TEAM

086

Sustainable Methanol Production Using Green H_2 and CO_2 Emissions

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Introduction

- CO_2 emissions from industrial plants contribute to climate change.
- Utilization of CO_2 and green H_2 to synthesize methanol
- Green hydrogen production via renewable-powered electrolysis.
- Carbon capture and utilization (CCU) is integrated for CO_2 feed purification.

Problem Statement

This project aims to address the environmental impact of traditional methanol production by designing a sustainable process that uses green hydrogen and captured CO_2. The goal is to produce high-purity methanol efficiently while reducing carbon emissions and relying on renewable energy, making the process both eco-friendly and economically viable.

Project Impact

- Economic: Competitive methanol pricing, new market potential
- Environmental: Reduces CO_2 emissions and fossil dependency
- Social: Aligns with Vision 2030 and creates green job opportunities

Final Target Specifications

Specifications	Target
Solar Input Power	1 kW
Amine Recovery	≥ 97%
H_2 purity	≥ 90%
CO_2 utilization	≥ 90%
Profit per year	≥ $4 million
ISO 45001 6.1	100% compliance

Constraints

Constraints	Target
Reactor design	Meet temp & pressure requirements
Electric heater selection	Meet process energy demands
Material selection	Withstand process conditions

3D Design of the Reactor

Testing & Validation

P: Working pressure S: Maximum allowable stress
R: Shell internal radius E: Joint efficiency
D: Head internal diameter

Shell Design

Material: Carbon Steel. Seamless Steel. pipe SA–106

Allowable Stress equal to 118 MPa at T = 250 C.

The equation for shell thickness is as follows:

$$Ts = \frac{P \times R}{S \times E - 0.6 \times P}$$

$$Ts = \frac{5 \times 0.1265}{118 \times 0.7 - 0.6 \times 5} = 0.008\ m$$

$$Ts(Final) = Ts + \text{ Corrosion Allowance} = 0.008 + 0.0025 = 0.0105\text{m}$$

Head Design

Material: Carbon Steel. Seamless Steel & Welded fittings. pipe SA–234

Allowable Stress equal to 118 MPa at T = 250 C

The equation for head thickness is as follows:

$$Th = \frac{P \times D}{2 \times S \times E - 0.2 \times P}$$

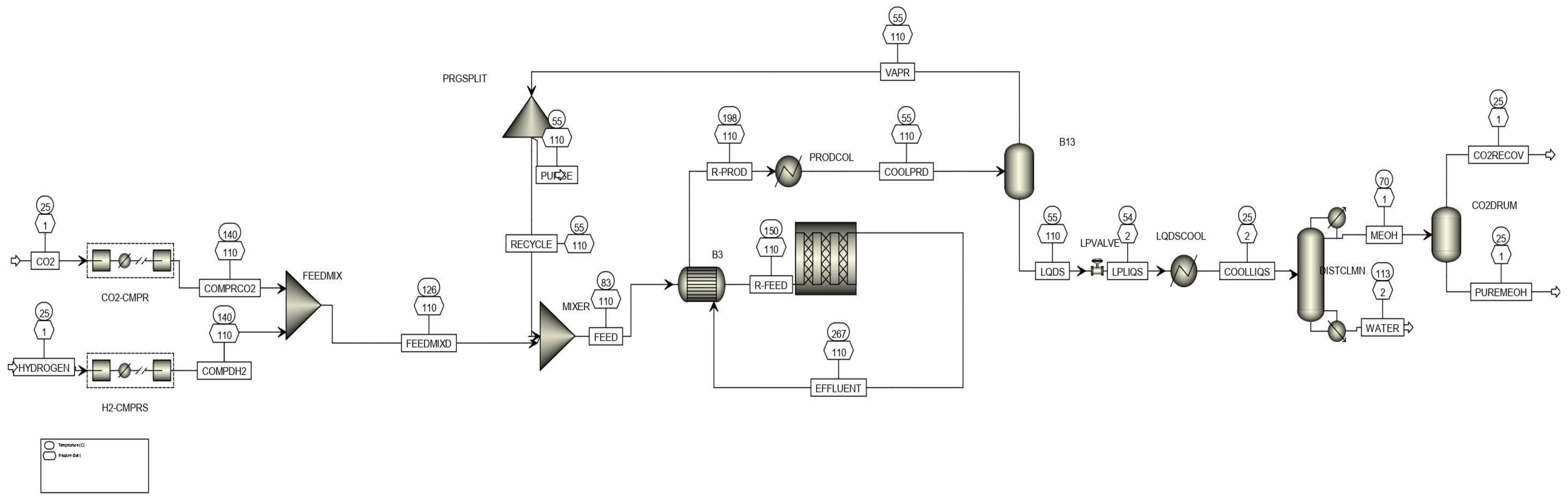
$$Th = \frac{5 \times 0.253}{2 \times 118 \times 0.7 - 0.2 \times 5} = 0.0077\text{ m}$$

$$Th(Final) = Th + \text{ Corrosion Allowance} = 0.0077 + 0.0025 = 0.0102\text{ m}$$

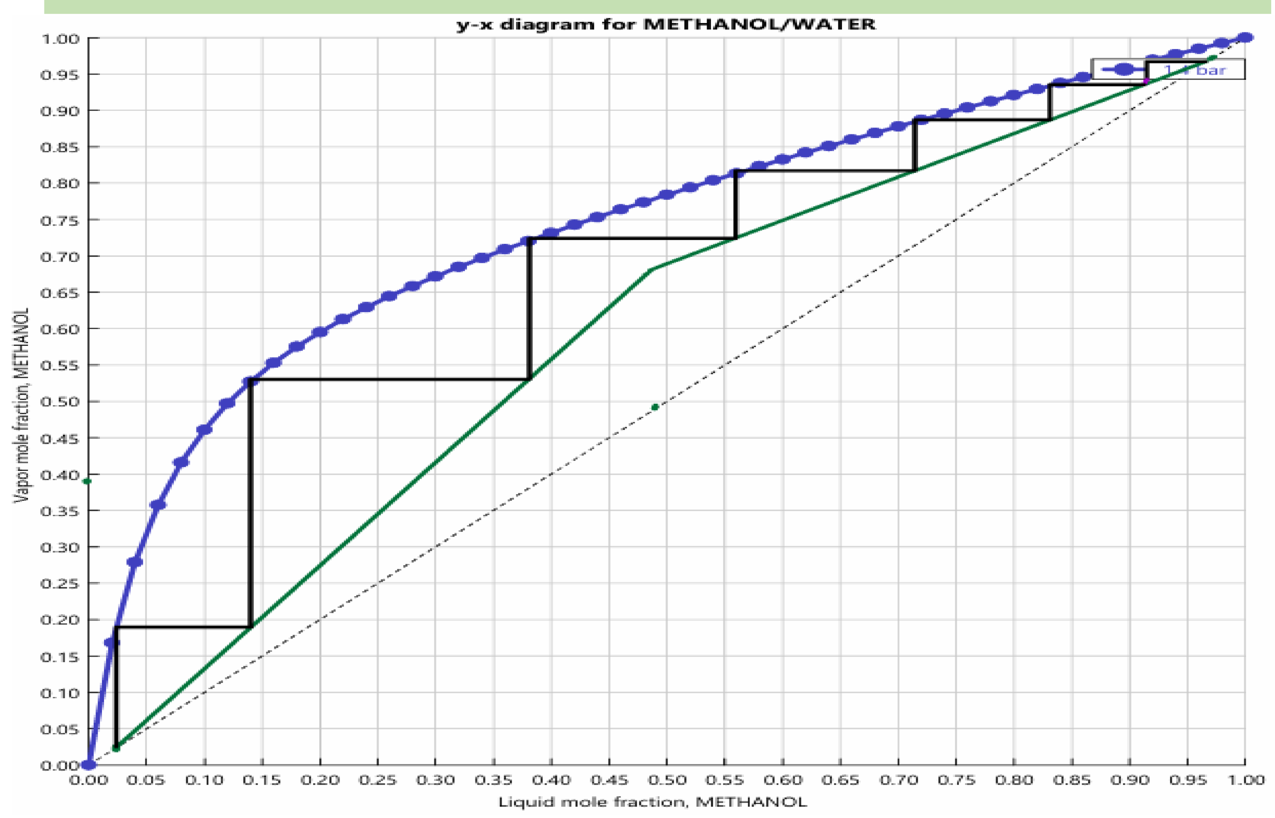
Since Th is less than Ts then Th can be the same as Ts.

$$Th(new) = 0.0105\ m$$

Process Flow Diagram



Methanol Water Separation



Top operating line: $y_{j+1} = \left(\frac{L}{V}\right) x_j + \left(1 - \frac{L}{V}\right) x_D$

$$y_{j+1} = \left(\frac{927.05}{1545.09}\right) x_j + \left(1 - \frac{927.05}{1545.09}\right)(0.97)$$

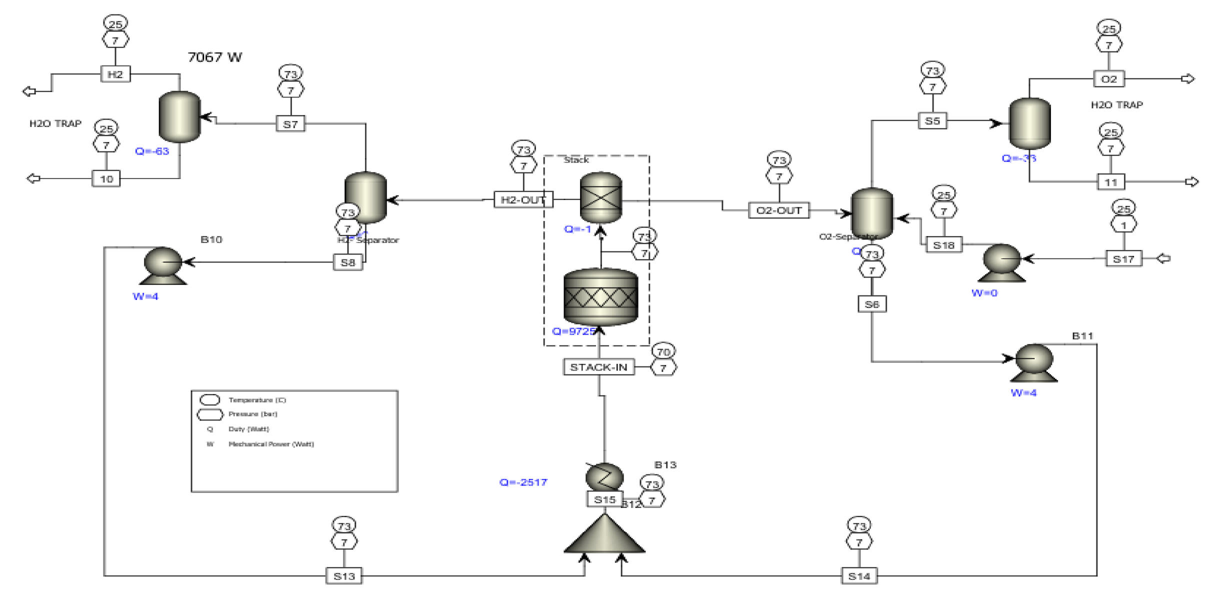
Bottom operating line: $y_k = \left(\frac{L}{V}\right) x_{k+1} + \left(\frac{L}{V} - 1\right) x_B$

$$y_k = \left(\frac{2179.95}{1549.09}\right) x_{k+1} + \frac{2179.95}{1549.09} x_B$$

N_{Actual}=2* $N_{theoritical}$=14 stages

$$\%Error = \frac{14 - 13.2}{13.2} * 100\% = 6.06\%$$

Green Hydrogen Production



Conclusion

The proposed design demonstrates a feasible pathway to produce sustainable methanol using captured CO_2 and green hydrogen. Achieving 98% CO_2 removal, 87.1% conversion, and 95% H_2 purity showcases the process's potential to reduce emissions and support a circular carbon economy.