PRECEPT 5: BIOMASS GASIFICATION

An air-blown, pilot-scale, electrically heated, atmospheric fluidized-bed gasifier converts 277.8 kg h^{-1} of *Miscanthus* into product gas. The composition of this biomass on a dry mass basis is reported in Table 1, whereas its moisture content on an as received (ar) basis is 10 wt%. The LHV of the biomass is 16 MJ kg^{-1} (ar basis). The used air stoichiometry value is $\lambda = 0.33$. The electrical heating system of the reactor introduces a power of 90 kW.

Fly ash is tapped off from cyclone(s) and filters, and it contains 35 wt% carbon (pure – LHV = 33 MJ kg^{-1}) and 65 wt% mineral matter. Assume that all the ash in the biomass goes to fly ash and that no carbon accumulation takes place in the bed. Air (21% O_2 and 79% N_2) and biomass are fed to the gasifier at ambient temperature.

It is requested:

1. Calculate the Carbon Conversion CC.
2. Evaluate the composition of the product gas and the gasification temperature by assuming chemical equilibrium (gaseous products: CH_4, CO, CO_2, H_2, H_2O, N_2, NH_3).
3. Determine Cold Gas Efficiency (CGE) and Hot Gas Efficiency (HGE) by considering as energy input not only the energy content of the biomass, but also the energy input from the electrical heating system.

Table 1: composition of the biomass feedstock on dry basis.

Component	**Wt% on dry basis**	**MM, kg/kmol**
C	48.0	12
H	6.0	1
O	42.0	16
N	0.5	14
Ash	3.5	-

Other data are the LHVs of syngas constituents:

- $CH_4 \rightarrow$ 50.016 MJ/kg
- $CO \rightarrow$ 10.104 MJ/kg
- $CO_2 \rightarrow$ 0
- $H_2 \rightarrow$ 119.97 MJ/kg
- $H_2O \rightarrow$ 0
- $N_2 \rightarrow$ 0
- $NH_3 \rightarrow$ 22.5 MJ/kg

For thermodynamic properties calculation (enthalpy), use the provided “Equil” program. For the estimate of fly ash enthalpy assume a constant specific heat of 1 kJ/kg-K.