\right)$$

Inports

The following table shows the inports.

Name	Unit	Description
mdot_Exh	[kg/s]	Exhaust gas mass flow
p_Out	[Pa]	Pressure downstream of the muffler
Reset	[]	Reset all integrators to their initial conditions
T_In	[K]	Inlet temperature of the muffler

Outports

The following table shows the outports.

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 🕮).
p_In	[Pa]	Pressure upstream of the muffler

Parameters

The following table shows the parameters.

Name	Unit	Description
Const_t_PT1_p_In_Muffler	[s]	First-order time constant for muffler pressure drop
Map_p_Drop_Muffler	[Pa]	Muffler pressure drop as a function of the inlet temperature and volumetric flow at the inport

Related topics

References

History of the MUFFLER Block.......... 42
Muffler (ModelDesk Parameterizing 🕮)
Muffler Diesel (ModelDesk Parameterizing 🕮)

Switches Exhaust System

Where to go from here

Information in this section

Switches of DPF

Introduction

The block contains switches to specify the correct model setup for the Diesel particulate filter.

Outports

The following table shows the outports.

Name	Unit	Description
Sw_DPF_AdditiveRegeneration	[0|1]	Switch to reduce minimal regeneration temperature by additive ▪ 0: Disabled ▪ 1: Enabled
Sw_m_Soot	[0|1|2]	Selects how soot formation is specified: ▪ 0: Calculated

Name	Unit	Description
		▪ 1: Reset ▪ 2: External

Parameters

The following table shows the parameters.

Name	Unit	Description
DPF additive regeneration switch	[0|1]	Switch to reduce minimal regeneration temperature by additive ▪ 0: Disable ▪ 1: Enable
Soot Formation switch	[0|1]	Selects how soot formation is specified: ▪ 0: Calculated ▪ 1: Reset ▪ 2: External

Related topics

References

Diesel Particulate Filter (ModelDesk Parameterizing 🕮)
Diesel Particulate Filter Engine (ModelDesk Parameterizing 🕮)
Diesel Particulate Filter V3 (ModelDesk Parameterizing 🕮)
History of the SWITCHES_EXHAUSTSYSTEM Block (ASM Diesel Exhaust Reference 🕮)

Switches of SCR AdBlue Tank

Introduction

The block contains switches to specify the correct model setup for the SCR AdBlue tank.

Outports

The following table shows the outports.

Name	Unit	Description
Const_p_AdBlueTank	[bar]	Pressure in AdBlue tank for SCR System
Sw_FillAdBlueTan	[0|1]	Switch to enable filling of AdBlue tank ▪ 0: Enable ▪ 1: Disable

Parameters

The following table shows the parameters.

Name	Unit	Description
Const_p_AdBlueTank	[bar]	Pressure in AdBlue tank for SCR System
Sw_FillAdBlueTan	[0|1]	Switch to enable filling of AdBlue tank ▪ 0: Enable ▪ 1: Disable

Related topics

References

Common Exhaust Parameters (ModelDesk Parameterizing 🕮)
History of the SWITCHES_EXHAUSTSYSTEM Block (ASM Diesel Exhaust Reference 🕮)

Switches of SCR Air Tank

Exhaust system

The block contains switches to specify the correct model setup for the SCR air tank.

Outports

The following table shows the outports.

Name	Unit	Description
Const_p_AirTank	[bar]	Pressure in AdBlue tank for SCR System
Const_T_AirTank	[°C]	Temperature in air tank for SCR System

Parameters

The following table shows the parameters.

Name	Unit	Description
Const_p_AirTank	[bar]	Pressure in AdBlue tank for SCR System
Const_T_AirTank	[°C]	Temperature in air tank for SCR System

Related topics

References

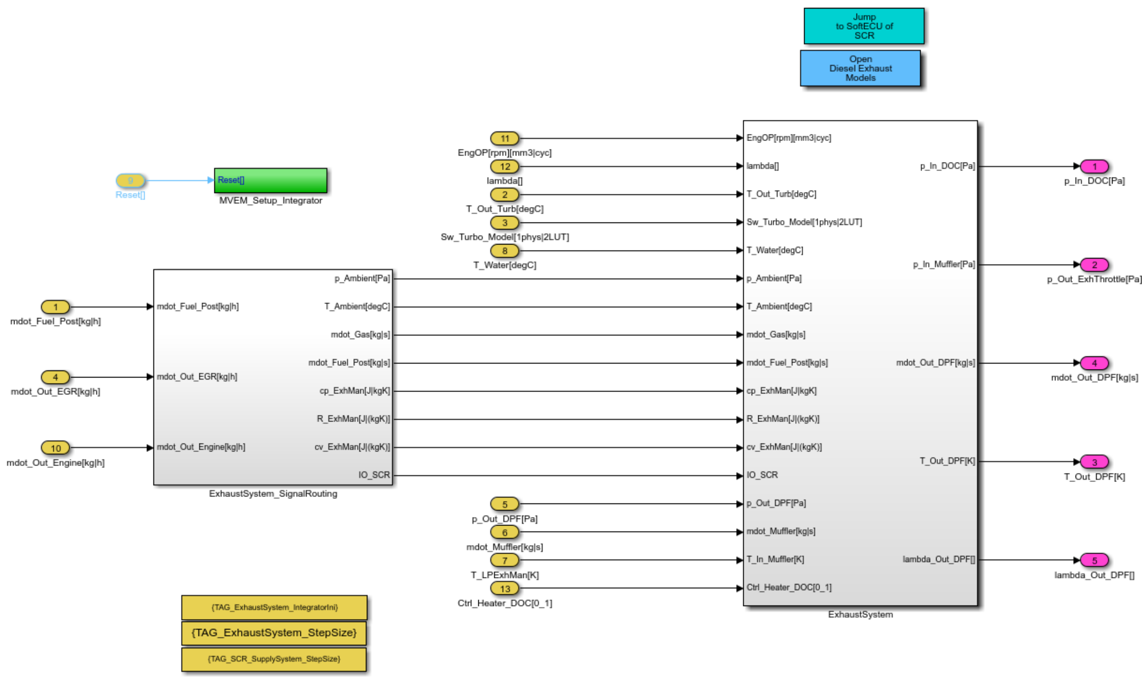
Common Exhaust Parameters (ModelDesk Parameterizing 🕮)
History of the SWITCHES_EXHAUSTSYSTEM Block (ASM Diesel Exhaust Reference 🕮)

Models

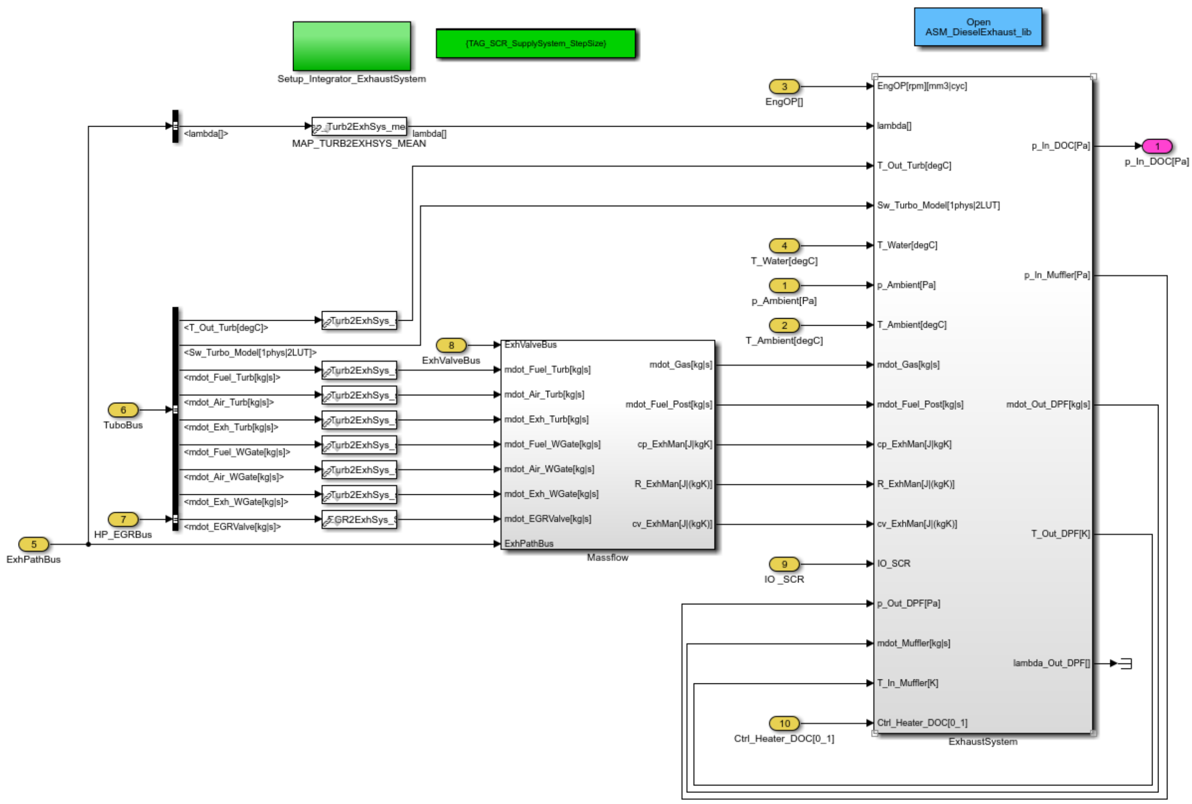
Exhaust

Introduction	For use inside ASM Diesel Engine and ASM Diesel Engine InCylinder an **Exhaust** model is provided.
Description	To use the same approach for different ASM models, the **ExhaustSystem** has been unified. It is located inside the **Exhaust** subsystem, which is different for ASM Diesel Engine and ASM Diesel Engine InCylinder.

ASM Diesel Engine The following illustration shows the Exhaust subsystem for ASM Diesel Engine.

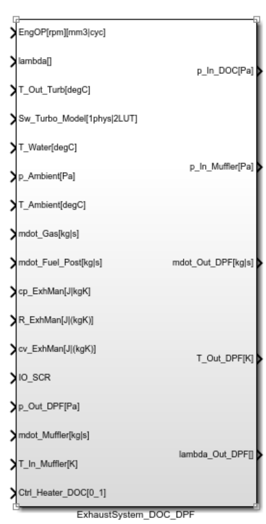


ASM Diesel Engine InCylinder The following illustration shows the Exhaust subsystem for ASM Diesel Engine InCylinder.



The light library contains one implementation of an exhaust system.

ExhaustSystem_DOC_DPF The basic model can simulate systems with DOC and DPF connected to ASM Diesel Engine and ASM Diesel Engine InCylinder models.



The simulation of the exhaust system takes place inside the ExhaustSystem subsystem. The other subsystems inside the Exhaust are used as auxiliary.

Inports

The following table shows the inports:

Name	Unit	Description
cp_ExhMan	[J/ (kg K)]	Isobaric heat capacity of exhaust gas
Ctrl_Heater_DOC	[0_1]	Control signal of DOC heater
cv_ExhMan	[J/ (kg K)]	Isochoric heat capacity of exhaust gas
EngOP	[rpm] [mm^3/cyc]	Engine operating point
IO_SCR_Supply	[0_1]	Control signal bus for SCR
lambda	[]	Lambda value after combustion process
mdot_Fuel_Post	[kg/s]	Post-injection mass flow
mdot_Gas	[kg/s]	Exhaust gas mass flow through the exhaust system (Exhaust gas leaving the engine deducting EGR mass flow)
mdot_Muffler	[kg/s]	Mass flow through the muffler
p_Ambient	[Pa]	Ambient pressure
p_Out_DPF	[Pa]	Pressure downstream of DPF
R_ExhMan	[J/ (kg K)]	Gas constant of exhaust gas
Sw_Turbo_Model	[1|2]	Switch for turbo model ▪ 1: Physical ▪ 2: Look-up table
T_Ambient	[°C]	Ambient temperature
T_In_Muffler	[K]	Temperature upstream of muffler
T_Out_Turb	[°C]	Temperature after turbocharger
T_Water	[°C]	Temperature of engine coolant (only used for SCR)

Outports

The following table shows the outports:

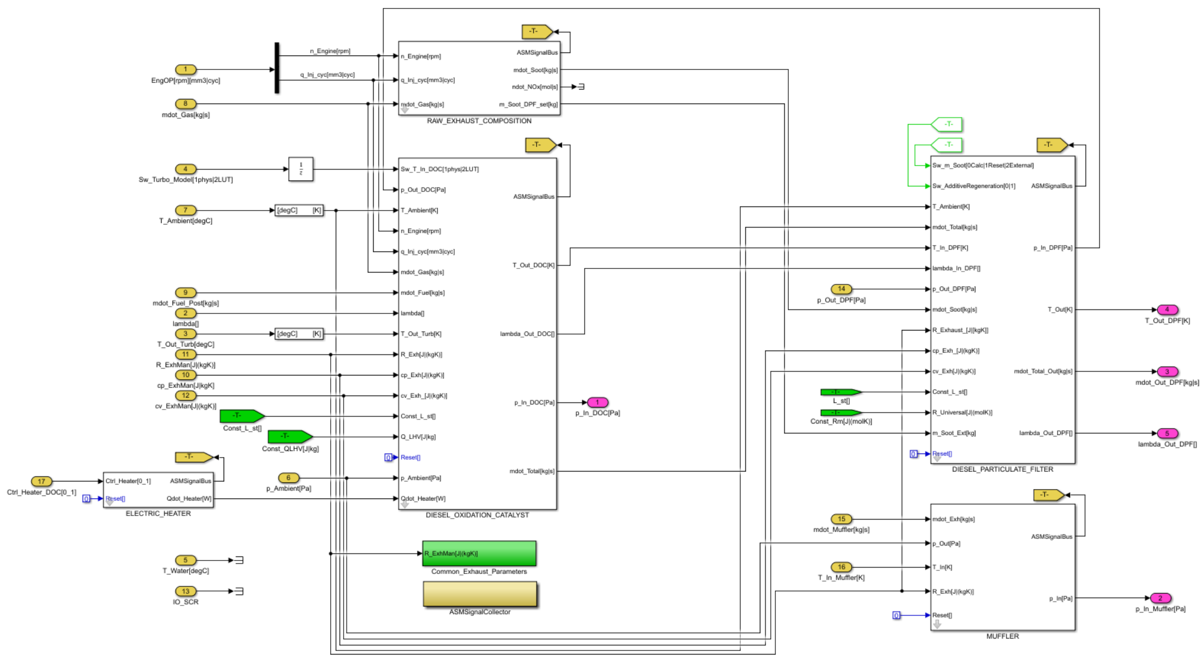
Name	Unit	Description
lambda_Out_DPF	[]	Lambda downstream of the DPF
mdot_Out_DPF	[kg/s]	Mass flow through the DPF
p_In_DOC	[Pa]	Inlet pressure of DOC
p_In_Muffler	[Pa]	Pressure upstream of muffler
T_Out_DPF	[K]	Temperature downstream of DPF

Subsystems

The ExhaustSystem block is composed of the following subsystems:

- COMMON_EXHAUST_PARAMETERS containing exhaust-specific constants that can be used by several exhaust components

- RAW_EXHAUST_COMPOSITION, which delivers an estimation of the raw emissions of the engine
- DIESEL_OXIDATION_CATALYST, the DOC model
- DIESEL_PARTICULATE_FILTER, the DPF model
- MUFFLER for modeling the pressure drop at the end of the exhaust pipe
- ELECTRIC_HEATER to calculate the heating power of the heating element



Related topics

References

New Features/Migration History of the ASMDieselExhaustLight Blockset

Introduction

The following topics provide an overview of the changes to the ASM products in the previous Releases.

For an overview of the new features and migration of the current Release, refer to Automotive Simulation Models (ASM) (New Features and Migration 📖).

Where to go from here

Information in this section

General Changes to the ASM Diesel Exhaust Blockset

Release 2020-A

ASMSignalBus The ASMSignalBus contains a new signal: T_In_Muffler[degC].

Release 2016-B

Look-up table migration The discontinued Simulink blocks Lookup and Lookup2D in the ASM library blocks were updated to the new standard Simulink Look-up table (n-D) block. Refer to Changes to all ASM Products (ASM User Guide 🕮).

The look-up tables were updated in the following blocks within this library:

- ADBLUE_PRESSURE_REGULATION_VALVE
- ADBLUE_PUMP
- AIR_NON_RETURN_VALVE
- AIR_REGULATION_VALVE
- ATOMIZER
- DIESEL_OXIDATION_CATALYST, DIESEL_OXIDATION_CATALYST_10_0, DIESEL_OXIDATION_CATALYST_4_0
- DIESEL_PARTICULATE_FILTER, DIESEL_PARTICULATE_FILTER_3_0
- INJECTION_VALVE
- MIXING_CHAMBER
- MUFFLER, MUFFLER_2_0
- PUMP_HOSE
- RAW_EXHAUST_COMPOSITION
- SCR_CATALYST, SCR_CATALYST_5_0
- THROTTLE
- UREA_DECOMPOSITION
- VENT_VALVE

License check of ASM Utils blocks The ASM_UTILS license was discontinued. The ASM Utils blocks now check the license of the ASM blockset in which they are used.

The Utils blocks in the following blocks within this library were updated:

- SCR_CATALYST_5_0

Release 2013-B

The ASM_DieselExhaust blockset has been revised.

- The same ExhaustSystem can be used for ASM_InCylinder_EngineDiesel and ASM_EngineDiesel.
- The block is vectorial, so it can simulate several ExhaustSystems simultaneously.

The following blocks are affected:

- DIESEL_OXIDATION_CATALYST
- DIESEL_PARTICULATE_FILTER

- PUMP_HOSE
- AIR_NON_RETURN_VALVE
- ADBLUE_PUMP
- UREA_DECOMPOSITION
- AIR_REGULATION_VALVE

Release 7.3

An integrator reset has been inserted to support a global reset in the ASM mean value engine models.

Release 6.3

ASM Diesel Exhaust is an add-on to ASM EngineDiesel or ASM EngineDiesel InCylinder.

Exhaust systems that contain Diesel Oxidation Catalyst (DOC) and Diesel Particulate Filter (DPF) are popular forms of aftertreatment in diesel engines. A DOC reduces CO and unburned hydrocarbons, and a DPF reduces the particulates (soot). Some recent systems use Selective Catalytic Reduction (SCR) technology to reduce nitrogen oxides. SCR has the advantage of running continuously without affecting engine operation (no increase in fuel consumption) and is usually installed either without or downstream of a DPF.

Models for these exhaust systems are provided by ASM Diesel Exhaust.

History of the DIESEL_OXIDATION_CATALYST Block

Release 2020-A

The block has new parameters: Const_m_Heater and Const_Conduct.

Release 2019-B

There is a new Qdot_Heater[W] inport. With this inport, an external heat source, e.g., of an electric heater, can be added into the component.

Release 2018-B

There is a new inport in the DIESEL_OXIDATION_CATALYST/Pressure_Drop/PT1_p_In_DOC block: p_Ambient[Pa]. It is used to initialize the integrator of the block.

Until now, the integrator was initialized with a constant block. During migration, a constant block with the original value is added to the new inport to obtain the same functionality as before.

Release 2017-A

A UnitDelay of the T_Out_Turb[K] inport inside the block has been removed. To keep the same functionality after migration, a UnitDelay block with the same initial condition is placed before the DIESEL_OXIDATION_CATALYST block. The initial value of the T_Out_DOC[K] integrator is set by a new parameter:

	Const_T_Out_DOC_Init. In previous Releases, this initial value was set by the removed UnitDelay.
Release 2015-B	The PT1 term has been moved to apply a delay on not only the pressure drop information but also the output pressure. This modification affects the simulation behavior. Hence, during migration, the link is changed to a former version of the block.
Release 2014-B	You can avoid negative lambda values by setting the value to **99** for the negative back flow through the DOC.
Release 2013-B	The block has a new parameter: Const_num_DOC. The same ExhaustSystem can be used for ASM_InCylinder_EngineDiesel and ASM_EngineDiesel. The block is vectorial, so it can simulate several ExhaustSystems simultaneously.
Release 7.3	The block has been adapted to support the engine reset functionality.
Release 7.1	The parameterization of the block is now supported by ModelDesk. ModelDesk provides a graphical user interface to configure models as well as modify, save and download parameters, etc. Parameters can also be exported to MATLAB ini files.
Release 6.5	The dependencies for the pressure drop have been changed from the mass flow to the volumetric flow and temperature at the inlet of the diesel oxidation catalyst. The block from the previous version has been moved to the Former versions subsystem in the ASM DieselExhaust Library. The migration procedure will change the library link to the Former versions block so that existing parameterizations are not affected.

Related topics

References

Diesel Oxidation Catalyst.. 13

History of the DIESEL_PARTICULATE_FILTER Block

Release 2018-A	The PT2 element of the lambda calculation is now initialized with 99 instead of zero.
Release 2018-B	The DIESEL_PARTICULATE_FILTER block has the new lambda_Out_DPF[] outport.
Release 2013-B	The block has a new parameter: Const_num_DPF. The units of R_Universal have changed from [kJ/(molK)] to [J/(molK)] and of Const_Ep_Soot from [kJ/mol] to [J/mol]. The same ExhaustSystem can be used for ASM_InCylinder_EngineDiesel and ASM_EngineDiesel. The block is vectorial, so it can simulate several ExhaustSystems simultaneously. The unit of Const_Ep_Soot has been changed to the SI unit [J|mol].
Release 7.3	The block has been adapted to support the engine reset functionality.
Release 7.1	The parameterization of the block is now supported by ModelDesk. ModelDesk provides a graphical user interface to configure models as well as modify, save and download parameters, etc. Parameters can also be exported to MATLAB ini files.
Release 6.5	The dependencies for the pressure drop have been changed from the soot mass and total mass flow to the soot mass and volumetric flow inlet of the diesel particulate filter. The block from the previous version has been moved to the Former versions subsystem in the ASM DieselExhaust Library. The migration procedure will not change the library link to the Former versions block. Existing parameterizations should not be affected negatively. The inport for disabling the soot formation has been modified, such that the soot mass in the particulate filter can be either calculated, disabled, or set to a fixed, externally specified value to improve the results of test bench runs.

Related topics

References

Diesel Particulate Filter.. 18

History of the ELECTRIC_HEATER Block

Release 2019-B	This is a new block. The ELECTRIC HEATER block calculates the heating power of the heating element. One application of the component functions as the heating of the diesel oxidation catalyst during the cold start phase.
Related topics	References Electric Heater........ 23

History of the MUFFLER Block

Release 7.1	The parameterization of the block is now supported by ModelDesk. ModelDesk provides a graphical user interface to configure models as well as modify, save and download parameters, etc. Parameters can also be exported to MATLAB ini files.
Release 6.5	The dependencies for the pressure drop have been changed from the mass flow to the volumetric flow and temperature at the inlet of the muffler. The block from the previous version has been moved to the Former versions subsystem in the ASM DieselExhaust Library. The migration procedure will change the library link to the Former versions block so that existing parameterizations are not affected.
Related topics	References Muffler........ 25

History of the RAW_EXHAUST_COMPOSITION Block

Release 7.1	The parameterization of the block is now supported by ModelDesk. ModelDesk provides a graphical user interface to configure models as well as modify, save and download parameters, etc. Parameters can also be exported to MATLAB ini files.

The input connections of the **Map_m_Soot_DPF_set[g]** look-up table has been corrected to engine speed and injection quantity. Previously, both inputs were connected to engine speed by mistake.

Release 6.5

An outport has been added to provide a desired soot mass for the diesel particulate filter, which can be useful during test bench simulations.

Related topics

References

Exhaust Composition.. 24

Appendix

Bibliography

List of literature

The following literature provides more details:

[Bos04] Bosch Handbook for Diesel-Engine Management. 4th Edition, 2004.

[Her04] Herr A.: Thermische Zersetzung von Festharnstoff für mobile SCR-Katalysatoranwendungen. Fakultät für Maschinenwesen und Verfahrenstechnik, TU Kaiserslautern, Dissertation, 2004.

[Kaef04] Käfer S.: Trockenharnstoff-SCR-System und Betriebsstrategie für Fahrzeuge mit Dieselmotor.Fakultät für Maschinenwesen und Verfahrenstechnik, TU Kaiserslautern, Dissertation, 2004.

[Sin05] Singh N., Johnson J. H., Parker G.G. and Yang S.L.: Vehicle Engine Aftertreatment System Simulation (VEASS) Model: Application to a Controls Design Strategy for Active Regeneration of a Catalyzed Particulate Filter. Michigan Technological University, SAE 2005.

[Sch03] Schär C.M.: Control of a Selective Catalytic Reduction Prozess. Dissertation, Swiss Federal Institute of Technology, Zurich, 2003.

[Sch06] Schär C.M. et al.: Control of an SCR Catalytic Converter System for a Mobil Heavy-Duty Application. Labaratory of Applied Thermodynamics, Aristotle University of Thessaloniki, Proc. IMechE Vol. 221 Part D: J. Automobile Engineering, 117–133, Thessaloniki, 2006.

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