Study of e-fuel production from hydrogen and carbon dioxide

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Abstract

The production of fuel using the e-fuel method was studied in the present project. The adopted method uses hydrogen and carbon dioxide to produce fuel. The goal is to produce fuel to cover the needs of ten thousand people. The equipment used in chemical reaction and production of used raw materials, as well as the equipment improving the purity of the product were studied and discussed. It was found that the basic ones needed in the present project were designed: reverse water shift gas reactor (RWSGR), heat exchanger, three phase separator. The energy and material balances were studied and then simulated using the HYSYS software. The produced e-fuel amount is 0.78 L/h and the average price is determined 3.07 $/L so, the project's financial feasibility has been carried out, and it has been found to be profitable and applicable on the reality. It was found that the capital cost is (53,853,494 $), labor costs is (793,500 $) and net profit after 12 years is (200 million $).

Process Description

The air enters adsorption process to separate carbon dioxide from air, and water enters electrolysis process to take hydrogen from the water. The hydrogen and carbon dioxide flow through two compressors (K-100, K-101), heater (E-100), and heat exchanger (E-102) to prepare them for the reaction's conditions. After that carbon dioxide and hydrogen enters RWGSR to produce carbon monoxide which is the main reaction to produce the hydrocarbons.

$$CO_2 + H_2 \longrightarrow CO + H_2O$$

Thin the carbon monoxide and hydrogen enters Fischer–Tropsch (FT reactor) which use Fischer–Tropsch reaction to produce the hydrocarbons products.

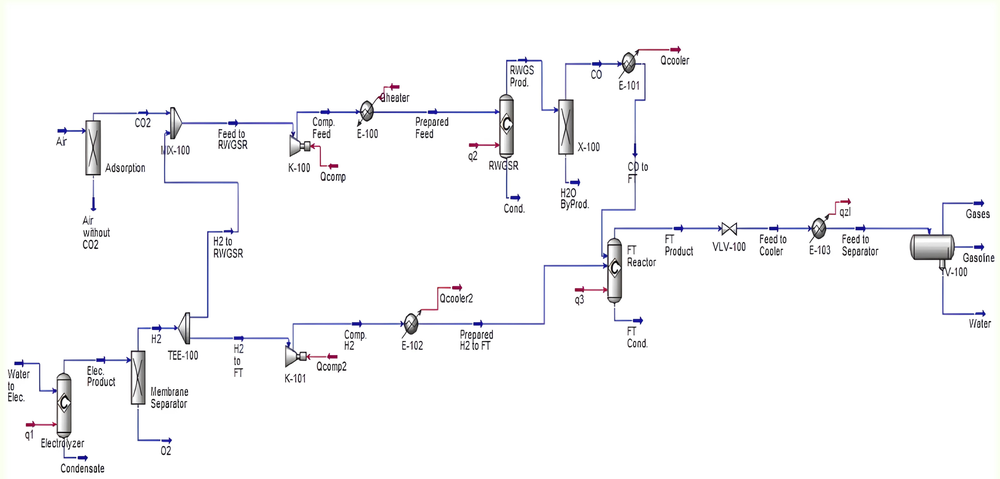
$$CO + 3\ H_2 \longrightarrow CH_4 + H_2O$$

$$CO + 17/8\ H_2 \longrightarrow 1/8\ C_8H_{18} + H_2O$$

$$CO + 7/3\ H_2 \longrightarrow 1/3\ C_3H_8 + H_2O$$

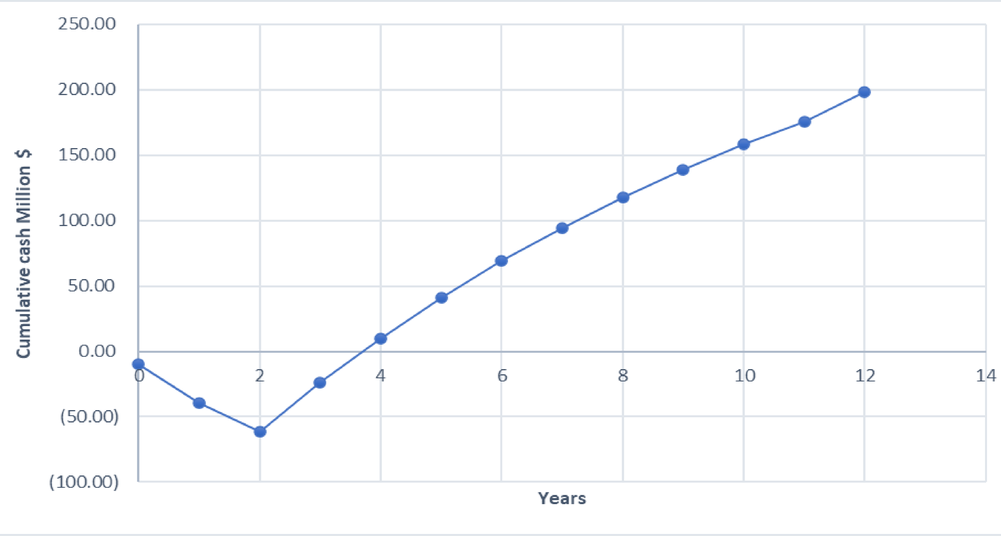
$$CO + 25/12\ H_2 \longrightarrow 1/12\ C_{12}H_{26} + H_2O$$

After that the hydrocarbon and water enters valve (VLV-100) and cooler (E-103) to prepare it for separation process. Finaly hydrocarbons and water enters three phase separator to prepare the fuel for the market.



Cumulative cash flow diagram

Product	Average Price ($/L)	Revenue ($/Y)
Gasoline	3.07	86,596,104



Capital Cost

Unit type	Equipment Code	Cost in 2024 ($)
Heat Exchangers	E-100	22,400
	E-101	28,500
	E-102	2,310,633
	E-103	31,600
Compressors	K-100	2,686,400
	K-101	2,886,100
Reactors	Electrolyzer	2,190,178
	RWGSR	611,800
	FT	395,096
Separators	V-100	17,300
	Adsorption	181,489
Total Capital Cost		11,361,496

Conclusion

In material balance calculations, estimate that the amount of hydrogen was (0.433 ton/h) and the carbon dioxide was (28.6 ton/h) used to produce fuel, which could cover the needs of 10,000 people. The amount of air required to produce carbon dioxide was (15699.1 ton/h) and the amount of water required to produce hydrogen was (12.2 ton/h). In energy balance calculations, it was found that the amount of energy needed for reactor was (-44.4kW), Electrolysis was (361.1 kW), and Separator was (52.78 kW). From here it has been noticed that the amount of energy is large due to the large amount of air used for production. It has been worked on designing the reactor, heat exchanger, and separator units and making tables for the sizes and volumes. In economic study, it was found that the capital cost was (53,853,494 $), labor costs was (793,500 $/h) and net profit after 12 years was (200 million $). The produced e-fuel costs 0.77$/L, while producing a liter of fuel using crude oil costs between 0.4$ to 0.7$. The cost may be higher, but the increasing percentage compared to the production method is reasonable, because the traditional production method takes hydrocarbon products directly from the ground petrol, while the e-fuel method uses reactors to produce renewable hydrocarbon.