Simulation and Multi-Objective Optimization of the Crude Oil Treatment Plant in Rumaila Oil Field

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ABSTRACT: *In this work, the oil treatment plant of the Rumaila oil field in Iraq was simulated using Aspen HYSYS. Industrial data from the plant was applied to validate the simulation results. The process was optimized in single-objective and multi-objective modes using a genetic algorithm. The process was optimized for reducing CO_2, H_2S, and CH_4 in the outlet oil flow, and the energy of the heater simultaneously by changing the molar flow and temperature of dry crude oil and water. The result shows that by decreasing the temperature of the dry crude oil and water, the amount of the consumed energy will decrease to a large extent, but the amount of H_2S, and CH_4 in the outlet oil will decrease. Also, it can be concluded that by separating more CO_2, H_2S, and CH_4 in the outlet oil, the temperature should be increased and as a result, the consumption of the energy will be increased. The single-objective optimization results showed that the amount of CO_2, H_2S, and CH_4 was decreased by 46.52%, 43.,94%, and 27.8%, respectively. On the other hand, the results from multi-objective optimizations illustrated a lower reduction in the amounts of CO_2, H_2S, and CH_4. Consequently, it was concluded that single-objective optimization results were better than multi-objective optimizations.*

KEYWORDS: *Oil treatment plant; Rumaila oil field; Simulation; Aspen HYSYS; Genetic Algorithm.*

INTRODUCTION

Customers' satisfaction during the economic challenges of modern technologies should be considered in all aspects of life. Maintaining the cost and the quality of products should be considered in the chemical industry [1]. The reason is that in industry, an innovative approach is a common practice for redesigning, rebuilding, and renewing a system to increase quality and standard leading to profits, though the industry should meet safety and environmental standards. Therefore, in designing each plant operation, some factors such as modeling, simulation, and optimization should be maintained in any industry [2].

Crude oil contains complex mixtures that are very difficult to handle, meter, or transport [3]. In addition, to the difficulty, it is also unsafe and uneconomical to ship or transport these mixtures to refineries and gas plants for processing [4]. However, environmental constraints are for the safety and acceptable handling the safety and

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acceptable handling of hydrocarbon fluids as well as the disposal of produced saltwater. It is therefore necessary to process the produced fluids in the field to yield products that meet a set of specifications handled safely by a customer [5].

Oil fields around the globe normally produce oil mixing with water, so we need a dehydration system to refine oil to sell on the market. Therefore, we are required to establish a desalting plant system to refine oil [6].

There [s broad research about experimental and simulations of desalting plants in literature [7]. Schramm explained the basic principles governing petroleum emulsions, in a very extensive manner which covered most aspects of the phenomenon [8]. Also, he explained that oil field emulsions differ because their oil contents consist of a wide range of hydrocarbons. Emulsion characteristics were further carried out by Clark and Pilehvari, who used four crude oil emulsions with different viscosities [9]. The findings revealed that the shear tress-shear behavior of the emulsions is highly dependent on oil droplet size. Their results showed that oil droplet size is also a dominant factor in the behavior of emulsions. *Aryafard et al.* [10] developed a mathematical model to predict water and salt separation efficiencies in an industrial two-stage crude oil desalting process. Their case study consists of mixing valves and electrostatic drums Emulsification connected in series. They used the population balance method to model the considering water droplet breakage and coalescence terms to predict the droplet size distribution. *Al-Otaibi et al*. [11] conducted a study on the performance of the desalting/dehydration by calculating the salinity and water cut efficiencies. They modeled and optimized the performance of the desalting/dehydration process system and applied an Artificial Neural Network (ANN) as a modeling technique for simulating and optimizing the desalting/dehydration process system. They compared neural network model predictions with the actual observations. Besides, they used a neural network to optimize the process. Their outcome was used to improve oil production operations by lowering the cost per barrel produced. *Aryafard et al.* [12] developed a mathematical model to predict water and salt removal efficiencies in an industrial crude oil desalting plant in steady-state condition. They considered that the desalting process consists of the mixing valve and AC electrostatic desalting drum. They modelled the mixing valve and desalting drum based on population balance method considering water droplet breakage and coalescence to predict the droplet size distribution. *Kim et al*. [13] implemented a mathematical modeling method to improve the efficiency of dewatering and desalting processes. Their simulation system is based on the module modeling principle and describes every module in terms of appropriate combinations of phenomena and processes. *Sotelo et al.* [14] simulated a dehydration/desalting plant of crude oil in dynamic mode using Aspen HYSYS. They studied control strategies to sustain international standard quality values in the resulting crude oil. They used a Relative Gain Array (RGA) mathematical tool to identify the strongest interaction between manipulated and controlled variables. They found that their proposed control scheme keeps in range salinity and water contents in the final product. *Pasban* and *Nonahal* [15] investigated the precision of analytical methods for determining salt content in Iranian crude oils. They used extraction with volumetric titration and electrometric procedure to determine the salt content. Their results showed that when water content in crude oil is less than 0.05 weight percent, both methods have the same results, but when there is an increase in associated water content in crude oil, the electrometric method with volumetric titration method depicts more accurate results in comparison with the extraction procedure [16].

There are some studies about the optimization of desalting plants in literature. In recent years, optimization using genetic algorithms has a great attention. Actually, GA is one of the most powerful algorithms in the optimization context [17, 18].

In this research, the desalination plant of Rumaila oil field in Iraq was simulated and optimized. The Rumaila oil field is one of the largest oil fields in the world located near Basra and about 20 miles from the Kuwaiti border in southern Iraq. It is spread over a 1,800 km² area and is owned by Iraq. The field was discovered by British Petroleum (BP) in 1953. In December 2015, the field produced 1,350,000 barrels per day. Currently, about 270 production wells are operating at Rumaila. Due to the corrosive effect of dissolved gases in crude oil, unlike other research in simulation and optimization desalination process, the minimizing of the amount of CO_2, H_2S, and CH_4 in the outlet oil flow and the reducing energy heat of plant were investigated. In this work, Aspen HYSYS and

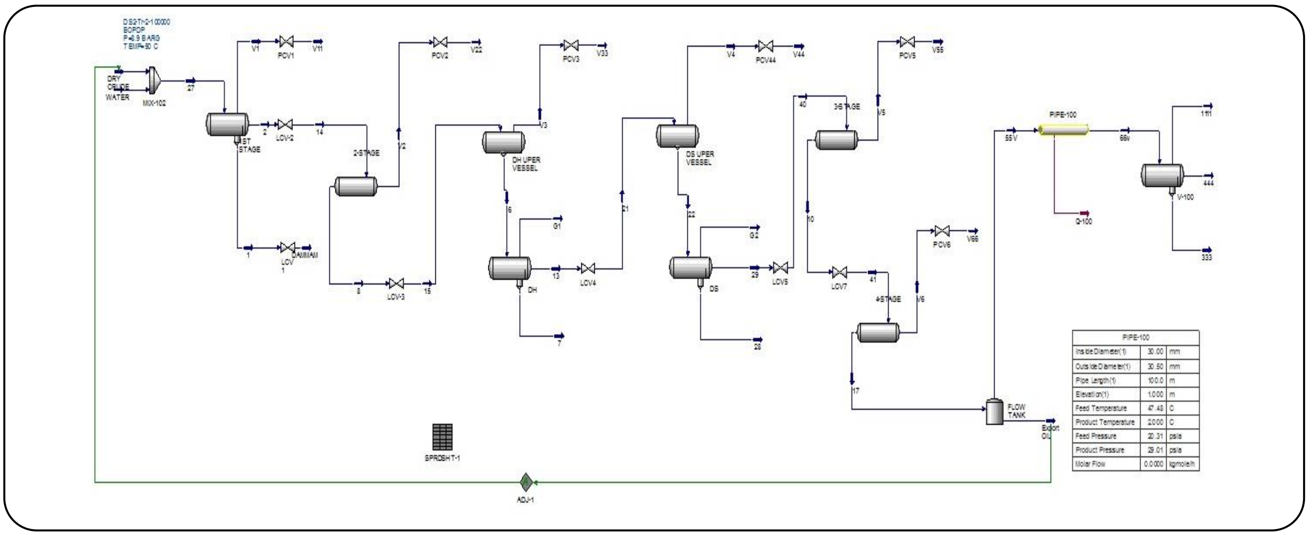

Fig. 1: PFD of crude oil treatment process of Rumaila oil field.

MATLAB was utilized for simulations and optimizations, respectively. In addition, both single- and multi-objective optimization processes are performed for justification.

SIMULATION AND OPTIMIZATION FRAMEWORK

Simulations

Process description

Simulations were done by means of Aspen HYSYS 8.8 which is a powerful simulator for processing oil in gas. Also, MATLAB software was used to optimize the process. Process flow diagram (PFD) of the crude oil treatment process of the Rumaila oil field is presented in Fig. 1.

Dry crude and water are mixed in a mixer and then sent to a heater to increase the temperature, then, the mixture of water and dry crude goes under three stages of dehydration and desalination stages using three phases: Two-phase separators to separate the salt and one phase to dissolve gases in the mixture. Properties of the dry crude, water, and export oil flows are listed in Table 1.

MP-PS1 to MP-PS5 are the heavy components of the dry crude oil. These components were defined using hypo components in the Aspen HYSYS 8.8 and the properties of these components are shown in Table 2.

The specifications of the equipment have been presented in Table 3. For simulations, the Peng-Robinson fluid package has been applied. For validation, the data from the plant was used and the results for dry crude, water, and export oil flows from simulations were compared with industrial data.

In Table 4, the validation results show that the simulations have great correspondence with industrial data.

Genetic Algorithm Optimization

Genetic algorithms are used for probabilistic optimization methods, which indicate simulations of evolution, and there are some stages. How genetic algorithms function is shown below

- Algorithm begins with a random population
- Algorithm builds a sequence of events for a new population in that each individual in a present generation creates a new population, which requires the following phases:

1- Scores each member of the current population by computing its fitness value. These values are called the raw fitness scores.

2- Scales the raw fitness scores to convert them into a more usable range of values. These scaled values are called expectation values.

3- Select members, called parents, based on their expectations.

4- Some of the individuals in the current population that have lower fitness are chosen as elite. These elite individuals are passed to the next population.

5- Produces children from the parents. Children are produced by combining the vector entries of a pair of parents (crossover) and then applying a random change to the created children.

- Children can be the current population and create a new generation.
- One stopping criterion can stop the algorithm.

Table 1: Properties of the dry crude, water and export oil flows.

Stream name	DRY CRUDE	WATER	Export OIL
Flow (kmol/hr)	6620	35230	2592
Temperature (ºC)	35.25	36	43.43
Pressure (kPa)	991.3	991.3	140
	Composition (mol%)		
Nitrogen	0.0165	0.0000	0.0000
CO_2	0.0101	0.0000	0.0002
H_2S	0.0001	0.0000	0.0000
Methane	0.3732	0.0000	0.0003
Ethane	0.1004	0.0000	0.0056
Propane	0.0719	0.0000	0.0268
i-Butane	0.0147	0.0000	0.0132
n-Butane	0.0432	0.0000	0.0479
i-Pentane	0.0168	0.0000	0.0285
n-Pentane	0.0240	0.0000	0.0442
MP-PS1	0.0941	0.0000	0.2331
MP-PS2	0.1012	0.0000	0.2583
MP-PS3	0.0754	0.0000	0.1925
MP-PS4	0.0417	0.0000	0.1066
MP-PS5	0.0166	0.0000	0.0425
H_2O	0.0000	1.0000	0.0002

Table 2: Properties of heavy components of crude oil.

Component	Molecular weight (g/mol)	Normal boiling point (ºC)	Ideal liquid density (kg/m^3)
MP-PS1	98.67	100.8	750.3
MP-PS2	168.5	223.2	806.7
MP-PS3	301	384.6	872.7
MP-PS4	512.8	545.9	937.9
MP-PS5	850	699.6	1004

Table 3: Specifications of each equipment.

Equipment	Pressure drop (kPa)	Delta T (ºC)
Heater (E-100)	1	10
Valve (LCV-1)	890.3	-
Valve (PCV-1)	100	-
Valve (LCV-2)	190.3	-
Valve (LCV-3)	150	-
Valve (PCV-2)	100	-
Valve (PCV-3)	200	-
Valve (LCV-4)	150	-
Valve (PCV-4)	200	-
Valve (LCV-5)	170	-
Valve (LCV-7)	140	-
Valve (PCV-5)	200	-
Valve (PCV-6)	100	-

Table 4: Validation results

	Simulation			Industrial data		
Stream name	DRY CRUDE	WATER	Export OIL	DRY CRUDE	WATER	Export OIL
Flow (kmol/hr)	6620	35230	2592	6620	35230	2595.1
Temperature (ºC)	35.25	36	43.43	35.25	36	44.64
Pressure (kPa)	991.3	991.3	140	991.3	991.3	138.1
Components (mol%)						
Nitrogen	0.0165	0.0000	0.0000	0.0165	0.0000	0.0000001
CO_2	0.0101	0.0000	0.0002	0.0101	0.0000	0.00022
H_2S	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001
Methane	0.3732	0.0000	0.0003	0.3732	0.0000	0.00028
Ethane	0.1004	0.0000	0.0056	0.1004	0.0000	0.0053
Propane	0.0719	0.0000	0.0268	0.0719	0.0000	0.0265
i-Butane	0.0147	0.0000	0.0132	0.0147	0.0000	0.0140
n-Butane	0.0432	0.0000	0.0479	0.0432	0.0000	0.0487
i-Pentane	0.0168	0.0000	0.0285	0.0168	0.0000	0.0286
n-Pentane	0.0240	0.0000	0.0442	0.0240	0.0000	0.0441
MP-PS1	0.0941	0.0000	0.2331	0.0941	0.0000	0.2331
MP-PS2	0.1012	0.0000	0.2583	0.1012	0.0000	0.2603
MP-PS3	0.0754	0.0000	0.1925	0.0754	0.0000	0.1945
MP-PS4	0.0417	0.0000	0.1066	0.0417	0.0000	0.1016
MP-PS5	0.0166	0.0000	0.0425	0.0166	0.0000	0.0423
H_2O	0.0000	1.0000	0.0002	0.0000	1.0000	0.0004

RESULTS AND DISCUSSION

Single-objective optimization

The main goal of single-objective optimization is to find the best solution, which corresponds to the minimum or maximum value of a single-objective function that lumps all different objectives into one. In this study, several variables have been considered separately as the objective function and the value of the independent optimal variables has been obtained [19]. In single-objective optimizations, the objective functions are minimizing the mole fraction of CO_2, H_2S, and CH_4 in the outlet oil flow. The results of the optimization of the amount of CO_2, H_2S, and CH_4 in the outlet oil flow are shown in Fig. 2.

Fig. 2 shows the result of minimizing the undesirable gases in crude oil in order to purify it for export. Clearly, in the 40th generation, optimization has reached a final optimized value.

Table 5 indicates that by optimizing of temperatures and molar flows of dry crude oil and water streams, we can optimize the amount of CO_2, H_2S, and CH_4 in the outlet oil flow. In fact, using the obtained variable supports the process's work in optimum conditions. With respect to this Table, it was found that the amount of CO_2, H_2S, and CH_4 decreased by 46.52%, 43.94%, and 27.8%, respectively.

Multi-objective Optimization

A multi-objective optimization is an area of multiple-criteria decision-making concerned with mathematical optimization problems involving more than one objective function to be optimized simultaneously. A multi-objective optimization has been applied in many fields where optimal decisions need to be taken in the presence of trade-offs between two or more conflicting objectives [20, 21].

Problems emerge in a multi-objective optimization cannot be solved and thus the conflicting issue exists in objective functions and the solutions are Pareto optimal, which is efficient or non-inferior. Improving objective function does not require devaluing other objectives and all Pareto optimal solutions are accepted without any bias. Researchers study multi-objective optimization problems from different viewpoints and, thus, there exist different solution philosophies and goals when setting and solving them [22].

Table 5: Optimized condition of the process.

Component	Mole fraction before optimization	Mole fraction after optimization	Molar flow of dry crude oil [kgmol/hr] (optimized value)	Temperature of dry crude oil [ºC] (optimized value)	Molar flow of water [kgmol/hr] (optimized value)	Temperature of water [ºC] (optimized value)
CO_2	0.00020405	0.00010911	5004.36	59.9989	37497.96	59.9998
H_2S	1.4194e-5	7.9567e-6	5007.24	59.9975	37479.6	60
CH_4	0.00032868	0.0002373	5018.04	59.9998	37495.44	60

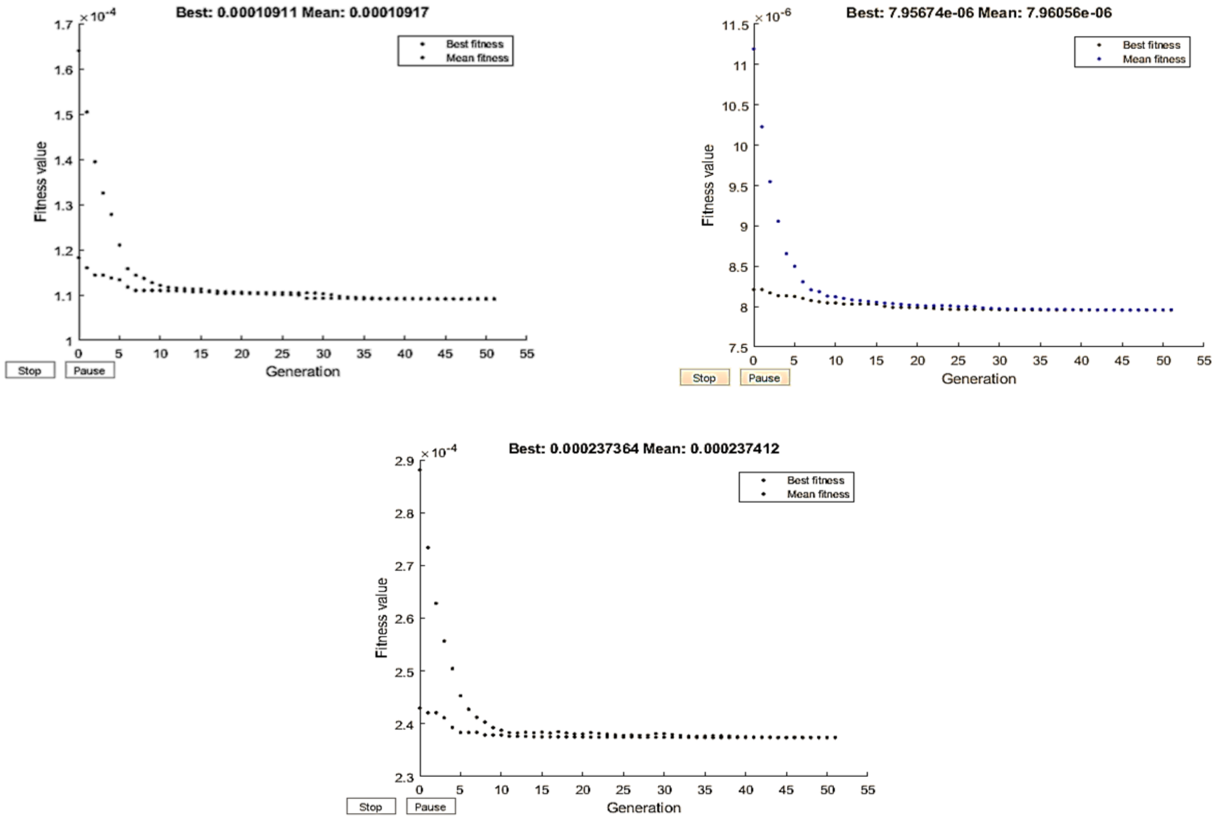

Fig. 2: Fitness value of optimization of (a) CO_2 (b) H_2S (c) CH_4.

Decision makers can use a single-objective optimization as a tool to solve a problem but is used as an alternative for multi-objective optimization problems. The reason is that one solution is appropriate for multi-objective optimization, though using both single- and multi-objective optimization can help improve compromised solutions [23].

We have optimized the process for reducing CO_2, H_2S and CH_4 in the outlet oil flow and the energy of the heater simultaneously by changing the molar flow and temperature of dry crude oil and water. In Figs. 14, 15, and 16, objective 1 is the energy of the heater and objective 2 is the mole fraction of CO_2, CH_4, and H_2S in the outlet oil flow, respectively.

In these plots, you can see the best-optimized values of CO_2, H_2S, and CH_4 in the outlet oil flow and the energy of the heater. Each point in this plot includes a set of optimized variables. Concerning the state of a plant, we can choose these data. The tables below show the result of multi-objective optimization.

Optimization of the process with two objectives

In this section, we have optimized the plant for reducing CO_2, H_2S, and CH_4 in the outlet oil flow and

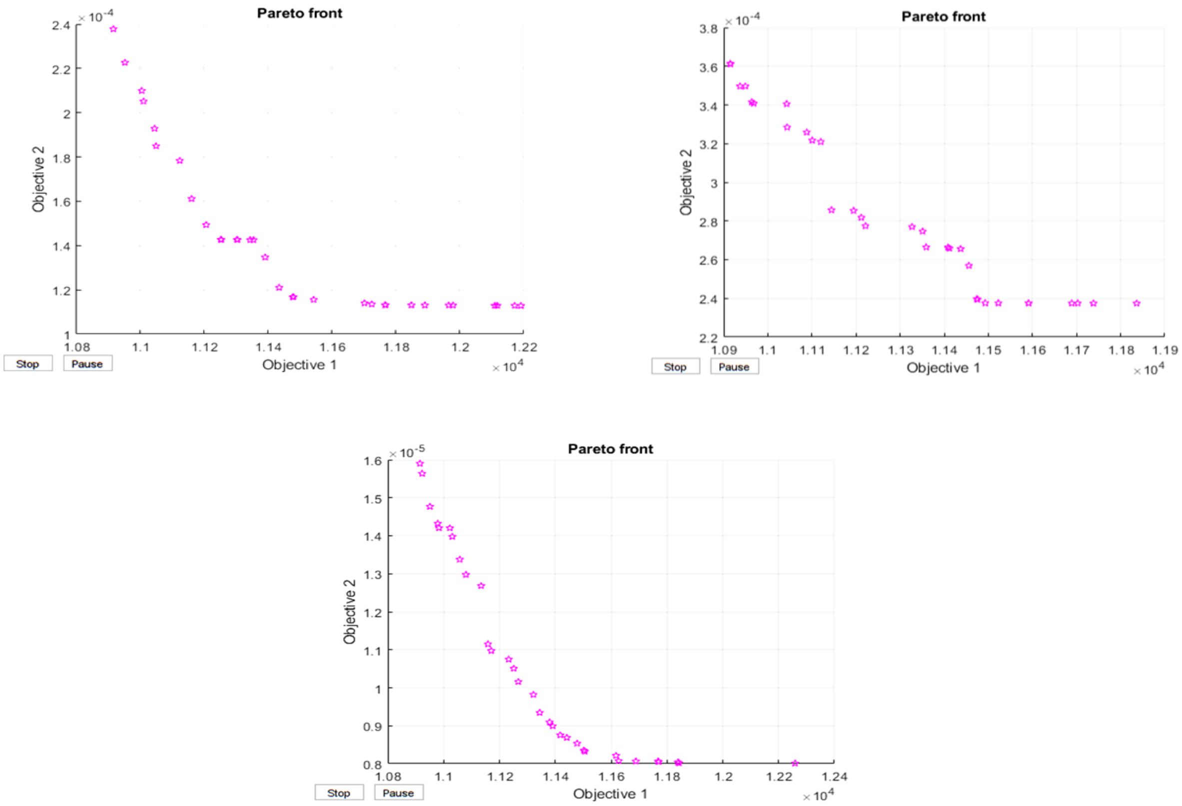

Fig. 3: Pareto plot for multi-objective optimization of a) CO_2 b) CH_4 c) H_2S and energy of the heater.

the energy of the heater simultaneously by changing the molar flow and temperature of dry crude oil and water. Every optimization in this section has two objectives. The results of multi-objective optimization are shown in Tables 6-8.

It was found that in a two-objective optimization using mole fraction of CO_2 and heater energy as objective functions, the amount of them was reduced by 34.98% and 4.49%, respectively. When mole fraction of H_2S and heater energy were used as objective functions, their amounts after optimizing, are reduced about 38.66% and 4.64%. Finally, applying mole fraction of CH_4 and heater energy as objective functions led to reduction of about 22.09% and 5.57% in their amount.

Optimization of the process with three objectives

In this section, we have optimized the plant for reducing CO_2, H_2S in the outlet oil flow and the energy of the heater simultaneously by changing the molar flow and temperature of dry crude oil and water. This optimization has three objectives.

Based on the Table 9, it is obvious that with decreasing of the temperature of the dry crude oil and water, the amount of the consumed energy is reduced to a large extent, but the amount of the CO_2 and H_2S in the outlet oil is decreased to a small extent. Also, it can be concluded that for more separation of the CO_2 and H_2S in the outlet oil, the temperature should be increased and as a result, the consumption of the energy will be increased. Furthermore, it was concluded that in three objectives optimization, the amount of mole fraction of CO_2, H_2S and energy of heater is decreased by 28.29%, 27.32% and 5.01%, respectively.

Optimization of the process with four objectives

In this section, we have optimized the plant for reducing CO_2, H_2S and CH_4 in the outlet oil flow and the energy of the heater simultaneously by changing the molar flow and temperature of dry crude oil and water. This optimization has four objectives.

Table 10 indicate that with decreasing of the temperature of the dry crude oil and water, the amount of the consumed energy is reduced to a large extent, but the amount of the CO_2, H_2S and CH_4 in the outlet oil is

Table 6: The result of multi-objective optimization (Mole fraction of CO_2 and Heater energy [kW]).

Data set	Component	Value before optimization	value after optimization	Molar flow of water [kgmol/h] (Optimized value)	Temperature of water[ºC] (Optimized value)	Molar flow of dry crude oil [kgmol/h] (Optimized value)	Temperature of dry crude oil [ºC] (Optimized value)
1	Mole fraction of CO_2	0.00020405	0.0001675	35405	56.87241	5034.499	57.88804
	Heater energy [kW]	12140	114477				
2	Mole fraction of CO_2	0.00020405	0.0001783	35336.13	44.30437	5003.419	31.00933
	Heater energy [kW]	12140	11123				
3	Mole fraction of CO_2	0.00020405	0.0001285	37117.81	58.38335	5341.508	59.24073
	Heater energy [kW]	12140	12117				
4	Mole fraction of CO_2	0.00020405	0.0001426	35226.63	45.73002	5085.473	56.283
	Heater energy [kW]	12140	11302				
5	Mole fraction of CO_2	0.00020405	0.0001348	36493.27	58.08219	5012.522	58.95494
	Heater energy [kW]	12140	11724				
6	Mole fraction of CO_2	0.00020405	0.0001210	35215.66	55.09441	5078.715	57.01581
	Heater energy [kW]	12140	11434				
7	Mole fraction of CO_2	0.00020405	0.0001131	36626.49	58.18088	5024.759	59.21189
	Heater energy [kW]	12140	11766				
8	Mole fraction of CO_2	0.00020405	0.0001129	36963.56	58.28993	5205.95	59.18807
	Heater energy [kW]	12140	11978				
9	Mole fraction of CO_2	0.00020405	0.0001139	35919.54	57.89996	5150.551	58.95228
	Heater energy [kW]	12140	11701				
10	Mole fraction of CO_2	0.00020405	0.0001142	35028.74	45.74064	5214.892	56.27503
	Heater energy [kW]	12140	11354				

Table 7: The result of multi-objective optimization (Mole fraction of H2S and Heater energy [kW]).

Data set	Component	Value before optimization	value after optimization	Molar flow of water [kgmol/h] (optimized value)	Temperature of water[ºC] (optimized value)	Molar flow of dry crude oil [kgmol/h] (optimized value)	Temperature of dry crude oil [ºC] (optimized value)
1	Mole fraction of H_2S	1.4194e-5	8.2122e-6	35668.14	59.93391	5093.72	56.20858
	Heater energy [kW]	12140	11618				
2	Mole fraction of H_2S	1.4194e-5	8.0417e-6	36462.13	59.97193	5128.279	59.08857
	Heater energy [kW]	12140	11839				
3	Mole fraction of H_2S	1.4194e-5	8.0648e-6	35629.35	59.5995	5168.359	59.86828
	Heater energy [kW]	12140	11689				
4	Mole fraction of H_2S	1.4194e-5	8.3507e-6	35218.14	59.68391	5093.72	54.45858
	Heater energy [kW]	12140	11502				
5	Mole fraction of H_2S	1.4194e-5	8.5354e-6	35218.14	58.68391	5093.72	53.45858
	Heater energy [kW]	12140	11478				
6	Mole fraction of H_2S	1.4194e-5	8.0648e-6	35629.35	59.5995	5168.359	59.86828
	Heater energy [kW]	12140	11689				
7	Mole fraction of H_2S	1.4194e-5	1.1149e-5	35097.09	45.55727	5020.756	44.17843
	Heater energy [kW]	12140	11590				
8	Mole fraction of H_2S	1.4194e-5	9.8191e-6	35283.55	55.90195	5048.838	38.81719
	Heater energy [kW]	12140	11322				
9	Mole fraction of H_2S	1.4194e-5	8.754e-6	35255.75	58.53577	5039.23	49.83126
	Heater energy [kW]	12140	11418				
10	Mole fraction of H_2S	1.4194e-5	8.0746e-6	35416.66	59.65037	5149.529	59.60127
	Heater energy [kW]	12140	11627				

Table 8: The result of multi-objective optimization (Mole fraction of CH4 and Heater energy [kW]).

Data set	Component	Value before optimization	value after optimization	Molar flow of water [kgmol/h] (optimized value)	Temperature of water[ºC] (optimized value)	Molar flow of dry crude oil [kgmol/h] (optimized value)	Temperature of dry crude oil [ºC] (optimized value)
1	Mole fraction of CH_4	0.00032868	0.0002375	35052.92	59.94355	5067.369	59.96661
	Heater energy [kW]	12140	11493				
2	Mole fraction of CH_4	0.00032868	0.0002664	35066.14	49.81883	5175.155	51.58422
	Heater energy [kW]	12140	11359				
3	Mole fraction of CH_4	0.00032868	0.0002569	35576.99	51.83111	5074.517	56.52771
	Heater energy [kW]	12140	11456				
4	Mole fraction of CH_4	0.00032868	0.0002375	35502.92	59.99042	5067.369	59.90411
	Heater energy [kW]	12140	11591				
5	Mole fraction of CH_4	0.00032868	0.0002746	35294.84	48.79244	5157.641	46.37184
	Heater energy [kW]	12140	11351				
6	Mole fraction of CH_4	0.00032868	0.0002374	36177.92	59.99823	5067.369	59.97833
	Heater energy [kW]	12140	11738				
7	Mole fraction of CH_4	0.00032868	0.0002656	35403.64	50.16648	5175.155	51.59594
	Heater energy [kW]	12140	11437				
8	Mole fraction of CH_4	0.00032868	0.0002657	35291.14	50.10398	5175.155	51.56859
	Heater energy [kW]	12140	11412				
9	Mole fraction of CH_4	0.00032868	0.0002374	35952.92	59.99042	5067.369	59.95099
	Heater energy [kW]	12140	11592				
10	Mole fraction of CH_4	0.00032868	0.0002817	35236.09	48.48284	5029.558	40.68667
	Heater energy [kW]	12140	11212				

Table 9: The result of multi-objective optimization with three objectives.

Data set	Component	Value before optimization	Value after optimization	Molar flow of water [kgmol/h] (optimized value)	Temperature of water[ºC] (optimized value)	Molar flow of dry crude oil [kgmol/h] (optimized value)	Temperature of dry crude oil [ºC] (optimized value)
1	Heater energy [kW]	12140	11402.05	35129.421	52.48	5012.456	52.13
	Mole fraction of CO_2	0.00020405	0.0001271				
	Mole fraction of H_2S	1.4194e-5	8.62e-06				
2	Heater energy [kW]	12140	11905.6	34233.699	38.76	5021.633	41.34
	Mole fraction of CO_2	0.00020405	0.000167				
	Mole fraction of H_2S	1.4194e-5	1.34e-5				
3	Heater energy [kW]	12140	11438.5	35123.123	43.24	5042.944	46.08
	Mole fraction of CO_2	0.00020405	0.0001712				
	Mole fraction of H_2S	1.4194e-5	1.1394e-05				
4	Heater energy [kW]	12140	11415.63		36.32	5023.643	42.34
	Mole fraction of CO_2	0.00020405	0.000170124				
	Mole fraction of H_2S	1.4194e-5	1.2014e-05				
5	Heater energy [kW]	12140	11541.1	35432.222	49.12	5021.343	41.11
	Mole fraction of CO_2	0.00020405	0.000140124				
	Mole fraction of H_2S	1.4194e-5	1.0213e-05				
6	Heater energy [kW]	12140	11402.6	3512.124	55.42	5063.642	55.16
	Mole fraction of CO_2	0.00020405	0.00011254				
	Mole fraction of H_2S	1.4194e-5	8.41e-06				
7	Heater energy [kW]	12140	11509.84	35457.837	59.21	5062.532	52.35
	Mole fraction of CO_2	0.00020405	0.00011874				
	Mole fraction of H_2S	1.4194e-5	1.112e-05				
8	Heater energy [kW]	12140	11418.34	35421.321	58.14	5036.241	58.45
	Mole fraction of CO_2	0.00020405	0.00013145				
	Mole fraction of H_2S	1.4194e-5	8.87e-06				
9	Heater energy [kW]	12140	11752.37	35421.214	57.223	5026.34	58.51
	Mole fraction of CO_2	0.00020405	0.00017854				
	Mole fraction of H_2S	1.4194e-5	8.81e-06				

Table 10: The result of multi-objective optimization with four objectives.

Data set	Component	Value before optimization	Value after optimization	Molar flow of water [kgmol/h] (optimized value)	Temperature of water[ºC] (optimized value)	Molar flow of dry crude oil [kgmol/h] (optimized value)	Temperature of dry crude oil [ºC] (optimized value)
1	Heater energy [kW]	12140	11399.02	35089.471	57.58	5023.824	56.32
	Mole fraction of CO_2	0.00020405	0.000116901				
	Mole fraction of H_2S	1.4194e-5	8.52e-06				
	Mole fraction of CH_4	0.00032868	0.000245307				
2	Heater energy [kW]	12140	11004.84	35043.699	34.96	5000.549	40.43
	Mole fraction of CO_2	0.00020405	0.000198				
	Mole fraction of H_2S	1.4194e-5	1.36e-5				
	Mole fraction of CH_4	0.00032868	0.0000324				
3	Heater energy [kW]	12140	11136.4	35091.184	41.14	5013.926	51.12
	Mole fraction of CO_2	0.00020405	0.000161255				
	Mole fraction of H_2S	1.4194e-5	1.14e-05				
	Mole fraction of CH_4	0.00032868	0.000289563				
4	Heater energy [kW]	12140	11111.85	35196.392	38.73	5010.049	47.34
	Mole fraction of CO_2	0.00020405	0.000173692				
	Mole fraction of H_2S	1.4194e-5	1.22e-05				
	Mole fraction of CH_4	0.00032868	0.000301561				
5	Heater energy [kW]	12140	11255.67	35282.936	51.22	5009.935	43.12
	Mole fraction of CO_2	0.00020405	0.000143259				
	Mole fraction of H_2S	1.4194e-5	1.03e-05				
	Mole fraction of CH_4	0.00032868	0.000271962				
6	Heater energy [kW]	12140	11380.4	35057.831	57.49	5009.761	56.42
	Mole fraction of CO_2	0.00020405	0.00011703				
	Mole fraction of H_2S	1.4194e-5	8.53e-06				
	Mole fraction of CH_4	0.00032868	0.000245446				

Table 11: The result of multi-objective optimization with four objectives.

Data set	Component	Value before optimization	Value after optimization	Molar flow of water [kgmol/h] (optimized value)	Temperature of water[ºC] (optimized value)	Molar flow of dry crude oil [kgmol/h] (optimized value)	Temperature of dry crude oil [ºC] (optimized value)
7	Heater energy [kW]	12140	11413.84	35114.081	58.26	5009.761	57.21
	Mole fraction of CO_2	0.00020405	0.000114581				
	Mole fraction of H_2S	1.4194e-5	8.36e-06				
	Mole fraction of CH_4	0.00032868	0.000242915				
8	Heater energy [kW]	12140	11518.34	35507.83117	59.34	5009.761	57.32
	Mole fraction of CO_2	0.00020405	0.000112456				
	Mole fraction of H_2S	1.4194e-5	8.21e-06				
	Mole fraction of CH_4	0.00032868	0.000240735				
9	Heater energy [kW]	12140	11552.37	35564.081	59.34	5037.88	57.11
	Mole fraction of CO_2	0.00020405	0.000112425				
	Mole fraction of H_2S	1.4194e-5	8.21e-06				
	Mole fraction of CH_4	0.00032868	0.000240693				
10	Heater energy [kW]	12140	11015.92	35043.69945	35.05	5014.61	40.23
	Mole fraction of CO_2	0.00020405	0.000196982				
	Mole fraction of H_2S	1.4194e-5	1.36e-05				
	Mole fraction of CH_4	0.00032868	0.0003236				

decreased to a small extent. Also, it can be concluded that for more separation of the CO_2, H_2S, and CH_4 in the outlet oil, the temperature should be increased, and as a result, the consumption of energy will be increased. In addition, it was found that in four objectives optimization, the amount of mole fraction of CO_2, H_2S, CH_4, and energy of the heater decreased by 29.1%, 27.48%, 25.94%, and 7.09%, respectively.

CONCLUSIONS

Desalination plants are very important for refining crude oil because the amount of undesirable substances present in crude oil determines the quality of crude oil. The optimization of the oil treatment process has a proper effect on the process, as it has an impact on the energy consumption of the de-emulsifier, the consumption of washing water, a reduction in the corrosion of the pipelines and equipment. To achieve this goal, simulating and optimizing this process with appropriate software and methods is inevitable. In this research, a simulation and optimization for this process by using ASPEN HYSYS and genetic algorithm was carried out. Romuila Oil field industrial process was used as a case study. The following results were obtained from processing simulation and optimization:

- Estimating the optimal value of independent variables in the oil treatment process can be one of the lowcost ways to increase the energy efficiency of the process and increase the quality of the export oil. A characteristic that indicates the optimization of this process is the increase in the quality of exported oil, which reduces the amount of carbon dioxide, methane and hydrogen sulfide gases, and reduces the amount of energy consumed in the process.

- Genetic algorithm is used as a powerful tool to optimize this process, which is implemented in both single-objective and multi-objective modes.
- A sensitivity analysis on the composition of the exported oil components shows that increasing the temperature of the inlet oil flow rate and washing water as well as the rate of washing water increases the quality of the oil but increasing the inlet oil flow rate reduces the quality of the incoming oil.

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