Production Optimization for Surface Network Modeling By Using Integrated Production Modeling (IPM)

By

Md Azri Bin Abd Halim

Dissertation submitted in Partial Fulfillment of the Requirements for the Degree Bachelor of Engineering (Hons)

(Petroleum Engineering)

MAY 2011

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CERTIFICATION OF APPROVAL

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Approved

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Project Supervisor

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May 2011

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

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ABSTRACT

Production optimization is very important since it is a method to improve the production with increase the production and reduce the operating cost. In this project, the scope study would be to investigate the best case of the surface network model that will use to increase the production in the field. Economy evaluation for each case in the model should be done in order to determine the profitable project which will give the optimum production and reasonable cost. Cases that can be done in this project would be the field which will produce naturally and with support by artificial lift such as gas lift.

The area that will do for project is Pentagon cluster. It is located in the MS-325 block. In this cluster, it will divide them into 5 fields which are field A, field B, field C, field D and field E. Currently all the wells is producing naturally which means that it should be produce without any artificial lift support and will considered as the base case. After integrate the surface network model for this cluster, the average annual production is for every year is about 2.350 MMSTB while the pressure at separator after make some sensitivity analysis is 877 psig. The problems that facing in this project is wells in field B where it has less annual production although the oil production that can recovered in this field is high . It is due to the insufficient pressure draw-down which is to produce the oil. It can be the characteristics of reservoir or well which is not good enough to produce the oil.

Hence, optimization study should be done in order to determine the method which can increase the production. The optimization that will do in this project is use the gas lift support at all wells in field B as the method to improve the production. The gas lift rate that use from the sensitivity analysis is 100 SCF/STB. Thus, the prediction production should be done for both cases in order to get the production forecast. From this prediction, it is easier to know the effect of gas lift in the field by looking the annual production and bottomhole pressure for pentagon cluster. Once integrate the model, economy evaluation should be done in order to know the economical of this project for both cases when the field is producing naturally or with support by gas lift. From the study, the cases that will consider in this project are the field which is producing naturally. It is because costs that use in to design the gas lift well are increasing than the cost that will get from the oil production.

ACKNOWLEDGEMENT

First of all, I would like to place my highest gratitude to my Final Year Project Supervisor, Iskandar Dzulkarnain, who has been very kind to guide me throughout my project for the duration around the one year. Next, I would like wish to express his appreciation to the management of Universiti Teknologi PETRONAS for the facilities including the computer software application that provided in the university. Besides that, I also want to wish thankful to Geosciences Petroleum Engineering Department which giving chance for me to done and make research for my topic in this final year project. Lastly, I also want to thank all people especially my friend, other lecturer, my family and also who involved either in the formal or not to make this project is successful and give moral support to me.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF EQUATION

CHAPTER 1:
INTRODUCTION

1.1 Background of Study

The area that will do for project is Pentagon cluster. It is located in the MS-325 block. In this cluster, it will divide them into 5 fields which are field A, field B, field C, field D and field E. Currently all the wells is producing naturally which means that it should be produce without any artificial lift support and will considered as the base case. After integrate the surface network model for this cluster, the average annual production is for every year is about 2.350 MMSTB while the pressure at separator after make some sensitivity analysis is 877 psig. The problems that facing in this project is wells in field B where it has less annual production although the oil production that can recovered in this field is high . It is due to the insufficient pressure draw-down which is to produce the oil. It can be the characteristics of reservoir or well which is not good enough to produce the oil. Thus, this project needs optimization in order to increase the production.

Hence, optimization study should be done in order to determine the method which can increase the production. The optimization that will do in this project is use the gas lift support at all wells in field B as the method to improve the production. The gas lift rate that use from the sensitivity analysis is 100 SCF/STB. Thus, the prediction production should be done for both cases in order to get the production forecast. From this prediction, it is easier to know the effect of gas lift in the field by looking the annual production and bottomhole pressure for pentagon cluster. Once integrate the model, economy evaluation should be done in order to know the economical of this project for the field is producing naturally or with support by gas lift. From the study, the cases that will consider in this project are the field which is producing naturally.

Based on the study, this project is very important since the output in this project is obtained the optimum production and cost. This result will be used as the reference for the engineer to monitor the production for pentagon cluster which have many wells that need to optimization. Thus, it will focus a few of the wells that need optimization since the annual production is low.

1.2 Problem Statement

1.2.1 Problem Identification

In Pentagon cluster, all the wells in each field is producing naturally which is without any artificial lift support. After design the surface network model, for this cluster, there are some wells in each field has less production although it have the high oil production. This included field E where all the wells is not producing the oil. This is due to the wells which do not get the optimum production for the oil to produce much production. It can be the characteristics of reservoir or well is not good enough to produce the oil. The solution that will used to investigate this problem is to put the well which has less oil production with the gas lift optimization in order to get the optimum production since some of the well not producing oil since it does not have the enough energy to flow the oil. With production optimization that will do in the network model, some cases for the model can be done and will be evaluated the economy in order to know the profitable of the project. From several cases that already did in this project, the best case for the network model which will give the good production and cost which can be used it in order to make production optimization for this field.

1.2.2 Significance of Project

In order to prevent this problem, analysis should be done by engineer to get the best solution. They should investigate this problem which cause the production is decrease. Basically, engineers should know the suitable pressure drop that will use to get the optimum production of the field. This can be done by making evaluation of the surface model based their economy analysis. The many cases should be done in order to know the best case that will give the high production and low operation cost. At the same time, the parameters should be considered in order to make the production optimization. The parameter that will focus in this project is the separator manifold pressure where the pressure that will give high production to the surface model that will integrate. This parameter will give the different characteristics of the reservoir and well which will give different optimum production and cost for the model.

1.3 Objective

The main target in this project is to develop the best case of the surface model which will give the optimum production and cost. It means that the model which will give economical and profitable project for engineer to implemented and monitored it. This can be achieved with this objective:

i. Design the surface model for both cases where the field is producing naturally and produce with support from gas lift in order to know the annual production for each case
ii. Make the production prediction based the models that already integrate for each case in order to know the forecast production and the production performance.
iii. Make economy evaluation for both surface models that already design in order to know the economical and profitable for pentagon cluster.
iv. Choose the best case that will implemented in this project. It means that the case which will give benefit to the oil company and operational company.

1.4 Scope of Study

In this final year project, the scope that will cover is optimization of the natural depletion reservoir field. It means that this field is producing naturally without using any recovery method to improve the production. Next, optimizations of gas lift well which is one of the recovery methods to improve the production. This method will be implemented once the production from the producing naturally field is less. Besides that, make the production prediction for both cases which is the production forecast that can generate from the model in order to know the production performance of this cluster. Last but not least, economy analysis for both cases. This can done by evaluate the cost that will spend in this project in order to know the profitable and economical of the project. Finally, the best cases will be chosen as the guide to implement the development project in pentagon cluster. The best cases would be considered as the profitable and economical project which will give the optimum production and cost. It also will benefit to the company to develop it.

1.5 The Relevancy of the Project

Based on the study, it is prove that the project will benefit and useful to the company who interested to develop the project. It is because it will make easier for the company and engineer to evaluate their production performance of the particular field. The output that obtained in field can be used to monitor the production since many fields and well that will handle by engineer. It means that, it will make easier for engineer to monitor the production in the office without going to offshore just only to know the production performance for all the wells. Besides that, from the output, engineer can defined the problem that facing in the field which causes the production has less production. From there, engineer can find the method of the optimization in order to improve the production. This project is useful because the production forecast can be determined from this project. Based the performance, engineer easier can make the reservoir management plan in order to implement the depletion strategy for certain period of the production. Lastly, it will make easier to analysis the economy of the project. It is useful since engineer can decide the suitable equipment and inventory that will used in this project which will give optimum production and cost and also will give the profitable project and economical project to be implemented.

1.6 Feasibility of the Project within the scope and Time Frame

Hopefully, during final year project which is about 12 months, all the objectives in this project is already achieved which is to get the optimum production and cost which will give benefit to the company who involved the optimization project in pentagon cluster. The evaluation from all the aspect already done in term of the tank model which will considered the reservoir fluid characteristics, well model which is considered the optimization for IPR and VLP, surface model which considered the suitable pipeline and separator that optimize the production and economy evaluation which is to know the economy of the well for each cases that done in the surface model. All the cases for network model should be done during this period where each wells is either producing naturally or producing with artificial lift such gas lift and the water injector. From each case, evaluation of surface model should be done to know which cases will give the optimum cost and optimum production.

CHAPTER 2:
LITERATURE REVIEW

2.1 Introduction

Basically, this project will focus more about the production optimization. This included the concept that have in the production optimization and the methods that use in the optimization. There are several topics that done in the literature review, this included:

1. Integrated Production Modeling (IPM)
2. Tank Model and Material Balance
3. Nodal Analysis
4. Inflow Performance Relationship (IPR)
5. Artificial Lift
6. Gas Lift
7. Production Optimization
8. Economy Analysis

2.2 Production Optimization

2.2.1 About Production Optimization

Basically, the target for production optimization is to maximize the production performance and minimize the cost [How, Kubat, 1996].

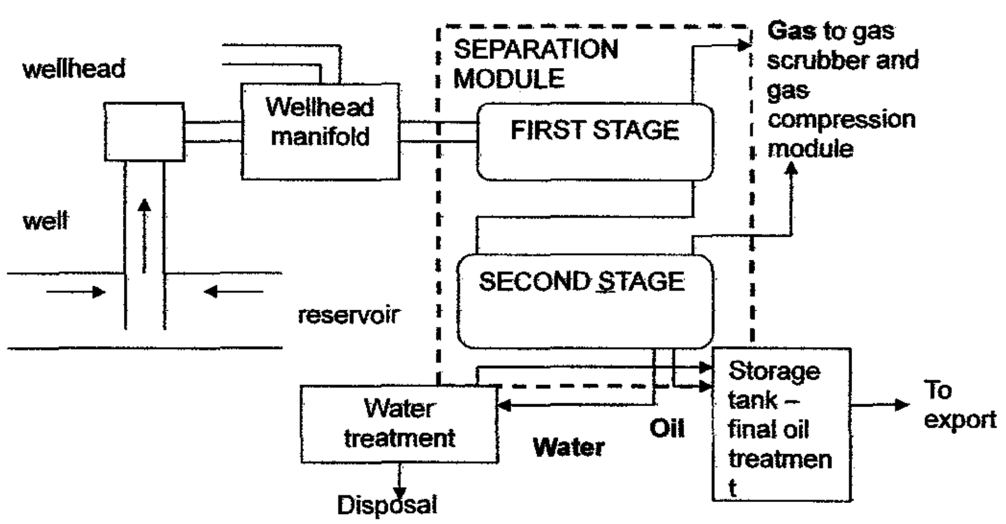

Figure 1: Production Process

In production optimization, it should be balance between the demand, deliverability and production rate [Sohrab, 2009]. There are many aspects that should be evaluated in production optimization. It will include the understanding of production system and reservoir fluid as mentioned in Figure 1 which is the production process for the oil production. In the reservoir fluid, it will consider the parameters that have in the reservoir such as viscosities, Gas Oil Ratio (GOR), densities which have in the Pressure Volume Temperature (PVT) and the tank model. In the production system, it will evaluate the wellbore performance which is the tubing and completion, the reservoir and surface facilities which included the pipeline and separator. All the parameters are important in making the production optimization of the field.

In the surface modeling, there are many parameters that will consider in increasing the flowing of production which come from the reservoir until the surface. This includes such as pipeline and separator. Separator is a pressure vessel which wills design to divide a combined liquid-gas system into individual components that are relatively free of each other for subsequent processing or disposition [Ken, Maurice, 1999]. The separators are use since it downstream equipment cannot handle the liquid-gas mixtures. A pipeline system is defined as a pipeline section extending from an inlet point (may be an offshore platform or onshore compressor station) to an outlet point (may be another platform or an onshore receiving station) [Nasir, 2010]. These lines are used to transport oil from field pressure and storage to large tank where it is accumulated for pumping into the long distance and will sent it to commercial places as mentioned in Figure 2

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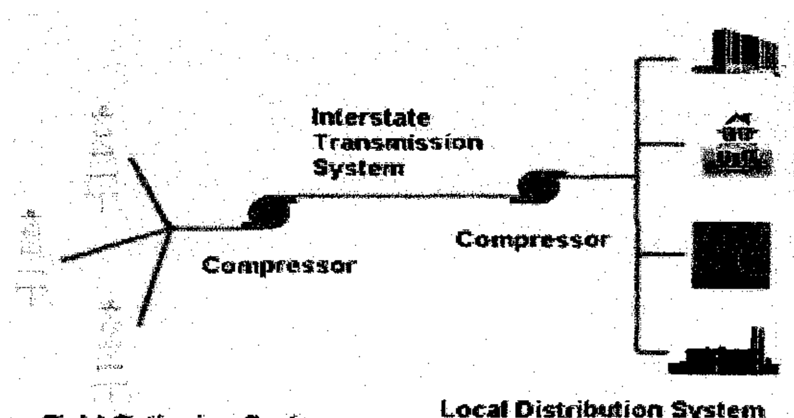

Figure 2: Pipeline

Pipeline and separator would be a part of the production optimization in the surface modeling. This process can be done by using Gap software as the tool to make optimization in the surface area. To build the surface model, gap software will linked to the well model and reservoir model. This included the nodal analysis and the tank model. From the model and analysis, evaluation of the field can be done to get the production optimization of the field. It also will involve the tubing and perforation part which is to know the suitable flowing pressure and production rate of the field. Currently, it will involve three software in this surface model which are gap (surface model), prosper (well model) and mbal (reservoir model).

There are some criteria and procedure to make the production optimization which is state at the below:

i. Identify the components in the system.
ii. Select one component to be optimized.
iii. Select the node location that will best emphasize the effect of change.
iv. Develop expression for inflow and outflow.
v. Calculate pressure drop versus rate for all components.
vi. Determine the effect of changing the characteristics of the selecting component.
vii. Optimize the production system.

From these criteria, the suitable criteria can be chosen in order to give the good production of the field. The forecast production can be defined to know the early production system in the field. In the future, the improvement can be done at the model with change some of the properties in the field in order to get the good production rate. This production optimization will do continuously since the production will be changing by time. Sometimes, it is not expected what happen in the field which will cause the production rate will decrease. Improvement of the field should be done in order to ensure that field always has good production.

2.2.2 Nodal Analysis

Nodal analysis is the apart of the production optimization. It is defined as determine the equilibrium state of particular flowing condition [Jose, 2008]. It also can predict the opportunities for optimization of the production. It is related by inflow & outflow performance curve of the well at particular condition referred. Inflow performance is defined as the performance from the reservoir to sand face while outflow performance is the performance from the completion to the wellhead. It is very important since it needs to optimize the production. Optimize production means that the points where the inflow & outflow performance can be intercept. However, the performance also depends with the constraint which can be the input data or the correlation (sensitivity) that will use in the analysis as mentioned in Figure 3. It means that the parameters or the variables. Currently, the sensitivity analyses that will use in make analysis such as water cut, skin, pressure & temperature. The purpose for make the sensitivity analysis is to increase the Productivity Index which is increase the annual production.

$$\boxed{q = PI\,(\bar{P}_R - P_{wf})}$$

Equation 1: Productivity Index

Normally, performance evaluation will consider: (Ali, 2010)

i. Reservoir constraints
ii. Completion constraints
iii. Wellhead constraints

The nodal analysis can be applicant by using the well model software which is the requirement for industry. The possible software that can be used such as wellflo and prosper. Both of the software can build the model; validate the well model & matching the data in order to optimize the production. It also provided the artificial lift which can be used in case the well need the artificial lifts which to increase & optimize the production. From the analysis, the well performance for the field can be evaluated.

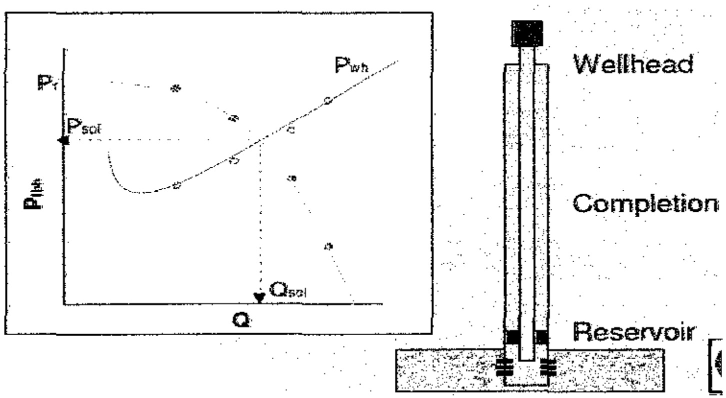

Figure 3: Nodal Analysis

2.2.3 Artificial Lift

Artificial lift is a method that used to improve the well productivity where it will raise the oil to the surface through a well after reservoir pressure has declined to the point at which the well no longer produces by means of natural energy [Cholet, 2000]. It may prove necessary from the beginning of production for oil wells when the reservoir does not have enough energy to lift the fluid to the surface process facilities. This is important as the way to increase the production of the field.

There are several factors which need to consider why choosing the artificial lift. This included:

1. Well and Reservoir Characteristics
2. Field Location
3. Operational Problems
4. Economics
5. Implementation on Artificial Lift Selection Techniques
6. Long Term Reservoir Performance and Facility Constraints

There are two form of artificial lift which is (Figure 4) [PETRONAS, 2006]:

1. Downhole or Surface Pumps where a pump is used to boost the transfer of liquid from the bottomhole to the wellhead, eliminating backpressure caused by the fluids flowing in the tubing or caused by surface facilities. An example of the pumps that use in the well are electrical submersible pump (ESP), Progressive Cavity Pump (PCP) and Hydraulic Jet Pump (HJP)

2. Gas lift which is accomplished by injecting gas into the lower part of the production tubing. Injection of gas into the production string aerates the flowing fluid, reducing the pressure gradient and lowering back pressure at the formation.

Besides that, acidizing, fracturing and reperforating also can be considered as the artificial lift. In this project, it will focus more on the gas lift as the artificial lift support in order to increase the production.

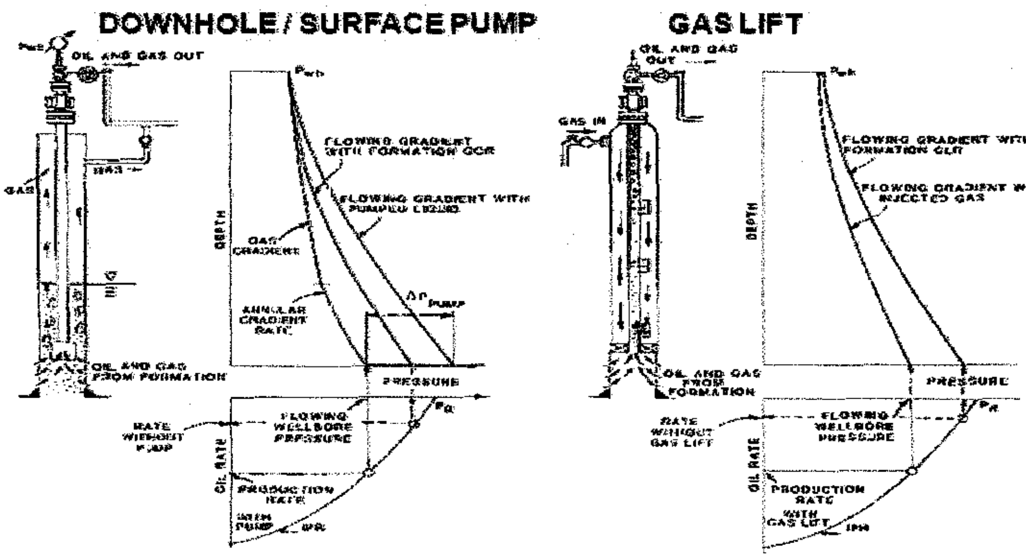

Figure 4: Downhole/Surface Pump & Gas Lift

2.2.4 Gas Lift

Gas Lift is uses as additional high pressure gas for supplement formation gas [Alberto, 2009]. The produced fluids are lifted by reducing fluid density in wellbore to lighten the hydrostatic column, or back pressure, load on formations (Figure 5).

The objectives that use gas lift it the wells [Cholet, 2000]:

1. Maximize the value of oil produced
2. Maximize design flexibility (decline of reservoir pressure, well PI and increase water cut)
3. Minimize well intervention
4. Stable well operation (stable tubing head/ casing head pressure)

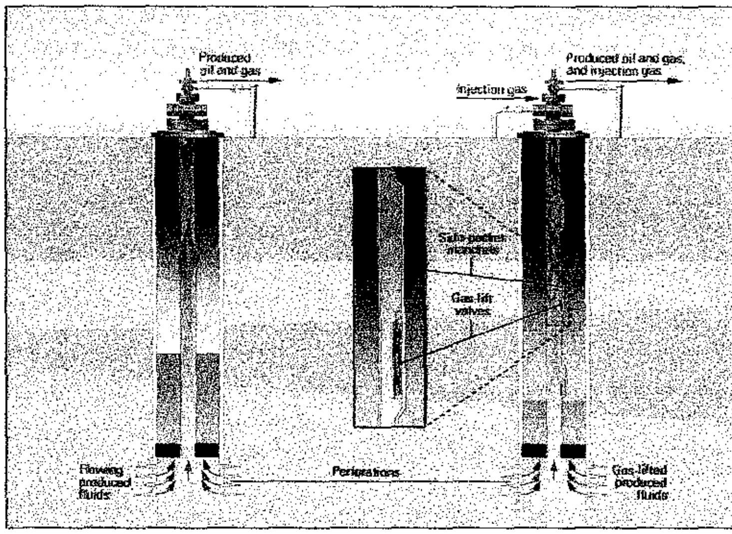

Figure 5: Gas Lift

There are methods of the gas field that will use in the wells. This includes:

i. Continuous flow which is similar to natural flow and is achieved by controlling the injection of gas into the fluid column to cause aeration from the point of injection (Figure 6). Gas is injected continuously to the production conduit at a maximum depth based on available gas pressure [Alberto, 2009].
ii. Intermittent or Batch flow (Figure 7) which is by injecting gas of sufficient volume & pressure into tubing beneath a fluid column to lift liquid to the surface, this usually require high gas rate to reduce the liquid fallback. The liquid to surface is in slug or piston form.

When injecting relatively the high pressure gas from the surface to a predetermined depth in the wellbore, the average specific gravity of the fluid decreases which causes a drop in the well face pressure (Pwf) which will generate additional draw-down which turns on increased fluid production [Alberto,2009].

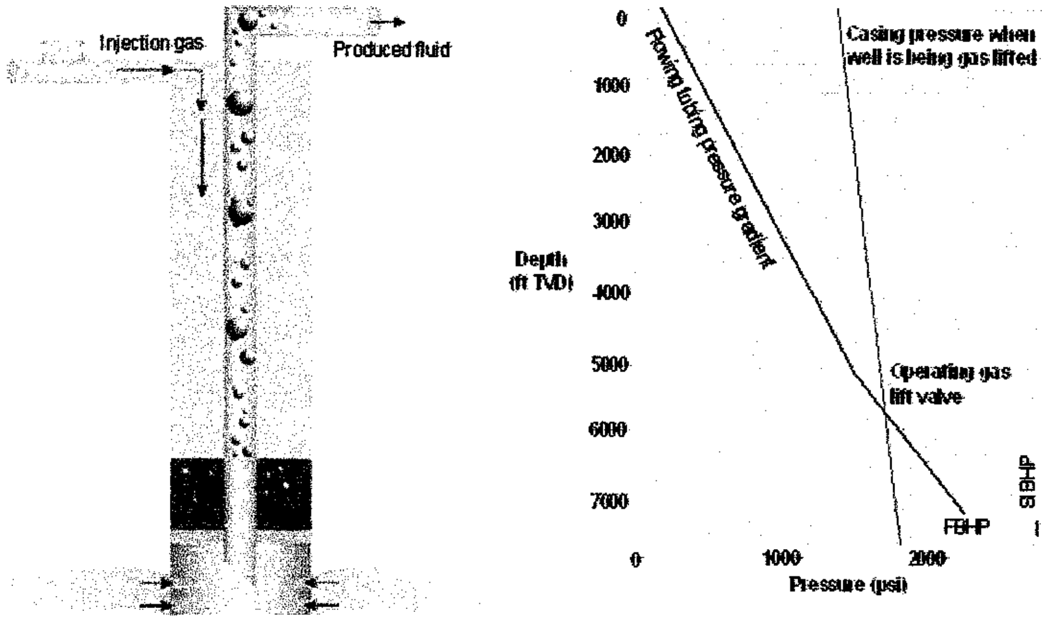

Figure 6: Continuous Gas Lift

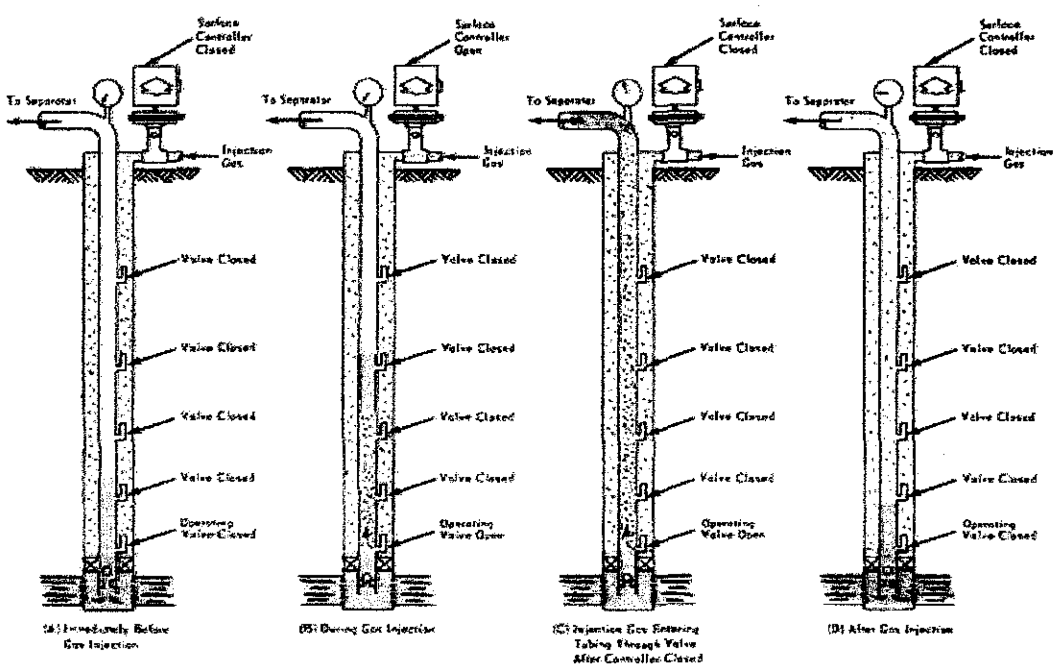

Figure 7: Intermittent Gas Lift

However, there are advantages and disadvantages when using the gas lift as artificial lift. This included as below:

Advantages

i. Initial downhole equipment costs lower
ii. Low operational and maintenance cost
iii. Simplified well completions
iv. Can produce high rates from high productivity wells
v. Flexible, easy to change rate
vi. Can handle large solid volume
vii. Lifting gassy wells is no problem
viii. Applicable offshore - platforms and subsea completions
ix. Crooked holes present no problem
x. Serviceable with wireline unit
xi. Easy to obtain downhole pressures and gradient

Disadvantages

i. High initial investment (compressor)
ii. Limited reservoir pressure drawdown
iii. Lift gas not always available
iv. Difficult to lift emulsions and viscous crude
v. Cannot effectively produce deep wells to abandonment
vi. Casing must withstand lift pressure

Many of the well in the world use the gas lift as the artificial lift since the operating cost is lower than the other artificial lift. Besides that, in our project also we will use gas source as our gas lift to supply to the well which needs many gas lift in order to increase the production oil.

2.2.5 Economy Evaluation

Basically, economy is a social science that studies how individuals, governments, firms and nations make choices on allocating scarce resources to satisfy their unlimited wants [Seba, 1998]. It means that how people make the analysis between things that have with the thing that want to be purchased. In petroleum economics, it is easier to describe that the resources (oil) that have in the must be balanced with the operation cost to develop the oil. It means that the operation cost that the oil company will used it for the development in their field must be equal or more with the oil that will produced from the field.

There are several purposes which need to have the economy evaluation. This included such as bidding to national oil companies to secure new petroleum acreages, sale and exchange of petroleum assets, project financing in the form of loans and evaluation of changes in governmental regulations which affect petroleum sector. In the evaluation of the economy, it will some cost that will consider in the several phases of the evaluation. This included from the acquisition, exploration, development, production and abandonment phases [Seba, 1998]. In this phase, it will involve some costs input costs such as the capital expenditure (CAPEX) cost which will considered the physical asset of the cost such as the inventory where the field have not start producing the oil while operation expenditure (OPEX) cost is considered the cost while the field in the operation when the company start to produce the oil.

There is some software that will used to evaluate the field performance. However, in this project, the software that will use is questor which is a project modeling, evaluation and decision support system for global application in the oil and gas industry. It uses a systematic approach to generate a field development basis, capital and operating costs, and project schedules. This systematic approach allows to produce weight and cost estimates quickly, consistently and accurately and to develop investment profiles [IHS, 2007]. In this project, questor will evaluate the operation cost from the network model that already builds by using petroleum expert application software. It will evaluate all the cases that already done in the network modeling which will provide the cost that will used to integrate the network model.

In questor, the input data would be the current production and the characteristics of the field. It is important to input this data since this will provide the production profile and daily production that field will produced the oil which will considered as the income money. From figure 8, production profile can be generated after input the characteristics of the field and the production data which consist of the injector rate and oil rate.

Other things that need to consider while making economy evaluation is the equipment and inventory cost. This will included the drilling rig cost, pipeline cost and the development well cost. The cost is different among of several factors. This included the location of the platform since all the oil is producing from around the world. Different location also will give the different cost of the component such as pipeline, material, and fabrication. The drilling rig also play the role while make the development cost where development platform in onshore is cheaper as offshore since it is difficult to build platform in the offshore. All the operation cost will list in figure 9 when using the questor application. Different development project will give the development cost of operation.

As a conclusion, it is important to have the economy evaluation since it will ensure that the cost that has is balanced or more with the development cost. It will give the profitable of the project either it is better for the field to be developed or not. Hence, it is better to have several cases while develop the field so that it can determine the best case which will give optimum production and optimum cost for development.

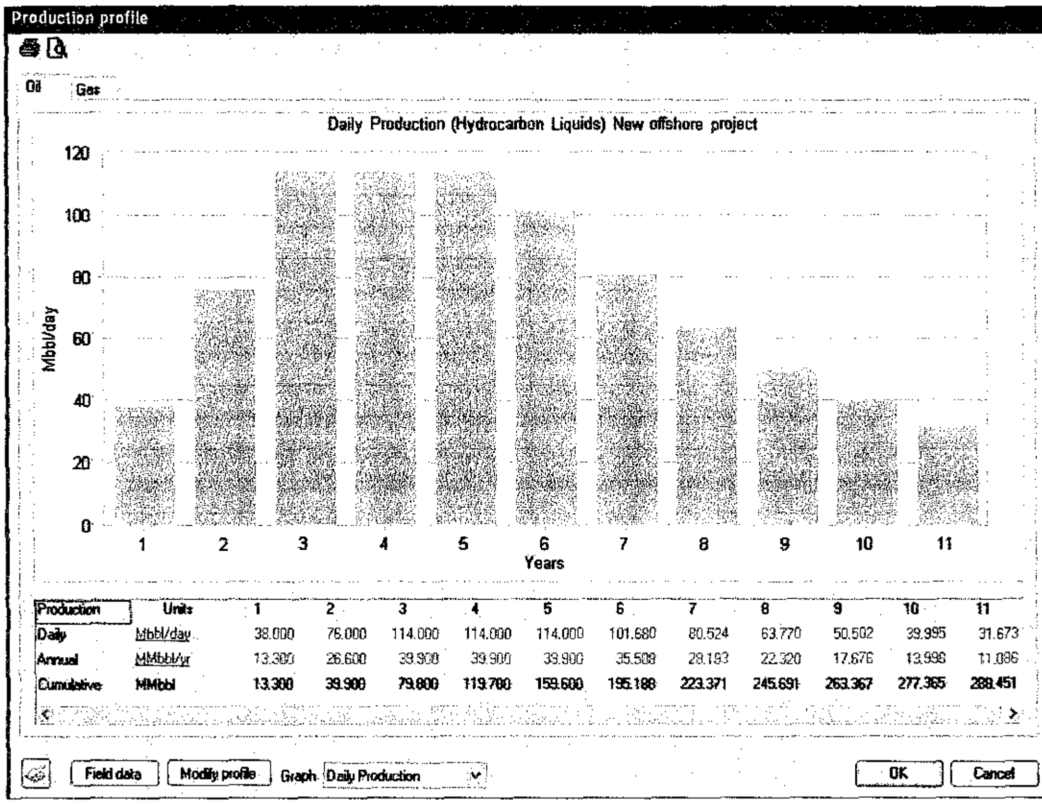

Figure 8: Production Rate

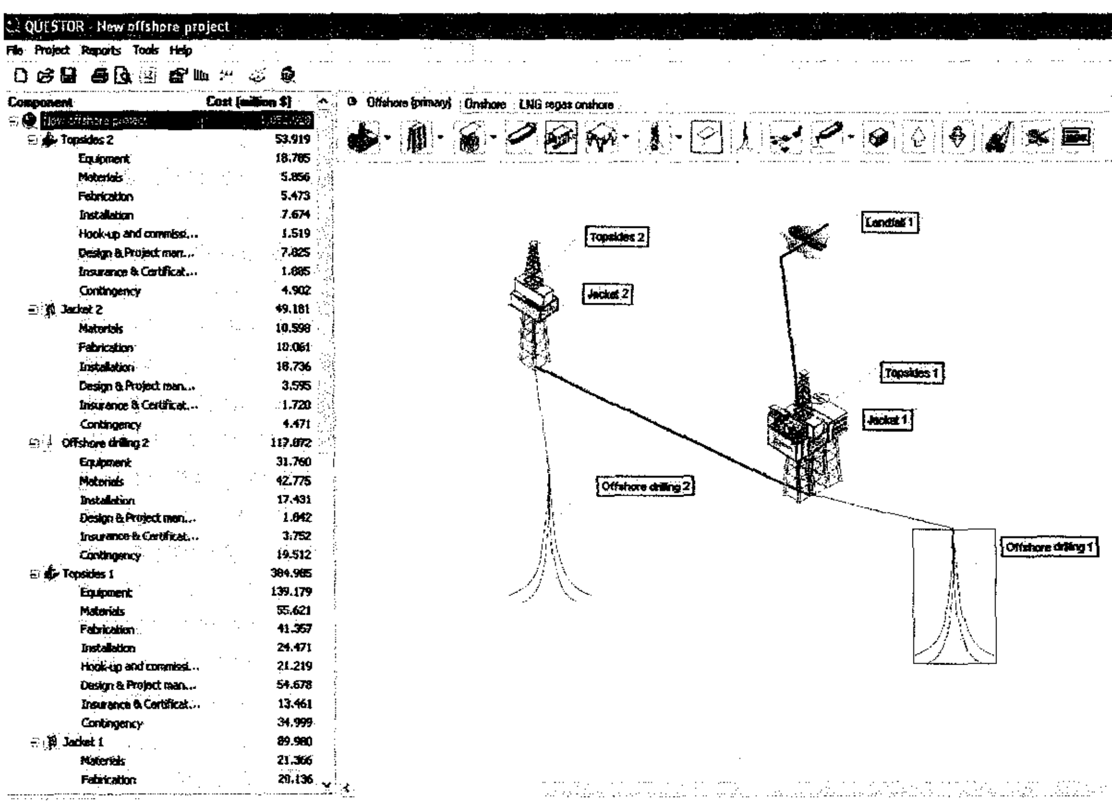

Figure 9: Project Cost

2.3 Process to Optimize Production

2.3.1 Integrated Production Modeling (IPM)

After know the concept for production optimization, it is important to know the process to optimize the production, this included such as IPM, IPR and tank model. Firstly, Integrated Production Modeling (IPM) is a tool which will evaluate the performance field where comes from the reservoir through wells, pipeline, facilities until it use to export and sales the production [Ageh et al, 2010]. It will give effective cost to access and optimize the field performance. IPM can be done by integrate the reservoir model, well model and surface network model. From the analysis, it will describe the behavior of the production system and find the solution to make the production optimization for the particular field [Lawati, Salmi, et al, 2010].

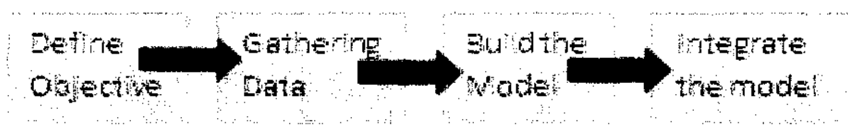

Figure 10: Integrated Production Modeling

From the figure 10, integrated model can be done once the reservoir, well and surface model is available. When to design the model, the data is very important to evaluate the field performance. Besides that, background field also important to know the characterization of the field which make easier to know the properties of their fluids.

There is some software that will use in IPM which will use in final year project which is a part of petroleum expert application software. This included:

i. Mbal (Material Balance) which is use to build the reservoir model, verify the Stock Tank Oil Initially in Places (STOIIP), make the production forecast and as requirement for the reservoir to have the injectors. It will provide the production forecast which will link to prosper and gap.

ii. Prosper is the middle system between mbal and gap which use to build the well model for the field. From the well model, prosper can use to validate the well model or well test especially for the producing field. Based the analysis, it would be the requirement for well to have the artificial lift such as gas lift and electrical submersible pump (ESP).

iii. Gap which is use to construct surface network modeling. From the modeling, we can optimize the production system in the surface, well and reservoir model. To get the production system, gap need to integrate with the reservoir and well model [Lawati, Salmi, et al, 2010]. Other parameters in the surface such as separator need also to optimize in order to improve the production.

An IPM package is very useful while proposed the new development in order to get the figure model of the field [Stoisits, Bashagour,et al, 2010]. From there, it will make easily to make the evaluation of the field which can select the suitable model to be proposed in development. The production forecast can be done once the production network modeling (Gap) will linked to the reservoir model (Mbal) and well model (Prosper).

2.3.2 Tank Model and Material Balance

Tank Model is build once we get the reservoir data (Figure11). From the tank, we can describe the behaviour that has in the reservoir. In the application software (Mbal), once the tank models already build, the evaluation can be done of the reservoir and possible to have some recovery in order to increase the production with the low cost.

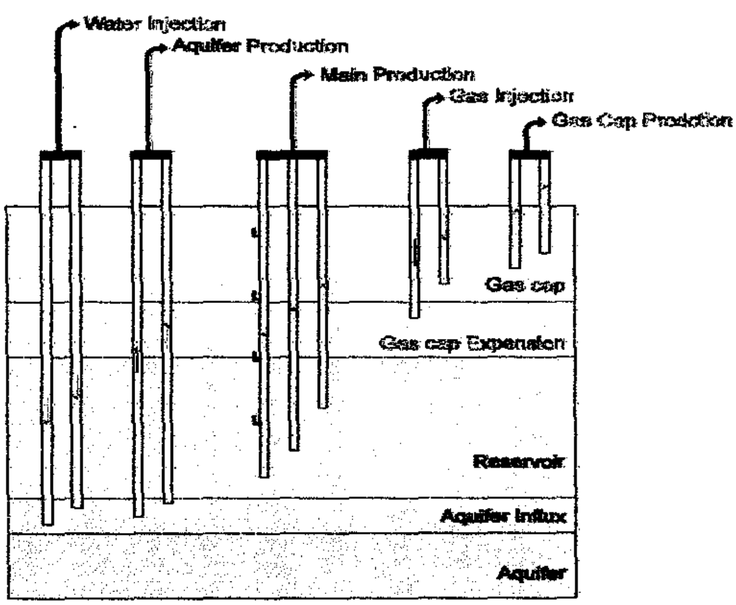

Figure 11: Tank Model Assumption

There are assumptions that already make in tank model [IPM, 2010]. This includes:

1. Homogeneous pore volume, gas cap & aquifers
2. Constant temperature
3. Uniform pressure distribution
4. Uniform hydrocarbon saturation distribution
5. Gas injection in the gas cap.

From the assumption that make in the tank model, the early prediction result can be done for the reservoir model. The purpose for material balance is since it will verify some of the geological data that done while working on geology and geophysics part and some of production data such as the recovery factor, oil initially in places (OIIP) and gas initially in places (GIIP) [Lee, Wattenberger, 1996]. Besides that, reserves estimation can be done for the field by using the material balance after running the prediction forecast from the tank model.

However, when evaluate the reservoir model; it only depends with performance from the reservoir simulation. Material balance is a part and process of the reservoir simulation part [Dake, 2001]. It is because reservoir simulation will give the complete and more accurate result as compare with the material balance. Material balance can be used for the early prediction which will provide the estimated production for the field since it will assume some of the parameter while making the prediction [Lee, Wattenberger, 1996]. It is more suitable to be used in the exploration well which to estimated the production for the field. However, it is also applicable for the producing field which is to make some correction of data that already work on in the geological part. Hence, it is also can be used to verify some of the production data that have for particular field.

Basically, in material balance equation (MBE), total volume of fluid must be equal with volume fluid that be produced and volume of remaining reserves.

The reservoir volume of original fluids in place	=	reservoir volume of fluids produced	+	volume of remaining reserves

Equation 2: Material Balance Equation

To achieve this equation, some of the assumption should be making in since material balance will not give the full value of the parameters [Dake, 2001]. This included:

i. Pressure which is the material balance equation is tank model. It means that, the assumption that make in the material balance and the tank model is same since tank model is a part of material balance. Pressure constant throughout the reservoir at any time. An average pressure has to be selected to represent fluid properties.
ii. Temperature where the changes in a reservoir take place at constant temperature, isothermal.
iii. Production rate time has no part within MBE. It means that the time is dependent for the material balance.
iv. PVT data measurements should be made or calculated to reflect behavior in the reservoir.

2.3.3 Inflow Performance Relationship (IPR)

IPR is a part of nodal analysis which will evaluate the performances which come from the reservoir constraint to the sandface. It is measured using bottomhole pressure gauges at regular intervals as part of the field monitoring production [Allen, Roberts, 1993]. IPR is relationship between flow rate (q) and wellbore pressure (P_{wf}) (Figure 12).

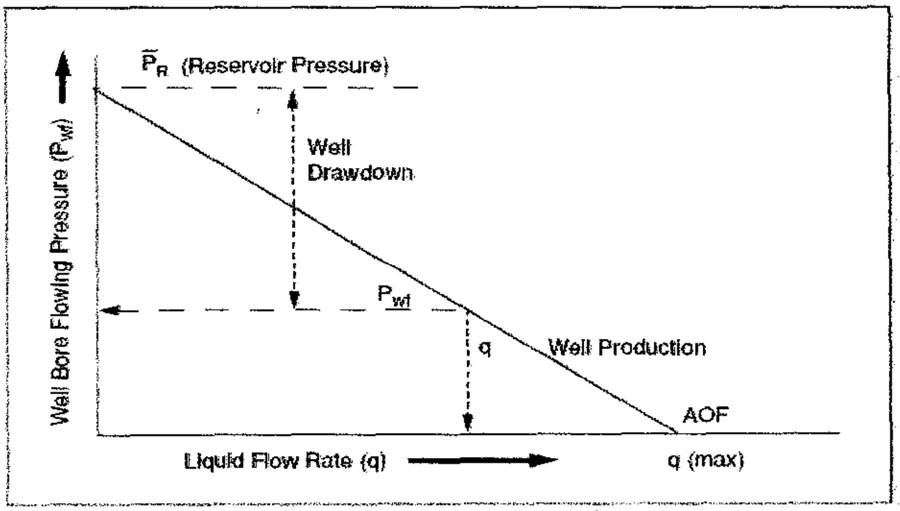

Figure 12: Straight line IPR (for an incompressible liquid)

A straight line IPR can be determined from two field measurements:

1. The stabilized bottom hole pressure with the well shut in {reservoir pressure of (P_R)}
2. The flowing, bottom hole, wellbore pressure (P_{wf}) at production rate q

IPR plot can be done by using other model instead of straight line. This included such as Vogel, Productivity Index (PI) entry and Darcy. In prosper software; there is option to select the model.

From the plot, the performances for the plot can be obtained by using this application. From the plot, pressure will decrease when the rate is increase (Figure 13). It is due to the reservoir condition concept which producing fluid will reduced the pressure. The pressure in the well should be maintained in order to optimize the production which helps from the injector or the producing well with some artificial lift.

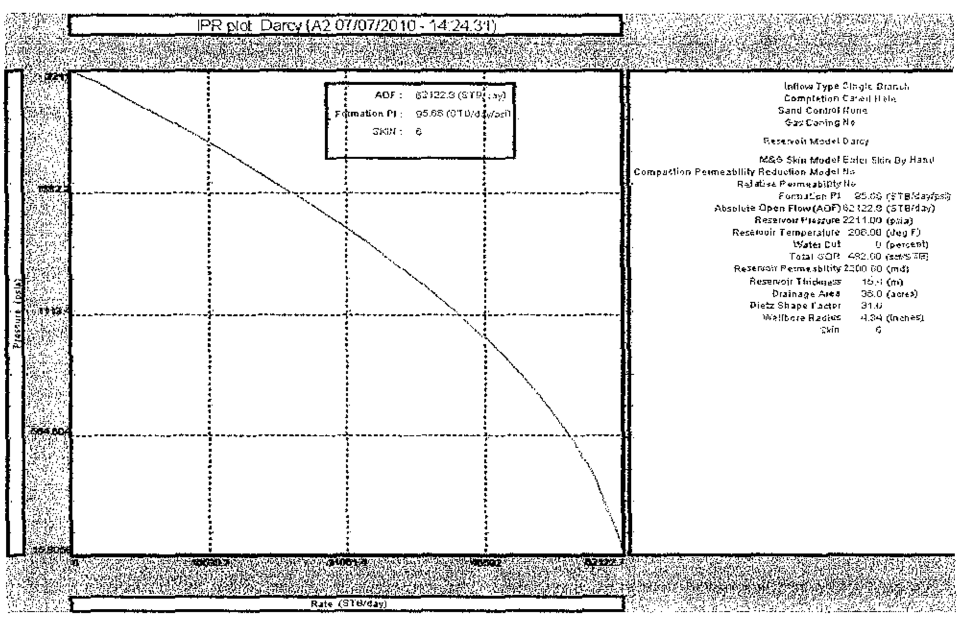

Figure 13: Prosper IPR Plot

CHAPTER 3:
METHODOLOGY

3.1 Research Methodology

In this final year project, mostly it will use the application software or tools to investigate the problem that will solve. In order to solve this problem, there are several methods that use in term the step while using the application software. Steps in research methodology:

i. Get the input data. This data can be getting from the history field report. In this report it will mention the parameter and value which is the fluid characteristics that will use to develop the field.

ii. Built the well model (Prosper) which will used to evaluate the well performance. Basically, the parameter that should be input from prosper is the characteristic of the well, Pressure, Volume, Temperature (PVT) data, equipment data, Inflow Performance Relationship (IPR) data and analysis summary (Figure 14). However, the most important that will do in this project is the interception between IPR and VLP plot in order to get the optimum production (Figure 32).

iii. Built the reservoir and tank model by using Material Balance (Mbal) which will used to evaluate the reservoir performance. Basically, the parameter that should be input from Mbal is the characteristic of the reservoir, PVT data, tank data and prediction result (Figure 15). Mbal software also can be used to make the prediction result for the field. However, things that already done in this project are build the tank model which will integrate with the well model and surface model.

iv. Built the surface and platform model (Gap) which will integrate the entire model in this stage (Figure 23). In this part, network model will connect with the wells and reservoirs for the fields. It also will integrate with the other component in this model such as pipeline, manifold and pressure. The output would be the optimum result that obtained from the separator.

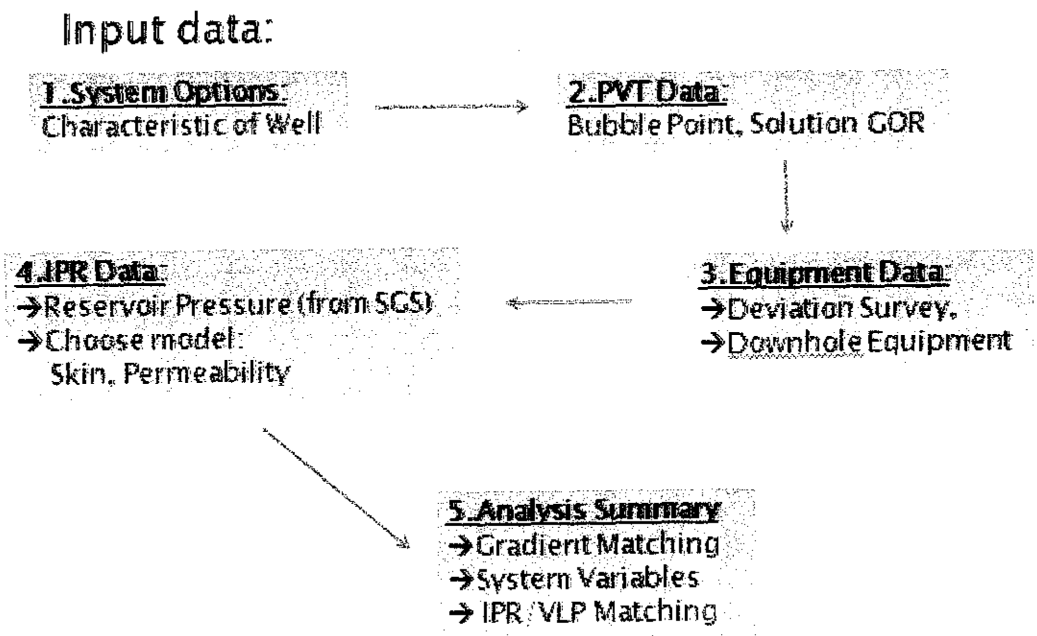

Figure 14: Well Model

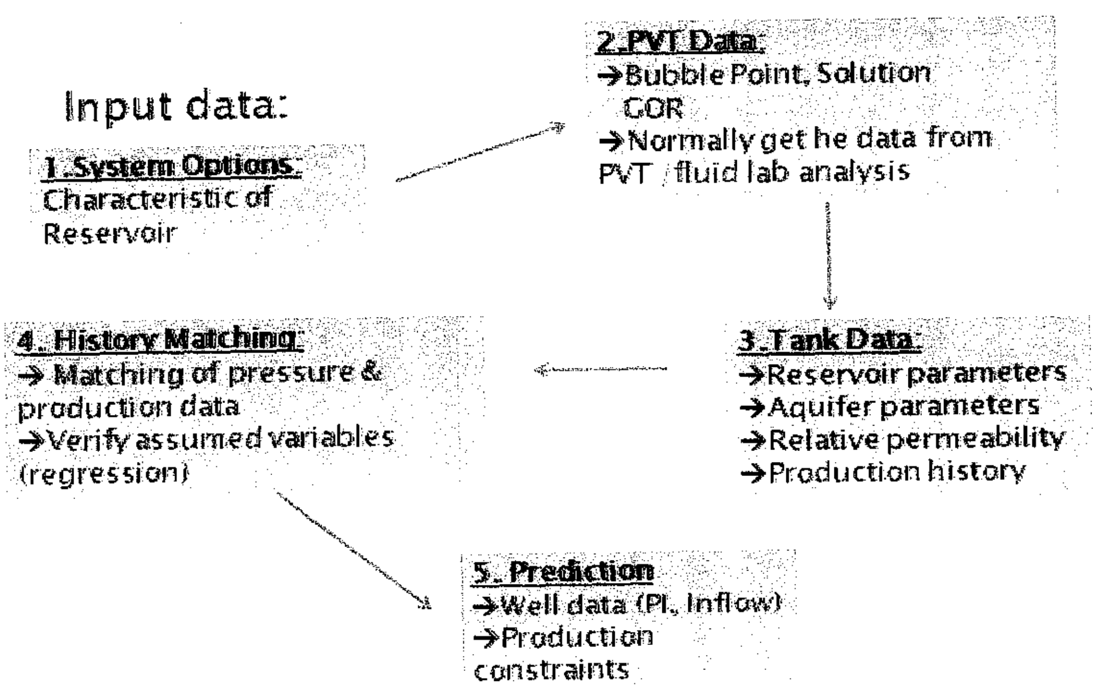

Figure 15: Tank Model

v. After already built the surface, it is important to make the production optimization for the well, reservoir and the platform. During the optimization, optimization will do some by make some changes for the parameters. In this project, the parameters that will consider is the separator manifold pressure and the gas lift rate that should be injected in the well. Basically, the evaluation of the network modeling which each wells is producing naturally as the base case. The other cases would be the model which has some changes for the pressure and gas lift rate which is the method for production optimization.

vi. After all the platform and surface already optimized, economy analysis of the field should be done in order to know the optimized pressure, production rate and gas list rate that should be injected to the well. The evaluation of the well model, reservoir model and surface model can be done by using questor application software in order to know the profitable of this field and choose the best case which will consider the development of the field.

In the development in order to achieve the network model, it will form a team which is called integrated asset team (Figure 16) where the function is a part of process to make the production optimization in order to manage. There would be a connection among each other in this team. This team will contain geologist which will provide the static modeling, reservoir engineer which will provide the dynamic modeling, production engineer which will provide well model and network modeling, process engineer which will handle the control production in downstream and also the economy analyst to make the economy evaluation (Jonanthan, 2010). All this background discipline will play their role so that they will get the production optimization for the field (Figure 17). They will evaluate the performance which starts from the reservoir, well; facilities and surface until the economy evaluation in order to maximize the production with minimize the cost.

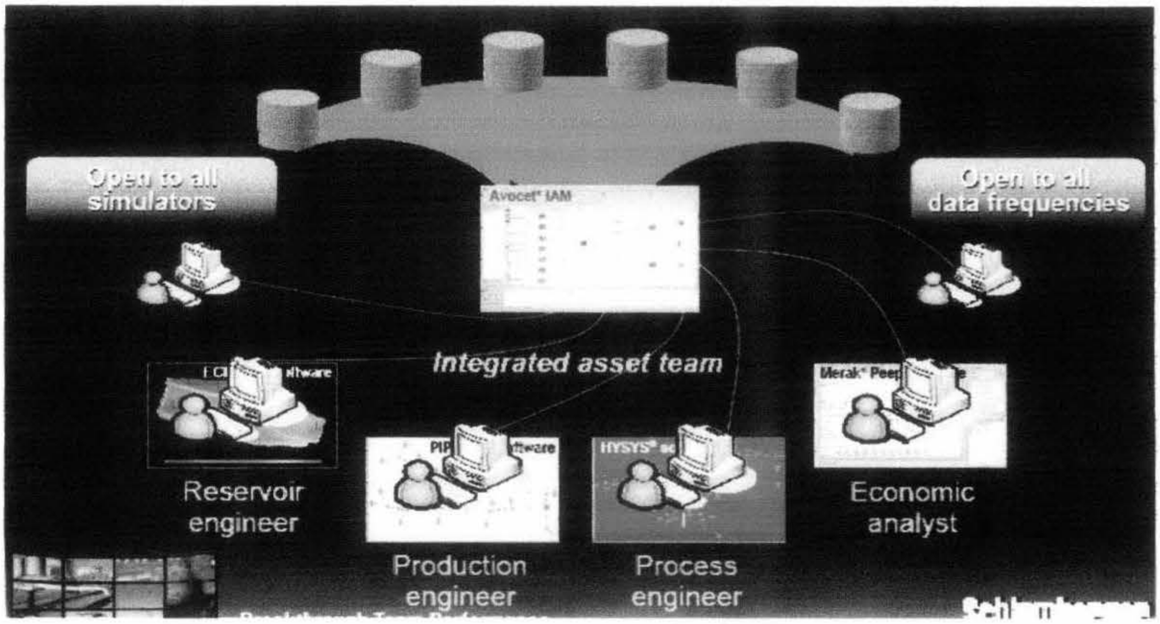

Figure 16: Integrated Asset Team

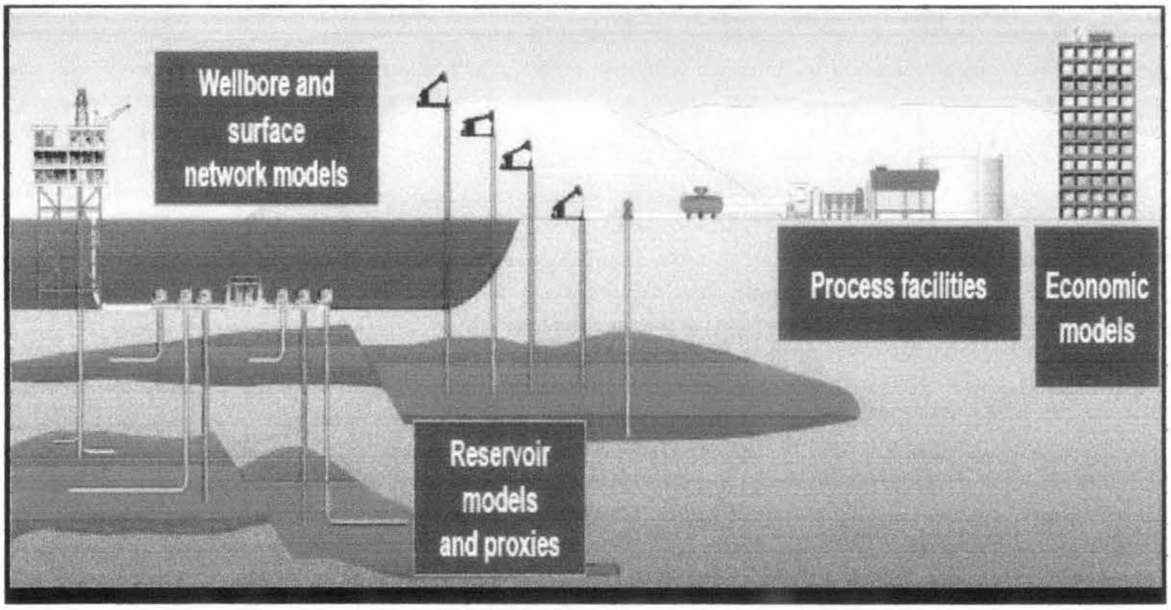

Figure 17: Flow for Production Optimization

3.2 Project Activities

For most of the time, this activity mostly using the software to built the well model, reservoir model and surface model. Before that, it is important to study the literature review which is the concept that has in the software or theory behind application. At the same time, reading of the journals or papers to identify the problems that fields always have which causes the result that they expected is slightly different with the actual production. Then, it needs to investigate the problem and find the suitable solution.

This solution will applicant in the application software where need to run the software in order to validate the model. Once the well already valid, production optimization can be done with make changes some variable to increase the production. This included the gas lift ware and the pressure. After the well already optimized, we can gather it in the network model to optimize the platform. Then, the production profile for this field can be generated from the surface model. At the same time, economy evaluation for each case in the model can be done for this field in order to know the economy for each case that already run for the field and also to get the optimum production and cost.

The most important is before make the surface network modeling is should have enough data to be evaluated. This data will be the parameter that maybe can consider and changes when to make the production optimization for the well. At the same time, it is important to have the basic knowledge to use some software to save the time for learning software during final year project period.

3.3 Key Milestone

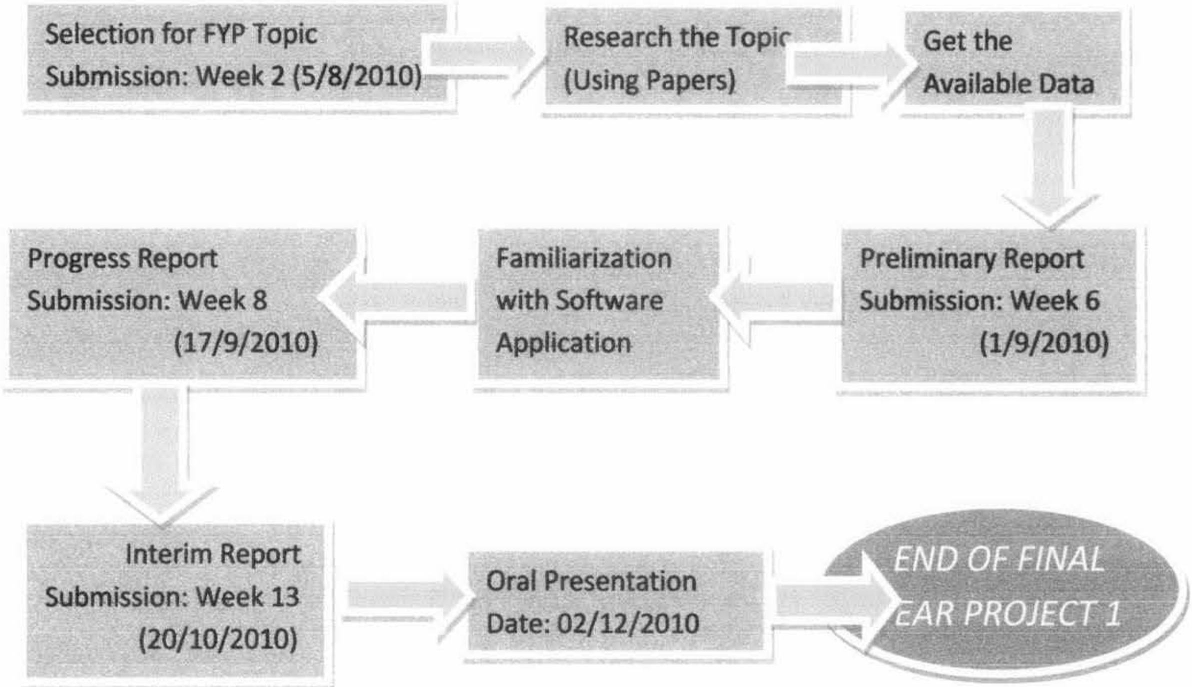

Figure 18: FYP1 Key Milestone

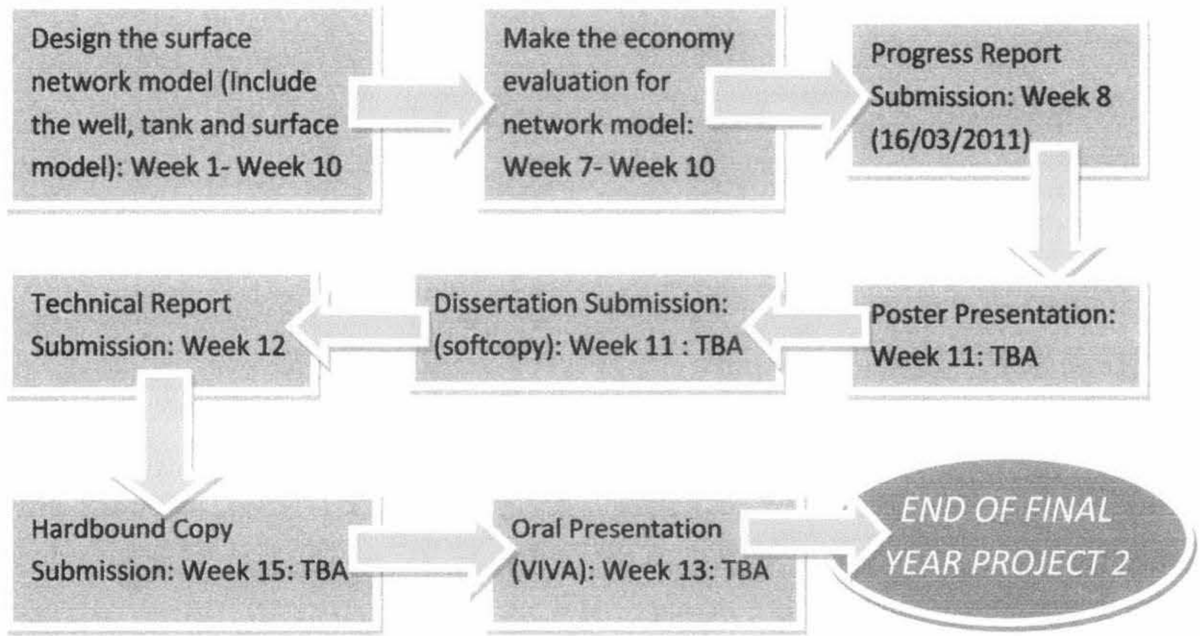

Figure 19: FYP2 Key Milestone

Probably in final year project 1, mostly it will study some papers or journals which use the Integrated Production Modeling (IPM) concept. From the study, it will define the problem that happens in the field which needs some solution to solve by using the IPM software application. All the discussion and analysis result will write it in the report. For FYP 1, the target of project will focus more the literature review which is the method to make the evaluation of the surface model while for FYP 2 will focus more to the make surface network model and economy analysis for the surface model. Figure 18 shows the key milestone for FYP 2 which is the milestone that will done for FYP 2.

3.4 Gantt Chart

Based from the final year project 1 Gantt chart (Figure 20), normally the target for this stage is make the literature review or the study of the concept that have in the production optimization in the surface modeling which is to know the methods that will use in order to get the optimum rate and production. At the same time, the familiarization of the application software is important since it will make easier when doing the simulation on the final year project 2.

From the final year project 2 Gantt chart (Figure 21), it will come to the application based the study that already make in the previous stage. In this part, the target would be design the surface network model which consist of well model and reservoir model and integrate it with all parameters that have in the surface model until it reach the top surface which is the separator. The several cases will do in order to choose the best case which will give high production and optimum cost. The economy evaluation will be do in order to get the operation cost based the cases that already do in the network model. Once already get the good integrated model which have optimum production and optimum cost, all the finding will report it as a dissertation. Providing the technical paper with oil and gas industry and the presentation with the industrial people should be done in order to find the potential for this project. From this stage, the potential for this project can be applicant in the future.

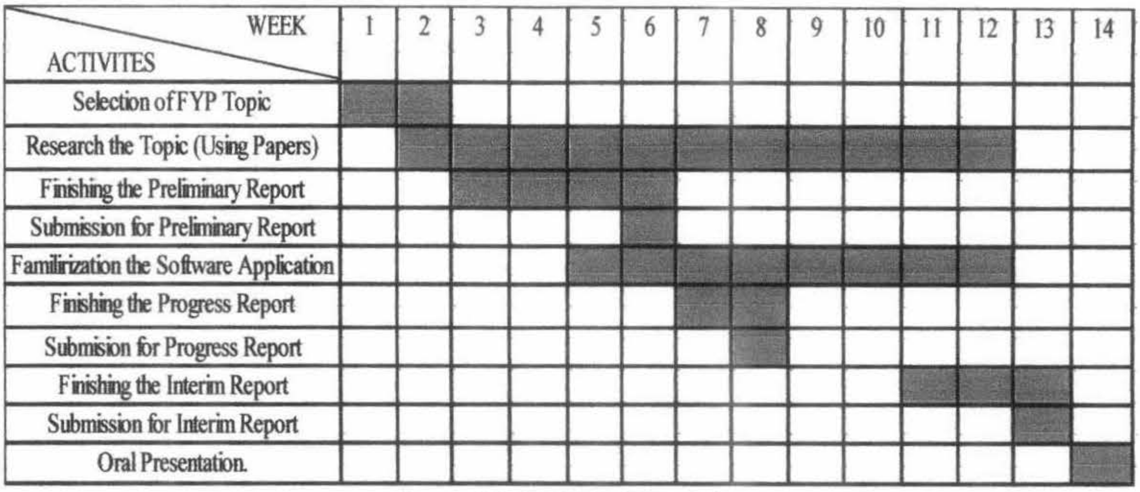

Figure 20: FYP 1 Gantt Chart

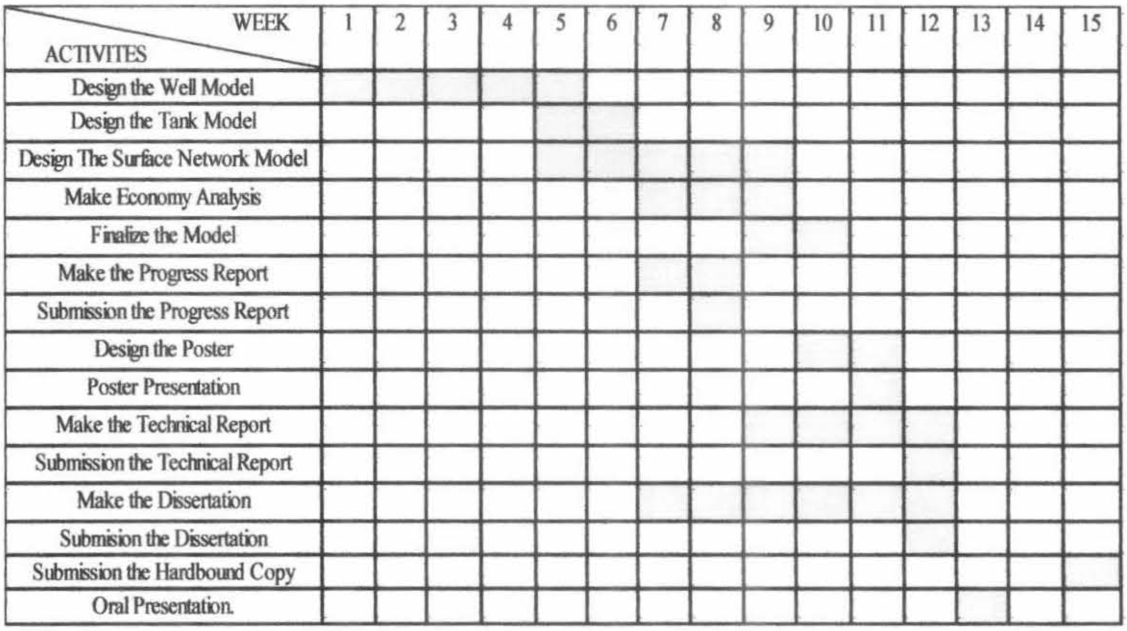

Figure 21: FYP 2 Gantt chart

3.5 Tools

For the most of the final year project, it will use the Integrated Production Modeling (IPM) application which comes from the petroleum expert package which includes some software that used in make production optimization. The IPM software that will use in this project is:

a. Mbal (Material Balance) which use to build the reservoir model, verify the Stock Tank Oil Initially In Places (STOIIP), make the production forecast and as requirement for the reservoir to have the injectors. (Figure 14)

b. Prosper which use to build the well model, validate the well model or well test and as requirement for well to have the gas lift. (Figure 15)

c. Gap which use to make surface network modeling, production profile, make production optimization and will optimized the pressure and temperature in the surface such as manifold and pipeline (Figure 23).

d. Questor which use to make the economy analysis for the surface network model. From there, we can know the profitable and cost operation for the network modeling (Figure 9).

CHAPTER 4:

RESULT AND DISCUSSION

4.1 Data Gathering

Overall, the data that will use in this project currently is based on the provided data that have in the field development project (FDP) report. This FDP report is provided by Geosciences and Petroleum Engineering Department (GPED), Universiti Teknologi PETRONAS (UTP). In FDP report, the data given is useful to be used in the tank model and well model. Also provided data is from the reservoir fluid data, well test data and production history data. This data is useful to design the simple well model and tank model which are without any optimisation of production. For surface model, this model can be done once the well model and tank model is already design and network it in the surface model. From the surface model, the result for the production can be obtained by knowing the oil rate which should be produced by each well. Besides that, from the prediction that done in the tank model which is based the Stock Tank Oil Initially in Places (STOIIP) and the other reservoir properties, the prediction result can be done to know the period for the oil to produce based the optimum production that get from each well. From this result, economy analysis can be done to know the operation cost that will done in this project for the each equipment model that have in the surface model.

4.2 Data Analysis

In tank model, the analysis will start with the analysis with PVT data. In this part, all the data from the reservoir fluid data will be input in the material balance (Mbal) software. In PVT analysis, parameters should be intercepting in the one point which is for pressure, volume and temperature. After PVT matched, the tank model should be input in order to build the tank model. In this part, all the requirement data such as pressure, porosity, permeability, oil in places and date of production should be input. Later, it will integrate with well model and surface model which will give the prediction production based the tank model that already designs.

In well model, the analysis will start with the analysis with PVT data. In this part, all the data from the fluid data will be input in the well model (prosper) software. In PVT analysis, parameters should be intercepting in the one point which is for pressure, volume and temperature. After PVT matched, the equipment model should be input in order to build the well model. There are several parts in this part which will need the several data. The data that will use for this project are well completion diagram which is to know the component that have in the completion and the well deviation survey which is to know the depth and directional of the well. After equipment data is design, analysis summary should be design in this well model. In this part, it is to ensure that the IPR plot should be intercepting with the VLP data (Figure 32). It is because it will give the optimum production which is the optimum oil production with the suitable pressure that will integrate with the tank model and optimise it in the surface network model. It is possible also to match the IPR and VLP plot from the well test data which is to know the production performance of the well. Overall, analysis summary have different method that can be done which the output would be the intersection between VLP and IPR plot but it depend with the availability data that have. IPR plot is the plot which considered the production performance from the reservoir to the sandface and VLP plot is the plot which considered the production performance from the sandface to the platform. Normally, the data can be obtained from the well and reservoir report which can determine background of the field.

4.3 Production Performance Result

4.3.1 Field with Producing Naturally

In this project, two network surface models already build by using Gap software. The two models that already design will represent as two cases that investigate in this project which are the model where the fields is producing naturally and field which producing with support from gas lift.

After build the well model and tank model, the entire model will integrate in the surface network model as in the Figure 23 and Figure 25. There are five platform in this field which will connected with one separator which label as manifold A, manifold B, manifold C, manifold D and manifold E. There are 24 wells in this field where it will integrate with 9 tank models. From 24 wells, there are 7 wells in the manifold A which namely A1-A7, 3 wells in manifold B which namely B1-B3, 8 wells in manifold C which namely C1-C8, 3 wells in manifold D namely D1-D3 and 3 wells in manifold E namely E1-E3. There are 9 tank models in this field which are namely as K140 which is connected with A1 well (Manifold A), K800 which is connected with A2-A6 wells (Manifold A) and H900 which is connected with A7 wells (Manifold A), M240 which is connected with all wells in Manifold B, N720 which is connected with C7 well (Manifold C), N240 which is connected with all wells in Manifold C except C7, N800 which is connected with all wells in Manifold D, K100 which is connected with E1 and E2 wells (Manifold E) and K500 which is connected with E3 well (Manifold E). All the wells and reservoir will tabulate in the figure 22.

Manifold	Reservoir	Well
A	K140	A1
	K800	A2, A3, A4, A5,A6
	H900	A7
B	M240	B1, B2, B3
C	N240	C1, C2,C3,C4,C5,C6,C8
	N720	C7
D	N800	D1, D2, D3
E	K100	E1, E2
	K500	E3

Figure 22: Connectivity for Surface Model

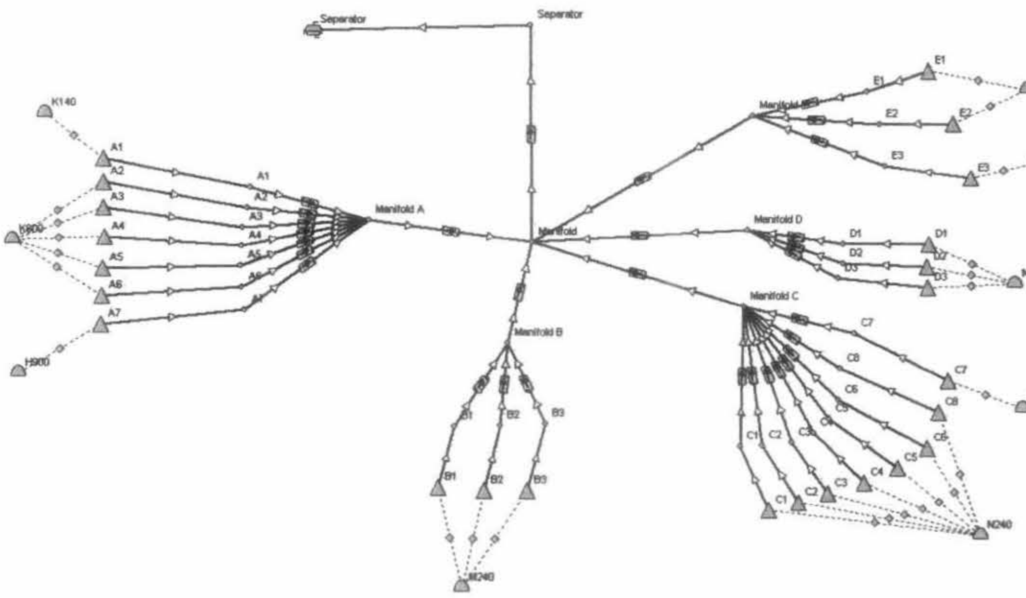

Figure 23: Network Modeling for Producing Naturally Field

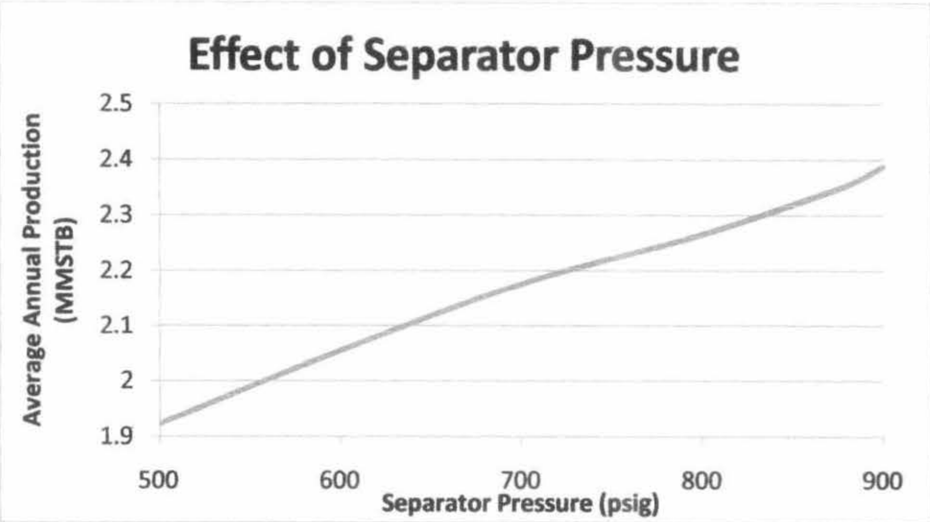

Figure 24: Effect of Separator Pressure in Oil Production

In this case, all the wells are produce naturally without optimization by the production constraints such as artificial lift and the injector (Figure 22). The length of the pipeline is set as 1000ft from the manifold to separator. After integrate the model which is without optimization with the constraints, it found that all 24 wells are producing the oil. The expectation production is starting from 1st January 2012. The separator manifold pressure at the separator is set as 877 psig after make the sensitivity analysis (Figure 24). All the oil production is flowing from the well to the manifold and finally to the separator by using the pipeline.

From the model, there are any results that can be obtained such as the oil production, temperature, water cut and pressure. Since, this project is mostly focus with the production optimization; the interest would be on the oil production from the separator and each manifold. The average total oil production rate that will get is 2.35 MMSTB/year. This rate is recorded at the separator. It is total of the production rate from all manifold production rates. This is considered as the first case since it already set the separator manifold pressure as 877 psig based the sensitivity analysis.

4.3.2 Field with Gas Lift Support

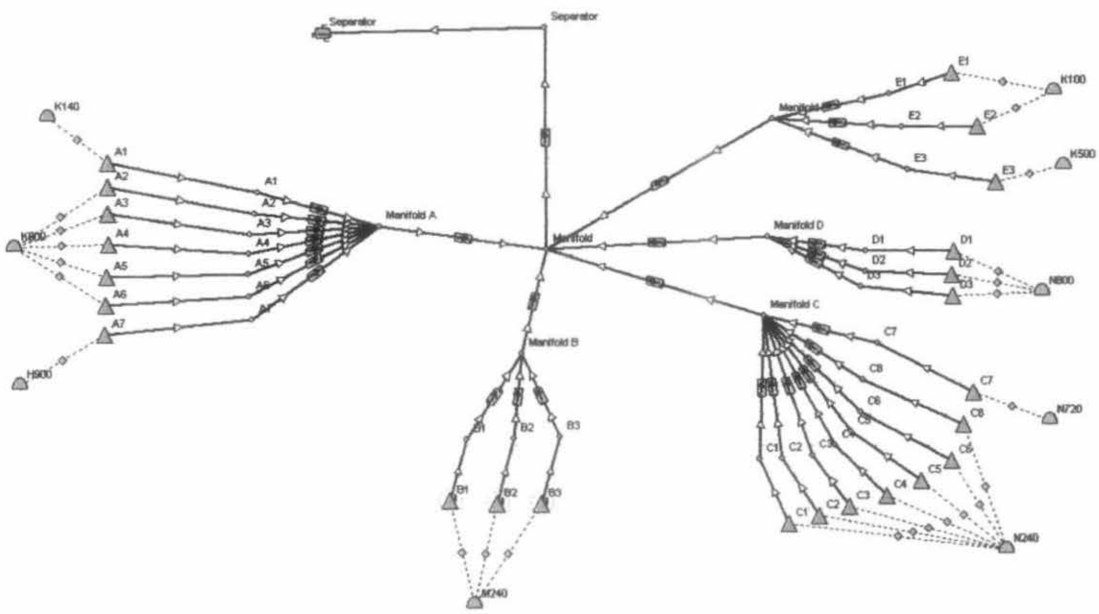

Figure 25: Network Modeling for Gas Lift Support Field

Figure 25 is showing the model where the field is producing with support from the gas lift. Overall, all the characterization and performance that set in this model is same with the model for producing naturally field. This included the separator pressure is set as 877 psig, all the wells are flowing from the well to the manifold and to the separator, the production prediction is expected from the 1st January 2012 and the length from the manifold to the separator is 1000ft.

The gas lift rate also maintained for all wells which using the gas lift support which is 100 STB/day. This value is constant since the target in this project is to know the performance of the production for producing naturally and gas lift support cases.

The difference that has in the network modeling for gas lift support is some of the wells in this model will produce by using gas lift support. From the analysis of production performance in each manifold, manifold B has less oil production as compare with the other manifold. It is due to the characterization that has in the manifold B which is high water cut even already make the drill stem test (DST) to this field. When the field has high water cut, it means that some percentage of oil columns in the reservoir is already fully with the water. Since water has high density from the oil, it will difficult to push the oil to the well which causes less production. Besides that the intersection that have in IPR and VLP plot do not give the high oil production since it is depend to the reservoir behavior which will give the IPR plot for the particular well. VLP plot that already generate in the well model also do not get the good production for the well. Thus, optimization should be done in order to increase the production.

Hence, the gas lift production will focus to all 3 wells in manifold B. The function of gas lift will use to decrease the fluid density which will push the oil to the surface. The main reason for focusing the manifold B since according to the history of the field, there has much oil in places that should be recovered from the reserves as compare with the manifold D and manifold E since both manifold has less oil in places as compare with manifold B. However, it shows that the total oil production from manifold D and manifold E is much as compare to manifold E. Thus, optimization should be done in manifold B in order to increase the production where use support from gas lift as the method to make production optimization.

Manifold	Oil Performance (MMSTB)
A	1.01
B	0.12
C	0.76
D	0.235
E	0.225
Total	2.35

Figure 26: Average Annual Production for Manifold

After integrate the surface model, the total oil production that recorded by the separator is slightly same with the total oil production that recorded by separator for producing naturally field which is 2.35 MMSTB. It is because this result is recorded when the first oil production for this field. Normally, the effect of gas lift can be seen for several years later from the first oil production. Hence, the effect of gas lift can be seen from the result that will mention on the next part which is production prediction.

4.4 Production Prediction

Year / Oil Production	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Produce Naturally	2.35	2.338	2.32	2.25	2.181	2.131	2.05	1.981	1.949	1.927	1.919	1.905	1.887	1.86
Gas Lift Support	2.35	2.341	2.326	2.252	2.183	2.132	2.055	1.985	1.952	1.93	1.92	1.906	1.89	1.862

Figure 27: Total Average Annual Production

After obtained the average oil production that recorded by the separator, it is important to make the production prediction for this pentagon cluster. It is because make easier to know the production performance for period time. From the Figure 27, it show that the statistics average oil production for every year starting from 2012-2025. Figure 28 also show that the average oil production plots for the field which is producing naturally and with support from gas lift.

Overall, the production performance will decrease after several of the year because much oil already produced and recovered from the reservoir. Oil column that have in the reservoir is already replaced with the water. It means that, all the reservoir already fully with the water, which will increase the water rate and high water cut to the particular field. Besides that, while producing the oil, pressure in reservoir also will decrease. It is because, the pressure in the reservoir already use to push the oil to the surface and will decrease for some of the period time. When the pressure already decreases, it needs some support such as gas lift in order to push the oil to the surface which will increase the production.

From the figure 28, the comparison for production performance can be obtained for the field which is producing naturally and with gas lift support. Overall, the production performance for both cases is almost same (Figure 27) where there is not much oil production difference when the field is producing with gas lift support. It shows that gas lift support will not give much effect of the production performance for the both cases.

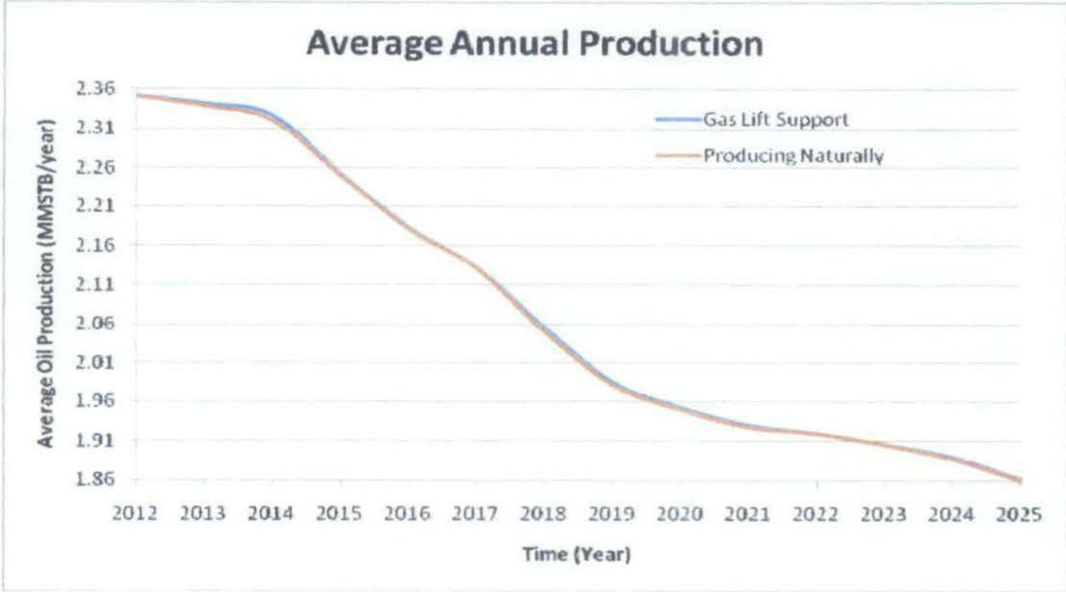

Figure 28: Average Annual Production Plot

4.5 Economy Analysis

Economy analysis is done by using Questor software where the main function is to make the cost forecast for the facilities and platform for this project. Evaluations for economy is starting when need to evaluate the facilities equipment that use in this project. This included the materials that use, the equipment, and the inventory. All the material will be evaluated according to the location of the materials that make and the quality of the materials as well. Figure 29 will show the facilities cost that will done to evaluate the surface model for the field.

The equipment that has in the facilities is depending with the surface model that will design in this project. Normally, in this facility, the evaluation costs that will evaluate are the type of the platform, the pipeline, the manifold until it connected to the well (Figure 30).

From the surface model, all the cases will be evaluated according to the cases that already done in this project. All the cases will evaluated and tabulate as shown in Figure 31. It shows that the total cost for the field which is support by gas lift is higher than the field that producing naturally. The total cost in this project means that all the cost that already spend to design the facilities in this surface model. Cost for gas lift field is much higher because it needs the cost for get the gas source from the other field which is has many gas reserves in the reservoir. Besides that, cost for flowing gas to be installed in the tubing and will push the oil flowing to the surface.

For oil producing naturally, the oil will start produce once the surface model is complete build which have complete facilities for oil flowing to the surface.

4.6 Discussion

Based from the performance, all the wells are producing the oil. The total production of the oil is depends with the field performance which is the optimum production that obtained from IPR and VLP plot (Figure 32). However, there would be cases for the other field where several well is not producing even already integrates the surface model. It is because the particular well does not get the optimum production and pressure to produce the oil. It means that there is not intersection between the VLP and IPR plot (Figure 33). This case can be happen when the parameters that already match in the well model is did not match when integrate with the tank model and network model. Changes of parameters should be done so that the VLP plot will be intercept with IPR plot. In other cases, when already use the data given in the report, and the well still do not get the optimum production. It means that this well need some support for artificial lift such as gas lift which will make easier for the oil to flow from the well to the surface model. This can be applicant for some wells where the oil is cannot produce naturally.

There is possible when the tank cannot flowing the oil through the well and pipeline to the surface. This can be happen when the oil in places that have in the reservoir is very low. So, it is not easier to produce the oil naturally especially when the reservoir pressure also low. The pressure that have in the low oil in places also low will cause the oil cannot flow to the surface. Besides that, the pressure is drop very fast when the oil is flowing from the tank into the pipeline will cause oil cannot flowing to the surface although still have many reserves in the reservoir. In this case, the reservoir needs the injector such as gas injector and water injector which is will maintain the reservoir pressure. It will cause the reservoir pressure drop slowly. So the potential, to flow the oil from the reservoir to the pipeline is high. So it can be applicant for some of the tank model which cannot or less producing the oil.

Once already integrate the model, it is important to choose the best model that will develop in this project. The chosen project based model and the prediction that already do in this surface model. In this project, total facilities cost would be cost that already spend in this project which is according to the cases that already make in this optimization. Hence, it needs some income money which is the benefit that gets in this project. The oil production that obtained from the field would be the income money that gets in this project. It is based the average oil that produce for every year which is count in the dollar. Based the production around 2000 MSTB/year, it can recovered all the expenditure cost in 4 year in case 1 barrel oil would be equivalent with the 100$ dollar. It means that, after 4year, the operating company will get the benefit from their project.

From the final result, the best cases that will chosen to develop this pentagon cluster project is the model with producing naturally. Although the support gas lift can increase the production, the production performance plot and result show that the average oil production is almost same where the difference percentage is less than 1% but the cost to have gas lift well is increase until 10% from initial expenditure cost. Practically, this project is more economical if the field is produce naturally as compare with the gas lift. Lastly, the best case that will implement in the pentagon cluster would be produce naturally field.

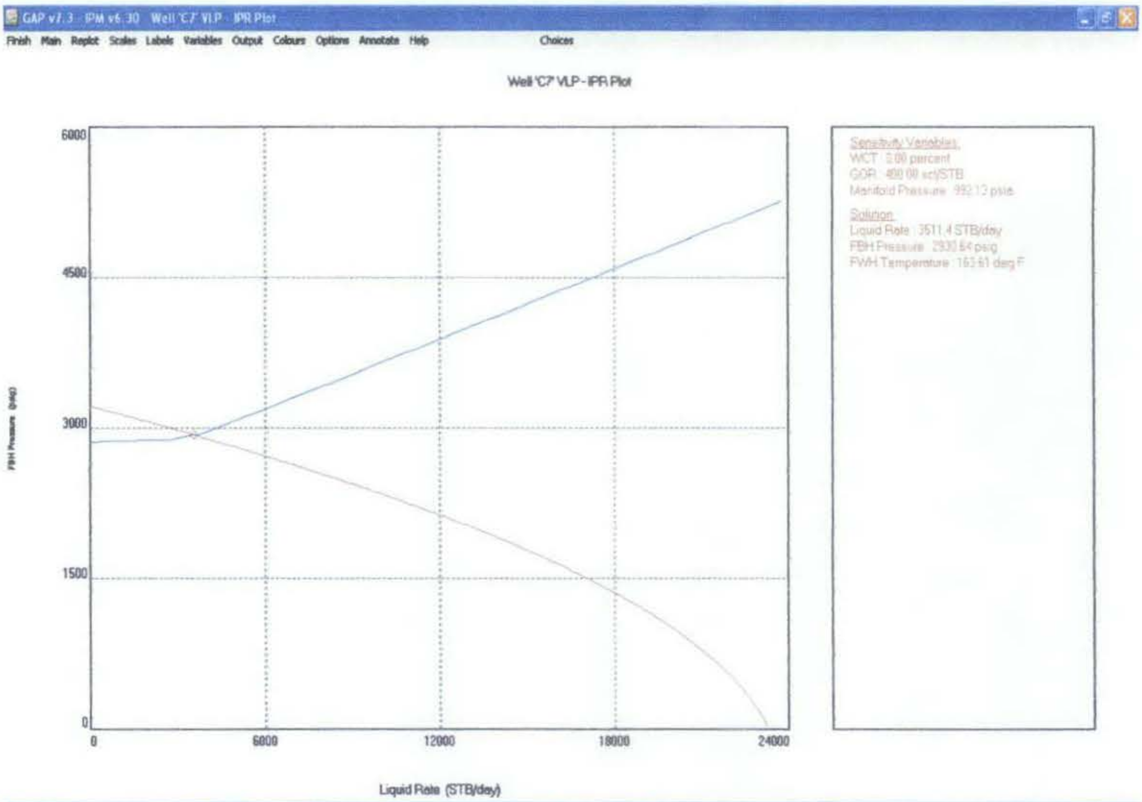

Figure 32: Well which IPR and VLP plot is intercept

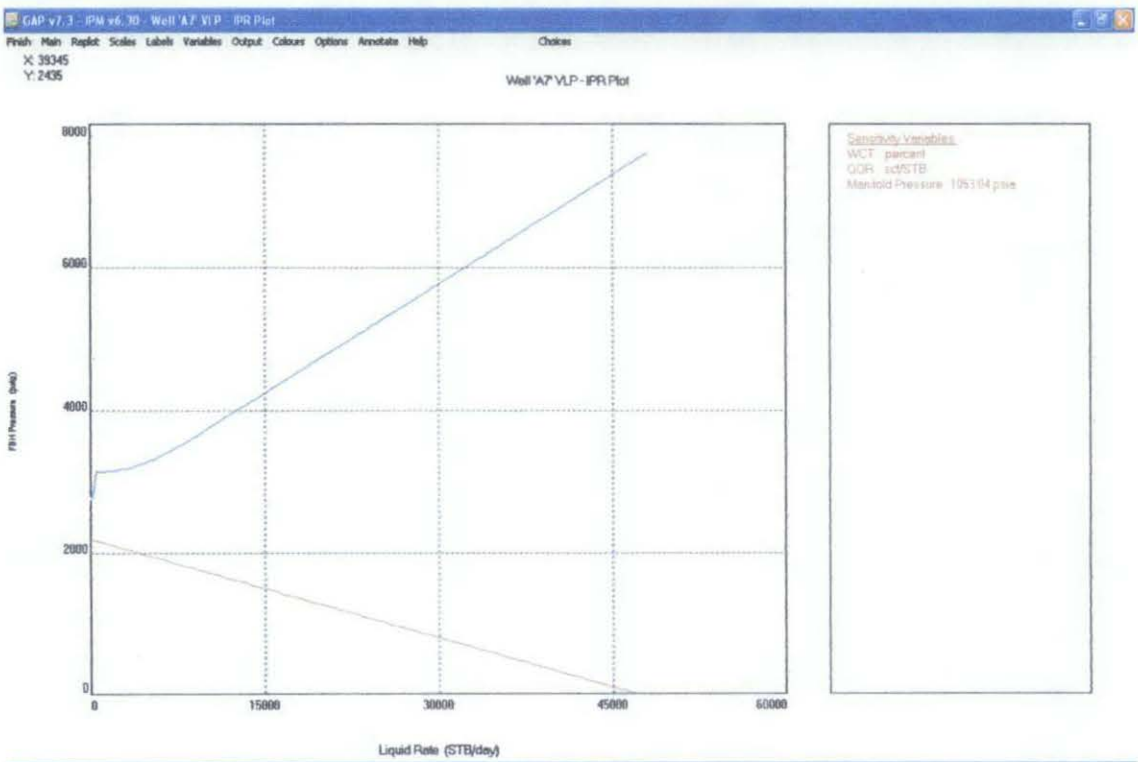

Figure 33: Well which IPR and VLP plot is not intercept

Besides that, the consideration for the surface model should be considered in order to ensure that the oil production can flow smoothly from the well to the separator through the pipeline. This included the bottom necked problem in the pipeline. Once the model have the bottom necked (Figure 34), it will cause the flowing of the oil will not stable because some of the oil will flowing from the manifold to the separator and some of the oil production is flowing to the separator and to the manifold. So, to solve this problem, the minimum pressure of the separator need to determine in order to make the flowing of the oil in the surface model is stable and smooth. After make the analysis, it founds that the suitable separator pressure should be set as 877 psig and above where this range of pressure will cause the flowing oil to the separator is stable. As the result, the separator pressure for 877 psig will be chosen as the surface model that will use for further optimization.

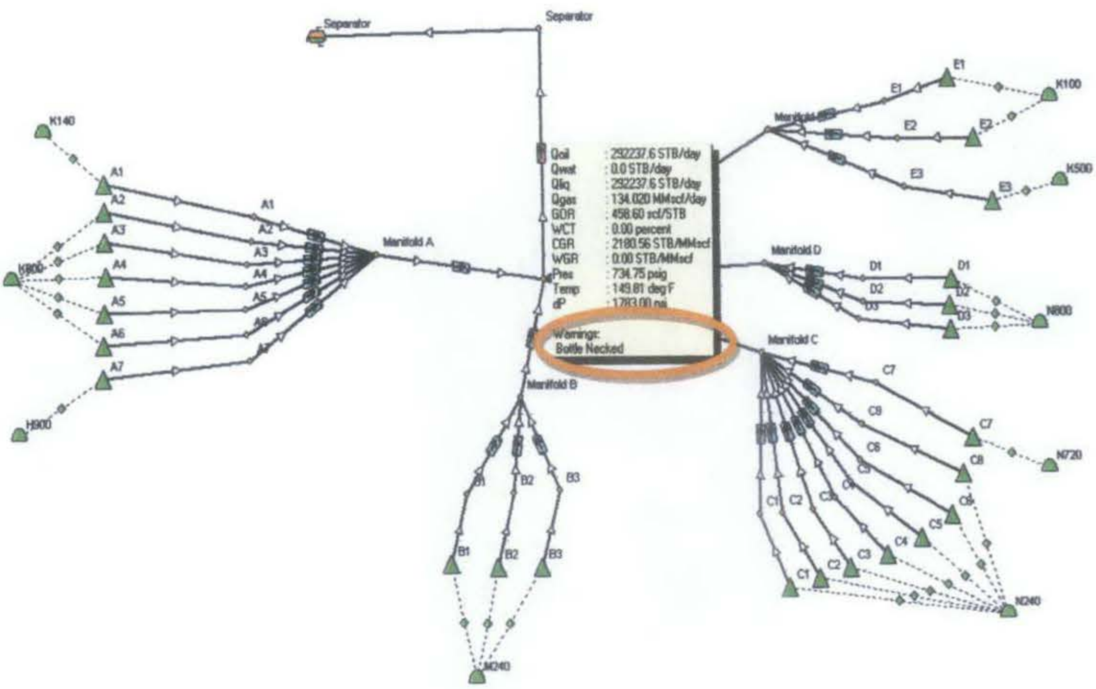

Figure 34: Network Model which have bottle necked

CHAPTER 5:

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As a conclusion, hopefully during this final year we can solve the problem of the field which is to choose the best case of the surface network model in order to get the optimum production. It is important to know the necessary for the field to have artificial lift or the injector and also make some changes or variables on order to improve and optimized the production. An evaluation of the field which included the reservoir, well, surface and economy evaluation should be done to know the field performance. After optimized the production, the production profile can be determined and make the evaluation of model can be done to know the field performance. This can be done by having several cases for surface network model and also make the economy evaluation for each case that worked on. This included cases where the field is producing naturally, support by artificial lift and some injector that implemented in the field. Lastly, the optimum result that obtained from the model which is the best case and considered as the good production and good operation cost for the oil company to develop the field. It will fulfill the requirement for production evaluation which is having high production and less operation cost.

From the finding, the finalize model that implemented in this project is the field which producing naturally without support gas field. The chosen case is based the consideration of the economical and profitable of the project and also effect of expenditure cost during this project.

5.2 Recommendation

There are several improvements that can be done to ensure the final year project is successful. This included identifying the problem that happens in the field. Sometimes we can noticed many problems that occur in the field such as high water cut, low production and do not have enough gas to push the oil to produce more oil.

Firstly, we should identify the parameter that will use in order to make the production optimization. Probably in this project, the target would be to optimize the gas lift rate that should be supply to the field in order to increase the production rate. The suitable parameter should be considered in order to give the better of the production rate of the oil. In this project, the parameter that will focus is separator manifold pressure and gas lift rate. This parameter will play their role in order to ensure that it will increase and decrease the production rate.

Based from the parameters, it is better for me to make the cases in order to know the better cases that will use to make the production optimization. The current production can be used as the base case for this project. Several cases should be done which is effect of parameters such as gas lift rate that will injected in the well and separator manifold pressure in order to know the production performance in the cases. Then, an economy evaluation should be done which is to investigate the cost that use to while make the optimization of the production. It is better to ensure the cost is in the balanced which give the project economy is valid and can be chosen as the strategic to increase production.

Lastly, it is much better if have the good knowledge to use application tools. It is important since make easier to make the production optimization of the field. Besides that, the analysis of the project can be done as soon as possible.

CHAPTER 6:

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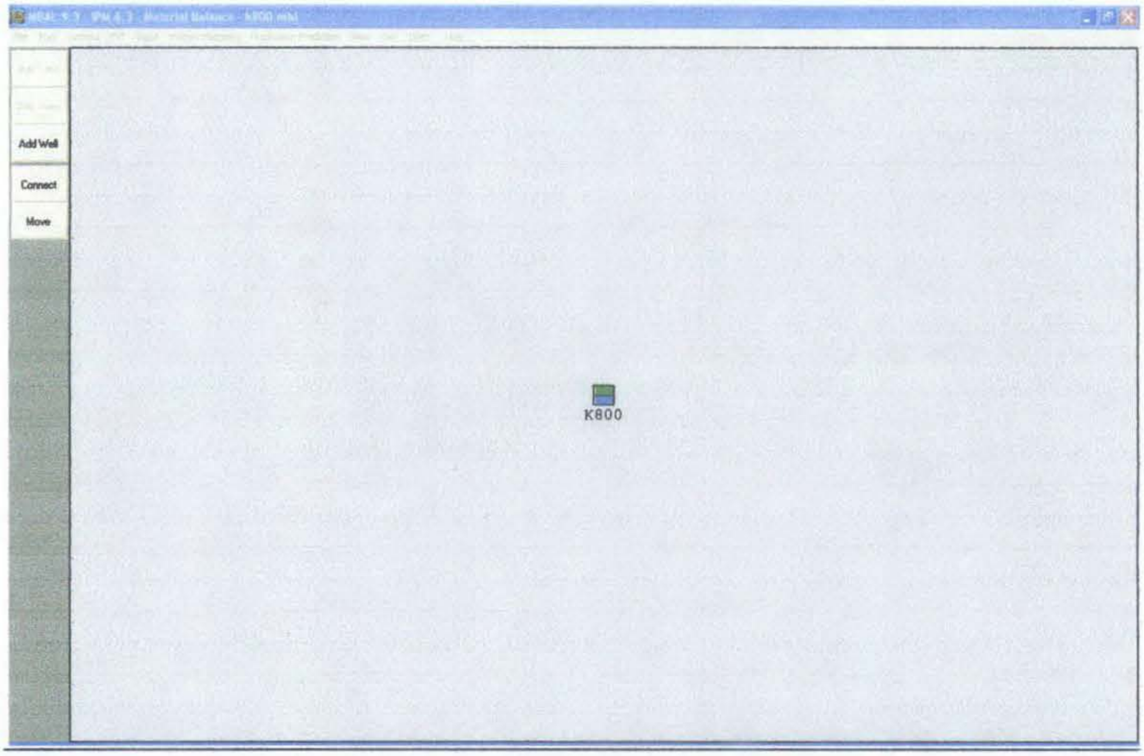
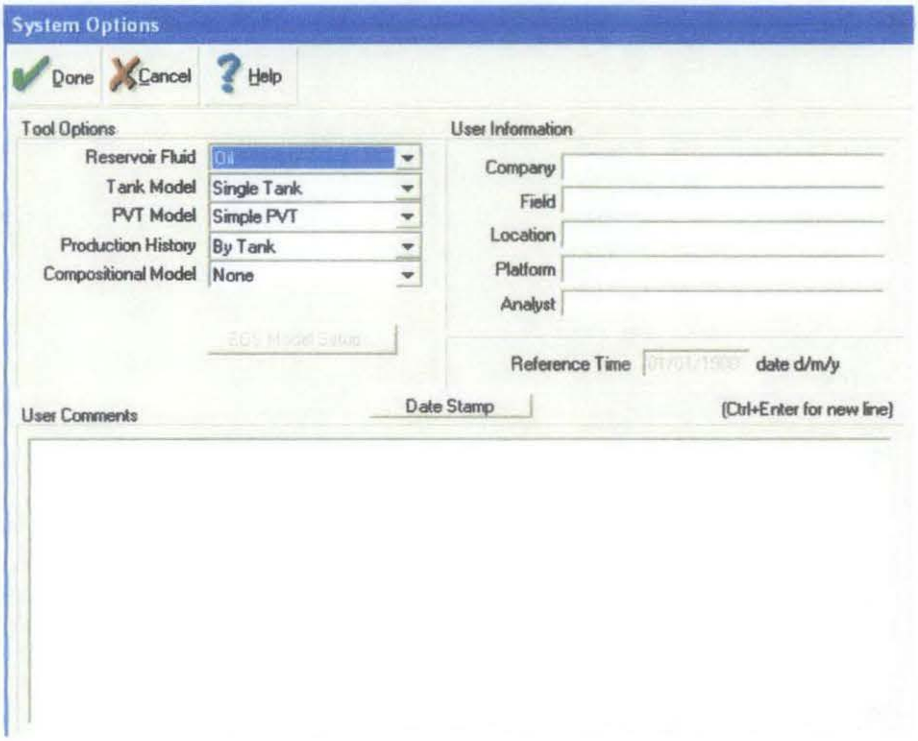
APPENDIX

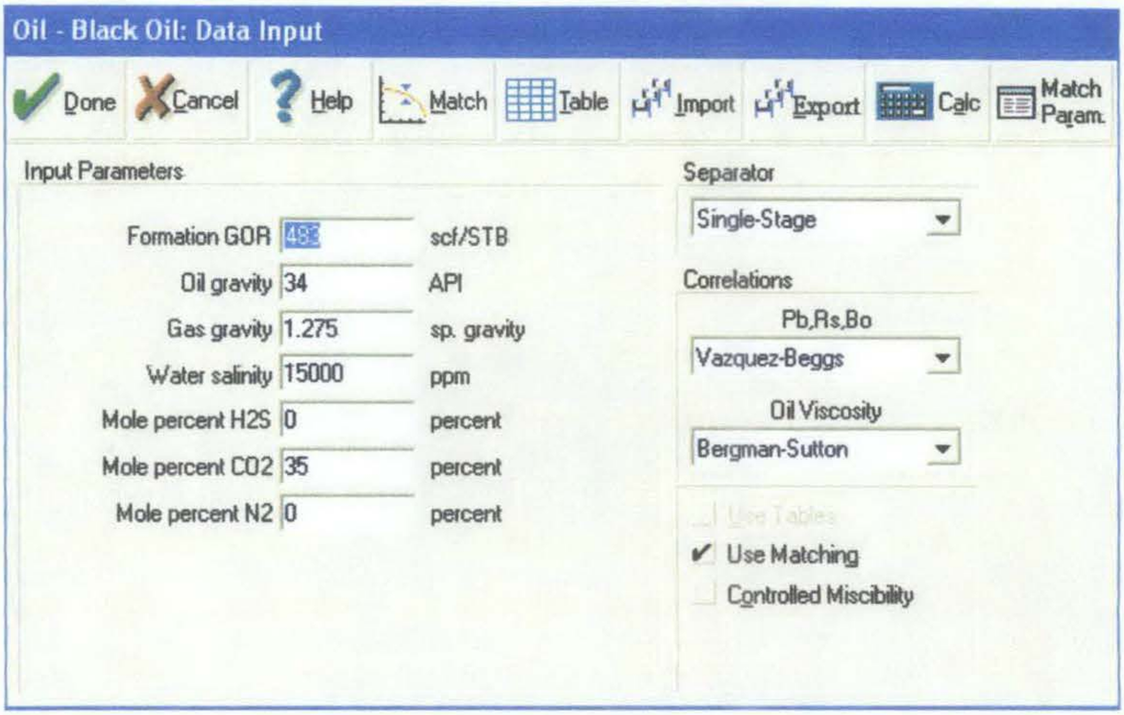
A. Steps in Mbal Software



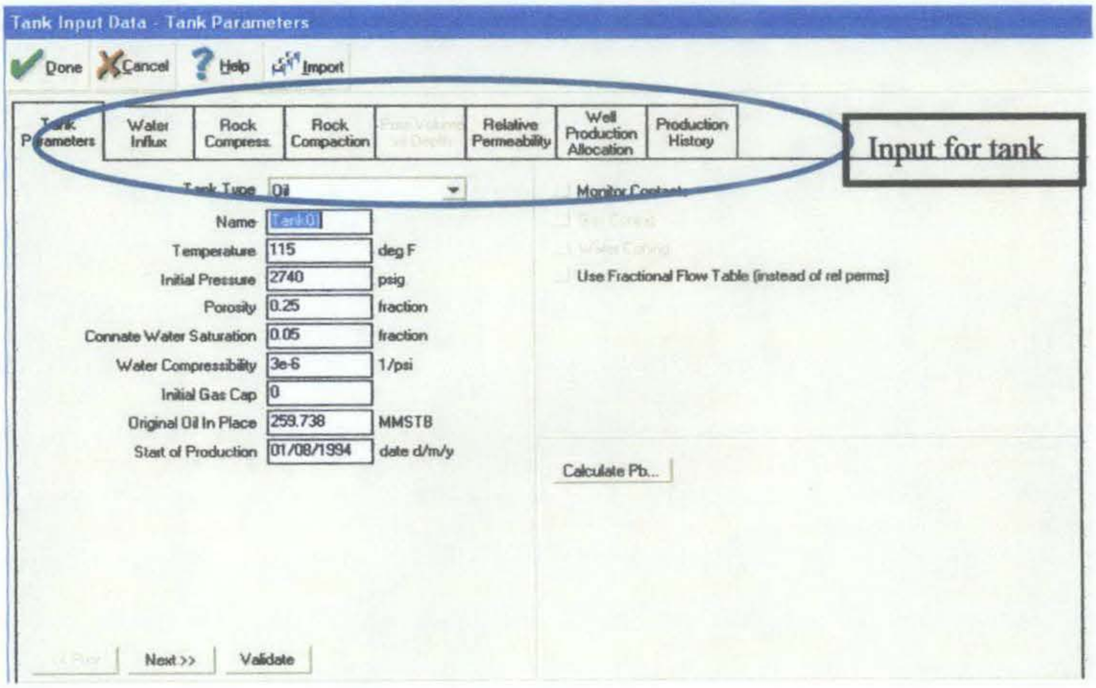
Mbal Interface



Mbal System Options



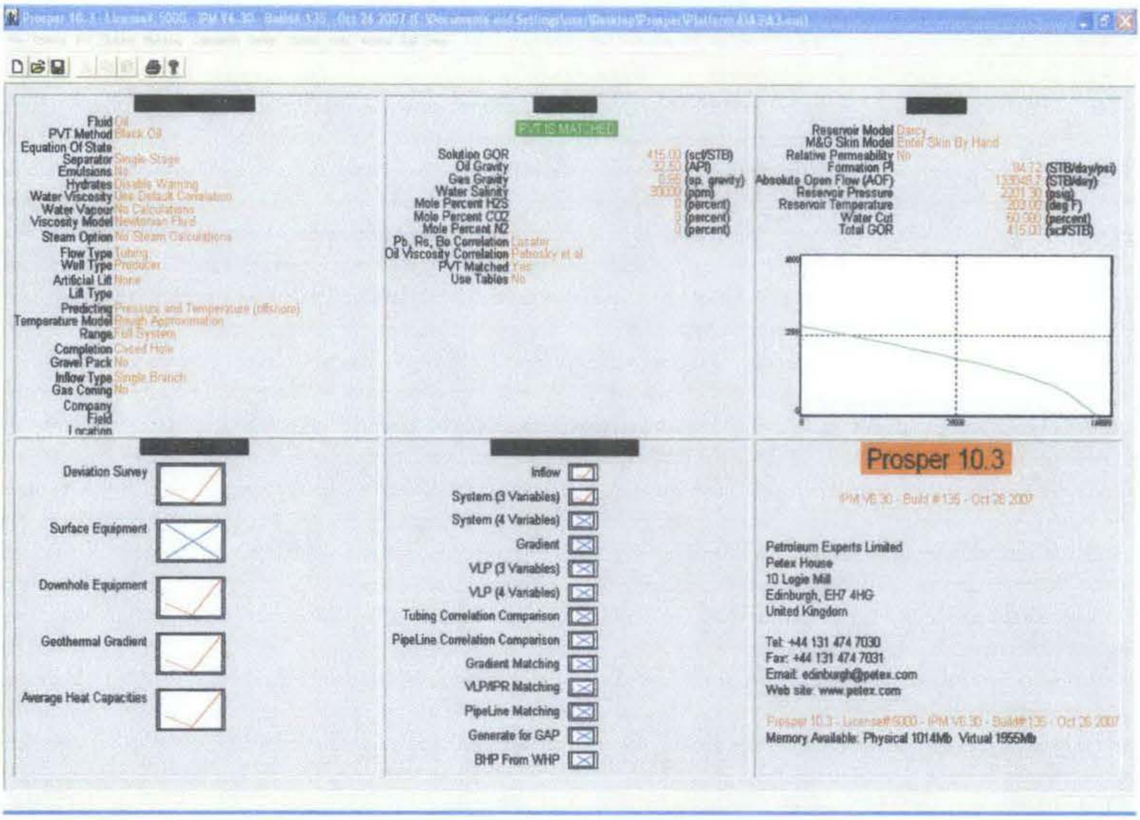
PVT Analysis



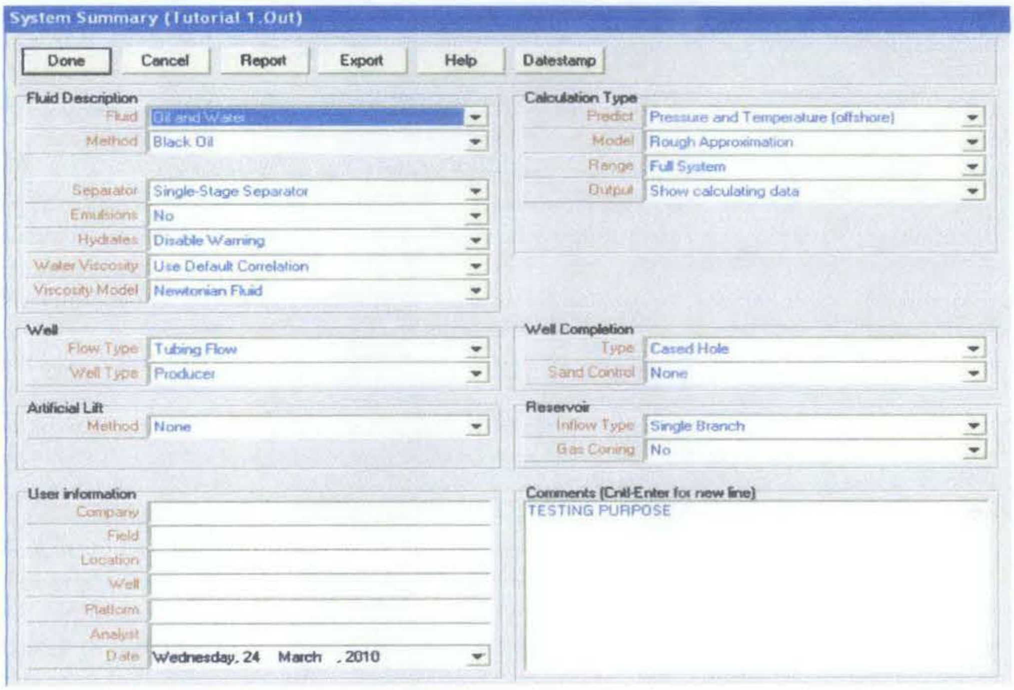
Tank Data

➔ From tank data, input the tank model in gap software

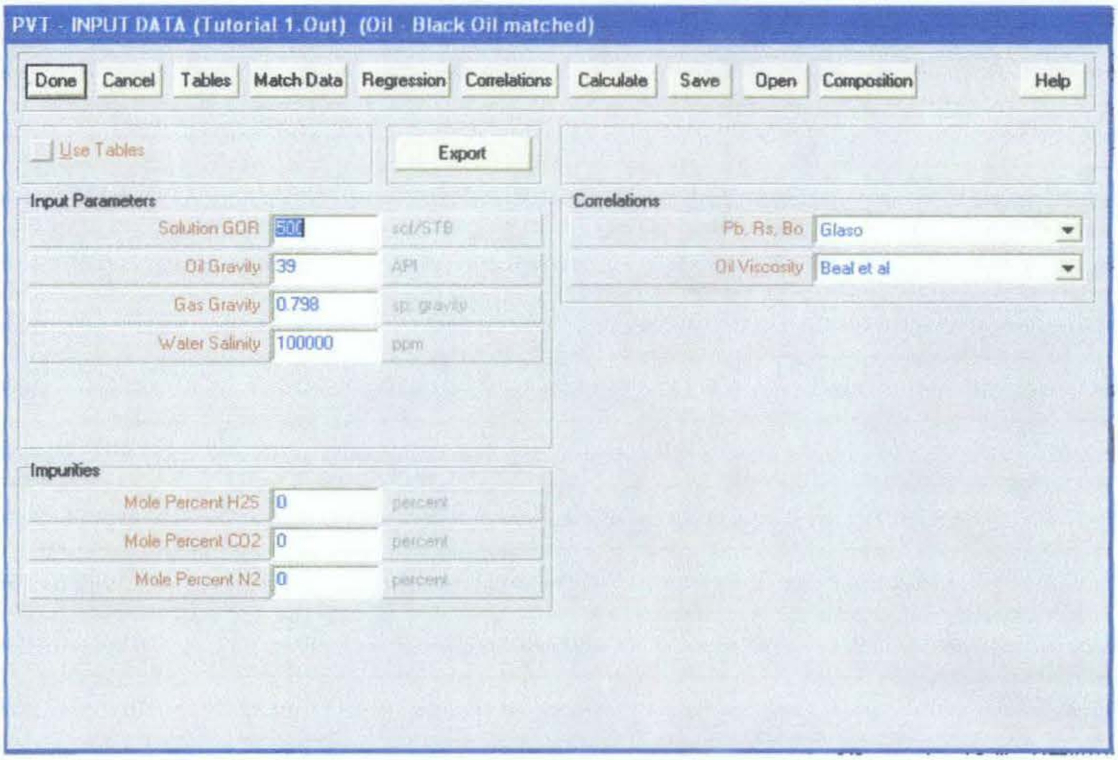
B. Steps in Prosper Software



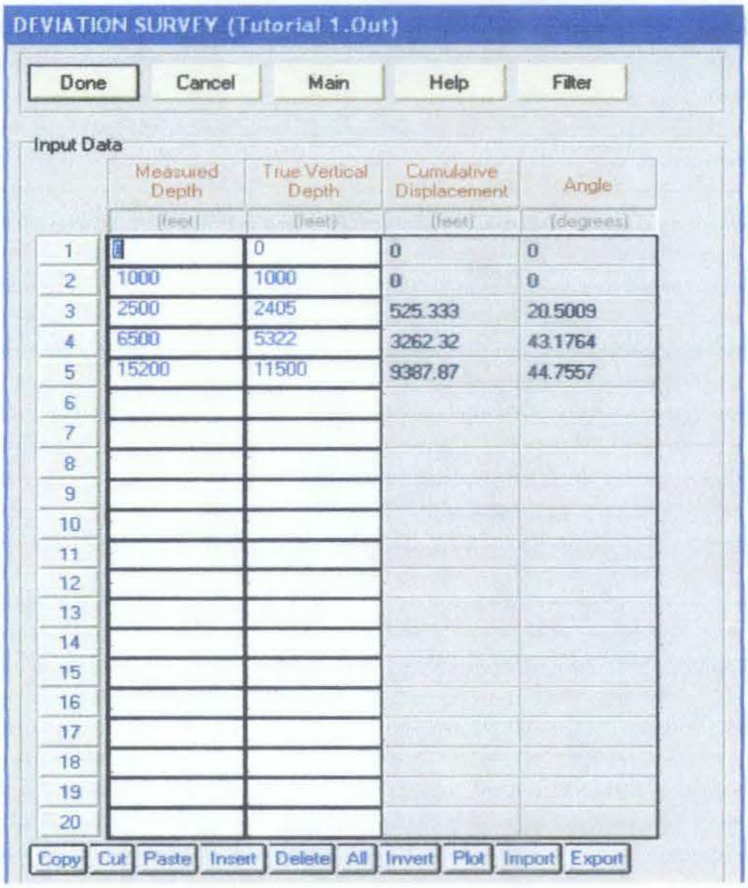
Prosper interface



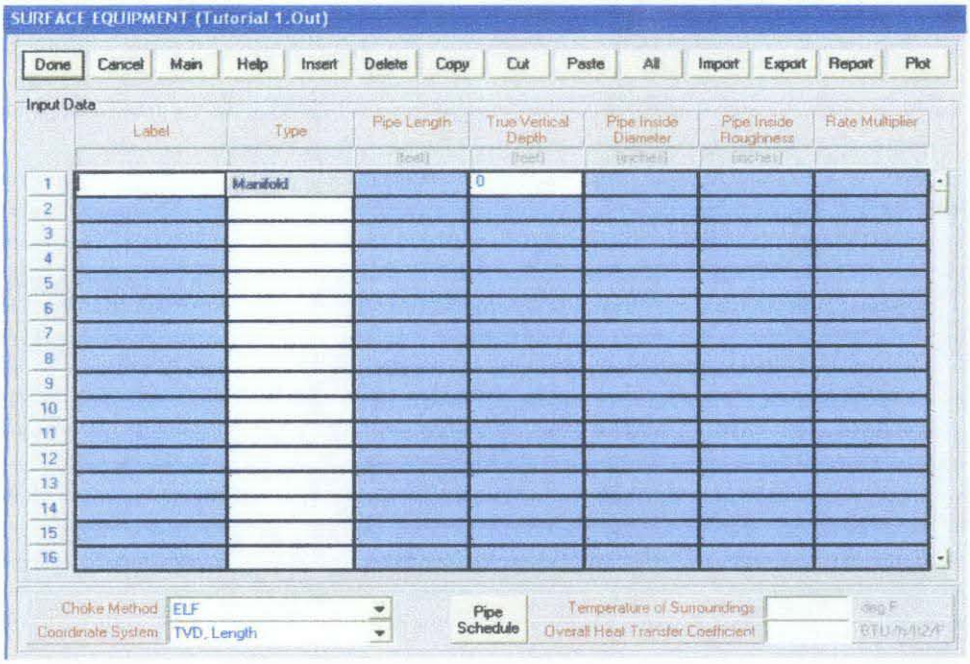
Option Summary



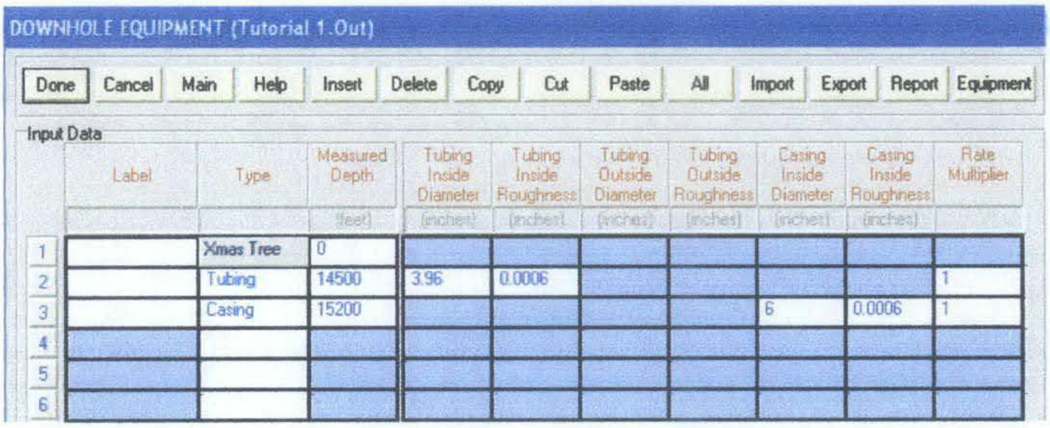
PVT Data



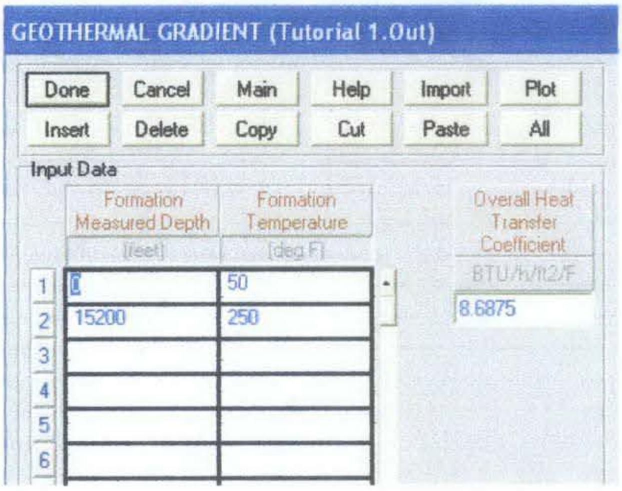
Deviation Survey



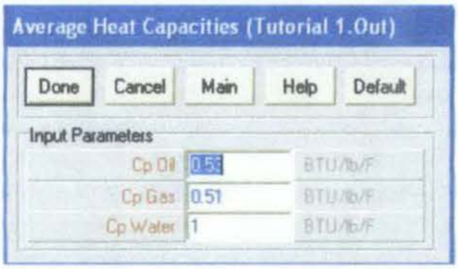
Surface Equipment



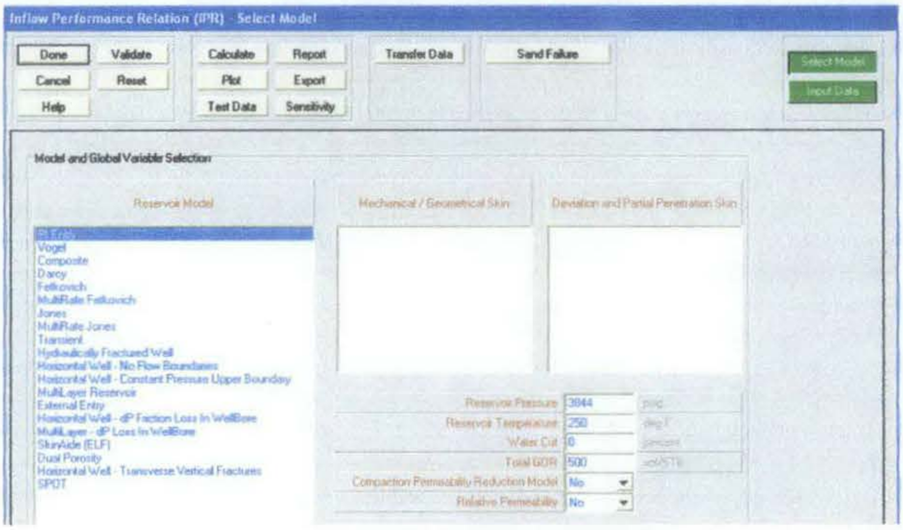
Downhole Equipment



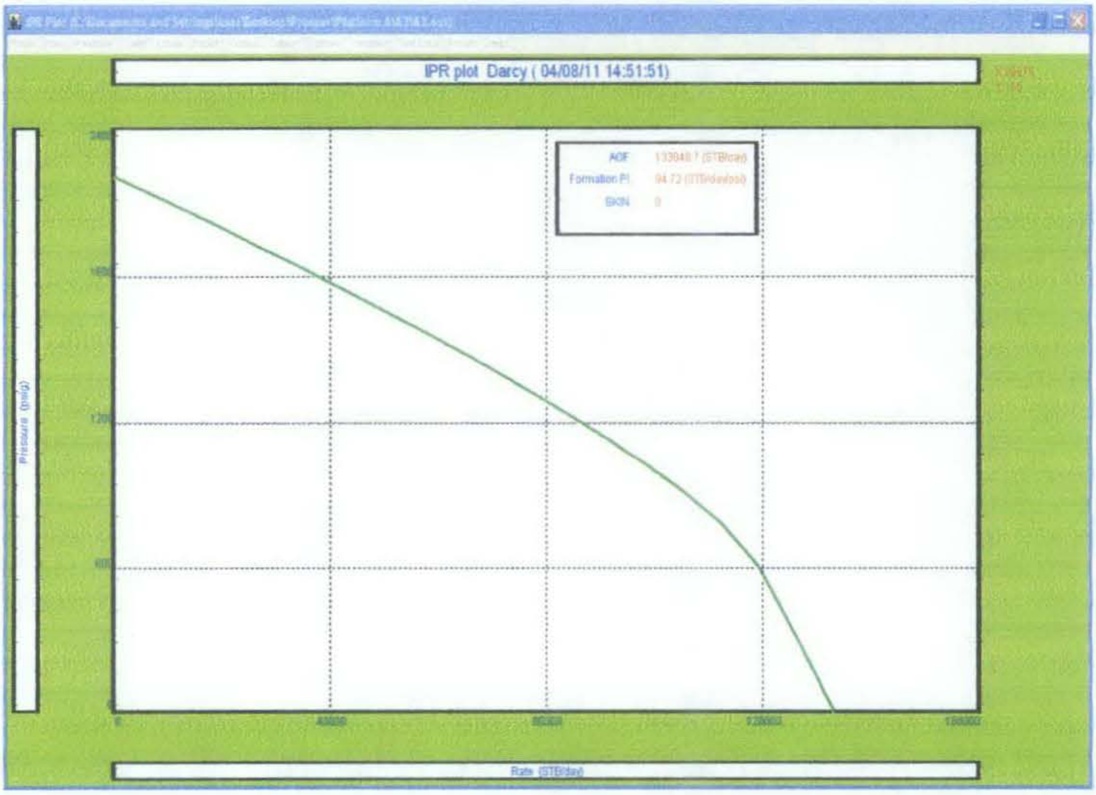
Geothermal Gradient



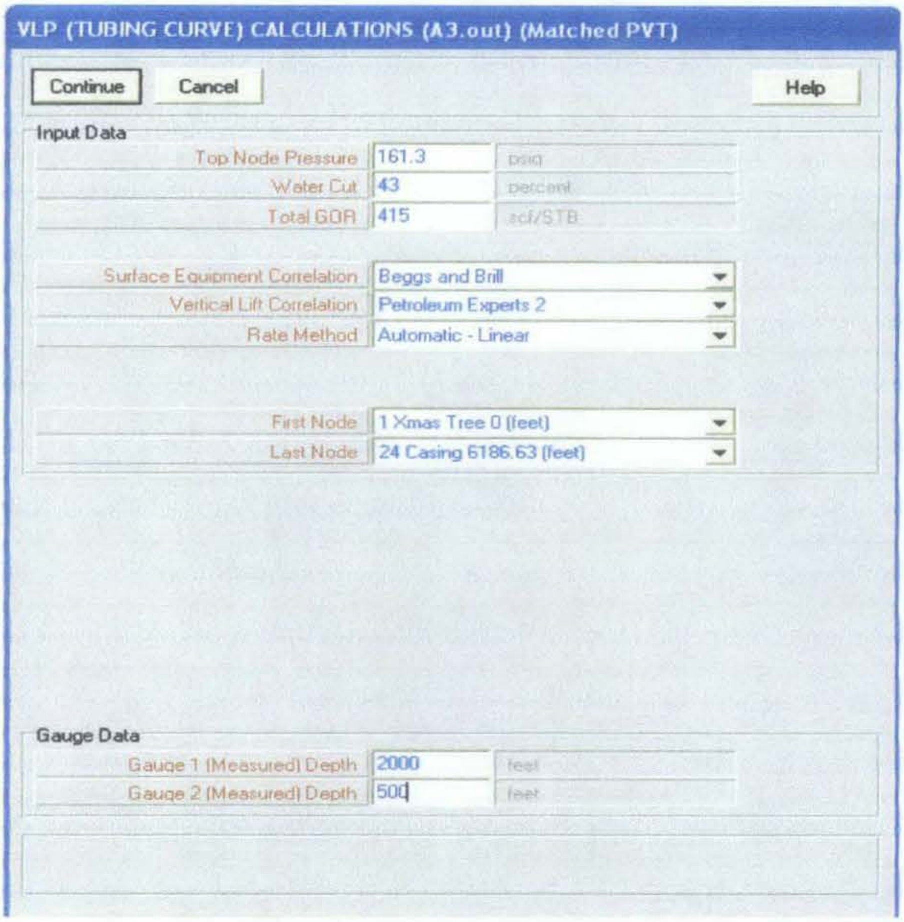
Average Heat Capacities



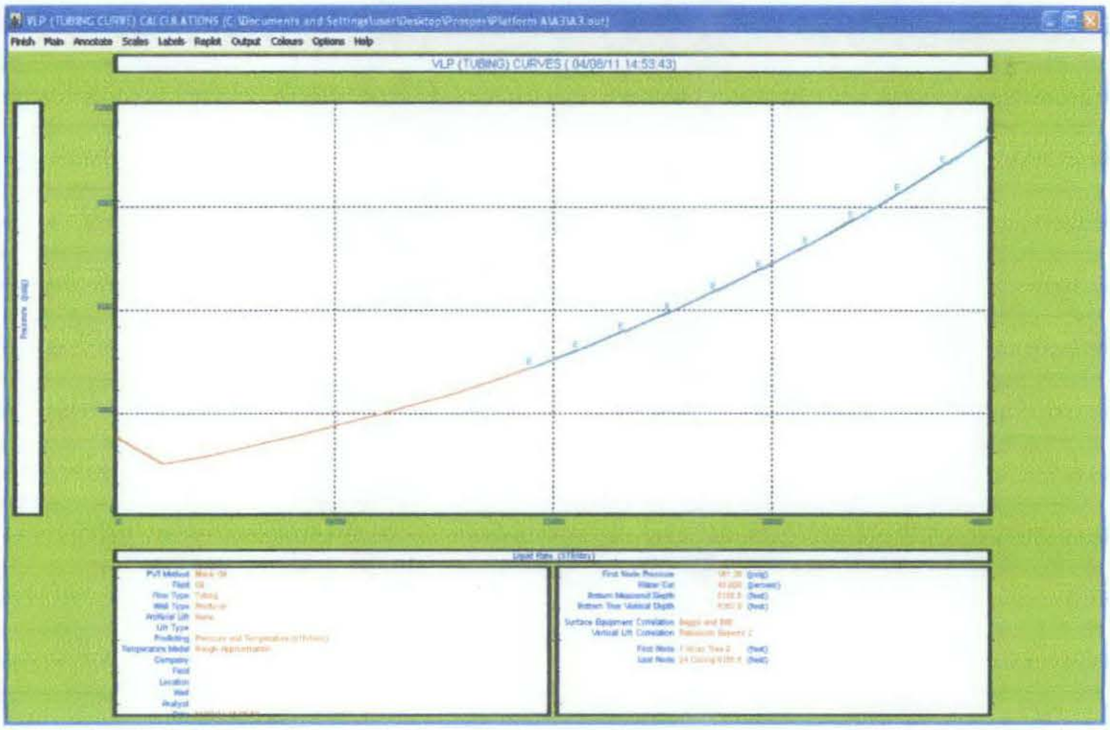
Generate IPR Data



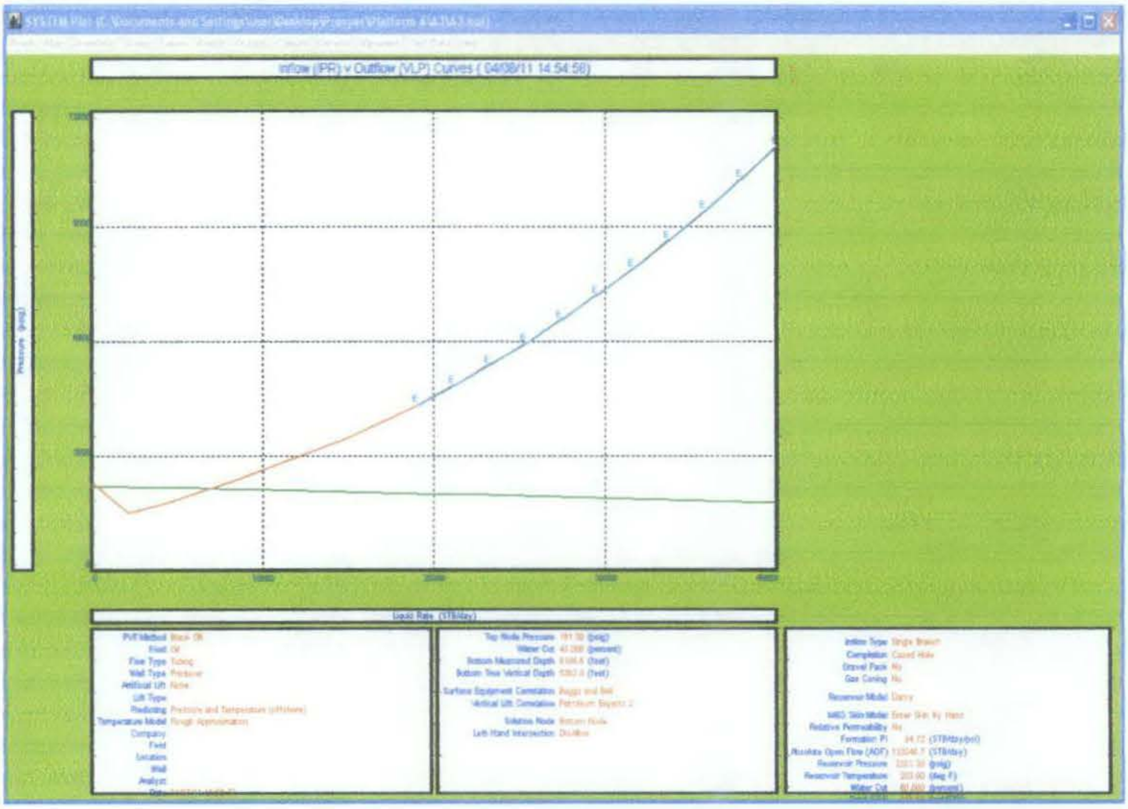
IPR Plot



Generate VLP data



VLP Plot



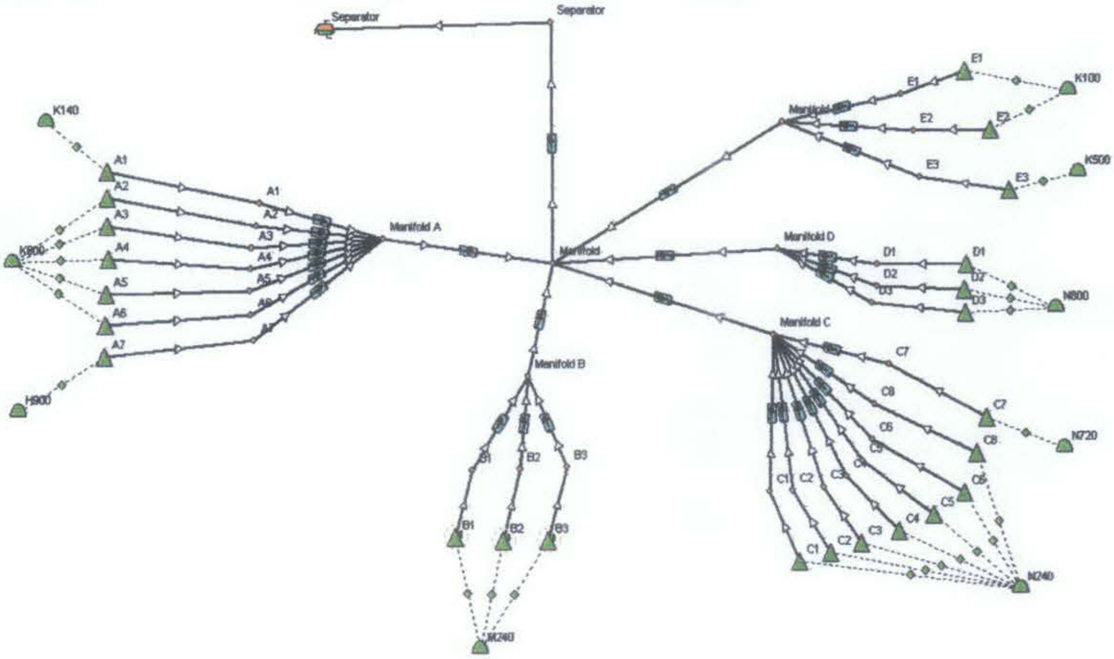
IPR & VLP Intersection

→ From intersection, the well model will input in gap software.

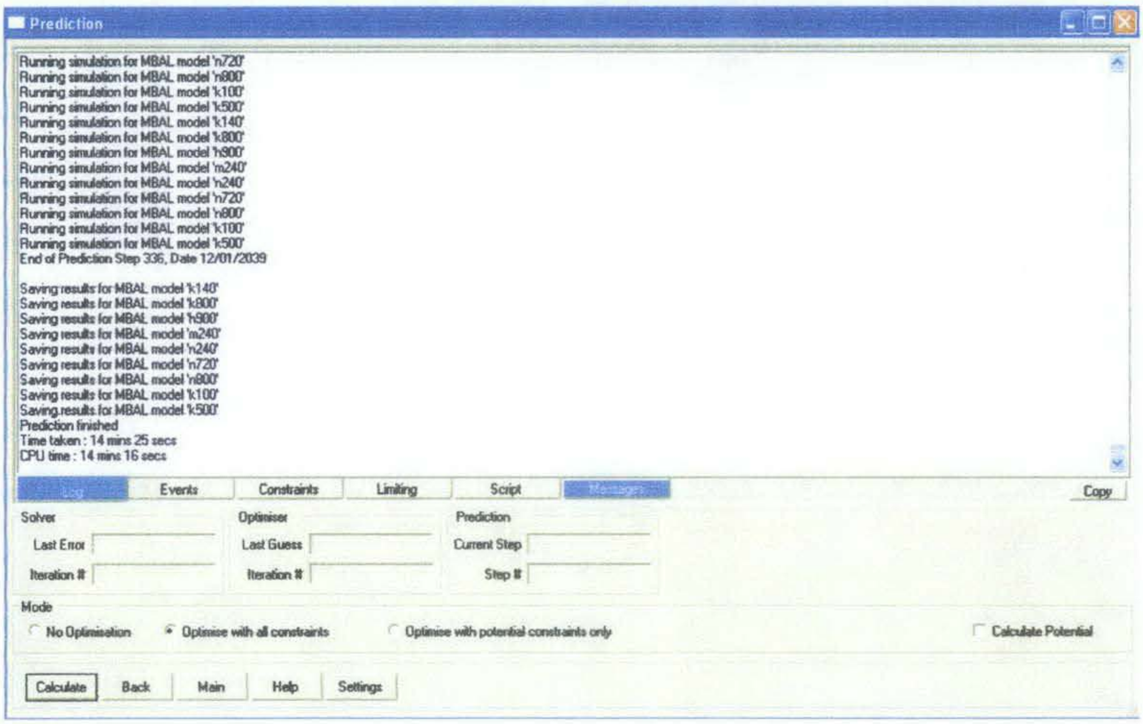
C. Steps in Gap Software

➔ Input data from tank and well model

➔ Integrate the model by adding manifold, pipeline and separator



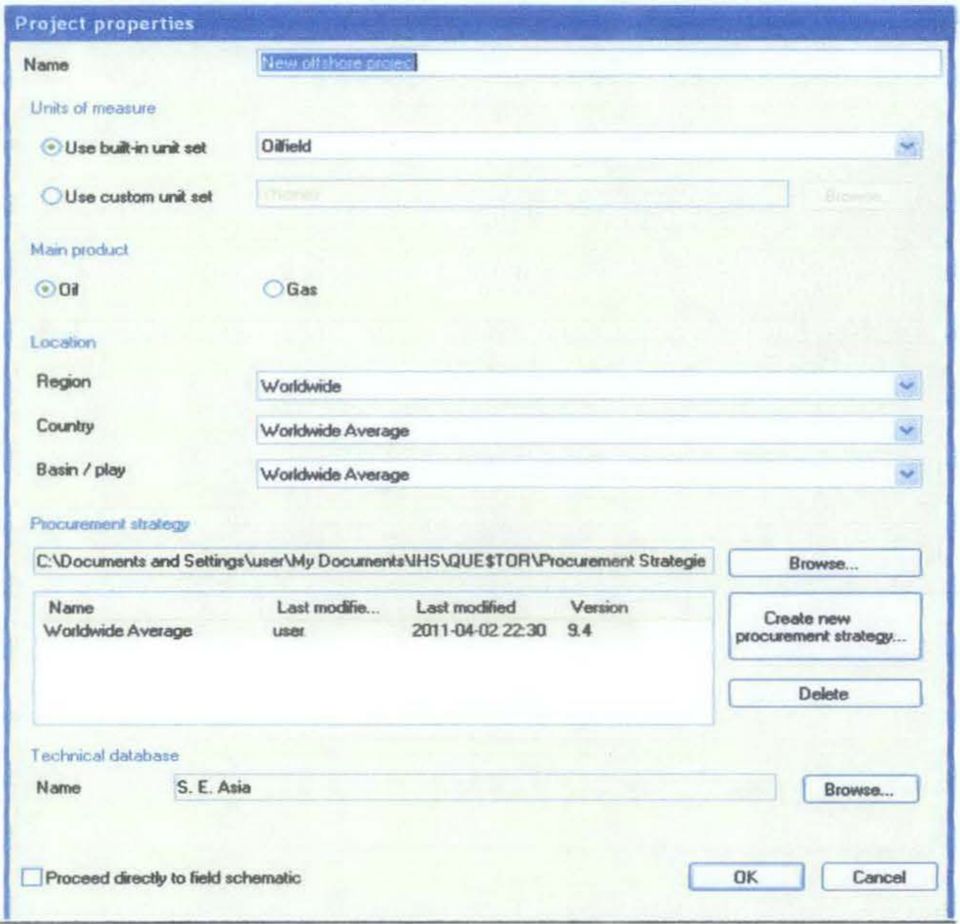
Integrating Surface Model



Prediction Surface Model

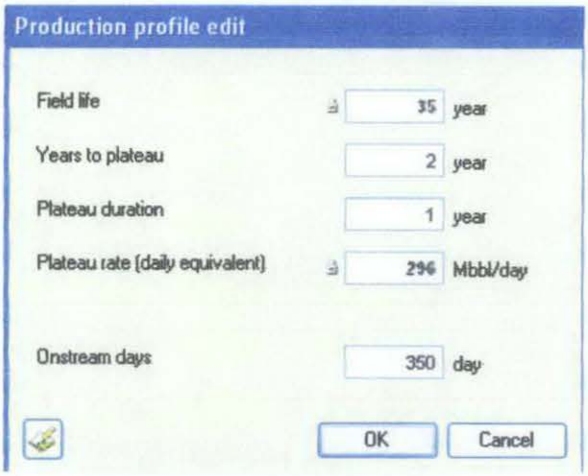
➔ Estimate the average oil production for every year and forecast for some 15 years.

D. Steps in Questor

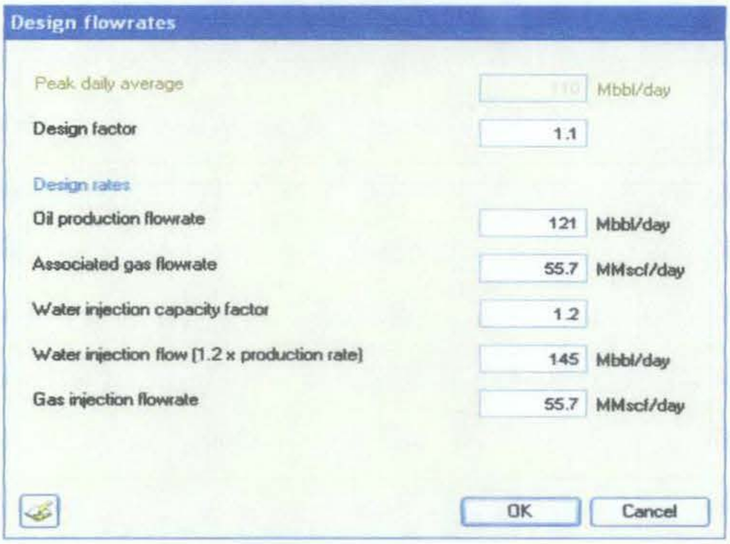


Project Properties

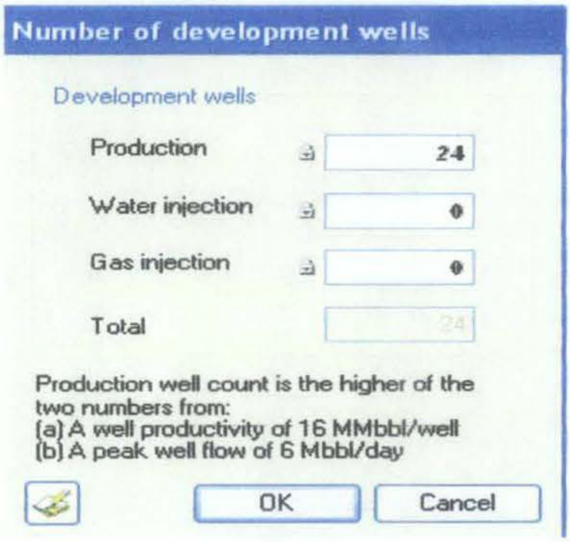
Field Properties



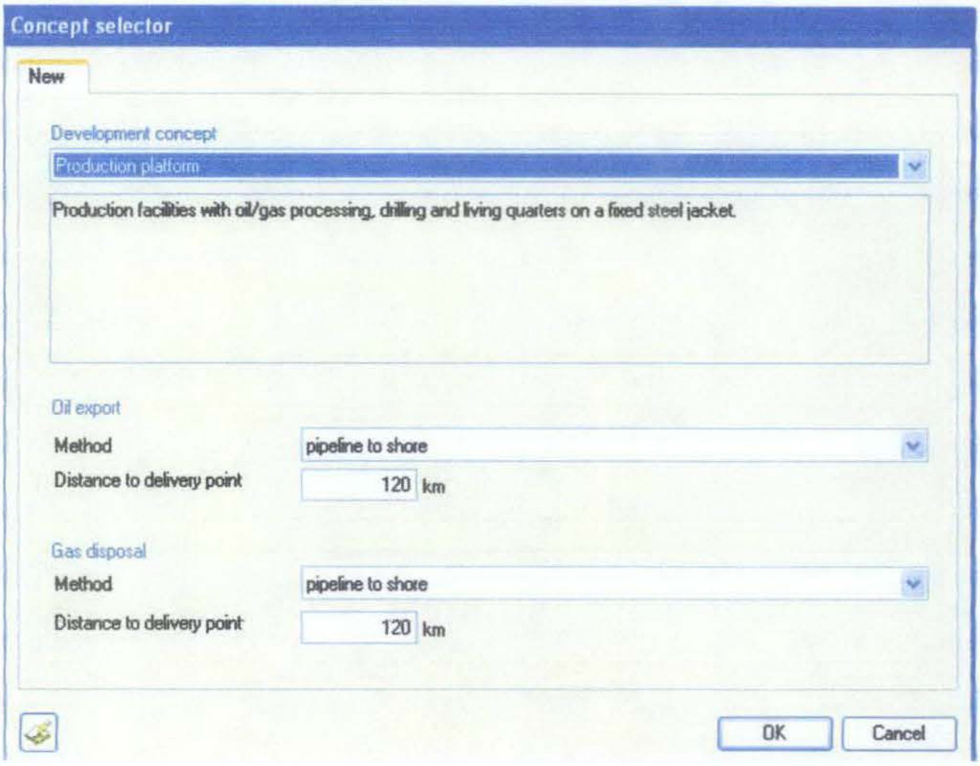
Production Profile



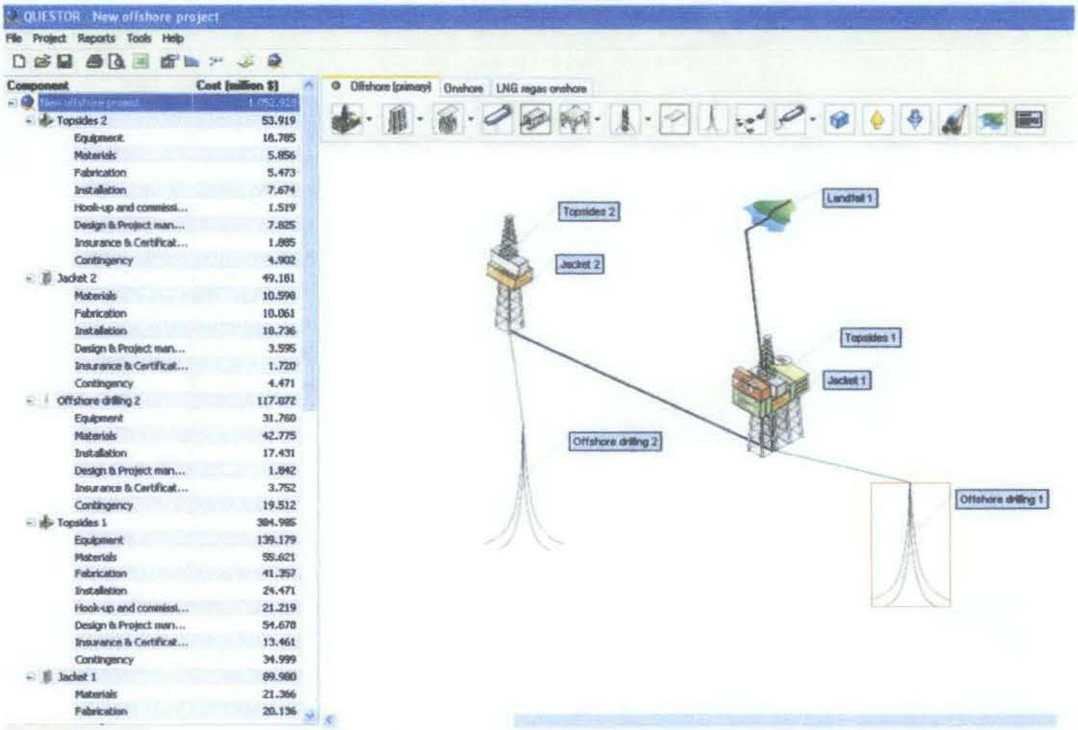
Design Flowrates



Development Wells



Design the platform



Project Analysis

➔ At project analysis, the design of the platform will build together with the total cost that will spend to build the platform.