Fuel cell Fundamentals & Technology Course Code MS/Phy-515

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Exernal reforming fuel cell

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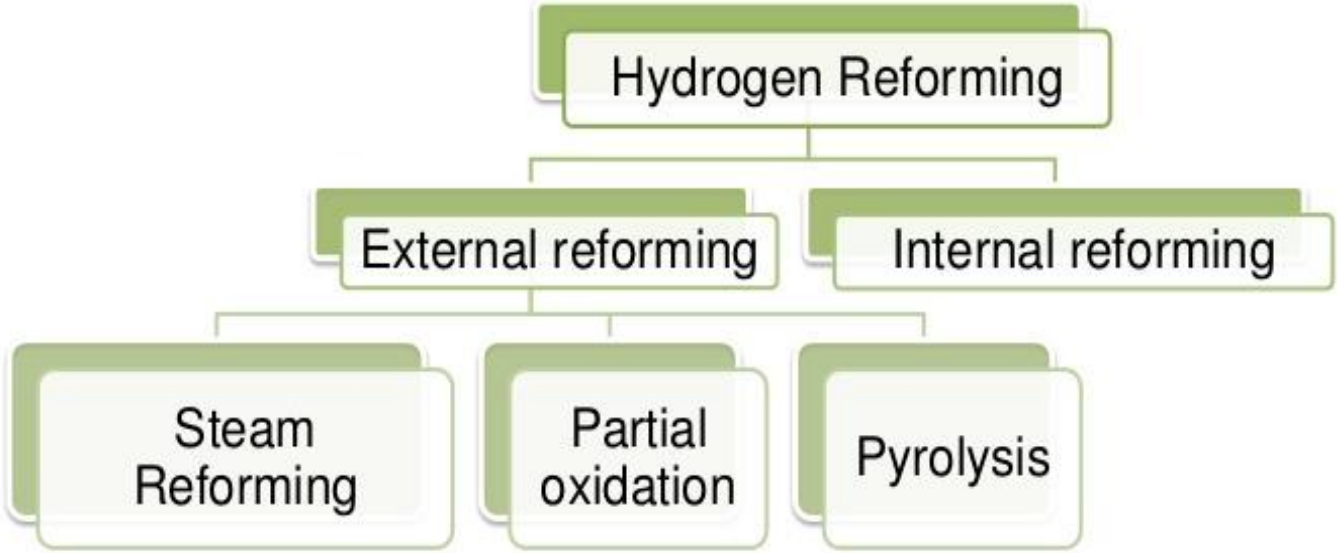
Fuelling of Fuel cells

- Hydrogen is the main fuel for fuel cells
- Hydrogen does not exist sufficiently as a gas
- Reforming of hydrogen from hydrogen contained substances is the way to obtain it

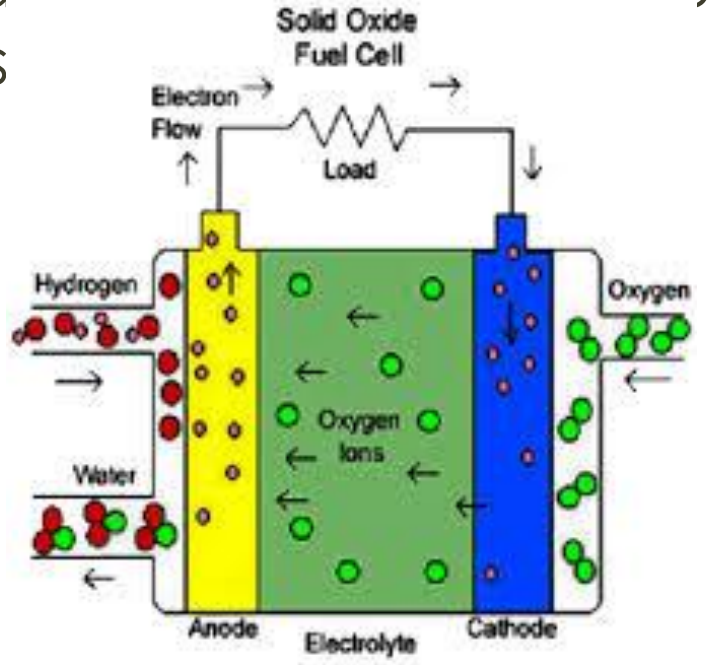
Facts: Sources of hydrogen in year 2000 (worldwide)

Natural gas	48%	96% from hydrocarbons
Oil	30%	
Coal	18%	
Water	04%	


Hydrogen Reforming
External reforming
Internal reforming
Steam Reforming
Partial oxidation
Pyrolysis

External reforming

- External reforming occur where a fuel is reformed to hydrogen prior to entering a fuel cell s



STEAM REFORMING

Steam reforming is a mature technology, practiced industrially on a large scale for hydrogen production.

- The basic reforming reactions for methane and a generic hydrocarbon C_nH_m are

$$CH_4 + H_2O \rightarrow CO + 3H_2 \quad [\Delta H = 206\,\text{kJ mol}^{-1}]$$

$$C_nH_m + nH_2O \rightarrow nCO + (\tfrac{m}{2} + n)H_2$$

$$CO + H_2O \rightarrow CO_2 + H_2 \quad [\Delta H = -41\,\text{kJ mol}^{-1}]$$

- The reforming reactions termed ***oxygenolysis*** *reactions*.
  The associated water-gas shift reaction are carried out normally over a supported **nickel catalyst** at elevated temperatures, typically above 500◦C.
- Reactions are reversible and normally reach equilibrium over an active catalyst, as at such high temperatures the rates of reaction are very fast.

- The combination of the two reactions taking place means that the overall product gas is a mixture of carbon monoxide, carbon dioxide, and hydrogen, together with unconverted methane and steam.
- The actual composition of the product from the reformer is then governed by the
- **Temperature of the reactor (actually the outlet temperature).**
- **The operating pressure.**
- **The composition of the feed gas.**
- **The proportion of steam fed to the reactor**.

- Another feature of reactions is that they are usually very *endothermic*, which means that heat needs to be supplied to the reaction to drive it forward to produce hydrogen and carbon monoxide.
- Higher temperatures (up to 700◦C) therefore favour hydrogen formation.

External reforming

- The biogas feed (FEED), consisting of methane and carbon dioxide, and water stream (WATER) is separately fed through compressor (COMP) and heater (HEATER) to reach the specified operating condition
- . In the reformer (REFORMER), biogas reacts with steam through steam reforming reaction in which the hydrogen and carbon monoxide can be generated.
- The obtained carbon monoxide is further reacted with the residual steam through water gas-shift reaction and thus, the production
  of carbon dioxide and hydrogen can be observed.
- The components consisting of CH_4, CO_2, H_2O, CO, and H_2 are considered as the possible species in steam reforming of methane. the synthesis gas (SYNGAS), which is composed of mainly hydrogen, is introduced into the anode side of SOFC (ANODE).

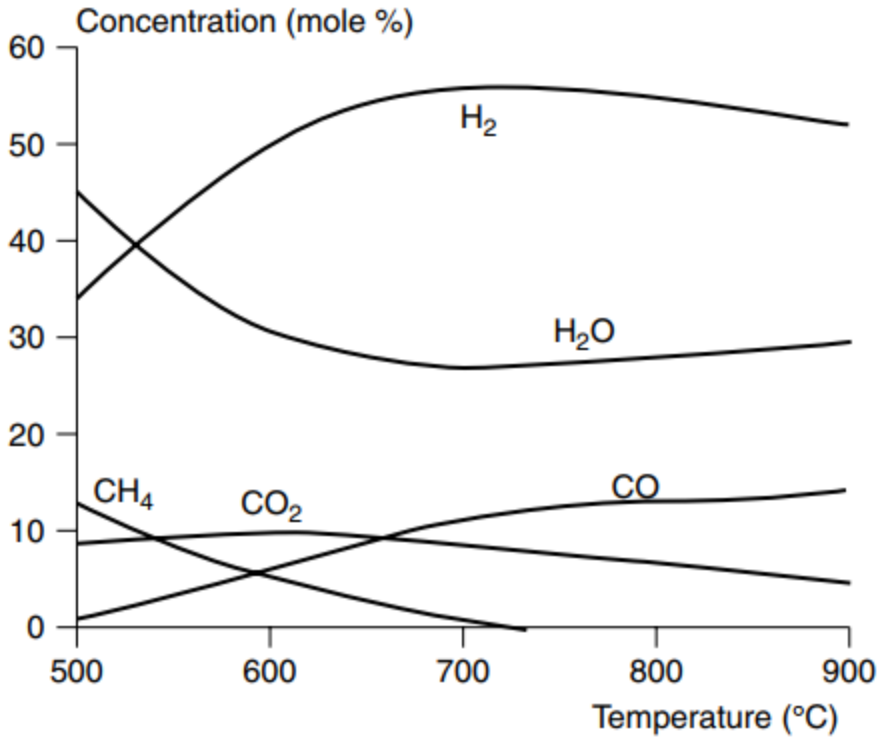


Fig :Equilibrium concentrations of steam reformation reactant gases as a function of temperature.

- Hydrocarbons such as methane are not the only fuels suitable for steam reforming.

- Alcohols will also react in an oxygenolysis or steam reforming reaction,

for example,
methanol

$$CH_3OH + H_2O \rightarrow 3H_2 + CO_2 \quad [H = 49.7 \text{ kJ mol}^{-1}]$$

The mildly endothermic steam reforming of methanol is one of the reasons why methanol is finding favour with vehicle manufacturers.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Thank You