International Journal of Multiphysics
Volume 19, No. 1, 2025
ISSN: 1750-9548

Simulation of Separation Processes in Vis-Breaking Unit of Oil Refinery Using Hysys

Hadi Asghari[1*] and Vahid Norri Nia[2] and Hadi Shami Zadeh[3]

1Department of Chemical Engineering, Faculty of Technical and Engineering, Ahar Branch, Islamic Azad University, Ahar, Iran

***Correspond Authors**: **Hadi Asghari**; Email: hadiasghari1027@gmail.com

2Department of Chemical Engineering, Islamic Azad University Ahar Branch, Ahar, Iran

Abstract

Oil refineries different units of the refinery, one of the viscosity reduction unit which reduces the viscosity of the feed unit in a vacuum distillation tower Thmandه with additional bearing material is wax. This material is heated to about 460-480 ° C. Products with lower viscosity fuel oil system, some gas is heavy and sulfur gasoline. For new designs Haysys can quickly create models for the evaluation of multiple options. After selecting the best projects can be very realistic models created on the basis that additional equipment and procedural details are also to be taken into account. Haysys can improve quickly with complex operations and to ensure correct operation. After Mass Flow simulation of exhaust gas from the top of the tower from 6153 to 6151 kilograms of product per hour is modified, and the naphtha output from the condenser from 9239 to 9250 kg per hour is increased, on the other hand to reduce the temperature of the fuel feed to the tower output from 53400 to 53090 kg per hour of the tower is reduced and the amount of tar output from 16010 to 16030 kg per hour tower is increased, reducing the temperature to increase the production of naphtha as well. In this section came to the conclusion that reducing the temperature at the top of the tower will also produce naphtha.

Keywords: Refinery- Visbreaker- Simulation- Haysys- naphtha- gas- Gasoil- Tar.

Introduction

Today, the world is progressing, and the most important technology that has accelerated this progress is the emergence of computers in the field of science. This technology has been widely used in all fields, from social and economic fields to other fields, and has a tangible impact on the growth of society. One of the fields in which this technology has accelerated its activities is engineering sciences. Using programming languages (such as C++, MATLAB, etc.) and working with specialized software for each field (such as HISIS for chemical engineering) are among these activities.

The reason for using software for chemical engineering can be stated as follows: the most important goal of an engineer is that he must always choose the easiest and most economical way to achieve the desired output. Of course, it should be noted that the easiest way will not always be the most economical way, and in this case, a chemical engineer must be able to identify the most optimal way. This goal cannot be achieved except by conducting various complex experiments, and since conducting experiments and calculations is time-consuming and costly (and in some cases, even creating the conditions for conducting experiments is very difficult), this is where engineering software comes to the aid of the chemical engineer and speeds up work and reduces costs. Because with its help, he can try different experiments under different conditions and perform the calculations related to it and achieve the most appropriate ones from an economic point of view. This has made one of the effective applications of computers in the oil, gas and petrochemical industries the simulation of production units using special software. This field has grown significantly in recent years, given the competitive environment of global markets and the movements observed in the field of increasing production efficiency, better use of resources and reducing costs, but many of the benefits of this work are still unknown.

Research method with Hysys software

This software is one of the products of Hy protech Canada and AIA Technology, which is used to simulate various chemical, pharmaceutical and petroleum processes.

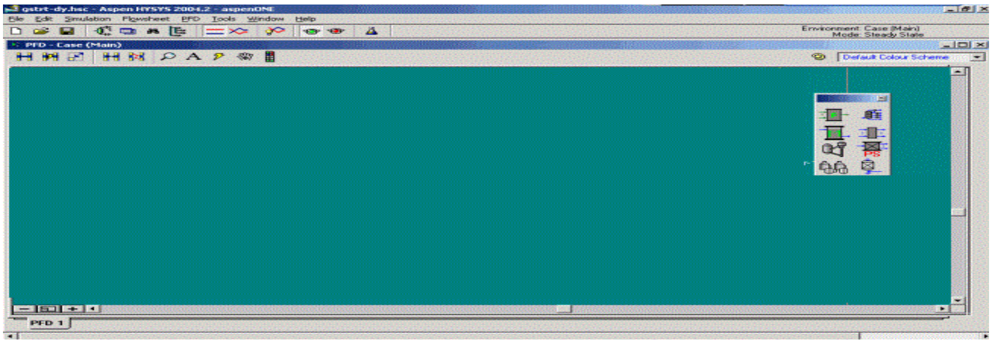

Figure (1): Hysys software environment (Razifar, 2000)

Among the salient features of this software are its high ability to reliably simulate chemical processes, very high graphic capabilities, and quick learning and easy use of the program by the user (Razifar, 2000). Modeling is the description of the nature of a production system (i.e., mass and energy balances) in the form of mathematical equations. The main characteristics of good models are accuracy, quantitativeness, and conciseness. These equations are generally nonlinear and in the form of algebraic, differential, or a mixture of the two. In simulation software, such models are stored in a library as various operations that can be combined to create a model of the process. Simulation, i.e. obtaining output data (e.g. product characteristics) by solving the above models based on input data (e.g. feed characteristics), in which data related to the characteristics of the devices are considered part of the model and some of them are given to the software by the user (Khalaji, 2006).

An oil refinery is an industrial unit in which crude oil is converted into more useful materials such as liquefied petroleum gas, kerosene, gasoline, diesel, fuel oil, asphalt and bitumen, and other petroleum products. Oil refineries are typically large and complex industrial units in which the different units are interconnected by numerous pipelines (Abolhamad, 2014).

Once the components have been separated and purified, the lubricating oil or fuel can be directly marketed. A fuel with a desired octane rating can be produced by combining smaller molecules such as isobutene with propylene or butylene through processes such as alkalization or dimerization. The octane rating of gasoline can also be improved through a catalytic upgrading process in which hydrogen is removed from the hydrocarbon and aromatic hydrocarbons are formed, which have a much higher octane rating. The intermediate products of the separator tower can be converted into lighter products through thermal cracking, hydrocracking, or fluid catalytic cracking processes. The final step in gasoline production is to blend different hydrocarbon materials with different octane ratings to achieve the desired product specifications. Large refineries typically have the capacity to refine from a hundred thousand to several hundred thousand barrels of oil per day. Because of the high capacity required, many refineries operate continuously for long periods of time, from several months to several years. Oil refineries have different complexities depending on the type of feedstock they are designed for, and accordingly, they produce different amounts and types of products. The investment amount for building a refinery with medium complexity is between 18 and 19 thousand dollars per barrel of refining capacity, and with increasing complexity, it sometimes requires an investment of up to 24 to 25 thousand dollars per barrel Abolhamad, 2014).

Viscosity Reduction Unit

The heavy product obtained from the bottom of the vacuum distillation tower has a high viscosity and cannot be directly sold as fuel oil, so the residue from the vacuum distillation tower (mixed with excess waxy materials) is sent to the viscosity reduction unit. DE concentrators are a type of thermal cracking that breaks heavy molecules under a certain temperature and pressure and converts them into lighter molecules. In these devices, heavy furnace oil, which contains a large amount of waxy materials and has low flow ability, i.e. it becomes more viscous in cold weather and cannot flow, is usually reduced in viscosity during a mild thermal cracking and its flow ability increases and can be used from there. As a result of thermal cracking in the concentrator, some lighter materials are produced, from which gas and gasoline are separated, and the remaining light materials remain in the fuel oil to facilitate its flow. Figure (1-10) shows a diagram of a concentrator unit. In this unit, the input feed comes from the bottom of the distillation unit's vacuum tower and, after heat exchange with the furnace outlet materials, enters the furnace. In the furnace, its temperature rises to 370 to 427 degrees Celsius. The pressure of the device is also about 75 pounds per square inch. Then, the furnace outlet is cooled in the vicinity of the oil that exits from the bottom of the device's separator tower. Then, its light gases are separated in the gas separator, after which it exchanges heat with the input feed and then enters the separator tower. In this tower, light gases are discharged from the top and gasoline from the middle of the tower. Fuel oil, whose viscosity has decreased, is discharged from the bottom of the tower as the main product. Some of the liquid from the bottom of the tower is returned to the outlet of the furnace to prevent excessive thermal cracking. In general, the products obtained from this device are:

- Low-viscosity fuel oil
- Heavy gas oil
- Sulfurized gasoline

To correct some of the characteristics of the fuel oil of this device, some kerosene or gas oil is added to it. The sulfurized gasoline obtained is also used as fuel in steam boilers (Niknejad and Nourinia, 2012). According to the information mentioned about the Hysis software and refinery units, in this article, according to the information and details related to it, the viscosity reduction unit in the refinery will be simulated using the Hysis software. They use oil to provide energy and heat in power plants, factories, offices and homes. Although most of the oil (about 85 percent) is used to provide energy, about 15 percent of it can be converted into various materials, including plastics, chemical fertilizers, various medicines, insecticides, cleaners, etc., due to the presence of various hydrocarbons.

Research conducted from the point of view of researchers

Sheikhi et al. (2010) used the Hysys industrial simulation software in their research to simulate a membrane air separation unit. The study of membranes was first carried out in the early 18th century. These membranes had no industrial or commercial application during the 19th and early 20th centuries and were only used on a laboratory scale to advance physical and chemical theories. Initially, natural membranes found in animal bodies were used until nitrocellulose was proposed as a membrane. With the efforts of people such as Alford Zsigmondy, Bachmann, and Frey, nitrocellulose membranes with fine pores were finally produced and marketed commercially in the early 1930s. The simulation results obtained with the help of these two software have been compared with the available experimental data, and there is a good agreement between the results. The method proposed in this article can be used in the simulation of non-ideal devices.

Halimifard (2012) used the HISIS software to simulate and investigate the reduction of the metal network to prevent the emission of polluting gases into the atmosphere in the Masjed Soleiman gas refinery. In the Masjed Soleiman gas refinery, large amounts of greenhouse gases (mainly carbon dioxide) are emitted into the atmosphere daily through the combustion of hydrocarbon compounds in the metal (flare). In addition, the emission of these valuable compounds is considered a waste of energy and national capital. In this project, a study of flaring reduction was conducted using simulation with specialized chemical engineering software (HISIS), and methods were presented for each of the operational units in the Masjed Soleiman gas refinery, and in order to justify the proposed methods, an economic estimate of each was made. The results of the proposed methods include preventing the annual emission of 578 tons of carbon dioxide gas into the atmosphere, providing fuel for amine and glycol reduction reboilers from recovered gases, and recovering 34.82 million cubic feet of gas annually, preventing the annual emission of 12.48 million cubic feet of gas to the metal (flare), increasing gas production in the refinery by 40.15 million standard cubic feet of gas (MMSCFY) annually, increasing gas condensate production by 1749685900 rials annually, and ultimately optimizing energy. From an economic perspective, implementing each of the proposed methods will require investment costs, but the income that can be obtained from implementing each one indicates that the return on investment and project profit for the Masjed-e-Sulayman gas refinery will be fully justified economically. In the work of Bilal et al. [2013], the Hysys software was used to simulate a kerosene desulfurization unit. The process parameters and conditions for all streams are presented according to the information obtained from the plant. According to the results obtained from the research, the desulfurization unit was successfully simulated under industrial conditions and almost 100% of the impurities were removed and the use of HISIS as a software package made it possible to study the effect of process variables in plants with the ability to show power or efficiency.

Nourinia and Shafiei (2013) in their research project, have used the simulation of the acetaldehyde process with dehydrogenation of ethanol in the HISIS software. In this simulation, an example of a petrochemical unit is considered, which uses ethanol as the initial feed and equipment such as packed reactor, heat exchangers, reboilers, coolers, feed pump, absorption tower, distillation tower, and two-phase separator are used to achieve the goals. From the comparison of the results of other researches and the information available from the petrochemicals in question in this field, it is clear that at least 0.14% increase in acetaldehyde production from the ethanol dehydrogenation process is understandable. Therefore, it is possible to produce more than 95,000 tons of this substance, which has numerous industrial uses. Taking some measures such as eliminating additional pumps and separator tanks and stoves and coolers played a major role in achieving these goals in this research, which is a way to both make the production of this substance cost-effective and use the equipment optimally.

Discussion

The results of the viscosity reduction unit simulation are shown in Figures 1-5.

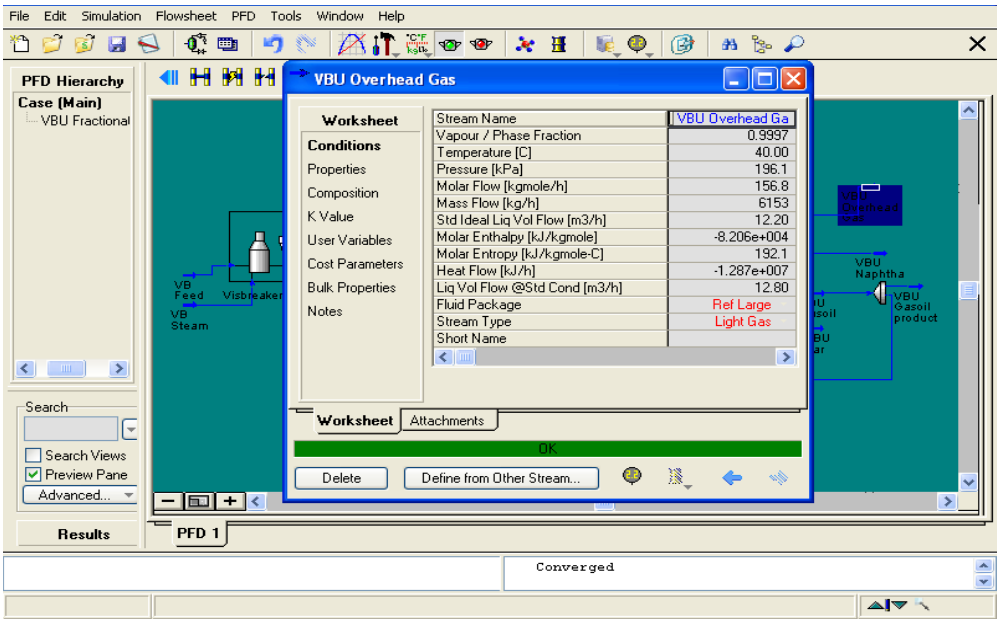

Figure (2): Gas characteristics obtained from the distillation tower PFD1

Figure (2) clearly shows the gas characteristics obtained from the top of the distillation tower in the first PFD. As can be seen, the Phase Fraction value is 0.9997, the gas temperature exiting the condenser is 40 ° C, and the pressure is 1.196, and the Mass Flow of this flow is 6153 kg / h.

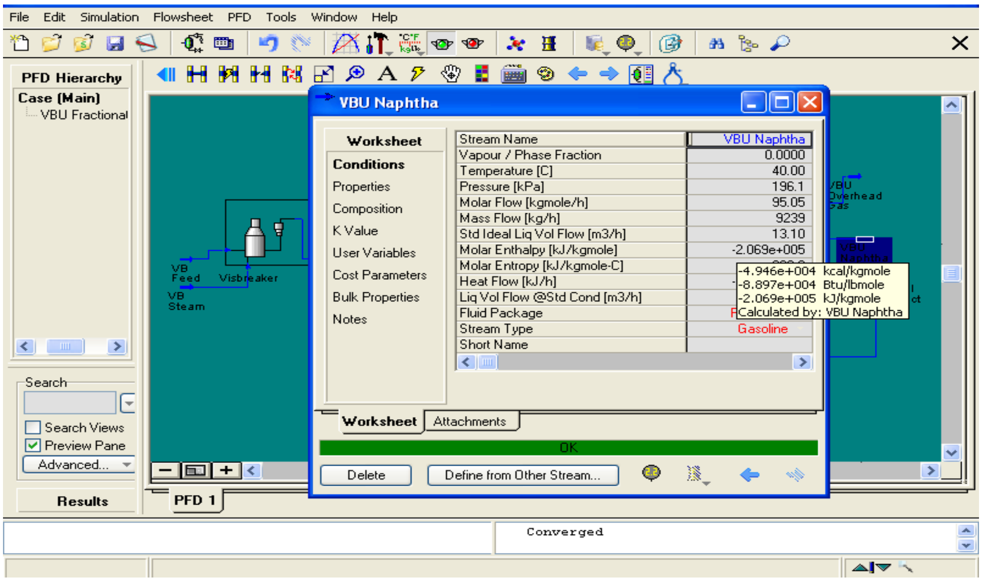

Figure (3): Characteristics of the naphtha stream obtained from PFD1

Figure (3) shows the characteristics of the naphtha stream obtained from the tower in PFD1. This stream is in liquid form and exits the condenser at a temperature of 40°C and a pressure of 1.196 kPa. This stream contains heavier hydrocarbons and exits the tower downstream of the gas stream, and the mass flow rate of this outlet stream is 9239 kg/h.

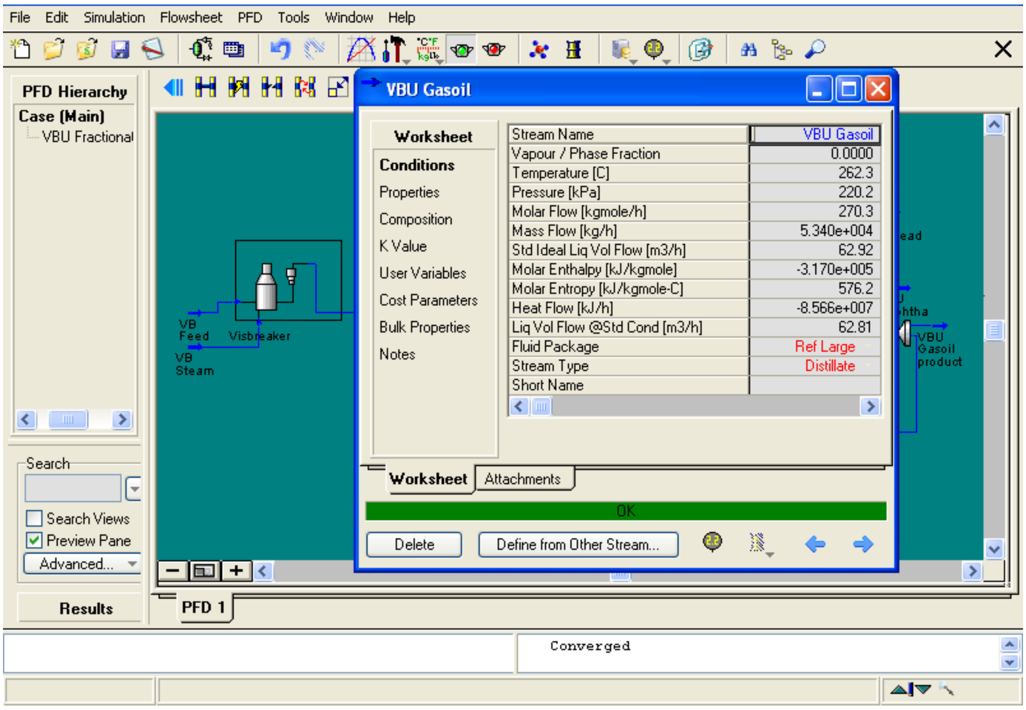

Figure (4): Gasoil stream characteristics from PFD1 tower

Figure (4) shows the gasoil stream characteristics from the outlet of the tower in the first PFD. This stream is liquid and exits from the approximately middle part of the tower at a temperature of 262.3°C as a liquid under a pressure of 191.6 kPa, which is higher than the products at the top of the tower. Having a high temperature is necessary to reduce the viscosity so that the stream does not lose its fluidity and can exit the distillation tower. This stream contains heavier hydrocarbons and exits the tower lower than the exhaust gas and naphtha streams. The mass flow rate of this stream is 53,400 kg/h. This stream contains hydrocarbons that can affect the inlet feed and cause the inlet stream to be further cooled.

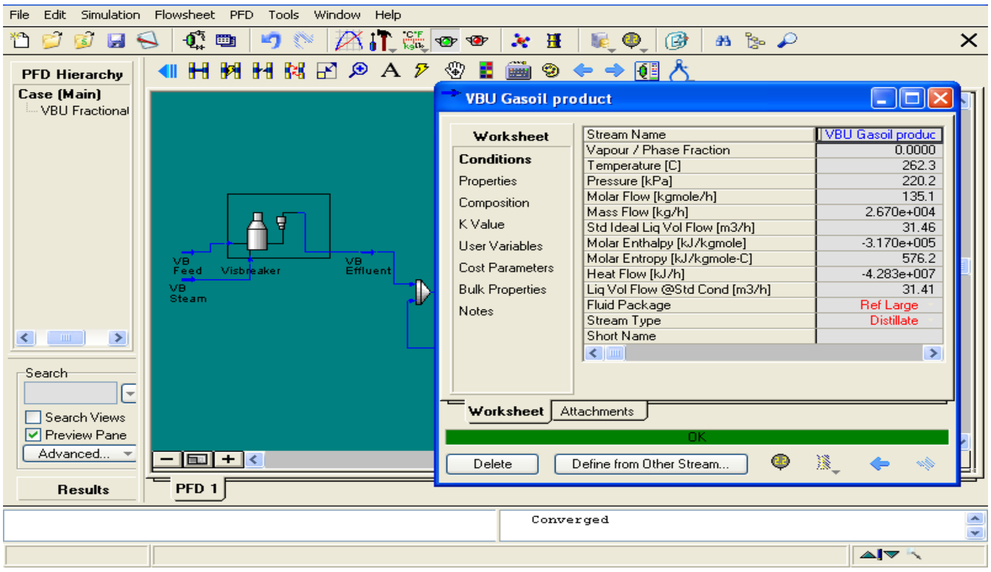

Figure (5): Gasoil flow out of flow divider PFD1

Figure (5) shows the gasoil flow out of the flow divider in the first PFD. The flow out of the distillation tower is called VBU Gasoil, which is used both as the product of this unit and as a coolant for the flow entering the tower. This flow passes through a flow divider to be used in both product and quench modes. The flow divider is a device that takes the input flow and divides it based on the information given to it in terms of Mass Flow or Molar Flow. In order to maintain equality between the two flows, an almost ideal case was considered for this simulation and the input flow rate was divided equally and the flow division ratio was set to 0.5 for both the return and products. In Figure (5), as can be seen, the Mass Flow is halved and the output product is the same as the VBU Product Gasoil. The flow divider only halves the flow rate and does not interfere with the change in state, temperature or pressure of the flow. The second flow, which is the return flow, has similar characteristics to the flow exiting the divider as the final product. The use of gasoil as a return flow is due to the low temperature of this product, as well as its viscosity and the presence of most hydrocarbons in it.

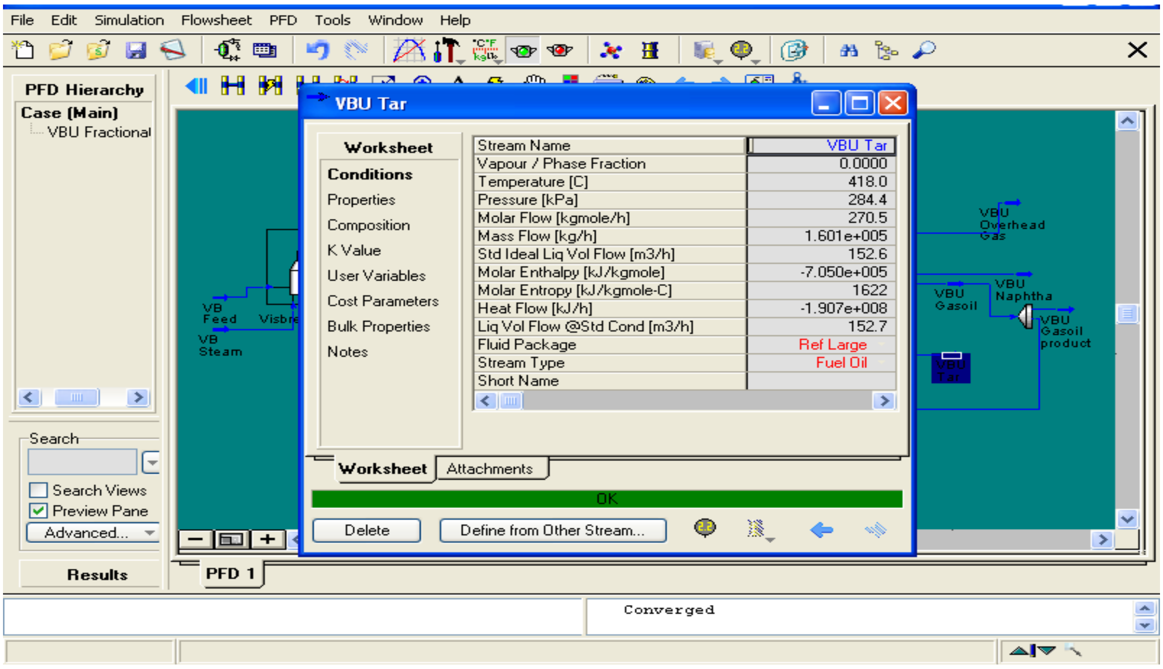

Figure (6): Tar stream exiting from the bottom of the tower as the bottom of the PFD1 tower

Figure (6) shows the Tar stream exiting from the bottom of the tower as the bottom of the tower in the first PFD. This stream is in liquid form and exits the lower part of the tower at a temperature of 418 ° C as a liquid under a pressure of 284.4 kPa. This stream has a completely higher temperature than the products at the top of the tower and in order to reduce the viscosity it must be at a higher temperature so that it does not lose its ability to be liquid and can exit the distillation tower. This stream contains very heavy hydrocarbons and exits the tower lower than the exhaust gas stream and naphtha and diesel. The mass flow rate of this outlet stream is 16010 kg/h. Tar is formed as the bottom of the tower in this unit as a result of the thermal cracking process. In this way, as a result of the thermal breakdown process, the vacuum tower residue is converted into a low-viscosity tar product, which contributes greatly to reducing the consumption of middle distillation materials for adjusting the viscosity of the final refinery furnace oil product.

Table 1-2-3 shows the Work BOOKs related to the flows of the first, second, and third parts of the first PFD. Information related to all flows related to the simulation is available in these tables. In these tables, the initial information, results, flow input and output to a device, and all the information necessary for re-simulation are summarized. As can be seen in Table (1), the specifications of the software manufacturer HYPROTECH and the country of the software manufacturer Canada are given at the top of the page. The name of the simulated unit Visbreaker is also written in SI units. In the lower part of the table, the input and output flows are given along with temperature and pressure information and mass and molar flow rates.

Table (2) shows the moving flows in a sequence. These flows are in a circular manner. The Unit Ops section contains the names of the operating units. These units include input flows and output flows. Table (3) contains a summary of the operating units in which the flows are sequential. This table shows the input and output flows from the operating unit in summary form.

Table (1): Work BOOK related to flows, part two, first PFD

HYPROTECH LIFECYCLE INNOVATION — LOST, Calgary, Alberta, CANADA	Case Name: Visbreaker
	Unit Set: SI
	Date/Time: Tue May 18 01:58:41 2010

Workbook: Case (Main) (continued)

Streams (continued)

Name		Gasoil Quench	Gasoil Quench Recy	Quenched Effluent	VB Steam	Q-VBUF
Vapour Fraction		0.0000	0.0000	0.7555	1.0000	---
Temperature	(C)	262.3	262.3 *	426.0	460.0	---
Pressure	(kPa)	220.2	220.2 *	220.2	686.5	---
Molar Flow	(kgmole/h)	135.1	135.1	837.2	50.49	---
Mass Flow	(kg/h)	2.669e+004	2.669e+004 *	2.297e+005	909.5	---
Std Ideal Liq Vol Flow	(m3/h)	31.45	31.45	241.6	0.9114	---
Heat Flow	(kJ/h)	-4.283e+007	-4.283e+007	-2.567e+008	-1.139e+007	---
Molar Enthalpy	(kJ/kgmole)	-3.170e+005	-3.170e+005	-3.067e+005	-2.257e+005	---

Unit Ops

Operation Name	Operation Type	Feeds	Products	Ignored	Calc. Level
VBU Fractionator	Column Sub-Flowsheet	VBUF Steam	VBU Overhead Gas	No	2500 *
		VBU Gasoil Steam	VBU Tar		
		Quenched Effluent	VBU Naphtha		
			VBU Decant Water		
			VBU Gasoil		
			Q-VBUF		
Tee	Tee	VBU Gasoil	VBU Gasoil product	No	500.0 *
			Gasoil Quench		
Recycle	Recycle	Gasoil Quench	Gasoil Quench Recycle	No	500.0 *
Visbreaker	Visbreaker	VB Feed	VB Effluent	No	500.0 *

Advanced Technologies, plc. 33 HYSYS Refinery4.0 (Build 552) P

Licensed to: LOST * Specified by user.

In Figure (6), the flow characteristics of the products exiting the distillation tower are shown in the form of a diagram. Here, the important point is what the output flow intensity was in the form of Mass Flow in the products.

Table (2): Amount of product production from the top of the tower to the bottom of the tower in terms of Mass Flow

Gas	6153 kg/hr
Naphta	9239 kg/hr
Gasoil	53400 kg/hr
Tar	16010 kg/hr

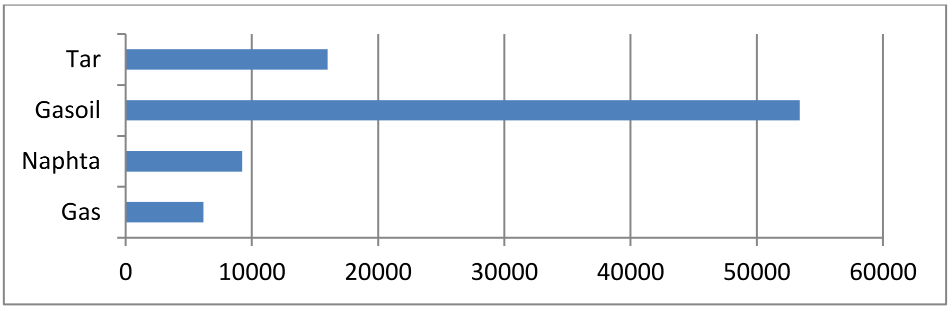

Figure (7): Product production diagram from the top of the tower to the bottom of the tower in terms of Mass Flow

It is clearly seen in Figure (7) that the gas produced in this unit is in the lowest category compared to other products, the reason is that the hydrocarbons in the feed of this unit are very heavy and it requires a lot of money to convert these hydrocarbons into a gaseous state. Also, according to the diagram, it can be seen that the amount of diesel produced is much higher than the other products, and this diesel can be used as a return flow to cool the feed flow entering the tower. The amount of naphtha or low-quality gasoline is higher than the produced gas and lower than diesel and tar, and the bottom product of the tower is also in the form of tar, which is in the lower category compared to diesel. This result is important in this regard because in the simulated unit, a product with a high output flow intensity (diesel) was produced compared to the bottom of the tower.

The results reported by the Hysys software from the simulation, with the cooler in the path

The results of the simulation, and the amounts of products obtained from the distillation tower can be seen in the figures below. In the second PFD, a cooler is used to simulate the viscosity reduction unit in the diesel return path to further cool the main feed stream.

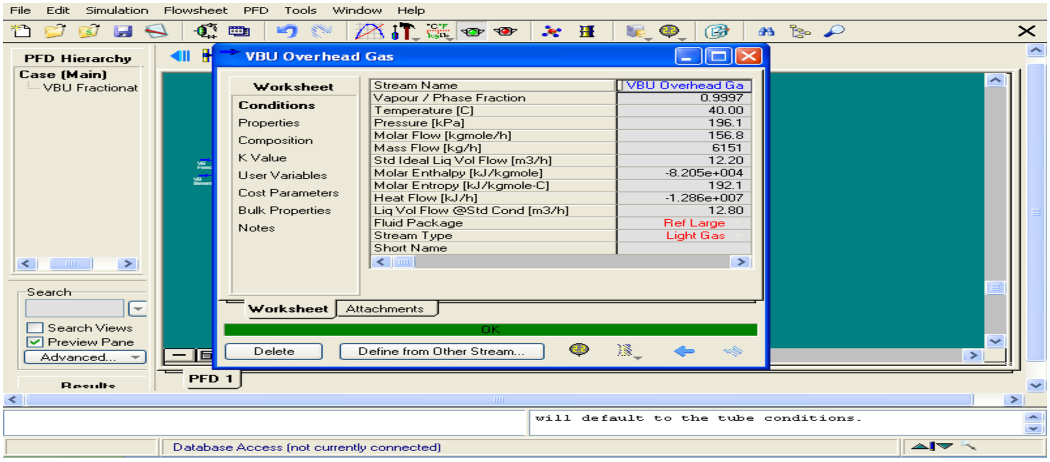

Figure (8): Gas characteristics obtained from the distillation tower PFD2 with cooler

Figure (8) clearly shows the gas characteristics obtained from the top of the distillation tower in the second PFD. As can be seen, the Phase Fraction value is 0.9997, the gas temperature exiting the condenser is 40 ° C, and the pressure is 1.196, and the mass flow rate of this stream is 6150 kg / h.

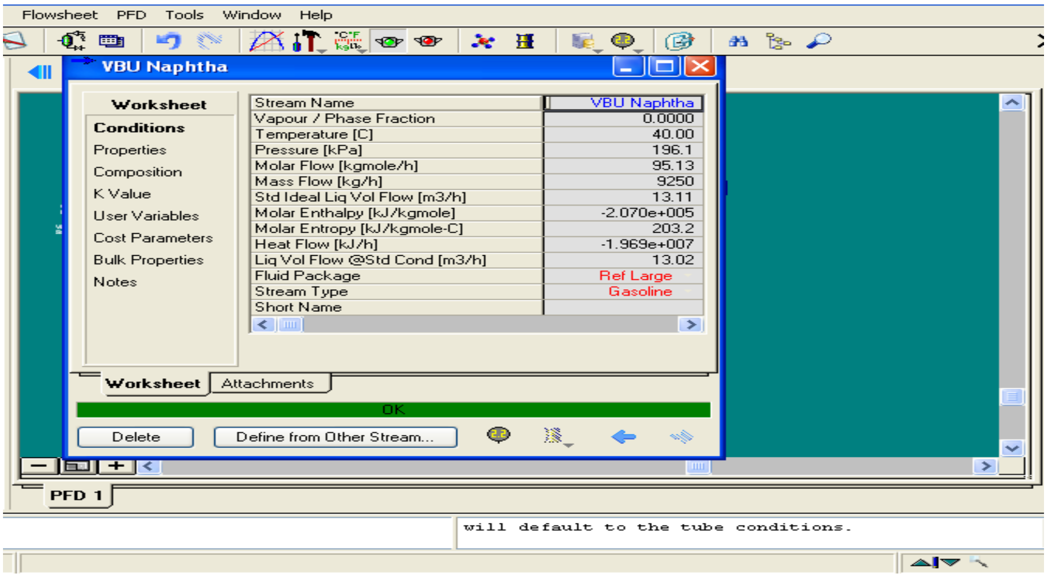

Figure (9): Characteristics of the naphtha stream obtained from the PFD2 tower with cooler

Figure (9) shows the characteristics of the naphtha or low-grade gasoline stream obtained from the tower in the second PFD. This stream is in liquid form and exits the condenser at a temperature of 40 ° C and a pressure of 1.196 kPa. This stream contains heavier hydrocarbons and exits the tower lower than the gas stream, and the mass flow rate of this outlet stream is 9250 kg/h.

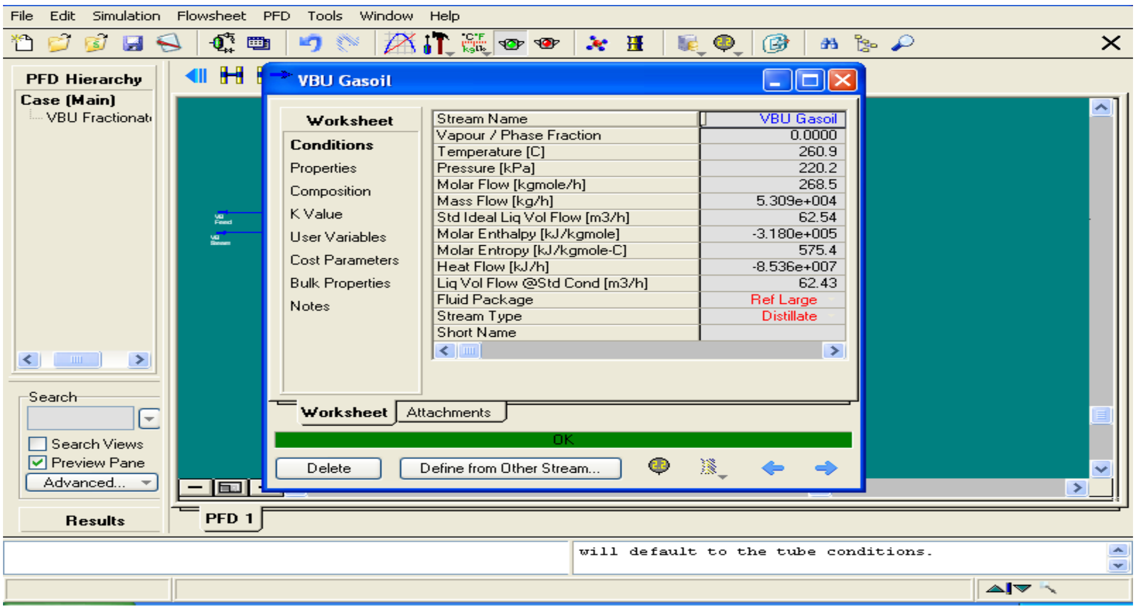

Figure (10): Characteristics of the diesel stream obtained from the PFD2 tower with cooler

Figure (10) shows the characteristics of the diesel stream obtained from the outlet of the tower in the second PFD. This stream is a liquid and exits the tower at a temperature of 260.9°C from the middle of the tower as a liquid under a pressure of 220.2 kPa. This stream has a higher temperature than the products at the top of the tower. The high temperature is necessary to reduce the viscosity so that the stream does not lose its fluidity and can exit the distillation tower. This stream contains heavier hydrocarbons and exits the tower lower than the exhaust gas and naphtha streams. The mass flow rate of this stream is 53,090 kg/h. This stream contains hydrocarbons that can affect the inlet feed and cause the inlet stream to be cooler than the inlet stream entering the tower.

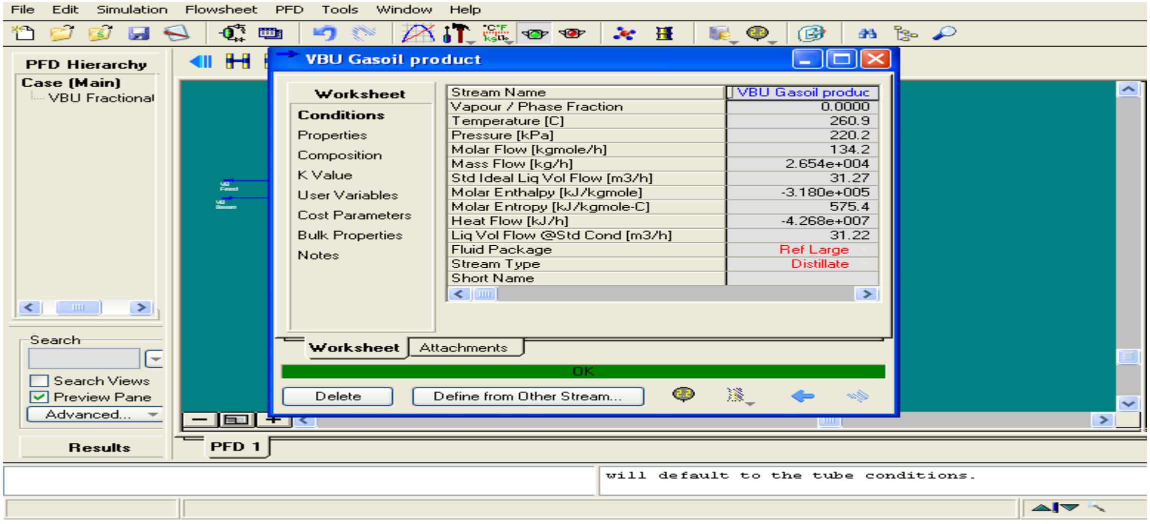

Figure (11): Gasoil flow characteristics obtained from the flow divider PFD2 with cooler

Figure (11) also shows the gasoil flow exiting the flow divider in the second PFD. The flow exiting the distillation tower is called VBU Gasoil, which is used both as the product of this unit and as a coolant for the flow entering the tower. This flow passes through a flow divider to be used in both the product and quench modes. The flow divider is a device that takes the input flow and divides the flow based on the information given to it in terms of Mass Flow or Molar Flow. In order to maintain equality between the two flows, an almost ideal case was considered for this simulation and the input flow intensity was divided equally and the flow division ratio was set to 0.5 for both the return and products. In Figure (4-10), as can be seen, the Mass Flow is halved and this output product is the same as the VBU Product Gasoil stream. The flow divider only halves the flow rate and the flow rate is 26,540 kg/h and does not interfere with the change in state, temperature or pressure of the flow. The second flow, which is a return flow, has similar characteristics to the flow exiting the divider as the final product. The use of gasoil as a return flow is also due to the low temperature of this product and its viscosity and the presence of most hydrocarbons in it. This flow is comparable to the flow exiting PFD 1. These flows also have a large difference in outlet temperatures. A comparison of the flows can also be discussed at the end of the chapter.

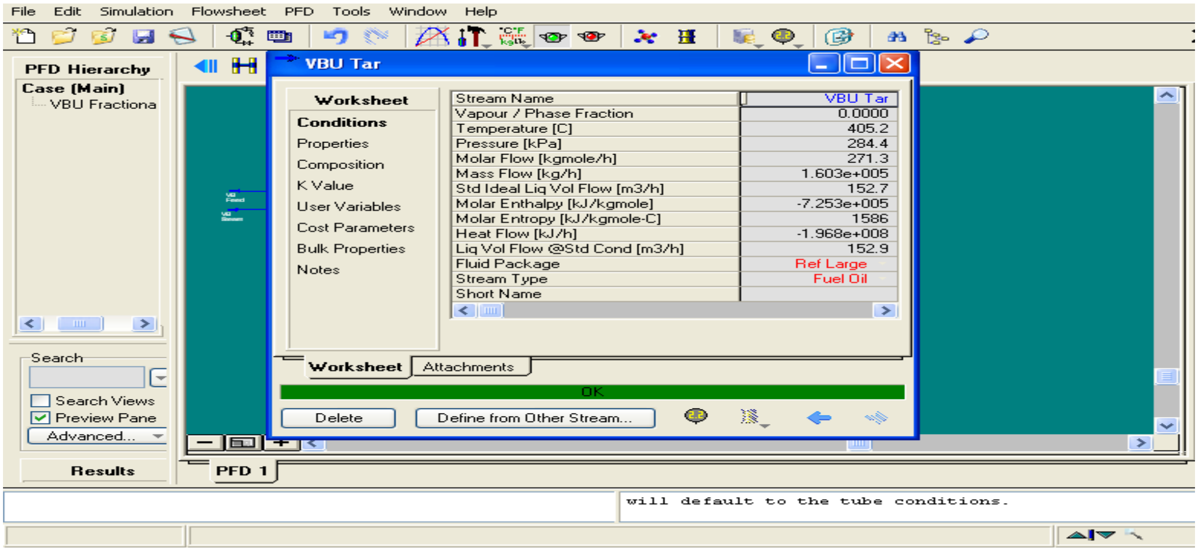

Figure (12): Tar stream characteristics obtained from the PFD2 tower with cooler

Figure (12) shows the Tar stream exiting the bottom of the tower as the bottom of the tower in the second PFD. This stream is in liquid form and exits the lower part of the tower at a temperature of 405.2 ° C under a pressure of 284.4 kPa. The liquidity of the stream is seen from the mole fraction, the number 0 indicates that the liquid stream exiting the tower is Tar, which has a higher temperature than the products at the top of the tower and must be at a higher temperature to reduce viscosity so that it does not lose its liquidity and can exit the distillation tower. This stream contains very heavy hydrocarbons and exits the tower lower than the exhaust gas stream, naphtha and diesel. The mass flow rate of this outlet stream is 16030 kg/h. Tar is produced as tower bottoms in this unit as a result of the thermal cracking process. In this way, as a result of the thermal cracking process, the vacuum tower bottoms are converted into a tar product with low viscosity, which contributes greatly to reducing the consumption of middle distillation materials for adjusting the viscosity of the final refinery furnace oil product.

Results

At the beginning of the simulation with the specialized software Hysis Refinery, library studies and the use of existing scientific articles and texts were carried out to obtain comprehensive information on oil viscosity reduction in a theoretical and comprehensive manner, and initial information was obtained. Then, the schematic of the oil viscosity reduction unit (PFD) in refineries, which was only available in a simple schematic, was drawn. In this schematic, only the main and key equipment in the process was shown. From the simple schematic, the input and output information of all equipment in the PFD was obtained and simulated with the help of Hysis software using the desired PFD. Based on the information obtained, the factors affecting the process were investigated and the results obtained from the simulation were examined and analyzed.

In general, it can be clearly seen that temperature is the most important factor in the formation of products and output flow rate. The most important issue in process principles is economic efficiency, and without considering economic efficiency, one cannot comment on the addition or removal of equipment. Adding a cooler in the process path increases the amount of naphtha or low-grade gasoline, but in return, the price of the cooler added in the process path must be economically efficient compared to the production of the product. In general, the results showed that reducing the input feed temperature increases the production of naphtha or low-grade gasoline, which has a higher value than other products.

Suggestions

1. The initial suggestion that can be given is to examine the results by adding or reducing equipment.

2. Investigating the economic justification of adding a cooler.

3. Pressure and temperature changes based on laboratory design based on the range of variables using the Mini Tab program and the RSM method and analyzing regression diagrams and standard deviation and data loading accuracy.

Reference

1. Abolhamad, G. 2014. Fundamentals of Oil Refining Book. Tehran University Press.
2. Bilal, S., Mohammed Dabo, I.A., Mujahid A.U., Kasim, S.A., Nuhu, M., Mohammed, A., Abubakar, H.M., Yahaya, U.B., Habib, A., Abubakar, B., Aminu, Y.Z. 2013. Simulation of Hydrodesulphurization (HDS) Unit of Kaduna Refining and Petrochemical Company Limited. Chemiicall and Prrocess Engiineerriing Researrch.13.
3. Halimifard, G. 2012. Investigation of metal mesh reduction to prevent the emission of polluting gases into the atmosphere in Masjed Soliman gas refinery using Hysys software. Shahrood Azad University.
4. Khalaji, Sh. 2006. Step-by-step training of HySys engineering software, introductory and intermediate levels. Dibagaran Publications, Tehran.
5. Niknejad, A., Nourinia, V. 2012. Internship report in LPG and pelletizer units of Tabriz branch. Tabriz Oil Refinery Education.
6. Nourinia, V., Shafiei, H. (2013) 2013. Simulation of acetaldehyde process with dehydrogenation of ethanol. Second Oil, Gas, Petrochemical Conference. Gachsaran Azad University.
7. Razifar, M. 2000. Comprehensive training book on chemical process simulation with HySys software. Pars New Technical Complex.
8. Sheikhi, A., Sotoudeh Gharebagh, R., Labaf, M.H., Abbasi, M. (2010) 2009. Simulation of air separation membrane unit using industrial simulators. Journal of Chemical and Petroleum Engineering. 43 (2), 23-33.