DEM
DEPARTAMENTO
DE ENGENHARIA MECÂNICA
TÉCNICO LISBOA

Equipamentos Térmicos

2nd Test (Second change) - 12 de Junho de 2015

Part II - Restricted Open Book

1. (3.0 v.) To burn liquid residues it was decided to apply in a furnace a pre-filming airblast atomizer ($\rho_{ar} = 1.18\,\mathrm{kg.m^{-3}}$). The atomizer discharge nozzle is located at 1.2 m of an oposed wall. The atomized liquid residue has the following properties:

ρ_L [kg.m^{-3}]	σ_L [N.m^{-1}]	μ_L [N.s.m^{-2}]	L [kJ.kg^{-1}]	ΔH [kJ.kg^{-1}]	T_B [°C]	M_{fuel} [kg.kmol^{-1}]	$(n_{O_2}/n_{fuel})_{\mathrm{stoich}}$ [−]
680	2.2×10^{-2}	5.0×10^{-4}	315	45000	130	110	12.5

Consider for the vapor of the atomized fluid: $c_{p,g} = 4.3\,\mathrm{kJ.kg^{-1}.K^{-1}}$ e $k_g = 0.05\,\mathrm{W.m^{-1}.K^{-1}}$.

(a) (1.5 v.) Estimate the maximum initial diameter ($d_{0,\max}$) of an atomized droplet at the surface of the discharge nozzle with a velocity equal to $15\,\mathrm{m.s^{-1}}$ to avoid impingement on the oposed wall. Consider the droplet vaporization scenario to estimate $d_{0,\max}$. Consider that the droplet is at its boiling point and in a stagnant air atmosphere with a temperature of 600 K (T_∞). (If not computed consider $d_{0,\max} = 120\,\mu\mathrm{m}$)

(b) (1.5 v.) Determine the air flow velocity (required for the atomization process - pre-filming airblast atomizer) to obtain a SMD equal to the diameter computed in the previous question ($d_{0,\max} = 120\,\mu\mathrm{m}$). Consider the stoichiometric air-to-fuel ratio.

2. (5.0 v.) Consider an incinerator that receives municipal solid wastes (MSW) from two neighboring cities. Table 1 presents some data about the average composition of MSW, estimated at the production site, as well as the total received amounts of MSW per day from each city. Before incineration the MSW are subjected to a pre-treatment stage using a *trommel* that removes only the "Metal" and "Glass" categories with separation efficiencies equal to 60% and 45%, respectively. Consider no moisture transfer between waste components during all stages of the waste flux (from the production site to the incinerator).

Taking into account Tables 1, 2 and 3 answer the following questions.

(a) (1.5 v.) Determine the mass percentage of MSW that are eliminated by the *trommel*. (If not computed consider 4.87% for the next questions)

(b) (2.0 v.) Determine the mass fraction of H_2O in the average MSW mixture. (If not computed consider $Y_{H_2O} = 39\%$)

(c) (1.5 v.) Determine the mass percentage of the category "Yard waste" in the MSW from the City A (entry C - Table 1).

Table 1: Known MSW composition from two neighboring cities.

	City A		City B	
Quantity (ton/day)	180		150	
Component	As generated [% mass]	H_2O at generation [% mass]	As generated [% mass]	H_2O at generation [% mass]
Metal	7	…	3	…
Wood	6	15	7	15
Yard waste	**C**	45	10	50
Glass	3	…	5	…
⋮	⋮	⋮	⋮	⋮
Total	100.0	–	100.0	–

Table 2: Ultimate analysis on a dry basis of "Wood" and "Yard waste" categories of the MSW mixture. $Y_{k,db}$ - mass fraction on a dry basis of component k.

Component, k	$Y_{k,db}$ [%]	Ash	C	H_2	O_2	S	N_2
Wood	1.70	0.10	1.20	0.20	0.20	0.00	0.00
Yard waste	8.40	0.60	6.00	0.60	0.80	0.10	0.30

Table 3: MSW mixture composition by category before and after pre-treatment and ultimate analysis on a dry basis of the MSW mixture. Y'_k - mass fraction not normalized. wb - wet basis, db - dry basis.

	Composition of MSW by category - [% mass]					Ultimate analysis (dry basis) [% mass]						
	Before pre-treat.	After pre-treatment										
Component, k	$Y_{k,wb}$	$Y'_{k,wb}$	$Y_{k,wb}$	$Y'_{k,db}$	$Y_{k,db}$	Ash	C	H_2	O_2	S	N_2
Metal	…	…	…	…	…	…	…	…	…	…	…
Wood	…	…	…	…	…	…	β	…	…	…	…
Yard waste	…	…	…	…	7.02	…	…	…	α	…	…
Glass	…	…	…	…	…	…	…	…	…	…	…
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Total	100	A	100	B	100	19.71	$45.05 + \beta$	6.26	$16.53 + \alpha$	0.85	4.26