

Production of Methanol using Natural Gas

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Abstract— As the world is concerned about energy security, climate change, greenhouse effect, other opportunity emerges for alternative fuels to displace petroleum fuels. One such alternative fuel is methanol. Methanol is one of the most versatile compounds developed and is the basis for hundreds of chemicals, thousands of products that touch our daily lives. This paper begins with a brief discussion about the history of methanol manufacture, its characteristics & applications with an overview of the economic aspects. The focus is on the study of commercial process of Manufacture of Methanol. Our aim is to design methanol plant having capacity of 2500 TPD. Methanol is produced by two different methods, one is from synthesis gas, which is derived from oil, and the other is from biomass, which is renewable root.

Key words: Methanol, Natural Gas

I. INTRODUCTION

Methanol also called wood alcohol is the simplest known alcohol. It was earlier manufactured by destructive distillation of wood thus it is also called wood alcohol. It finds direct applications as denaturant, antifreeze, solvent and used in fuel blending. Apart from that, it is a primary raw material for intermediate chemicals like formaldehyde, dimethyl ether, low prices ethylene and biodiesels through transesterification.

II. GENERAL DESCRIPTION OF METHANOL

Methanol (CH₃OH) is a simple one-carbon alcohol that is a colorless and tasteless liquid with a faint odor. Other names are Methyl-alcohol and Wood-alcohol. It is most commonly produced from natural gas but can also be derived from renewable bio-feed stocks and from coal through gasification.

It is a light, flammable, colorless liquid which is volatile and has a distinct odor whose Boiling point is 67.4 °C, Melting point: -97.6 °C and a density of 791 kg/m³ at 20°C. It is polar, acid-base neutral, and generally considered non-corrosive. It is miscible with most organic solvents and is capable of dissolving many inorganic salts.

Methanol is a liquid under normal conditions, allowing it to be stored, transported and dispensed easily, much like gasoline and diesel fuel is currently. It can also be readily transformed by dehydration into dimethyl ether, a diesel fuel substitute with a cetane number of 55.

Methanol can be efficiently produced from a wide variety of sources including still-abundant fossil fuels (natural gas, coal, oil shale, tar sands, etc.), but also agricultural products and municipal waste, wood and varied biomass. [1][2]

A. Properties of Methanol [1]

| | |
|------------------|------------------------------|
| Synonyms | Methyl alcohol, Wood alcohol |
| Chemical formula | CH ₃ OH |
| Molecular weight | 32.04 g/mol |

| | |
|---------------------------|--------------------------------|
| Chemical composition (%) | |
| Carbon | 37.5 |
| Hydrogen | 12.5 |
| Oxygen | 50 |
| Melting Point | -97.6°C |
| Boiling Point | 64.6°C |
| Density at 20°C | 791kg/m ³ |
| Energy content | 5420 kcal/kg 173.2 kcal/mol |
| Energy of vaporization | 9.2 kcal/mol |
| Flash point | 11°C |
| Explosive limits in air | 7 – 36% |
| Auto ignition temperature | 455°C |

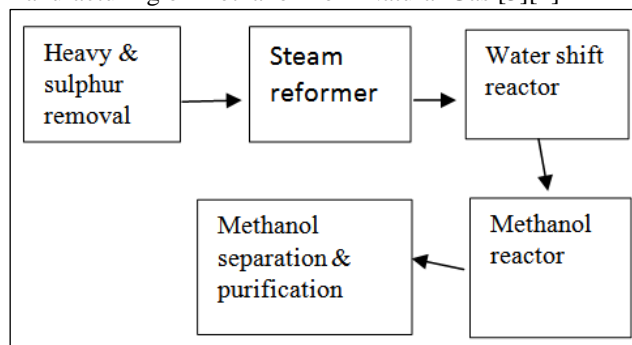
B. Uses

Methanol can be used as a fuel or fuel additive (e.g. neat methanol fuel, methanol blend with gasoline, MTBE, TAME and methanol to gasoline). It can also be used for the production of chemicals like formaldehyde, acetic acid, chloromethane, methyl methacrylate, dimethyl terephthalate, methyl amines, and glycol methyl ethers. It is also used as a solvent for windshield, antifreeze, inhibitor to hydrate formation in natural gas processing and as a substrate for crop growth.

III. RELATED WORK

In this section, we will focus on the related work that has been done previously by several researchers.

Manufacturing of Methanol from Natural Gas [3][4]



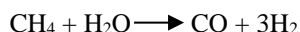
A. Natural gas pretreatment

The natural gas contains about 94% methane that is our desired raw dc material because higher hydrocarbons have a tendency to block the reformer tubes and moreover it is important to treat natural gas to remove sulphur content present in it.

B. Methane reforming

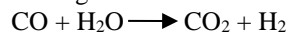
Steam methane reforming uses an external source of hot gas to heat tubes in which a catalytic reaction takes place that converts steam and lighter hydrocarbons such as methane into hydrogen and carbon monoxide, using heavier hydrocarbon feed chokes up the reformer tubes and fouls the catalyst the temperature of the reformer is about 1100K the

steam of gas exiting the reformer are used to heat up the feed to the reformer rest of the heat is rejected via a heat exchanger.



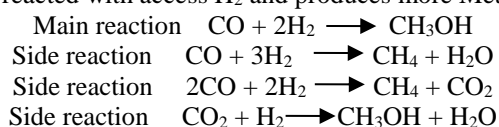
C. Water shift reactor

This reactor brings the CO:H₂ ratio to about 1:4, because the higher CO partial pressure causes the fouling of the catalysts in the methanol reactor the CO content is reduced in this reactor and simultaneously the hydrogen content is increased via the water gas shift reaction.



D. Methanol reactor

In this reactor CO and H₂ get reacted in presence of catalyst (Cu-Zn-Al oxide based) at 550 K temperature and 75 bar pressure and produced Methanol. Here, some amount of CH₄ and CO₂ is also produced by the side reaction. Here, CO₂ is reacted with access H₂ and produces more Methanol.



IV. OTHER IMPORTANT CONSIDERATIONS [11]

A. Health and Safety

Human health and safety is an important consideration in the presence of flammable materials Such as methane and methanol. Monitoring of fugitive emissions is especially important since Methane is colorless and odorless and is therefore not readily identifiable. Although methane and methanol do not pose high hazards to health, effective measures must be taken to ensure the integrity of plant personnel health and safety. Methanol and methane are both flammable and present fire and explosive hazards. Methanol should be handled in a confined area, which must be well ventilated. Respirators must be used while working in an area where methanol vapor concentration is high. Also, gloves and other protective equipment must be used while working in areas of high methanol concentration.

B. Process Control and Instrumentation

Process control equipment must be utilized to operate the process equipment within design specifications and to handle possible plant upsets. Process control equipment monitors the temperatures and pressures of reactors, the effectiveness of separation equipment, and all process streams throughout the plant to ensure safe and on-spec operation. Deviations from set-point should provide signals to the controller, and appropriate action(s) must be taken to prevent endangerment of human life, destruction and/or damage of process units, and production of off spec product.

C. Environmental [12]

1) Chemical Toxicity:

As previously stated, humans are most commonly exposed to methanol through skin contact and vapour inhalation. Although carcinogenicity of methanol has not been determined, exposure to methanol has been linked to reproductive defects in rats⁸. Methanol is known to cause headaches, dizziness, giddiness, insomnia, nausea, gastric

disturbances, conjunctivitis, blurred vision, and blindness in humans. High doses of methanol may be fatal. OSHA's regulatory concentration of methanol for human exposure without adverse effects in an 8 hour day is 260 mg/m³ or 198 ppm⁵.

2) Potential Safety Problems:

Methanol is readily degraded in the environment by photo oxidation and biodegradation processes. Half-lives of 7 – 18 days have been reported for the atmospheric reaction of methanol with hydroxyl radicals. Methanol is readily degradable under both aerobic and anaerobic conditions in a wide variety of environmental media including fresh and salt water, sediments and soils, ground water, aquifer material and industrial wastewater. Methanol is of low toxicity to aquatic and terrestrial organisms, and effects due to environmental exposure to methanol are unlikely to be observed except in the case of a spill [9].

V. CONCLUSIONS

Methanol production is a high-risk venture and for such ventures the ROI should ideally be 20–40% in order to justify construction and operation of the plant. The calculated ROI of 26% with annual earnings of roughly \$203 million per year suggest a worthwhile investment.

It is expected that most of the methanol needed in an expanding world market will be produced from natural gas in the future. Several technologies are available for methanol production, and the optimal choice depends mainly on scale. For large scale plants Autothermal Reforming (ATR) at a steam-to-carbon (S/C) ratio of 0.6 combined with boiling water reactors optionally with an adiabatic top layer for the synthesis represents the superior choice for low investment. A case study has shown that a plant with this technology will have a higher single line capacity and a 15-20% lower cost compared to plants based on combinations of steam reforming and Autothermal (or secondary) Reforming. The ATR based plants at low S/C-ratio may be designed to produce either fuel grade or high purity methanol.

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