DEM
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DE ENGENHARIA MECÂNICA
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Equipamentos Térmicos

2nd Test - 27 May 2015

Part II - Restricted Open Book

1. (3.0 v.) The application of burners for liquid residues is under consideration in an incinerator unit. The burners are composed by pressure-jet atomizers. The discharge orifice diameter is equal to 0.5 mm, the injection pressure differential across the nozzle is 12 bar and the flow number (FN) corresponds to 1.69×10^{-7} m^2. The atomized liquid has the following properties:

ρ_L [kg.m^{-3}]	L [kJ.kg^{-1}]	ΔH [kJ.kg^{-1}]	T_B [°C]	M_{fuel} [kg.kmol^{-1}]	$(n_{O_2}/n_{fuel})_{\text{stoich}}$ [−]
730	280	45000	180	140	15.5

Consider for the vapor of the atomized fluid: $c_{p,g} = 4.2$ kJ.kg^{-1}.K^{-1} e $k_g = 0.07$ W.m^{-1}.K^{-1}.

(a) (1.0 v.) Determine the average spray velocity. (If not computed consider 20 m.s^{-1} for the following question)

(b) (2.0 v.) Assuming that all spray droplets have a velocity equal to the average velocity computed in (a) estimate the required distance to completely burn a droplet with an initial diameter of 120 μm. Consider that the droplet is at its boiling point and in a stagnant air atmosphere with a temperature of 400 K (T_∞).

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 well mixed in the proportion of the daily received quantities and are subjected to a pre-treatment stage using a *trommel* that removes only the "Metal" and "Glass" categories with different efficiencies. 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) (2.0 v.) Compute the *trommel* separation efficiency of the category "Metal" and determine the mass fraction on a wet basis of the component "Glass" (entry A in Table 3) considering the *trommel* separation efficiency for "Glass" equal to 60%. Consider the separation efficiency as the percentage of removed material.

(b) (2.0 v.) Determine the mass fractions on a dry basis of components "Paper" and "Food waste" (entries B and C of Table 3, respectively). Consider the mass fraction of H_2O in the MSW mixture (Y_{H_2O}) equal to 40.24%.

(c) (1.0 v.) Determine the ultimate analysis on a wet basis of the MSW mixture that is incinerated.

Tabela 1: Known MSW composition from two neighboring cities.

	City A		City B	
Quantity (ton/day)	120		165	
Component	As generated [% mass]	H_2O at generation [% mass]	As generated [% mass]	H_2O at generation [% mass]
Metal	4.0	...	3.0	...
Paper	...	3.0	...	3.0
Plastics	...	...	...	...
Leather/Rubber	...	...	...	...
Textiles	...	...	...	...
Wood	...	...	...	...
Food waste	37.0	75.0	41.0	85.0
Yard waste	...	...	...	...
Glass	3.0	...	5.0	...
Miscellaneous	...	...	...	...
Total	100.0	–	100.0	–

Tabela 2: Ultimate analysis on a dry basis of "Plastics" category 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
Plastics	2.50	1.00	1.00	0.10	0.10	0.10	0.20

Tabela 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	...	0.86	...	...	...	...	...	...	...	...	...
Paper	21.11	...	22.23	...	**B**	...	...	...	...	...	...
Plastics	...	...	...	...	11.67	α	...	...	...	...	...
Leather/Rubber	...	...	...	...	...	...	...	...	...	...	...
Textiles	...	...	...	...	...	...	...	...	...	...	...
Wood	...	...	...	...	...	...	...	...	...	...	...
Food waste	...	...	...	...	**C**	...	...	...	β	...	...
Yard waste	...	...	...	...	...	...	...	...	...	...	...
Glass	...	...	**A**	...	...	...	...	...	...	...	...
Miscellaneous	...	...	...	...	...	...	...	...	...	...	...
Total	100	D	100	E	100	$12.79 + \alpha$	52.62	6.28	$17.44 + \beta$	0.80	3.88