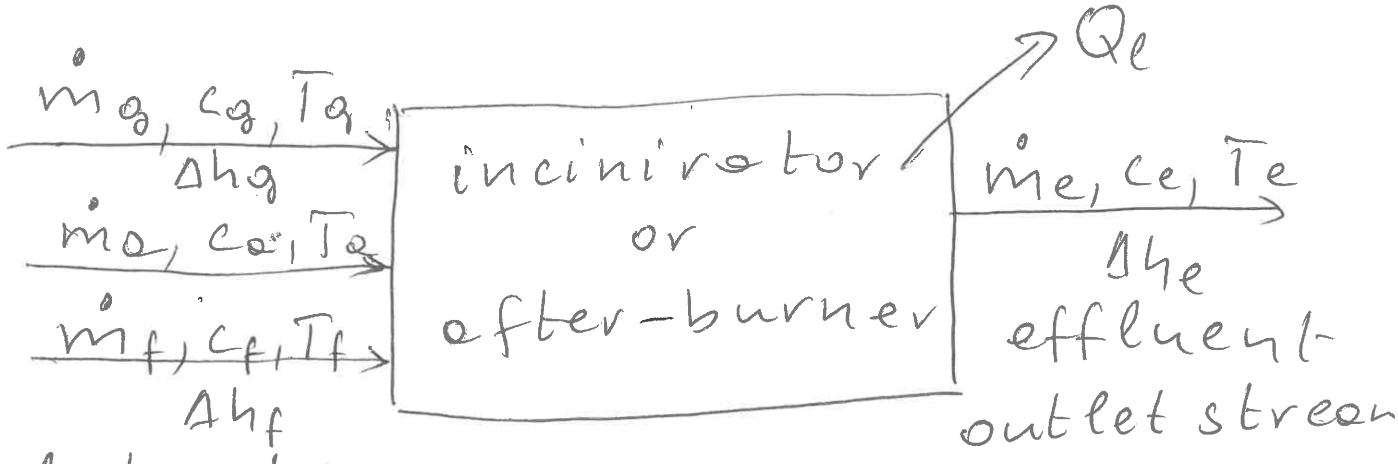
Additional fuel demand at chemical oxidation



inlet streams

$\dot{m}$ mass flow rate (kg/s)

c specific heat (J/kg K)

Δh lower calorific value (J/kg)

If combustible component(s) remain(s) back

$$\Delta h_e > 0$$

Not perfect burning (heat loss)

$\dot{Q}_l$ heat loss through the equipment wall.

To determine additional fuel demand ($\dot{m}_f$) we use material balance and heat balance!

Mass balance

$\sum$ inlet streams = $\sum$ outlet streams

$$\dot{m}_g + \dot{m}_a + \dot{m}_f = \dot{m}_e \qquad (1)$$

Heat balance

$\sum$ inlet heat flows = $\sum$ outlet heat flows

$$\dot{m}_g (c_g T_g + \Delta h_g) + \dot{m}_a c_a T_a + \dot{m}_f (c_f T_f + \Delta h_f) = \dot{m}_e (c_e T_e + \Delta h_e) \qquad (2)$$

cT product represents the sensible heat

Δh represents th latent heat

Equation 1 is substituted inutto Equation 2;

[Mass balance is substituted into heat balance]

$$\dot{m}_g(c_g T_g + \Delta h_g) + \dot{m}_a c_a T_a + \dot{m}_f(c_f T_f + \Delta h_f) =$$
$$= (\dot{m}_g + \dot{m}_a + \dot{m}_f)(c_e T_e + \Delta h_e) + \dot{Q}_l$$

Reducing the equation

$$\dot{m}_f(c_f T_f + \Delta h_f - c_e T_e - \Delta h_e) = \dot{m}_g(c_e T_e + \Delta h_e - c_g T_g - \Delta h_g) +$$
$$+ \dot{m}_a(c_e T_e + \Delta h_e - c_a T_a) + \dot{Q}_l$$

and:

$$\dot{m}_f = \frac{\dot{m}_g(c_e T_e + \Delta h_e - c_g T_g - \Delta h_g) + \dot{m}_a(c_e T_e + \Delta h_e - c_a T_a) + \dot{Q}_l}{c_f T_f + \Delta h_f - c_e T_e - \Delta h_e}$$

Easy to realize:

if $\Delta h_e > 0$, Nominator ↑, Denominator ↓ and

$\dot{m}_f$ ⇑ or $\dot{m}_f / \dot{m}_g$ ⇑

fuel demand; specific fuel demand

similarly T_e ↑ outlet temperature increases ~~w~~ fuel demand also!

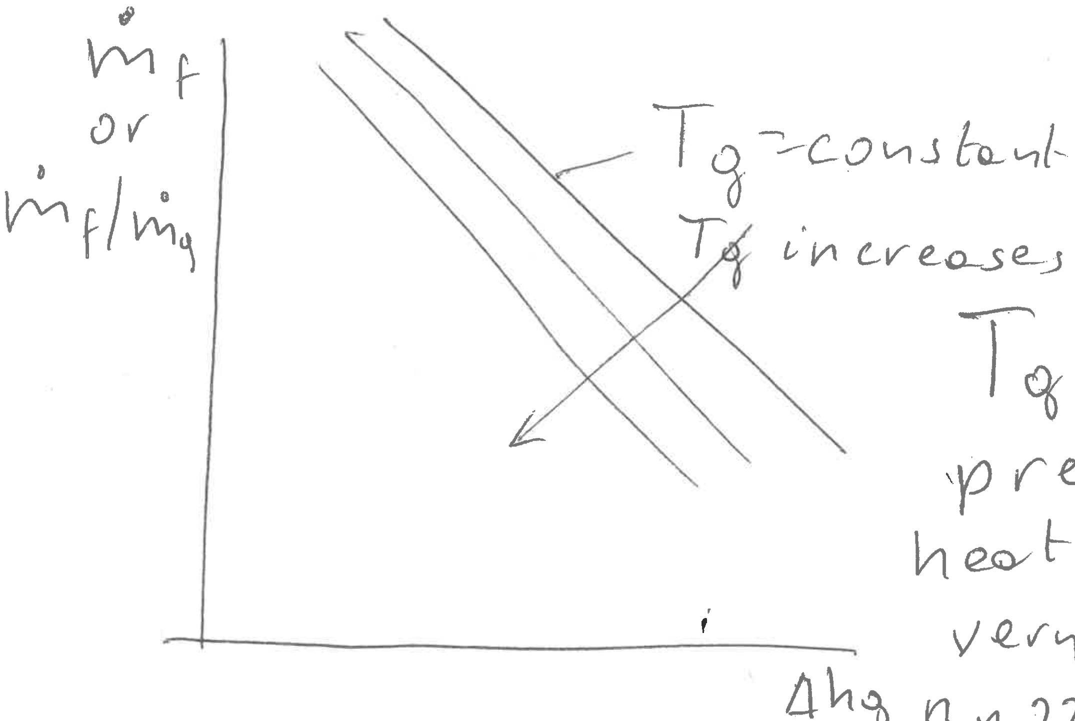
important to have

- as perfect burning as possible
- as low outlet temperature as possible (heat utilization), but important to fulfill requiremen

Generally specific heats are given and $\dot{m}_e$ can be calculated knowing the composition ($C_mH_nO_p$; m, n, p)

Reducing the equation can be seen that:

$$\underline{\underline{\dot{m}_f}} \text{ or } \underline{\underline{\dot{m}_f/\dot{m}_g}} \sim \underline{-C_1 T_g - C_2 \Delta h_g}$$

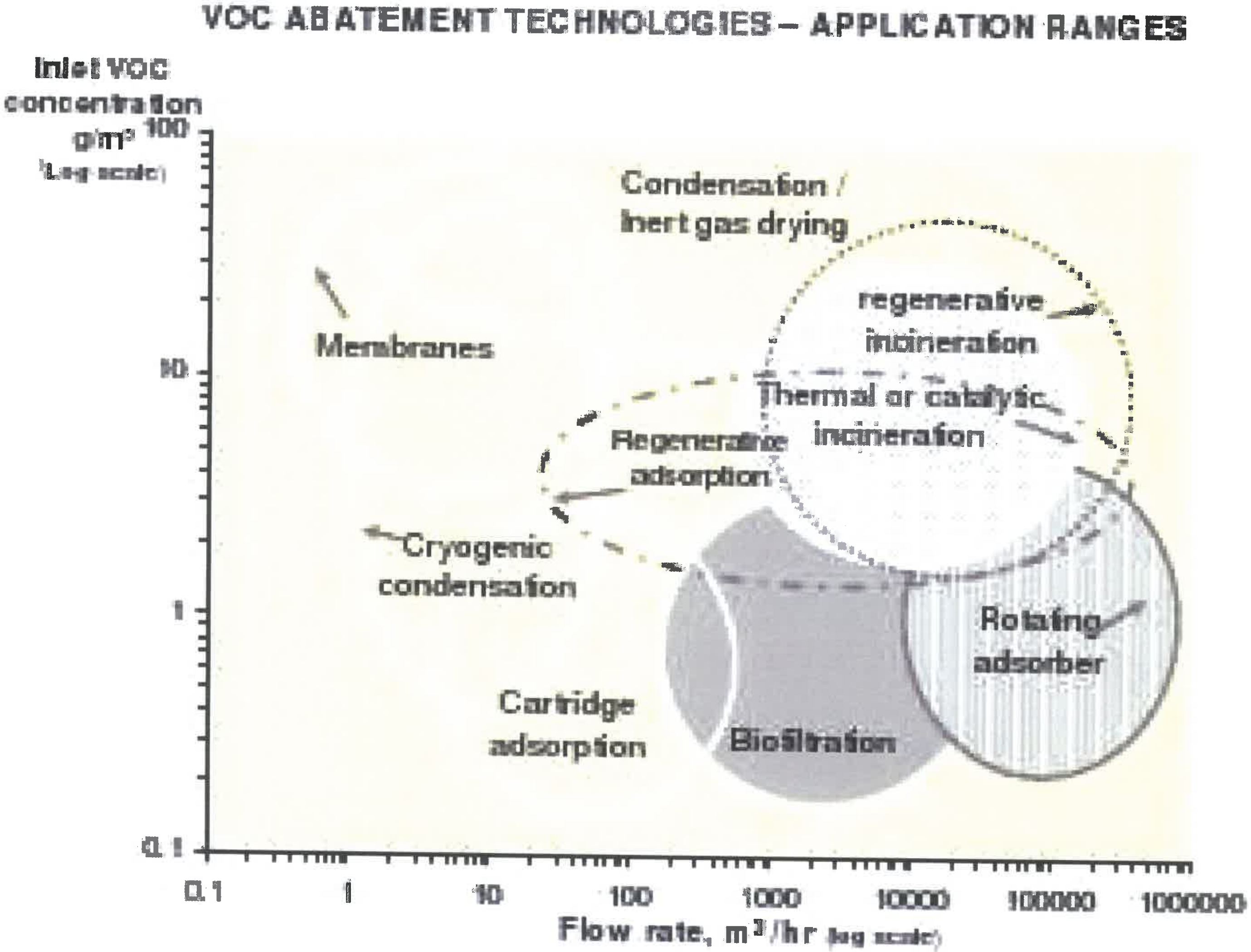


if T_g↑ or Δh_g↑ fuel demand decreases

T_g↑ $\dot{m}_f$↓

preheating and heat utilization very important

Bp. 22. 04. 2019



VOC ABATEMENT TECHNOLOGIES – APPLICATION RANGES
Inlet VOC concentration g/m³ (Log scale)
100
10
1
0.1
Condensation / Inert gas drying
Membranes
regenerative incineration
Thermal or catalytic incineration
Regenerative adsorption
Cryogenic condensation
Rotating adsorber
Cartridge adsorption
Biofiltration
0.1
1
10
100
1000
10000
100000
1000000
Flow rate, m³/hr (log scale)

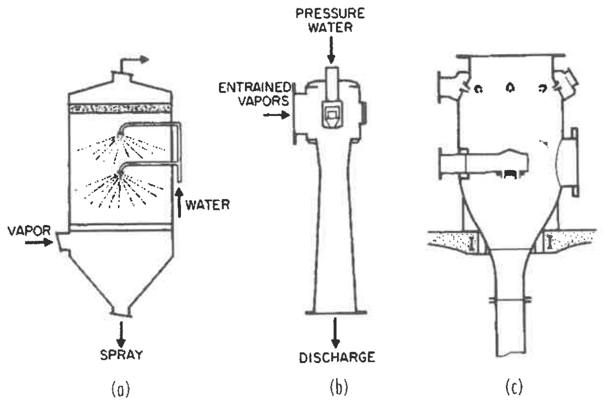


FIG. 25-15 Typical direct-contact condensers. (*a*) Spray chamber. (*b*) Jet. (*c*) Barometric.

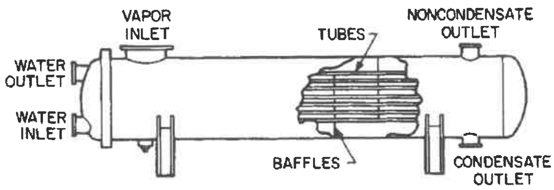


FIG. 25-16 Typical surface condenser (shell-and-tube).

#1

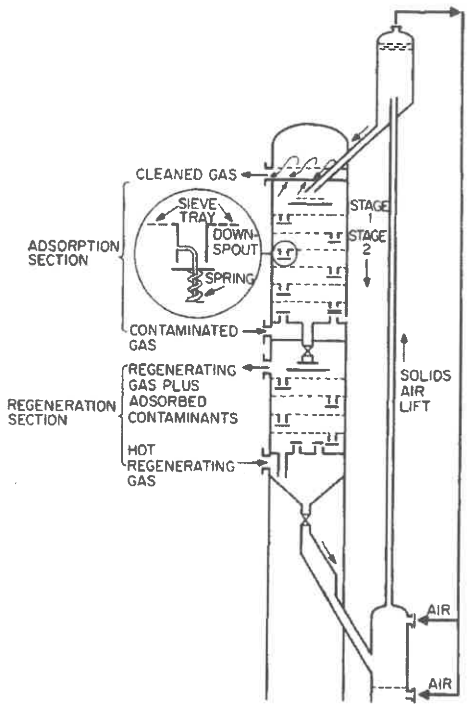


FIG. 25-12 Multistage countercurrent adsorption with regeneration.

#2

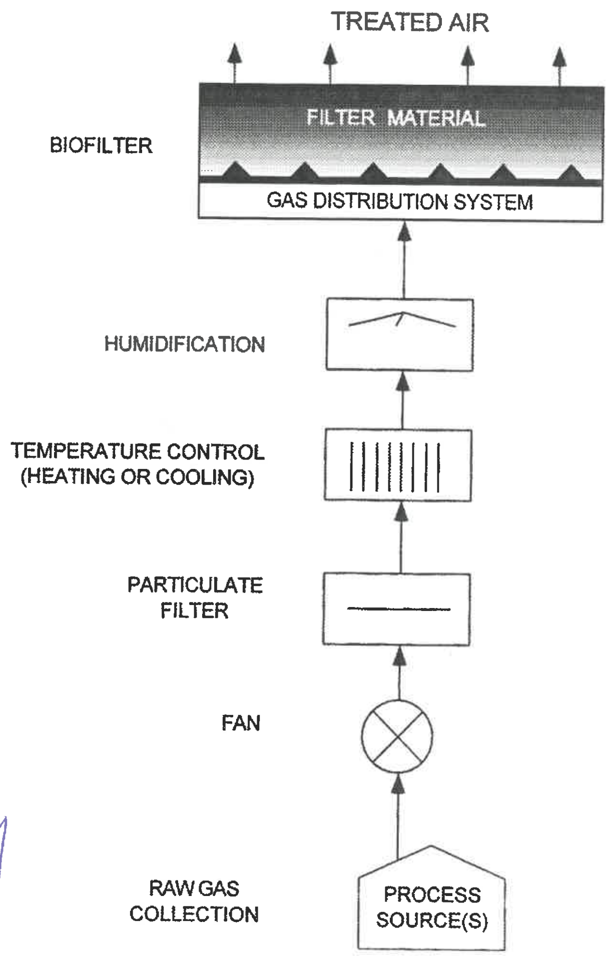


FIG. 25-17 Schematic flowsheet illustrating the individual elements of an open, single-layer biofilter system. Particulate filtration and/or temperature adjustment is often combined with the equipment to adjust gas humidity content.

#4

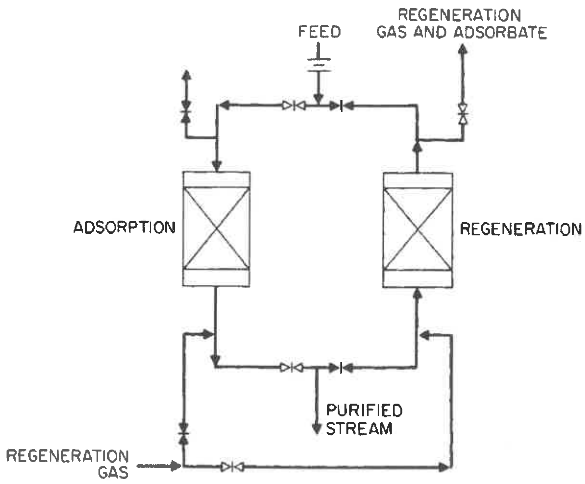


FIG. 25-10 Typical two-bed adsorption system.

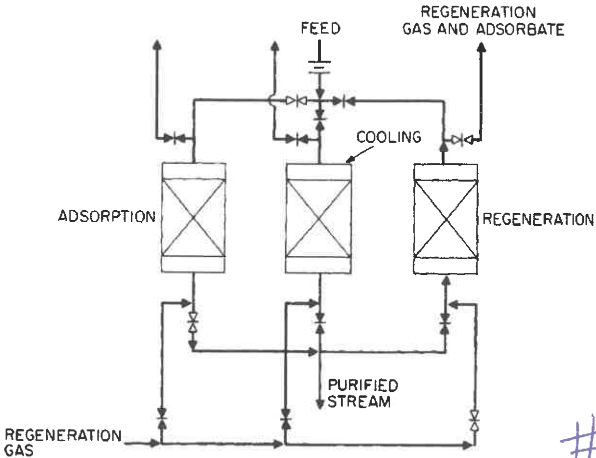
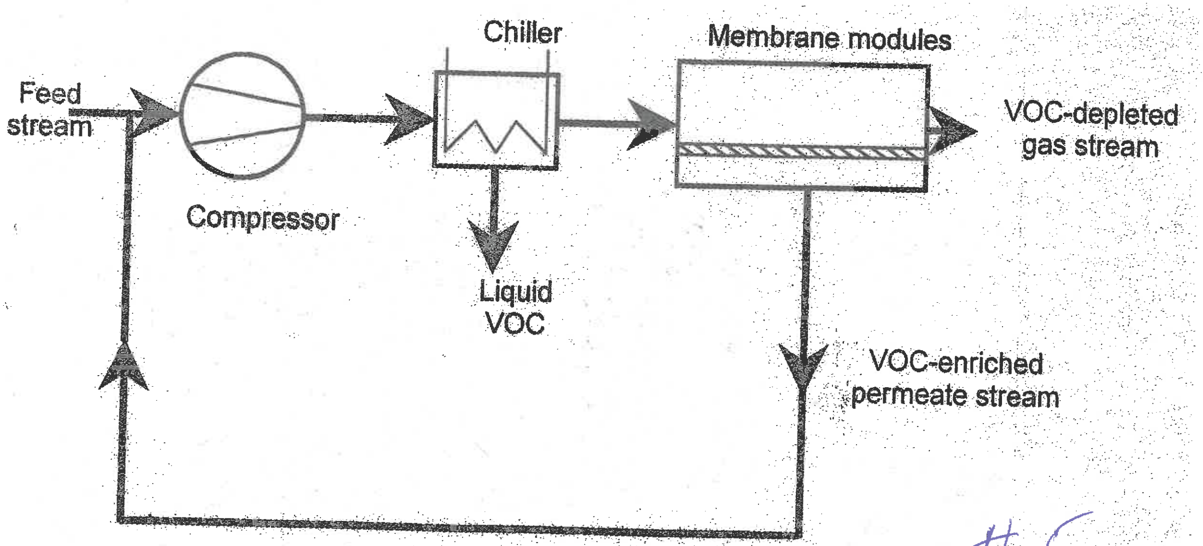


FIG. 25-11 Typical three-bed adsorption system.

#3



#5

Flow diagram showing the application of a membrane vapor permeation system to effluent gas treatment and VOC recovery: condenser on the compressed feed gas side. (Adopted from Lokhandwala et al., 1999.)

#6

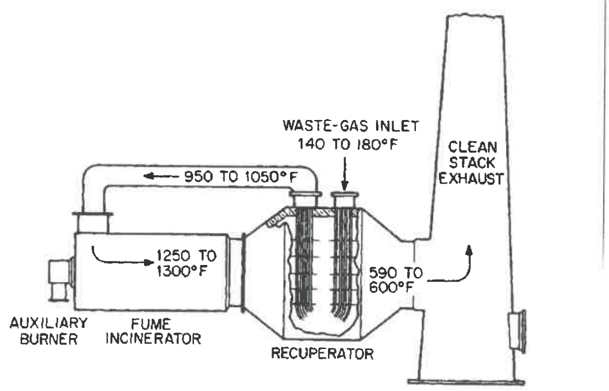


FIG. 25-14 Thermal combustion with energy (heat) recovery.

#7

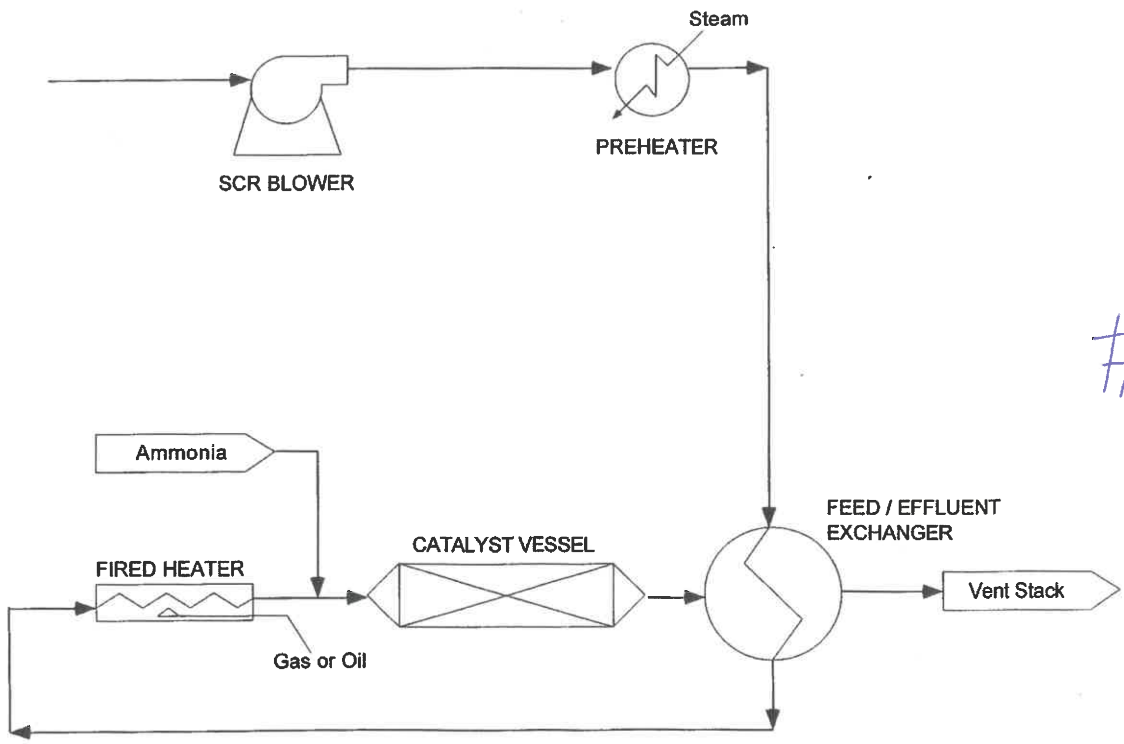
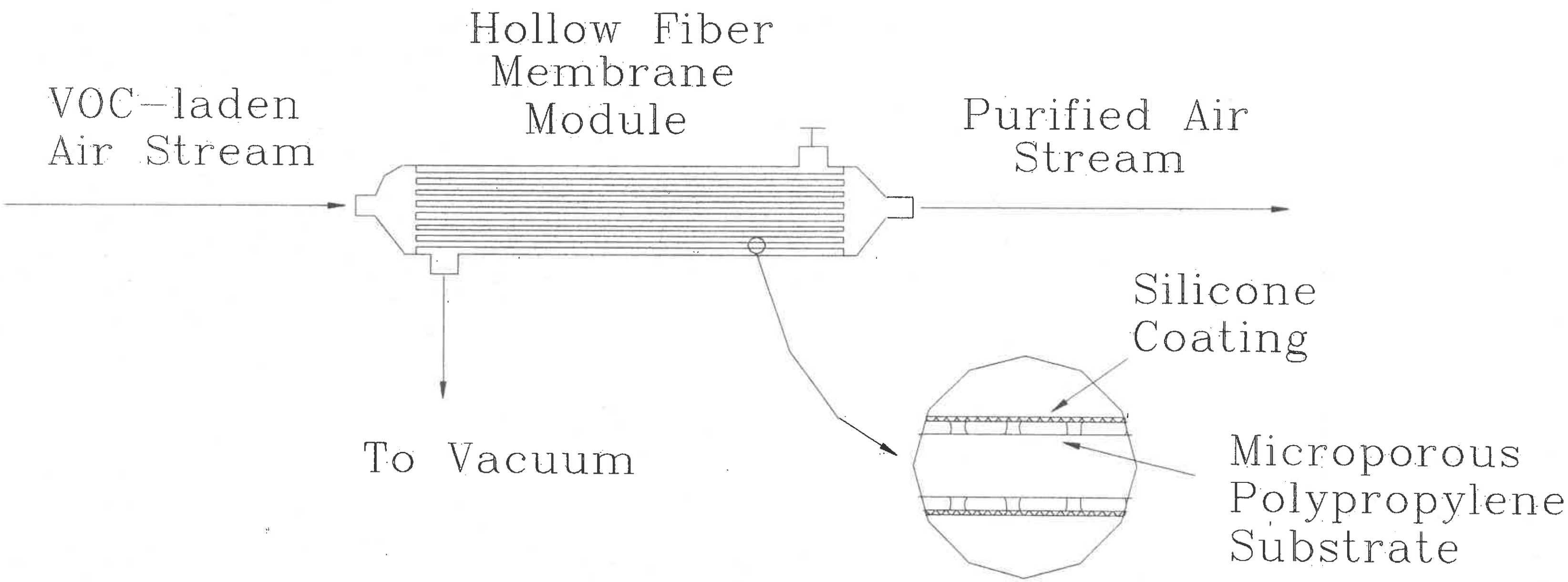


FIG. 25-22 Selective catalytic reduction of nitrogen oxides.

VOC Removal from N_2/Air at Atmospheric Pressure by Permeation through a Hollow Fiber Module



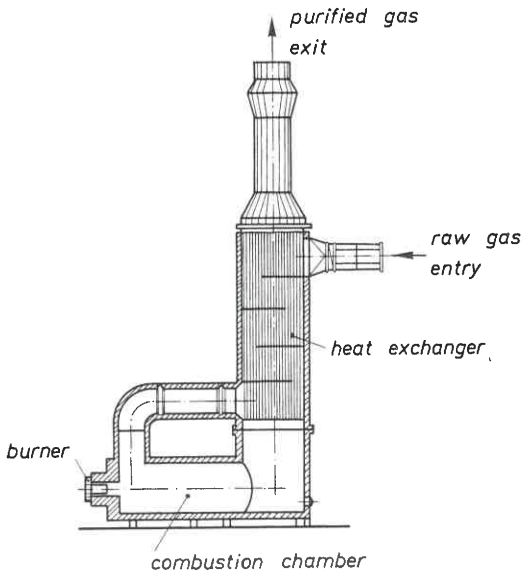


Figure 1.

Thermal combustion plant

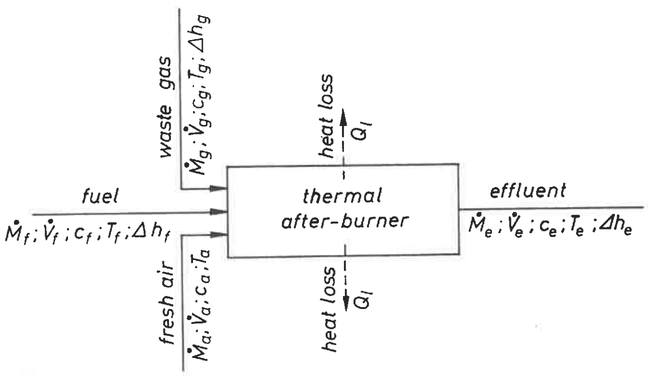


Figure 2.

Heat balance of a thermal after-burner

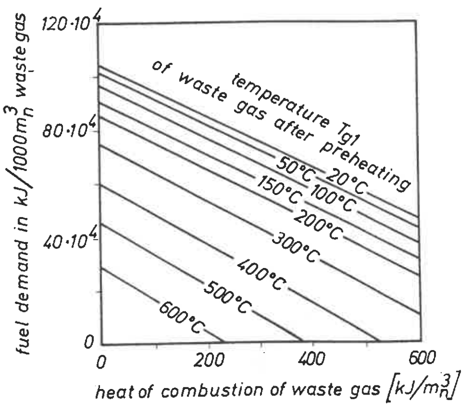


Figure 4.

Fuel demand per 1000 m_n^3 of waste gas as a function of heat of combustion Δh_g of waste gas and temperature T_{g1} of waste gas at the inlet of the thermal after-burner

Dr. Parti Mihály; 463-2635
Department of Fluid Mechanics

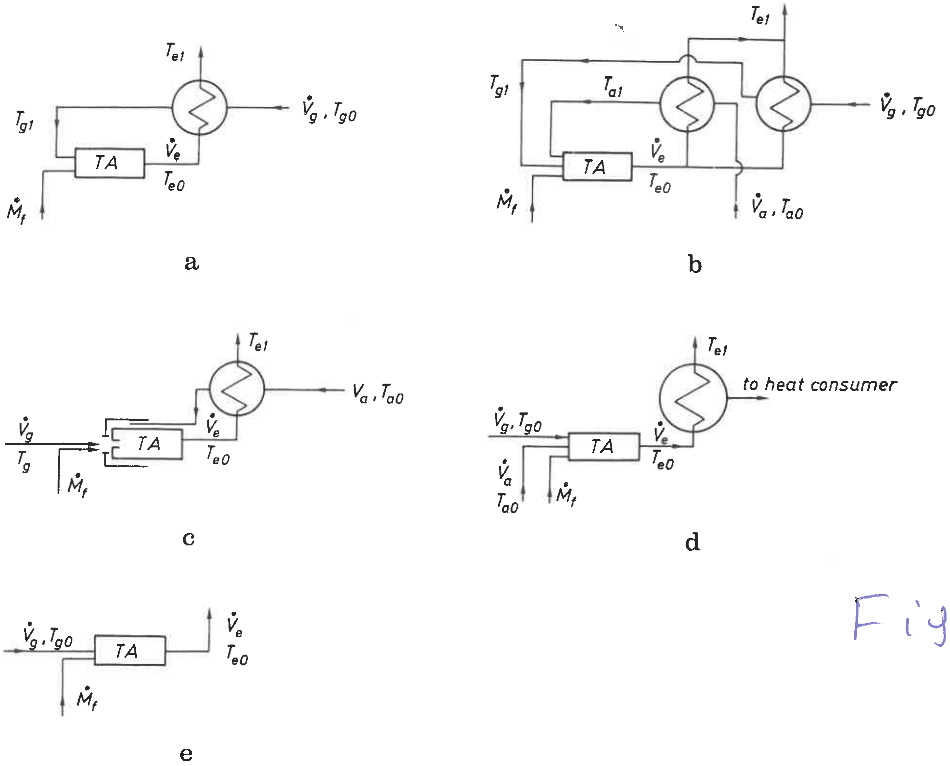
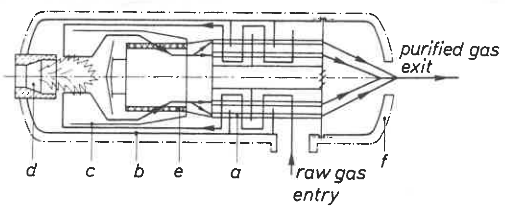


Figure 3.

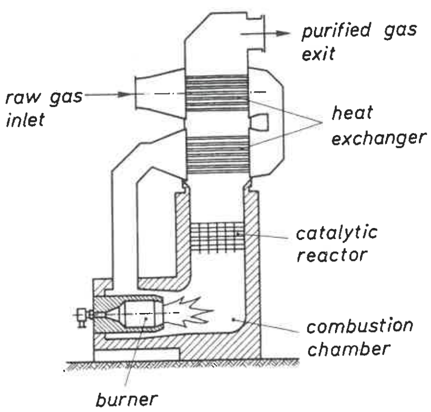
Various systems of heat recovery for thermal after-burners



a heat exchanger
b outer shell
c inner shell
d burner
e catalytic reactor
f insulation

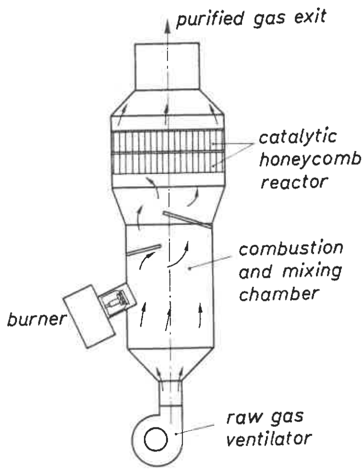
Figure 5.

Catalytic after-burner with ring layer of particulate catalyst



Catalytic after-burner with array of ceramic cylinders coated with active catalytic material

Figure 6.



Catalytic after-burner with coated monolyths as the catalyst

Figure 7

Dr. Parti Mihály; 463-2635
Department of Fluid Mechanics