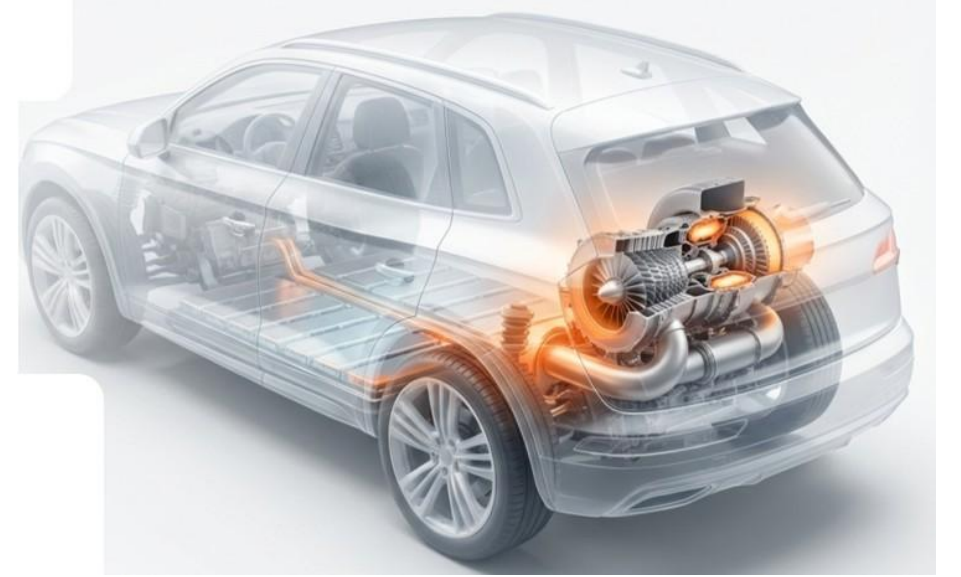


# Modelling of 1D Micro Gas Turbine For Range Extender Electric Vehicles

5. INTERNATIONAL GAZIANTEP SCIENTIFIC RESEARCH  
CONGRESS

27/12/2025

Dr. Harun Güçlü



*Towards greater goals...*



*Towards greater goals...*

## Outline

Motivation

Simple Brayton Cycle

1D Model of MGT

Results

Future Work

Acknowledgement

## ➤ Motivation

# Solving Range Anxiety: The Micro Gas Turbine Solution

### Why Use a Micro Gas Turbine (MGT) Range Extender?



#### A Compact Power Plant for Your EV

An MGT is a small jet engine that runs a generator to recharge the EV's battery.



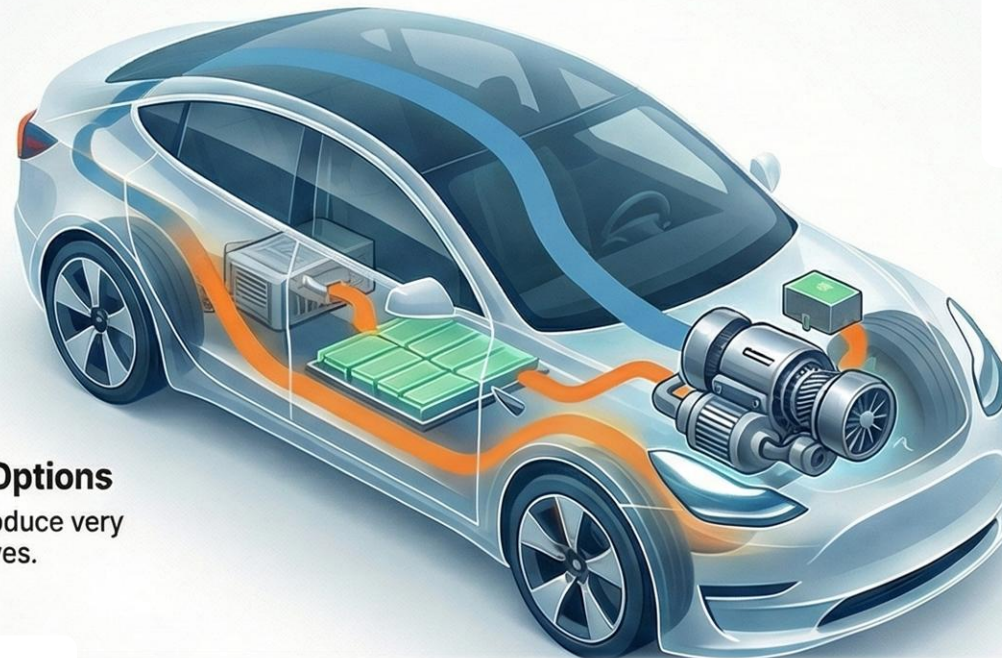
#### High Power, Low Weight

MGTs offer a high power-to-weight ratio, crucial for maintaining vehicle efficiency.

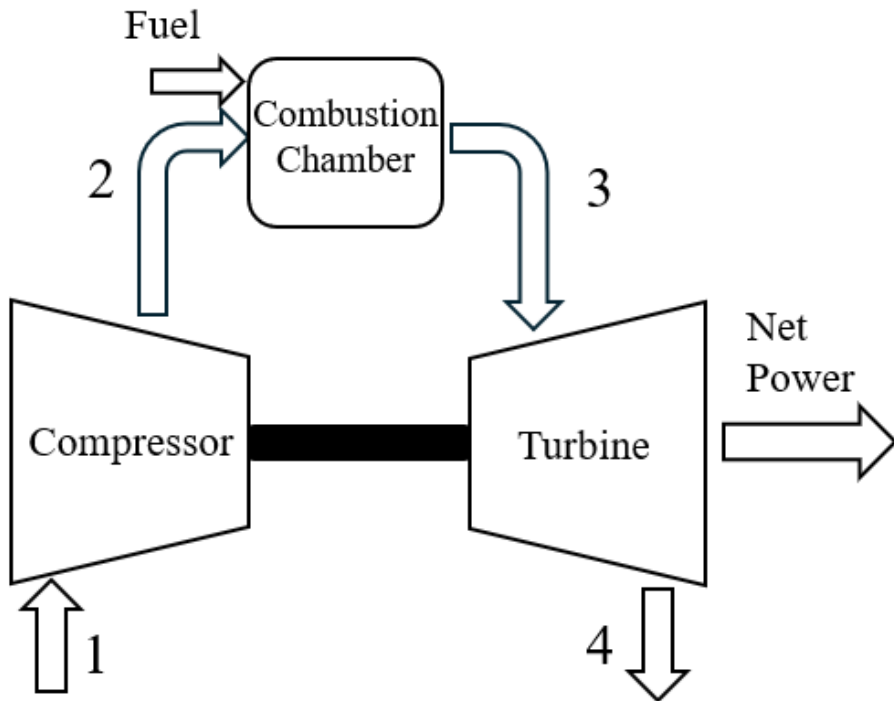


#### Advantages Over Traditional Options

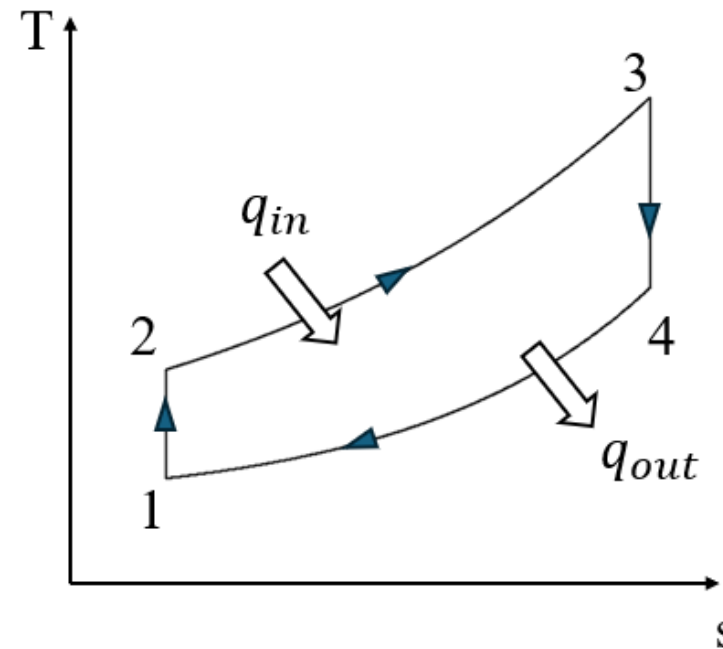
MGTs are fuel-flexible, reliable, and produce very clean emissions compared to alternatives.



## Simple Brayton Cycle



- 1-2 Isentropic compression (in a compressor)
- 2-3 Constant-pressure heat addition
- 3-4 Isentropic expansion (in a turbine)
- 4-1 Constant-pressure heat rejection

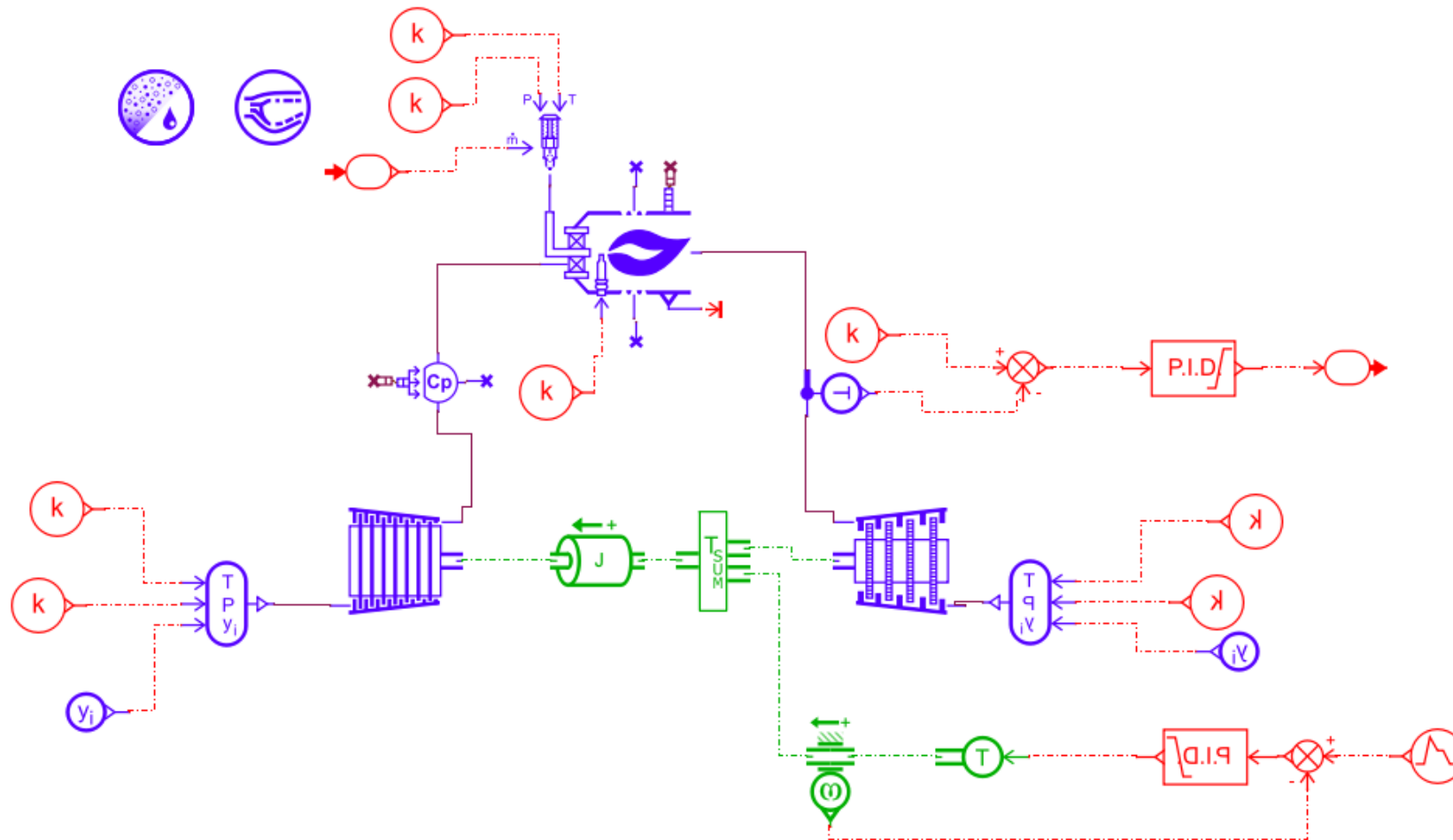


$$P_{net} = (T_t - T_c) \cdot \omega$$

$$Q = \dot{m}_f \cdot LHV$$

$$\eta_t = \frac{P_{net}}{Q}$$

## ➔ 1D Model of MGT



	Unit	Value
Air flow	kg/s	0.85
Design point of shaft	rpm	90 000
Net Power	kW	182
Compressor efficiency	-	0.786
Turbine efficiency	-	0.879
Pressure ratio	-	5
Turbine Inlet Temperature (TIT)	K	1275
Specific fuel consumption (SFC)	kg/kWh	0.318
Ambient Pressure	barA	1.013
Ambient Temperature	K	288.15

Mixture parameters

Mixture index  1

Gas properties

Linear  NASA

Liquid properties

User defined  Thermal-hydraulic

Air composition

Mass basis  Mole basis

Species (6)	HC	Liq.	Air
<input checked="" type="checkbox"/> N2			<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> O2			<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> Argon			<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> CO2			
<input checked="" type="checkbox"/> CH4	<input checked="" type="checkbox"/>		
<input checked="" type="checkbox"/> H2O			

Species #2 definition

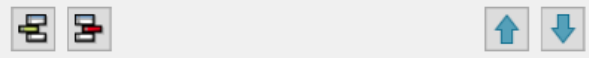
Species name  O2  Hydrocarbon  Liquid  Used in air composition

Chemical composition  Gas properties Hydrocarbon properties Liquid properties  Air composition

Chemical composition  2\*O

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	H																He	
	Hydrogen																Helium	
	1.01																4.00	
2	Li	Be																
	Lithium	Beryllium																
	6.94	9.01																
	11	12																
3	Na	Mg																
	Sodium	Magnesium																
	22.99	24.30																
	19	20																
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
	Potassium	Calcium	Scandium	Titanium	Vanadium	Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc	Gallium	Germanium	Arsenic	Selenium	Bromine	Krypton
	39.10	40.08	44.96	47.87	50.94	52.00	54.94	55.84	58.93	58.69	63.55	65.38	69.72	72.64	74.92	78.96	79.90	83.80
	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
	Rubidium	Strontium	Yttrium	Zirconium	Niobium	Molybdenum	Technetium	Ruthenium	Rhodium	Palladium	Silver	Cadmium	Indium	Tin	Antimony	Tellurium	Iodine	Xenon
	85.47	87.62	88.91	91.22	92.91	95.96	98.00	101.07	102.91	106.42	107.87	112.44	114.82	118.71	121.76	127.60	126.90	131.29
	55	56	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
6	Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
	Caesium	Barium	Lutetium	Hafnium	Tantalum	Tungsten	Rhenium	Osmium	Iridium	Platinum	Gold	Mercury	Thallium	Lead	Bismuth	Polonium	Astatine	Radon
	132.91	137.33	174.97	178.49	180.95	183.84	186.21	190.23	192.22	195.08	196.97	200.59	204.38	207.20	208.98	210.00	210.00	220.00
	87	88	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
7	Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus	Uuo
	Francium	Radium	Lawrencium	Rutherfordium	Dubnium	Seaborgium	Bohrium	Hassium	Meitnerium	Darmstadtium	Roentgenium	Oganesson	Ununtrium	Flerovium	Nunpentium	Ivermorium	Nunseptium	Nunoctium
	223.00	226.00	262.00	261.00	262.00	266.00	264.00	277.00	268.00	271.00	272.00	285.00	284.00	289.00	288.00	292.00	0.00	294.00

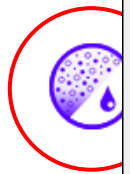
Show all



Air composition (mole basis): 0.78109 N2 + 0.20954 O2 + 0.00937 Argon



1

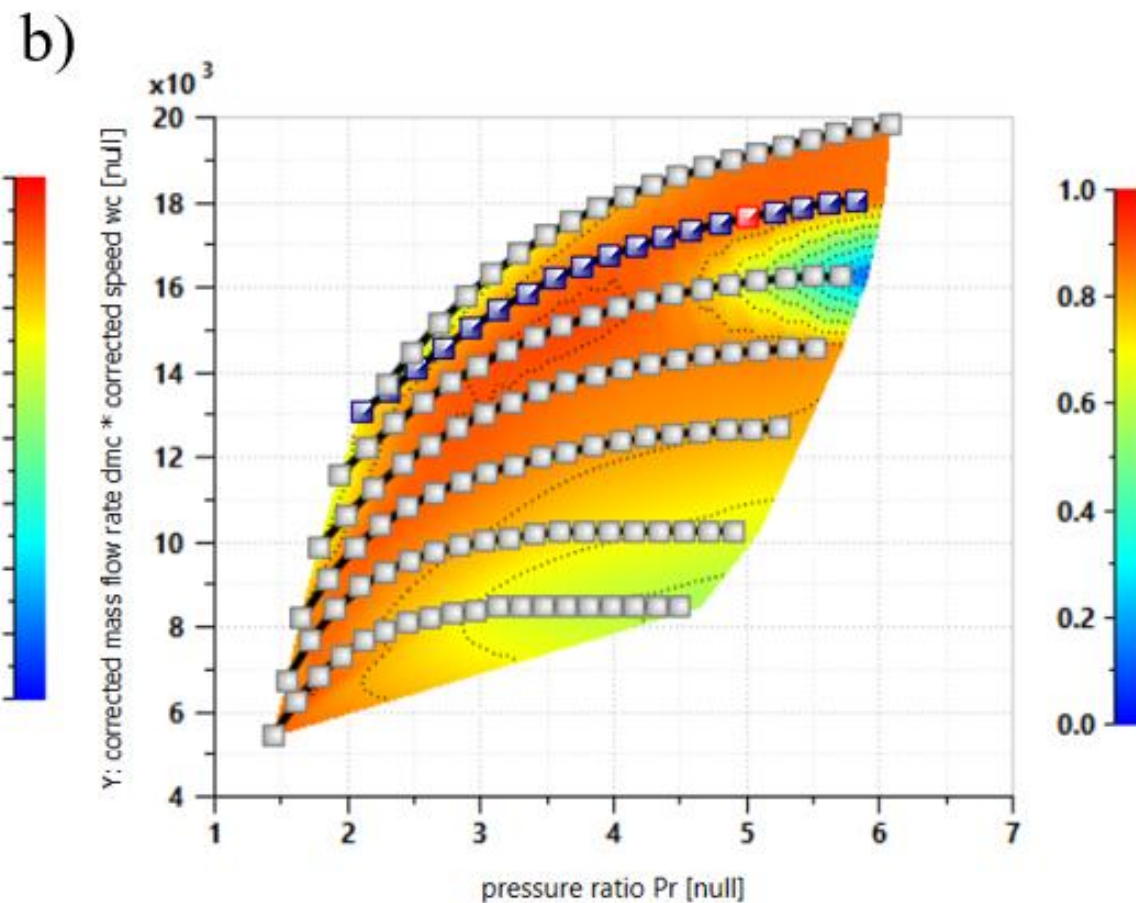
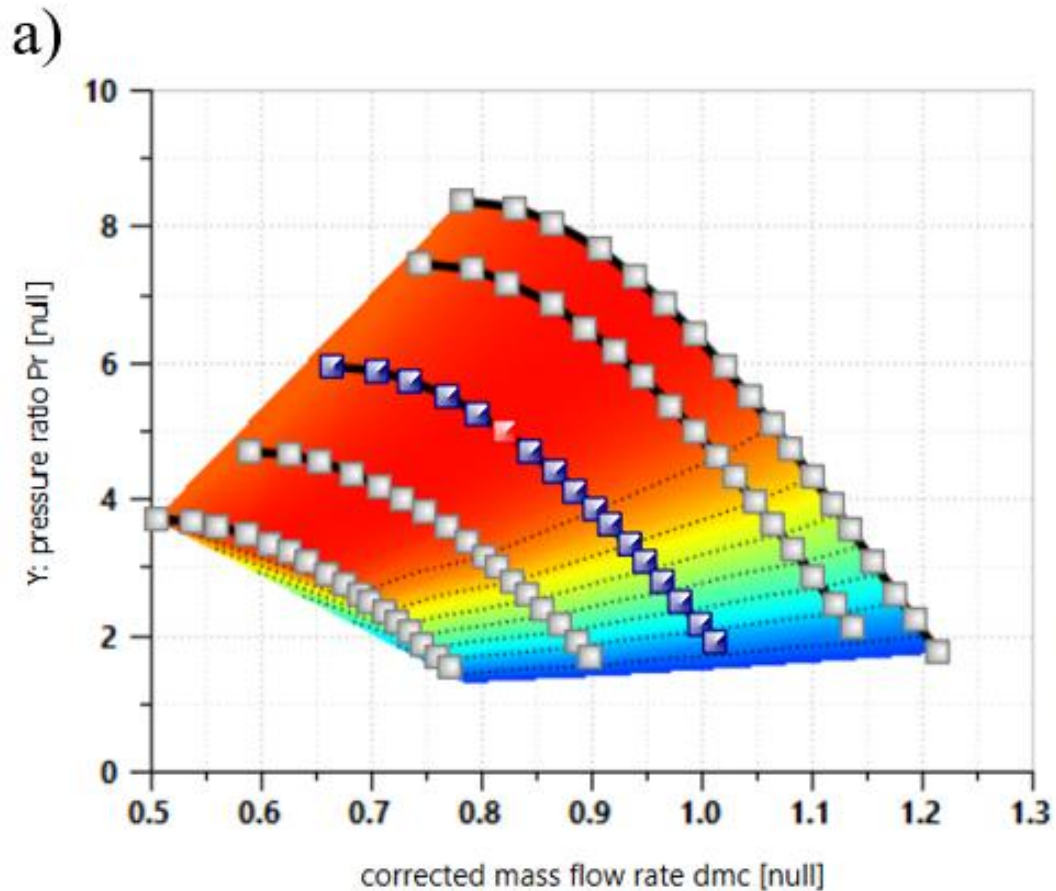


k

k

y<sub>i</sub>

# 1D Model of MGT



(k)

(k)



Combustion definition [gte\_combustor\_def]

**Index Parameters**

Mixture index 1

Combustor Index 1

**Heat generated by combustion based on**

low heating value (LHV)     enthalpy of formation (hf0)

**Reaction Rate**

Coefficient 100000

Number of species 6 Load Species

			Reactants (<0)			Products (>0)		
Name	Formula		Name	Formula	Stoichiometry	Name	Formula	Stoichiometry
N2	N <sub>2</sub>	<span style="border: 1px solid #ccc; padding: 2px;">➔ Reactant</span>	O2	O <sub>2</sub>	-2	CO2	CO <sub>2</sub>	1
O2	O <sub>2</sub>	<span style="border: 1px solid #ccc; padding: 2px;">➔ Product</span>	CH4	CH <sub>4</sub>	-1	H2O	H <sub>2</sub> O	2
Argon	Ar							
CO2	CO <sub>2</sub>							
CH4	CH <sub>4</sub>							
H2O	H <sub>2</sub> O							

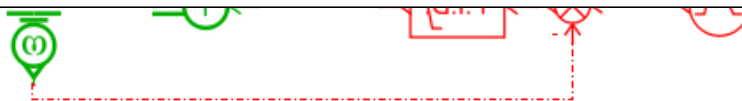
Reactant

Product

n°	Equation
1	2 O <sub>2</sub> + CH <sub>4</sub> → CO <sub>2</sub> + 2 H <sub>2</sub> O

Help
OK
Cancel
Apply

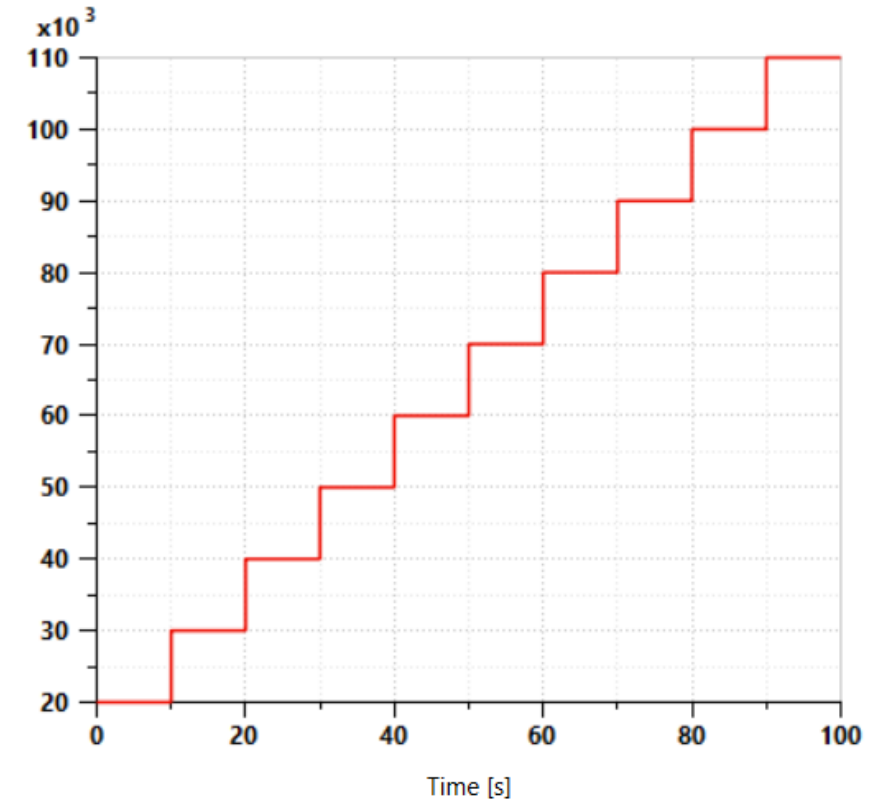
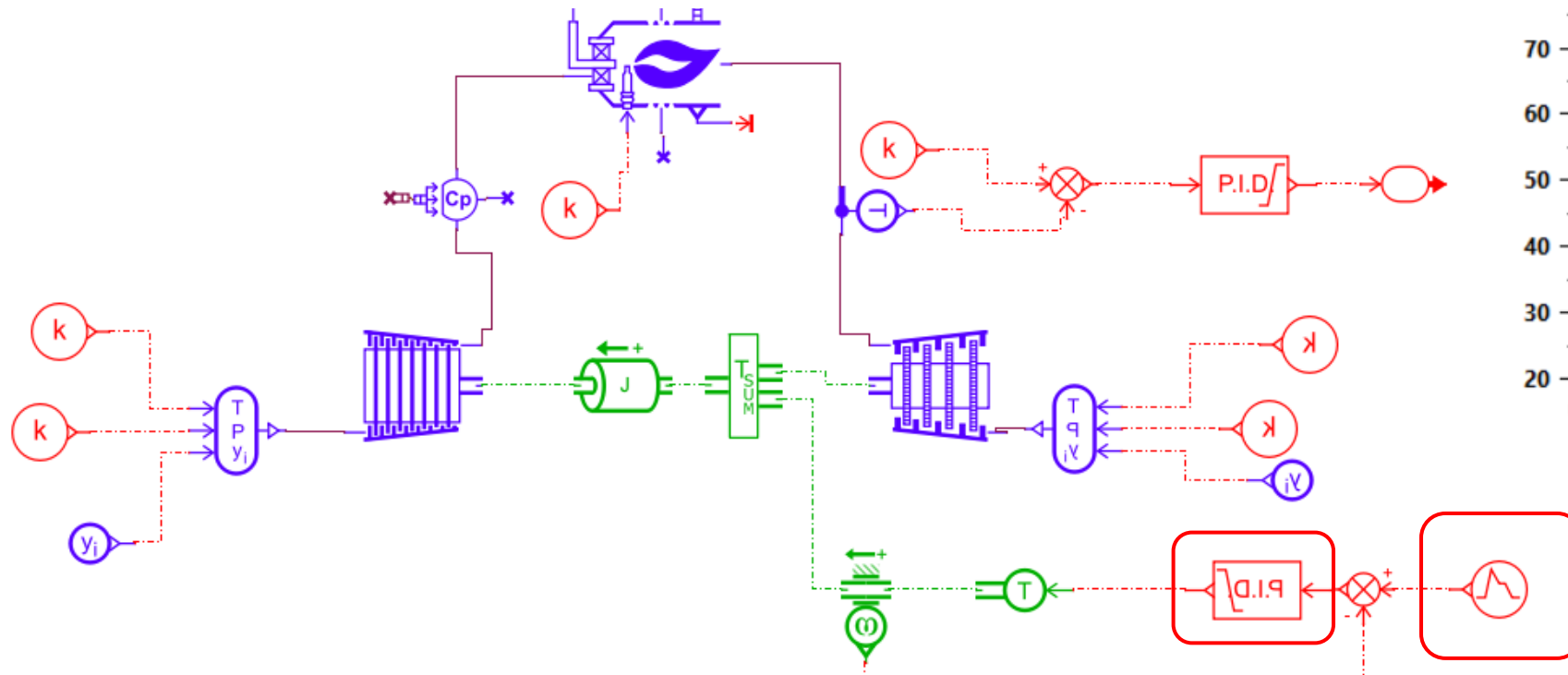
Value
0.85
90 000
182
0.786
0.879
5
1275
0.318
1.013
288.15



Title	Value	Unit	Tags	Name
# integral part		0	null	ipart
controller type		PID		outputtype
limit output	<b>yes</b>			outlim
proportional gain	<b>0.1</b>	null		Kp
integral gain	<b>0.5</b>	null		Ki
derivative gain	0	null		Kd
time constant for first order lag used to est...	0.001	null		tau
▼  saturation				
maximum permitted output value	<b>15</b>	null		outmax
minimum permitted output value	<b>-100</b>	null		outmin
anti windup method	back calculation and tracking			antiwind
backtracking gain	1	null		Ks



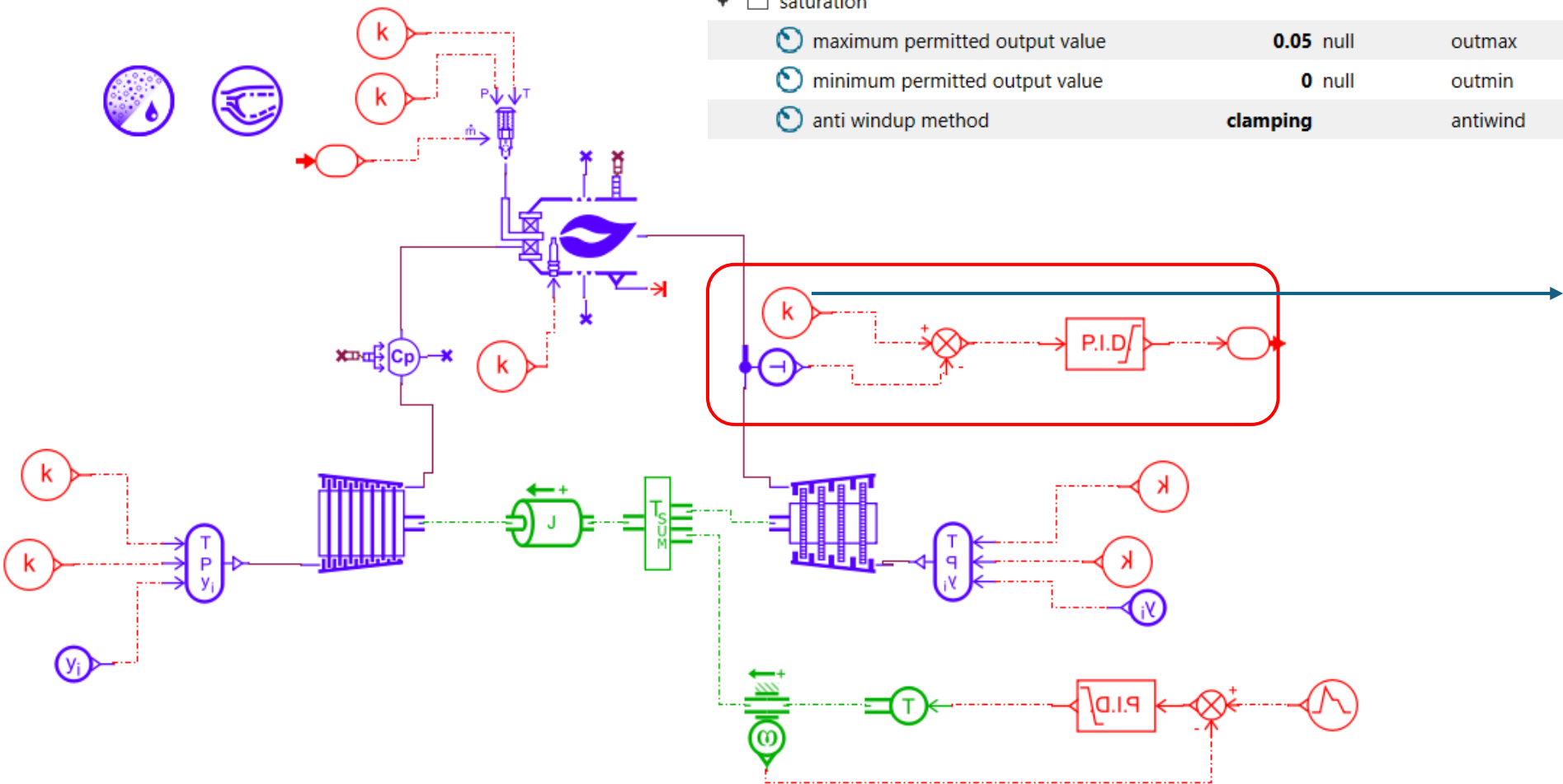
*Towards greater goals...*





...towards greater goals...

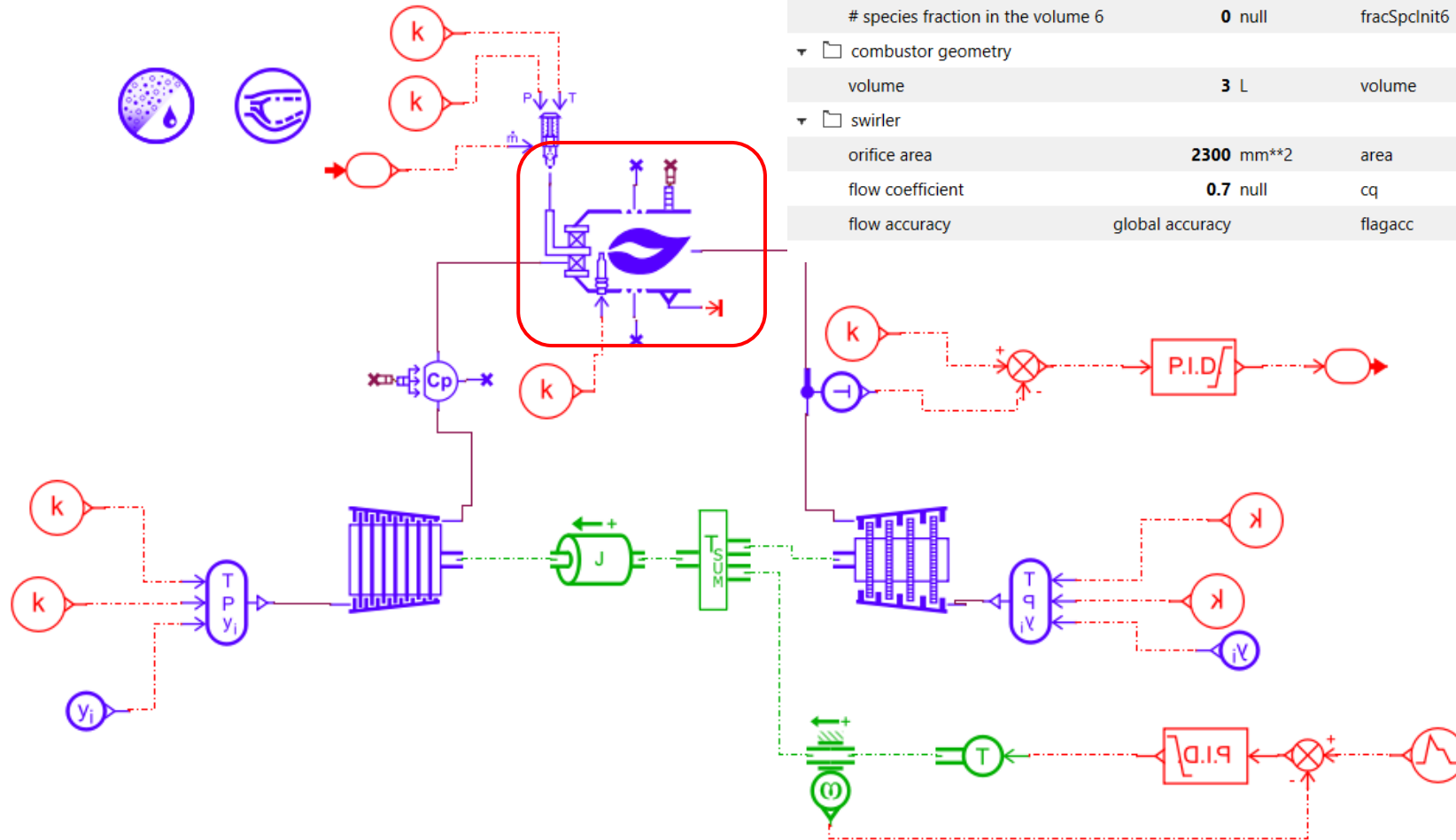
# ➔ 1D Model of MGT



# dummy state variable for estimating derivative ...	0	1/s	w	
# integral part	0	null	ipart	
controller type		PID	outputtype	
limit output	<input checked="" type="checkbox"/>	<b>yes</b>	outlim	
proportional gain	<input checked="" type="checkbox"/>	<b>0.0001</b>	null	Kp
integral gain	<input checked="" type="checkbox"/>	<b>0.0005</b>	null	Ki
derivative gain	<input checked="" type="checkbox"/>	0	null	Kd
time constant for first order lag used to estimat...	<input checked="" type="checkbox"/>	0.001	null	tau
▼ <input type="checkbox"/> saturation				
maximum permitted output value	<input checked="" type="checkbox"/>	<b>0.05</b>	null	outmax
minimum permitted output value	<input checked="" type="checkbox"/>	<b>0</b>	null	outmin
anti windup method	<input checked="" type="checkbox"/>	<b>clamping</b>		antiwind

- 900 K
- 1000 K
- 1100 K
- 1275 K

# ➔ 1D Model of MGT



Title	Value	Unit	Tags	Name
efficiency definition	constant			effDef
combustion efficiency	<b>0.99</b>	null		effCombConst
▾ initial values				
Ⓜ pressure at port 4	<b>5</b>	barA		press4
# temperature in the volume	<b>480</b>	K		temp0
initial fraction mode	mass basis			initFracMode
# species fraction in the volume 1	<b>0.78109</b>	null		fracSpclnit1
# species fraction in the volume 2	<b>0.20954</b>	null		fracSpclnit2
# species fraction in the volume 3	<b>0.00937</b>	null		fracSpclnit3
# species fraction in the volume 4	<b>0</b>	null		fracSpclnit4
# species fraction in the volume 5	<b>0</b>	null		fracSpclnit5
# species fraction in the volume 6	<b>0</b>	null		fracSpclnit6
▾ combustor geometry				
volume	<b>3</b>	L		volume
▾ swirler				
orifice area	<b>2300</b>	mm**2		area
flow coefficient	<b>0.7</b>	null		cq
flow accuracy	global accuracy			flagacc

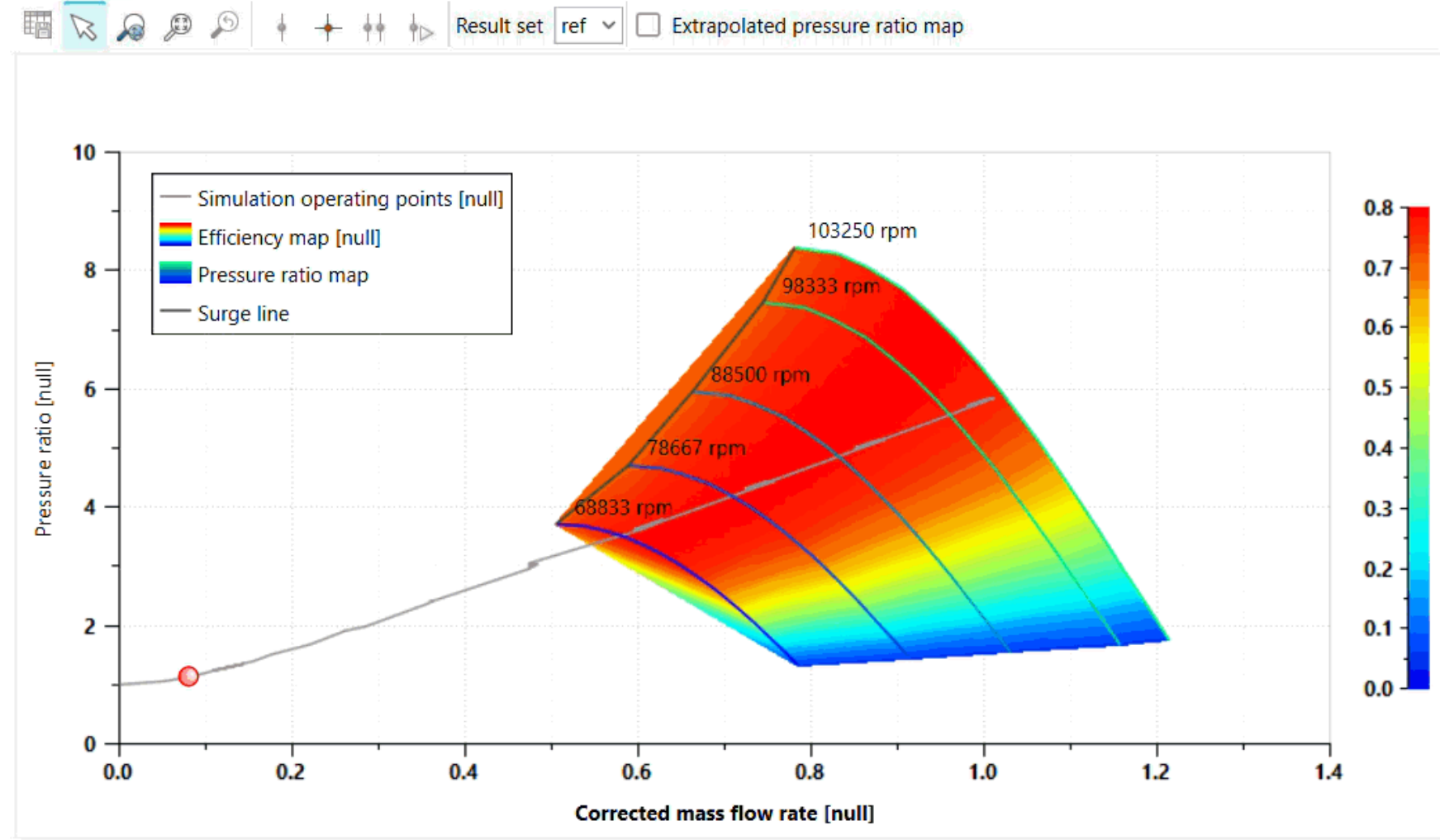


*Towards greater goals...*



water goals...

➔ Result



**Simulation points visualization**

time	= 0.18	s		
dmc	= 0.08	kg/s	efficiency	= 0.54 null
PR	= 1.13	null	corrected speed	= 13700 rev/min
surge margin	= -5.01	%		

Close



Towards greater goals...

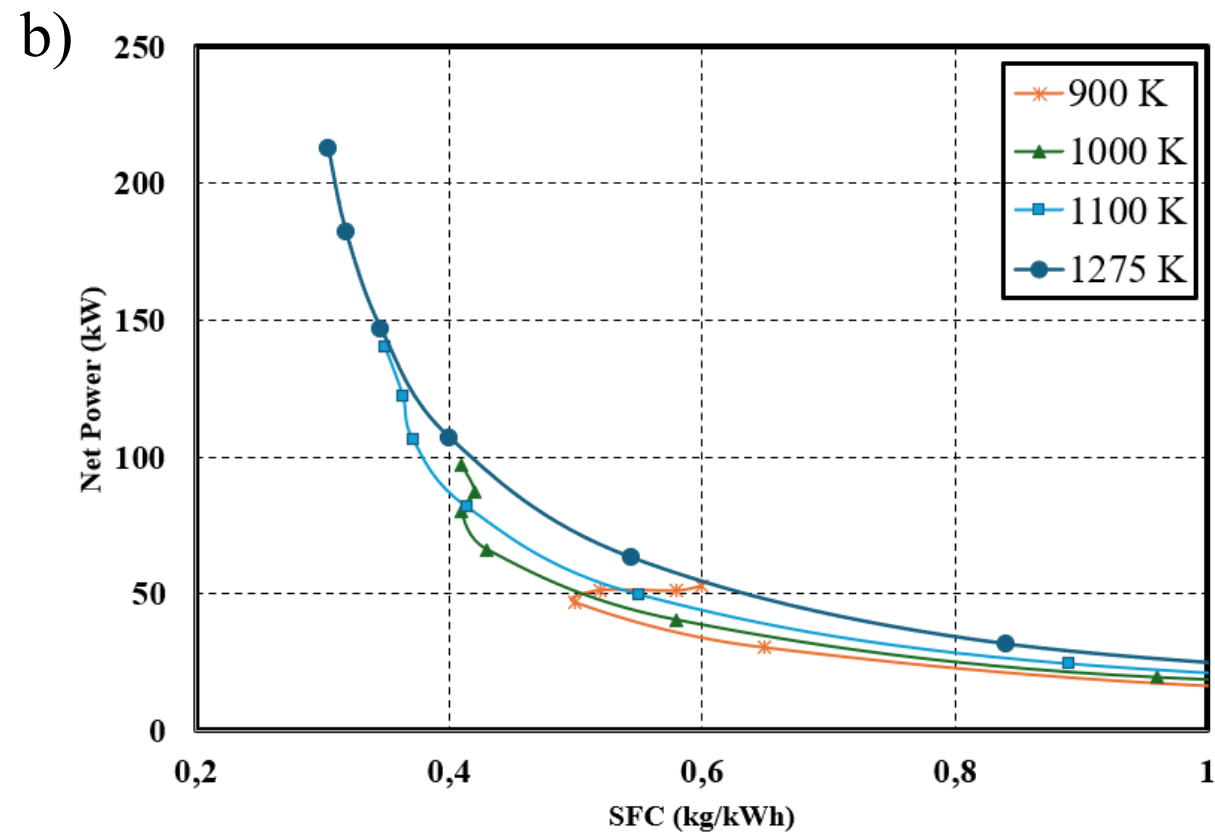
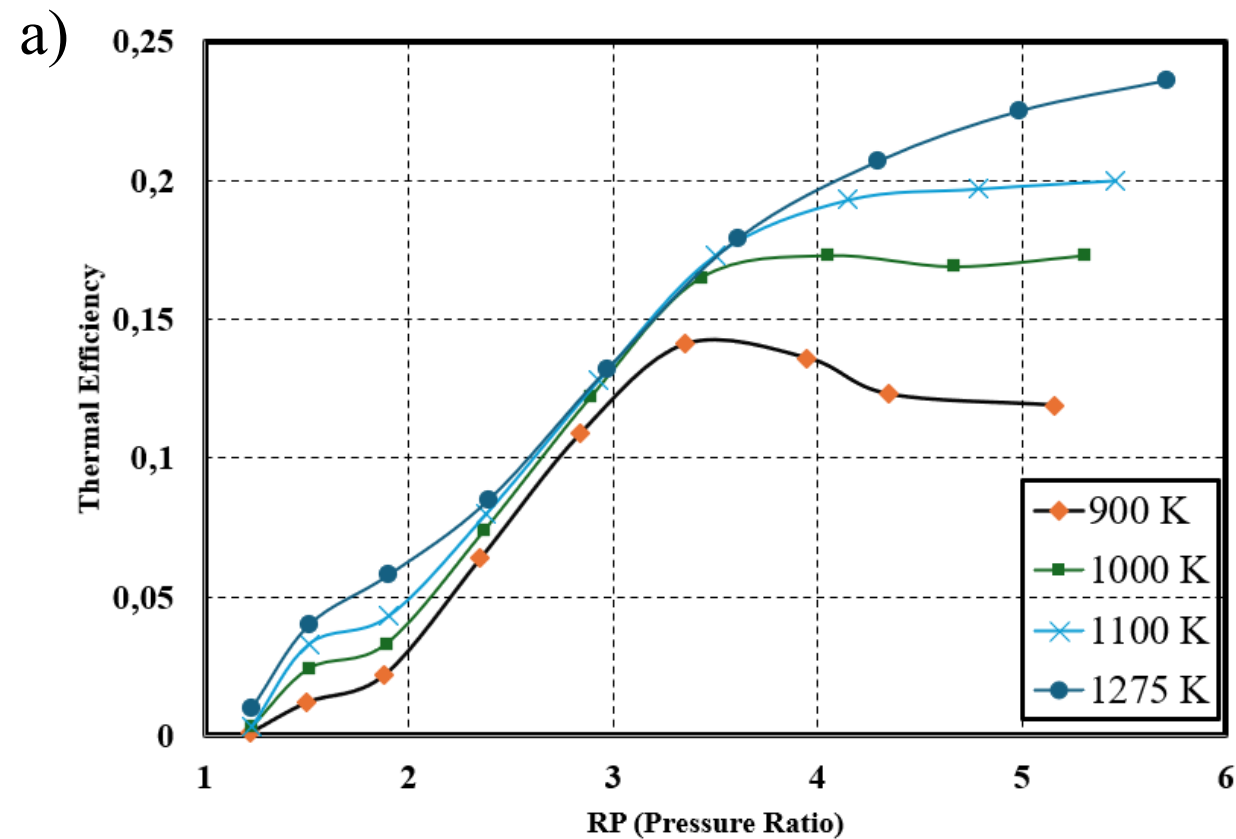
$$P_{net} = (T_t - T_c) \cdot \omega$$

$$Q = \dot{m}_f \cdot LHV$$

$$\eta_t = \frac{P_{net}}{Q}$$

$$SFC = \frac{\dot{m}_f}{P_{net}}$$

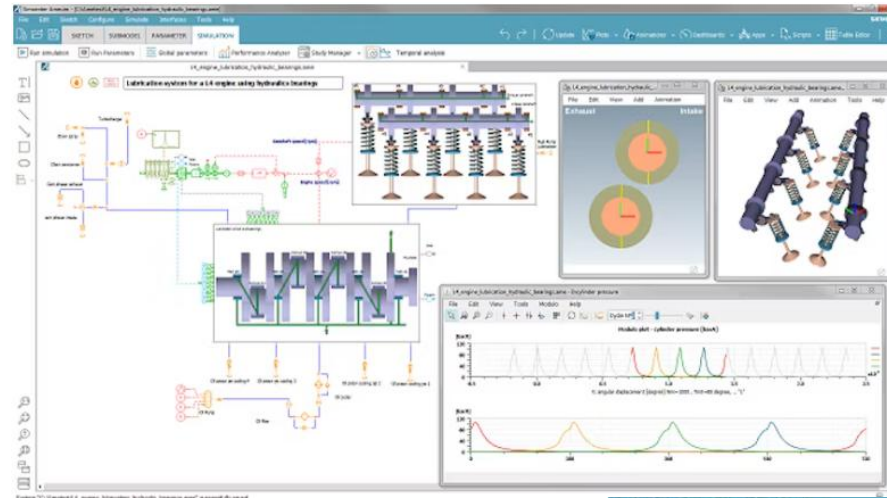
## Results



## ➤ Acknowledgement



**SIMOFIS**<sup>®</sup>



The author would like to thank Simofis Engineering Inc. (Simofis Mühendislik A.Ş.) for providing the academic license of Siemens Simcenter Amesim, which enabled the development and analysis presented in this study.