CERTIFICATION OF APPROVAL

Predication Reservoir Parameters of

Pressure Transient Analysis with an Alternative of Temperature Transient Analysis

by Using PanSystem Simulator

By

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A project dissertation submitted to the
Petroleum Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(PETROLEUM ENGINEERING)

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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.

HAFIZ ADRI BADRON

ABSTRACT

This project is about "Predication Reservoir Parameters of Pressure Transient Analysis with an Alternative of Temperature Transient Analysis by Using PanSystem Simulator". The background of this project and its objectives is to study Pressure and Temperature Transient Analysis. In this project, the scope of study will be focusing on well testing not only in Pressure Transient Analysis but also in Temperature Transient Analysis. In doing this interpretation, the author will be using a well testing simulator called PanSystem from Weatherford. The beauty of Pansystem will also be described in this report. He compares the result from PanSystem to another simulator, which is Saphir with the input data used is the same and the finalized model is identical. The purpose of this study is to be able to use the well testing software and do the interpretation and analysis from it. And once this is achieved, the results from the interpretation will the findings, which is the ultimate objective of the project which is to predict reservoir parameters.

ACKNOWLEDGEMENT

I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals and organizations. I would like to extend my sincere thanks to all of them.

I am highly indebted to Dr. Muhannad Talib Shuker as my supervisor for his guidance and constant supervision as well as for providing necessary information regarding the project & also for their support in completing the project.

I would like to express my gratitude towards my parents and my friends for their kind co-operation and encouragement which help me in completion of this project.

I would like to thank also Mr. Ahmad for helping me to begin with this project and helping me to find the other simulator.

And a lot of thank you to the people around who involved directly or indirectly in making my project a success.

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ABBREVIATIONS AND NOMENCLATURES

Q	= Production flow rate, Bbl/day
k	= Formation permeability, mD
h	= Net reservoir thickness, ft
P	= Pressure, psia
B	= Formation volume factor, res. Bbl/STB or SCF/STB
μ	= Viscosity, centipoise
R_e	= External radius, ft
R_w	= Well radius, ft
S	= Dimensionless skin factor
m	= Slope
P_{1hr}	= Pressure after 1 hour of test, Psia
P_{wf}	= Flowing bottomhole pressure, Psia
Φ	= Formation porosity, %
C_t	= Total compressibility, psi^{-1}
R_i	= Radius of investigation, ft
L	= Distance to boundary
μ_{JT}	= Joule-Thomson Coefficient

CHAPTER 1

INTRODUCTION

1.1 Project Background

Predication reservoir parameters of Pressure Transient Analysis with an alternative of Temperature Transient Analysis by using PanSystem simulator is the project to be carry out for the entire Final Year Project period, which will be conducted for entire two semesters. Predication reservoir parameters are a branch of work related to well testing analysis. For simplicity, well testing involving pressure analysis for characterization is called Pressure Transient Analysis (PTA). With one of the objectives of well testing is to get information about a well and to characterize the reservoir, this project is in parallel with the work conducted in the industry. And to add more, this project will be based on real data, which is test data obtained from a test conducted on a vertical, injector well in one of the Malaysia's field. PanSystem is one of the simulators in the market that is used to do PTA. PTA is basically about pressure recorded as a function of time and interpreted using various analysis methods. These include pressure buildup tests and drawdown tests for production wells and injectivity and fall-off tests for injection wells. In PTA, in order to obtained information, models such as the wellbore storage model, flow model and boundary model will be applied on the test data. This will be further explained later in this report. The analyzing procedures are based on classical Darcy Law, which refers to the mathematical equation that relates between flow rate, pressure and time. Once interpretation done, the result will be compared with another result obtained from other simulators. The final result will be based on which simulator will produce the best fitting to the test data based on the same model used. This project will also touch on Temperature Transient Analysis (TTA). This is more to analyzing the temperature data obtained the same time the pressure data is obtained but most of the time being neglected for analysis.

1.2 Problem Statement

Pressure Transient Analysis is important in determining the reservoir parameters. Through the simulator built, it is capable of catering thousands of pressure data and the rates involved and generate the derivative plot to match with a model. This really eased the job of a reservoir engineer. But since there are many well testing simulators in the market, this will be a point which simulator is easier to be run.

On top of comparing simulators, in well testing, interpretation can be done not only from the pressure data but also the temperature. This is called the Temperature Transient Analysis. In some of the reservoir, it is hard to interpret from the pressure. So it is an alternative and also another window to view on the events that is happening to the reservoir.

1.3 Objective

The objectives of this study will be like as below:

- To be able to use the PanSystem simulator for analysis
- To be able to interpret from pressure data and obtain the desired reservoir parameters
- To characterize reservoir based on transient temperature data

1.4 Scope of Study

The scopes of study for this project:

- To learn about Pressure and Transient Analysis and Temperature Transient Analysis
- To run simulation and interpret data
- To analyze and compare result

1.5 Significance of the Project

This project is significant in equipping individual with skills in running a simulator. This is because nowadays, the transient analysis, which the predication reservoir parameters are done mostly using simulators. It is an added value for individual to have the skills in running PanSystem simulator, applying the analytical and numerical models on data to characterize reservoir.

1.6 Feasibility of the Project

The project is based on computer simulation to predict the reservoir parameters based on matching the data with the simulation models. The project is estimated to complete within 5 months of research and simulation period. Since the simulator is already in-house, the expenditure for this project is at its minimum. Positive outputs are expected and general reservoir characterization will be summarized out at the end of this project.

CHAPTER 2

LITERATURE REVIEW

Well test in which pressure is recorded as a function of time and interpreted using various analysis methods. These include buildup tests ad drawdown tests in production wells and fall-off tests in injection wells [1]. In this chapter, discussions will not only on predication reservoir parameter but also matters related to the raw data, other related data such as rock and well properties, PVT data, governing theories behind both transient analysis, issues related to the analysis and issues related to the well testing.

2.1 Measuring Gauges

In the field, the method of acquiring the pressure, temperature and related data are variable. In the tubing string, previously, Slickline (SL) will be run-in hole (RIH). Slickline is a single-strand wireline used to run and retrieve tools and flow-control equipment in oil and gas wells. The single round strand of wire passes through a stuffing box and pressure-control equipment mounted on the wellhead to enable Slickline operations to be conducted safely on live wellbore. But this will be quite costly since it needs to be run from time to time and also this will also contribute to Non-Productive Time (NPT) if the test is pressure build-up test. Lately, with the development of technology, the capability of acquiring data is easier. With the application of Permanent Downhole Gauge (PDG), continuous pressure recording can be obtained frequently, and most likely that the data can be deliver to your desktop daily. And for the temperature, it is possible to have multipoint temperature sensors since production mostly from multilayer reservoirs. For any particular well, it can be equipped with multiple temperature sensors and single Downhole pressure gauge. This is because rate will be change at the surface, throttling the reservoir whether the rate is decreasing or increasing. . Figure 1.0 is the sample of the gauge and sensors configuration.

The reason for having multiple temperature sensors equipped at the string is to measure the temperature changes at each of the reservoir layers. This temperature change can be related to possible near wellbore condition such as formation damaged radius, formation damaged permeability, formation permeability and skin factor. This is very significant because each of the layers is different from one another as the result of deposition. Whereas for the pressure measurement, there is only one pressure Downhole gauge because the pressure measurement is taken when there is change in the surface rate. Either increase or decrease in rate, from theoretical point of view, both can achieve the same objective, which is pressure disturbance.

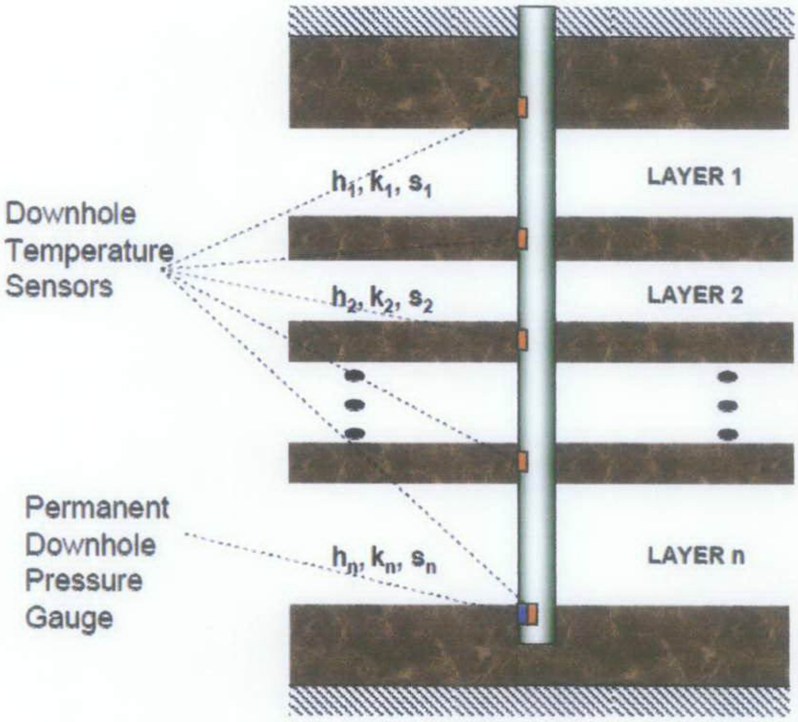


Figure 1.0: Permanent Downhole Gauge and Downhole Temperature Sensors Configuration [4]

2.2 Data

The data obtained from the gauge is called 'Raw data'. This is because the data is originally from the field and it is not filtered. The purpose of filtering is to reduce noise, which will affect the analysis later on. The raw data will be not hundred but thousands of line. Some of the operator programs the measurement to be taken every half a minute.

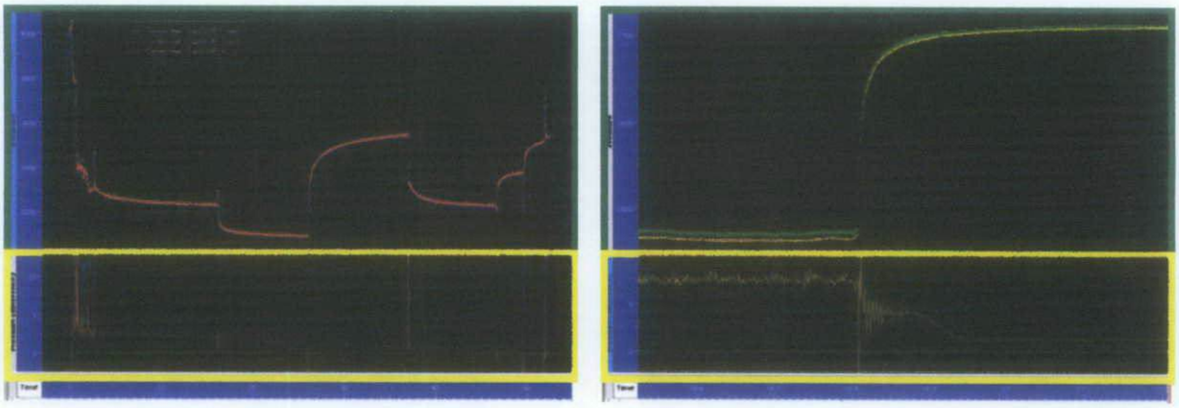


Figure 2.0: Typical Dual Pressure Gauge Data Diagnostic

Another thing that is related to the difference between the quality of data measured by gauges attached to Slickline and the Permanent Downhole

Gauge is that for the Slickline, the tendency for the gauges to encounter drift or failure is high. Once this happens, the data is no longer valid. The way to know whether drift occurs during run-in the Slickline, there will be the top and bottom gauges. When two pressure sensors are set at the same depth, as with a dual gauge carrier, their difference can be used to check their synchronization (time shift) and their coherence. From here the problem with the gauge may be identified. From Figure 2.0, it shows the error in reading which caused by drift. The upper panel (blue box) in the figure shows the data for the test data obtained from top and bottom gauges. At the lower pane (yellow box), it shows the difference in pressure taken during test. This difference is the difference between the top and bottom gauges.

PVT data is important since it has the values for the fluid properties. These fluid properties are important as it is the value taken based on the reservoir fluid sample tested. Properties such as the oil or gas formation volume factor, B_o the oil and gas viscosity, μ_o, μ_g and the reservoir pressure and temperature are included in this PVT data. This data usually can be found from PVT report, where the analysis was done from service contractor or hired laboratories.

The next important data is the petrophysical data. The data such as the net sand thickness and average porosity are two input data that we can get. From petrophysical data also we can compare the permeability that we get from the analysis with the average permeability determined. It is a matter of diagnostic from the legacy data so that the analysis does not contain to much error.

On top of the valuable data above, some additional information such as the geological map would be handy because in predicting the boundary model, it is possible to determine any major fault or any signatures that can help in making decision. This is because, with the help of the map, the distance from well to the boundary can be estimated and this can be compared with the result obtained from the PTA.

2.3 Theory

2.3.1 Pressure Transient Analysis (PTA)

From the set of graph obtained from the pressure, temperature and rates data, we get the derivative curve. From the curve, we can see the pressure plot and differential or derivative plot. In the derivative plot, the big hump at the initial of the plot is indicating the Wellbore Storage. After a period of time, the effect vanishes and from there we can start to find the parameters that we want. All of these parameters are theoretically can be calculated. From the basic classical Darcy Law, we get his equation of [2]:

$$Q = \frac{141.2\, kh\, \Delta P}{B\mu \ln\left(\frac{r_e}{r_w} - \frac{3}{4} + S\right)}$$

Basically for PTA, we have analysis done on the Drawdown (DD) or Build-up (BU) for the producing well and Fall-off (FO) for the injecting well. Of the two analyses, the build-up is the most preferable since the pressure is much stable since there are no changes at surface rate.

$$\Delta p_{BU} = \frac{162.6\, qB\mu}{kh}[\log(\frac{t_p \Delta t}{t_p + \Delta t}) + \log\left(\frac{k}{\Phi\mu c_t r_w^2}\right) - 3.228 + 0.8686S]$$

The equation above is the general equation used in pressure build-up analysis. It is the same as the pressure drawdown equation used for analysis. The build-up equation is similar to the drawdown because of as the producing time t_p was long enough to reach IARF. where k is the permeability that we want to find from this well testing. It can be obtained by the equation of [2]:

$$K = \frac{162.6\, qB\mu}{mh}$$

and S is the dimensionless skin that we want to find to detect whether the well is encountering formation damage or stimulation. The value of skin is important in determining whether the well is having formation damage or not. This can be notified with the positive of negative value of skin. If the skin is positive, then the well has formation damage. If not, then the well is in stimulation. The equation for skin is [2]:

$$S = 1.151\,[\frac{P_{1hr} - P_{wf}}{m} - \log(\frac{k}{\Phi\mu C_t r_w^2}) + 3.23]$$

Other parameters that can be calculated with well testing are the Radius of Investigation (Ri), Distance to Boundaries (L). Following are the equations [2]:

$$R_i = \sqrt[2]{\frac{k\Delta t}{948\Phi\mu c_t}}$$

$$L = \sqrt[2]{\frac{0.000148 k \Delta t_x}{\Phi c_t}}$$

The simulator will calculate all the parameters above and shows the result. But something to highlight in this theory part is a few matters related to the well testing that can be done manually in having a better result.

For the well shut-in procedure, it is better to shut it near the depth of investigation, which is at the depth where the gauge is located. This is because instead of shutting at the surface, Downhole shut-in gives less wellbore storage or after-flow effect (WBS) period. This is because wellbore storage effect is the matter of unloading fluid entering the wellbore and settles down. From the graph, the region which the WBS lays is in the Early-Time region. Once the Early-Time region ends, the Middle-Time region can be analyzed. It is here that the stabilized rate of pressure resides. From here the slope of the graph can be determined, which the permeability can be calculated. Then at the Late-Time region, the boundary model will be defined to best fit and characterized the reservoir. Figure below explained briefly on the flow regimes.

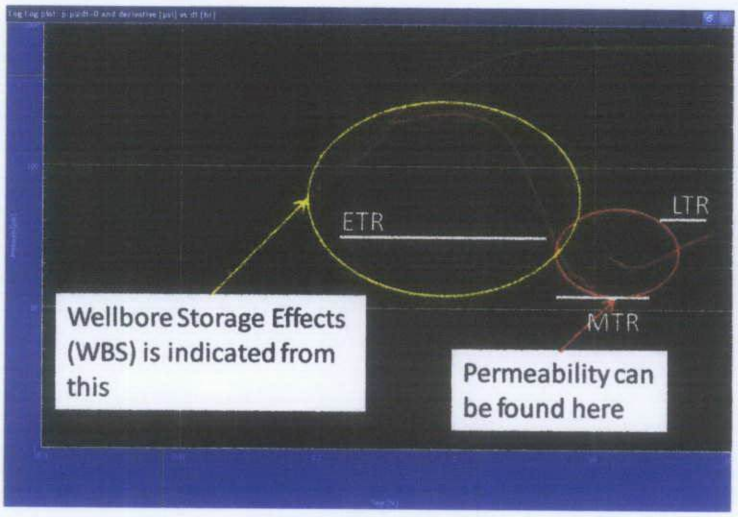


Figure 3.0: Flow regimes for Pressure Buildup and Injection Fall-Off tests

Many analysts rely on pressure derivative curve to diagnose wellbore storage period and radial flow regime on pressure transient data. However, there are field examples that flow regimes cannot be accurately determined [4].

The wellbore storage effect delays the formation pressure response and distorts the early portion of pressure transient data. Diagnosing the radial flow regime is important because it provides values for permeability and skin.

For this pressure build-up, the purpose of well shut-in is to let the pressure build-up. The longer the well being shuts, the near reservoir pressure it will reach. The period of shut-in also depends on the quality of

2.3.2 Temperature Transient Analysis (TTA)

For TTA, two main dynamic factors that involved are the Joule-Thomson and frictional heating effects.

Joule-Thomson effect is when a fluid expands at constant enthalpy because of a pressure drop, the temperature of the fluid changes. The change in temperature per unit pressure is called Joule-Thomson Coefficient, $\mu_{JT.}$ The equation derived from the thermodynamics text is:

$$\mu_{JT} = (\frac{\delta T}{\delta P})_h = \frac{\frac{VT}{Z}(\frac{\delta Z}{\delta T})_P}{C_p}$$

For an ideal gas, the coefficient is zero which means that the gas expands at constant enthalpy, no temperature change.

For real fluids, the coefficient has cooling and warming effect. If the value of the constant is positive, it is the cooling effect whereas if the value if negative, it is the warming effect.

For the frictional heating effect, for example, as the fluid flows from reservoir towards wellbore, sand-face temperature increases due to friction between fluid molecules and porous medium.

For oil producing wells, the sand-face temperature is always higher than original reservoir temperature. For gas producing wells, the sand-face temperature can be either higher or lower or equal to original reservoir temperature due to simultaneous effect of frictional heating and JT cooling effect.

As discussed in section 2.3.1, the early portion of the well test data is usually affected by the wellbore storage effect and can be influenced by skin and reservoir permeability. Since different factors including wellbore storage, skin and reservoir heterogeneity affect pressure response, detecting end of wellbore storage and flow regimes might have uncertainties. Wellbore storage effect may distort the early time flow regimes and cause uncertainty in detecting first plateau on derivative curve. Therefore, determining accurate time at which wellbore storage stabilizes has a significant impact on the analysis and interpretation of pressure data [4].

There is one solution, which is to record Downhole flow rate using a flow meter such as spinner. It can determine the end of wellbore storage effect, where the Downhole flow rate becomes zero. But the problem with spinner is it often underestimates the end of the wellbore storage period.

This is because the Downhole flow rates which are less than the spinner threshold cannot be detected [4].

CHAPTER 3

METHODOLOGY

3.1 Methodology and Project Work Flow

In this chapter, explanation will be made and graphical will be provided as a reference. In the graphical part, both PanSystem and Saphir will be included, since this project involves both simulators.

In analyzing the Pressure Transient Analysis, there are several steps involved in doing interpretation from the simulator. Firstly, the data needs to be input to the simulator by means of available user-to-simulator interface. All the data are ranging from PVT, rock properties, wellbore parameters and test data consists of time, pressure and rate. Figure 4.0 shows the pressure and injection rate being plotted against time. Details regarding the relevant data have been explained in Chapter 2.

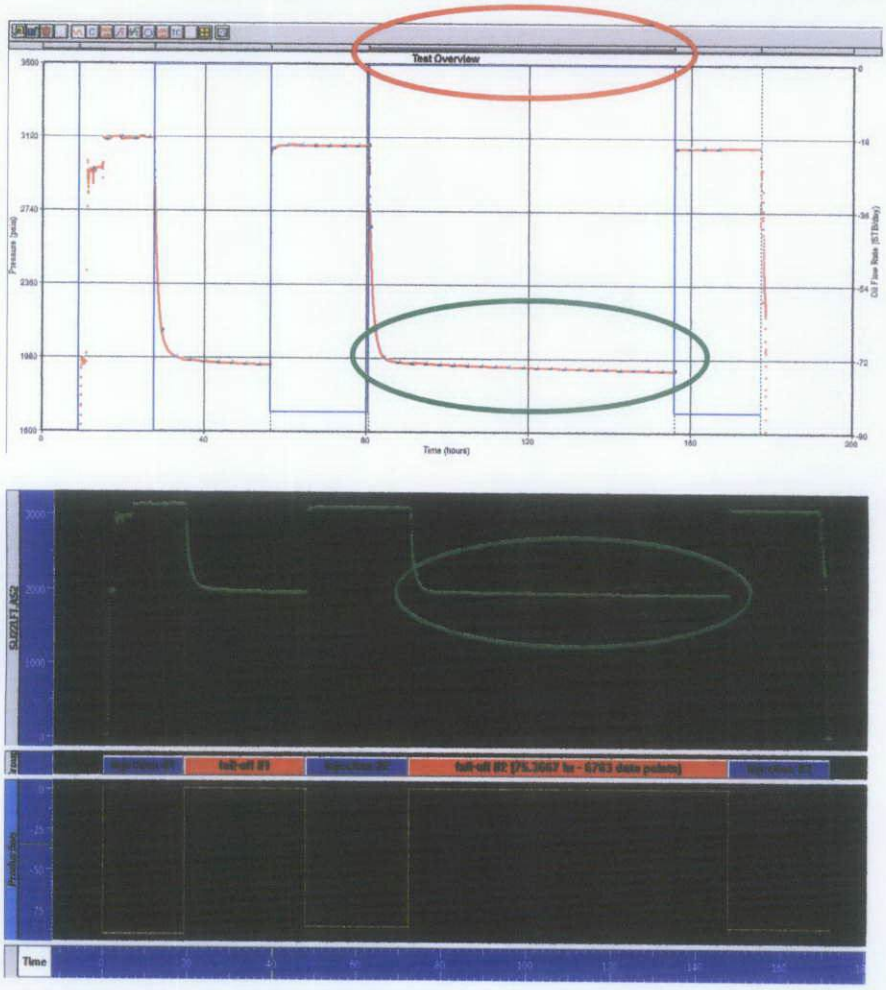


Figure 4.0: Pressure, P and Water Injection Rate, q_w versus time; top: PanSystem, bottom: Saphir

Since there is multiple injection and fall-off sections, it is advisable to make sure the sections are split correctly so that there will be noise that will affect the analysis. Once splitting is done, the next step is to come up with suitable model that characterize and represent the reservoir. By rule of thumb, the longer the fall-off period, the better since the pressure have longer time to stabilize in the reservoir, thus providing near reservoir condition. It is obvious that in Figure 4.0, the later fall-off will be selected for analysis (green circle). In Figure 4.0, both PanSystem and Saphir show clear display on the pressure, rate and time data. Both have two fall-offs. the beauty of PanSystem is that, before proceeding to analysis, the second fall-off slot need to be selected. In fact, in other analysis also, either PBU or DD, the period needs to be selected in order to analyze. The selection is by clicking on the bar above the specific period (red circle). But for Saphir, it would require the next step, which is in Figure 5.0, to view the selected test data pressure change and derivative plot.

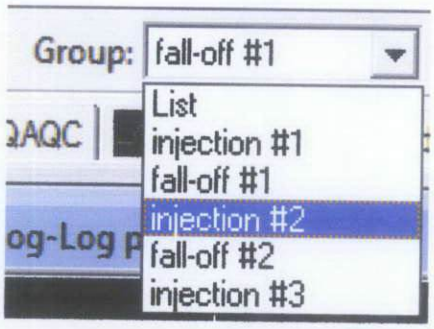
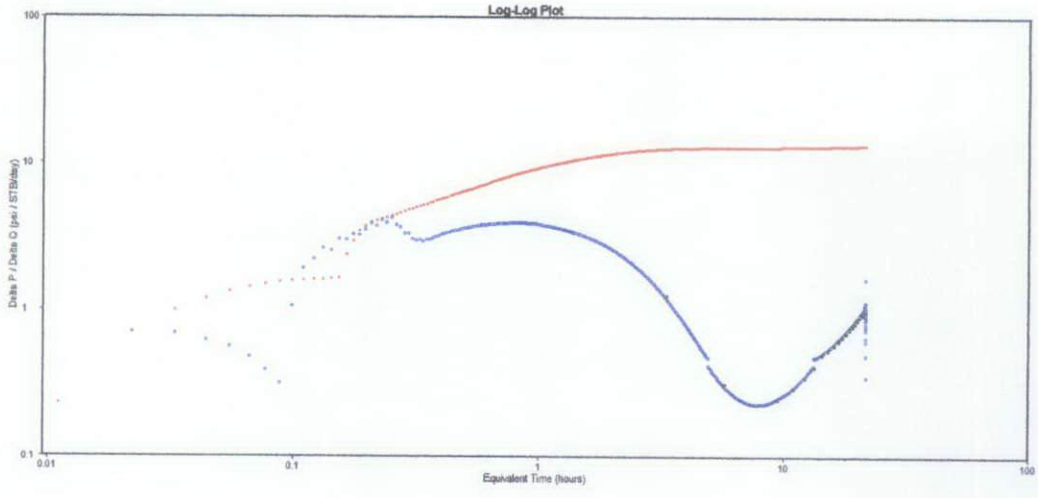


Figure 5.0: Test analysis period selection for Saphir

Once this process is done, then the Log-Log plot can be obtained. Figure 6.0 shows the Log-Log plot for the Fall-Off #2.



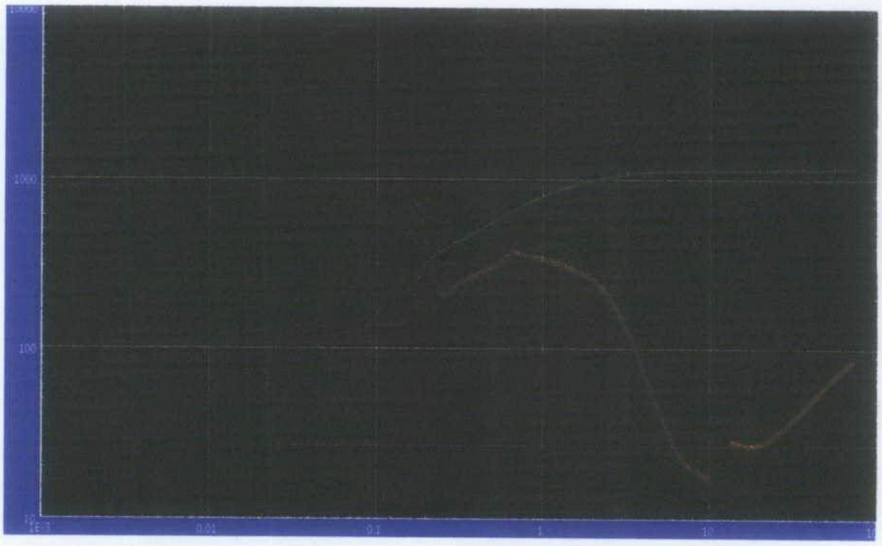


Figure 6.0: Log-Log plot of Fall-Off #2; top: PanSystem, bottom: Saphir

Since there is unstable reading at the early part of the data, data filtering can be done to minimize the potential factor that might affect the analysis. Figure 7.0 shows the filtered data.

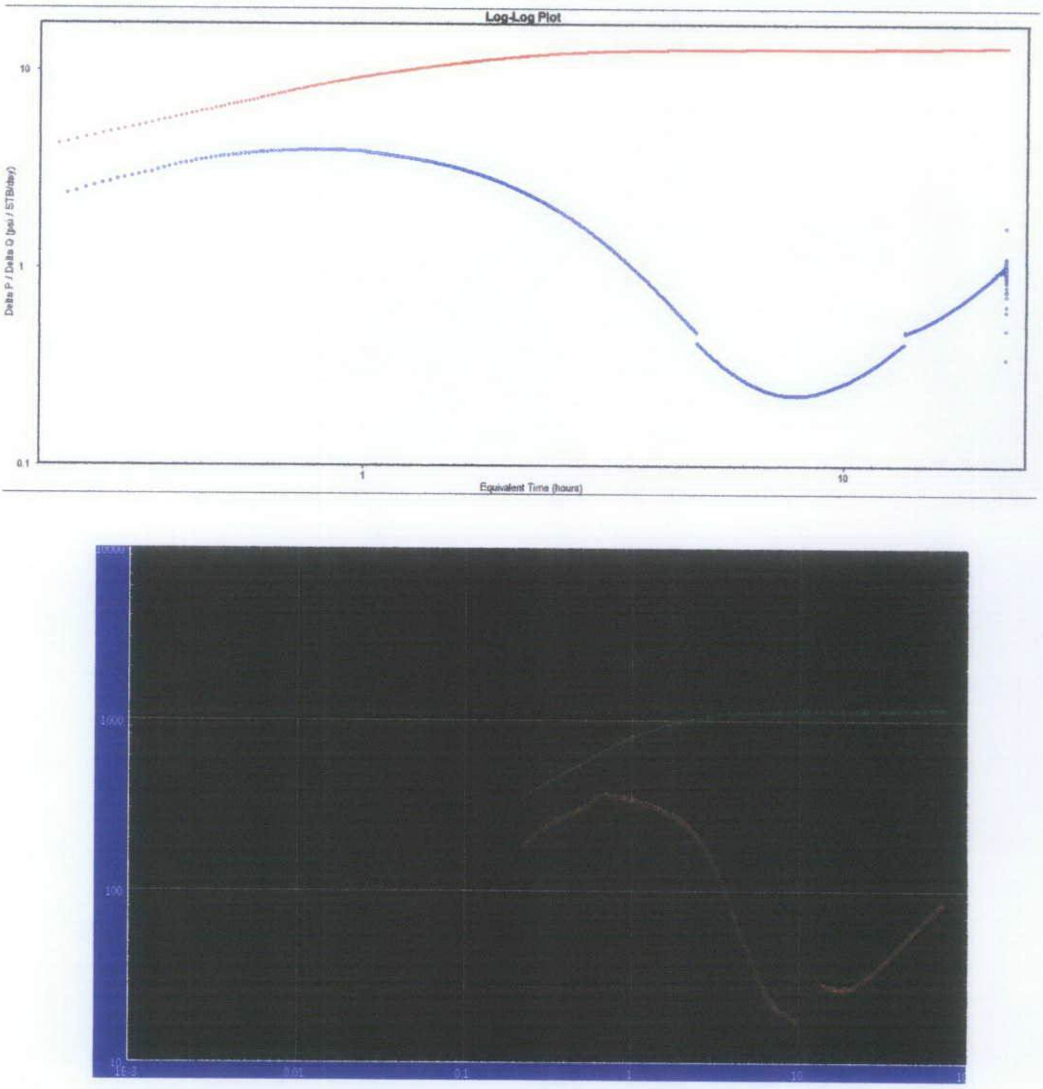
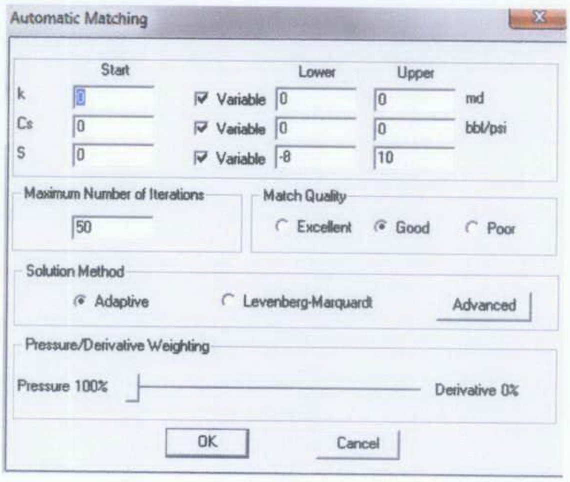


Figure 7.0: Filtered plotted data of Fall-Off #2; top: PanSystem, bottom: Saphir

After input data, then next step is to history match between the model and the data. This is accomplished by applying wellbore storage, flow and boundary model that can match the test data. From here, we can observe from the derivative curve display where we try to find the best match of the model for the data. This can be done by both analytical and numerical method. Mostly in the project, only the analytical section is used for improving the model. For analytical method, the reservoir and boundary model will be determined in fitting the model's curve to the data's curve. Determination of model will be made based on the test data plotted curvature. This will incorporate the information learnt in the Advance Well Test Analysis class and additional info from the reference book. Determining the value of the parameters such as storage coefficient, skin, reservoir pressure and others will result in model's curve fitting the data's curve nicely or not. This can be done by keying in the the lower and upper constraint for each parameter and the simulator will iterate for the best value to match the model to the test data. Figure 8.0 shows the windows that will set the constraints for simulator's iteration to match the test data. Most of the time, this is much easier for Saphir than PanSystem.



Parameter		Minimum	Value	Maximum	Unit
Well & Wellbore parameters (Tested well)					
C		2.6E-4	0.0026	0.026	bbl/psi
Skin		4.10717	14.1072	24.1072	
Reservoir & Boundary parameters					
k		0.363376	3.63376	36.3376	md
Ri		27	270	2530	ft
M		0.9	9	90	
D		0.07	0.7	7	
Re	✓	253	2530	25300	ft

Figure 8.0: Model parameters' upper and lower constraint for simulator iteration; top: PanSystem, bottom: Saphir

Expectation after iteration is that the model will match the test data. Figure 9.0 shows the result of simulation iteration, matching the model for the test data. For this section, this is not the best match, just an example of matching. This is not the end result as it will be discussed in Chapter 4.

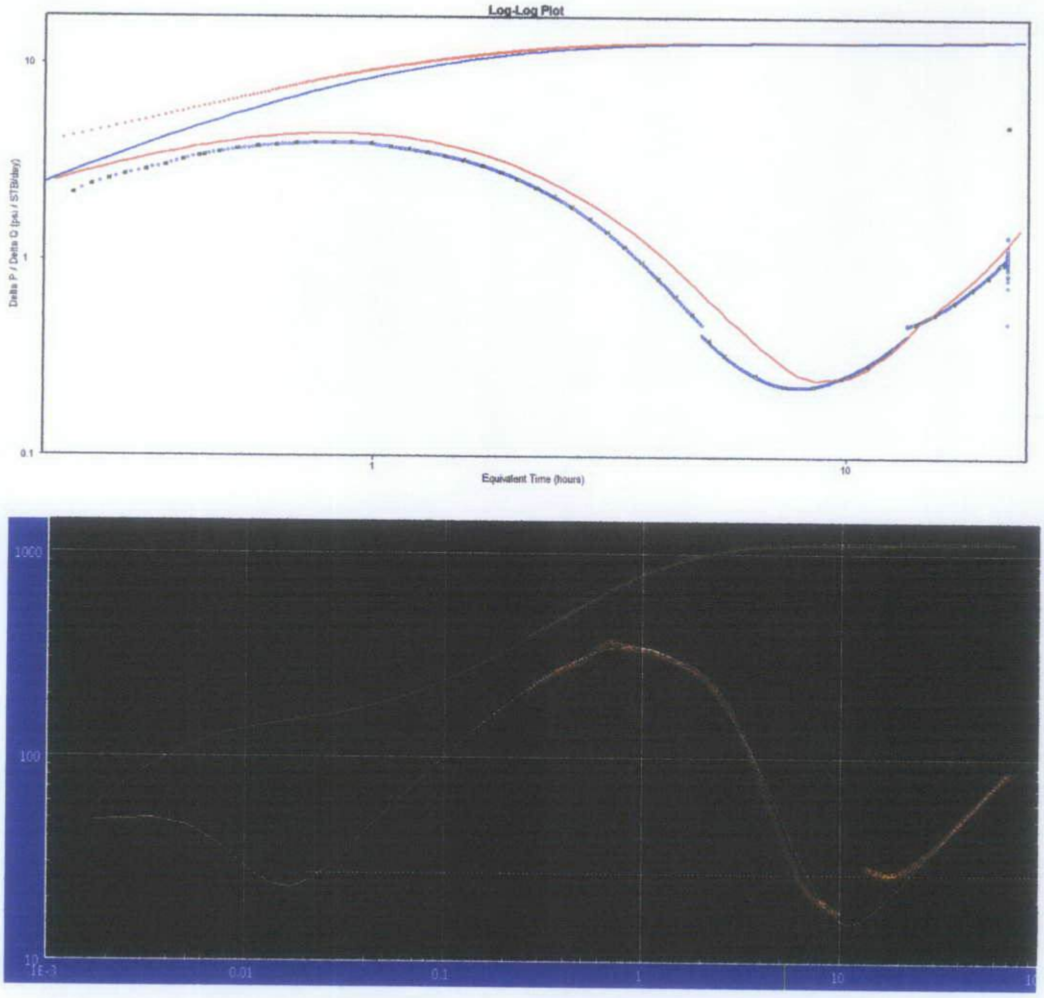


Figure 9.0: Sample of model matching of the test data; top: PanSytem, bottom: Saphir

After matching, then it better to quality check the results. This is an important part because in order to have a presentable result characterizing the reservoir, a diagnostic must be carried out to determine the percent error in result with available data. For the error percentage determination, it will be discussed further in Chapter 4: Result and Discussion. Figure 10.0 shows the example of Horner plot. This is important in diagnostics to check and confirm that not only the Log-Log plot (pressure change and derivative plot) is matching but also the Horner plot and also the History plot. For History plot, do refer Figure 11.0

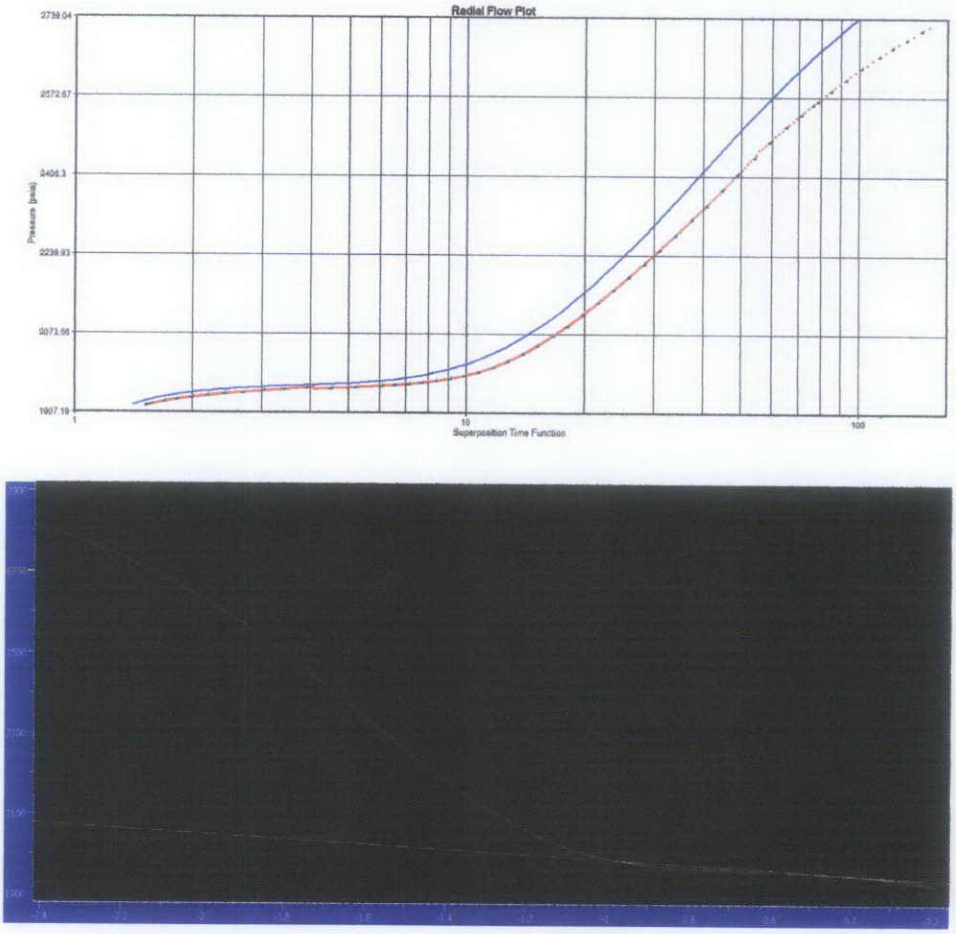


Figure 10.0: Semilog plot of Fall-Off #2; top: PanSystem, bottom: Saphir

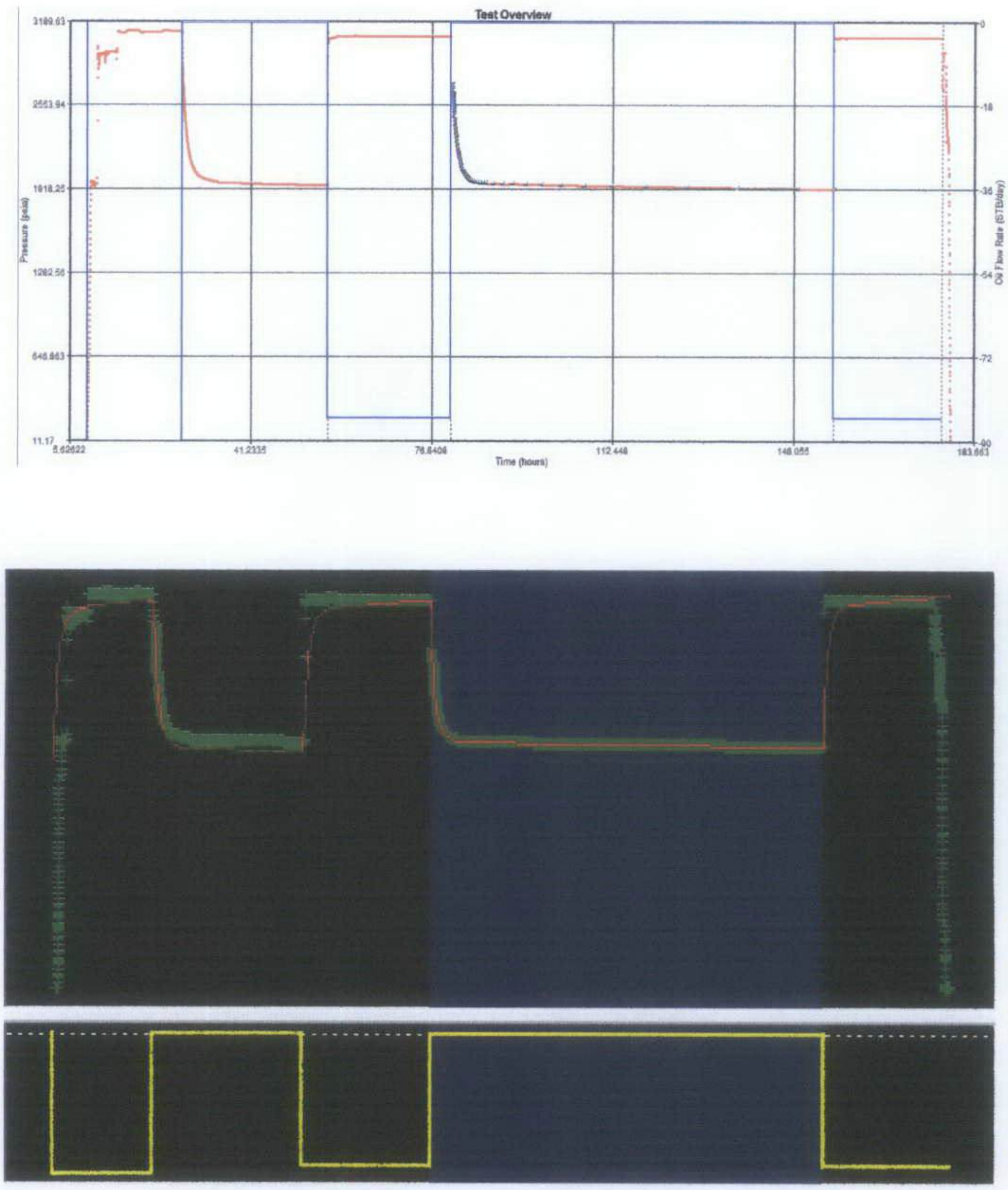


Figure 11.0: History plot; top: PanSystem, bottom: Saphir

For the Temperature Transient Analysis, the analysis is conducted in Microsoft Excel spreadsheet. Application of concepts and theories discussed in Sub-Chapter 2.3.2 will be extensively applied.

For the analysis technique, the Log-Log plot is chosen. The plot is basically derived based on the Gringarten et al. and Bourdet et al. type curves. The plotting functions are ΔP, $\Delta P'$ against Δt. Gringarten et al. type curve is derived from previous Ramey type curve and the Bourdet et al type curve is derived from Gringarten et al type curve [11].

Gringarten et al type curve is used for the change in pressure graph and the Bourdet et al type curve is for the pressure derivative. The pressure derivative is more sensitive to the change in the reservoir. This will be used to determine the flow regime, for the tests of PBU and IFO, three separate regions of Early-Time, Middle-Time and Late-Time [11].

3.2 Tools and Equipment

In the project, PanSystem simulator by Weatherford will be used to conduct the analysis to predicate reservoir parameters. Concurrently, another simulator, Saphir-Ecrin will be used.

PanSystem is a simulator built to do analysis for Pressure Transient Analysis. Its function is to analyze on the pressure and derivative curve. The curve is plotted in terms of pressure, temperature and flowrate as a function of time. This information will be combined with reservoir fluid data and rock properties. The simulator will calculate the parameters and display sets of curve to be analyzed.

On top of PanSystem, Kappa Saphir-Ecrin is used to conduct the analysis. This is to compare which simulator is more user-friendly and will provide best solution to the raw data from the test.

3.2.1 Deliverability Applications

3.2.1.1 These are few deliverability applications from PanSystem.

1. Fitting to measured test point data

   For oil and water fluid types, the deliverability or Injectivity can be calculated from the result of transient welltest and extended drawdown analysis, or from production test data [10].

   For gas and condensate fluid types, the deliverability or Injectivity can be calculated from the results of transient and extended drawdown analysis, or from production test data, using LIT or simplified C-and-n methods [10].

2. Production Forecasting

   This facility in the simulator provides a prediction of well production of the well have been determined.

3. Inflow Performance Relationship

   This is an application where PanSystem will calculate the deliverability or injectivity from the result obtained from transient welltest and extended drawdown analysis.

4. Report Generation

   PanSystem can generate report based on the analysis done. This is very convenient for future work reference

3.2.1.2 These are few deliverability or other applications from Saphir

1. Test Design

2. Flexible Plot

3. Inflow Performance Relationship/Absolute Open Flow

   This is similar to PanSystem

4. KIWI

   This is an option tool that will generate pressure change and derivative plot for sensitivity analysis. Since the simulator cannot be undo, this can help in decision making and saving time

5. Rate Prediction

6. Report Generation

As for Section 3.2.1.1 and 3.2.1.2, not all the application has been used except the KIWI.

Table 1.0 shows the project planning for Final Year Project 1(FYP 1) and Final Year Project 2 (FYP 2) while Figure 2.0 shows the activities Flow Chart for this whole period of Final Year Project 1

Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Selection of Project Topic														
Preliminary Research Work														
Submission of Preliminary Report														
Learning Simulator														
VIVA 1														
Learning Simulator														
Report Draft														
Submission of Interim Report														

Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Alternative Simulation Search														
Data Acquisition														
Simulation														
Submission of Progress Report														
Submission of Pre-SEDEX Poster														
Submission of Dissertation														
VIVA 2														
Submission of Hardbound														

Table 1.0: Project Progress; FYP 1 (top), FYP 2 (bottom)

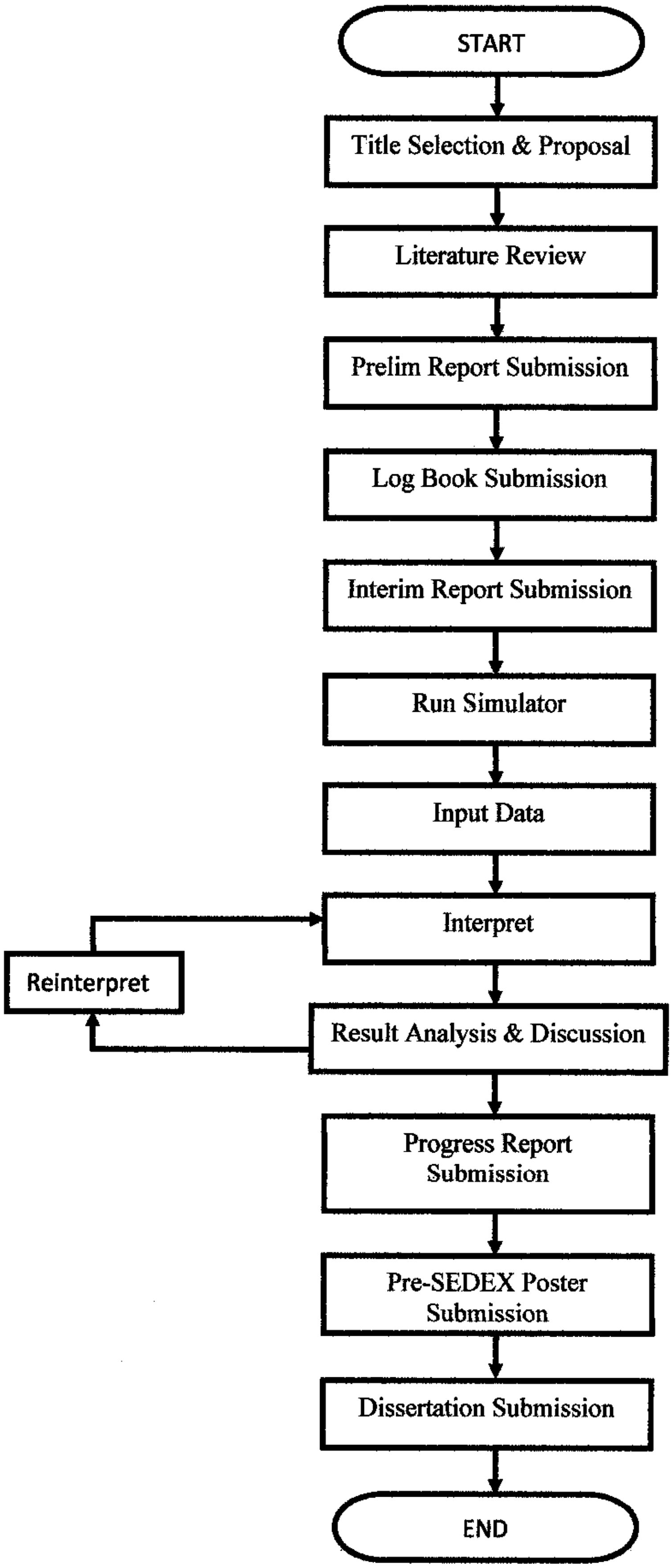


Figure 12.0: Project Activities Flow Chart

CHAPTER 4

RESULT AND DISCUSSION

For the result, it is expected that the test data will be plotted on Log-Log plot of ΔP and ΔP' (Psi) against Δt (hour). As we can recap back, the analysis is done on Fall-Off #2. This is a significant decision made by looking at the time of the test was conducted. For a PBU or IFO test, the longer the test, the better as the pressure is tested to build or fall-off right after injection to reach near reservoir pressure. For comparison, figure below shows the significant different between the two fall-off sections.

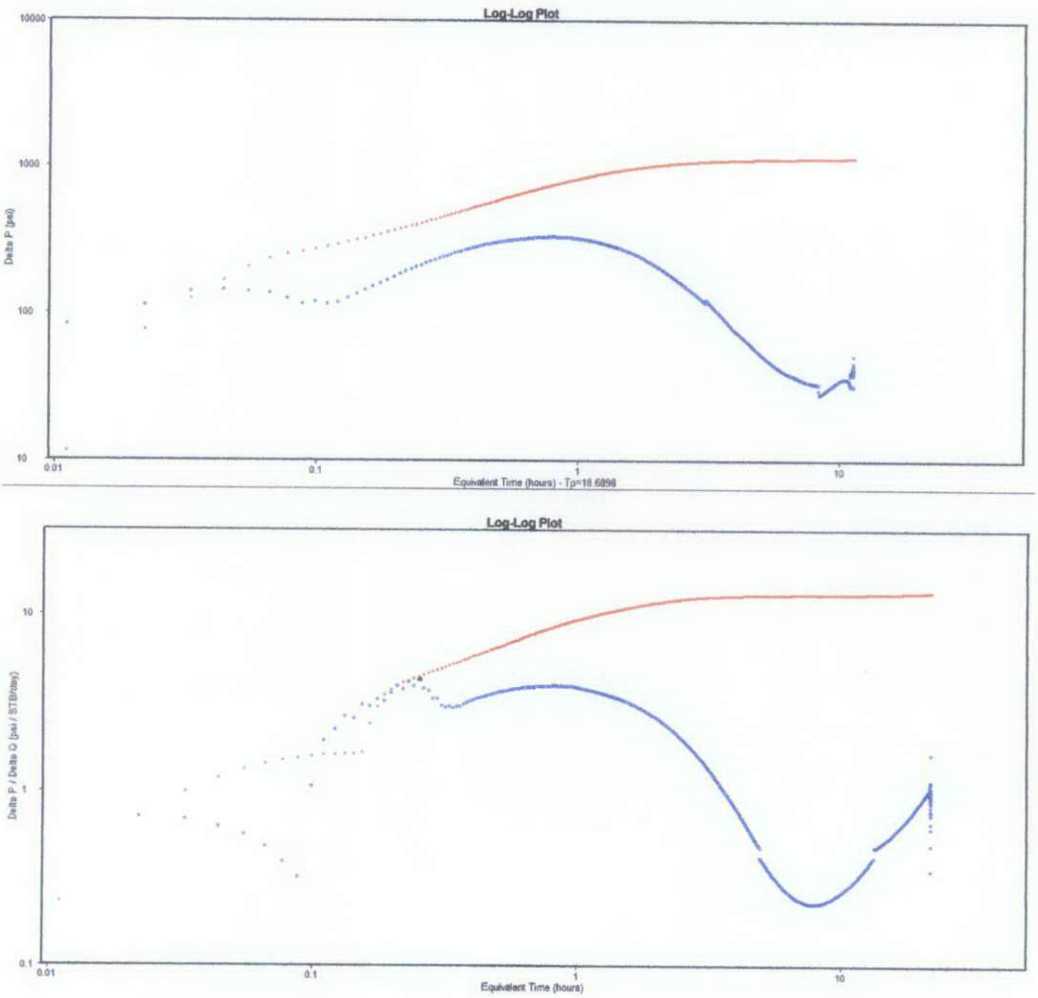


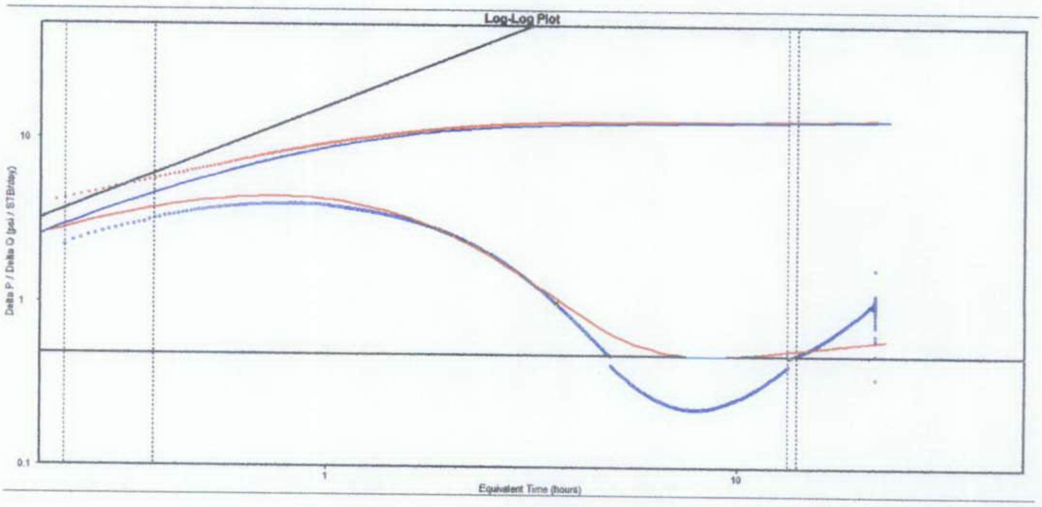
Figure 13.0: Comparison between Fall-Off #1 (top) and Fall-Off #2 (below) for PanSystem

Figure 14.0: Comparison between Fall-Off #1 (top) and Fall-Off #2 (below) for Saphir

From the comparison, we observed at the LTR, Fall-Off #2 shows a more developed region than Fall-Off #1. This will reduce the uncertainty of encountering the possibilities of boundary.

For the models used to define the test data, another simulation is conducted to compare between models. And for sure, with this data, Infinite Acting Radial Flow model is not suitable as the LTR will not match between the test data and model. But the model's simulation will be included as for reference and comparison between available models.

Model #1



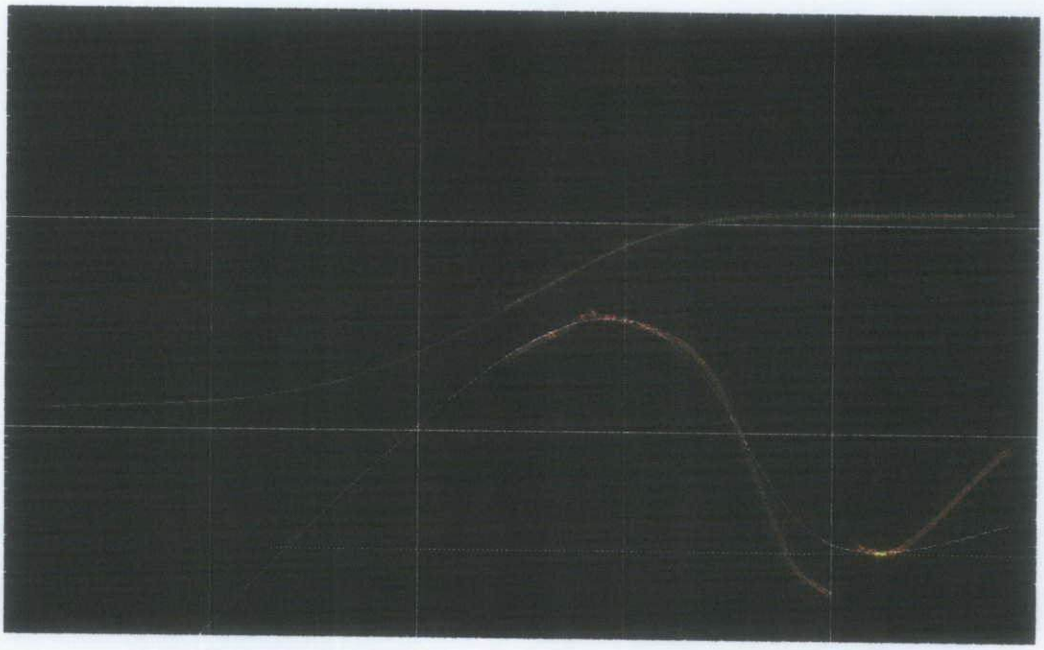
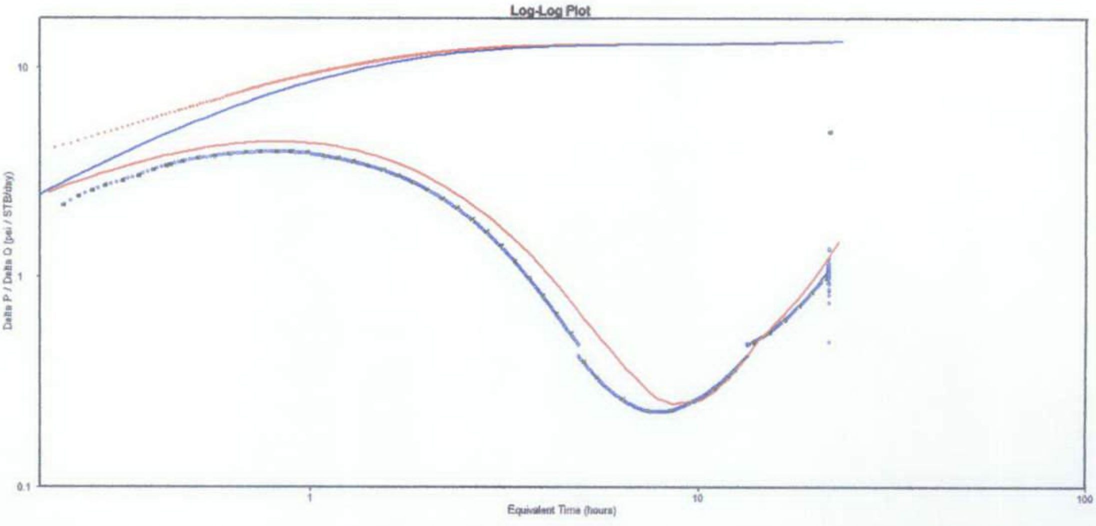


Figure 15.0: Comparison for Model #1; top: PanSystem, bottom: Saphir

Model #2



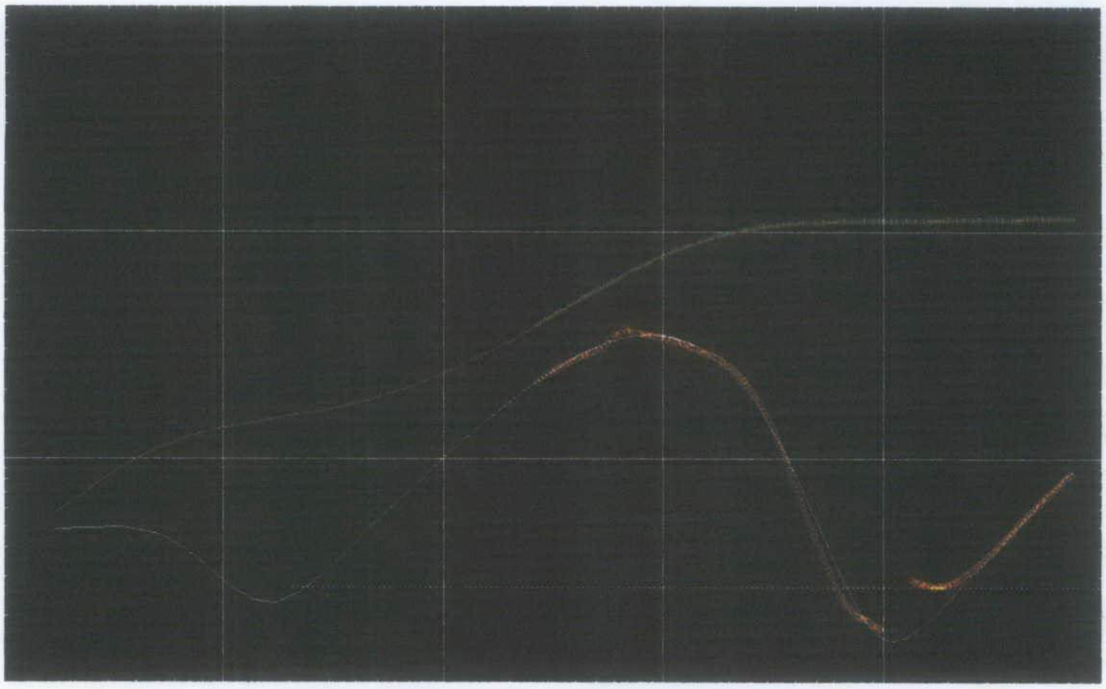
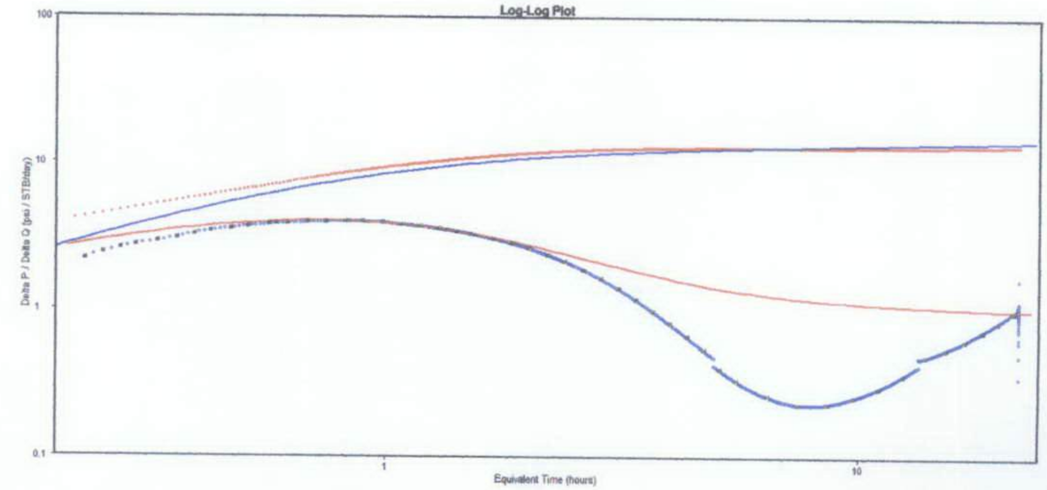


Figure 16.0: Comparison for Model #2; top: PanSystem, bottom: Saphir

Model #3



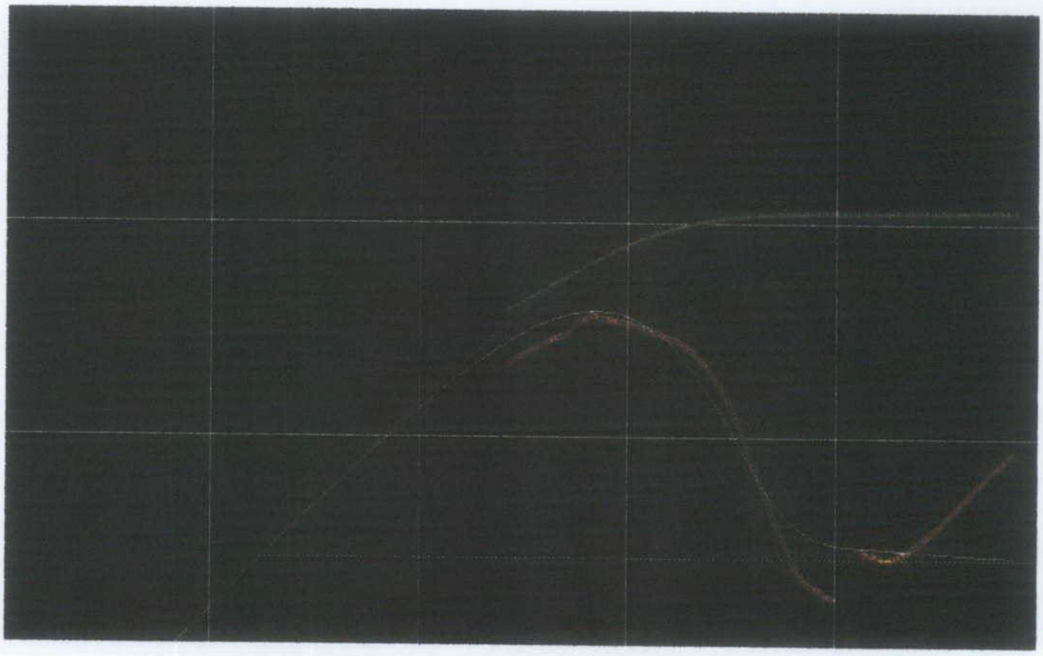


Figure 17.0: Comparison for Model #3; top: PanSystem, bottom: Saphir

Before we continue analyzing the result based on plot interpretation, since the early part of the Log-Log plot is filtered due to noise occurrence. Here is the graphical evidence of the reason the occurrence. Suspected there was a rate change during fall-off due to the trend of the pressure.

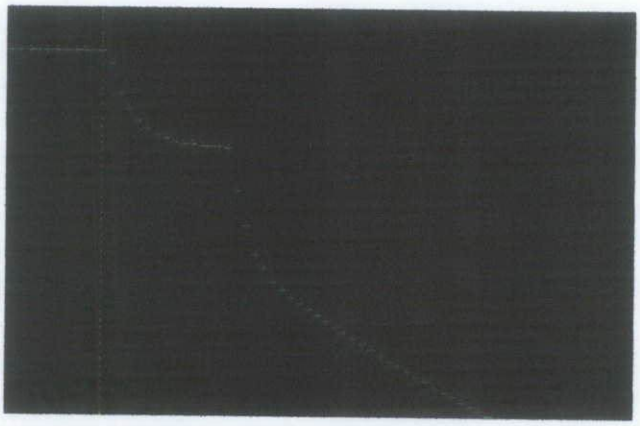


Figure 18.0: Reason of noise occurrence, rate-like changing pressure response

If observed clearly, the wellbore storage model is not Classic Wellbore Storage or Constant Wellbore Storage. This is because initially that is the preferable model since the noise has been reduced but after referring to the Horner plot, the Early-Time region of the model does not match the test data. After applying the Changing Wellbore Storage (Fair), the model fits the data. Observation and comparison made and Figure 19.0 and 20.0 will show the evidence of the analysis done.

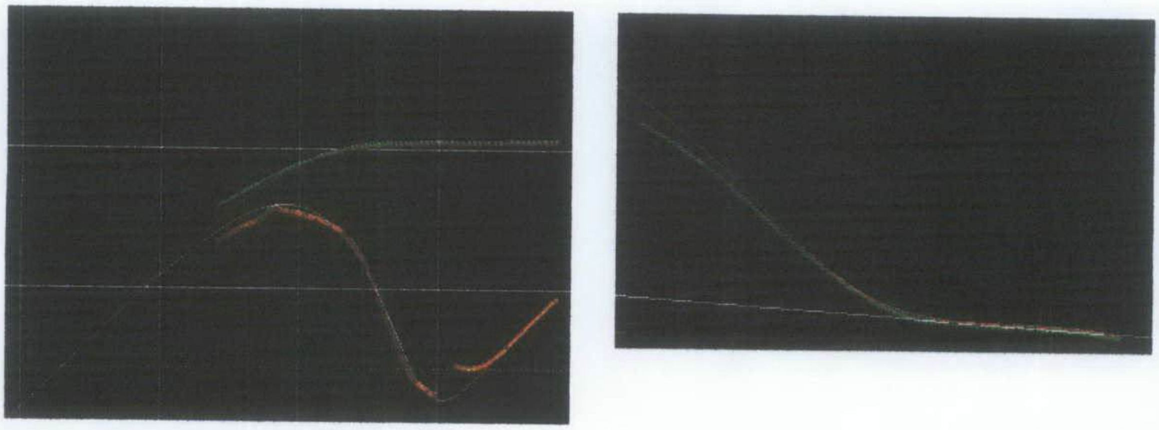


Figure 19.0: Constant Wellbore Storage model, not matching at ETR Horner plot

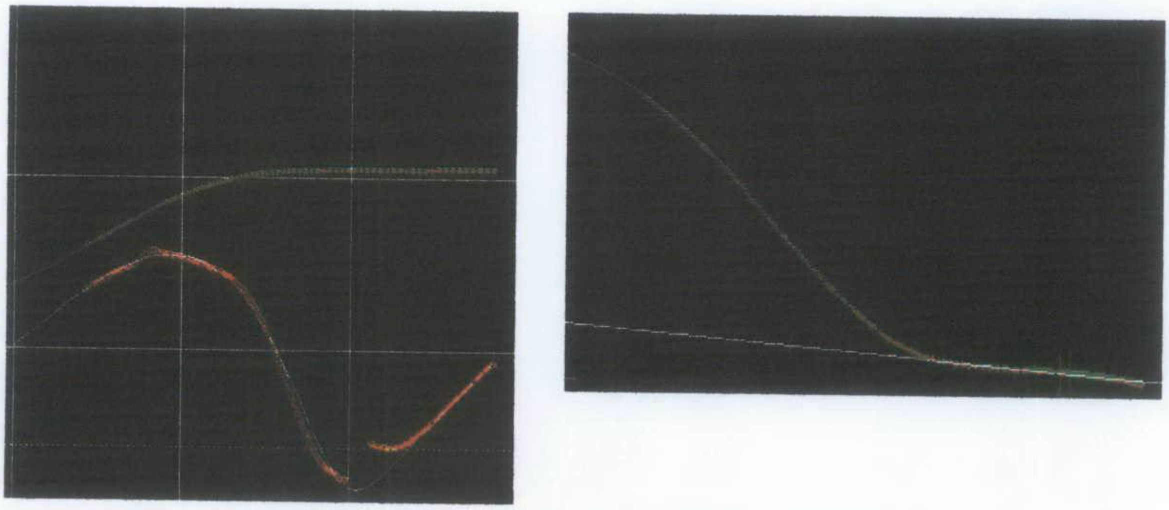


Figure 20.0: Changing Wellbore Storage model, matching at ETR Horner plot

It is obvious that from the matched plot, Model #2 is the best matched. So it will be chosen and the summary of the models used will be in Table 3.0.

Model	Well Model	Wellbore Model	Reservoir Model	Boundary Model
#1	Vertical	Changing Storage (Fair)	Radial Homogeneous	Single Fault
#2	Vertical	Changing Storage (Fair)	Radial Composite	Circle
#3	Vertical	Changing Storage (Fair)	Radial Homogeneous	Infinite

Table 2.0: Simulation's model (both applies on PanSystem and Saphir)

And for the quality check on the model matched with the test data, Table 4.0 will summarized the percentage difference between it.

Parameters	Model Value	Semilog Value	Percentage Difference, %
Permeability, K, mD	3.73	3.72	0.27
Skin, S	14.8	14.2	4.22
Pi, Psia	1819.22	1924.38	5.46

Table 3.0: Percentage difference calculation between model and semilog

For the Temperature Transient Analysis, the expected results is interpretation based on the temperature graph and applying the relevant theories and concepts.

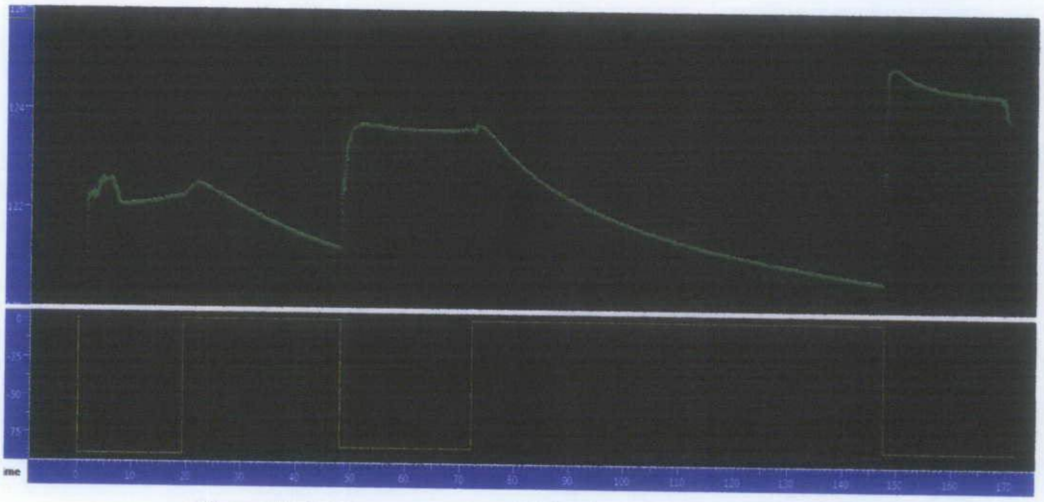


Figure 21.0: Temperature and injection rate versus time plot

Observed that from both fall-offs trend, there are slight pressure increase (yellow circle). This shows the effect of negative Joule-Thomson effect, which is warming effect. This is can be explain that the water injected to the reservoir settling and the heat is contained. As the test time moves, the temperature start to decrease, showing Joule-Thomson cooling effect of reservoir fluid. Once the injection started again, the temperature hiked up. To compare between injectivity #2 and #3, the temperature rise for injection #3 is high. This due to the instantaneous warming effect of the injection process, inclusive of all the friction which can be quantified as frictional heating effect. This is an indication that the reservoir might have a low-permeability.

CHAPTER 5

CONCLUSION

From the test data, the model #2 is an acceptable one as the percentage difference between the model's value with the semilog value fall in between +- 10%. Between PanSystem and Saphir, the model in Saphir is fitting the test data compared to PanSystem. This shows that Saphir is better than PanSystem. This strengthens the point that Saphir is not only user easier to run but also provide better solution, given same modeling applied to the same data. Pressure Transient Analysis is a common thing worldwide but for Temperature Transient Analysis is rarely conducted in Malaysia and we often neglect the temperature data. So this research is to implement the Temperature Transient Analysis in Malaysia Field. On top of that, it is exciting to be able to run several well testing simulators in getting the result from the same data.

RECOMMENDATIONS

For recommendation, with this project done, it is beneficial for UTP Geosciences and Petroleum Department (GPED) to have more than one pressure transient analysis or well testing analysis simulator. It is beneficial for the students as this will help them to experience the excitement of using simulator. Relying on PanSystem alone is not a problem but due to its little bit tedious steps, this will discourage students to learn.

As for expansion and continuation of this project, there is nothing much for the major part which is the major objectives of this project. But for the minor objective, which is regarding Temperature Transient Analysis, there is a lot of improvement can be done.

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