Simulink Report: Turbine_

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Model - Turbine_

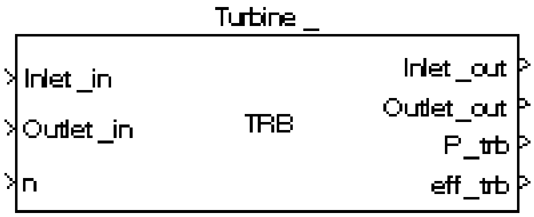


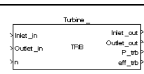
Tabelle 1.1. Turbine_ Simulation Parameters

Solver ode14x	*ZeroCross* on	*StartTime* 0.0*StopTime* 10.0
RelTol 1e-3	*AbsTol* auto	*Refine* 1
InitialStep auto	*FixedStep* auto	*MaxStep* auto

Tabelle 1.2. Turbine_ Summary Information

NumModelInputs	N/A	*NumModelOutputs*	N/A
NumVirtualSubsystems	N/A	*NumNonvirtSubsystems*	N/A
NumNonVirtBlocksInModel	N/A	*NumBlockTypeCounts*	N/A
NumBlockSignals	N/A	*NumBlockParams*	N/A
NumZCEvents	N/A	*NumNonsampledZCs*	N/A

Systems

Name	**Parent**	**Snapshot**	**Blocks**	**Signals**
Turbine_	<root>		Turbine_	Turbine_<1> Turbine_<2> Turbine_<3> Turbine_<4>

Blocks

Tabelle 1.3. Block Type Count

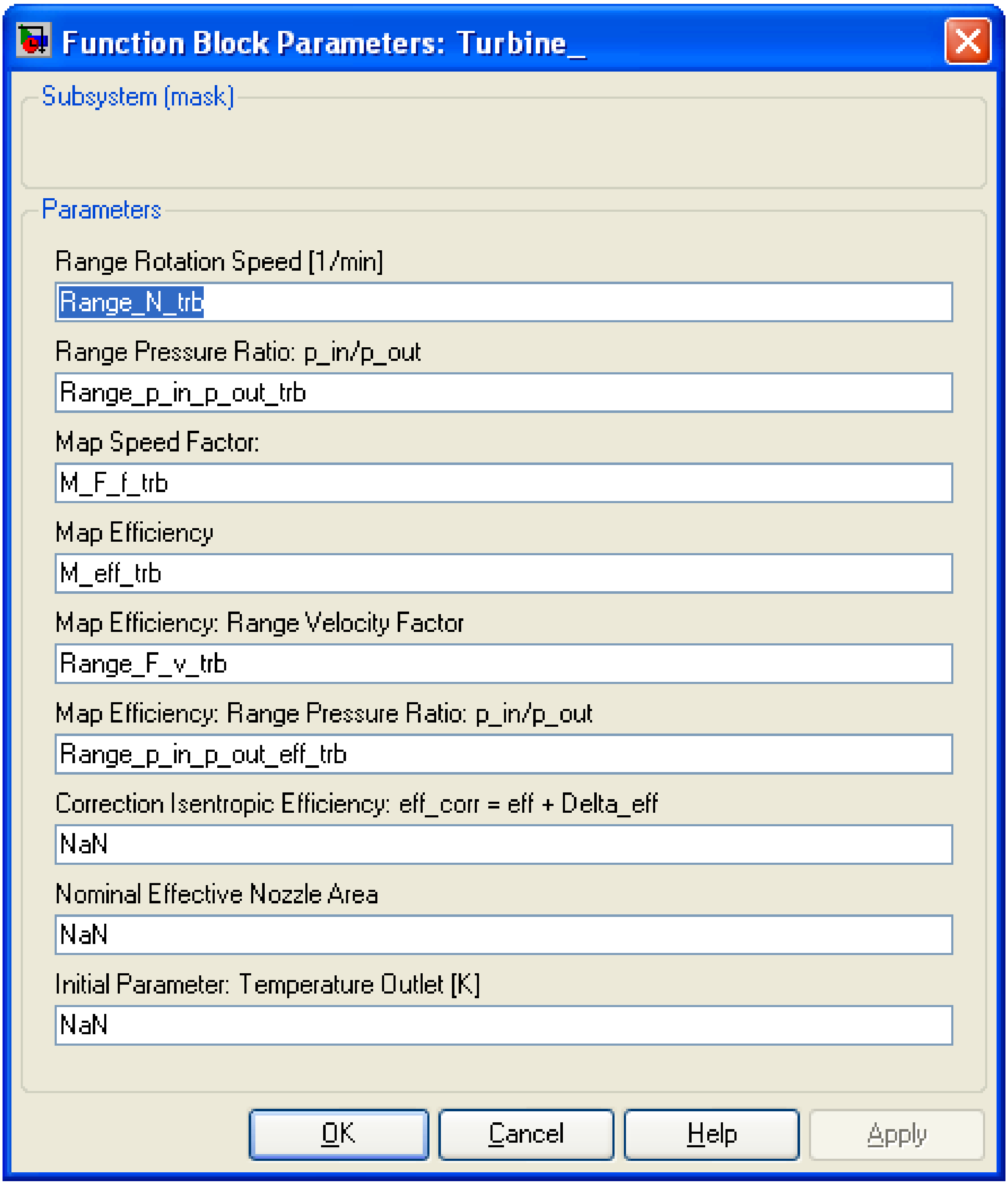
BlockType	**Count**	**Block Names**
Inport	28	Inlet_in, Outlet_in, n, p_inlet, p_outlet, rho_inlet, T_inlet, x_H2O_gas, x_CO2, x_H2O_liq, m_dot_air, eff, eff_bar, p_inlet, rho_inlet, T_inlet, p_0, T_0, T_outlet, A_n, n, F_f, T_air_inlet, T_0, n, T_inlet, x_H2O_gas, x_CO2
Outport	15	rho_outlet, T_outlet, m_dot_air_inlet, m_dot_air_outlet, x_H2O_gas_outlet, x_H2O_liq_outlet, P_trb, m_dot_air,

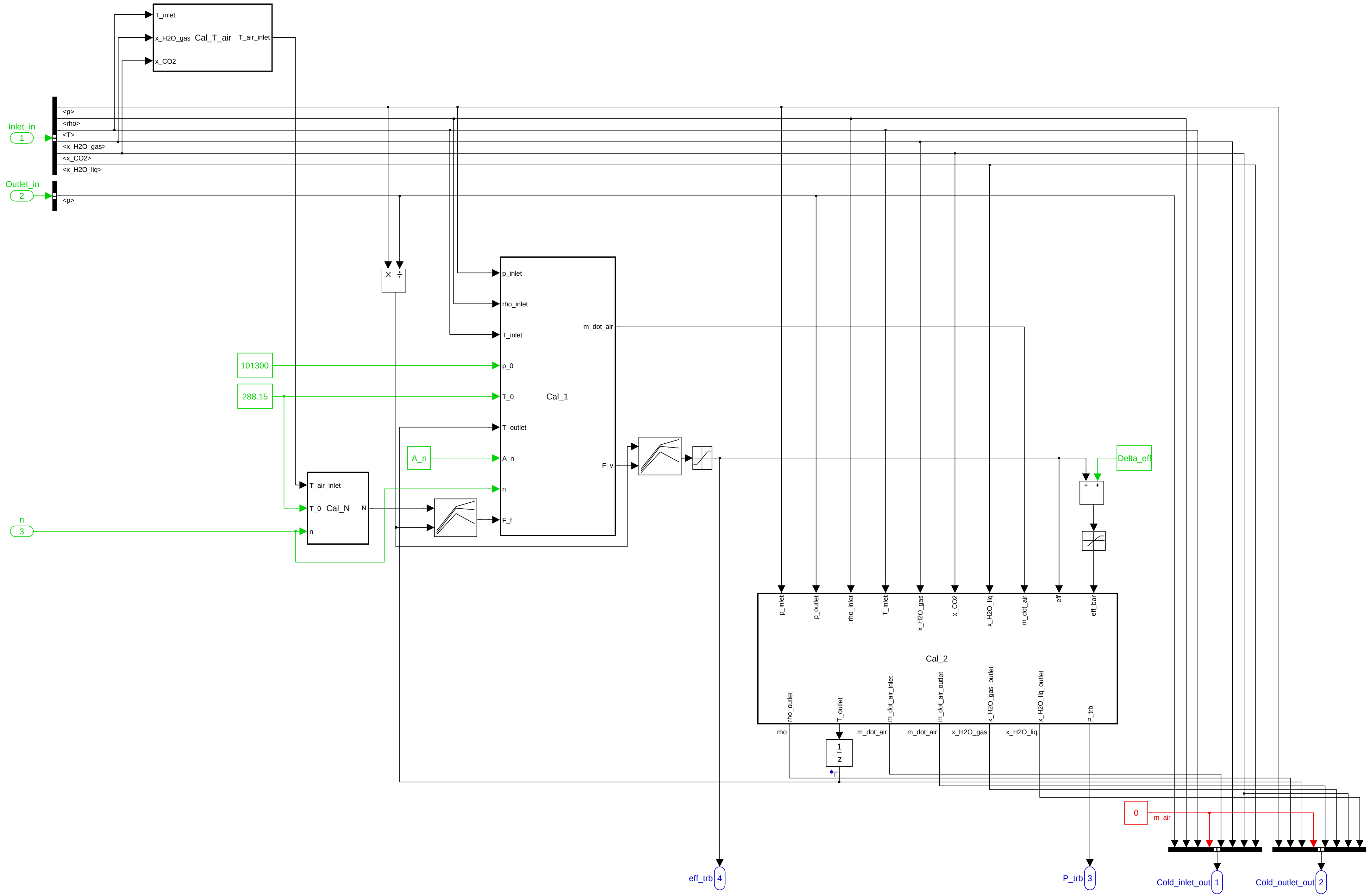
BlockType	Count	Block Names
		F_v, N, T_air_inlet, Cold_inlet_out, Cold_outlet_out, P_trb, eff_trb
Constant	5	A_n, Delta_eff, T_0, m_air, p_0
Terminator	4	Terminator , Terminator , Terminator , Terminator
Stateflow (m)	4	Embedded MATLA Function1, Embedded MATLA Function2, Embedded MATLA Function3, Embedded MATLA Function4
S-Function	4	SFunction , SFunction , SFunction , SFunction
Demux	4	Demux , Demux , Demux , Demux
Saturate	2	Saturation1, Saturation2
Lookup2D	2	Lookup Table (2-D)2, Lookup Table (2-D)4
BusSelector	2	Bus Selector, Bus Selector3
BusCreator	2	Bus Creator1, Bus Creator2
UnitDelay	1	Unit Delay
Sum	1	Add
SubSystem	1	Turbine_
Product	1	Divide

Data and Functions

Tabelle 1.4. Model Functions

Function Name	Parent Blocks	Calling string
NaN	Turbine_ Turbine_ Turbine_	`NaN` `NaN` `NaN`


Function Block Parameters: Turbine_
Subsystem (mask)
Parameters
Range Rotation Speed [1/min]
Range_N_trb
Range Pressure Ratio: p_in/p_out
Range_p_in_p_out_trb
Map Speed Factor:
M_F_f_trb
Map Efficiency
M_eff_trb
Map Efficiency: Range Velocity Factor
Range_F_v_trb
Map Efficiency: Range Pressure Ratio: p_in/p_out
Range_p_in_p_out_eff_trb
Correction Isentropic Efficiency: eff_corr = eff + Delta_eff
NaN
Nominal Effective Nozzle Area
NaN
Initial Parameter: Temperature Outlet [K]
NaN
OK
Cancel
Help
Apply



Inlet_in
Outlet_in
n
Cal_T_air
T_inlet
x_H2O_gas
x_CO2
T_air_inlet
<p>
<rho>
<T>
<x_H2O_gas>
<x_CO2>
<x_H2O_liq>
Cal_1
p_inlet
rho_inlet
p_0
T_0
T_outlet
A_n
F_f
m_dot_air
F_v
101300
288.15
Cal_N
N
Delta_eff
Cal_2
p_outlet
x_H2O_liq
eff
eff_bar
rho_outlet
m_dot_air_inlet
m_dot_air_outlet
x_H2O_gas_outlet
x_H2O_liq_outlet
P_trb
rho
x_H2O_gas
m_air
eff_trb
Cold_inlet_out
Cold_outlet_out

```
function T_air_inlet = Cal_T_air(T_inlet,x_H2O_gas,x_CO2)

% *************************************************************************
% * Definition of a turbine
% *
% * Number of inputs :                 3
% *
% * Parameter: Characteristic Maps:    Speed Factor, Efficiency
% *
% *
% * Relevant input variables of Turbine
% *
% * Pressure:                          p_in
% * Density:                           rho_in
% * Temperature:                       T_in
% * Content water vapor:               x_H2O_gas_in
% * Content CO2:                       x_CO2_in
% * Content water:                     x_H2O_liq_in
% *
% *
% * Relevant output variables of Turbine
% *
% * Temperature:                       T
% * Mass flow dry air:                 m_dot_air
% * Content water vapor:               x_H2O_gas
% * Content CO2:                       x_CO2
% * Content water:                     x_H2O_liq
% *
% ************************************************************************
% * Embedded Matlab Function Cal_T_air:
% *
% * Calculations:
% * 1. Calculation dry bulb temperature T_air.
% *
% *
% * Assumptions:
% * 1. The specific enthalpy of the inflowing gas mixture is equal the enthalpy
% *    of a dry air flow.
% *
% *
% * Last modification : 15.03.2008
% * Author : Christian Müller(HAW)
% *
% ************************************************************************

% * 1. Calculation dry bulb temperature T_air
c_p_air     = 1005;
c_p_H2O_gas = 1870;
c_p_CO2     = 830;
r_0         = 2500000;
T_air_inlet =↙
(c_p_air*T_inlet+x_H2O_gas*c_p_H2O_gas*T_inlet+x_CO2*c_p_CO2*T_inlet+x_H2O_gas*r_0)↙
/c_p_air;
% ************************************************************************
```

```
function N = Cal_N(T_air_inlet,T_0,n)

% *************************************************************************
% * Definition of a turbine
% *
% * Number of inputs :                 3
% *
% * Parameter: Characteristic Maps:    Speed Factor, Efficiency
% *
% *
% * Relevant input variables of Turbine
% *
% * Pressure:                          p_in
% * Density:                           rho_in
% * Temperature:                       T_in
% * Content water vapor:               x_H2O_gas_in
% * Content CO2:                       x_CO2_in
% * Content water:                     x_H2O_liq_in
% *
% *
% * Relevant output variables of Turbine
% *
% * Temperature:                       T
% * Mass flow dry air:                 m_dot_air
% * Content water vapor:               x_H2O_gas
% * Content CO2:                       x_CO2
% * Content water:                     x_H2O_liq
% *
% ************************************************************************
% * Embedded Matlab Function Cal_N:
% *
% * Calculations:
% * 1. Calculation corrected rotational speed N.
% *
% *
% * Last modification : 15.03.2008
% * Author : Christian Müller(HAW)
% *
% ************************************************************************

% * 1. Calculation corrected rotational speed N
N = n/sqrt(T_air_inlet/T_0);
% ************************************************************************
```

```
function [m_dot_air,F_v]  = Cal_1(p_inlet,rho_inlet,T_inlet,p_0,T_0,T_outlet,A_n,n,F_f)

% *************************************************************************
% * Definition of a turbine
% *
% * Number of inputs :                 3
% *
% * Parameter: Characteristic Maps:    Speed Factor, Efficiency
% *
% *
% * Relevant input variables of Turbine
% *
% * Pressure:                          p_in
% * Density:                           rho_in
% * Temperature:                       T_in
% * Content water vapor:               x_H2O_gas_in
% * Content CO2:                       x_CO2_in
% * Content water:                     x_H2O_liq_in
% *
% *
% * Relevant output variables of Turbine
% *
% * Temperature:                       T
% * Mass flow dry air:                 m_dot_air
% * Content water vapor:               x_H2O_gas
% * Content CO2:                       x_CO2
% * Content water:                     x_H2O_liq
% *
% ************************************************************************
% * Embedded Matlab Function Cal_1:
% *
% * Calculations:
% * 1. Definition specific gas constants.
% * 2. Calculation mass flow.
% * 3. Calculation velocity factor.
% *
% *
% * Last modification : 15.03.2008
% * Author : Christian Müller(HAW)
% *
% ************************************************************************

F_v         = 0;

% * 1. Definition specific gas constants
c_p_air     = 1005;
c_p_H2O_gas = 1870;
c_p_CO2     = 830;
r_0         = 2500000;
% ************************************************************************

% * 2. Calculation mass flow
if F_f < 0
   F_f      = 0;
end
```

```
m_dot_air   = 0.0403*F_f*p_inlet*A_n/sqrt(T_inlet);
% ************************************************************************

% * 3. Calculation velocity factor
if T_inlet > T_outlet
   F_v      = n/(3320*sqrt(1.8)*sqrt(T_inlet-T_outlet));
end

if T_inlet <= T_outlet
   F_v      = 0;
end
% ************************************************************************
```

```
function [rho_outlet,T_outlet,m_dot_air_inlet,m_dot_air_outlet,x_H2O_gas_outlet,↙
x_H2O_liq_outlet,P_trb] = Cal_2(p_inlet,p_outlet,rho_inlet,T_inlet,x_H2O_gas,x_CO2,↙
x_H2O_liq,m_dot_air,eff,eff_bar)

% ************************************************************************
% * Definition of a turbine
% *
% * Number of inputs :                3
% *
% * Parameter: Characteristic Maps:    Speed Factor, Efficiency
% *
% *
% * Relevant input variables of Turbine
% *
% * Pressure:                         p_in
% * Density:                          rho_in
% * Temperature:                      T_in
% * Content water vapor:              x_H2O_gas_in
% * Content CO2:                      x_CO2_in
% * Content water:                    x_H2O_liq_in
% *
% *
% * Relevant output variables of Turbine
% *
% * Temperature:                      T
% * Mass flow dry air:                m_dot_air
% * Content water vapor:              x_H2O_gas
% * Content CO2:                      x_CO2
% * Content water:                    x_H2O_liq
% *
% ***********************************************************************
% * Embedded Matlab Function Cal_2:
% *
% * Calculations:
% * 1. Definition specific gas constants.
% * 2. Calculation mass flow.
% * 3. Calculation outlet temperature and density.
% * 4. Calculation delivered power.
% *
% *
% * Last modification : 15.03.2008
% * Author : Christian Müller(HAW)
% *
% ***********************************************************************

% * 1. Definition specific gas constants
R_air           = 287.058;
R_H2O_gas       = 461.523;
R_CO2           = 188.924;
c_p_air         = 1005;
c_p_H2O_gas     = 1870;
c_p_CO2         = 830;
c_p_H2O_liq     = 4173;
c_p_H2O_ice     = 2050;
r_ice           = 333000;
```

```
R_avg            = (R_air+x_H2O_gas*R_H2O_gas+x_CO2*R_CO2)/(1+x_H2O_gas+x_CO2);
c_p_avg          = (c_p_air+x_H2O_gas*c_p_H2O_gas+x_CO2*c_p_CO2)/(1+x_H2O_gas+x_CO2);
c_v_avg          = c_p_avg-R_avg;
gamma_avg        = c_p_avg/c_v_avg;
% *************************************************************************

% * 2. Calculation specific work
w_trb            = eff*c_p_air*T_inlet*(1-((p_outlet/p_inlet)^((gamma_avg-1)↙
/gamma_avg)));
w_trb_bar        = eff_bar*c_p_air*T_inlet*(1-((p_outlet/p_inlet)^((gamma_avg-1)↙
/gamma_avg)));

if w_trb < 0
   w_trb         = 0;
   w_trb_bar    = 0;
end
% *************************************************************************

% * 3. Calculation outlet temperature and density
T_outlet         = T_inlet-(1/c_p_air)*w_trb;

rho_H2O_gas_sat  = 4.44259*exp(15.05703*(T_outlet-273.15)/(208.07254+(T_outlet-↙
273.15)))/1000;
rho_air_inlet    = rho_inlet/(1+x_H2O_gas+x_CO2);
x_H2O_gas_sat    = rho_H2O_gas_sat/rho_air_inlet;

if x_H2O_gas_sat > x_H2O_gas
   x_H2O_gas_sat = x_H2O_gas;
end

x_H2O_gas_outlet = x_H2O_gas_sat;
x_H2O_liq_outlet = x_H2O_liq+(x_H2O_gas-x_H2O_gas_outlet);

R_avg            = (R_air+x_H2O_gas_outlet*R_H2O_gas+x_CO2*R_CO2)/↙
(1+x_H2O_gas_outlet+x_CO2);
c_p_avg          = (R_air+x_H2O_gas_outlet*c_p_H2O_gas+x_CO2*c_p_CO2)/↙
(1+x_H2O_gas_outlet+x_CO2);

rho_outlet       = p_outlet/(R_avg*T_outlet);
% *************************************************************************

% * 4. Calculation delivered power
if p_outlet == p_inlet
   m_dot_air     = 0;
end

P_trb            = m_dot_air*w_trb_bar;

m_dot_air_inlet  = -m_dot_air;
m_dot_air_outlet =  m_dot_air;
% *************************************************************************
```