Sudan University of Science and Technology
College of Petroleum Engineering and Technology
Department of Transportation and Refining Engineering

Blending Process of Rawat Crude and Nile Blend in Elobied Refinery

عملية خلط خام الراوات مع خام مزيج النيل في مصفاة الأبيض

Project submitted in partial fulfillment of the
requirement for the Bachelor of Engineering (Honrs)
Degree in Transportation and Refining Engineering

Prepared by:

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Processing Blending of Rawat Crude &Nile blend in Elobied Refinery

Graduation project submitted to college of Petroleum Engineering and Technology in Sudan University of Science and Technology

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Date: October 2018

الإستهلال

قال تعالى:

﴿ وَمَا تَوْفِيقِي إِلَّا بِاللَّهِ ۚ عَلَيْهِ تَوَكَّلْتُ وَإِلَيْهِ أُنِيبُ ﴾

سورة هود الآية (88)

Dedication

We dedicate this project to our parents for the love and support they have provided throughout our entire life, they were there for every decision we have made and helped our dreams become reality, to our friends and families for their help and encouragement.

Also, we dedicate this research to our colleagues in the Transportation and Refining department, specially and to all batch 23th petroleum engineering Students.

Acknowledgement

Acknowledgment First of all, we would like to thank Great and Almighty God who gave us the power to fulfill this study. Thanks, should be given to our supervisors **Mrs. Nehad Omer Hassan** and **Mrs. Malaz Mustafa Mohamed** for their continuous advice and encouragement throughout the entire course of our study.

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التجريد

خام الراوات يعد من الخامات المكتشفة حديثا في السودان لكنه ذا نقطة انسكاب مرتفعة ومحتوى شمعي عالي لهذا تم خلط هذا الخام مع خام مزيج النيل للتغلب على هذة المشكلة و تمت هذة الدراسة للاستفادة من الكمية المنتجة من هذا الخام وذلك عن طريق مزج خام الراوات مع الخام الرئيسي الداخل لمصفاة الابيض خام مزيج النيل)بنسب متفاوتة للحصول على خليط يمكن تقطيره(في برج التقطير بمصفاة الابيض و تمت محاكاة هذة العملية باستخدام برنامج الهايسس

تمت المحاكاة بادخال خام مزيج النيل والراوات بنسب متفاوتة (60/40)و(50/50)و(30/70) وقد اوضحت النتائج ان زيادة نسب خام الراوات على خام مزيج النيل يؤدي الى زيادة المتبقي في اسفل برج التقطير

Abstract

The objective of this study is to define the optimum ratio of Rawat to Nile Blend feed stream to Elobied refinery. Rawat crude has recently been discovered in Sudan, but has a high pour point and wax content, that’s why we blend it with Nile blend to overcome these short comings. The project studies the advantage of blending Rawat crude with the main crude that is fed to Elobied refinery (Nile Blend crude) by using different ratios to obtain a blend that can be distilled in distillation column of Elobied refinery. This has been done by using Aspen HYSYS simulator.

It is simulated by entering Nile Blend and Rawat Crude with different ratios (40/60), (50/50) and (70/30). The results showed that as the ratio of Rawat crude to Nile Blend is increased in the feed crude, the percentage of residue in the bottom of the distillation column increases.

The key words: Rawat, blending, Nile Blend, distillation, simulation, Aspen HYSYS.

Table of Contents

List of figures

List of tables

Chapter 1

Introduction

1.1 Introduction

Crude oil is a naturally existing mixture of hydrocarbons, generally in the liquid state, that may also include compounds of sulfur, nitrogen, oxygen, and metals and other elements (ASTM D-4175). Inorganic sediment and water may also be present. The word petroleum “rock oil “derives from the Latin Petra (rock or stone) and oleum (oil) and was first used in 1556 in treatise published by Georg Bauer(Riva, 2006).

Refineries are designed to manufacture marketable petroleum products from import streams of a variety of crude oils, it’s classified according to the number of processes available for transforming crude into petroleum products.

Simple refineries are designed to distill crude oil into a limited range and yield and products. They are referred to as topping or hydro skimming plants. Topping is the most basic distillation process. Hydro skimming involves distillation in the presence of hydrogen.

Complex refineries involve a combination of interrelated processes to produce a broader range of refined products. They commonly utilize thermal and catalytic cracking that enables deeper conversion of the crude oil feedstock into higher yields of more value blend marketable products(Speight, 2010).

All refineries have a design distillation capacity also known as nameplate capacity. This capacity specifies the volume of crude per day or year that can be processed in a crude distillation unit at the maximum utilization of the plant. Downstream of the crude distillation unit is an array of processing plants that can further enhance the yield of certain petroleum products. The processes include catalytic cracking, hydrocracking, visbreaking (thermal cracking) and coking. This commonly referred to as charge capacity(Speight, 2010).

Blending is the process of mixing and combining hydrocarbon fractions, additives and other components to produce a finished product with specific performance properties(OSHA technical manual, 2005). Crude oil blending is often undertaken to increase the sale price or process-ability of a lower grade crude oil by blending it with a higher grade, higher price crude. The objective is to produce blended crude oil with a target specification at the lowest cost using the minimum quantity of the higher cost crude.

1.2 Problem statement

With depletion of crude resources Rawat crude offers a great opportunity, but it is hard to process in Elobied Refinery due to its different properties especially pour point and wax content.

1.3 Research objective

Determine the optimum ratio of blending Rawat and Nile blend crudes that allowed it to separate in distillation column.

1.4 Scope of project:

In this project HYSYS simulation has been used to determine optimum ratio Rawat crude and Nile blend, mixtures.

Chapter 2

Literature Review

2.1 Introduction

Petroleum forms by the breaking down of large molecules of fats, oils and waxes that contributed to the formation of kerogen. This process began millions of years ago, when small marine organisms abounded in the seas. As marine life died, it settled at the sea bottom and became buried in layers of clay, silt and sand. The gradual decay by the effect of heat and pressure resulted in the formation of hundreds of compounds.

Because petroleum is a fluid, it is able to migrate through the earth as it forms. To form large, economically recoverable amounts of oil underground, two things are needed: an oil pool and an oil trap. An oil pool, which is the underground reservoir of oil, may literally be a pool or it could be droplets of oil collected in a highly porous rock such as sandstone. An oil trap is a non-porous rock formation that holds the oil pool in place. Obviously, in order to stay in the ground, the fluids – oil and associated gas – must be trapped, so that they cannot flow to the surface of the earth. The hydrocarbons accumulate in reservoir rock, the porous sandstone or limestone. The reservoir rock must have a covering of an impervious rock that will not allow the passage of the hydrocarbon fluids to the surface(Fahim, Al-Sahhaf, & Elkilani, 2009).

The elementary composition of crude oil usually falls within the following table 2-1

Table 2-1: Elementary composition of crude oils

Element	Percent by weight
Carbon	84-87
Hydrogen	11-14
Sulfur	0-3
Nitrogen	0-0.6

2.2 Composition of petroleum

Petroleum is not a uniform material. Its composition can vary with the location, age and also individual well. On a molecular basis, petroleum is a complex mixture of hydrocarbons and organic compounds of sulfur, oxygen and nitrogen, as well as compounds containing metallic constituents, particularly vanadium, nickel, iron and copper. The hydrocarbon content may be as high as 97%, for example, in the light paraffinic petroleum or as low as 50% or less as illustrated by heavier asphaltic crude oils.

Crude oils and high-boiling crude oil fractions are composed of many members of a relatively few homologous series of hydrocarbons(Nelson, 1970). The composition of the total mixture, in terms of elementary composition, does not vary a great deal, but small differences in composition can greatly affect the physical properties and the processing required to produce salable products. Petroleum is essentially a mixture of hydrocarbons, and even the non-hydrocarbon elements are generally present as components of complex molecules, predominantly hydrocarbon in character, but containing small quantities of oxygen, sulfur, nitrogen, vanadium, nickel, and

chromium(Jones & Pujadó, 2006). The hydrocarbons present in crude petroleum are classified into three general types: paraffins, naphthene's, and aromatics. In addition, there is a fourth type, olefins, that is formed during processing by the cracking or dehydrogenation of paraffins and naphthene's.
There are no olefins in crude oils.

Crude oils are classified based on hydrocarbons as:

- paraffin base.
- naphthene base.
- asphalt base.
- Aromatic base in some crudes.

2.2.1 Paraffins

The paraffin series of hydrocarbons is characterized by the rule that the carbon atoms are connected by a single bond, and the other bonds are saturated with hydrogen atoms. The general formula for paraffins is C_nH_{2n+2}.

The simplest paraffin is methane, CH_4

When the number of carbon atoms in the molecule is greater than three, several hydrocarbons may exist that contain the same number of carbon and hydrogen atoms but have different structures. This is because carbon is capable not only of chain formation, but also of forming single- or double-branched chains that give rise to isomers that have significantly different properties. For example, the motor octane number of n-octane is –17 and that of isooctane (2,2,4-trimethyl pentane) is 100. The number of possible isomers increases in geometric progression as the number of carbon atoms increases. There are 2 paraffin isomers of butane, 3 of pentane, and 17 structural isomers of octane, and by the time the number of carbon atoms has increased to 18, there are 60,533 isomers of cetane. Crude oil contains molecules with up to

70 carbon atoms, and the number of possible paraffinic hydrocarbons is very high.

2.2.2 Naphthene’s (Cycloparaffins)

Cycloparaffin hydrocarbons in which all of the available bonds of the carbon atoms are saturated with hydrogen are called naphthene’s. There are many types of naphthene’s present in crude oil, but, except for the lower-molecular-weight compounds such as cyclopentane and cyclohexane, they are generally not handled as individual compounds.

2.2.3 Aromatics

The aromatic series of hydrocarbons is chemically and physically very different from the paraffins and cycloparaffins (naphthene’s). Aromatic hydrocarbons contain a benzene ring, which is unsaturated but very stable, and frequently behave as saturated compounds.

The cyclic hydrocarbons, both naphthenic and aromatic, can add paraffin side chains in place of some of the hydrogen attached to the ring carbons and form a mixed structure. These mixed types have many of the chemical and physical characteristics of both of the parent compounds, but generally are classified according to the parent cyclic compound(Gary, Handwerk, & Kaiser, 2007).

2.2.4 Olefin

Olefins do not naturally occur in crude oils but are formed during processing. They are very similar in structure to paraffins, but at least two of the carbon atoms are joined by double bonds. The general formula is C_nH_{2n}. Olefins are generally undesirable in finished products because the double bonds are reactive and the compounds are more easily oxidized and polymerized to form gums and varnishes. In gasoline boiling-range fractions, some olefins are desirable because olefins have higher octane numbers than paraffin compounds with the same number of carbon atoms. Olefins containing five carbon atoms have high reaction rates with compounds in the classify petroleum based on various distillation properties It has been suggested that a crude should be called asphaltic if the distillation residue contained less than 2% wax and paraffinic if it contained more than 5%.

2.3 Crude oil properties

Crude petroleum is very complex, and except for the low-boiling components, no attempt is made by the refiner to analyze for the pure components contained in the crude oil. Relatively simple analytical tests are run on the crude, and the results of these are used with empirical correlations to evaluate the crude oils as feedstocks for the particular refinery. Each crude is compared with the other feedstocks available and, based upon the operating cost and product realization, is assigned a value. The more useful properties are discussed.

2.3.1 API Gravity

The density of petroleum oils is expressed in the United States in terms of API (American Petroleum Institute) gravity rather than specific gravity. specific gravity and API gravity refer to the weight per unit volume at 60°F as compared to water at 60°F. The units of API gravity are $°API$ and can be calculated from specific gravity by the following:

$$°API = \frac{141.5}{S.G\ @\ 60°\mathrm{F}} - 131.5 \quad \text{———} (1)$$

Crude oil gravity may range from less than 10 °$API$to over 50 °API but most crudes fall in the 20 to 45 °API range. API gravity always refers to the liquid sample at 60°F (15.6°C).

Crude oils can generally be classified according to gravity as:

Table 2-2: Classification of crude Oils

Crude Category	API Gravity
Light crudes	API > 38
Medium crudes	38 > API > 29
Heavy crudes	29 > API > 8.5
Very heavy crudes	API < 8.5

2.3.2 Pour Point

The pour point is defined as the lowest temperature at which the sample will flow. It indicates how easy or difficult to pump the oil, especially in cold weather. It also indicates the aromaticity or the paraffinity of the crude oil or the fraction. A lower pour point means that the paraffin content is low pour point for the

and fraction above 232 C (450 F) are determined by standard tests like ASTM D97(Fahim et al., 2009).

2.3.3 Sulfur content, WT%

Influence on the value of crude oil, although nitrogen, Total Acid Number (TAN), and metals contents are increasing in importance. The sulfur content is expressed as a percentage of sulfur by weight and varies from less than 0.1% to greater than 5%. Crudes with greater than 0.5% sulfur generally require more extensive processing than those with lower sulfur content.

Although the term “sour” crude initially had reference to those crudes containing dissolved hydrogen sulfide independent of total sulfur content, it has come to mean any crude oil with a sulfur content high enough to require special processing. There is no sharp dividing line between sour and sweet crudes, but 0.5% sulfur content is frequently used as the criterion(Gary et al., 2007).

2.3.4 Viscosity

The resistance to flow or the pumpability of the crude oil or petroleum fraction is indicated by the viscosity. More viscous oils create a greater pressure drop when they flow in pipes. Viscosity measurement is expressed in terms of kinematic viscosity in centistoke’s (cSt) and can also be expressed in say bolt seconds. The viscosity is measured at 37.8 C (100 F) by ASTM D445 and by ASTM D446 at 99 C (210 F)(Fahim et al., 2009).

2.3.5 Flash point

The flash point is a measure of the tendency of the, material to form a flammable mixture with air under controlled laboratory conditions or it is the temperature at which the vapor above the oil will momentarily flash or explode. The flash point is used to establish the flammable criteria in transporting the material. Generally shipping and safety regulations will be based on the flash point criterial(Speight, 2015).

Flashpoint

$$F = 0.77\ (\text{ASTM } 5\%\ F - 150\ F) \qquad \text{——————} (2)$$

2.3.6 Pour Point Blending

The pour point is the lowest temperature at which oil can be stored and still capable of flowing or pouring, when it is cooled without stirring under standard cooling conditions. Pour point is not an additive property and pour point blending indices are used, which blend linearly on a volume basis(Nelson, 1970).

2.3.7 Density

In physic and material science the density (ρ) of a body is a measure of how tightly the matter within it is packed together, and is given by the ratio of its mass (m) to its volume (V). Its SI unit is kilograms per cubic meter (kg/m3). It is also sometimes given in the unit of grams per cubic centimeters (g/cm3).

2.4 Definitions and properties of liquid fuels

The composition of petroleum varies with the location, age and also individual well. The high proportion of carbon and hydrogen indicate that hydrocarbons are the major constituents of petroleum. The principal types of hydrocarbon present in crude oil are normal, branched or cyclic saturated hydrocarbons, aromatic hydrocarbons or compounds with molecular structure associating both these basic types.

The properties of crude petroleum and its fractions can be determined by various ways. Crude oils are roughly classified into different bases according to the nature of principal type of hydrocarbons present in it. The bases are:

1- paraffin base This type of petroleum is mainly composed of the saturated hydrocarbons from $CH_4$to $C_{34}H_{72}$ and a little of the napthenes and aromatics.

2- naphthene based It contains mainly cycloparaffins or naphthene's with smaller amount of paraffins and aromatic hydrocarbons.

3- mixed base or intermediate base It contains both paraffinic and asphaltic hydrocarbons and are generally rich in semi-solid waxes.

4- aromatic base crudes contain a relatively high percentage of the lower aromatic hydrocarbon.

2.5 Crude distillation unit

Distillation is a separation process requires differences to be recognized and utilized.

We separate many things by detecting a difference in a physical property, color, size, weight, shapes for example it also requires acting according to such information.

Separation by distillation implies a difference in boiling points or volatilities of two or more materials.

The components making up crude oil are numbered in thousands. Many of these components have similar physical properties including boiling points, that may differ by only a few degrees. Therefore, it is difficult to separate some pure compounds from the complex mixture of components in crude oil by distillation alone.

There are other methods of separation used in a refinery for example, extraction with a solvent, crystallization, and absorption. However, distillation is the most common method. Fortunately, it is rare to attempt to separate pure compounds and it is often enough to separate groups of compounds from each other by boiling range.

Crude can be separated into gasoline, naphtha, kerosene, diesel oil, gas oil, and other products, by distillation at atmospheric pressure. Distillation is an operation in which vapors rising through fractionating decks in a tower are intimately contacted with liquid descending across the decks so that higher boiling components are condensed, and concentrate at the bottom of the tower while the lighter ones are concentrated at the top or pass overhead.

Crude is generally pumped to the unit directly from a storage tank, and it is important that charge tanks be drained completely free from water before charging to the unit. If water is entrained in the charge, it will vaporize in the exchangers and in the heater, and cause a high pressure drop through that equipment. If a slug of water should be charged to the unit, the quantity of steam generated by its vaporization is so much greater than the quantity of vapor obtained from the same volume of oil, that the decks in the fractionating column could be damaged.

Water expands in volume 1600 times upon vaporization at 1000C at atmospheric pressure. If crude oil were a final product, it would have just been a grade fuel struggling to establish itself against coal. If we separate the many compounds in crude oil into groups we find that these groups have characteristics make them considerably more valuable than the whole crude oil. some of these group are products some may be feedstock to other processing units where they are chemically changed into more valuable products. These products, in turn, are usually separated or purified by distillation.

2.5.1 Refining Process

The first process encountered in any conventional Refinery is the atmospheric crude distillation Unit. In this unit the crude oil is distilled to produce distillate Streams which will be the basic streams for the refinery product slate. These streams will either be subject to further treating downstream or become feed stock for conversion units that may be in the refinery configuration a schematic flow diagram of an atmospheric crude unit is shown in Figure (2.1).

Crude oil is pumped from storage to be heated by exchange against hot overhead and product side streams in the crude unit. At a preheat temperature of about 200 to 2500 °F water is injected into the crude to dissolve salt that is usually present. The Mixture enters a desalted drum usually containing an electrostatic precipitator. The salt water contained in the crude is separated by means of this electrostatic precipitation.

The water phase from the drum is sent to a sour water stripper to be cleaned before disposal to the oily water sewer, it must be understood however that this 'de-salting' does not remove the organic chlorides which may be present in the feed , this will be discussed later when dealing with the tower's overhead system.

The crude oil leaves the desalter drum and enters a surge drum. Some of the ends and any entrained water are flashed off in this drum and routed directly to the distillation tower flash zone (they do not pass through to the heater). The crude distillation booster pump takes suction from this drum and delivers the desalted crude under flow control to the fired heater via the remaining heat exchange train. On leaving heat exchanger train, the crude oil is heated in a fired heater to a temperature that will vaporize the distillate products in the crude tower, some additional is added to the crude to vaporize about 5% more than required for the distillate streams, this is called over flash and is used to ensure good reflux streams in the tower.

The heated crude enters the fractionation tower in a lower section called the flash zone. The unvaporized portion of the crude leaves the bottom of the tower via a steam stripper section, while the distillate vapors move up the tower counter current to a cooler liquid reflux stream.

Heat and mass transfer take place on the fractionating trays contained in this section of the tower above the flash zone. Distillate products are removed from selected trays (draw-off trays) in this section of the tower, these streams are stream stripped and sent to storage. The full naphtha vapor is allowed to leave the top of the tower to be condensed and collected in the overhead drum. A Portion of this stream is returned as reflux while the remainder is delivered to the end processes for stabilizing and further distillation. The side stream distillates shown in the diagram are:

l. Heavy gas oil (has the highest Boiling Point).
2. Light gas oil (will become Diesel).
3. Kerosene (will become Jet Fuel).

unit section is included at the light gas oil draw off. This is simply an internal condenser which takes heat out of that section of the tower. This in turn ensures a continued reflux stream flow below that section. The product side streams are stripped free of entrained light ends in separate stripping towers, these towers

also contain fractionation trays (usually four but sometimes as many as six) and the

side stream drawn off the main tower enters the top tray of its respective stripper. steam is injected below the bottom tray and moves up the tower to leave at the top, together with the light ends strip out, and is returned to the main fractionators at a point directly above the side stream draw-off tray. These side stream stripper towers are usually stacked one above the other in a single column in such a way as to allow free flow from the side stream draw-off tray to its stripper tower. On a few occasions, where the particular side stream specification requires it, the stripping may be effected by reboiling instead of using steam one such requirement maybe in the kero side stream if this stream is to be routed directly into jet fuel blending and therefore must be dry.

The residue (unvaporized portion of the crude) leaves the flash zone to flow over four stripping trays counter current to the flow of stripping steam. This stripping steam enters the tower below the bottom stripping tray. Its purpose primarily is to strip the residue free of entrained light ends

Pressure for the liquid/vapor separation. This becomes an important factor in the design and operation of the atmospheric crude distillation unit. The stripped residue leaves the bottom of the unit to be routed either through the unit's heat exchanger system and the to product storage or hot to some downstream processing unit such as a vacuum distillation unit or a thermal cracker(Jones & Pujadó, 2006).

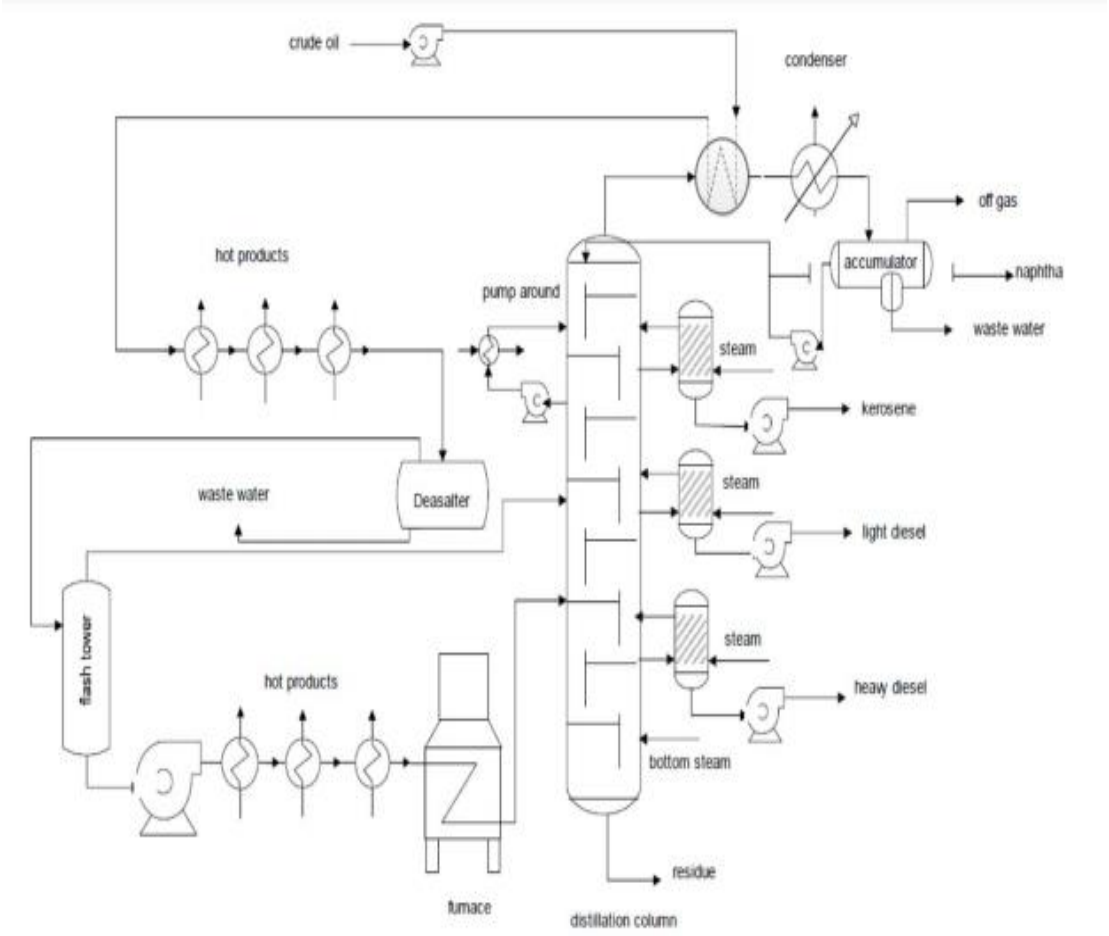


Figure 2.1 Atmospheric crude unit

2.6 Elobied refinery

Is a simple refinery. It was a facility which originally built in 1979 as 10,000 BPSD crude topping plant in US. In 1995 it was revamped and modified and rebuilt in Sudan with a design capacity of 10,000 bbl/day. It is located at El Obeid city, North Kordofan State, Sudan. Location coordinates are: Latitude 13.2714, Longitude 30.2362. The refinery was upgraded to15,000 bbl/day in 2002. ORC consists of one Crude Distillation Unit (CDU), therefore it is considered as single complexity refinery. It is producing wide range of products Furnace (63%), gas oil (24%), kerosene (7%) and naphtha (6%)

2.6.1 The refinery facilities:

- Storage system**.**
- Heat exchanger network (preheating).
- Crude heaters.
- Distillation column & side strippers.
- Water coolers & air coolers.
- Pumps.
- Cooling water towers.
- Steam boilers.
- Control room.
- Plat forms.
- Workshops.
- Warehouse.
- Plant power generation.
- Laboratory.
- Firefighting system.
- Waste water treatment

2.6.1.1 Storage system

Five tanks for crude oil, 5000 cubic meter each plus tank 3000 cubic meter.

*Three tanks for gas oil, 5000 cubic meter each.

* Two tanks for kerosene, 600 cubic meter each.

* Three tanks for naphtha, 600 cubic meter each plus one tank 5000 cubic meter.

* One tank for diesel oil, 5000 cubic meters.

* Two tanks for water, 600 cubic meters.

* Two tanks for slops, 180 cubic meters.

2.6.1.2 Heat exchangers

Consist of eight heat exchangers, its function is to increase of the crude oil and decrease the temperature of the finished products, so as to reduce crude heaters load and reduce fuel consumption.

2.6.1.3 Crude heaters

It consists of two heaters, to increase crude temperature to the point that allows the fraction of the products.

2.6.1.4 Main column and side strippers

After crude being heated to required temperature the crude flows to the fractionating column, where light naphtha, kerosene, Gasoil, residue is separated and purified.

2.6.1.5 Water and air coolers

Its function is to reduce the temperature of the finished products to the lowest possible figure so as to be stored safely in its storage taiknks. `

2.6.1.6 Pumps

There are groups of pumps, some pumping the crude oil and finishing product to and from process unit, and the others, pumping products to loading areas.

2.6.1.7 Cooling water towers

Its function is to reduce the temperature of the circulation water from the process to cooling water tower.

2.6.1.8 Steam boiler:

It produces steam which is used in heaters, stripping of the light products in the column after been superheated in the heaters, and what left is used to heat crude oil and fuel oil if needed.

2.6.1.9 The control room:

This stands as director which directs the process operation automatically through (SCADA) electronic instrument.

2.6.1.10 The platforms:

There are three loads out platforms, two for road trucks and the third one for the wagons loading.

2.6.1.11 Work shop:

There is work shop which repairs and maintains all fixed and running equipment.

2.6.1.12 Warehouse:

There is warehouse for storing spare parts needed in refinery maintains.

2.6.1.13 Plant power generation:

There are three generators, 530 KW, 60HZ, each, beside three generators for domestic use, its average load is 250KW, 50HZ.

2.6.1.14 The laboratory:

Controls product quality specification while plant is on-stream, and issues immediately reports to tune operating condition to meet the required specification.

2.6.1.15 Firefighting system:

The firefighting system contains three firefighting pumps, cooling rings, foam system, fire trucks and fire extinguishers.

2.6.1.16 Waste and water treatment:

All waste streams and waste water in refinery are accumulated and collected in large basin where is separated physically separate the oil from water the water transferred to the Lagoon which containing fishes to make biotest before it is used for irrigation, the oil transferred to storage tank. There is new laboratory for bio testing well been added in future.

2.7 Blending

Currently there is an increasing number of oil fields where oil is enriched with high-melting paraffin hydrocarbons, resinous and asphaltene substances and is characterized by high pour point and viscosity values. In addition, continuous development of oil fields and waterflooding leads to generation of stable oil-water emulsions. Blending of crude oil could be important for transportation because blends could have better flow properties than single crudes, and blending of crude oils also influence the product value and refining efficiency(MacDougall, 2005).

Crude oil blending is an ordinary operation for refineries. Operating on an optimal blending ratio can generate a 1-5%higher yield from the atmospheric and vacuum distillation.1-5Moreover, higher-value product yields, higher-quality product, and lower energy costs could also be obtained by blending distillation technology. In China, because of the shortage of crude oil and the continuously increasing need for petroleum products in the domestic market, more imported crude oils were processed in different refineries; therefore, it is urgent to study the principle of blending distillation for various crude types(Li et al., 2007).

In general, crude oils are always considered to be complex colloidal dispersed systems. Some properties of system can be changed by crude oil blending, which lead to the enhancement of the relative volatility of the components and an increase in the distillation yield(Pet., L.J., & Y.P., 1987).

The crude oil feed-stocks used for blending often vary in quality and for this reason crude oil blenders normally use viscosity or density trim control systems. When the crude oil blender is started the required flow rate and component ratio is set by the control system based on the ratio in the recipe. A density or viscosity analyzer, installed at a homogeneous point in the blender header, generates a control signal, which is used to continually optimize the blended product by adjusting the component ratio, this ensures that the blended product remains as specified at all times during the batch. Crude oil blending equipment is designed and selected to ensure minimal pressure drop and maximum reliability. Jiskoot crude oil blenders use a controller with unique self-learning control algorithms that instantly respond to changes in process conditions or feedstock quality. Components are continuously measured and adjusted during the batch to ensure optimum quality and minimum give-away.

Blended products are volume corrected to standard conditions using API 2540 / IP 200. Loading and blend documentation can be automatically produced in volume or mass units by the controller.

Cameron's crude oil blenders are designed to ensure consistent quality throughout the batch even during tank changes, feedstock starvation, loss of power or the unlikely failure of a system component. The final product is mixed in the blender header to ensure product consistency and the accuracy of any analyzer fitted. This also provides an ideal location for an automatic sampler.

Crude oil blending can be performed by two technologies In-tank blending (batch blending) Specific volumes of different kinds of crude oils stored in separate tanks are loaded into a blending tank where they are mixed until a homogenous composition is achieved. The tanks are mechanically stirred. Samples must be withdrawn to determine whether the blend is homogeneous and whether it conforms to its predetermined specification. In the event of discrepancy, correction of the blend must be conducted. The entire procedure of in-tank blending is very time consuming and expensive.

2.7.1 In-line blending

In contrast to tank blending, in-line blending is performed by simultaneously transferring different crude oils through an on-line static mixing device to the final blend tank. The predetermined flow ratio between the different crudes will provide a blend of the required quality. In-line blending enables on-line correction of the quality of the blend, by changing the ratio between feeds. The blend is produced instantaneously and no stirred ‘blending tanks’ are required. To operate the blending process efficiently and without error, on-line process analyzers are required to instantaneously measure the blend downstream and to feed the blending operators with the required quality details of the blend in production. This enables real-time and on-line correction during the blending process, providing the blend of predetermined properties. This reduces corrective re-blending of an entire tank, as well as unnecessary giveaways.

2.8 Literature Review

Heavy Oil from North Kuwait does not have an intrinsic commercial value by itself. The crude is estimated to have an API in the 11-18 API range and high sulfur of >5% wt., which makes extremely difficult the processing operation in a conventional crude oil refinery. Notwithstanding, currently there are two options to make this crude marketable by diluting or Blending the Heavy Oil (11 API) with a much lighter crude oil to produce a blend to be placed in the open market(Luzardo, 2010).

The blending optimization of Maxilla and Cabinda crude oils and Maxilla and Daqing crude oils is investigated to provide a consistent and optimal feedstock to refinery operations. The blending effect of Maxilla and Cabinda crude oils is better than that of Maxilla and Daqing crude oils (Distillation Yields and Properties from Blending Crude Oils: Maxilla and Cabinda Crude Oils, Maxilla and Daqing Crude Oils)(Li et al., 2007).

Reducing the viscosity of heavy crude oil This study shows that the blending of the heavy crude oil with a limited amount of lighter crude oil provided better performance than the other alternatives. Experimental measurements in terms of shear stress s–shear rate _c; and yield stress s0 were conducted on the mixture of heavy crude oil–light , crude oil shows that the heavy crude oil required a yield stress of 0.7 Pa, whereas no yield stress was reported for the heavy crude oil–light crude oil mixture , It was found that the blending heavy crude oil with a limited amount of lighter crude oil is the most appropriate and favorable method to lower the heavy crude oil viscosity(Hasan, Ghannam, & Esmail, 2010).

Chapter 3

Methodology

3.1 Introduction

Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies for the operation of the system(Fàbrega, Vilà, Careglio, & Papadimitriou, 2013).

Over the past decades the use of simulations has been widely accepted in chemical engineering for design and analysis of processes ,The commercial process simulation has proven to be an important tool for plant design and operations and are now art for the design, analysis and optimization of chemical engineering for design and analysis of processes , The commercial process simulation has proven to be an important tool for plant design and operations and are now considered as state of art for the design, analysis and optimization of chemical processes , There are several process simulation software packages available in today's market the most widely used simulators are Aspen HYSYS@ , this program uses in CDU and petroleum industry and its powerful software tool that can be used by engineers to design a plant and process .

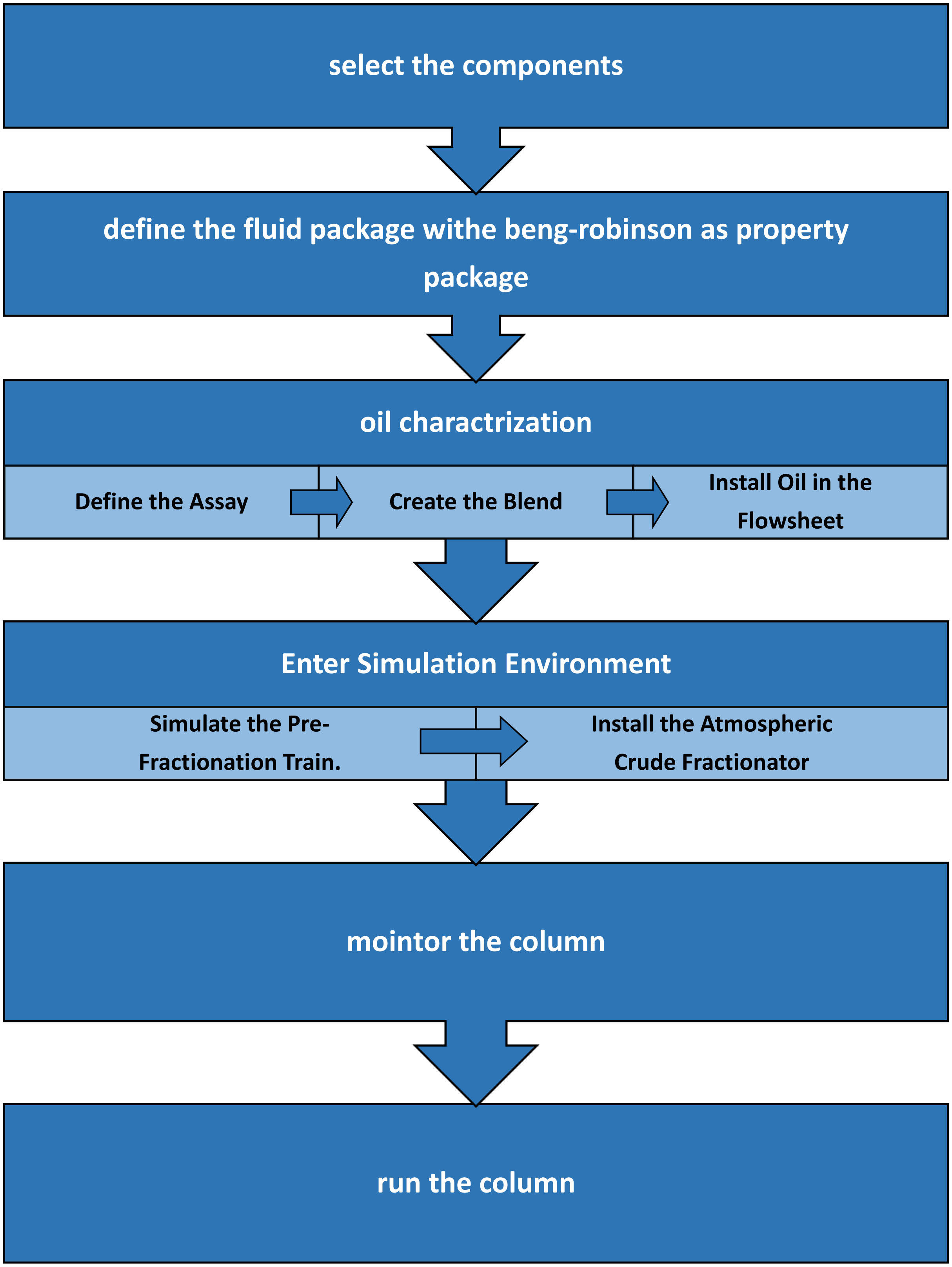
3.2 HYSYS Program

HYSYS is a powerful software tool that can be used by engineers to design plants and processes, optimize production, and enhance decision-making.

Aspen HYSYS Refining contains a database, the petroleum assay, that you can use to store and calculate the physical and petroleum properties of the crude oil stream. The petroleum assay is a vector that stores physical properties and assay properties for a specific component list.

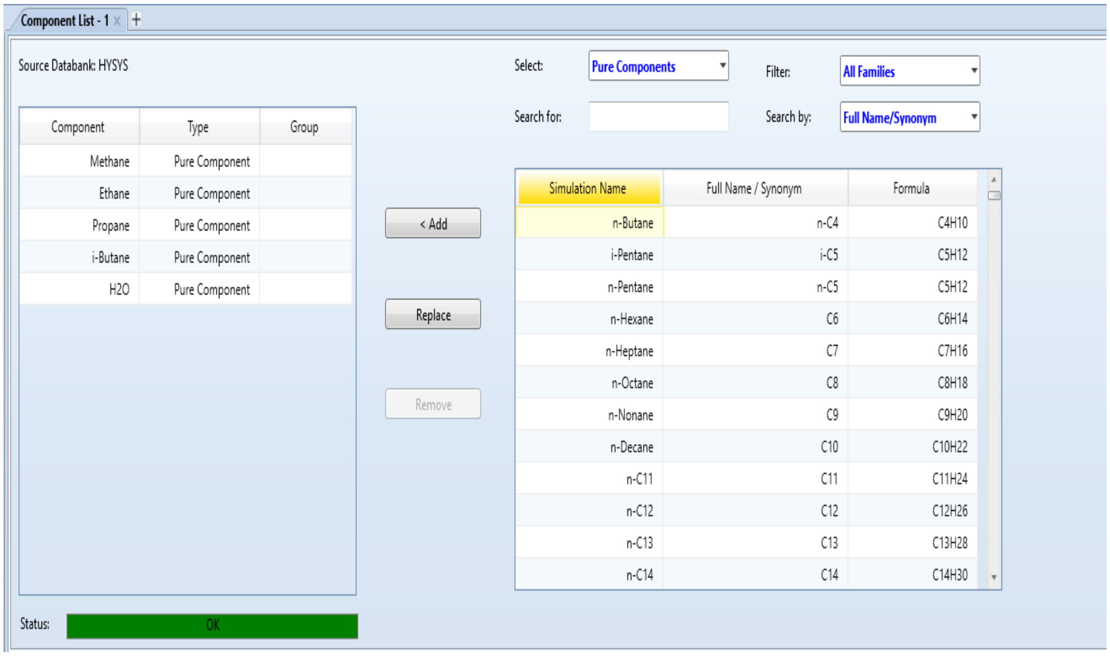
The Aspen HYSYS (V8.8) simulation program was used for the simulation studies and the investigation of the effect of various operating parameters, because it offers a high degree of flexibility to accomplish a specific task. This flexibility combined with a consistent and logical approach to show these capabilities are delivered makes HYSYS an extremely adaptable process simulation tool.

3.3 Process simulation steps



3.3.1 Select the components

The first thing which was done in order to build up the simulation case was selecting the components (Figure 3.1)



Source Databank: HYSYS

Select: Pure Components

Filter: All Families

Search for:

Search by: Full Name/Synonym

Component	Type	Group
Methane	Pure Component	
Ethane	Pure Component	
Propane	Pure Component	
i-Butane	Pure Component	
H2O	Pure Component	

Simulation Name	Full Name / Synonym	Formula
n-Butane	n-C4	C4H10
i-Pentane	i-C5	C5H12
n-Pentane	n-C5	C5H12
n-Hexane	C6	C6H14
n-Heptane	C7	C7H16
n-Octane	C8	C8H18
n-Nonane	C9	C9H20
n-Decane	C10	C10H22
n-C11	C11	C11H24
n-C12	C12	C12H26
n-C13	C13	C13H28
n-C14	C14	C14H30

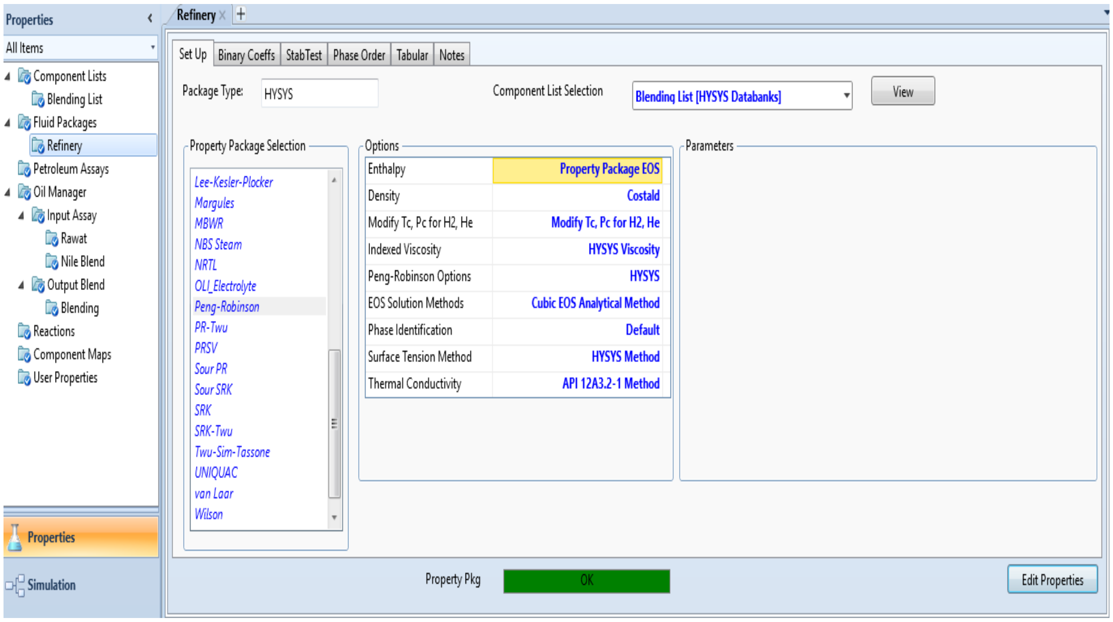
Status: OK

Figure 3.1 Selection the Components

3.3.2 Fluid package

HYSYS has strong thermodynamic foundation. The Peng-Robinson Equation of State was used among the equation of states models (Figure 3.2) because it has a high accuracy for a variety of systems over a wide range of conditions. It also rigorously solves most single-phase, two-phase, and three-phase systems with a high degree of efficiency and reliability.

select define the fluid package



Package Type: HYSYS

Component List Selection: Blending List [HYSYS Databanks]

Property Package Selection
- Lee-Kesler-Plocker
- Margules
- MBWR
- NBS Steam
- NRTL
- OLI_Electrolyte
- Peng-Robinson
- PR-Twu
- PRSV
- Sour PR
- Sour SRK
- SRK
- SRK-Twu
- Twu-Sim-Tassone
- UNIQUAC
- van Laar
- Wilson

Options

Enthalpy	Property Package EOS
Density	Costald
Modify Tc, Pc for H2, He	Modify Tc, Pc for H2, He
Indexed Viscosity	HYSYS Viscosity
Peng-Robinson Options	HYSYS
EOS Solution Methods	Cubic EOS Analytical Method
Phase Identification	Default
Surface Tension Method	HYSYS Method
Thermal Conductivity	API 12A3.2-1 Method

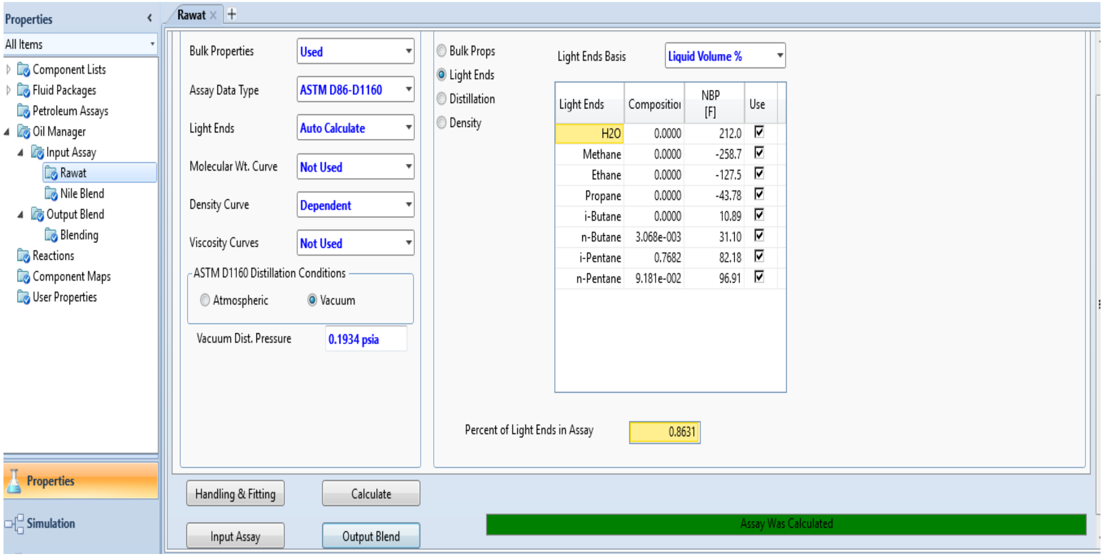
Parameters

Property Pkg: OK

Figure 3.2 Selection Fluid package

3.3.3 Oil characterization

Input the crude assay data of Rawat & Nile Blend crudes



Bulk Properties: Used

Assay Data Type: ASTM D86-D1160

Light Ends: Auto Calculate

Molecular Wt. Curve: Not Used

Density Curve: Dependent

Viscosity Curves: Not Used

ASTM D1160 Distillation Conditions: ○ Atmospheric ● Vacuum

Vacuum Dist. Pressure: 0.1934 psia

○ Bulk Props
● Light Ends
○ Distillation
○ Density

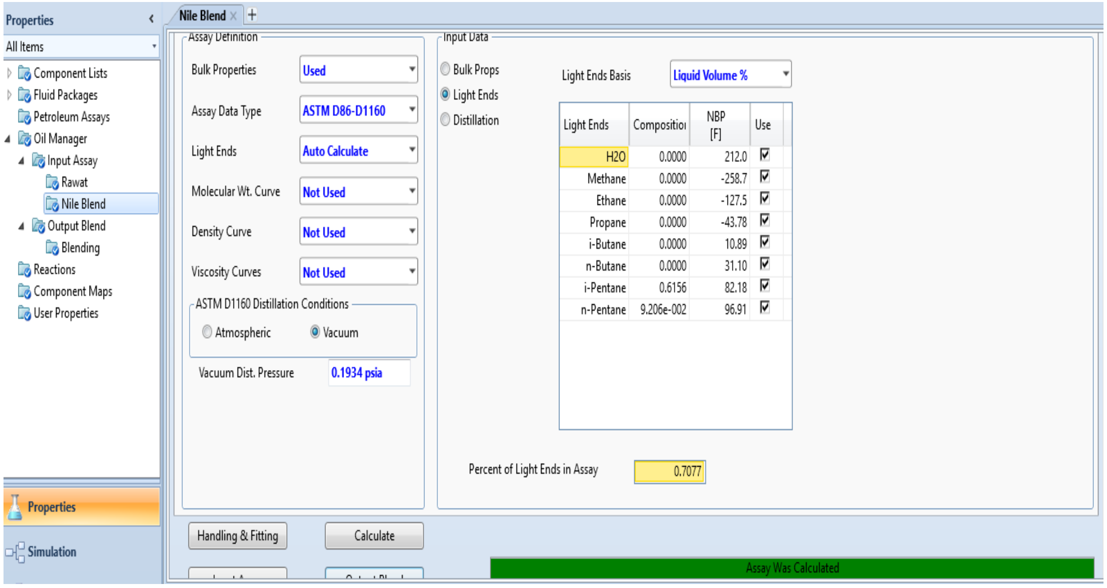
Light Ends Basis: Liquid Volume %

Light Ends	Compositio	NBP [F]	Use
H2O	0.0000	212.0	☑
Methane	0.0000	-258.7	☑
Ethane	0.0000	-127.5	☑
Propane	0.0000	-43.78	☑
i-Butane	0.0000	10.89	☑
n-Butane	3.068e-003	31.10	☑
i-Pentane	0.7682	82.18	☑
n-Pentane	9.181e-002	96.91	☑

Percent of Light Ends in Assay: 0.8631

Assay Was Calculated

Figure 3.3 Crude assay data of Rawat crude



Bulk Properties: Used
Assay Data Type: ASTM D86-D1160
Light Ends: Auto Calculate
Molecular Wt. Curve: Not Used
Density Curve: Not Used
Viscosity Curves: Not Used

ASTM D1160 Distillation Conditions
○ Atmospheric ● Vacuum
Vacuum Dist. Pressure: 0.1934 psia

○ Bulk Props
● Light Ends
○ Distillation

Light Ends Basis: Liquid Volume %

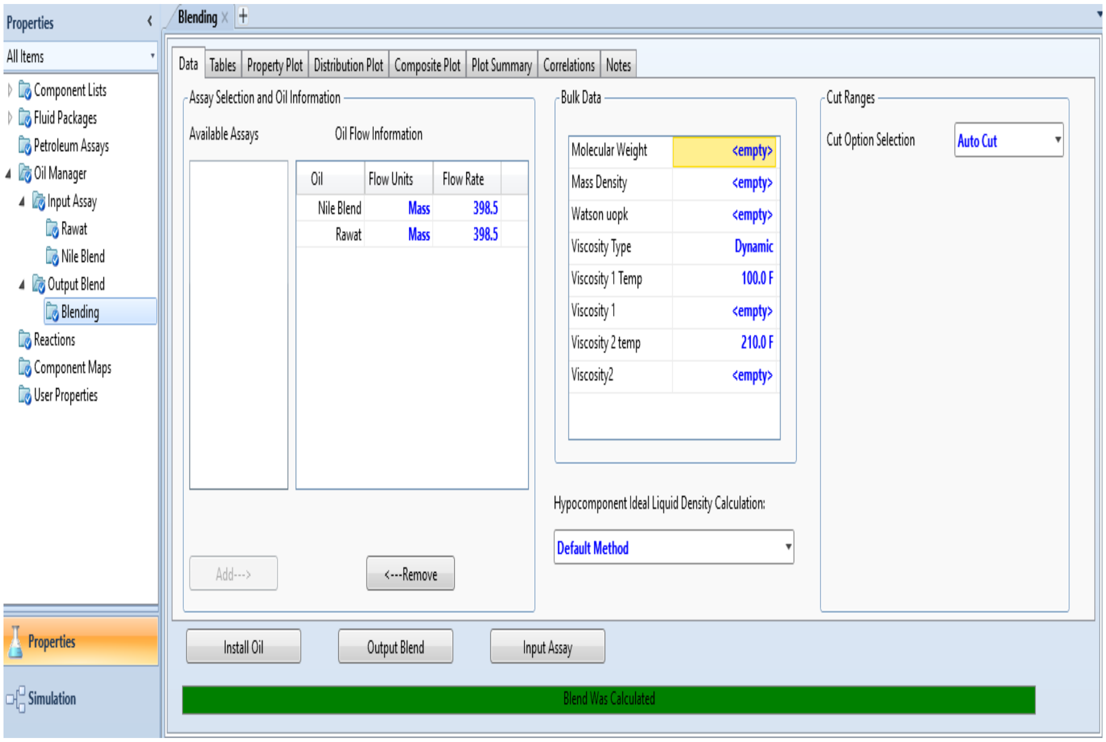
Light Ends	Compositio	NBP [F]	Use
H2O	0.0000	212.0	☑
Methane	0.0000	-258.7	☑
Ethane	0.0000	-127.5	☑
Propane	0.0000	-43.78	☑
i-Butane	0.0000	10.89	☑
n-Butane	0.0000	31.10	☑
i-Pentane	0.6156	82.18	☑
n-Pentane	9.206e-002	96.91	☑

Percent of Light Ends in Assay: 0.7077

Assay Was Calculated

Figure 3.4 Crude assay data of Nile Blend crude

Create blend between Nile blend and Rawat crude



Oil	Flow Units	Flow Rate
Nile Blend	Mass	398.5
Rawat	Mass	398.5

Molecular Weight	<empty>
Mass Density	<empty>
Watson uopk	<empty>
Viscosity Type	Dynamic
Viscosity 1 Temp	100.0 F
Viscosity 1	<empty>
Viscosity 2 temp	210.0 F
Viscosity2	<empty>

Hypocomponent Ideal Liquid Density Calculation: Default Method

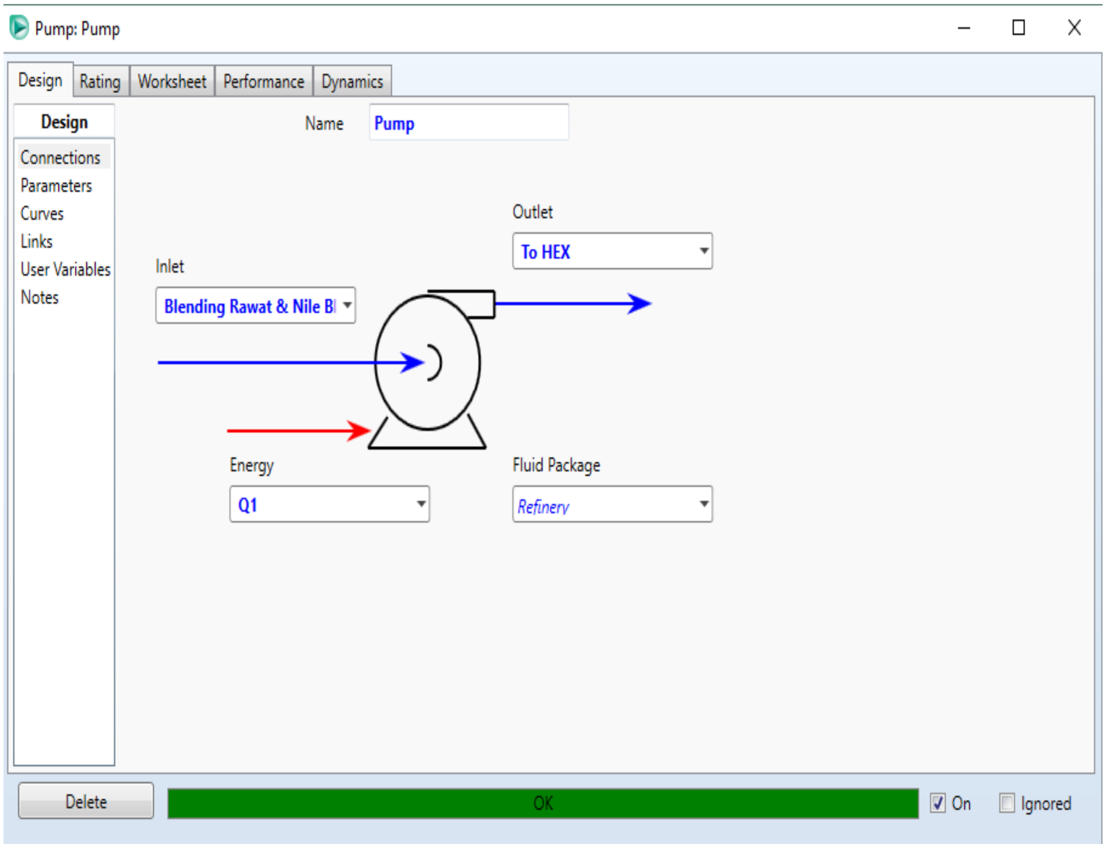
Cut Option Selection: Auto Cut

Blend Was Calculated

Figure 3.5 Blend between Nile blend and Rawat crude

3.3.4 Simulation Environment

After adding the blending Rawat and Nile Blend stream, entering to simulation environment and first add pump.



Name: Pump

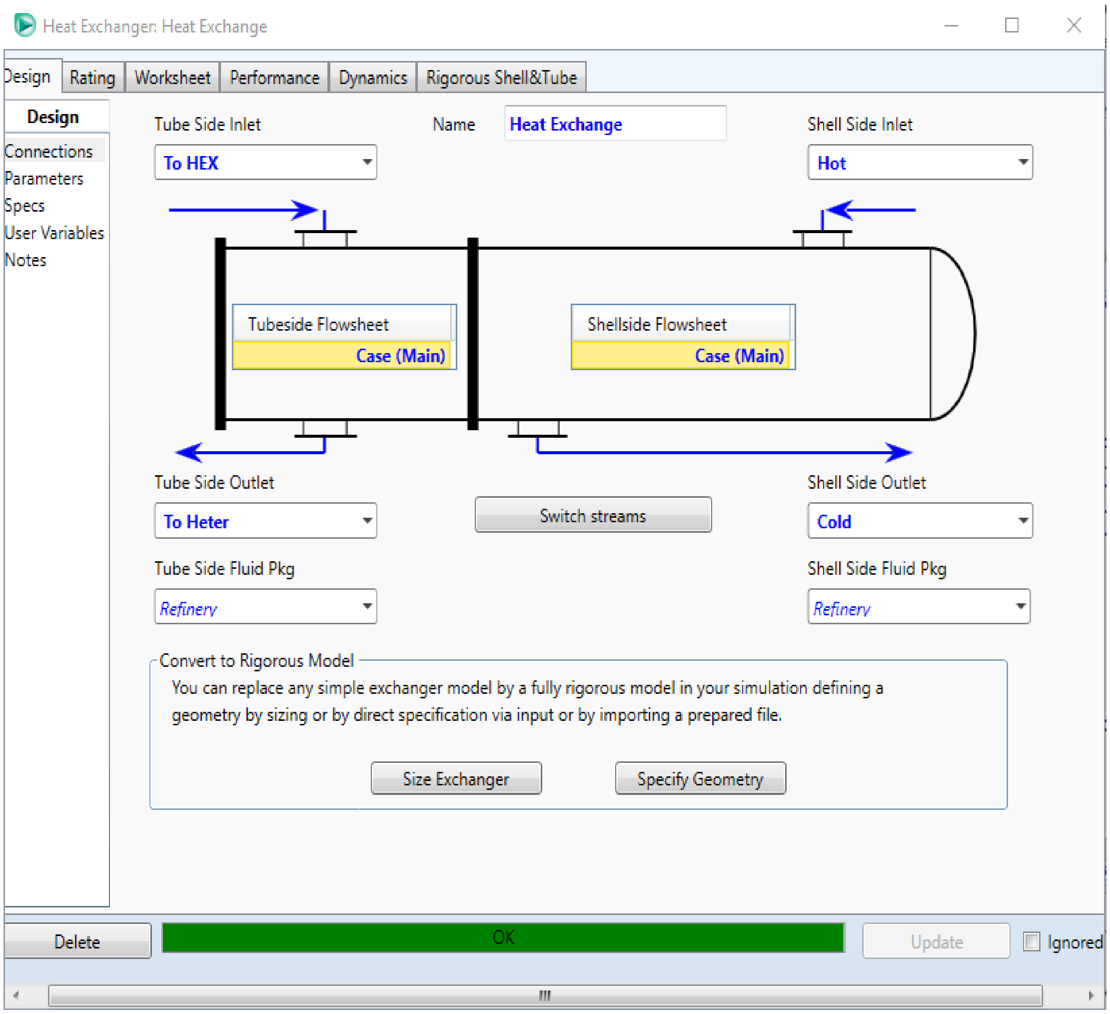
Inlet: Blending Rawat & Nile Bl

Outlet: To HEX

Energy: Q1

Fluid Package: Refinery

Figure 3.6 Main pump of crude



Tube Side Inlet: To HEX

Name: Heat Exchange

Shell Side Inlet: Hot

Tube Side Outlet: To Heter

Shell Side Outlet: Cold

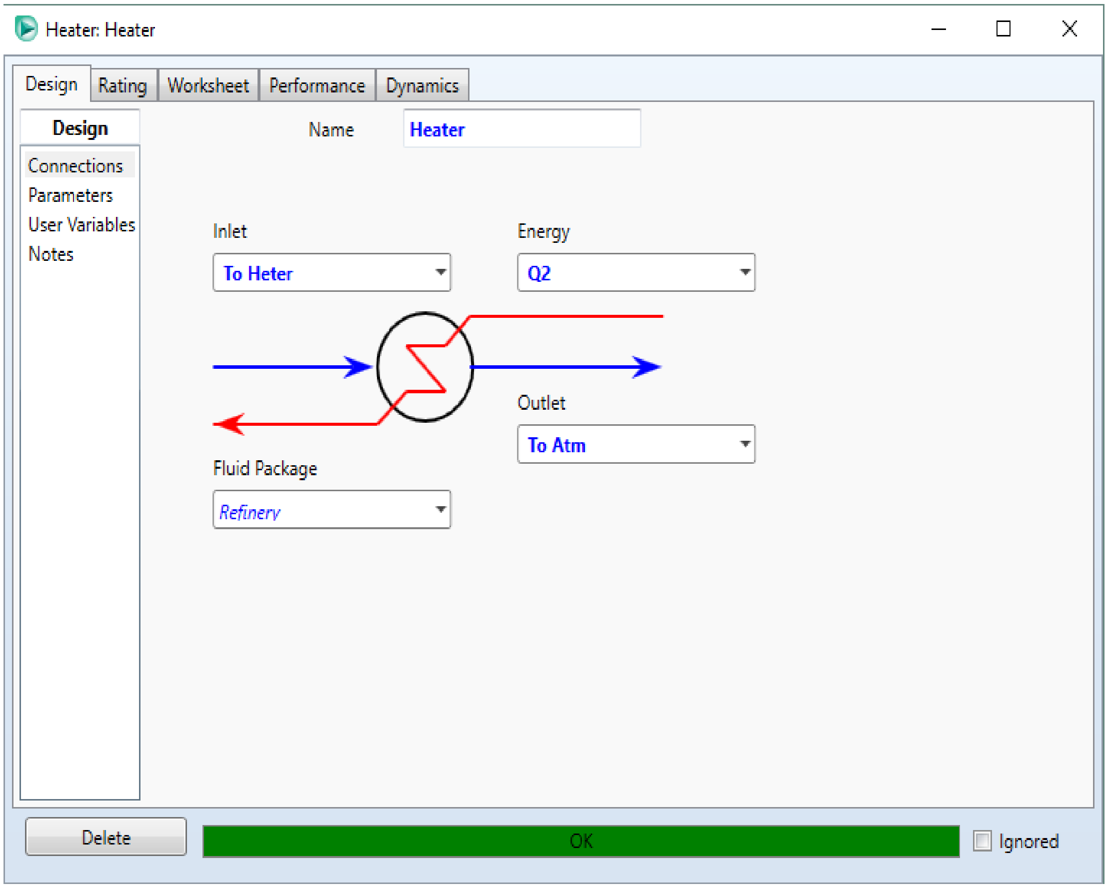
Tube Side Fluid Pkg: Refinery

Shell Side Fluid Pkg: Refinery

Convert to Rigorous Model

You can replace any simple exchanger model by a fully rigorous model in your simulation defining a geometry by sizing or by direct specification via input or by importing a prepared file.

Figure 3.7 Heat exchange



Name: Heater

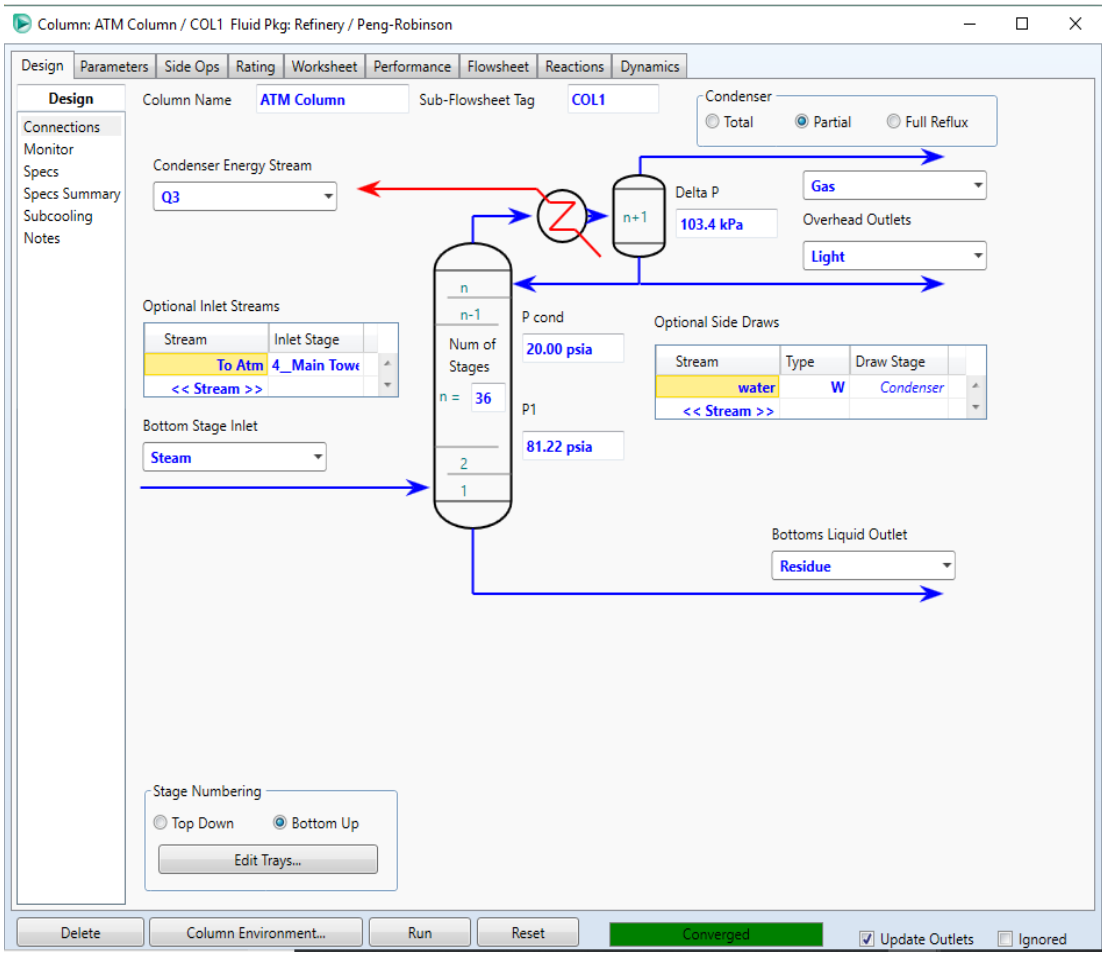
Inlet: To Heter

Energy: Q2

Outlet: To Atm

Fluid Package: Refinery

Figure 3.8 Heater


Column: ATM Column / COL1 Fluid Pkg: Refinery / Peng-Robinson

Column Name: ATM Column
Sub-Flowsheet Tag: COL1

Condenser: ○ Total ● Partial ○ Full Reflux

Condenser Energy Stream: Q3

Delta P: 103.4 kPa

Overhead Outlets: Gas; Light

Optional Inlet Streams

Stream	Inlet Stage
To Atm	4__Main Towe
<< Stream >>	

Num of Stages n = 36

P cond: 20.00 psia

P1: 81.22 psia

Optional Side Draws

Stream	Type	Draw Stage
water	W	Condenser
<< Stream >>		

Bottom Stage Inlet: Steam

Bottoms Liquid Outlet: Residue

Stage Numbering: ○ Top Down ● Bottom Up

Converged

☑ Update Outlets ☐ Ignored

Figure 3.9 Fractionator column

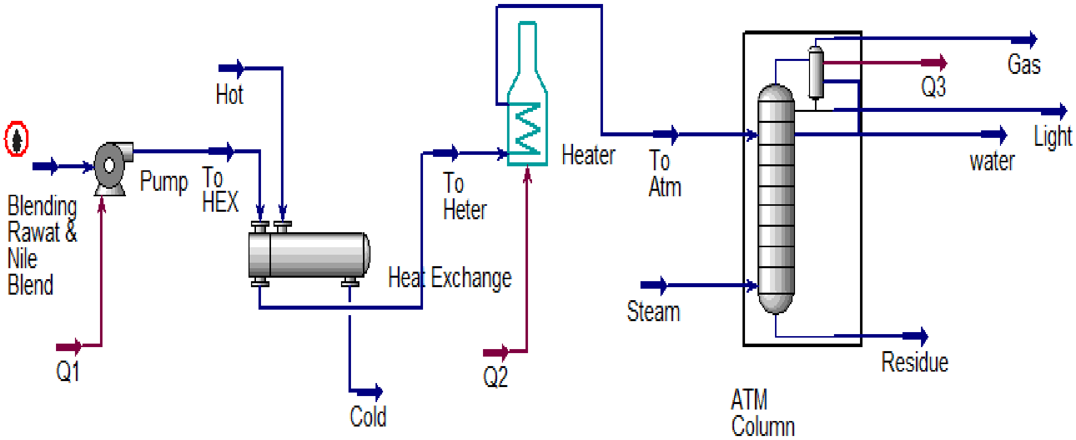


Figure 3.10 over all scheme

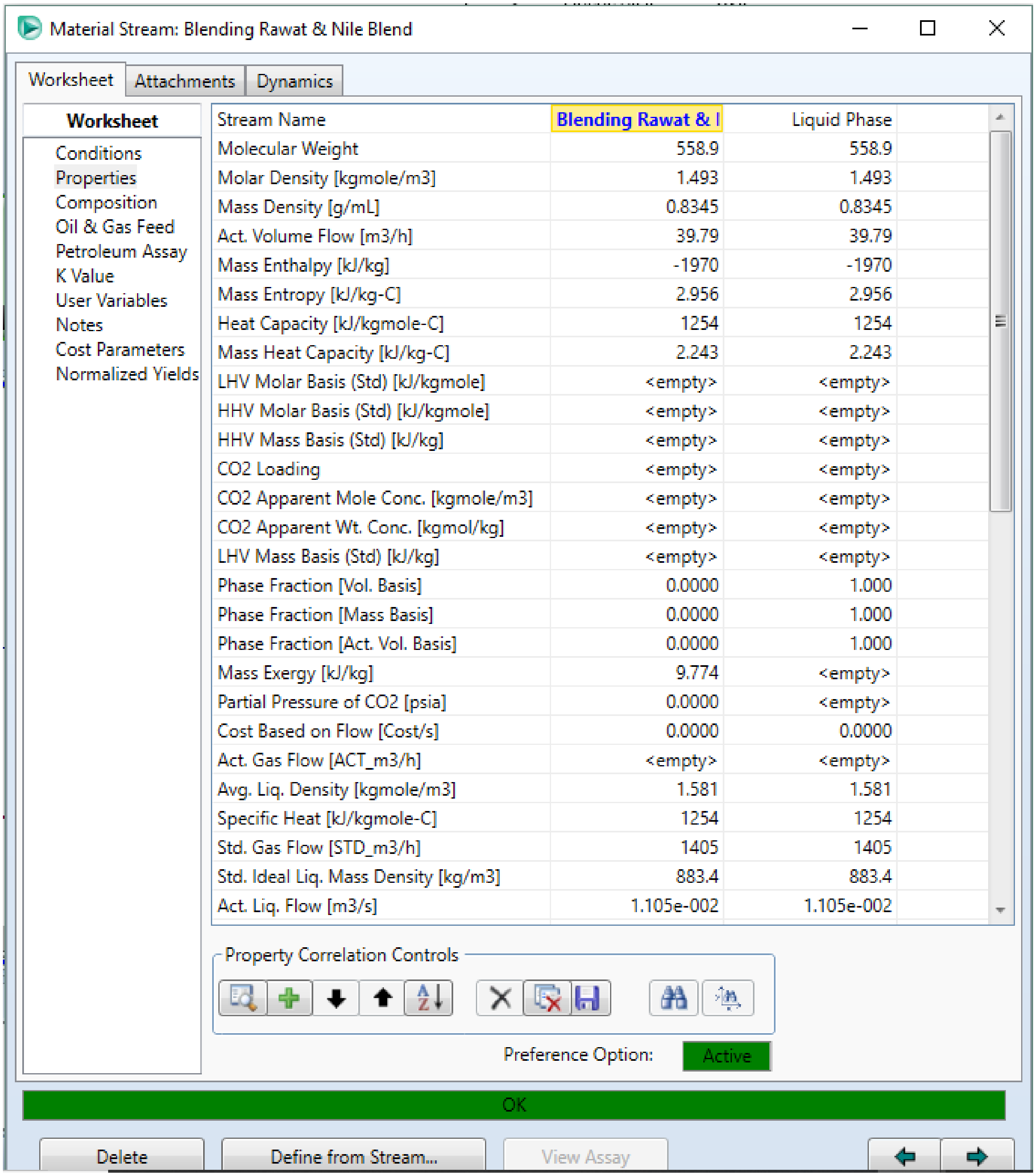
Chapter 4

Results and Discussion

4.1 Simulation results

Shows the results of ratio 50:50 & 40:60 & 30:70 for Rawat crude and Nile blend crude from Figure 4.1 to Figure 4.5.

4.1.1 Ratio 70% Rawat and 30% Nile blend

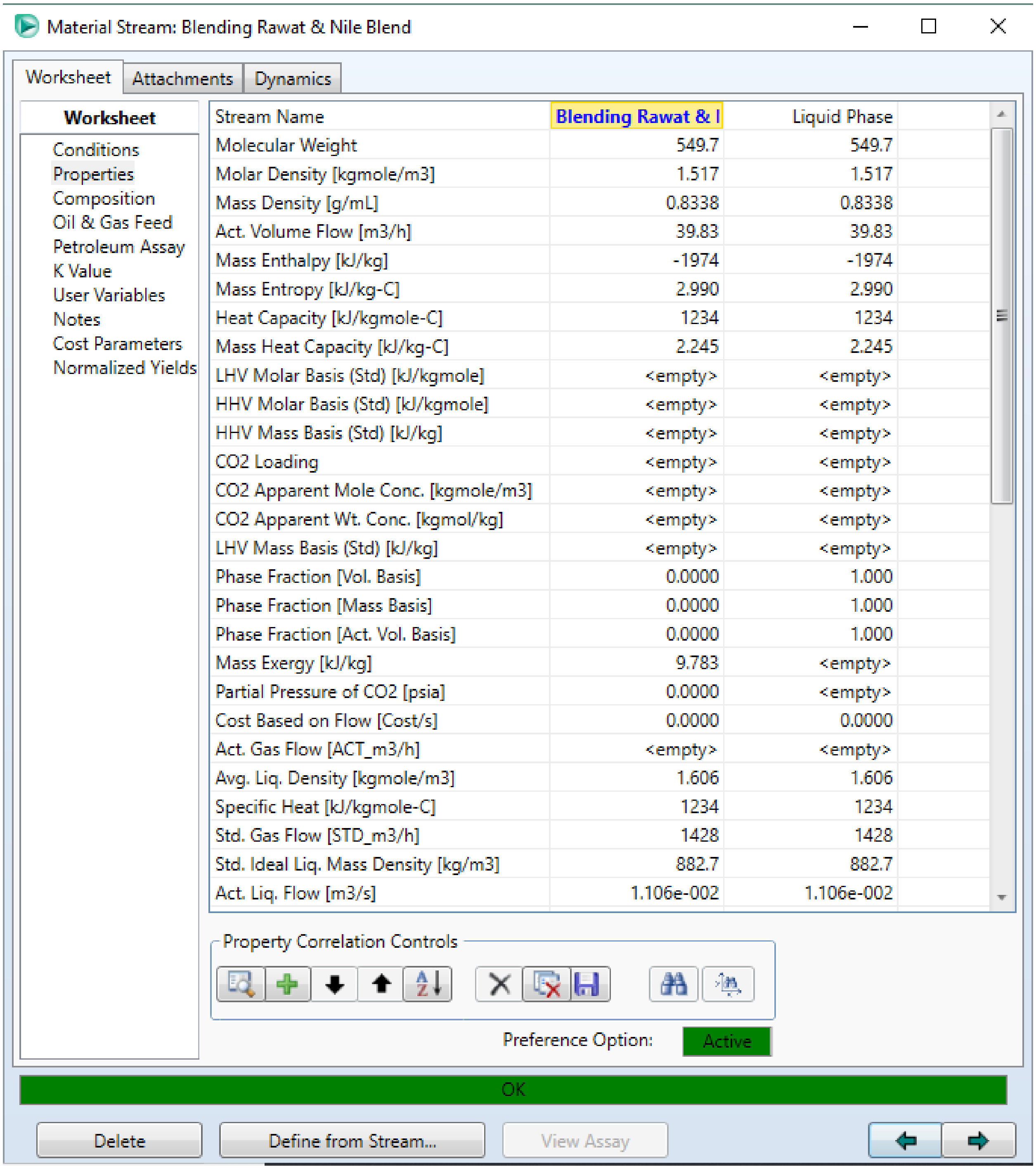


Stream Name	Blending Rawat & I	Liquid Phase
Molecular Weight	558.9	558.9
Molar Density [kgmole/m3]	1.493	1.493
Mass Density [g/mL]	0.8345	0.8345
Act. Volume Flow [m3/h]	39.79	39.79
Mass Enthalpy [kJ/kg]	-1970	-1970
Mass Entropy [kJ/kg-C]	2.956	2.956
Heat Capacity [kJ/kgmole-C]	1254	1254
Mass Heat Capacity [kJ/kg-C]	2.243	2.243
LHV Molar Basis (Std) [kJ/kgmole]	<empty>	<empty>
HHV Molar Basis (Std) [kJ/kgmole]	<empty>	<empty>
HHV Mass Basis (Std) [kJ/kg]	<empty>	<empty>
CO2 Loading	<empty>	<empty>
CO2 Apparent Mole Conc. [kgmole/m3]	<empty>	<empty>
CO2 Apparent Wt. Conc. [kgmol/kg]	<empty>	<empty>
LHV Mass Basis (Std) [kJ/kg]	<empty>	<empty>
Phase Fraction [Vol. Basis]	0.0000	1.000
Phase Fraction [Mass Basis]	0.0000	1.000
Phase Fraction [Act. Vol. Basis]	0.0000	1.000
Mass Exergy [kJ/kg]	9.774	<empty>
Partial Pressure of CO2 [psia]	0.0000	<empty>
Cost Based on Flow [Cost/s]	0.0000	0.0000
Act. Gas Flow [ACT_m3/h]	<empty>	<empty>
Avg. Liq. Density [kgmole/m3]	1.581	1.581
Specific Heat [kJ/kgmole-C]	1254	1254
Std. Gas Flow [STD_m3/h]	1405	1405
Std. Ideal Liq. Mass Density [kg/m3]	883.4	883.4
Act. Liq. Flow [m3/s]	1.105e-002	1.105e-002

Preference Option: Active

Figure 4.1 Properties of blending 70:30

4.1.2 Ratio 60% Rawat and 40% Nile blend

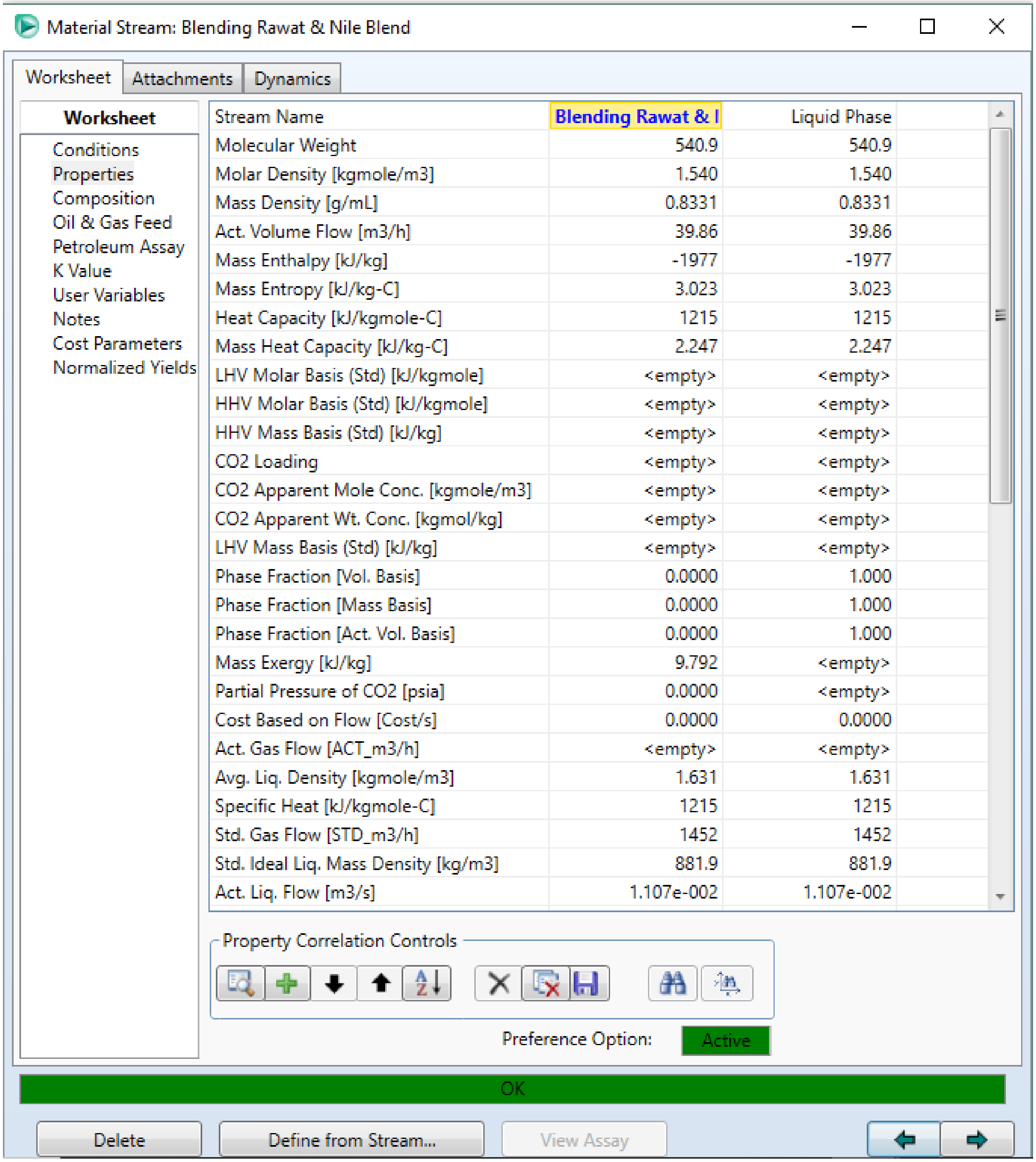


Stream Name	Blending Rawat & I	Liquid Phase
Molecular Weight	549.7	549.7
Molar Density [kgmole/m3]	1.517	1.517
Mass Density [g/mL]	0.8338	0.8338
Act. Volume Flow [m3/h]	39.83	39.83
Mass Enthalpy [kJ/kg]	-1974	-1974
Mass Entropy [kJ/kg-C]	2.990	2.990
Heat Capacity [kJ/kgmole-C]	1234	1234
Mass Heat Capacity [kJ/kg-C]	2.245	2.245
LHV Molar Basis (Std) [kJ/kgmole]	<empty>	<empty>
HHV Molar Basis (Std) [kJ/kgmole]	<empty>	<empty>
HHV Mass Basis (Std) [kJ/kg]	<empty>	<empty>
CO2 Loading	<empty>	<empty>
CO2 Apparent Mole Conc. [kgmole/m3]	<empty>	<empty>
CO2 Apparent Wt. Conc. [kgmol/kg]	<empty>	<empty>
LHV Mass Basis (Std) [kJ/kg]	<empty>	<empty>
Phase Fraction [Vol. Basis]	0.0000	1.000
Phase Fraction [Mass Basis]	0.0000	1.000
Phase Fraction [Act. Vol. Basis]	0.0000	1.000
Mass Exergy [kJ/kg]	9.783	<empty>
Partial Pressure of CO2 [psia]	0.0000	<empty>
Cost Based on Flow [Cost/s]	0.0000	0.0000
Act. Gas Flow [ACT_m3/h]	<empty>	<empty>
Avg. Liq. Density [kgmole/m3]	1.606	1.606
Specific Heat [kJ/kgmole-C]	1234	1234
Std. Gas Flow [STD_m3/h]	1428	1428
Std. Ideal Liq. Mass Density [kg/m3]	882.7	882.7
Act. Liq. Flow [m3/s]	1.106e-002	1.106e-002

Preference Option: Active

Figure 4.2 Properties of blending 60:40

4.1.3 Ratio 50% Rawat and 50% Nile blend



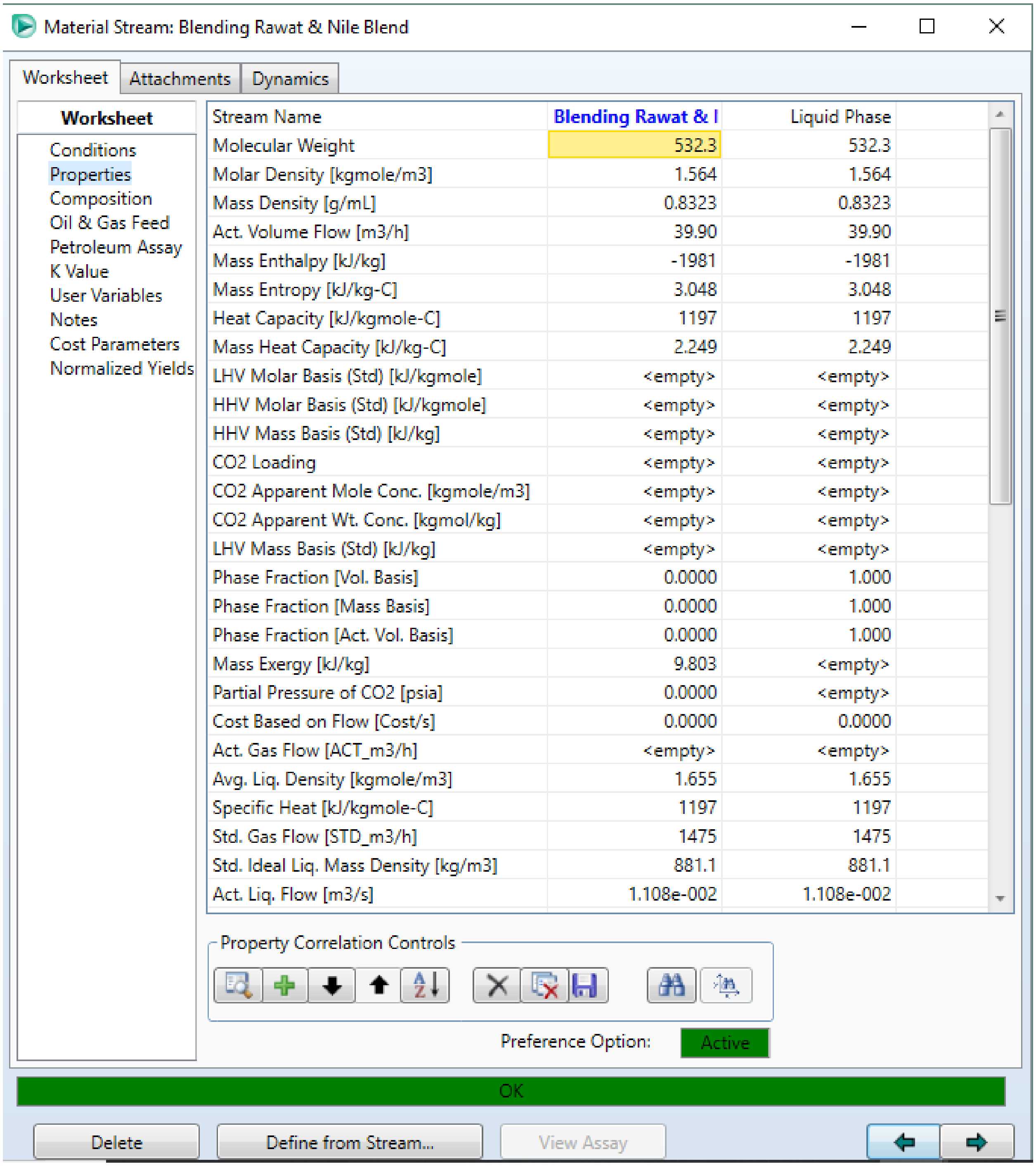
Stream Name	Blending Rawat & I	Liquid Phase
Molecular Weight	540.9	540.9
Molar Density [kgmole/m3]	1.540	1.540
Mass Density [g/mL]	0.8331	0.8331
Act. Volume Flow [m3/h]	39.86	39.86
Mass Enthalpy [kJ/kg]	-1977	-1977
Mass Entropy [kJ/kg-C]	3.023	3.023
Heat Capacity [kJ/kgmole-C]	1215	1215
Mass Heat Capacity [kJ/kg-C]	2.247	2.247
LHV Molar Basis (Std) [kJ/kgmole]	<empty>	<empty>
HHV Molar Basis (Std) [kJ/kgmole]	<empty>	<empty>
HHV Mass Basis (Std) [kJ/kg]	<empty>	<empty>
CO2 Loading	<empty>	<empty>
CO2 Apparent Mole Conc. [kgmole/m3]	<empty>	<empty>
CO2 Apparent Wt. Conc. [kgmol/kg]	<empty>	<empty>
LHV Mass Basis (Std) [kJ/kg]	<empty>	<empty>
Phase Fraction [Vol. Basis]	0.0000	1.000
Phase Fraction [Mass Basis]	0.0000	1.000
Phase Fraction [Act. Vol. Basis]	0.0000	1.000
Mass Exergy [kJ/kg]	9.792	<empty>
Partial Pressure of CO2 [psia]	0.0000	<empty>
Cost Based on Flow [Cost/s]	0.0000	0.0000
Act. Gas Flow [ACT_m3/h]	<empty>	<empty>
Avg. Liq. Density [kgmole/m3]	1.631	1.631
Specific Heat [kJ/kgmole-C]	1215	1215
Std. Gas Flow [STD_m3/h]	1452	1452
Std. Ideal Liq. Mass Density [kg/m3]	881.9	881.9
Act. Liq. Flow [m3/s]	1.107e-002	1.107e-002

Preference Option: Active

OK

Figure 4.3 Properties of blending 50:50

4.1.4 Ratio 40% Rawat and 60% Nile blend



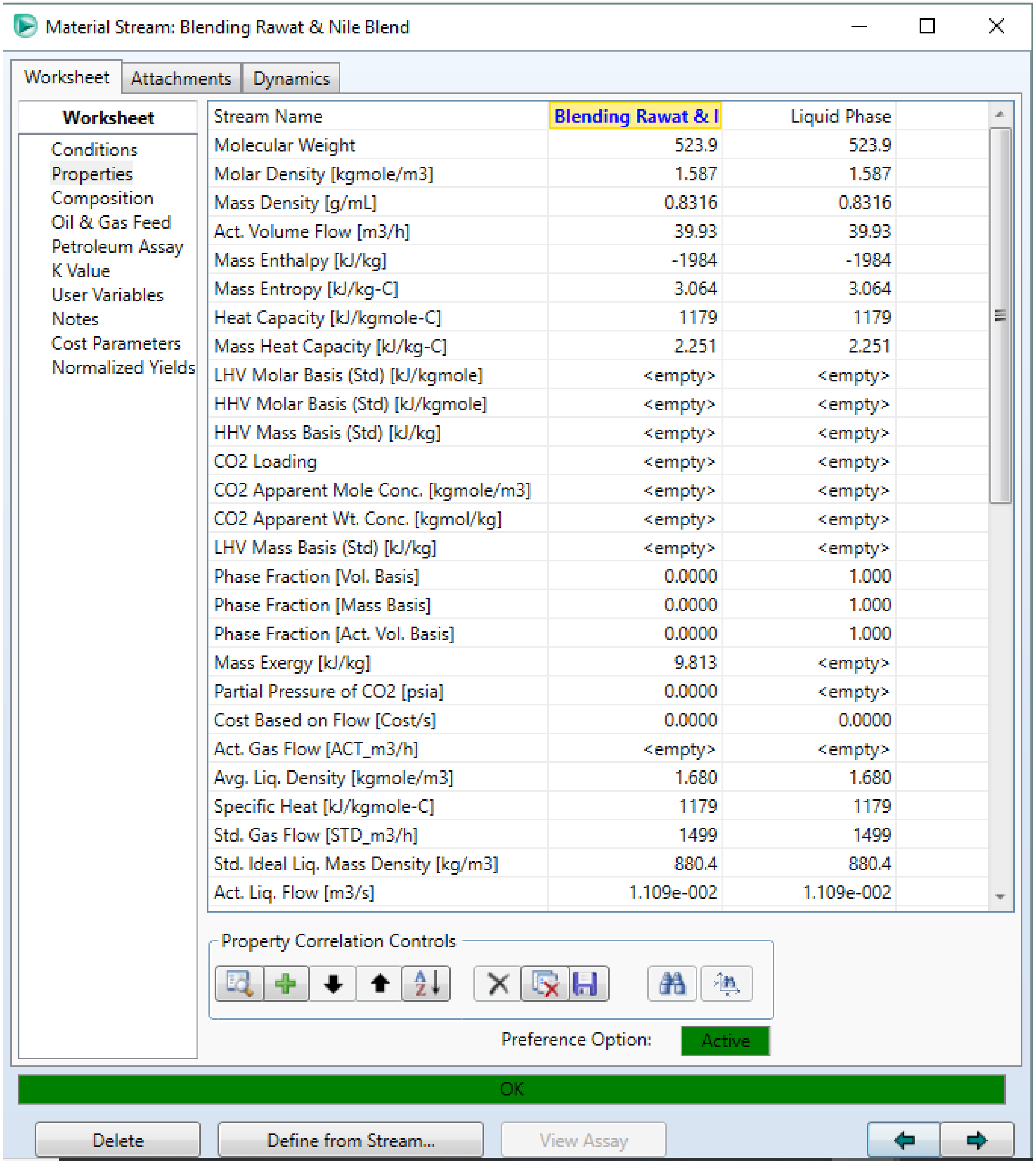
Stream Name	Blending Rawat & I	Liquid Phase
Molecular Weight	532.3	532.3
Molar Density [kgmole/m3]	1.564	1.564
Mass Density [g/mL]	0.8323	0.8323
Act. Volume Flow [m3/h]	39.90	39.90
Mass Enthalpy [kJ/kg]	-1981	-1981
Mass Entropy [kJ/kg-C]	3.048	3.048
Heat Capacity [kJ/kgmole-C]	1197	1197
Mass Heat Capacity [kJ/kg-C]	2.249	2.249
LHV Molar Basis (Std) [kJ/kgmole]	<empty>	<empty>
HHV Molar Basis (Std) [kJ/kgmole]	<empty>	<empty>
HHV Mass Basis (Std) [kJ/kg]	<empty>	<empty>
CO2 Loading	<empty>	<empty>
CO2 Apparent Mole Conc. [kgmole/m3]	<empty>	<empty>
CO2 Apparent Wt. Conc. [kgmol/kg]	<empty>	<empty>
LHV Mass Basis (Std) [kJ/kg]	<empty>	<empty>
Phase Fraction [Vol. Basis]	0.0000	1.000
Phase Fraction [Mass Basis]	0.0000	1.000
Phase Fraction [Act. Vol. Basis]	0.0000	1.000
Mass Exergy [kJ/kg]	9.803	<empty>
Partial Pressure of CO2 [psia]	0.0000	<empty>
Cost Based on Flow [Cost/s]	0.0000	0.0000
Act. Gas Flow [ACT_m3/h]	<empty>	<empty>
Avg. Liq. Density [kgmole/m3]	1.655	1.655
Specific Heat [kJ/kgmole-C]	1197	1197
Std. Gas Flow [STD_m3/h]	1475	1475
Std. Ideal Liq. Mass Density [kg/m3]	881.1	881.1
Act. Liq. Flow [m3/s]	1.108e-002	1.108e-002

Preference Option: Active

OK

Figure 4.4 Properties of blending 40:60

4.1.5 Ratio 30% Rawat and 70% Nile blend



Stream Name	Blending Rawat & I	Liquid Phase
Molecular Weight	523.9	523.9
Molar Density [kgmole/m3]	1.587	1.587
Mass Density [g/mL]	0.8316	0.8316
Act. Volume Flow [m3/h]	39.93	39.93
Mass Enthalpy [kJ/kg]	-1984	-1984
Mass Entropy [kJ/kg-C]	3.064	3.064
Heat Capacity [kJ/kgmole-C]	1179	1179
Mass Heat Capacity [kJ/kg-C]	2.251	2.251
LHV Molar Basis (Std) [kJ/kgmole]	<empty>	<empty>
HHV Molar Basis (Std) [kJ/kgmole]	<empty>	<empty>
HHV Mass Basis (Std) [kJ/kg]	<empty>	<empty>
CO2 Loading	<empty>	<empty>
CO2 Apparent Mole Conc. [kgmole/m3]	<empty>	<empty>
CO2 Apparent Wt. Conc. [kgmol/kg]	<empty>	<empty>
LHV Mass Basis (Std) [kJ/kg]	<empty>	<empty>
Phase Fraction [Vol. Basis]	0.0000	1.000
Phase Fraction [Mass Basis]	0.0000	1.000
Phase Fraction [Act. Vol. Basis]	0.0000	1.000
Mass Exergy [kJ/kg]	9.813	<empty>
Partial Pressure of CO2 [psia]	0.0000	<empty>
Cost Based on Flow [Cost/s]	0.0000	0.0000
Act. Gas Flow [ACT_m3/h]	<empty>	<empty>
Avg. Liq. Density [kgmole/m3]	1.680	1.680
Specific Heat [kJ/kgmole-C]	1179	1179
Std. Gas Flow [STD_m3/h]	1499	1499
Std. Ideal Liq. Mass Density [kg/m3]	880.4	880.4
Act. Liq. Flow [m3/s]	1.109e-002	1.109e-002

Preference Option: Active

Figure 4.5 Properties of blending 30:70

Table 4.1 Molecular weight percentages

Rawat %	Nile Blend %	Molecular weight	
70	30	558.9	
60	40	549.7	
50	50	540.9	
40	60	532.3	
30	70	523.9	

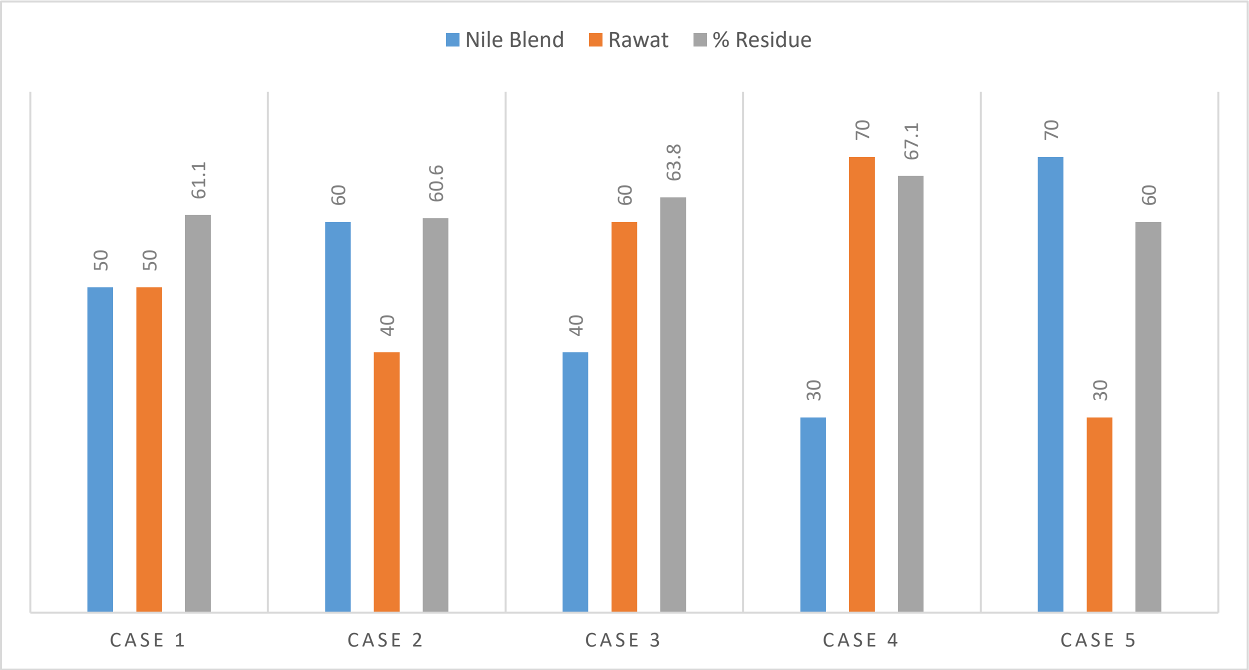


Figure 4.6 Blend constitutes vs Residue

4.2 Discussion

As we notice in the Figure 4.6 we can safely say with confidence that the data show the Rawat blend when blended with Nile Blend will yield a better mixture that gives more valuable products that is far better in the processing.

We also found the relationship between the molecular weight and the residue yield from the processing, when the molecular weight increases the residue increases and vice versa, so we can conclude the relationship to be directly proportional between the molecular weight and residue, as in Figure4.6 when the mixture constitutes was 50% Rawat blend and 50% Nile Blend it yielded out residue of 61.1%, but when using a mixture of only 30% Nile blend and the majority 70% was made of Rawat blend this produces a residue of percentage 67.1%. Care must be taken into mixing not to use too much of the Nile Blend and forgetting about the Rawat Blend which is our main focus of the whole study.

Chapter 5

Conclusions and Recommendations

5.1 Conclusions

We have concluded this study in which we have simulated blending the Rawat crude due to its high pour point with the Nile Blend in El Obeid refinery, by using Aspen HYSYS. the results yielded was very encouraging, which showed that when blending occurs, the Rawat blend the residue came from both Rawat and Nile Blend yield decreases with increasing ratio of Nile Blend this is due to increase in molecular weight.

5.2 Recommendations

There are recommendations and suggestion that improve the process such as:

- Addition of a side stripper to the distillation column.
- Addition of a flash separator before the distillation column in the unit.
- Residue can be processed in a delayed coker.

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