ANNOUNCEMENT FOR STUDENT CONTEST PROBLEM COMPETITION 2010

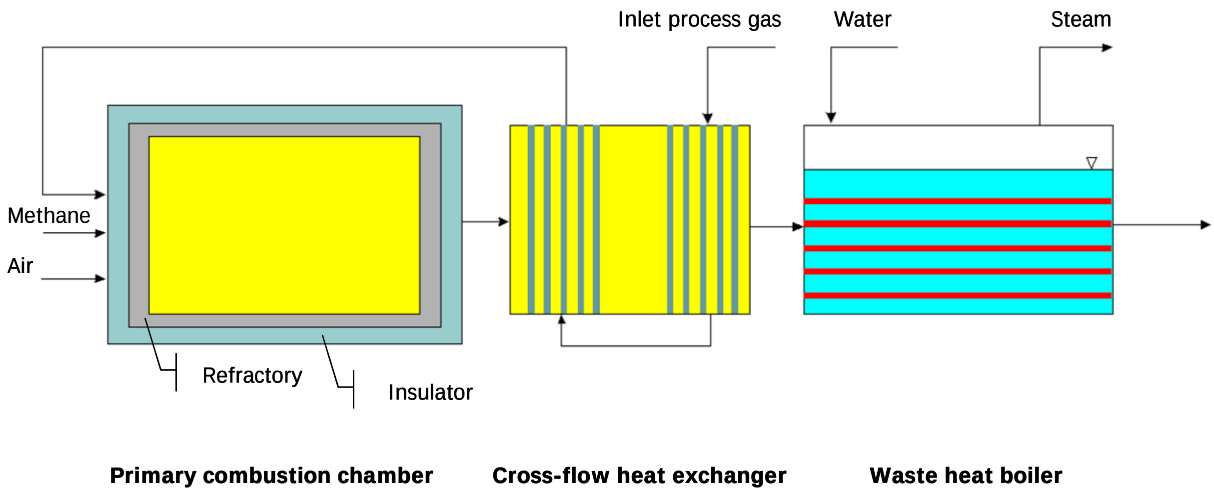
AWARD 1000 EUR

EURECHA - The European Committee for Computers in Chemical Engineering Education. The participants have approximately three months to prepare and submit solutions to the problem no later than **April the 30th, 24:00**. Solutions can be prepared by individuals or by teams.
The written report, not exceeding 12 pages including figures, should be sent to EURECHA secretariat in electronic **pdf** form as e-mail attachment to Professor I.M. Mujtaba (I.M.Mujtaba@bradford.ac.uk).
The jury will select the best solution, based on technical excellence, quality of the report and originality.
The winner will receive:

- A cheque of 1000 EUR (to cover the travel and accommodation expenses, rest as a gift)
- An invitation to get the award at the ESCAPE 20 symposium, held in Ischia, Italy, June 6-9, 2010. http://www.aidic.it/escape20
- Selected solution will be posted on the EURECHA web site.

Thermal destruction of a VOC by an incineration unit with heat recovery

A process gas stream containing monochlorobenzene must be destroyed thermally in an incineration plant. The plant layout is based on the following equipment: a primary combustion chamber, a crossflow double tube heat exchanger to preheat the inlet process stream up to 600 °C and a waste heat boiler with fired tubes to produce steam at 30 bar.



The student must design the three process units. It is necessary to quantify the geometrical dimensions of each process unit as well as its inlet and outlet streams in terms of flowrate, compositions, and temperature. Any additional information/dimension/quantity necessary for the measuring of the process/plant is welcome. Finally, the student should provide and discuss the assumptions, and possible simplifications taken to design the plant.

Design specifications

- Primary combustion chamber
  Outlet gas temperature: 1200 °C.
  Gas residence time inside the chamber: 2 s.
  External skin temperature: 80 °C.
  Outlet oxygen mole fraction: 6 %.
  Insulator thickness: 30 cm.
  Insulator thermal conductivity: 0.2 W/m K.
  Refractory thermal conductivity: 1.0 W/m K.
  A methane flowrate can be used to reach the required design temperature. If auxiliary methane is used, then an air stream must be fed according to the stoichiometric ratio.

- Cross-flow double-tube heat exchanger
  The cold-gas process stream passes inside the tubes. The hot gases flow shell-side with an average velocity of 5 m/s. The tube internal diameter is 2.54 cm. The student has to evaluate the exchange area, and the number, layout, and spacing of the tubes.

- Waste heat boiler with fired tubes
  The hot gases pass inside the tubes (whose internal diameter is 2.54 cm). The tubes are parallel, longitudinal, and are drowned in water. The student has to evaluate the exchange area, the number of tubes and the steam flowrate. The inlet process water is at 20 °C. Both the cross-flow heat exchanger and the waste heat boiler dissipate about 5% of the overall exchanged heat.

Chemical and physical data

Inlet process stream (to be thermally destroyed)

Mass flowrate: 1000 kg/h			Temperature:	150 °C	Pressure:	1 atm
Mass fractions:	O_2	=	0.1	N_2	=	0.7
	H_2O	=	0.18	C_6H_5Cl	=	0.02

Heats of combustion:

C_6H_5Cl	=	6397 kcal/kg
CH_4	=	11945 kcal/kg

Gas viscosity: $\mu = 1.8464 \cdot 10^{-5} \cdot \left(\frac{T}{300}\right)^{0.75}$ kg/m s where T [K]

Gas thermal conductivity: $k = 2.62 \cdot 10^{-2} \cdot \left(\frac{T}{300}\right)^{0.75}$ W/m K where T [K]

Water heat of vaporization:

$$\Delta H_{ev}(T) = 4.0726 \cdot 10^{7} \cdot \left[\frac{1-T_R}{1-T_R^*}\right]^{0.38} \quad \text{J/kmol K}$$

$$T_R = \frac{T}{T_C}; \quad T_R^* = \frac{373.15}{T_C}; \quad T_C = 647.3 \text{ K} \quad \text{where } T \text{ [K]}$$

Steam viscosity: $\mu = 8.92 \cdot 10^{-5} \cdot \left(\frac{T}{300} \right)^{0.75}$ kg/m s where T $[\mathrm{K}]$

Steam thermal conductivity: $k = 1.96 \cdot 10^{-2} \cdot \left(\frac{T}{300} \right)^{0.75}$ W/m K where T $[\mathrm{K}]$

Water vapor pressure:

$$P_v(T) = \exp\left(73.649 - \frac{7.2582 \cdot 10^3}{T} - 7.3037 \ln(T) + 4.1653 \cdot 10^{-6} \cdot T^2 \right) \quad \text{Pa} \quad \text{where } T \; [\mathrm{K}]$$

Gas heat capacity: $c_p = a + bT + cT^2$ kcal/kmol K where T [°C]

Component	a	b	c
CO_2	9.0	$7.183 \cdot 10^{-3}$	$-2.475 \cdot 10^{-6}$
O_2	6.95	$2.326 \cdot 10^{-3}$	$-0.770 \cdot 10^{-6}$
H_2O	7.76	$3.096 \cdot 10^{-3}$	$-0.343 \cdot 10^{-6}$
N_2	6.77	$1.631 \cdot 10^{-3}$	$-0.345 \cdot 10^{-6}$
HCl	6.45	$1.975 \cdot 10^{-3}$	$-0.547 \cdot 10^{-6}$