**Palacký University Olomouc**

**Faculty of Science**

Department of Geology


# Design of oil and gas separation train by Aspen HYSYS in the Kurdistan Region of Iraq

**Bachelor thesis**


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**Petroleum Engineering (B0724A330002)**

**Fulltime study**

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**Advisors: Dr. Rebar Mahmmud**


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**Abstrakt:**

Aspen AspenTech HYSYS (nebo jen HYSYS) je simulátor procesního a chemického inženýrství a používá se k matematické simulaci chemických procesů začínající od jednotlivých operací až po design komplikované chemické a petrochemické výroby. HYSYS dokáže zpracovat širokou škálu výpočtů chemického inženýrství, včetně hmotnostní bilance, energetické bilance, rovnováhy pára-kapalina, přenosu tepla, přenosu hmoty, chemické kinetiky, frakcionace a poklesu tlaku. V průmyslu a akademii je Aspen HYSYS široce používán pro ustálené a dynamické simulace, návrh procesů, modelování výkonu a optimalizaci. Tato bakalářská práce simuluje použití ropy obsahující vysoké množství síry obsažené ropě, která se dobývá z ropných polí v Severním Iráku. Výsledkem simulace je návrh optimálních operačních podmínek k oddělení ropy, plynu a vody kde výsledný produkt je surová ropa, která splňuje požadavky pro transport ropy ropovodem do rafinérií nebo do určeného místa k dalšímu prodeji. Dalším objektem testu je čištění a utilizace kyselého přírodního plynu, který vzniká při separaci surové ropy.

**Abstract:**

Aspen AspenTech's HYSYS (or just HYSYS) is a chemical process simulator used to mathematically simulate chemical processes ranging from single operations to whole chemical plants and refineries. HYSYS can handle a wide range of chemical engineering calculations, including mass balance, energy balance, vapor-liquid equilibrium, heat transfer, mass transfer, chemical kinetics, fractionation, and pressure drop. In industry and academics, HYSYS is widely used for steady-state and dynamic simulation, process design, performance modeling, and optimization. This bachelor thesis simulates the utilization of sulfur-rich oil extracted from Northern Iraqi oil fields. The simulation aims to establish optimal operational conditions for separating oil, gas, and water, ultimately producing crude oil that complies with transportation requirements via pipeline to refineries or designated locations for subsequent sale. Additionally, the study addresses the purification and utilization of acidic natural gas generated during the crude oil separation process.

**Keywords:** Oil and gas separation, Aspen HYSYS, Simulation, Kurdistan Region

**Number of pages: 36**

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I declare that I have prepared the bachelor's thesis myself and that I have stated all the used information resources in the thesis.

In Olomouc, January 2, 2024 ……………………………………………

**Chabuk Faris Noaman**

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I gratefully thank Dr. Rebar Mahmmud for providing opportunities and facilities to accomplish this research, and I would also like to extend my heartfelt appreciation to my friends who have been there for me throughout my studies. Your understanding, support, and willingness to lend a helping hand during challenging times have been truly invaluable. Your presence has brought joy and companionship, making my journey even more enriching and meaningful.

## List of Content:

# 1. Introduction

## 1.1 Study area oil field

Kurdistan is an independent area in northern Iraq wealthy in natural resources, particularly crude oil. There are various oil fields in the Republic of Iraq, some of which are in the Kurdistan Region. There are 13 petroleum fields in the region, one of which is the Khurmala oil field. It is located southwest of Erbil City and is home to 64 crude oil wells. The oil industry is a significant contribution to the Iraqi Kurdish economy.

All ways of life and ecosystems are negatively impacted by crude oil production operations and phases in Khurmala, including discoveries, loading/unloading stations, and storage facilities (Wang et al, 2019). These processes' environmental impact cannot be underestimated or ignored. The most concerning consequence is soil contamination, which can affect soil engineering qualities and have a severe influence on civil engineering infrastructure protection (Shah et al, 2003). The release of crude oil from gas, liquid, or solid components; compounds; or mixes may result in changes in the physical or chemical composition of the soil (Urum et al, 2005). The most harmful cause of soil contamination is crude petroleum. If the soil has been polluted with crude oil, it is no longer suitable for engineering applications due to the influence of crude oil on shear strength characteristics, leading to a lack of bearings, excessive settlement, and significant cracking of existing foundations and structures (Rahman et al, 2010).

However, it should be mentioned that the bulk of soil contamination happened in the past, even though it persists now via routine industrial and agricultural activities (Meegoda et al, 1998). Furthermore, agricultural operations, seeping from aboveground or subsurface storage tanks, and inadvertent discharges can all result in soil pollutant outcrops (Estabragh et al, 2014). Several researchers investigated the geotechnical properties of oil-contaminated soils, including (Akinwumi et al, 2014), (and Wang et al,2013). Soil permeability has also greatly lowered. Furthermore, saturated quartz sand with motor oil can result in a significant reduction in soil friction angles and a dramatic rise in soil volumetric strain (Evgin et al, 1992). Furthermore (Alfach et al, 2020). showed that crude oil contamination of soil had a negative influence on the pile's base in terms of geotechnical behavior deterioration. Furthermore (Khosravi et al, 2013). evaluated the influence of gas oil contamination on the geotechnical parameters of fine and coarse-grained soil; a decrease in the MDD and optimal humidity levels was also seen with an increase in Atterberg's clay and silt limits. In recent years, many technologies have been used to rehabilitate crude oil-polluted soil. Petroleum contamination soils can produce solubility and remove crude oil soil components, according to the solvent/surfactant soil-washing procedure (Wang et al, 2019). Although biosurfactant solutions have a significant capacity to extract crude oil from polluted soil through washing conditions, the results revealed that the washing-temperature efficiency of crude oil removal from contaminated soil was the most significant factor, with washing time being the least influential (Urum et al, 2005).

In turn, bioremediation of crude oil-polluted soil was accomplished in the laboratory by isolating strains of the most efficient biodegradable material; this study demonstrates that many aromatic and saturation hydrocarbons with chemical compositions like crude oil were successfully extracted by the strain (Yan et al, 2015). Active degradation of crude oil-polluted salty soil may be done utilizing several remediation procedures such as nitrogen additions, arbuscular mycorrhiza inoculation, and Suaeda salsa cultivation (Gao et al, 2014). Other research used pyrolytic therapy to repair soil. The working temperature had a greater effect on pyrolytic effectiveness than the reaction time (Kang et al, 2020). As previously stated, almost all literature research focuses on agriculture, soil science, and climate. As a result, it is critical to assess these study findings to enhance practical soil remediation through engineering applications. Thus, oil-contaminated soils must be healed effectively using procedures that improve the soil's mechanical and geotechnical qualities (Balba et al, 1998). Furthermore, the most effective technique is solidification/stabilization, which is accomplished by incorporating cement, (Alpaslan & Yukselen, 2002) and other bonding products into a mixture used to impale the contaminants in the polluted medium and ensure long-term safety. Solidification is a procedure that encapsulates contaminated media and turns it into a homogeneous solid substance with good structural integrity to modify its physical characteristics. Stabilization is a procedure that reduces the harmful potential of contaminated soil by decreasing its solubility, mobility, or toxicity. Consequently, this technique can produce good outcomes. (Akinwumi et al, 2016) for example, and Yu et al. According to (Yu et al, 2018).

Improving crude oil soil with a variable mix of Portland cement boosted its strength while decreasing its permeability and flexibility, making the soil more acceptable after the cement treatment. Similarly, (Shah et al, 2003) observed improved soil geotechnical qualities with the use of several additives, such as cement, lime, and fly ash, to stabilize crude oil-contaminated soils.

(Wang et al, 2020). demonstrated in additional experimental work that the results of the geotechnical properties showed a significant increase in undrained shear strength, solid content (water content), and Atterberg limit values of the soil, achieved by using different curing times and various doses of cement after stabilizing the mature fine tailings. Nasr, A. M. (2014). conducted more studies on the strength behavior of sand when polluted with oil by employing cement kiln dust (CKD) to establish the stabilized soil's engineering qualities for application in rural road building. The addition of CKD enhanced the unconfined compressive strength and California bearing ratio (CBR) values of the oil-contaminated sand. The stability of contaminated sand reduces as the proportion of oil increases. As a result of the improved geotechnical qualities of construction and engineering applications, (Al-Rawas et al, 2005). concluded that oil-contaminated ground might be reused when stabilized with cement or cement by-pass dust, providing practical, safe, and cost-effective solutions. The effectiveness of employing two different types of cement to stabilize oil-contaminated soil was tested in this study.

Furthermore, the physical, mechanical, and chemical behavior of both contaminated crude oil soil and stabilized soil has been investigated to allow for their reuse as earth construction materials. This type of research has yet to be conducted in the oil fields of Iraq's Kurdistan Region.

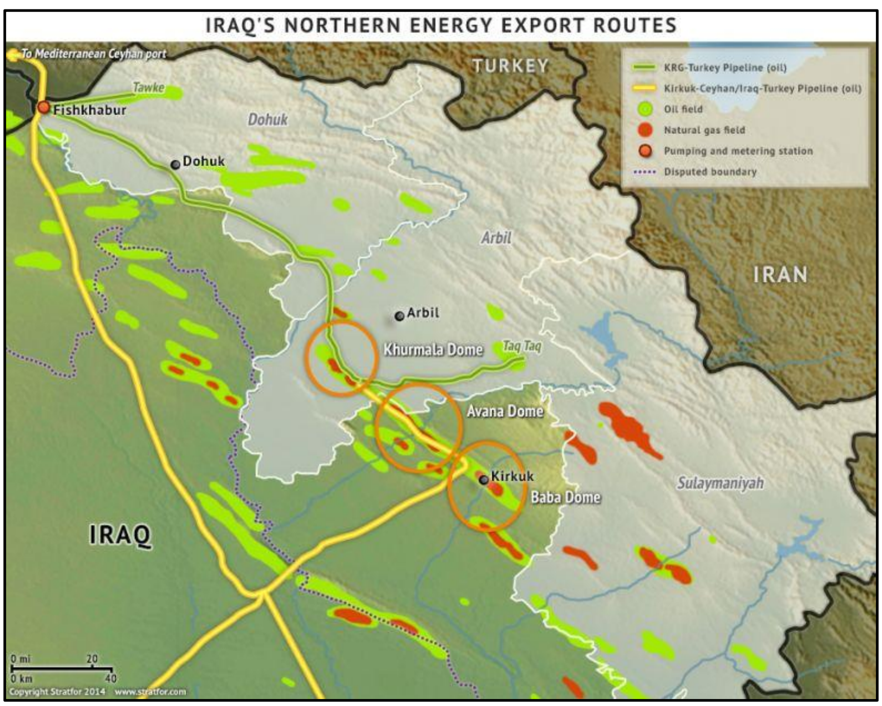



Figure 1**:** study oil feild

## 1.2 Geology of the study area

Six lithostratigraphic units of Middle Paleocene to Eocene age in the northern part of Iraq are represented by the Kurmala Formation, which is the middle part of the tectonostratigraphic Ap 10 mega sequences (Sharland et al, 2001). These units are the Kolosh, Sinjar, Kurmala, Avanah, Grecus, and Pilaspi formations.

In the Noth Iraqi high folded zone, the Khurmala Formation was observed. Locally anhidrotic, the carbonates of the Khurmala Formation interfinger alongside the clastic of the Kolosh Formation. The geographical extent of the formation is confined to a strip that runs between the Chemchemal – Qizil Dagh area in the southeast and Bashiqa – Jabal Maqlub in the northwest. The southeast portion of the Kolosh corresponds to the relict basin where the Khurmala Formation was most likely formed (Jassim and Goff, 2006).

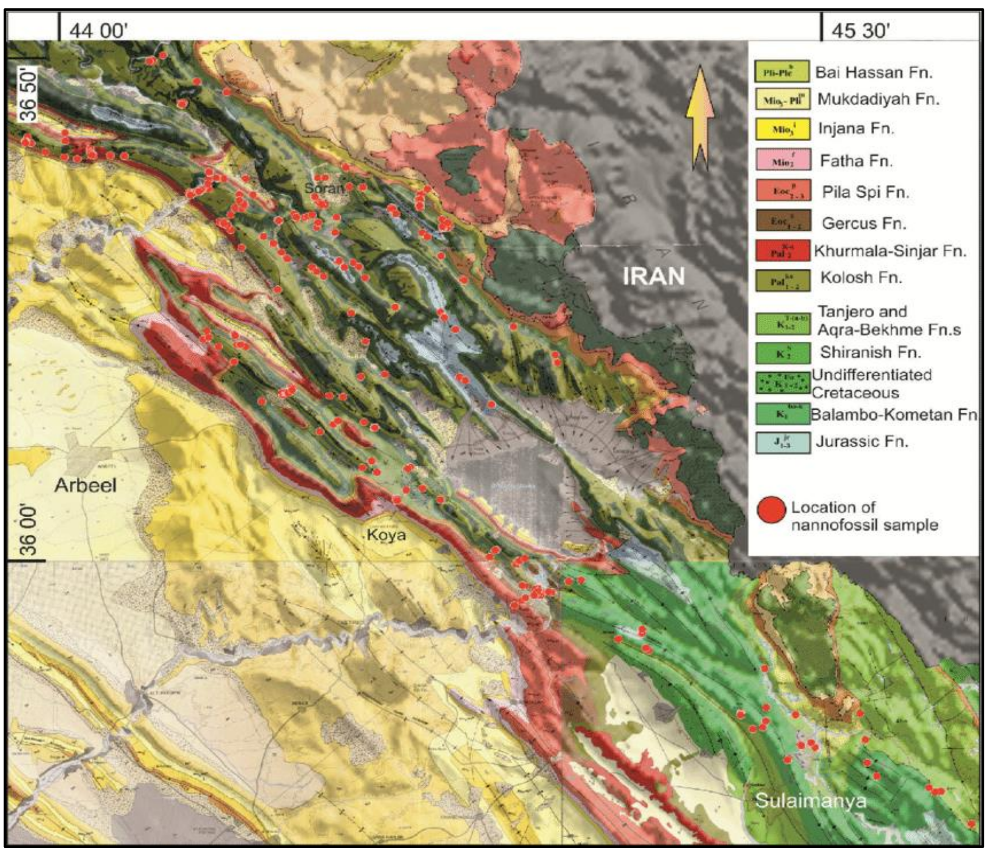



Figure 2**:** Geological map of Kurdistan Region, the study area is indicated in red color (Ahmed et al, 2015).

## 2. Project task

The task of the project is to simulate and design an oil and gas separation facility based on the Khurmala oil field case scenario. I'm using real data from existing fields to design and optimize the already existing production facility.

## 2.1 Information about the study oil field

Study area, located 35 kilometers southwest of Erbil, the capital of the Kurdistan Region of Iraq (KRI), represents the northern sector of the Kirkuk field, as shown in Figure 3 Since 2007, it has been under the administration of the Kurdistan Regional Government (KRG), with operational management entrusted to the Kurdistan-based oil services company, the KAR Group. Following a capacity expansion in 2018, the field now boasts a processing capability of 200,000 barrels per day (Zhang et al, 2019).

Presently, Khurmala stands as the primary source of fuel for the Iraqi Kurdistan region, overseen by the KAR Group (KAR Group, 2012). Specifically associated with natural gas, the field currently witnesses the flaring of this resource on-site.

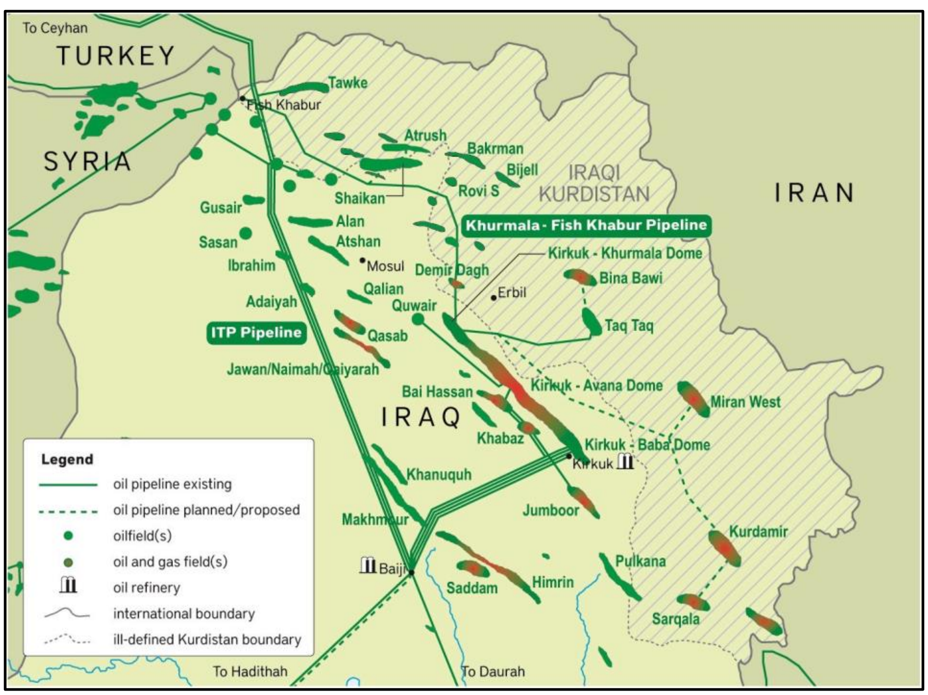



Figure 3: the oil field

## 2.2 Sample with crude oil in laboratory lab

**Sample identification**

Crude oil sample: (Ca) is 150 ml in a 750 ml glass container without further identification

**Scope of work and methodology**

**Simulated distillation (evaluation of fractional composition)**

The simulated distillation was carried out using a gas chromatograph (ThermoQuest TRACE 2000) by cryogenic furnace cooling with liquid nitrogen. To process results for simulated purposes distillation was used software Chrome-Card/SimDiChrom. ($1^{st}$) was dosed per chromatography column µl of a 15 % carbon desulphated solution of the sample. A carbon desulphated solution of a mixture of alkanes containing n alkanes from $C_3$ to approx. $C_{100}$, analyzed under the same conditions as the evaluated sample.

The density was measured by an oscillating density meter at a temperature of 15 °C by ČSN EN ISO 12185.

**Outcomes**

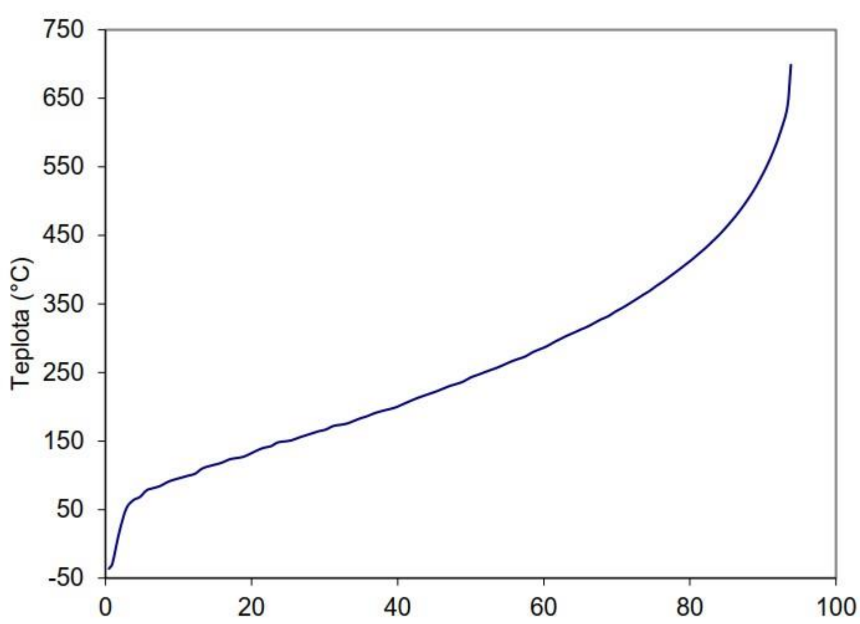



**Diagram 1**, the distilled quantity (% hm.)
Distillation curve by simulated distillation according to ASTM D2887

## 2.3 A small pipeline will be designed

For the separation process, pipelines are designed between different separation equipment to transmit the produced crude oil from one stage into another stage. First, crude oil is produced from the production tube to the high-pressure separator by the pipeline. The flow can be controlled via valves. Then, to the low-pressure separator by another pipeline, etc... So, the separation is a closed system. All equipments are interlinked with each other by pipelines. Transmission pipes that transfer natural gas over long distances are frequently subjected to high pressures (up to 10 MPa). At city gate stations, high-pressure natural gas is frequently irreversibly throttled to lower the pressure to a low level for various uses. The usable gas pipeline pressure energy is squandered throughout this operation. As a result, it would be critical to recover the high-pressure gas energy utilizing proper energy utilization technologies (He et al, 2013). The separation facility is generated by Hysys software, and the red line is the pipeline, as can be seen in the figure 4:

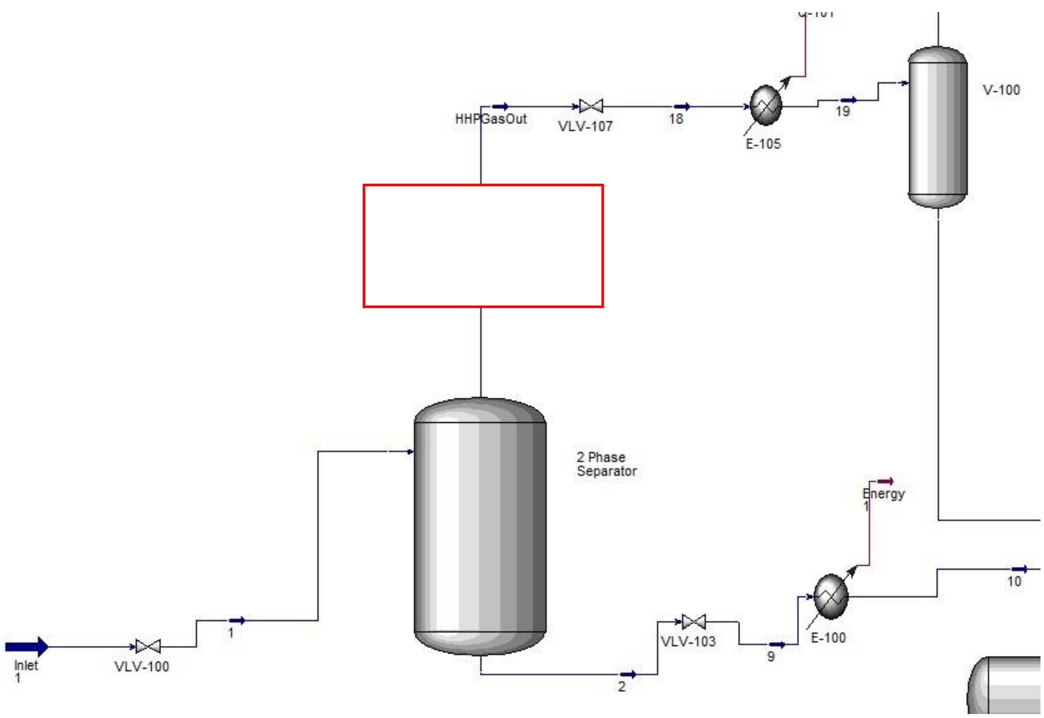



Figure 4: Pipeline

## 2.4 Gas cleaning

Gas cleaning is an essential part of the overall gasification technology, both to protect catalysts from poisoning and to meet the end specification for the syngas, which varies depending on whether it is to be used in gas turbines, chemicals manufacturing, or to produce the pure hydrogen required by low-temperature fuel cells (Rand et al, 2009). In comparison to natural gas steam reforming, Coal gasification produces syngas with (1) greater quantities of carbon monoxide, which must be converted to carbon dioxide and hydrogen; and (2) typically larger levels of contaminants, which must be removed from the gas before use. Particulates, sulfur dioxide, nitrogen oxides ($NO_x$), the alkali metals sodium and potassium, and mercury are the primary pollutants in coal-fired syngas (Rand et al, 2009). Ammonia, arsenic, beryllium, cadmium, chromium, hydrogen chloride, hydrogen fluoride, lead, and other trace elements are present at minor or negligible levels. Nickel and selenium are also possible. To protect downstream process equipment (particularly gas turbines) from fouling, erosion, and/or corrosion, to prevent poisoning of the catalyst used for the shift reaction, and to meet environmental regulations, all of these species must be removed to acceptable limits by final gas polishing. For low-temperature fuel cells, it is critical to polish the hydrogen fuel thoroughly to eliminate any remaining contaminants and carbon monoxide that might poison the platinum electrocatalyst (Rand et al, 2009).

Gas treatment in the petroleum separation process is a common method for producing elemental sulfur to burn hydrogen sulfide under controlled circumstances. Water and hydrocarbons are removed from feed gas streams using knockout pots. The gasses are then subjected to a catalyst to extract more sulfur. Sulfur vapor is condensed and collected from combustion and conversion.

The treatment of exhaust gases has a significant impact on fuel usage. Exhaust gas treatment using gasoline direct injection systems is subject to stringent requirements. Catalytic converters must also achieve their activation temperature at low exhaust gas temperatures, especially during part-load operation. Flexible multiple injection may be used to perform selective exhaust manifold heating solutions, successfully lowering hydrocarbon emissions during cold starts (Demirbas, 2005).

## 2.5 string generator

A random string generator is a piece of software that generates random strings of text or integers. These strings can be used for a variety of things, such as passwords, security codes, and serial numbers (Katapodis, 1977).

## 2.6 Heat exchanger.

A heat exchanger is a mechanism that transfers heat from one source to another. Heat exchangers are used for both cooling and heating. To prevent mixing, the fluids may be separated by a solid wall, or they may be in direct touch. They are widely employed in space heating, refrigeration, and air conditioning, as well as in power plants, chemical plants, petrochemical facilities, petroleum refineries, natural gas processing, and sewage treatment (Heckl et al, 2005). A heat exchanger is most often seen in an internal combustion engine, where a circulating fluid known as engine coolant runs through radiator coils and air flows through the coils, cooling the coolant and heating the incoming air. The heat exchanger is shown in Figure 5.

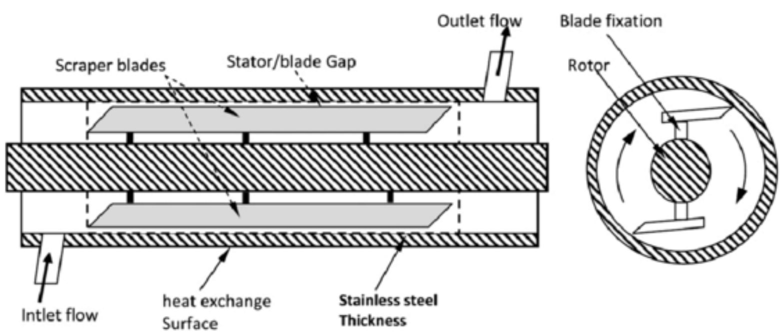



Figure 5**:** is a heat exchanger that contains an inlet flow, and the flow goes through the scarper blades to affect the flow temperature. Then, the fluid flows out through the outlet.

## 2.7 Control system

For liquids, this is accomplished through the use of a level controller and a level valve. A float on a spring is the classic level controller. As the liquid level in the separator rises, the float rises until it shuts a switch, allowing some liquid to escape. When the level returns to its usual operating level, the switch reopens and the level valve closes (Liao et al, 2008).

A two-phase separator includes a single liquid-level controller and level valve; a three-phase separator contains an oil outlet, an oil-level controller, and a level valve, as well as a water outlet, an oil-level controller, and a level valve. How is the gas regulated if the level valves control the liquid coming out of the separator? The gas is confined in a nearly constant volume because the liquid is incompressible and the liquid level in the separator remains fairly constant. The pressure rises as more gas enters the separator. A pressure controller is installed either in the separator-gas area or on the outlet-gas pipe. When the pressure exceeds the set point, the controller sends a signal to the pressure-control valve in the gas outlet pipe, directing it to open. Pressure-control valves are typically modulating, which means they progressively open wider as pressure increases to a value greater than the set point and close as pressure lowers to a value less than the set point. In other words, whatever liquid enters the separator must also depart through the level-control valve. The level controller detects high or low liquid levels and adjusts the level valve accordingly (Liao et al,2008). Whatever quantity of gas enters the separator must depart through the pressure-control valve in the same amount. The pressure controller detects pressure in the separator opens the pressure-control valve if the pressure exceeds the specified set point, and closes it if the pressure falls below the required level. If the incoming stream is cut off, all of the output valves close, keeping the pressure and level in the separator constant.

## 2.8 Risk and Safety Environment

For many years, the oil and gas sector has emphasized health and safety. Nonetheless, occupational hygiene exposures are not often taken seriously enough to establish the real danger to workers. The biggest occupational health concerns that your employees should be aware of are listed below. For many years, the oil and gas sector has emphasized health and safety. Nonetheless, occupational hygiene exposures are frequently taken with caution to evaluate the real danger to workers (Oldenburg, 2008).

Workers in the oil and gas sector who are exposed to chemicals generated and utilized in the industry may develop occupational illnesses of the lungs, skin, and other organs at varying degrees depending on the quantity and length of exposure time. Noise-induced hearing loss (NIHL) can occur in those who are exposed to dangerous noise levels. Other risks include restricted areas, which can injure or kill unskilled personnel (Oldenburg, 2008). Employers in the oil and gas sector must prepare and implement a documented exposure control plan (ECP) anytime their employees are at risk of being exposed to chemical hazards such as drilling fluids, hydrogen sulfide, silica, diesel exhaust, and mercury.

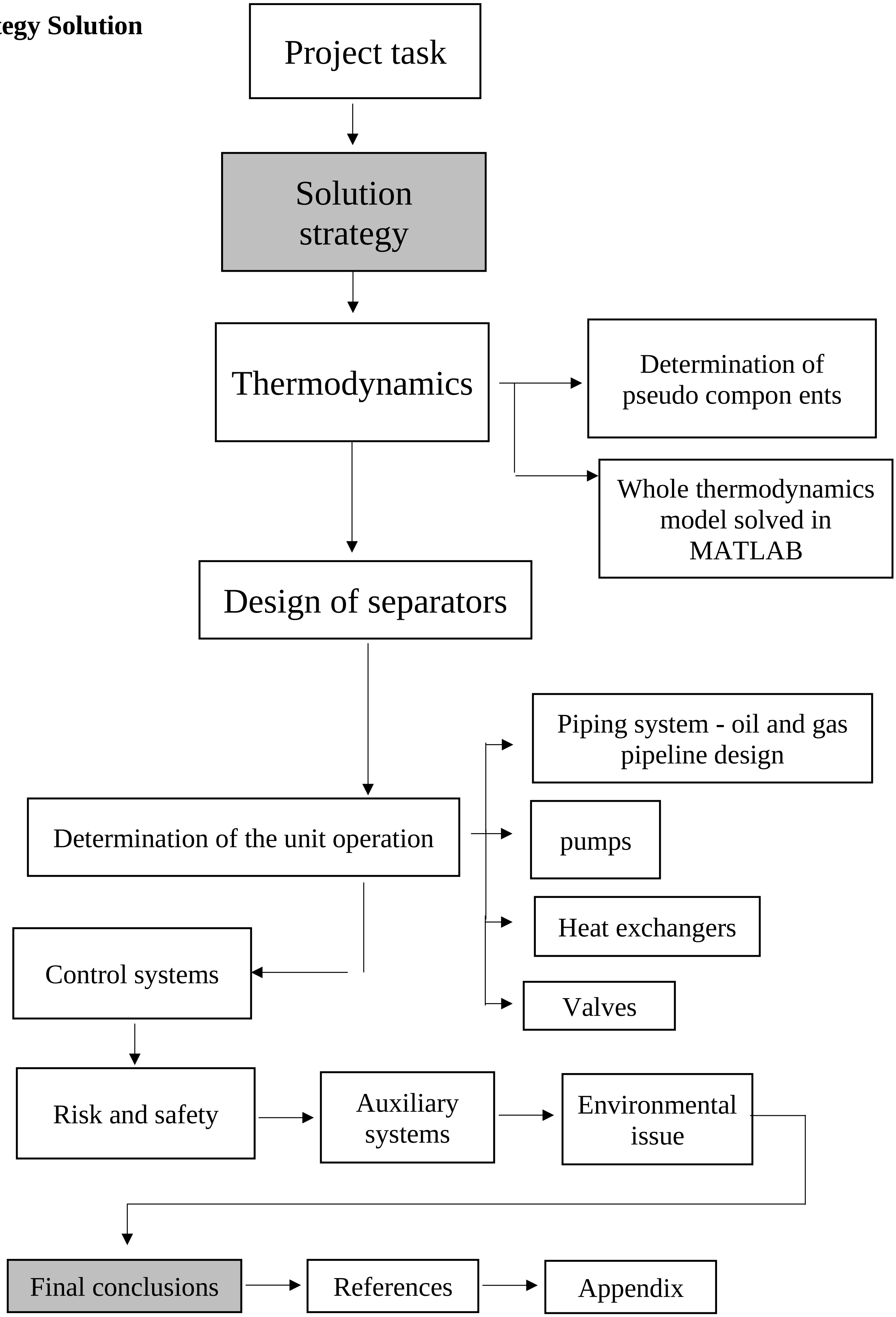
## 2.9 Valves

A valve is a mechanical or natural item that controls the flow of a fluid (gases, liquids, fluidized solids, or slurries) by opening, shutting, or partly blocking numerous channels. Valves are technically fittings, although they are normally treated separately. Fluid moves from greater pressure to lower pressure through an open valve. The name comes from the Latin valve, which means "moving part of a door," and Volver, which means "to turn, roll (Wang et al, 2004).

The most basic and ancient type of valve is a flexibly hinged flap that swings down to restrict fluid (gas or liquid) movement in one direction but is pushed up by the flow itself when the flow is traveling in the other direction. This is known as a check valve because it prevents or "checks" flow in one direction. Modern control valves can manage downstream pressure or flow and are controlled by sophisticated automation systems.

Figure 6: Control Valves for Two-Phase Separation (Fadaei et al, 2021)

## 3. Strategy Solution



# 4. Theory about design separation

Separators operate on the premise that the three components have different densities, allowing them to stratify while flowing slowly, with gas on top, water on the bottom, and oil in the center. Sand and other materials will sink to the bottom of the separator.

## 4.1 Theory about separation

The most fundamental separation in oil and gas processing is the physical separation of fluids. One of the most basic pieces of industrial equipment is an oil and gas separator. Because of the manufacturing machinery utilized. Its performance is critical to the running of a manufacturing plant due to its front-end location in on-stream processing. Oil and gas separators were among the earliest pieces of oil industry production equipment introduced. Regardless of its lifetime, the separator retains its original and critical role in the separation of liquids and gases. This article will examine some, but not all, separator design concerns in detail.

## 4.2 HYSYS simulation models

Aspen HYSYS (or simply HYSYS) is a chemical process simulator created by AspenTech that is used to mathematically simulate chemical processes ranging from single operations to whole chemical plants and refineries. Because of its capabilities in steady-state and dynamic simulation, process design, performance modeling, and optimization, HYSYS is widely utilized in industry. HYSYS is a piece of software that allows the user to create a process model and then simulate it using complicated computations (models, equations, math calculations, regressions, and so on).
And the simulation process is only sketching and modeling equipment. It is primarily concerned with the physical and chemical characteristics of how unit activities will function!

# 5. Simulation of the separation process

## 5.1 The obtained data:

The data of molar fractions of the crude oil compositions from the study area oil field are as follows:

Table 1: Excel of the separation process

| Composition | Molar Fraction |
|---|---|
| Methane | 0.01 |
| Ethane | 0.01 |
| Propane | 0.15 |
| I-butane | 0.16 |
| N-butane | 0.85 |
| I-pentane | 1.15 |
| N-pentane | 1.85 |
| N-hexane | 1.88 |
| N-heptane | 1.88 |
| N-octane | 1.90 |
| N-nonane | 1.93 |
| N-decane | 1.94 |
| N-C11 | 0.077 |
| N-C12 | 0.0822 |
| N-C13 | 0.0893 |
| N-C14 | 0.0902 |
| N-C15 | 0.101 |
| N-C16 | 0.0002 |
| N-C17 | 0.00019 |
| N-C18 | 0.00013 |
| N-C19 | 0.00009 |
| H2O | 0.5 |
| Nitrogen | 0.00217 |
| CO2 | 0.00072 |
| H2S | 0.05 |
| C20+ HDA* | 0 |
| C20+ HBA Oil* | 0 |
| C20+ HBA NE* | 0.00081 |

## 5.2 laboratory analysis and opting for the date from the simulations.

The simulated distillation was carried out using a gas chromatograph (ThermoQuest TRACE 2000) by cryogenic furnace cooling with liquid nitrogen. To process results for simulated purposes distillation was used software Chrome-Card/SimDiChrom. $1^{st}$ was dosed per chromatography column μl of a 15 % carbon desulphated solution of the sample. A carbon desulphated solution of a mixture of alkanes containing n alkanes from $C_3$ to approx. $C_{100}$, analyzed under the same conditions as the evaluated sample, and this figure 7 is the lab.
The density was measured by an oscillating density meter at a temperature of 15 °C by ČSN EN ISO 12185.


Figure 7: lab/office UCT Prague

## 5.3 The simulation:

When the data is obtained on the crud oil, it is applied to the HYSYS. In the beginning, I must create how many fields I have and the data that I got is enough for how many fields. Then I must choose Peng Robinson to continue my project as shown in Figure 8.

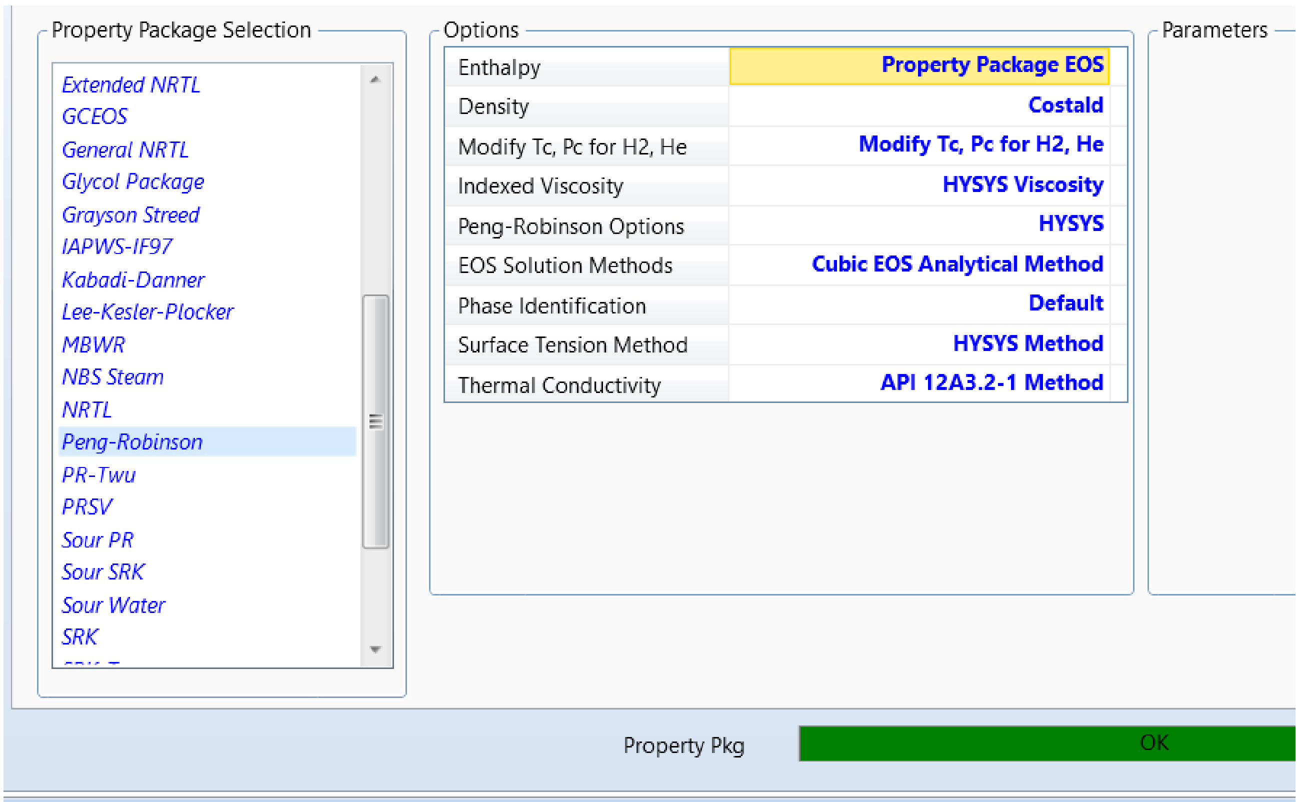



Figure 9: Peng Robinson

Then I put all the compositions that I'm going to use in it one by one. After doing the properties it gives me three options for each of the options, I must choose what I got in the data of crude oil. For bulk properties, I put density on it, and for the light ends date of composition is shown in Figure 10.

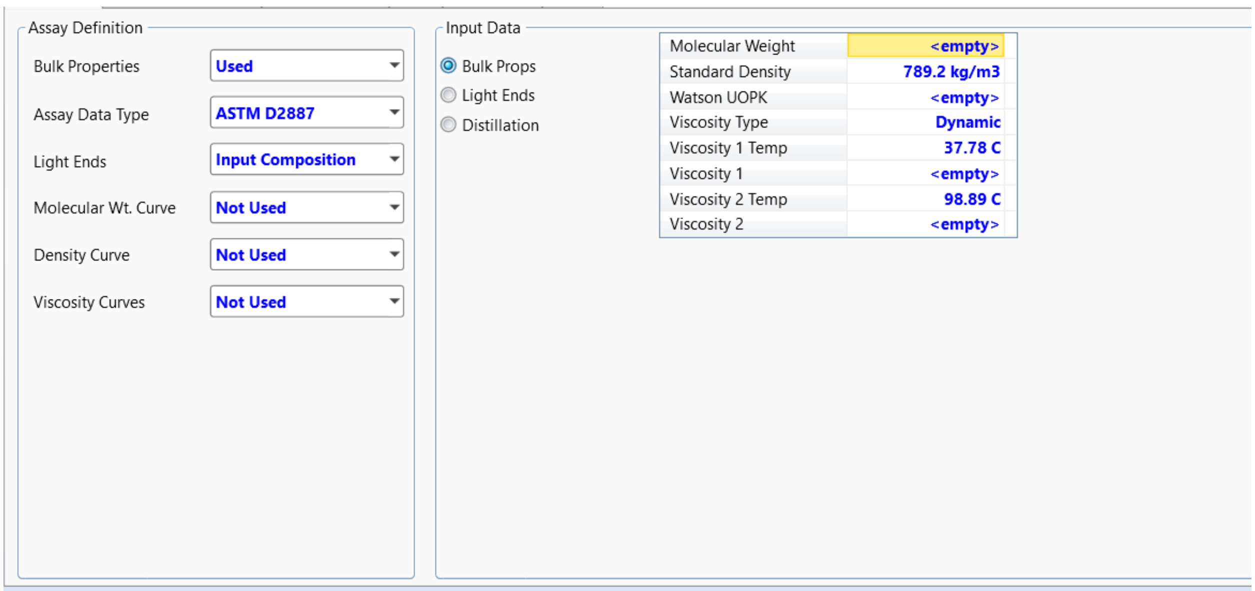



Figure 10: Bulk prop and light ends

For distillation, the temperature is out of the compositions as shown in figure 11.

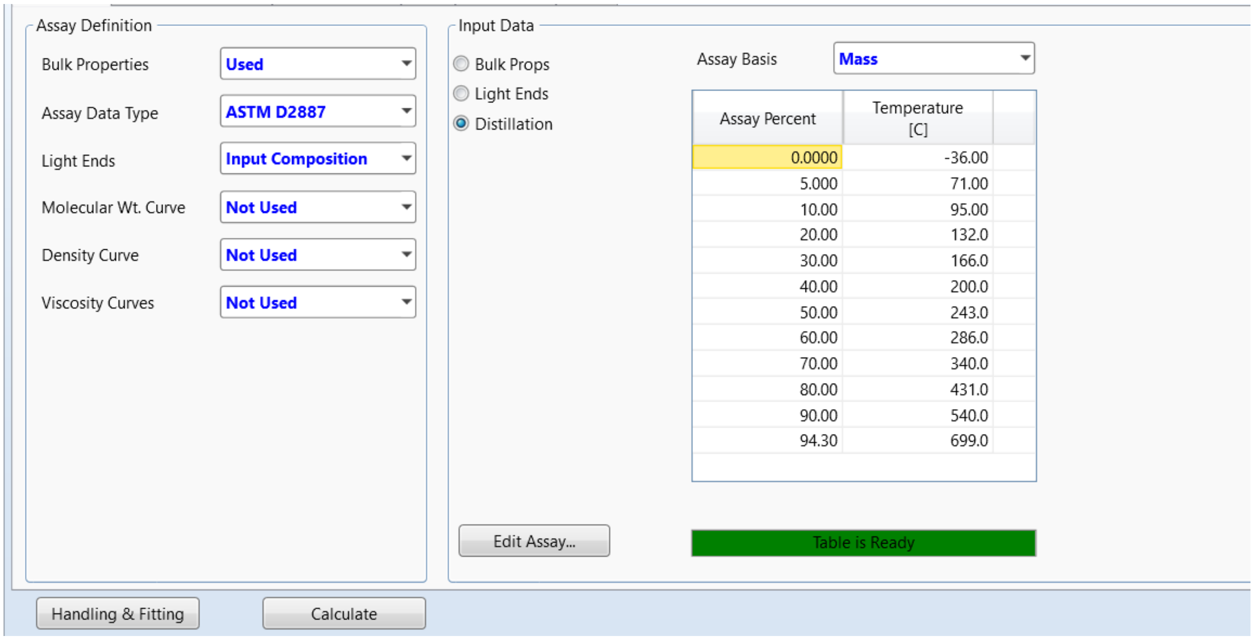



Figure 11: Distillation

The data are applied to the Hysys software. By clicking on model plates we can create two inlets as we can see in the figure 13. The first inlets include (Methane to Decane) compositions. The inlet is interlinked to the two-phase vertical separator by a short pipeline. Data of the two-phase separator are as follows: (vessel temperature = 64.51 C), (vessel pressure = 350 kPa), (liquid volume percent = 50%). The gas and oil are separated. The gas is sent to the vertical separator also by a short pipeline. A cooler is between a valve which is used to decrease the temperature and three phase separator to affect the system we also bring it to the simulation by model plates as follows: (decreased temperature = -50C), (pressure drop = 5 kPa), (DUTY = 5.520 e + 004 kj/h). Also, from the same inlet, the oil is separated by the two-phase separator and the same as the first inlet we brought in model plates. The separated oil is sent to the three-phase high-pressure separator by pipeline, the three-phase separator is controlled as follows: (vessel temperature = 40.00 C), (vessel pressure = 150 kPa), ( liquid volume percent =50%). The separated crude oil is sent to a three-phase low-pressure separator. Between both of first HP separator and the first LP separator, a heater is applied as follows: (DT = 0.2567 C), (pressure drop = 0 kPa), (DUTY = 10 kJ/h). From the LP separator, the oil is sent by the pipeline to the pipe segment.

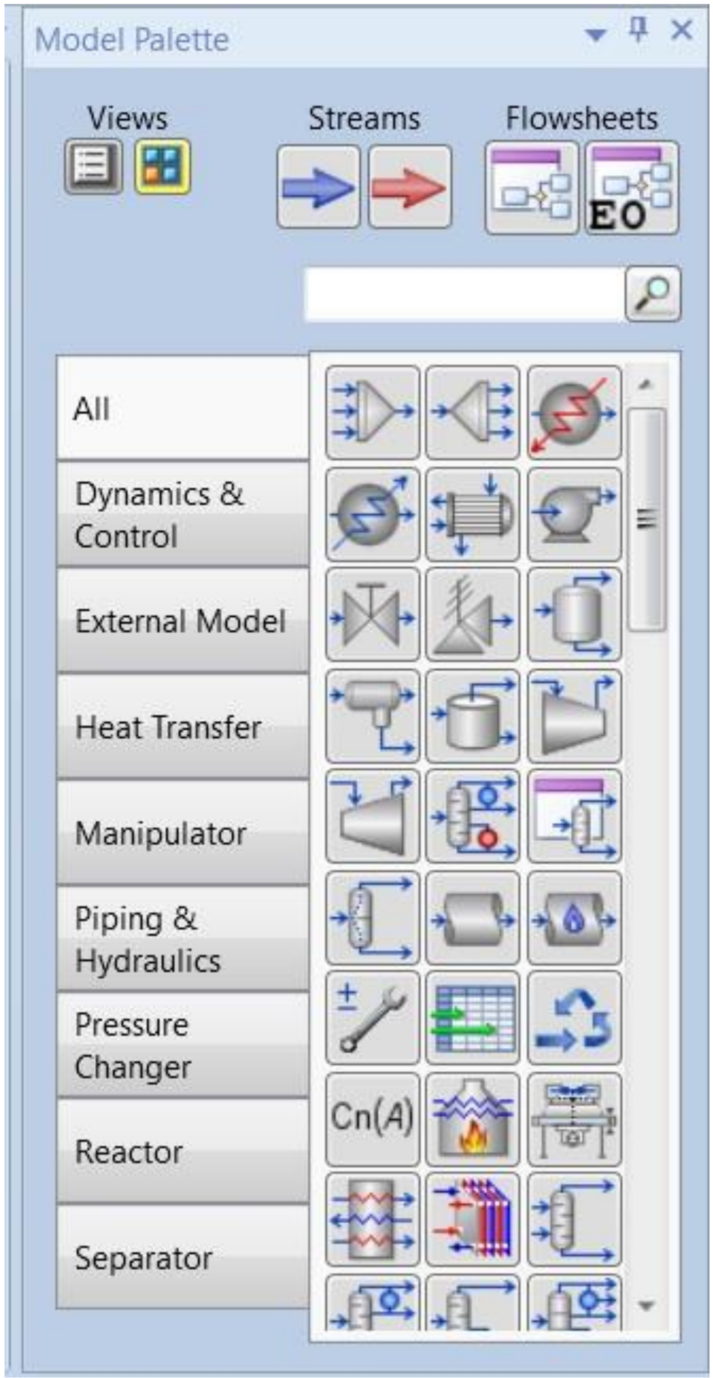



Figure 12: model plates, to apply equipment such as separator, valve, compressor... etc

The second inlet includes (methane to C20 and $H_2S$ +$H_2O$) compositions. The crude oil is sent to the two-phase slug catcher separator. The separated crude oil from the gas is sent to a three-phase high-pressure separator. The high-pressure separator is controlled as follows: (vessel temperature =40 C), vessel pressure = 250 kPa), and liquid volume percent = 50%). The oil is separated and sent to a low-pressure separator. And is controlled as follows: (vessel temperature = 40 C), vessel pressure = 50 kPa), (liquid volume percent = 50%). The oil is separated and mixed with the first LP separator by mixer, and both of them are sent to the same pipe segment. The gas is separated and mixed with the separated gas of the first LP separator. Then, both of them were sent to the gas treatments. As we can in Figure 13.

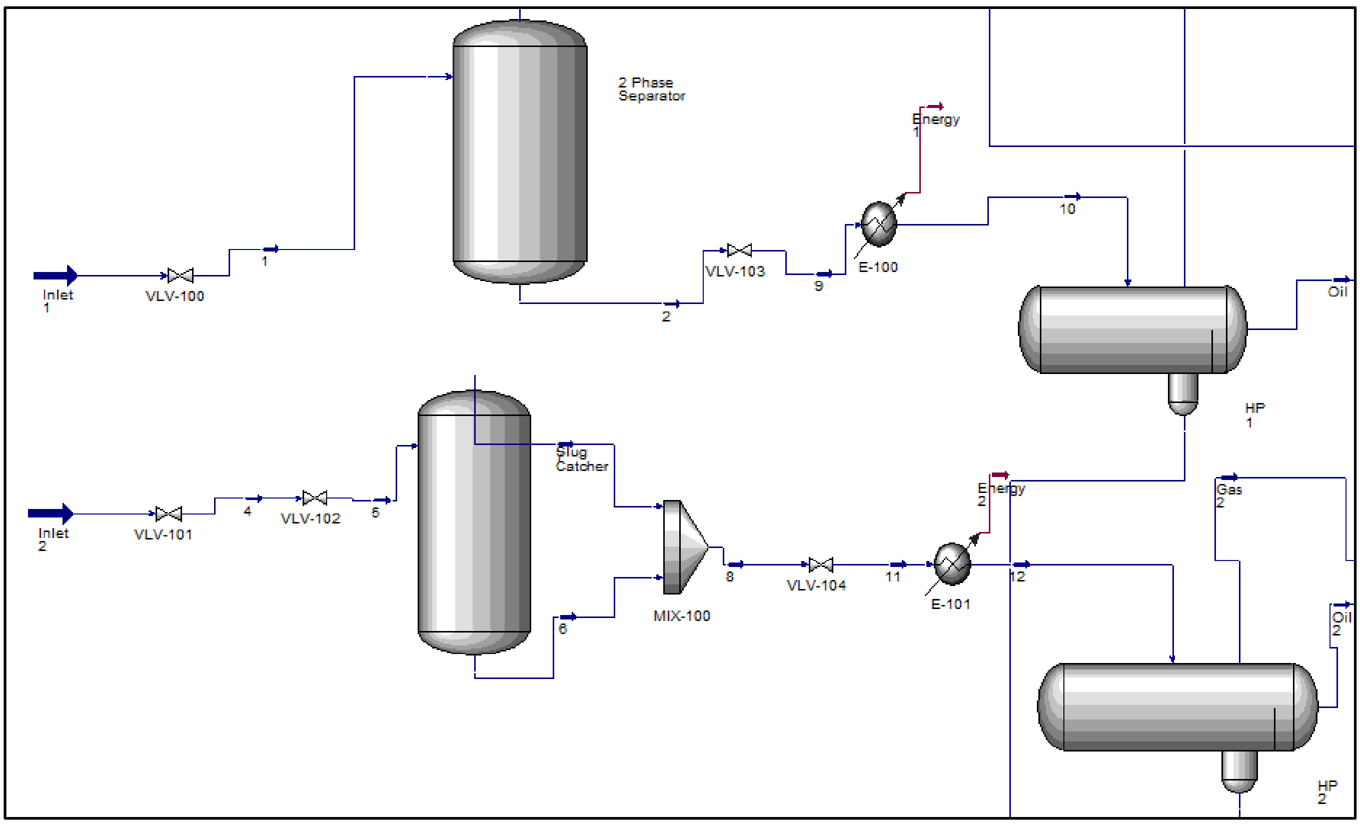



Figure 13: LP separatore and HP separatore

## 6. Results:

The distillation of the interpreted crude oil sample in the lab, at different temperatures, is shown in Diagram 1 below.

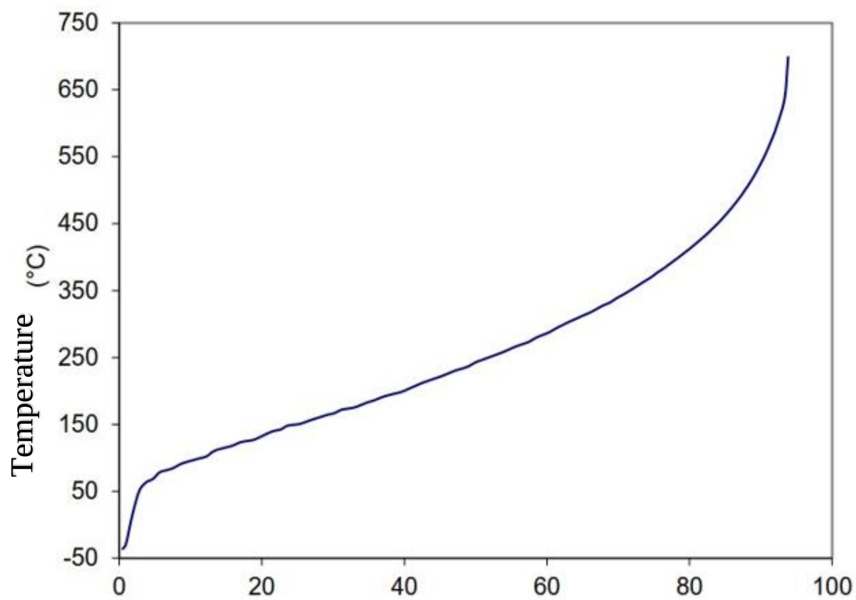


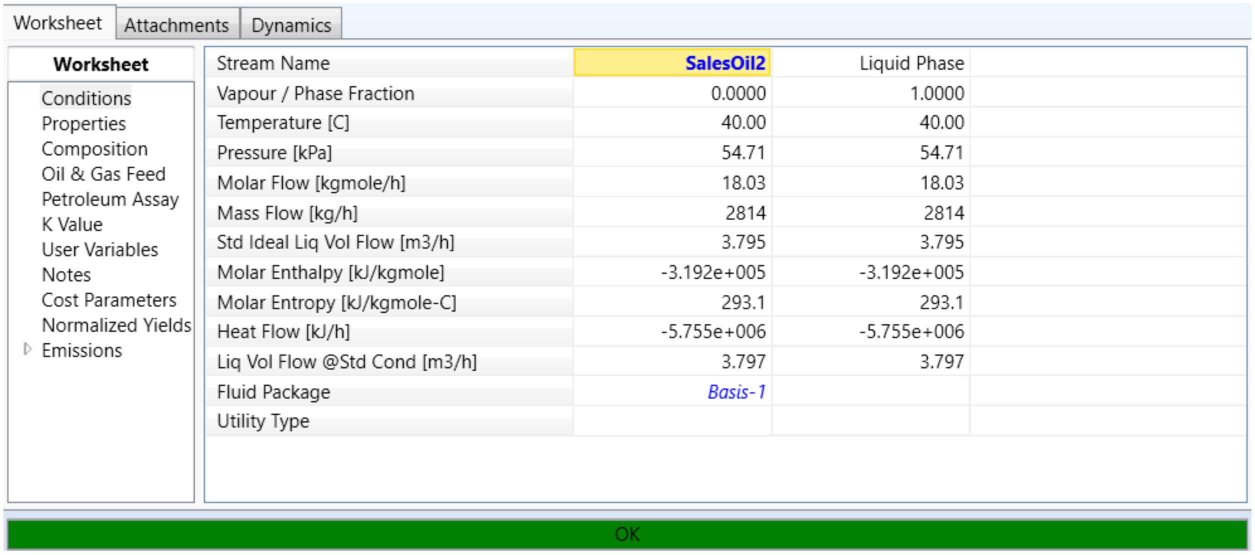

Diagram 1, the distilled quantity (% hm.)
Distillation curve by simulated distillation according to ASTM D2887

When the density of the crude oil at 15 °C is (789.2 kg/$m_3$), the hydrocarbon components of the oil sample, are obtained as the following table (2) below.

Table (2), the compositions

| | |
|---|---|
| methane + Ethan | <0.01 |
| propan | 0.15 |
| i-butan | 0.16 |
| n-butan | 0.85 |
| i-pentan | 1.15 |
| n-pentan | 1.85 |
| cyclopentan | 0.2 |
| $c_6$ | 2.8 |

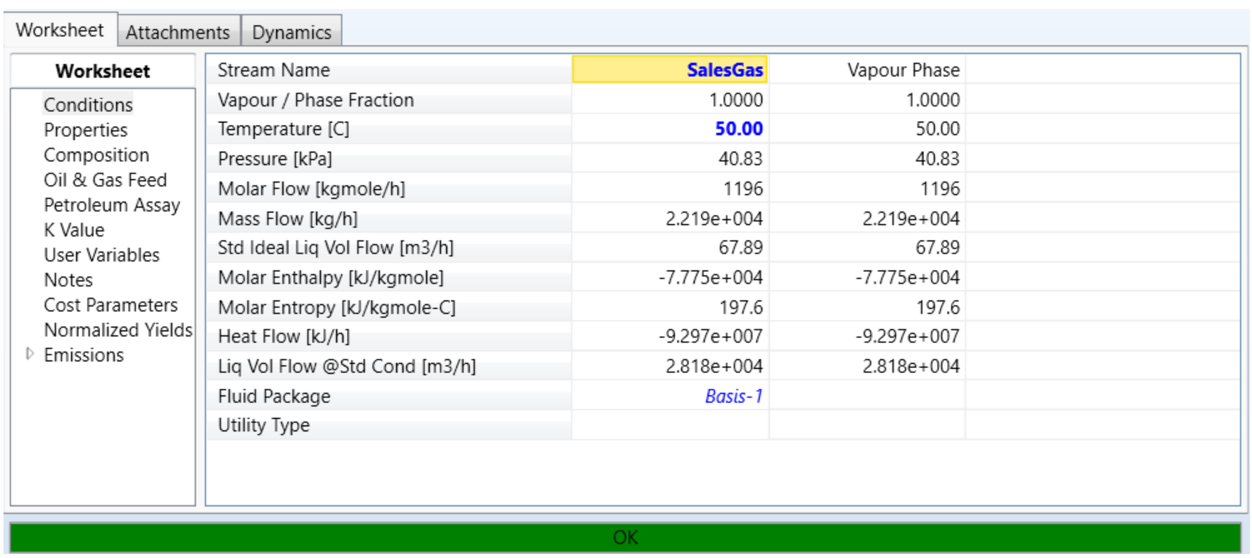
The produced sale oil conditions are obtained as shown in Figure 14 below.




| Stream Name | SalesOil2 | Liquid Phase |
|---|---|---|
| Vapour / Phase Fraction | 0.0000 | 1.0000 |
| Temperature [C] | 40.00 | 40.00 |
| Pressure [kPa] | 54.71 | 54.71 |
| Molar Flow [kgmole/h] | 18.03 | 18.03 |
| Mass Flow [kg/h] | 2814 | 2814 |
| Std Ideal Liq Vol Flow [m3/h] | 3.795 | 3.795 |
| Molar Enthalpy [kJ/kgmole] | -3.192e+005 | -3.192e+005 |
| Molar Entropy [kJ/kgmole-C] | 293.1 | 293.1 |
| Heat Flow [kJ/h] | -5.755e+006 | -5.755e+006 |
| Liq Vol Flow @Std Cond [m3/h] | 3.797 | 3.797 |
| Fluid Package | Basis-1 | |
| Utility Type | | |

Figure 14: Sale of oil

The produced sale gas conditions are obtained as shown in Figure 15 below.




| Stream Name | SalesGas | Vapour Phase |
|---|---|---|
| Vapour / Phase Fraction | 1.0000 | 1.0000 |
| Temperature [C] | 50.00 | 50.00 |
| Pressure [kPa] | 40.83 | 40.83 |
| Molar Flow [kgmole/h] | 1196 | 1196 |
| Mass Flow [kg/h] | 2.219e+004 | 2.219e+004 |
| Std Ideal Liq Vol Flow [m3/h] | 67.89 | 67.89 |
| Molar Enthalpy [kJ/kgmole] | -7.775e+004 | -7.775e+004 |
| Molar Entropy [kJ/kgmole-C] | 197.6 | 197.6 |
| Heat Flow [kJ/h] | -9.297e+007 | -9.297e+007 |
| Liq Vol Flow @Std Cond [m3/h] | 2.818e+004 | 2.818e+004 |
| Fluid Package | Basis-1 | |
| Utility Type | | |

Figure 15: Sale gas

## 6.1 phase envelop

Phase envelop are shown in Figure 16 below. the phase is liquid due to low temperature and high-pressure conditions. When the pressure decreases to (1502) kPa at (315.1) C, the liquid makes the first bubble because the pressure is the same as the bubble point, and the liquid is altered to gas, it has become two phases. At the same pressure but at a higher temperature of (400) C, the whole liquid becomes gas because the temperature is higher than the dew point (blue line).

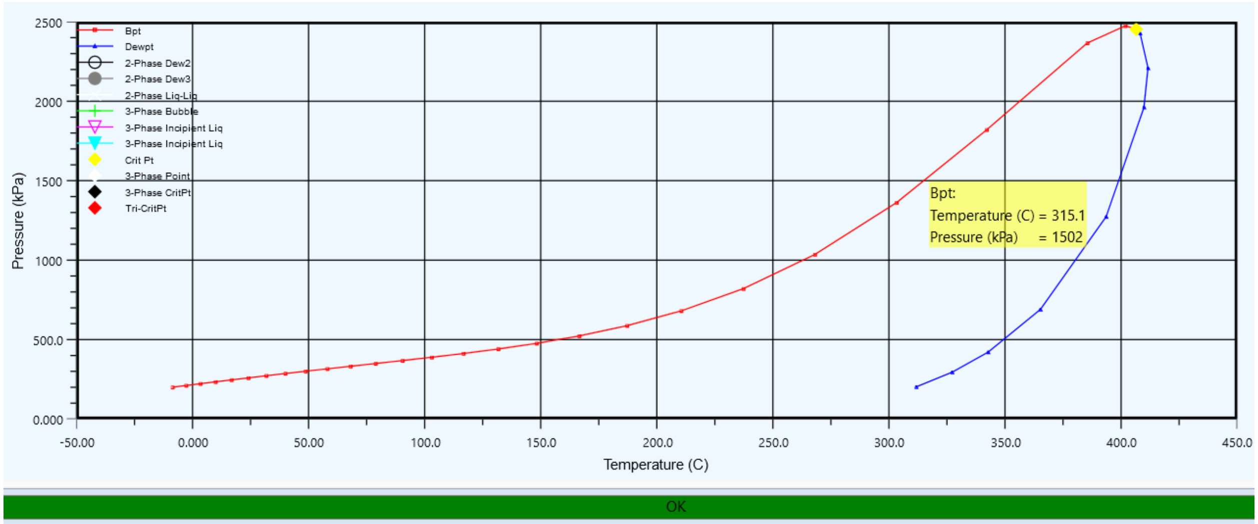



Figure 16: Phase envelop

## 7. Discussions:

Using Peng Robinson for easly and spesific project. The data are applied to the Hysys software to know how the separation process will be, and what will be the rate of the separated oil and gas? Two inlets are created in the software because there are two wells that data are obtained from. Methane to Decane compositions is applied to the first inlet because the crude oil compositions of the first well are mostly methane to decane. The inlet is interlinked to a two-phase vertical separator by a short pipeline because gas is separated from the oil. Data of the two-phase separator are as follows: (vessel temperature = 64.51 C), (vessel pressure = 350 kPa), (liquid volume percent = 50%). There is a higher temperature and pressure from this separator compared to HP and LP separators because the temperature and pressure are decreased. The gas and oil are separated. The gas is sent to the vertical separator to separate toxic gasses and make a sweet gas. A cooler is between them to decrease the temperature as follows: (decreased temperature = -50C), (pressure drop = 5 kPa), (DUTY = 5.520 e + 004 kj/h). Also, from the same inlet, the oil is separated by the two-phase separator. The separated oil is sent to the three-phase high-pressure separator because it works by very high pressure to separate the heavy oil from the gas and its three phases separate oil, gas, and water. The three-phase separator is controlled as follows: (vessel temperature = 40.00 C), (vessel pressure = 150 kPa), ( liquid volume percent =50%). The separated crude oil is sent to a three-phase low-pressure separator because the separated oil from the HP separator is still not pure oil and some compositions exist. The LP separator is working again to separate more gas and water from the oil. Between both of first HP separator and the first LP separator, a heater is applied as follows: (DT = 0.2567 C), (pressure drop = 0 kPa), (DUTY = 10 kJ/h), because the pipeline between both separators decreased the temperature by one celsius and the its corrected by the heater. So, now the temperature is the same as the LP separator which is 40 C. From the LP separator the oil is sent by the pipeline to the pipe segment because, in the khurmala field, the separated crude oil is transported to Turkey by the pipe segment.

The second inlet includes (methane to C20 and $H_2S$ +$H_2O$) compositions. The crude oil is sent to the two-phase slug catcher separator to catch the slug and foam that exist with the crude oil. The slug catcher catches the foam before the crude oil goes to the high-pressure separator because it could be a problem for the process inside the separators due to flow path luggage. The separated crude oil from the foam is sent to a three-phase high-pressure separator. The high-pressure separator is controlled as follows: (vessel temperature =40 C), vessel pressure = 250 kPa), and liquid volume percent = 50%). The oil is separated and sent to a low-pressure separator. And is controlled as follows: (vessel temperature = 40 C), vessel pressure = 50 kPa), (liquid volume percent = 50%). The oil is separated and mixed with the first LP separator by mixer, and both of them are sent to the same pipe segment. The gas is separated and mixed with the separated gas of the first LP separator. Then, both of them were sent to the gas treatments.

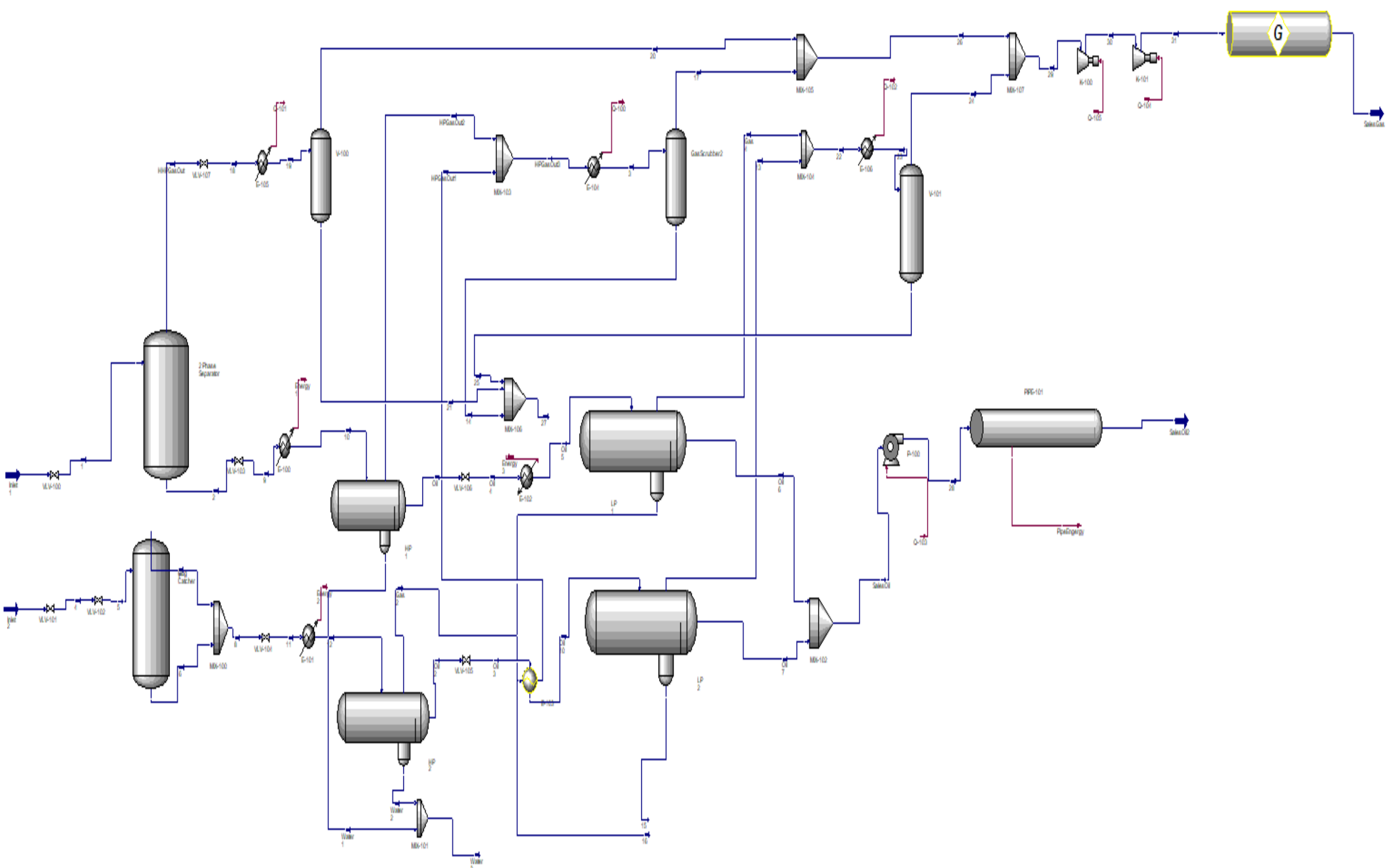


Figure 17: separation process in HYSYS

## 8. Conclusions:

The heavy crude oil of study area is separated by the separation process, oil and gas are produced. The Aspen Hysys is a proper software to show the conditions of the produced sale oil and sale gas. The heavy crude oil undergoes more treatments to seperate oil and gas. By phase envelpo (change of pressure and te.mperature) the high hydrocarbon gases can be seperated from low hydrocarbon gases. HYSYS able to carry out a large number of basic calculations for chemical components. And for my master degree im going to learn more about the feilds and which one is better for oil and gas.

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