Fuel cell Fundamentals & Technology

Course Code MS/Phy-515

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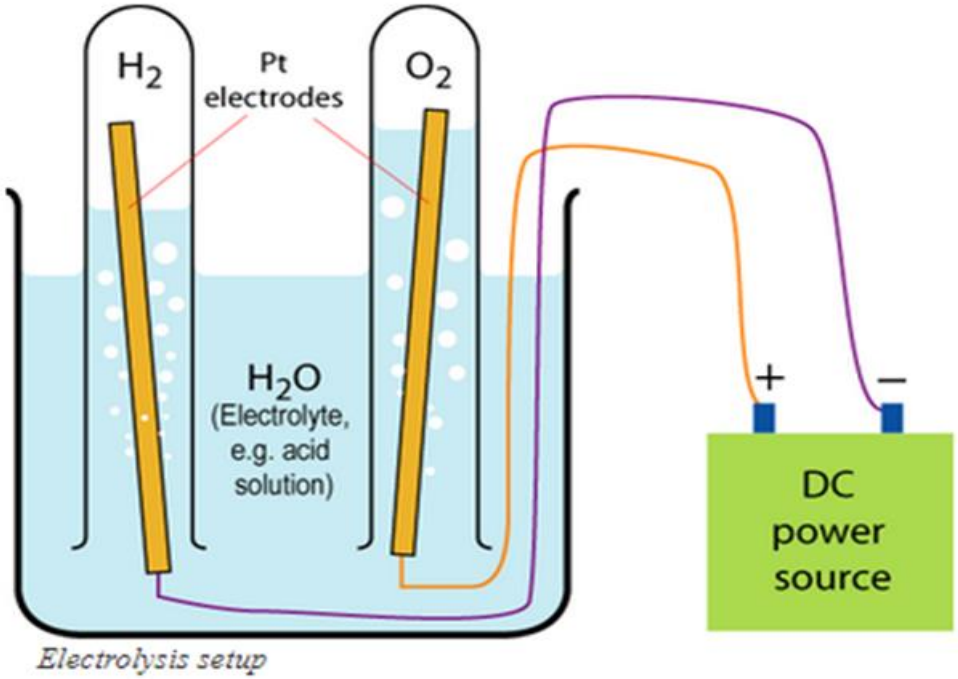
internal reforming of fuel cell

Outline:

- Fuel cell
- Reforming of fuel cell
- Types of reforming
  - External reforming
  - Internal reforming
- Internal reforming in MCFC and SOFC fuel cell
- Types of internal reforming
- Advantages
- Disadvantages
- applications

Fuel cell:

- It converts the chemical energy into electrical energy.
- Converts hydrogen and oxygen into water.



Electrolysis setup

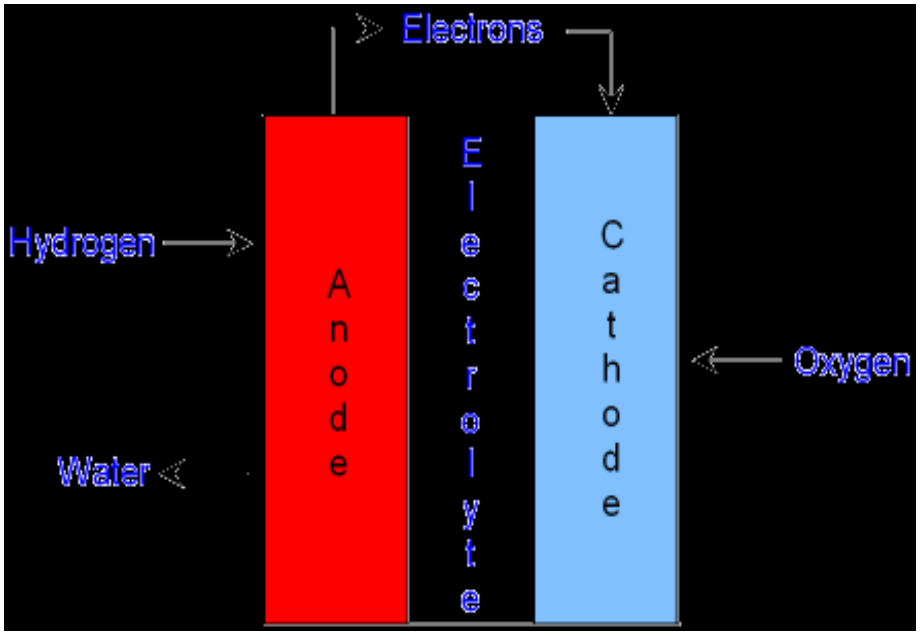
Reforming of fuel cell:

- Pure hydrogen is extracted from a hydrogen source, such as hydrocarbon or alcohol fuels, and then provides the hydrogen to the fuel cell. This is called reforming of fuel cell.
- Hydrogen fuel reformer is extracting the hydrogen itself.

Types of reforming:

There are usually two types of reforming:

- Internal reforming
- External reforming (steam reforming)



Internal reforming reactions:

- endothermic reforming of low molecular weight hydrocarbons (e.g. natural gas) can be provided by the electrochemical reaction in the stack. Chemically the reaction is described as follows-

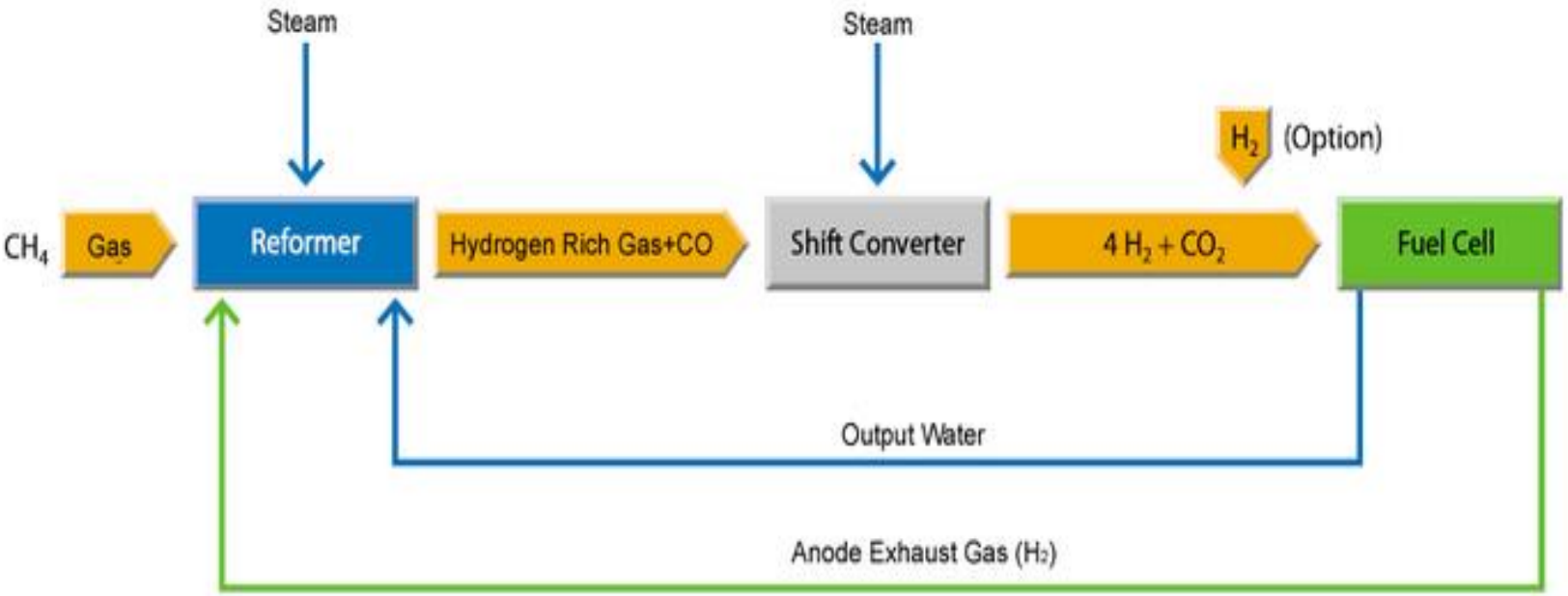
  $CH_4 + H_2O = CO + 3H_2$

  $CO + H_2O = CO_2 + H_2$ (this is the water gas shift reaction)

  This gives the overall **methane reforming reaction:**

  $CH_4 + + 2H_2O = CO_2 + 4H_2$

Internal reforming:



Reformer Reaction

$CH_4 + H_2O \rightarrow CO + 3H_2$

$\Delta H = +205{,}8$ kJ/mol

Shift Reaction

$CO + H_2O \rightarrow CO_2 + H_2$

$\Delta H = -42{,}3$ kJ/mol

Total

$\Delta H = +163{,}5$ kJ/mol

Internal Reforming in MCFC and SOFC Fuel Cells

With high grade heat generation in the MCFC and SOFC type it is possible to have internal reforming of methane gas at the anode.

In the **MCFC** appear at **650ºC** and a nickel catalyst is required to promote reforming at this temperature.

In the **SOFC** the reaction products appear at a temperature of **1000ºC** which is sufficient to perform the reforming process without the requirement for a precious metal catalyst.

Types of internal reforming:

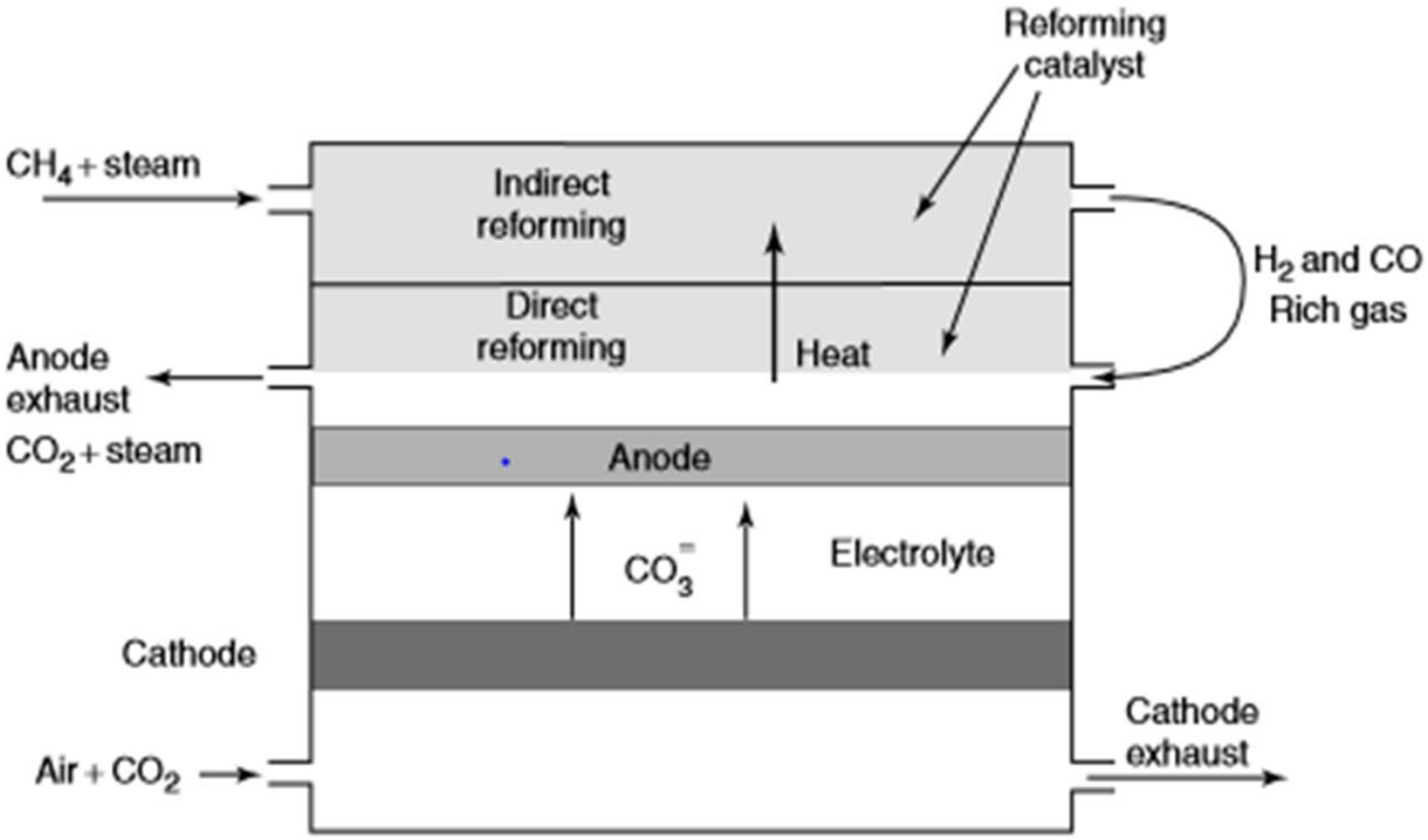
- Direct internal reforming
- Indirect internal reforming

Direct internal reforming (DIR) offers a high cell performance compared with indirect internal reforming (IIR).

With DIR, **hydrogen** is consumed directly by the electrochemical reaction.

With IIR, the reforming reaction and electrochemical reactions are separated

Figure:


Reforming catalyst
CH_4 + steam
Indirect reforming
Direct reforming
Heat
H_2 and CO Rich gas
Anode exhaust
CO_2 + steam
Anode
$CO_3^=$
Electrolyte
Cathode
Air + CO_2
Cathode exhaust

Advantages:

- Internal reforming eliminates the cost of an external reformer.
- System efficiency is improved.
- Nickel is a good reforming catalyst(low surface area).

Disadvantage

- Potentially more complex cell configuration.
- In MCFC systems (including natural gas) contain impurities (e.g. sulphur compounds) that are harmful for both the MCFC anode and the reforming catalyst.

Applications of internal reforming:

- System cost is reduced
- With DIR, less steam is required (the anode reaction in the SOFC and MCFC produces steam).
- There is a more even distribution of hydrogen
- The methane conversion is high, especially in DIR systems where the cell consumes hydrogen as it is produced.
- The efficiency of the system is higher.
- internal reforming provides an elegant method of cooling the stack.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Thank You