Operating Condition of Optimizing High CO_2 Content of Natural Gas Liquids

by

Zarul Hafiz Bin Rashidi

Dissertation submitted in partial fulfillment of the requirement for the
Bachelor of Engineering (Hons)
(Chemical Engineering)

SEPTEMBER 2012

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CERTIFICATION OF APPROVAL

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Approved by,

(A.P Dr Kashayar Nasrifar)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

SEPTEMBER 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

ZARUL HAFIZ BIN RASHIDI

ABSTRACT

Natural gas liquid is one of the products from petroleum reservoir. Natural gas liquid or NGL is one of the components of natural gas that are liquid at surface in field facilities or in gas-processing plants (Schlumberger Oilfield Glossary website, 2012). The compositions of this substance are propane, butane, pentane, hexane and heptanes, but not methane and ethane, since these hydrocarbons need refrigeration to be liquefied. NGL can be separated to several classes such as low (condensate), intermediate (natural gasoline) and high (liquefied petroleum gas) vapor pressure based on their vapor pressure

The best operating condition (temperature and pressure) need to be study and analyze in order to produce highest composition of liquid in natural gas liquid. Phase diagram of natural gas component give us the hint and reference how to manipulated and vary the operating conditions. From the phase diagram, the composition of liquid at certain temperature and pressure can be calculated even though there contain more than two components in the mixture. Information such as Cricondenbar, Cricondentherm, Critical Point, bubble point curve and dew point curve of natural gas give us a lot of information to manipulate the operating condition.

A simulation of model process of natural gas liquid must be done to get the best operating conditions of production natural gas liquid (NGL). This simulation can be done using HYSYS. From the simulation, we compare from different operating condition with the composition of liquid and CO2 in the substance.

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CHAPTER 1
INTPRODUCTION

1.1 BACKGROUND

Nowadays, demands of natural gas liquid (NGL) keep increasing year by year. Production of NGL which are can be separated through the process of absorption, adsorption, condensation, or any other methods in gas processing or cycling plants before transportation of natural gas in pipelines (Oil and Gas IQ website, 2012). Applications of NGL widely used in the most of the manufacture industry. Examples of NGL application are used as fuel to generate public or industrial power station and raw material for chemical synthesis. NGL can also be kept as a liquid to be used as an alternative transportation fuel (California Energy Commission, 2012). Due to high demand of this liquid, high efficiency of process need to be done in order to satisfy worldwide demand.

There a lot of NGL production plant in this world. The most common technology apply to produce NGL is Natural Gas Liquid Recovery. The main purposes of this technology are to separate and purify heavier hydrocarbon from our natural gas (Sep – Pro System, 2012). Natural gas will easily into liquid under pressure inside of pipeline. Formation of natural gas in liquid phase inside of pipeline will cost a lot of problem such as slowing the flow and increasing the wear on the piping. So it is better to do a separation of natural gas in liquid phase before it entering the pipeline. According to Naturalhub, 2012 extracted hydrocarbons, such as propane, butane, and naphtha, can be sold more profitably as separate products. Some of the equipment exist inside the natural gas plant are cross heat exchanger, three phase separators and propane refrigeration,

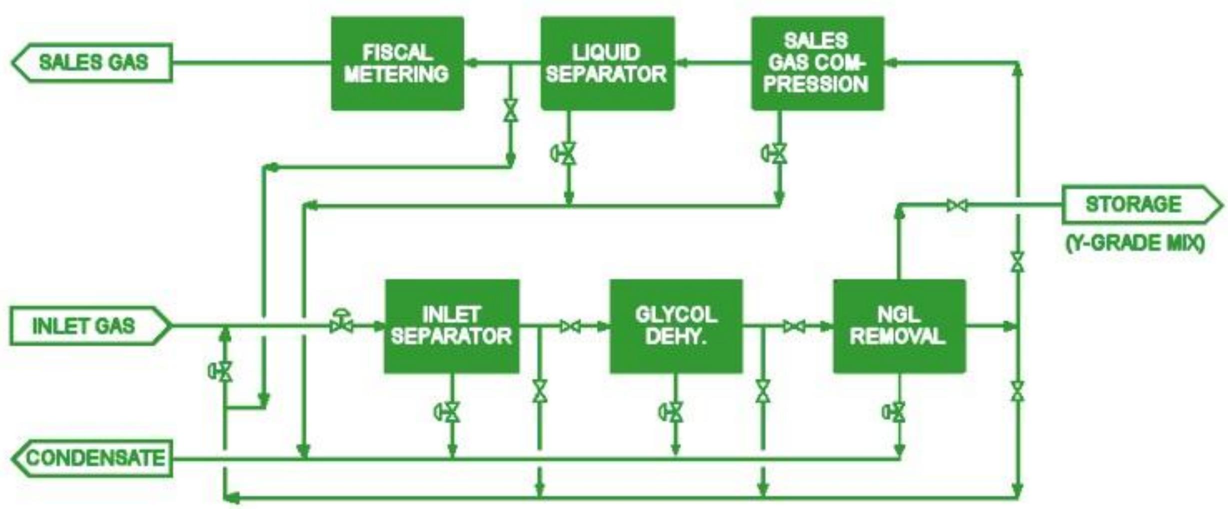


Figure 1.1: Example of process flow diagram for natural gas liquids recovery plant

So in this report, the author purposes the new operating conditions that give highest composition of liquid in natural gas liquid production. During production of NGL, we prefer highest composition of liquid in NGL compare to composition of vapor phase. It is because, liquid phase of NGL give us a lot of economical benefit compare to vapor phase. Liquid phase also give us a less complicated transportation problem and it is easier for storage purpose (The Oil Drum, 2012). Production of natural gas liquid depends on the operating conditions such as temperature and pressure. From this two operating parameters, the composition of liquid based on the phase diagram of natural gas liquid will vary. Other than highest amount of liquid composition, amount of CO2 need to be minimize in order give better economically benefit of natural gas industry **(**Nurulhuda Azmi, Removal of High CO2 Content in natural gas by formation of hydrates a potential solution for CO2 gas emission, 2008 **)**. From this project, comparison of operating condition and the result of composition of liquid will be study and determine the best operating condition with highest amount of liquid and lowest amount of CO2 composition.

1.2 PROBLEM STATEMENT

Phase behavior of natural gas depending on temperature and pressure of our system. It is easier to explain the behavior of natural gas if there is pure substance and only have one phase at certain temperature and pressure. But as we dealing with natural gas, we have to consider mixture of component and difference phase of mixture at certain temperature and pressure.

Based on the phase diagram of natural gas, as vary the pressure at isothermal condition, natural gas start to change the form from liquid to liquid+gas phase. And amount of liquid composition is increase as we vary pressure at constant temperature but at one point, the amount of liquid will be highest and as we keep decrease the pressure the amount of liquid will be decrease (Chapter 3, phase transition,2012). In this project through simulation and calculation is to determine at what pressure give us the highest amount of liquid at constant temperature. And during this project, the value of pressure must be determined from different temperature also.

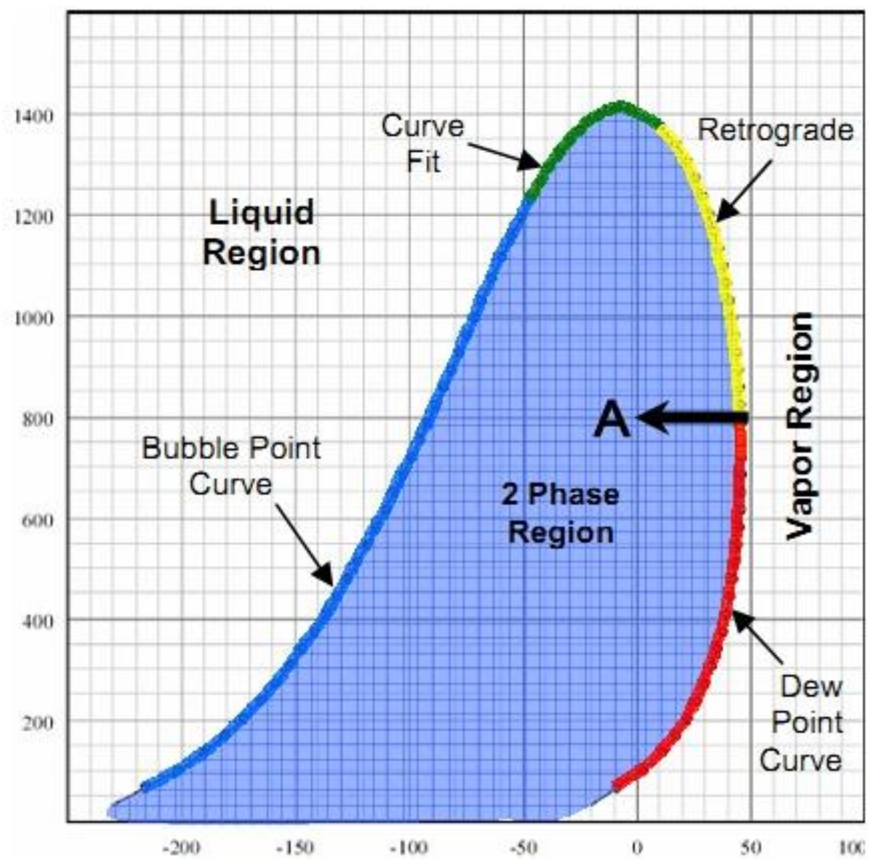


Figure 1.2: Phase diagram of natural gas

1.3 OBJECTIVES

Our main objective in this project is to do a simulation production of Natural Gas Liquid as vary the operating condition (temperature and pressure) to get highest composition of liquid on the mixture. Other than that, the percentage of carbon dioxide produce during production of NGL will also be considered because this substance will give a bad effect to our product and equipment.

1.4 SCOPE OF STUDY

For this project, our scope of study will focus on the simulation of the see the relationship between the effects of operation condition to our composition of liquid inside of natural gas liquid. Study regarding the phase diagram of natural gas will lead to the specific relationship between operating condition and percentage of liquid in our mixture. From each constant temperature and vary the pressure, the amount of liquid will different. Thus the aim of this project to do a simulation to get the best operating condition of production of Natural Gas Liquid that will give us highest percentage of liquid.

CHAPTER 2
LITERATURE REVIEW

2.1 RETROGRADE CONDENSATIONS OF NATURAL GAS

During production of natural gas liquid, retrograde conditions occur. The formation of liquid hydrocarbons in a gas reservoir as the pressure in the reservoir decreases below dew point pressure is called as retrograde conditions (Schlumberger Oilfield Glossary website, 2012). This condensation will occur at isothermal condition (constant temperature) and as pressure vary from below of its dew point. According to Francis S. Manning, Oilfield Processing of Petroleum: Natural Gas, Volume 1, retrograde phenomenon is the interesting phenomenon of multi-component system compare to the behavior of single-component systems

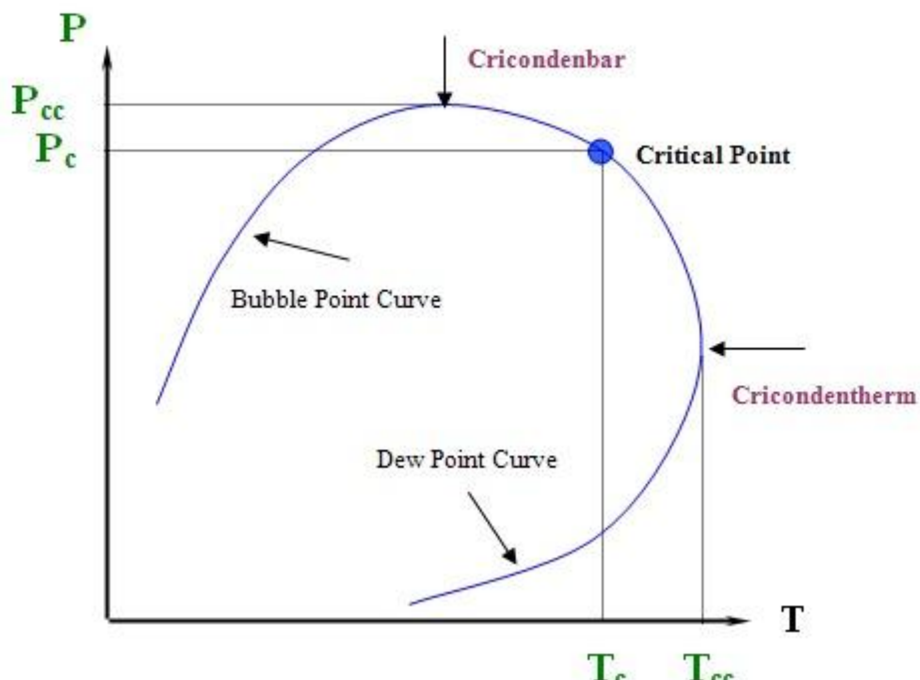


Figure 2.1: Cricondenbar, cricondentherm and critical point

From phase diagram on figure 2, cricondenbar point to cricondentherm point call as retrograde curve. Cricondenbar is the point where pressure point of vapor-liquid coexistence for multi-component system. For cricondentherm, this point is where the temperature point of vapor-liquid coexistence. This two point same as for single component system that is bubble point and dew point.

Differ from single component system, retrograde condensation for multi-component system give us differ result as we vary the pressure at isothermal condition. For single component system, at constant temperature, from dew point to bubble point, the amount of liquid increase from 0% to 100% and it will completely in liquid phase after it reach the bubble point. But for multi-component system, starting in an all vapor condition (0 % liquid), by increasing pressure, our systems enter to the two-phase region. Thus, some liquid has to drop out, as the pressure keeps increasing, according to general knowledge more liquid will be form. But, based on the graph below, our system did not reach to 100% liquid and it goes back to 0% liquid condition. Due to retrograde condensations, it is important to determine and maintain pressure to keep our mixture at maximum liquid dropout.

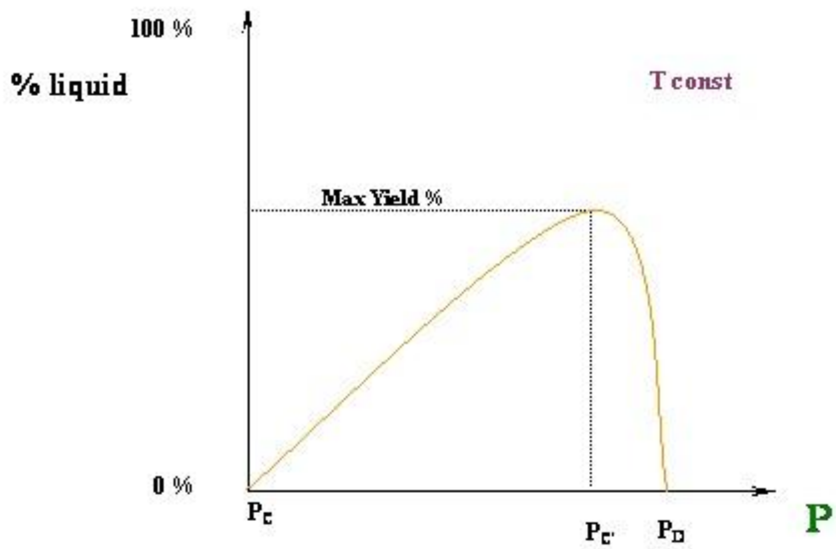


Figure 2.2: Liquid Yield for the Isothermal Compression

2.2 PREDICTION OF NATURAL GAS LIQUID DENSITY

Based on the phase diagram of common natural gas, there specific region that we called it as dense phase. In phase dense region, the natural gas have a approximately same viscosity to gas of natural gas but a density closer to a liquid phase behavior. Because of this unique behavior, this region becomes attractive to oil and gas industry. Based on Procurement Model Analysis: CAPEX vs OPEX, 2009, rather than for transportation advantage, high density of natural gas also provides reducing of pressure drop which result lower operational expenditure (OPEX).

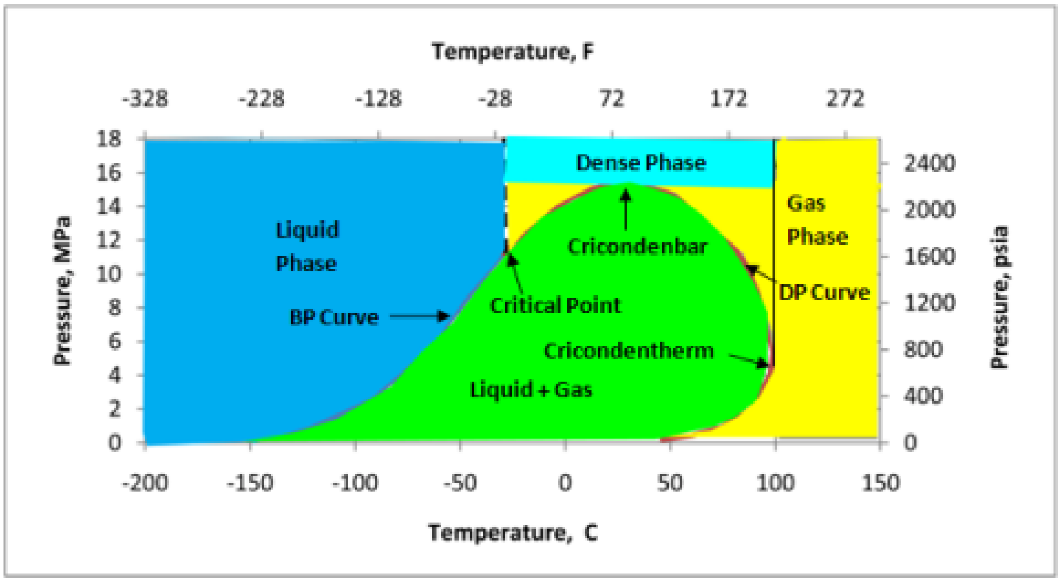


Figure 2.3: Dense phase for typical natural gas phase diagram

For common composition of natural gas contain 80% of methane, 8% of ethane, 4% of propane, 3% of i-Butane, 2% of n-Butane, and small percentage of i-pentane to n-decane (Variation of properties in the dense phase region, *Dr. Mahmood Moshfeghian).* Based on this common composition, study and analysis while manipulating temperature and pressure the affect towards density of phase dense. The behavior and characteristic of natural gas can be determined by HYSYS software for a series of temperature and pressure. Process of manipulating of temperature and pressure of natural gas represent by figure 2.4.

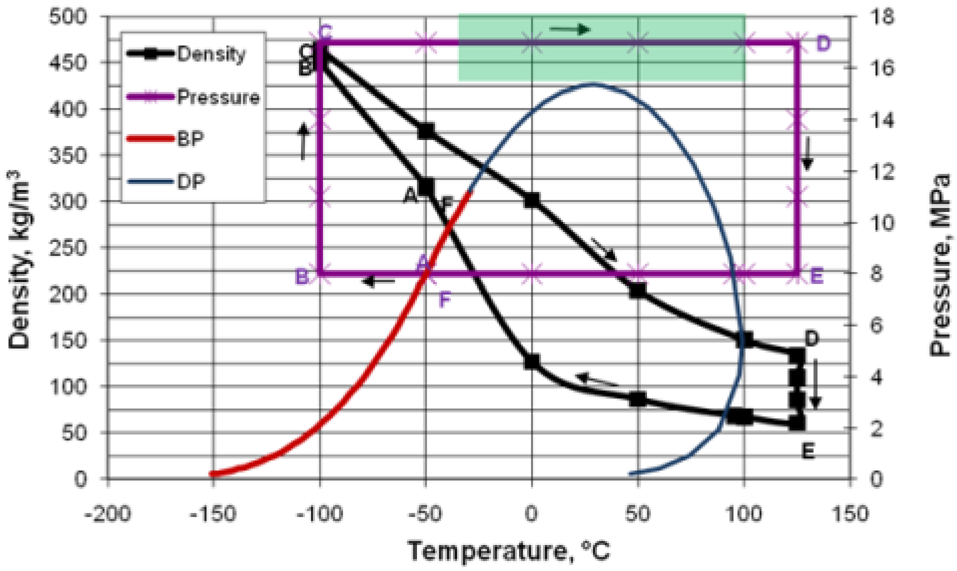


Figure 2.4: Density of natural gas as function of pressure and temperature

Based on the figure above, the distributions of density while the temperature and pressure changing. Green box indicate the dense phase of natural gas, while the purple line indicate as the temperature and pressure changing for this study. As the result, the black lines indicate of density of natural gas. From point A to B, for maintain pressure but the temperature decrease from -50^oC to -100^oC, the density of natural gas increase sharply from 300 kg/m^3 to 450 kg/m^3. Proceed to next path, which is from point B to C. Isothermal path at temperature constant at -100^oC, density of natural gas slightly increase. Next isobaric path from point C to point D, increases of temperature from -100^oC to 125^oC causes the extremely decreasing of density from 450 kg/m^3 to 125 kg/m^3. As the pressure decrease for path from point D to E, the reduction density of natural gas increase. For line E to F, cooling of natural gas causes the increasing of density. From this manipulation of pressure and temperature, it can be conclude that the density of dense phase natural gas slightly same with the density of liquid phase while pass through the dense phase region.

CHAPTER 3
METHODOLOGY

3.1 PROJECT ACTIVITIES

To study the condensation of natural gas and behaviour of composition liquid and CO2, composition of each component inside natural gas is very important. According to Emerson Process Management, Carbon Dioxide (CO2) measurement in natural gas, 2010, natural gas mainly consist of Methane (70-90%), Ethane, Propane or other higher hydrocarbon (up to 20%) and carbon dioxide can go from several ppm up to 8%. As the main objective of this final year project to find best operating condition of high carbon dioxide content, so the composition of natural gas used in this project is 8% from total composition. Compositions all component of natural gas as below.

Table 3.1: Natural gas Composition used in the simulation

Component	Mole fraction
Methane	0.6661
Ethane	0.12526
Propane	0.08043
Butane	0.03081
Pentane	0.00811
Hexane	0.00212
Heptane	0.00056
Octane	0.00021
Nitrogen	0.0063
CO2	0.0801
Total	1

For this simulation, the working temperature range depends on cricondenthem and cricondenbar of natural gas. This is because these two points are maximum temperature or pressure of vapour-liquid exists. Based on these two points, later temperature range of simulation will decided.

In order to get the precise and accurate reading of liquid percentage in this simulation, Peng Robinson basis for fluid package are the most suitable due to natural gas unique behaviour. In this simulation, flash drum being used to separate vapour and liquid of natural gas. Any changes of temperature and pressure inside the flash drum will be effect the percentage of liquid drop in natural gas. Formation of liquid drop also will favour the formation of carbon dioxide inside liquid drop. For process flow diagram of this simulation as below:

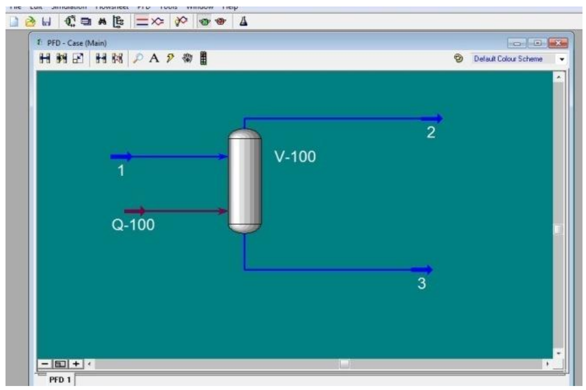


Figure 3.1: Process flow diagram for condensation of natural gas

From the process flow diagram, stream 1 is the feed of natural gas in to flash drum. Meanwhile, for stream 2 indicates the amount of vapour after flash drum and stream 3 is the amount of liquid. As variation of pressure and temperature occur, any changes of percentage liquid of natural gas recorded in the stream 3 (bottom stream).

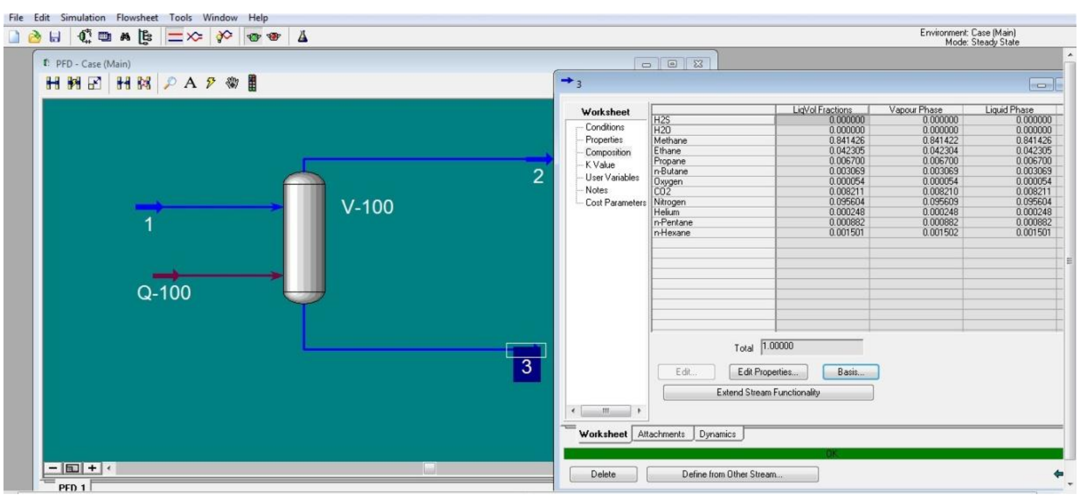


Figure 3.2: Example of liquid percentage detail after separation using flash drum

3.2 PROJECT FLOW CHART

For methodology in this project, it is important to understand the process first before run the simulation to get best operating condition for production of natural gas liquid.

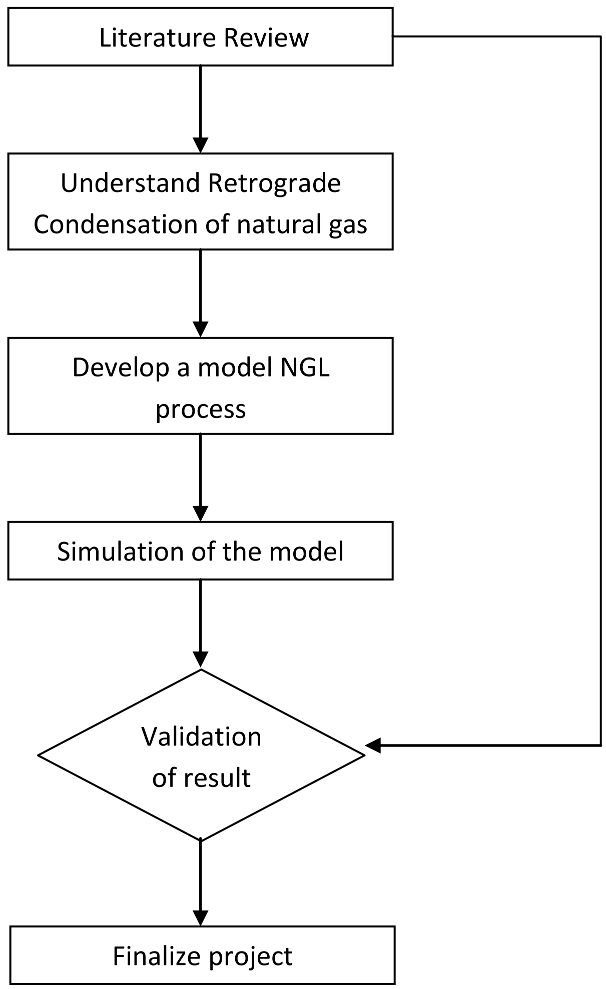


Figure 3.3: Project flow chart

I. Literature Review
   - Literature review on natural gas current condition
   - Findings and figure out the phenomenon of retrograde condensation
   - Understands the importance of natural gas in liquid phase
   - Understands the effect of amount CO2 content in natural gas

II. Retrograde Condensation
   - Understands the effect of retrograde condensation to natural gas characteristic
   - Understands the common and typical temperature and pressure of retrograde phenomenon occur to natural gas

III. Develop of model
   - Study the common and latest technology of refrigeration of natural gas in the oil and gas industry
   - Understand the equipment use to cooling and maintain the pressure of natural gas
   - Develop of model from the latest technology study of refrigeration of natural gas

IV. Simulation of model
   - Simulate the model by manipulating the operating condition of temperature and pressure
   - Extract data of liquid composition and CO2 content from each pairing of operating condition of model

V. Validation of Data
   - Repeat the simulation of model with different pair of operating condition
   - Comparison of data for each simulation to study the liquid composition and CO2 content in natural gas

VI. Finalize project

- Compile all the data of simulation and study the pattern
- Suggest the new operating condition of model that provides highest composition of liquids and lowest amount of CO_2 content in natural gas
- Prepare a proper documentation for report

3.3 TOOLS AND EQUIPMENT

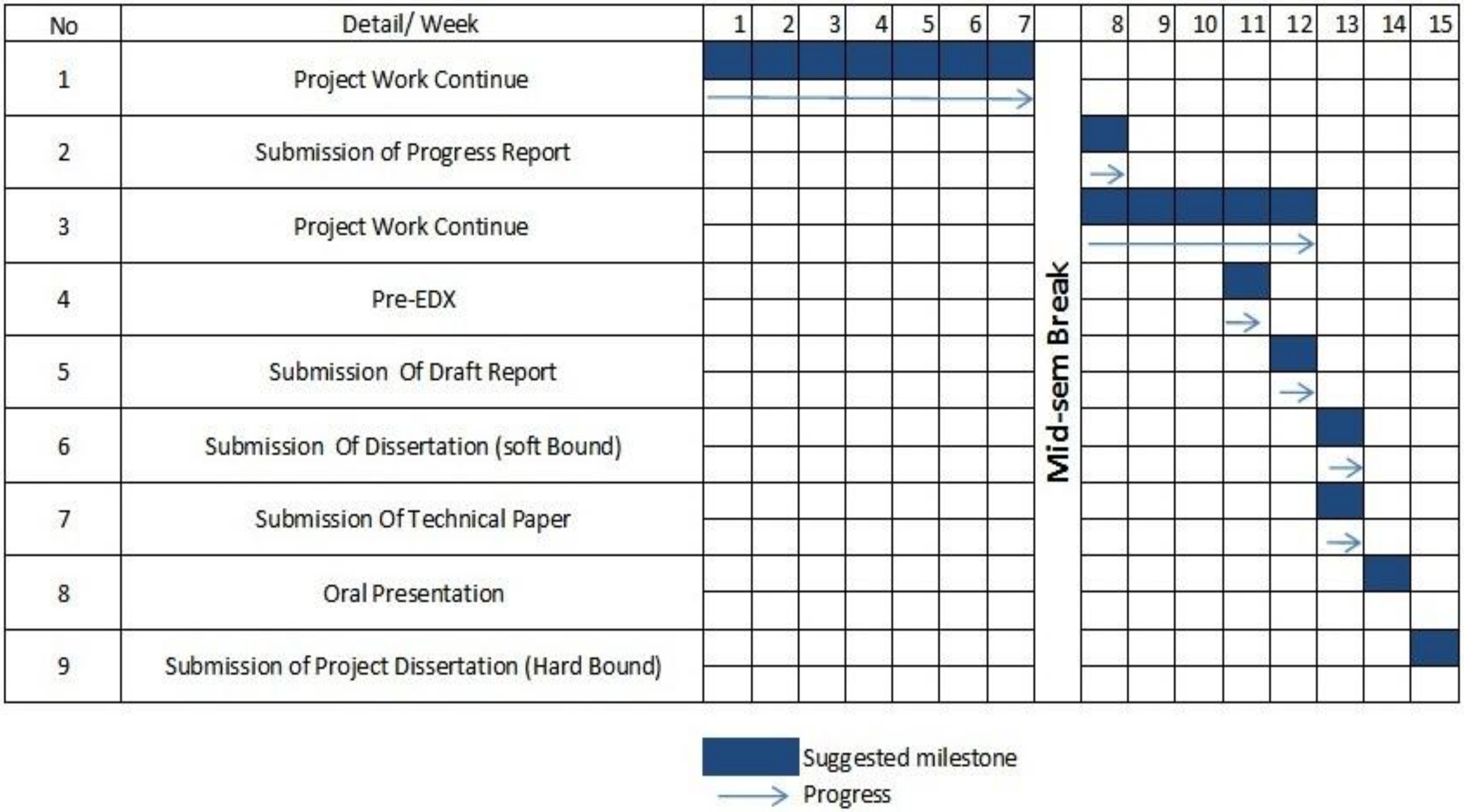
- Microsoft Excel - data collection and analysis
- ICON/HYSYS – run simulation of liquefied process model
- Microsoft Word - report writing

3.4 KEY MILESTONE

Table 3.2: Table of key milestone

No	Activities	Week
1	Project Work Continue	1 to 12
2	Submission of Progress Report	8
3	Pre-EDX	11
4	Submission Of Draft Report	12
5	Submission Of Dissertation (soft Bound)	13
6	Submission Of Technical Paper	13
7	Oral Presentation	14
8	Submission of Project Dissertation (Hard Bound)	15

3.5 GANT CHART



CHAPTER 4
RESULT AND DISCUSSION

4.1 DATA GATHERING

4.1.1 Phase Envelope

As mention earlier in literature review chapter, phase envelope of natural gas very unique due to multi-component system composition. In this simulation after entering all composition of natural gas (refer Table 3.1), develop a phase envelope. Flowrate of feed into flash drum in this simulation assume to be 100 kgmole/h. Initial temperature of reservoir assumes also to be 60 ^{o}C. Natural gas will be cooled it down below than initial temperature to produce liquid drop. Based on phase envelope, it provides Cricondenthem and cricondenbar that can be used to predict the temperature range for simulation. Cricondenthem and cricondenbar are where highest temperature or pressure of vapour-liquid exists. Phase envelope of this simulation is as below.

From the phase envelope above, red color curve indicate bubble point while blue color curve indicate dew point curve. Table for dew point and bubble point of phase envelope attach at appendix of this report. According to phase envelope, Cricondenthem occur at 36.92^{o}C, while Cricondenbar occur at 111.406 Bar. Cricondenbar occur at temperature equal to 0^{o}C, so that temperature range that will be used in this simulation is between 0 – 36^{o}C. Interval for each temperature study is 2^{o}C. This is because difficult to analyze liquid drop formation if interval of temperature used is too big. After complete all 18 set of data between 0 – 36^{o}C, analysis of amount liquid drop and amount of carbon dioxide produce can be made.

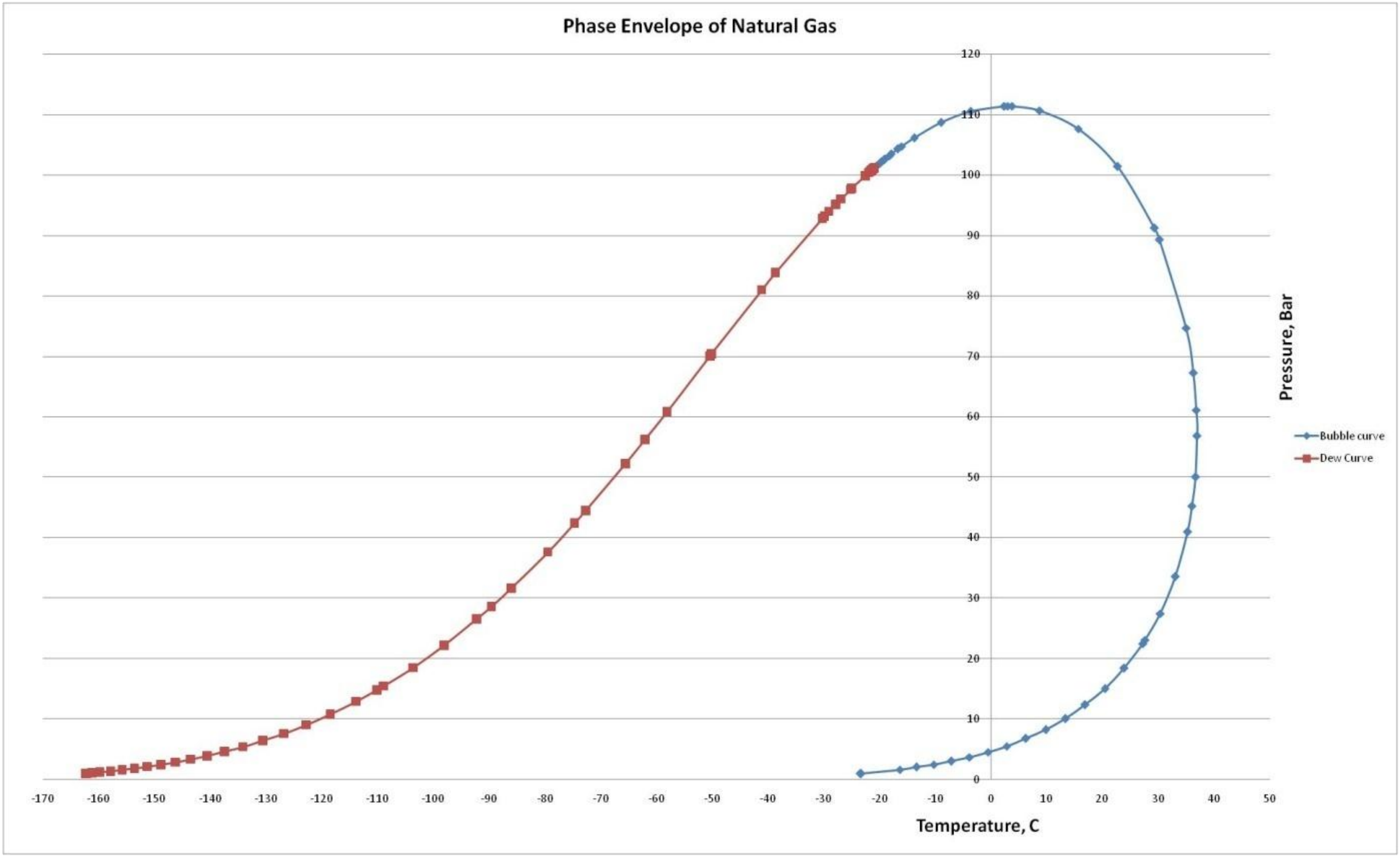


Figure 4.1: Phase envelope of natural gas simulation

4.1.2 Liquid Percentage

In this project, temperature of simulation will be constant and decreasing of pressure starting with pressure equal to 115 Bar. This is because the cricondenbar of this simulation occur at 111.406 Bar. Repeat the same procedure of simulation using different set of temperature. So that, there is no liquid drop occur beyond this pressure. For each isothermal compression of pressure simulation, formation of liquid drop at bottom product of flash drum will be recorded.

Based on table 4.2, show that example of liquid drop formation at 5 different temperatures. Full data of liquid formation, may refer to appendix. Yellow box indicate the highest amount of liquid drop occur at that temperature constant. After completing of all 18 set of data, pattern of liquid drop formation keep decreasing when temperature used in the simulation high. Highest amount of liquid drop recorded when temperature equal to 0^oC. Further explanation regarding liquid drop formation will be discussed in data analysis chapter

Table 4.1: Example of liquid drop formation

Liquid drop, isothermal compression					
Temperature Pressure/ bar	T = 0 kgmole/	T = 8 kgmole/	T = 16 kgmole/	T = 24 kgmole/	T = 32 kgmole/
110	0.0000	0.0000	0.0000	0.0000	0.0000
105	10.7618	4.3040	0.0000	0.0000	0.0000
100	15.6066	8.1270	2.5830	0.0000	0.0000
95	16.7557	9.7370	4.2960	0.3144	0.0000
90	16.7625	10.3600	5.2250	1.3060	0.0000
85	16.2844	10.4600	5.6670	1.9220	0.0000
80	15.5663	10.2600	5.8180	2.2700	0.0000
75	14.7177	9.8630	5.7450	2.4210	0.1076
70	13.7926	9.3353	5.5210	2.4250	0.2563
65	12.8186	8.7142	5.1840	2.3170	0.3170
60	11.8097	8.0230	4.7604	2.1240	0.3109
55	10.7719	7.2759	4.2700	1.8667	0.2572
50	9.7067	6.4820	3.7271	1.5635	0.1734
45	8.6122	5.6472	3.1443	1.2322	0.1265
40	7.4849	4.7765	2.5346	0.8918	0.0857
35	6.3204	3.8762	1.9143	0.5655	0.0567
30	5.1159	2.9573	1.3079	0.2811	0.0005
25	3.8745	2.0430	0.7533	0.0672	0.0000
20	2.6163	1.1822	0.3076	0.0000	0.0000
15	1.4085	0.4712	0.0304	0.0000	0.0000
10	0.4320	0.0498	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000

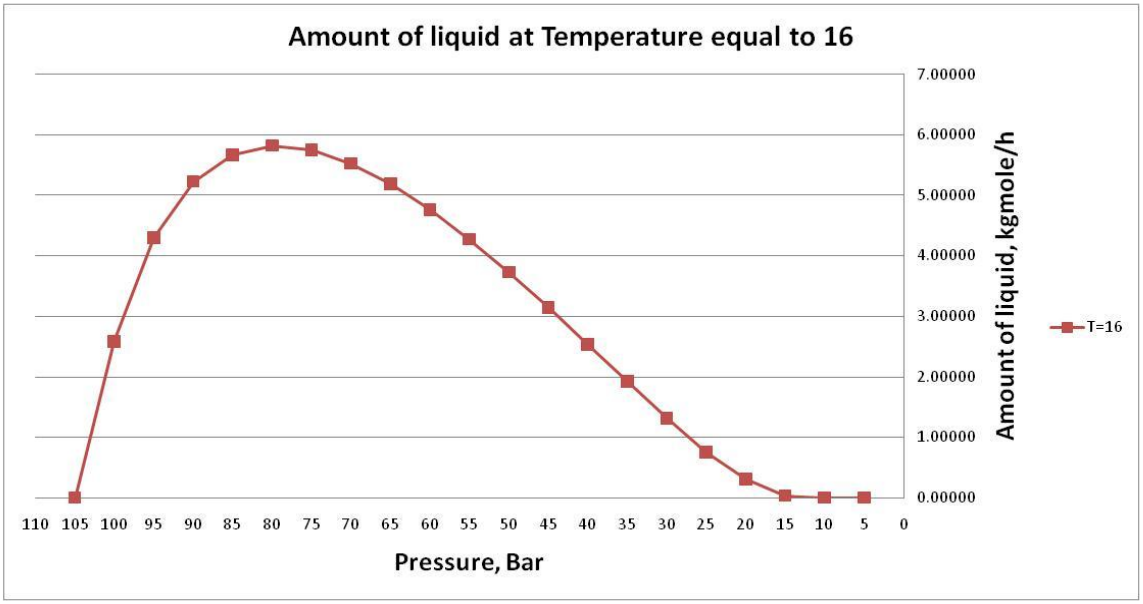


Figure 4.2: Amount of liquid drop form at temperature equal to 16^oC

Figure 4.2 shows that the isothermal compression of pressure at temperature equal to 16 ^oC. Based on this figure, at pressure equal to 105 bar, there is no amount of liquid drop produce (0%). As we decrease the pressure, liquid drop start to produce. For example at pressure equal to 95 bar, the amount of liquid drop is 4.296 kgmole/h (73%). The amount of liquid drop reach maximum that is 5.818 kgmole/h (100%) when pressure equal to 80 bar. As pressure keep decreasing, the amount of liquid start to decrease also, for example when pressure equal to 55 bar, the amount of liquid drop is 4.27 kgmole/h (73%). Liquid drop will continuously drop until 0 kgmole/h (0%) as pressure keep decreasing. There is no liquid drop anymore when pressure equal to 10 bar.

4.1.3 Carbon Dioxide content

Based on liquid drop formation data, highest amount of liquid occur at temperature equal to 0^oC. So that study and analysis about carbon dioxide content will be at this temperature. Repeat the simulation at temperature equal to 0^oC and recorded the formation of liquid of each component. Record all the data for each component for different pressure.

Table 4.2: Composition content at temperature equal to 0^oC

Pressure	105	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5
Methane	6.713	9.123	9.210	8.664	7.901	7.071	6.237	5.429	4.662	3.943	3.277	2.666	2.111	1.615	1.180	0.807	0.501	0.265	0.104	0.021	0.000
Ethane	1.644	2.512	2.809	2.905	2.899	2.830	2.717	2.571	2.396	2.198	1.979	1.744	1.495	1.237	0.976	0.721	0.482	0.274	0.115	0.024	0.000
Butane	0.670	1.136	1.383	1.543	1.654	1.734	1.789	1.825	1.842	1.843	1.825	1.787	1.725	1.633	1.502	1.321	1.076	0.760	0.399	0.102	0.000
Pentane	0.219	0.377	0.463	0.518	0.557	0.585	0.606	0.622	0.633	0.640	0.643	0.642	0.637	0.627	0.608	0.577	0.526	0.438	0.290	0.096	0.000
Hexane	0.069	0.119	0.144	0.160	0.170	0.177	0.182	0.186	0.189	0.191	0.192	0.193	0.193	0.192	0.191	0.188	0.182	0.170	0.141	0.071	0.000
Heptane	0.022	0.036	0.043	0.047	0.049	0.051	0.052	0.053	0.053	0.053	0.054	0.054	0.054	0.054	0.054	0.054	0.053	0.052	0.049	0.036	0.000
Octane	0.009	0.015	0.018	0.019	0.020	0.020	0.020	0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.020	0.018	0.000
Nitrogen	0.044	0.054	0.051	0.045	0.038	0.032	0.027	0.022	0.018	0.014	0.011	0.009	0.007	0.005	0.003	0.002	0.001	0.001	0.000	0.000	0.000
CO2	0.001	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Propane	1.370	2.231	2.634	2.862	2.995	3.065	3.086	3.064	3.004	2.906	2.769	2.591	2.369	2.101	1.785	1.425	1.033	0.637	0.290	0.065	0.000
Total	10.762	15.607	16.756	16.762	16.284	15.566	14.718	13.793	12.819	11.810	10.772	9.707	8.612	7.485	6.320	5.116	3.874	2.616	1.408	0.432	0.000

Table 4.3: Carbon Dioxide content at temperature equal to 0^oC

CO2 content, T = 0 C	
Pressure/ bar	kgmole/h
105	0.001095
100	0.001585
95	0.001691
90	0.001673
85	0.001600
80	0.001498
75	0.001381
70	0.001254
65	0.001122
60	0.000989
55	0.000855
50	0.000723
45	0.000595
40	0.000473
35	0.000358
30	0.000255
25	0.000164
20	0.000090
15	0.000037
10	0.000008
5	0.000000

Amount of carbon dioxide produce so small but the effect of carbon dioxide to unit or equipment in the plant should not be neglect. Initial amount of carbon dioxide in natural gas is 8% and the amount of carbon dioxide in bottom stream with others liquid drop is 1%.

4.2 DATA ANALYSIS

Analysis of data from liquid drop formation and carbon dioxide will lead to the best operating condition. Highest amount of liquid drop for each temperature interval recorded in table 4.4. Based on table 4.4, highest amount of liquid drop occur at temperature equal to 0^oC and 2^oC.

Plot the highest amount of liquid drop at natural gas phase envelope to study the pattern of highest liquid drop occur to temperature and pressure. From this phase envelope, pattern of highest liquid drop point will occur at lower pressure as temperature increase. The amounts of liquid drop also lower as temperature increase. For example temperature at 2 ^oC, highest amount of liquid drop that is 16.84 kgmole/h occur at pressure equal to 93 Bar. As increase the temperature of simulation to 6^oC, highest amount of liquid drop is 11.87 kgmole/h occur at pressure equal to 88 Bar. The amounts of liquid drop also decrease as we increase the temperature of simulation.

Table 4.4: Highest amount of liquid for each temperature interval

Temperature	Pressure- bar	kgmole/h
0	93	16.8400
2	91	15.0400
4	90	13.3900
6	88	11.8700
8	87	10.4700
10	85	9.1750
12	83	7.9720
14	81	6.8550
16	80	5.8180
18	78	4.8600
20	76	3.9780
22	74	3.1710
24	72	2.4390
26	70	1.7850
28	68	1.2110
30	66	0.7218
32	63	0.3215
34	59	0.0152
36	57	0.0000

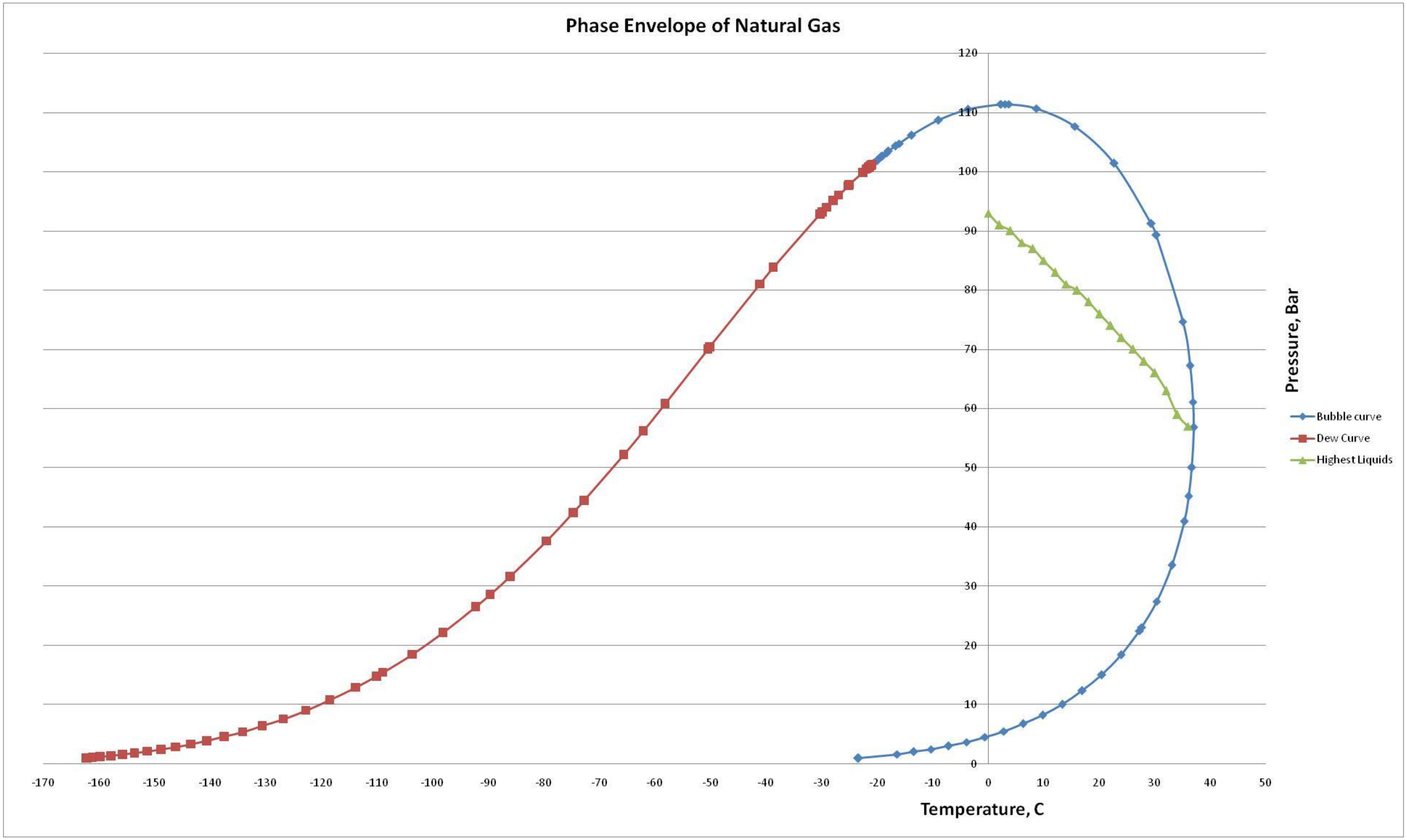


Figure 4.3: Highest liquid drop curve in phase diagram

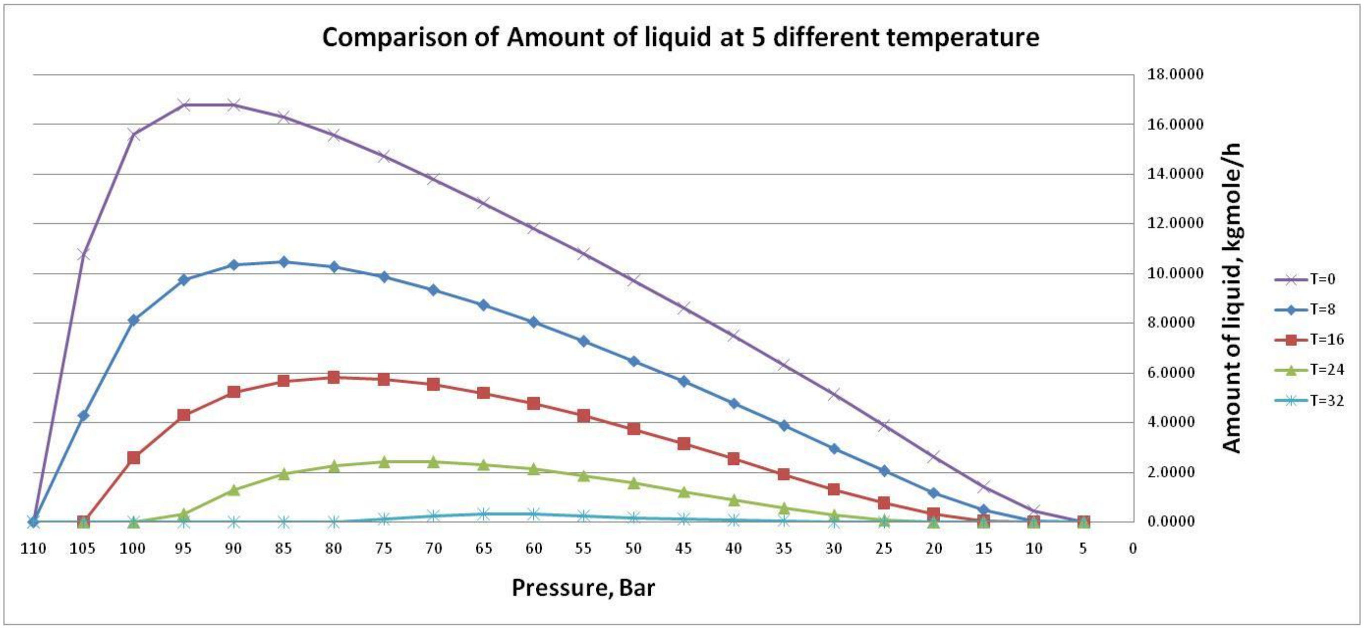


Figure 4.4: Comparison of liquid drop formation at 5 different temperatures

As mention earlier in this chapter, the highest amounts of liquid drop occur at temperature equal to 0^{o}C. Compress the pressure of reservoir starting from pressure equal to 110 bar until pressure equal to 0. Formations of liquid drop starting from 0% until it reach 100% (maximum amount of liquid drop) and the amount of liquid start to decrease again until it reach back to 0%.

Table 4.5: Highest amount of liquid at temperature equal to 0^{o}C

Temperature Pressure/ bar	T = 0 kgmole/h
110	0.0000
105	10.7618
100	15.6066
95	16.7557
94	16.8200
93	16.8400
92	16.8400
91	16.8100
90	16.7625
89	16.6900
88	16.6100
87	16.5100
86	16.4000
85	16.2844
80	15.5663
75	14.7177
70	13.7926
65	12.8186
60	11.8097
55	10.7719
50	9.7067
45	8.6122
40	7.4849
35	6.3204
30	5.1159
25	3.8745
20	2.6163
15	1.4085
10	0.4320
5	0.0000

After study in detail the formations of liquid in this temperature, the highest amount of liquid occur at temperature equal to 92 bar that is 16.84 kgmole/h. the amount of carbon dioxide from total liquid drop occur at this pressure is 0.00169 kgmole/h or 0.01%. Table 4.6 show the composition of all components at temperature equal to 0 ^{o}C and pressure equal to 92 bar.

Table 4.6: Composition of component temperature equal to 0^{o}C and pressure equal to 92 bar

Liquid drop	
T = 0 , P = 92	
Methane	8.92200
Ethane	2.88189
Butane	1.48610
Pentane	0.49823
Hexane	0.15417
Heptane	0.04558
Octane	0.01843
Nitrogen	0.04718
CO2	0.00169
Propane	2.78475
Total	16.84001

Based on this analysis, the conclusion can be made is the best operating condition of formation of liquid drop natural gas with high carbon dioxide content is temperature equal to 0^{o}C and pressure equal to 92 bar. This operating condition will give formation of liquid drop to 16.84 kgmole/h and amount of carbon dioxide is ony 0.00169 kgmole/h.

CHAPTER 5
CONCLUSION

5.1 CONCLUSION

As conclusion, the best operating conditions can be done by studying the phase diagram behaviour and also after a simulation of process natural gas liquid. These operating conditions must archive our main project goal that is to obtain highest composition of liquid inside the Natural Gas Liquid (NGL). Other than that, these operating conditions also must give us the products that have lowest composition of CO_2. This model of simulation also may be useable to others gas to liquid process to get the best operating conditions of their process.

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APPENDICES

Bubble curve		
T (°C)	P (MPa)	P (Bar)
-23.434	0.101325	1.01325
-23.2985	0.102338	1.023383
-16.3634	0.167057	1.670567
-13.3829	0.204043	2.040435
-10.3143	0.249219	2.492193
-7.15833	0.304397	3.043971
-3.91703	0.371791	3.717915
-0.59421	0.454107	4.541071
2.803918	0.554648	5.546477
6.268091	0.677448	6.774482
9.784967	0.827437	8.274372
13.33593	1.010634	10.10634
16.89538	1.234391	12.34391
20.4284	1.507689	15.07689
23.88751	1.841495	18.41495
27.208	2.249208	22.49208
27.63424	2.309759	23.09759
30.3009	2.747188	27.47188
33.04177	3.355423	33.55423
35.25198	4.098323	40.98323
36.06072	4.517179	45.17179
36.66387	5.005703	50.05703
36.96178	5.683402	56.83402
36.84695	6.113979	61.13979
36.30331	6.7246	67.246
35.01705	7.467632	74.67632
30.22228	8.93202	89.3202
29.32611	9.120985	91.20985
22.68225	10.14387	101.4387
15.61929	10.76594	107.6594
8.714808	11.06866	110.6866
3.730188	11.13944	111.3944
3.001947	11.14055	111.4055
2.267602	11.13944	111.3944
2.257654	11.13941	111.3941
-3.64341	11.05256	110.5256
-8.9795	10.86431	108.6431
-13.7907	10.61417	106.1417
-16.0177	10.4746	104.746
-16.6657	10.4313	104.313
-17.9291	10.34353	103.4353
-18.302	10.31678	103.1678
-19.0362	10.26302	102.6302
-19.2544	10.24676	102.4676
-19.6867	10.21419	102.1419
-20.0106	10.18946	101.8946
-20.6104	10.14296	101.4296
-20.917	10.11883	101.1883

Table 6.1: Bubble curve point for natural gas used in simulation

Dew curve		
T (°C)	P (MPa)	P (Bar)
-162.352	0.101325	1.01325
-162.215	0.102338	1.023383
-161.904	0.104674	1.046742
-161.222	0.109943	1.099434
-159.817	0.121438	1.214383
-157.859	0.139013	1.39013
-155.794	0.159612	1.596119
-153.615	0.183832	1.838317
-151.311	0.2124	2.124001
-148.871	0.246206	2.462063
-146.284	0.286339	2.863387
-143.536	0.334132	3.341322
-140.614	0.391225	3.912247
-137.502	0.459626	4.59626
-134.183	0.5418	5.417998
-130.641	0.640758	6.407578
-126.857	0.760165	7.601655
-122.812	0.904452	9.044523
-118.489	1.078916	10.78916
-113.871	1.289795	12.89795
-110.096	1.481979	14.81979
-108.943	1.544289	15.44289
-103.696	1.850456	18.50456
-98.1232	2.216948	22.16948
-92.227	2.652515	26.52515
-89.6122	2.861619	28.61619
-86.0157	3.165249	31.65249
-79.5024	3.761651	37.61651
-74.6711	4.24126	42.4126
-72.6974	4.445782	44.45782
-65.5925	5.219127	52.19127
-62.0716	5.6209	56.209
-58.1262	6.082138	60.82138
-50.4327	7.000541	70.00541
-50.1166	7.038432	70.38432
-41.1322	8.100013	81.00013
-38.6769	8.380182	83.80182
-30.2481	9.279474	92.79474
-29.86	9.318053	93.18053
-29.0742	9.395303	93.95303
-27.8662	9.511668	95.11668
-26.936	9.599226	95.99226
-25.176	9.759822	97.59822
-25.0113	9.774498	97.74498
-22.5754	9.984232	99.84232
-21.9432	10.03634	100.3634
-21.7757	10.04999	100.4999
-21.5231	10.07043	100.7043
-21.3697	10.08277	100.8277
-21.072	10.10654	101.0654
-20.9173	10.11881	101.1881

Table 6.2: Dew curve point for natural gas used in simulation