Calculation in the book

Item		Unit	Hydrogen	Oxygen
Given:				
Tank content		m^3	3.0	3.0
Pressure	25 bar	N/m^2	2.50E+06	2.50E+06
Temperature	20 °C	°C	293.15	293.15
Gas constant		Nm/ (kg K)	4124.4	259.83
Sought				
Mass $m = p \cdot V / R \cdot T$	Tn=273.15	kg	6.20	98.47

$$m = \frac{p\left[\mathrm{N/m^2}\right] \cdot V\left[\mathrm{m^3}\right]}{R\left[\mathrm{Nm/kg\,K}\right] \cdot T\left[\mathrm{K}\right]} \quad [\mathrm{kg}]$$

Item		Unit	Hydrogen	Oxygen	Air
Given:					
Temperature t	150 °C	K		423 °C	
Pressure p	25 bar	bar		2.5.E+06	
Molar mass M		kg / kmol	2.016	31.999	28.964
Gas constant R		Nm / (kg K)	4124.4	259.83	287.06
Molar volume of ideal gas normal conditions υ_n		m^3 / kmol		22.41	
Results					
Density at normal conditions	$\rho = M / \upsilon_n$	kg / m^3	0.09	1.43	1.29
Density at actual conditions	$\rho = p / R\ T$	kg / m^3	1.43	22.74	20.58

Calculated in the book

Item		Symbol	Unit	Values	
Given					
Substance		-	-	Oxygen	Hydrogen
Volume		V	m^3	0.25	0.25
Initial pressure		p_1	bar	5.0	5.0
Initial temperature	25 °C	T_1	K	298.15	298.15
Final temperature	60 °C	T_2	K	333.15	333.15
Properties					
Density (0°C)		ρ	kg /m^3	1.43	0.09
Gas constant		R	J/kg K	259.80	4,124.80
Heat capacity		c_p	kJ/kg K	0.92	14.30
Heat capacity		$c_\upsilon = c_p - R$	kJ/kg K	0.66	10.18
Results					
Mass		$m = pV/RT$	kg	1.61	0.10
Pressure, isochoric process		$p_2 = T_2 \cdot p_1/p_2$	bar	5.59	5.59
Heat transfer		$Q = m \cdot c_\upsilon \cdot (T_2 - T_1)$	kJ	37.3	36.2

Ex. 1-6_Air preheating

Item		Symbol	Unit	Values
Given				
Boiler capacity		Q	kJ/s	20,000
Air	20,000 m3/h	V	m^3 /s	5.56
Pressure, constant	1 bar	p	bar	1.00E+05
Temperature	20 °C	T_1	K	293 °C
Temperature	80 °C	T_2	K	353 °C
Air Properties				
Gas constant		R	J/kg K	287.1
specific heat		c_p	kJ/kg K	1.00
Results				
Mass flow of air		$m=p\,V/RT$	kg/s	6.60
Heat flow		$Q=m \cdot c_p \cdot (T_2 - T_1)$	kJ/s	396

Note: Temperature dependency of c_p is neglected

Ex. 1-7 Expansion of Fluids

Item		Symbol	Unit	Isothermal	Adiabatic	Polytropic
Given						
Volume, air	20 liter	V_1	m^3	0.02		
Initial pressure	12	p_1	N/m^2	1.2.E+06		
Final pressure	1	p_2		1.E+05		
Temperature	25 °C	T_1	K	298.15		
Properties						
Gas constant		R	kJ/kg K	0.287		
Specific heat	cp= 1.00	$c_\upsilon = c_p - R$	kJ/kg K	-	0.713	0.71
Exponent		κ, n	-	1.00	1.40	1.30
Results						
Mass		$m = p \cdot V / R \cdot T$	kg	0.280		
Final volume		V_2	m^3	0.240	0.122	0.142
Final temperature in K		T_2	K	298.2	144.4	165.6
Final temperature in °C		t_2	°C	25.0	-128.7	-107.6
Volume expansion work		W_{V12}	kJ	-59.6	-30.9	-35.6
Heat transfer		Q_{12}	kJ	59.6	0.0	8.8

Note: Formulas are different in the columns

Calculation in the text part

Item		Symbol	Unit	Values
Given				
Type of plant		-	-	Steam coal
Electrical output		P_e	MW_e	600
Fuel, hard coal		LHV	MW_t/t	8.13
Capacity of boiler	$\eta = 40\%$	P_Q	MW_t	1,500
Excess air		-	-	6%
Combustion characteristics				
Minimum combustion air		V_{A_min}	m_n^3/kWh_t	0.98
Minimum dry flue gas		V_{FGD_min}	m_n^3/kWh_t	0.95
Minimum wet flue gas		V_{FGW_min}	m_n^3/kWh_t	1.02
CO_2 Emissions			kg / MWh_t	342
Results				
Fuel consumption	t= 1 h	Q_F	MWh_t / h	1,500
mass flow		m_F	t / h	185
Air-to-fuel ratio		λ	-	1.06
Combustion air volume		V_A	m_n^3/h	1,558,200
Dry flue gas volume		V_{FGD}	m_n^3/h	1,510,500
Wet flue gas volume		V_{FGW}	m_n^3/h	1,621,800
CO_2 Emissions			t / h	513

Item	Symbol	Unit	Values	
Given				
Evaporation pressure	p_s	bar	80	180
Super heat temperature	t_4	°C	540	540
Intermediate Calculations **)				
Saturation temperature	t_s	°C	295	357
Enthalpy of saturated water	h'	kJ / kg	1,317	1,732
Enthalpy of saturated steam	h''	kJ / kg	2,759	2,510
Enthalpy of superheated steam	h_4	kJ / kg	3,497	3,390
Results				
Evaporation heat *r*	$h''-h'$	kJ / kg	1,442	778
Super heat enthalpy	$h_{sh}-h''$	kJ / kg	739	880
Total heat demand	$h_{sh}-h_1$	**kJ / kg**	**2,180**	**1,658**

*) temperature of condensate

**) Properties of steam are calculated with the Tool FluidEXL

The maximum CO_2 content of a fuel (HFO) in flue gas is **15.90%**, the metered is **11.70%**.
Calculate: excess air ratio, O_2 content in the flue gas and flue gas losses for the following cases:
Case 1: base case as found
Case 2: lower excess air ratio higher CO_2
Case 3: further reduction of excess air, and higher CO_2
Case 4: as 2 and 20 °C lower flue gas temperature (frequent cleaning of boiler)
Case 5: as above and preheating of combustion air by waste heat

I t e m	**Unit**	**Case**				
		1	**2**	**3**	**4**	**5**
Given						
Maximum CO_2	%	15.9	15.9	15.9	15.9	15.9
Metered CO_2	%	11.70	**12.7**	**13.8**	12.70	12.70
Flue gas temperature	°C	230	230	230	***210***	210
Combustion air temperature	°C	25	25	25	25	***100***
Carbon monoxide CO	%	0	0	0.3	0	*0*
Results						
Excess air ratio λ	-	1.36	1.25	1.15	1.25	1.25
Oxygen content	%	5.55	4.23	2.77	4.23	4.23
Flue gas losses	%	10.20	9.51	8.86	8.58	5.10
CO losses	%	0.00	0.00	1.11	0.00	0.00
Efficiency of combustion	%	**89.80**	**90.49**	**90.03**	**91.42**	**94.90**
Plus percentage points	%	**0.00**	**0.69**	**0.22**	**1.62**	**5.09**
Cost savings						
Annual fuel consumption (25 t/h boiler)	t/a	**10,000**	**9,924**	**9,975**	**9,823**	**9,463**
Fuel savings referred to case 1	t/a	**0**	**76**	**25**	**177**	**537**
Cost savings (fuel price 115 US$/t)	US$/a	**0**	**8,766**	**2,836**	**20,343**	**61,741**
Savings in percent	%		**0.76**	**0.25**	**1.77**	**5.37**