CHAPTER I
INTRODUCTION

Hydrogen is forecasted to become a major source of energy in the future. Molecular hydrogen is a clean burning fuel, can be stored as a liquid or gas. It could be distributed via pipelines, and has been described as a long-term replacement for natural gas.

In addition, hydrogen is widely used feedstock in the chemical, food, and refining industries. In refineries, hydrogen is in high demand and used in desulfurizatrion, hydrotreating processes. It is predicted that the demand for hydrogen will increase from 10% to 15% per year (see Table 1.1) (Hairston, 1996). Both refineries and chemical companies use hydrogen for the production of commodity, fine and specialty chemical such as toluenediamine, hydrogen peroxide, NH_3, specialty hydrogenation, pharmaceuticals, and application for synthesis gas (such as methanol and higher alcohols production).

In 1988 methanol synthesis and other chemicals' production accounted for 6.7% of hydrogen sales. Ammonia synthesis accounted for 40% of the world's consumption of hydrogen and is comprised mainly of the units to produce the large volumes of hydrogen necessary to reduce N_2 to NH_3. Thus, NH_3 synthesis plants are really another form of hydrogen production. Because of the excess capacity of NH_3, it can be attractive to convert NH_3 synthesis plants into hydrogen production units. Moreover, hydrogen is used by the steel industry for annealing of steels. The electronic industry uses hydrogen in the production of devices. Hydrogen is used in a large quantity in the food processing industry, especially for the hydrogenation of fats and oils. Furthermore, there are special applications for bulk quantities of hydrogen as a fuel, such as in propelling the US space shuttle.

Table 1.1 Non refinery US demand for H_2 (in billions of ft^3)

Market	1994	2000
Chemical processing	82	128
Electronics	9	15
Food processing	4	5
Metal manufacturing	3	4
Other markets	13	17
Total	111	169

Hydrogen can be produced from natural gas, naphtha, coke, vacuum residue, refinery off gas, etc.. Table 1.2 summarizes some current source materials for the world's production of hydrogen. It is clear that natural gas accounts for almost 50% of the world's feedstock for hydrogen (Scholz, 1993). Electrolysis, a seemingly environmentally attractive source for hydrogen production, is a very small percentage simply because its depends on cheap power, which is regionally dependent on the presence of limited and inexpensive hydroelectric sources of power.

Table 1.2 Feedstocks for H_2 production

Source	World capacity (1988) (%)
Natural gas	48
Petroleum	30
Coal	18
Electrolysis	4

There are several processes that are used for converting the above feedstocks to hydrogen such as steam reforming, partial oxidation and CO_2

reforming. Hydrogen can be also produced from pyrolysis, gasification, hydroelectric power, photoelectrolysis and photocatalysis of water. However, steam reforming of hydrocarbons, especially, steam reforming of methane is the largest and generally the most economic way to produce hydrogen.

In steam reforming process, steam-reforming reaction is highly endothermic. It is, then, necessary to operate at high temperature, above 500°C, to obtain the maximum yield of product. Thus, there are many problems introduced to the process. The thermal stability of the catalyst is certainly one, with steam tending to favor catalyst and support sintering. However, the major problem lies in the formation of coke. Carbon will deposit on the catalyst and cause the blockage of catalyst pores and catalyst deterioration, leading to reactor shutdown.

To solve coke formation problem, autothermal system is introduced. Autothermal system is a combination of steam reforming process and partial oxidation process. Heat (energy) from the partial oxidation reaction will be supplied continuously to steam reforming reaction. No heat from the external source is needed. Therefore, the outlet temperature can be reduced with very low steam/carbon ratio, whilst avoiding carbon deposition.