Natural Gas Sweetening

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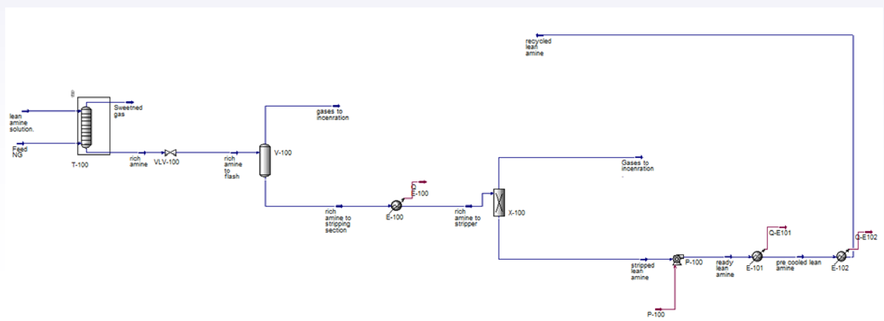
Abstract:

Acid gases, such as carbon dioxide (CO_2) and hydrogen sulfide (H_2S), pose a significant challenge in the production and utilization of natural gas, leading to pipeline and equipment damage as well as operational issues. This study investigates the sweetening process for the removal of acid gases from natural gas, focusing on process optimization, equipment design, and economic analysis to ensure compliance with quality standards and safe utilization. The absorption process was selected over alternative methods due to its suitability for low acid gas concentrations, high selectivity for H_2S removal, and flexibility in handling variations in feed gas composition. The process was simulated using Aspen HYSYS, demonstrating successful natural gas sweetening. Material and energy balance calculations were performed for the process equipment, with particular emphasis on the detailed design of the cooler (E-101) and stripper (T-101). A comprehensive economic analysis was conducted, yielding promising results. The estimated net present value at the end of the project's life (NPV) is 646.460 million dollars, with a discounted rate of return on investment (ROI) of 65.96 %. The discounted payback period is projected to be 1.52 years after the two-year construction phase, indicating a highly profitable and rapidly recoverable investment. Recommendations for further research include exploring advanced equipment design and optimization techniques to enhance the efficiency of the sweetening process. The study also emphasizes the importance of this process in the context of Saudi Arabia's Vision 2030, aligning with the Kingdom's strategic objectives for economic diversification and sustainable development. The efficient utilization of natural gas, facilitated by advanced sweetening processes, plays a crucial role in achieving long-term sustainability goals. Future research should consider the alignment of the sweetening process with specific targets and initiatives outlined in Vision 2030, ensuring its contribution to the overall national agenda for economic and environmental advancement. This approach will not only optimize natural gas utilization but also support Saudi Arabia's transition towards a more diversified and sustainable economy.

Process Description

The sweetening of natural gas is deemed crucial due to the presence of acidic and toxic compounds, such as hydrogen sulfide (H_2S) and carbon dioxide (CO_2), which must be removed to ensure the gas meets environmental and safety standards. This process is conducted to mitigate the corrosive and toxic nature of these compounds, thereby safeguarding infrastructure integrity, promoting worker safety, and meeting regulatory requirements. The removal of these contaminants also enhances the calorific value of natural gas, ensuring efficient combustion and reducing emissions of harmful pollutants into the atmosphere.

The typical process employed in sweetening natural gas involves the use of amine solutions, which selectively absorb H_2S and CO_2 from the gas stream. Among the various methods, the most common process for sweetening natural gas is the amine gas treating process, where amines such as monoethanolamine (MEA), diethanolamine (DEA), or methyldiethanolamine (MDEA) are used as the absorbents. This process is widely adopted due to its efficiency, flexibility, and ability to achieve stringent gas purity requirements .



EQUIPMENT DESIGN:

Summary of Cooler design:

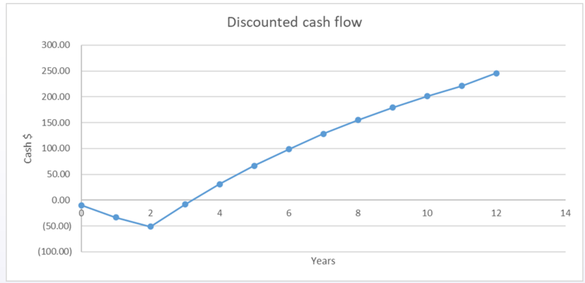
Name			**E-101**		
Q (W)	246000000	**No. tubes**		11524	
Shell pass	1	**Tube arrangement**		square	
Tube Pass	1	**Tube pitch (mm)**		20	
Type	fixed tubesheet	**Bundle diameter (m)**		2.22	
TEMA	AEL	**Shell diameter (m)**		2.24	
A_{HT} (m^2)	4239.89	**Baffle spacing (m)**		0.90	
Tube Dimensions			Baffle cut		25
d_o (mm)	16	**t shell (mm)**		3.88	
t (mm)	2	**Support**		saddle	
d_i (mm)	12				
L (m)	7.32				

Summary of Stripper Design:

Equipment Name		**Distillation column**	
Objective	regeneration of rich amine to lean amine	**Plate thickness**	0.005
Equipment Number	Stripper	**Plate spacing**	0.5
Type	Vertical	**Plate type**	Reverse flow
Thickness (mm)	3.81	**Number of holes**	13368
Tray Spacing (m)	0.5	**Head and Closure**	tori-spherical
Reflux ratio	11.128	**Insulation**	85% magnesia
Diameter (m)	2.42	**Pressure drop (Pa)**	722.20
Height (m)	11.095	**Number of trays**	19

Capital Cost:

Equipment Type	Cost in 2024 ($)
Cooler (E-101)	1814013.37
Stripper (T-101)	632538.58
Absorber (T-100)	488163.16
Rest of Equipment Cost	22752584.89
Total	25687300



Conclusion:

In conclusion, the natural gas sweetening project has demonstrated significant potential for enhancing Saudi Arabia's energy sector and aligning with the Kingdom's Vision 2030 objectives. Through rigorous process design and simulation using Aspen HYSYS, an efficient sweetening system has been developed to remove impurities such as hydrogen sulfide and carbon dioxide from natural gas streams.

The project's economic viability has been thoroughly evaluated, yielding promising results. A substantial net present value (NPV) of 646.460 million dollars is projected at the end of the plant's operational life, indicating a highly profitable venture. The discounted rate of return on investment (ROI) of 65.690% further underscores the project's financial strength, suggesting returns that more than double the initial investment. Moreover, the discounted payback period of 1.520 years following the two-year construction phase is particularly noteworthy, implying a rapid recovery of the initial investment.

These financial indicators strongly support the project's alignment with Saudi Arabia's Vision 2030 goals of economic diversification and sustainable development. By efficiently utilizing natural gas resources, the project contributes to reducing the Kingdom's reliance on oil exports and fostering a more diverse energy portfolio. The advanced sweetening process plays a crucial role in ensuring the quality of natural gas for both domestic consumption and potential export markets, thereby enhancing Saudi Arabia's position in the global natural gas market.

Environmental considerations have been integral to project design. The efficient removal of acid gases not only improves the quality of natural gas but also mitigates potential environmental impacts.

The natural gas sweetening project also demonstrates the potential for knowledge transfer and capacity building within the Kingdom. By utilizing advanced technologies and processes, it is anticipated that local expertise in gas processing and purification will be significantly enhanced.. As the project progresses, opportunities for collaboration with educational institutions and research centers may be explored, further contributing to the development of a skilled workforce in the energy sector.

Moreover, the success of this project could serve as a catalyst for further investment in the natural gas value chain. By demonstrating the viability and profitability of advanced gas processing technologies, it may attract both domestic and