

Aspen HYSYS-based Modeling of Liquefied Natural Gas Production from an Indigenous Natural Gas Source

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ABSTRACT

Pakistan is currently facing a serious energy shortage due to a lack of domestic technology and local expertise in key engineering fields. Pakistan contains rich natural gas reserves. Most natural gas contains a high percentage of light hydrocarbons and low percentages of carbon dioxide and nitrogen. Natural gas liquids are hydrocarbons that alter the hydrocarbon dew point (HCDP) of natural gas. Therefore, to raise the hydrocarbon dew points and generate revenue, these hydrocarbon dew points must be removed before further transportation. In this study, a steady-state, single-stage industrial process model was developed to remove natural gas liquids (NGLs) from natural gas. Process flow diagrams (PFDs) for two ISS configurations, the turbine expander (TE) and the gas subcooling process (GSCP), are integrated into the Aspen HYSYS V10 standard process simulator. The program uses the Peng-Robinson formula of state as the fluid package. The performance of the two processes was evaluated based on three different natural gas sources: Sohi, Qadirpur, and Zamzam. Based on feed composition. The effects of feed flow rate, input temperature, and pressure were studied. An economic and cost assessment of these two operations was also performed. The HHV values of NGL generated from Qadirpur, Zamzama, and Sui gas in TE configuration are 1.38×10^6 , 1.51×10^6 and 2.3×10^6 KJ/kg.mol, respectively. The HHV values of the return gas in TE configuration at Qadirpur, Zamzama, and Sui were estimated to be 7.68×10^5 , 6.78×10^5 , and 8.53×10^5 KJ/kg.mol, respectively. Feed pressure significantly affects the production of natural gas liquids and electricity requirements. It was noticed that the production of NGL increased non-linearly with increasing input pressure. The GSCP configuration led by Sui shows the highest capital cost of \$12.1 million, while the TE configuration led by Zamzama shows the lowest capital cost of \$11.4 million.

1. Introduction

The hydrocarbons, like oil, natural gas, and coal, are expected to rise to supply more than 75% of the world's energy utilization through 2040 [1-3]. Natural gas is considered the cleaner fossil fuel compared to others and is estimated to grow faster than coal and oil

in the coming days [4-6]. Additionally, domestic production of dry natural gas in the United States (US) increased by 5% in 2015 with 27,097.0 billion cubic feet, which is an all-time high in US history. Natural gas is easily supplied by the pipeline, or it can be physically converted into compressed natural gas

(CNG) by a compression process or liquefied natural gas (LNG) by compression and refrigeration processes. In 2015, 96.6% of U.S. natural gas imports were transported by pipeline, of which 3.3% was LNG and 0.01% was CNG [8, 9]. Therefore, there is an urgent need to efficiently and sustainably separate natural gas resources into marketable gas (tail gas) and heavier hydrocarbon molecules. The condensed hydrocarbon molecules, for example, the C_5+ components, are described as natural gas liquids (NGLs) and are high-value products.

The United States is currently planning to expand its petrochemical capacity to utilize natural gas condensates, especially ethane and propane [10]. Common methods for separating natural gas liquids from natural gas feedstocks include Joule-Thompson (JT) expansion, absorption, outer cooling, or turbine expansion. In several conditions, a mixture of these processes can be able to enhance energy efficiency and may improve product recovery [11]. The choice of a natural gas liquids extraction process depends on many aspects, which include the heat content of the target gas, the gas composition, the ability to improve the production of the target product, and the characteristics of the liquefied petroleum gas (LPG) and condensate (C_5+) [12-14]. Proven that the turbine expander process reliably achieves higher plant efficiency and high liquid recovery in the gas and oil sector.

Hence, this study discusses the industrial single-stage standard (ISS) and its advanced and optimized designs for assessment and modelling. It is Important to point out that the operating flexibility of the ISS and the CO_2 cooling constraints pave the way for the development of many other valuable NGL regaining schemes [15, 16]. Sustainable chemical process design can contribute to social welfare, environmental protection, and economic growth. The main condition for selecting chemical method designs has regularly been economic valuation, which evaluates capital and operational budgets and performs a cost analysis to reveal the profit on investments. But this does not suggest that other rising concerns, like safety and environmental protection, should be neglected. These factors play a progressively important role in the selection standards for chemical process design and have gained wide recognition in the field of process systems engineering (PSE). In recent years, PSE has expanded its focus to sustainability issues of power system design [17]. Therefore, methods, for example, process integration superstructure, optimization, and process amplification with their application in feasible design and power system integration have caught the researcher's attention in this field [18].

This study presents a steady-state, single-stage industrial process model for natural gas liquids (NGL) recovery, specifically designed for Pakistan's natural gas reserves. A key innovation of this study is the integration of expansion turbine (TE) and gas subcooling process (GSCP) configurations into Aspen HYSYS V10 software, enabling direct performance comparisons. The Peng-Robinson equation of state was used to accurately simulate the thermodynamic characteristics of regional gas flow. Analysis of three natural gas sources—Sui, Qadirra, and Zamzama—demonstrated the applicability of this approach to Pakistan's energy needs. Quantitative analysis of hydrocarbon dew point variation and high heating value (HHV) data provided detailed information on energy recovery for each source. This dual-configuration, source-specific analysis has not been previously reported for the Pakistani gas industry. Consequently, this study combines technical feasibility and economic evaluation to present a promising approach to alleviate energy shortages through regional technological solutions. Therefore, this study aims to develop a steady-state model of a natural gas liquids recovery system based mainly on ISS technology with an advanced configuration. Through the simulation of the developed model, parametric studies were conducted on many important operating parameters such as feed composition, feed flow rate, feed temperature, feed pressure, etc. Finally, an economic analysis of the developed model was performed.

2 Modeling and simulation work

2.1 General description

In the current study, two different NGL process configurations were designed using the standard Aspen HYSYS V10 process simulator. The main focus of this study comprises the three most important steps. Figure 1. explains the subsequent layout applied to frame a feasible process for NGL recovery.

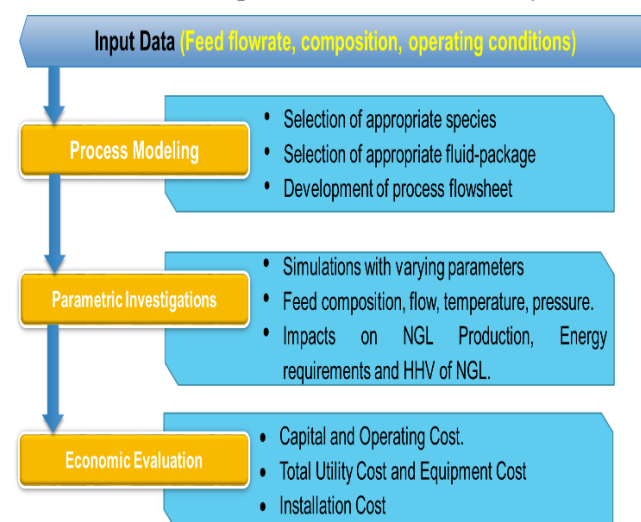


Fig. 1. Schematic diagram of Methodology

2.1.1 Step 1: Process Modeling

The equilibrium-state models of two distinct GTL method configurations were designed to estimate the requirements of energy and material by using ASPEN HYSYS V10 software under the same operating conditions.

2.1.2 Step 2: Investigate Parameters

Then, using convergent flow diagrams for both configurations, the effects of various operating parameters such as feed pressure, feed temperature, feed flow rate, and feed composition on total NGL production, heating cost, and process energy requirements were investigated.

2.1.3 Step 3: Economic Evaluation

In addition, capital and operating charges, as well as depreciation, equipment, and its equipment expenses, were calculated with ASPEN's economic evaluation software.

2.2 Model Development

Modeling and simulation play a prominent role in the design of chemical process circuits. In the present study, two different gas-to-liquid material and energy balances of (GTL) flowsheet configurations were estimated using ASPEN HYSYS V10 software. It is also used for "what if" analysis and sensitivity analysis to enhance the model of the baseline scenario. The Bing-Robinson equation of state (Equation 1) was used because it is a suggested software program for the thermodynamic properties of hydrocarbon systems [19].

$$P = \frac{RT}{\hat{v} - b} - \frac{a}{\hat{v}(\hat{v} + b) + b(\hat{v} - b)}$$

Where P is Pressure, R is the universal gas constant, $\hat{v}$ is Specific volume, T is Temperature, and Z represents the Compressibility factor of real gas.

Both process models, namely, the turboexpander process (abbreviated as TE) and the gas subcooling process (abbreviated as GSCP), were programmed in thermodynamic-state mode. The process model was established based on the initial operational conditions (incorporating pressure, temperature, and flow rate) given by [20]. Table 1 shows the input data of feed flow rate, composition, and process conditions. The feed composition utilized in the current work is the mean value of three indigenous natural gas resources, namely: Sui field (Sui, Balochistan), Qadirpur field (Ghotki), and Zamzama field (Dadu). Table 2 shows

the common parameters for all the simulated configurations.

Table 1.

Feed Condition and Composition

Components	Feed Compositions		
	ZAMZAMA (BHPB)	SUI (PPL)	QADIRPUR (OGDCL)
C ₁	7.3731×10 ⁻¹	9.4344×10 ⁻¹	8.4398×10 ⁻¹
C ₂	1.388×10 ⁻²	1.006×10 ⁻²	1.113×10 ⁻²
C ₃	3.34×10 ⁻³	2.59×10 ⁻³	2.91×10 ⁻³
n-C ₄	9.2×10 ⁻⁴	6.6×10 ⁻⁴	6.8×10 ⁻⁴
i-C ₄	1.06×10 ⁻³	7.0×10 ⁻⁴	7.6×10 ⁻⁴
n-C ₅	4.2×10 ⁻⁴	2.8×10 ⁻⁴	2.9×10 ⁻⁴
i-C ₅	5.1×10 ⁻⁴	3.9×10 ⁻⁴	4.2×10 ⁻⁴
C ₆₊	1.5×10 ⁻³	2.1×10 ⁻⁴	4.8×10 ⁻⁴
C ₇₊	0	1.62×10 ⁻³	0
CO ₂	2.56×10 ⁻²	2.04×10 ⁻³	1.944×10 ⁻²
N ₂	2.1554×10 ⁻¹	3.797×10 ⁻²	1.1991×10 ⁻¹
Feed Condition			
Parameter		Value	
Mass Flowrate (Kg/h)		84,000	
Temperature (°C)		49	
Pressure (psia)		1000	

2.2.1 Turbo Expander (TE)

As shown in Figure 2, an industry standard single-stage (ISS) turbo-expansion (TE) process configuration has been modeled in ASPEN HYSYS. This provides the base for the following setup: Feed stream-1, having the parameters and composition shown in Table 1, and containing a large amount of methane. It is cooled to -55°C in dual series heat exchangers (E100) and (E-101). The feed stream is then pumped into the V-100 tank to form vapor stream 4 and liquid stream 5, respectively. Stream 4 is fed to the turbo-expander (K-100), which cools the vapor before it injects the top of the demethanizer (T-100) at 40°C. The booster compressor (K-101) runs on a very similar shaft as K-100; The energy from the K-100 is

transformed into dynamic energy (Mechanical energy) to drive the K-101. The expansion valve (VLV-100) reduces the fluid pressure from the flow 5 to the pressure of the T-100. The T-100 has four different discharge flows: Streams 16 and 17 exit the tower, are cooled by E-106 and E-105, respectively, and then processed to 32 and 21 degrees. Stream 8 above T-100 is heated to 41°C in stream 11 by E-102 and E-103. The gas is condensed in K-101 and K-102 to attain pipeline requirements. The bottom of T-100 is drained through P-100 and afterwards reheated by E-104 before being delivered as an NGL product.

Table 2

Frequently used factors for specific converged unit operations

Parameter	Unit	Value
Number of theoretical trays including reboiler	No.	41.0
Sales gas outlet pressure	psia	730.0
Efficiency of Pump/Expander and Compressor	%	75.0
Sales gas outlet temperature	°C	49.0
Product specification (C_1/C_2)	ratio	0.02
Demethanizer bottom stage pressure	psia	337.0
Demethanizer top stage pressure	psia	334.0
Thermodynamic property package	Peng-Robinson	
Pressure loss across the heat exchangers, shell, and tube sides	psia	10.0

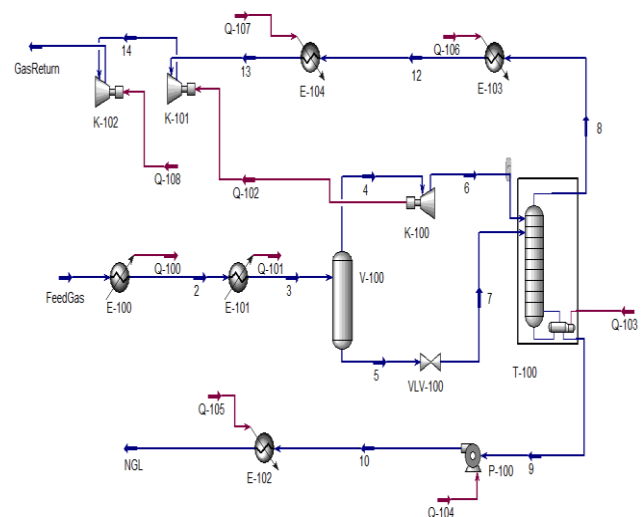


Fig. 2. Assembled workflow scheme of Turbo-Expander process (TEp)

2.2.2 Gas Sub-Cooled process (GSCp)

The flow diagram for the Gas Subcooling Convergence Process (GSCp) (PFD) is explained in Figure 3. The GSP process is similar to the ISS process, but with several adjustments to increase the recovery of ethane from the demethanizer overhead. Similar to the TE process, stream-3-3 is expanded in V-100, and air stream 4 is expanded in K-100 before even being sent to T-100. Unlike the TE process, bottom stream 5 is chilled and extended in E-107 and VLV-100 before being directed to a preceding flash column (V-101). Top stream-16 is then subsequently combined with the T-100 overhead in MIX-100 and then undergoes the same standardized heating and compression process as TE. The bottom portion of stream 17, which comprises primarily ethane and heavy hydrocarbons, is sent to T-100. Contacting this stream with steam can promote the recovery of methane gas. The final product is LNG streams.

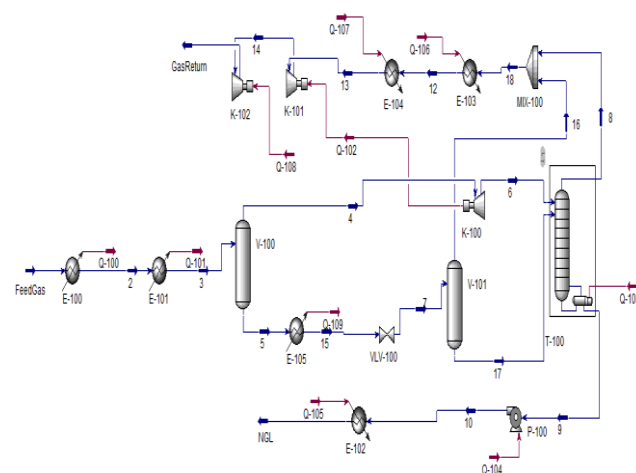


Fig. 3. Assembled workflow scheme of Gas Sub-Cooled Process (GSCp)

2.3 Parametric investigations

Next, two convergent models (GSCp and TE) were employed to study the impacts of diverse operational situations, such as feed composition, feed pressure, feed temperature, and feed flow rate. The effects of these variables on total NGL production, total process energy requirements, higher heating value (HHV) of NGLs, and gas recovery are considered for selected processes. Table 3 provides detailed information for the various simulation cases.

Table 3.

Variable parameter detail for various cases

Sr. No.	Feed Parameter	Variation Range
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1	Natural Composition	Gas	Zamzama, Qadirpur, Sui
2	Pressure		5000 to 9000 psia
3	Temperature		30 to 80 °C
4	flowrate		50000 to 95000 Kg/hr

2.4 Economic Evaluation

Aspen Economic Evolution is an embedded software that provides standard costing methods for various processes. In this study, two operations were economically evaluated using three feed formulations. Total capital costs, total operating cost, total operating costs, equipment cost, and total installation cost were estimated and compared.

3. Results And Discussions

3.1 Overviews Of The Model

Natural gas liquids are the heavier hydrocarbons in natural gas. These natural gas liquids have a higher heating value but raise the hydrocarbon dew point (HCDP) of natural gas, causing serious problems for natural gas pipelines. Despite the problems associated with HCDP, it can be used as a heat source if it is separated from the natural gas. Thus, there is a requirement to remove natural gas liquids from natural gas. There are various removal techniques available worldwide. In this study, two configurations, namely an expander turbine (commonly referred to as ISS) and a gas subcooling process, were modeled using Aspen HYSYS V10. Three different combinations of local gas sources, such as Sohi, Qadirpur, and Zamzam, were used. Then, the effects of diverse operating parameters, such as feed flow rate, feed pressure, and feeding temperature, were studied. Ultimately, an economic evaluation was performed. The results will be discussed in the following sections.

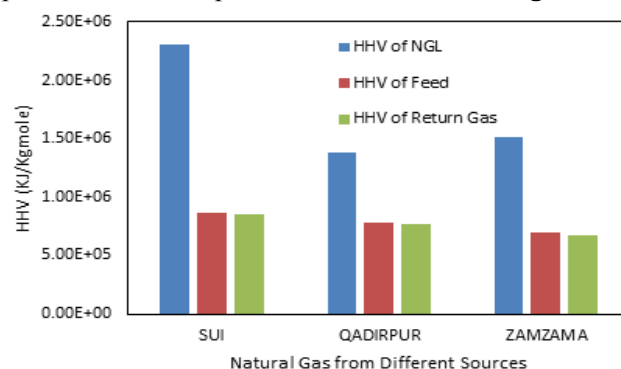
3.2 Effect Of Feed Composition

As mentioned earlier, the natural gas component is derived from three local natural gas sources: Sohi, Kadirpur, and Zanzama, which are used in the model to study their effects. Figure 4(a) shows the peak heating values (HHVs) of the produced LNG, feed gas, and return gas for the selected gas compositions. The high heating value of the LNG produced from Sohi, Kadirpur, and Zanzama gases is 2.3×10^6 , 1.38×10^6 , and 1.51×10^6 kJ/kg mol, respectively. The high heating value of the feed gas was estimated using the formula, and the high heating value of the Sohi, Kadirpur, and Zanzama feed gases was 8.71×10^5 , 7.79×10^5 , and 6.96×10^5 kJ/kg mol, respectively. It

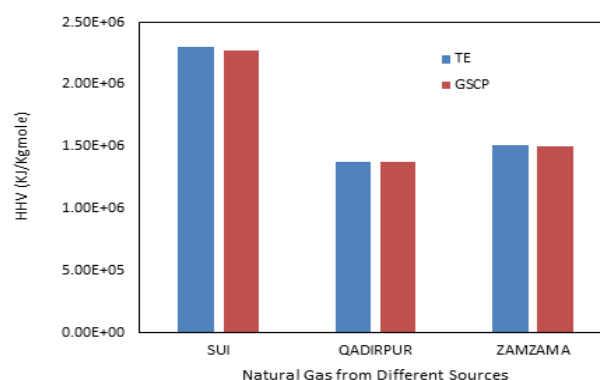
can be noted that the HHV value of the parent natural gas is lower than that of the produced natural gas. Compared to liquids. This is due to the presence of a large amount of low-calorie substances, such as methane gas.

After the recovery of natural gas liquids, the gas will be returned to the national grid. The estimated HHV values of the return gases (Suyi, Kadirpur, and Zamzama) were 8.53×10^5 , 7.68×10^5 , and 6.78×10^5 KJ/kgmol, respectively. It can also be seen from Figure 4 that the HHV values of the feed gas and the reflux gas after NGL removal are very different. This is because the fraction of LNG liquids removed is very small, and as the main source of heating, their impact on the high heating value of the gas is almost negligible.

Figure 4(b) presents the effect of the two configurations on HGTL production for all selected gas compositions. The previous section discussed the high heating value of LNG produced from ethylene oxide using different gas sources. The LNG liquids produced via the GSCP process have high heating values of 2.28×10^6 , 1.37×10^6 , and 1.5×10^6 kJ/kg mol from the Sui, Qadirpur, and Zamzameh gas reservoirs, respectively. A slight difference was observed between the GSCP and TE configurations. Based on the simulation cases of this study, the TE shows good performance compared to the GSCP configuration.



(a)



(b)

Fig. 4. The Higher Heating Value of: (a) NGL, Feed Gas and Gas Return with TE model and (b) NGL with TE and GSCP model.

3.3 Effect Of Feed Flowrate

The TE_p and GSC_p models were analyzed by adjusting the input flow rates while maintaining the constant pressure and temperature, as shown in Table 2. Figure 5(a) indicates the effect of feed flow rate on NGL production at various feed gas compositions in the TE_p design. It was observed that the NGL mass flow rate rises linearly with rising feed flow rate.

It was observed that Sui well had the lowest NGL production due to the higher percentage of methane in the gas obtained from Sui well. Zamzama gas produced the highest NGL at all feed flow rate variations due to the higher content of heavy hydrocarbons. Moreover, the difference in NGL production increased slightly with the increase in feed flow rate. At the highest feed flow rate, i.e., 95,000 kg/h of feedstock, the NGL production was 3429 kg/h and 3795 kg/h, respectively. The production from the Sui, Qadirpur, and Zamzama gas reservoirs was 4632 kg/h.

Figure 5(b) illustrates the corresponding power requirements (energy required) for feed flow rate variations for all selected combinations with TE configurations. It is observed that as the feed flow rate increases, the power requirement also increases. In addition, it can be seen that the power requirement for the production of NGLs at the Sui gas storage facility is significantly higher than the other two storage facilities. The possible reason is the smaller proportion of heavy hydrocarbons in the Sui current. At the highest feed flow rate, i.e., 95,000 kg/h loading, the power requirements for Sui, Qadirpur, and Zamzama gas components are 26166.25 kW, 15085.49 kW, and 13644.69 kW, respectively.

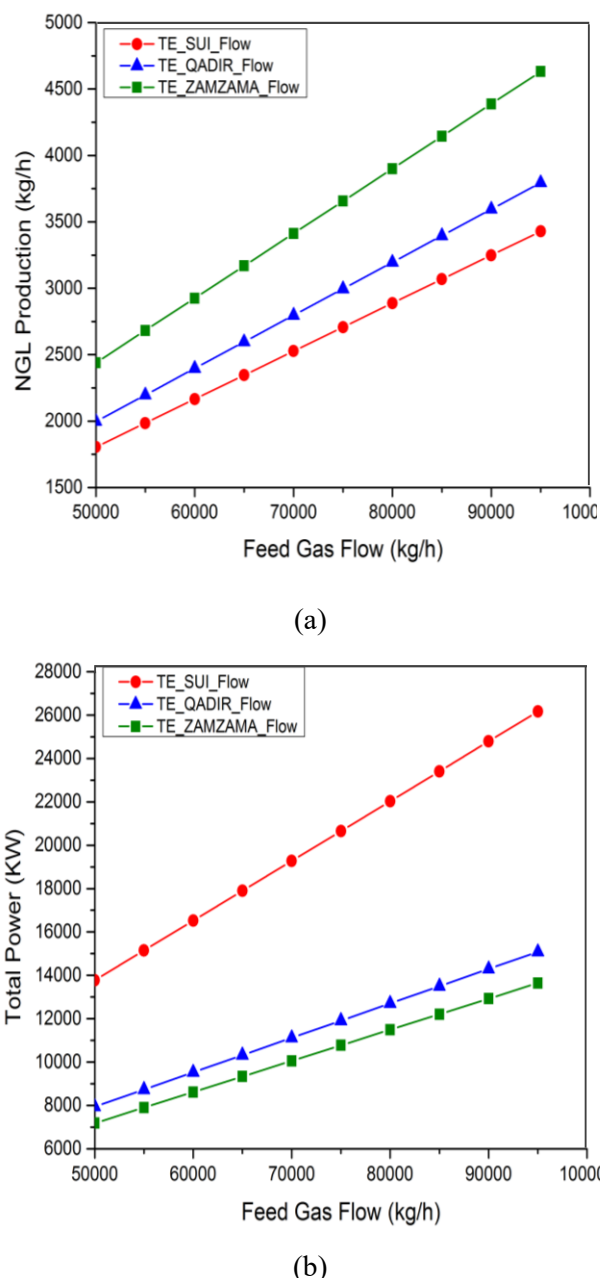
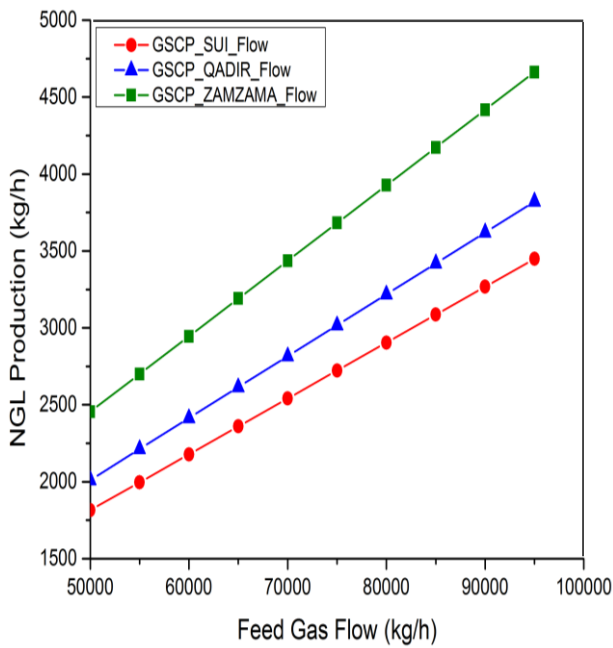
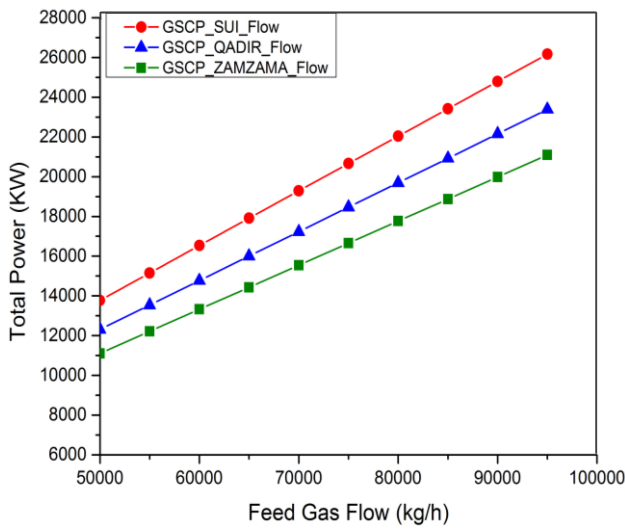


Fig. 5. The effect of feed flow rate on: (a) NGL Production with TE_p Model and (b) Total Power requirements with TE_p model.

Correspondingly, Figure 6(a) shows the effect of feed flow rate on NGL production in the GSC_p formation at different feed gas compositions. Figure 6(b) shows the corresponding energy requirements (total energy) for all selected components versus feed gas flow rate for GSCP formation. Almost similar trends were observed. At the maximum feed rate of 95,000 kg/h, the natural gas liquids production from Sui, Qadirpur, and Zamzam gas reservoirs was 3,449 kg/h, 3,822 kg/h, and 4,663 kg/h, respectively. Similarly, at the highest feed rate of 95,000 kg/h, the power requirements of Sui, Qadirpur, and Zamzam gas components during charging were 26,175.19 kW, 23,388.25 kW, and 21,096.94 kW, respectively.



(a)



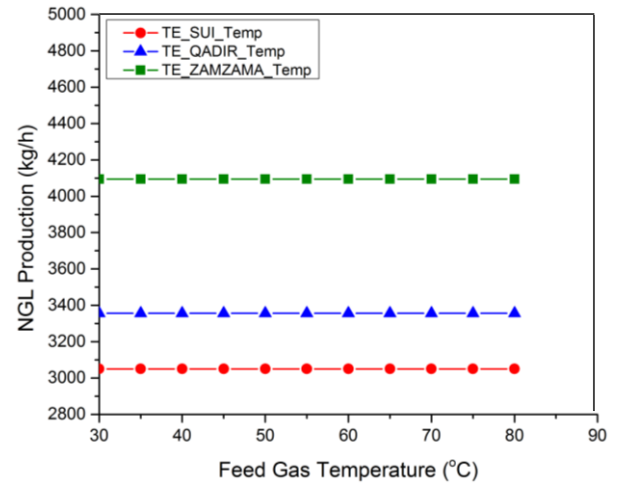
(b)

Fig. 6. The Effect of input flow rate on: (a) NGL production with GSCp Model and (b) Total Power requirements with GSCp model.

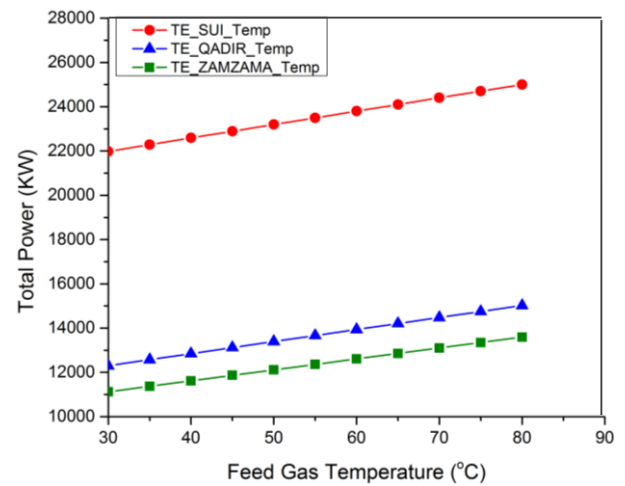
3.4 Effect Of Temperature Feed

Figures 7(a) and 7(b) show the effect of temperature on NGL production and power demand in the TEp model, respectively. Similarly, Figures 7(c) and 7(d) show the effect of temperature on NGL production and power demand in the GSCP configuration, respectively. No significant effect on NGL production was observed in any configuration. However, the energy demand showed an increasing trend with increasing temperature in both configurations. At the maximum supply temperature of 80°C, the power demand for Sui, Qadirpur, and Zamzama gas components for TE configuration was 25003.211 kW, 15022.165 kW, and 13592.72 kW, respectively. Similarly, for GSCP configuration, the

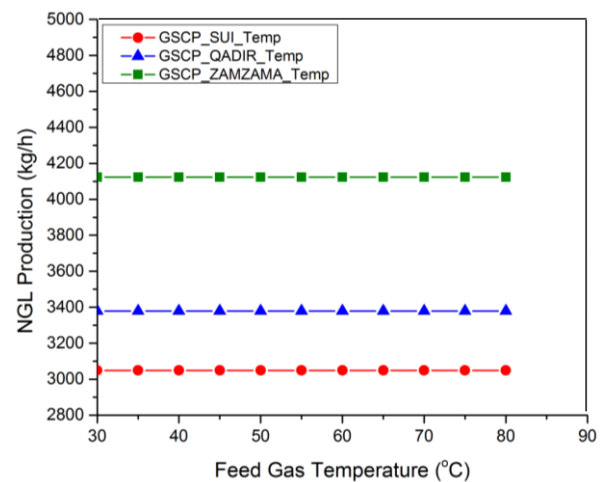
power requirements at Sui, Qadirpur, and Zamzama gas compositions are 25012 kW, 22362.315 kW, and 20180.37 kW, respectively, at the maximum feed inlet temperature of 80°C.



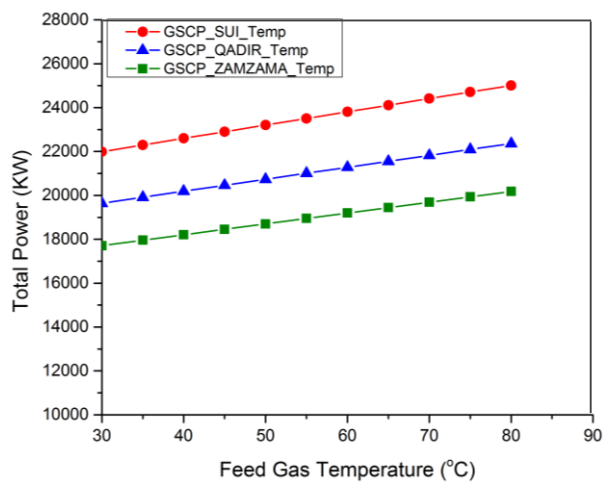
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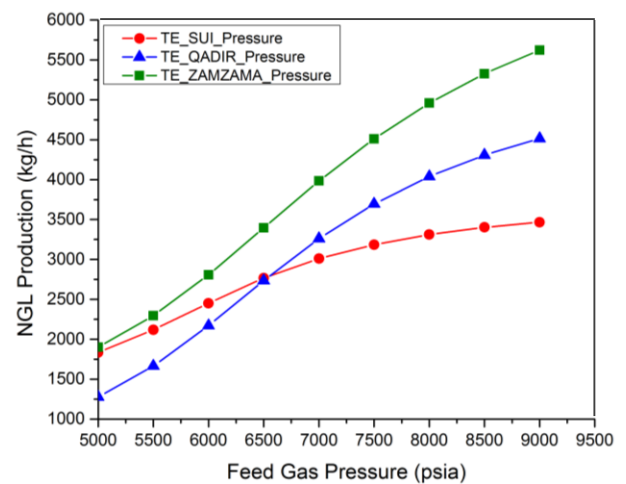
(b)



(c)



(d)

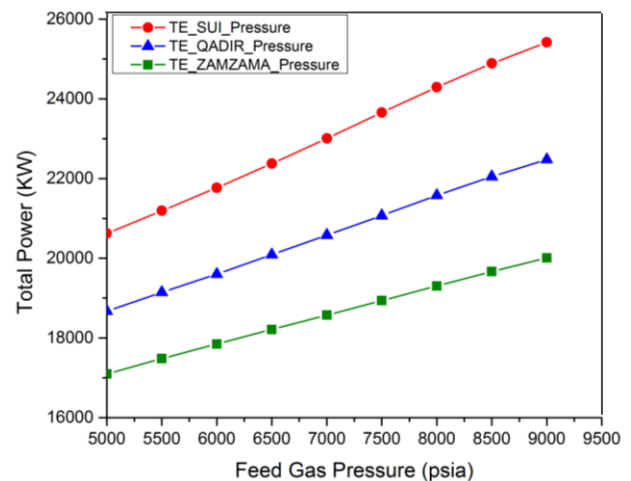


(a)

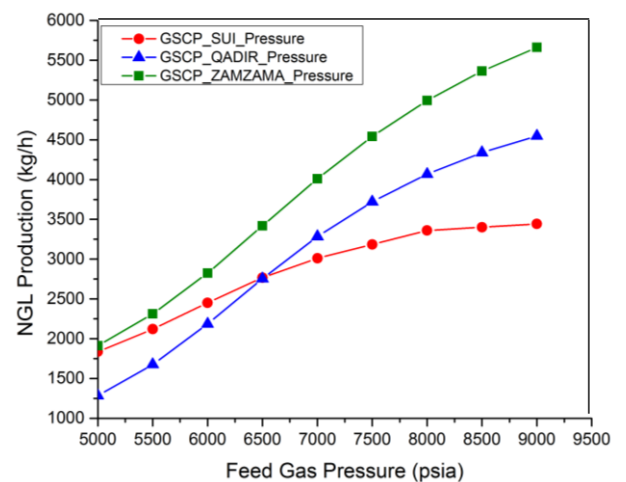
Fig. 7. Effect of Temperature input on: (a) NGL Production with TE Model (b) Total Power requirements with TEp model (c) NGL Production with the GSCp Model and (d) Total Power requirements with GSCP Model.

3.5 Effect Of Feed Pressure

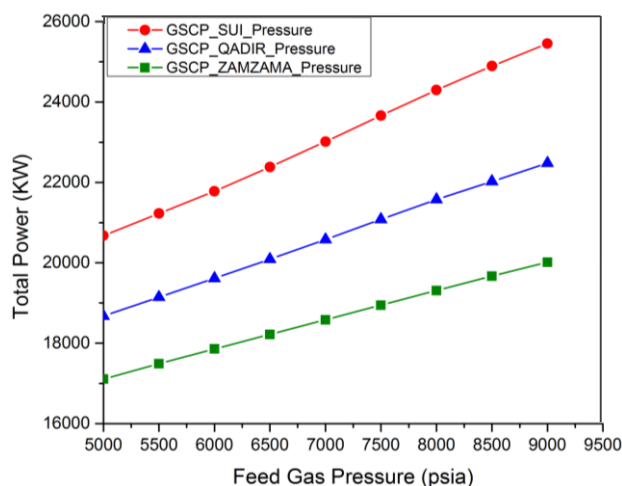
Figures 8(a) and 8(b) demonstrate the effect of pressure on NGL production and energy requirements for power generation, respectively. Correspondingly, the effects of pressure on NGL production and energy requirements for GSCP formation are pointed out in Figures 8(c) and 8(d), correspondingly. Feed pressure significantly affects natural gas liquids production and energy requirements. It can be observed from Figures 8(a) and 8(c) that NGL production rises non-linearly with increasing feed pressure. It was also noted that for both formations at low pressures, the Sui feed gas formation produced more gas liquids than the Qadirpur feed gas formation, but above 6500 psi, the Qadirpur gas formation produced more gas liquids than the Sui gas formation. However, Zamzam produced more NGL than the other two formations at all pressures. However, for both configurations, the power demand also shows an increasing trend with increasing temperature. When the maximum feed inlet temperature is 80°C, the power requirements of the Sui, Qadirpur, and Zamzama gas components are 25003.211 kW, 15022.165 kW, and 13592.72 kW, respectively, for the TE configuration. Similarly, for the GSCP configuration, when the maximum feed inlet temperature is 80°C, the power requirements of the Sui, Qadirpur, and Zamzama gas components are 25012 kW, 22362.315 kW, and 20180.37 kW, respectively.



(b)



(c)



(d)

Fig. 8. The effect of input Pressure on: (a) NGL Production with the TEp Model (b) Total Power requirements with the TEp Model (c) NGL Production with the GSCp Model and (d) Total Power requirements with the GSCp Model.

4.6 The Economic Assessment Of The Processes

This study estimated the different costs of the two processes using the Aspen Economic Evolution software in HYSYS. The analysis revealed that the projected capital costs for both configurations ranged from \$8 million to \$9 million, suggesting potential application in the Pakistani industry. Among the study cases, gas-fired GSCP operations in the Sui gas field recorded the highest capital costs at \$9.879 million, reflecting the complexity and high capital requirements of this configuration. Conversely, gas-fired TE operations in the Zamzama gas field recorded the lowest capital costs at \$8.725 million, demonstrating their relative economic advantages. The approximately \$1.154 million difference between the two fields highlights the impact of feedstock composition and site-specific operating conditions on project economics [21]. The GSCP Sui process can achieve higher energy recovery rates but requires a higher financial investment. In contrast, the Zamzama TE process is emerging as a cost-effective alternative due to its low initial capital investment [22]. This comparative analysis highlights the trade-off between maximizing efficiency and minimizing capital expenditures. It also emphasizes the need to carefully select process configurations based on the project's economic priorities. Overall, these results provide crucial information to decision-makers, helping them strike a balance between technical efficiency and financial sustainability in the Pakistani natural gas sector.

5. Conclusion

Natural gas liquids are the heavier hydrocarbons in natural gas. These natural gas liquids have a higher

heating value but raise the hydrocarbon dew point (HCDP) of natural gas, posing serious problems for natural gas pipelines. Despite the problems associated with HCDP, it can be used as a heat source if it is separated from natural gas. Thus, there is a need to remove natural gas liquids from natural gas. There are various removal techniques available worldwide. In this study, two configurations, namely an expander turbine (commonly referred to as ISS) and a gas subcooling process, were simulated using Aspen HYSYS V10. Three different combinations of local gas sources, such as Sohi, Qadirpur, and Zamzam, were used. The effects of various operating parameters, such as feed flow rate, feed temperature, and feed pressure, were then investigated. Finally, an economic evaluation was performed. In the TE configuration, the higher heating value (HHV) of LNG generated from Qadirpur, Sui, and Zamzameh fields is 1.38×10^6 , 2.3×10^6 , and 1.51×10^6 KJ/kgmol, respectively. In the TE configuration, the higher heating value of gas from Sui, Qadirpur, and Zamzameh fields is estimated to be 8.53×10^5 , 7.68×10^5 , and 6.78×10^5 KJ/kgmol, respectively. The HHV of LNG produced from Qadirpur, Sui, and Zamzameh gas fields using the GSCP process are 1.37×10^6 , 2.28×10^6 , and 1.5×10^6 kJ/kgmol, respectively. It can be noted that there is a slight difference between the GSCP and TE configurations. According to the simulation cases in this study, TE shows good performance compared to the GSCP configuration. The maximum feed rate is 95000 kg/h. The feed and natural gas liquids production reached 3429 kg/h and 3795 kg/h, respectively. After adopting renewable energy technology, the natural gas production from Sui, Qadirpur, and Zamzam gas storage facilities reached 4632 kg/h. The maximum feed rate is 95000 kg/h. The charging power requirements of the three gas storage facilities, Sui, Qadirpur, and Zamzam, are 26,166.25 kW, 15,085.49 kW, and 13,644.69 kW, respectively. It was found that with the rise in feed flow rate, the power demand also increases. He also mentioned that natural gas liquids are at the Sui gas terminal. The energy required to produce is much higher than that of the other two gas terminals. There is no significant impact of either configuration on NGL production. However, in both configurations, energy demand increases with increasing temperature. Feed pressure significantly affects NGL production and electricity demand. It was noticed that NGL production increased non-linearly with increasing feed pressure. The GSCp model operated by Sui has the highest capital cost of \$12.1 million, while the TE configuration operated by Zamzama has the lowest capital cost of \$11.4 million.

Conflict of interest: The authors declare no conflict of interest.

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