A Study of Stability and Vibration of the Drill String

by

Abdul Hafeez Bin Abdul Shukur

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Mechanical Engineering)

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CERTIFICATION OF APPROVAL

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Approved by,

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(Dr. Tadimalla Rao)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
May 2012

CERTIFICATION OF ORIGINALITY

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

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ABDUL HAFEEZ BIN ABDUL SHUKUR

ABSTRACT

Drill strings are used for drilling for oil and gas. A drill string is essentially a long pipe with a drill bit at its lower end. Drill strings experience instability leading to excessive vibrations causing bit failure. Since a drill string is essentially a long series of pipes connected together with a bit at the end, it behaves as a string, hence the name drill string. The excessive of vibrations can be causes of flexibility of drill strings. These vibrations take place in three-dimensional space namely axial, torsional and lateral.

Theoretical analysis of stability and vibration of drill strings has been performed by many authors. Thus, all of their research paper can be used a literature review to further investigate on how and why the vibration is always occur. At the same time however, the vibration cannot be vanished. In fact, it is because of the vibration that the drilling work can be done at the first place.

Nowadays, the oil and gas company plan to explore an extreme deep reservoir underground either at offshore or onshore to extract the fossil fuel. Due to grueling condition of drilling work, the technology of drill string need to improve in order to sustain any challenge that may come during the drilling working progress. Thus, it is necessary to analyze and study the drill string behavior first.

By using a numbers of specific software to model and simulate the drill string behavior, the vibration of drill string can be analyzed. Specifically, the data regarding the natural frequencies of the drill string behavior can be retrieved in this research based on the result that will obtain from the modeling process. The findings at the end of this paper may provide a method to overcome an excessive vibration of drill string and provide more stability to the drill string, thus more convenience drilling work.

ACKNOWLEDGEMENT

Throughout the whole period of conducting the Final Year Project, many have provided immeasurable amount of guidance, ideas, assistance, support and advice. I hereby express my warmest gratitude and appreciation to my supervisor, Dr Tadimalla Rao for the continuous support and encouragement of my final year project, for his valuable suggestions, patience, motivations, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis.

My biggest thanks to the Final Year Project coordinator, Dr Hassan Fawad and all Mechanical Engineering Department lecturers for their cooperation in providing me all the necessary information, references and guidance to conduct this study. My special appreciation also goes to staffs and technicians that help me in conducting laboratory analysis and assist me by provide some additional information and lesson regarding of my thesis studies.

Deepest gratitude to my family, friends and others who always give their best guidance, cooperation and support throughout all of these semesters from the beginning of my project until the completion of the project. Last but not the least, I wish everyone the very best and continue to provide excellent guidance and support for innovative research in the future.

Thank you.

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CHAPTER 1
INTRODUCTION

1.1 PROJECT BACKGROUND

The research is about studying the stability and vibration of a drill string. The drill string is one of the main essential equipment that had been used to drill the ground or formation in oil and gas industry for so many years. From time to time as the technology and expertise keep improving, the technology that been use for the drill string is also need to improve. A slightly problem occurred to this drill string during its working activity, it will cost a lot to the project management in term of financial. Thus, the performance of the drill string became very essential to the drilling project. The stability and vibration of a drill string is one of the factors that can determine the performance of the drill string. The best drill string can be said that experienced less vibration and most stable during the drilling process in the wellbore and the least drill string is vice versa. This research will analyze the causes of the vibration experienced by the drill string and the effects of the stability and vibration that occur to the drill string. At the end of the research, any new methods or mitigation plan can be invented in order to improving the drill string performance in the wellbore regarding with the stability and vibration based on the findings that will be made later.

1.2 PROBLEM STATEMENT

Drilling vibration has been shown to be a leading cause of drill string component failures such as Measurement While Drilling (MWD) failure, drill string twist-off and stabilizer wear [1]. In order to avoid all of these failures, it is important to understand first the vibration of the drill string. There are many factors that can be related to the vibration. The drilling mud flow rate, the drill string weight, the weight on bit and angular velocity are four major factors that can effects the stability and vibration of a drill string. All of these factors can influence the frequency trigger by the drill string. However, it is quite impossible to have no vibration at all during any drilling works. The vibration of drill string will always occur at any circumstances regarding where and how the drilling work is conduct but there is some ways on how to minimize the effect of the vibration that will result in decreasing of the drill string failures.

1.3 OBJECTIVE AND SCOPE OF STUDY

The objectives of this project are to:

- Analyze the stability and vibration of a drill string.
- Study the cause of failure creates by vibration of a drill string.
- Understand the relation of the natural frequency and resonance of the drill string performance.
- Analyze the factors that contribute to the vibration of a drill string.
- Discover potential of the methods or plans improving the drill string performance when the vibration occurs.

The scopes of study for this project are simplified as follows:

- Understand the component or design of the drill string.
- Understand the general concept of vibration.
- Study on past research papers, articles and journals regarding the vibration of drill string.

1.4 PROJECT FEASIBILITY

The time of the project to be completed is nine months which divided into two semesters. In order to ensure the successfulness of the project, the author will spend some times to read journals related to topic and understand the topic properly along with spending a lot time discussing with the author's supervisor. Nine months time frame should be sufficient to complete the project within the scope and time frame.

CHAPTER 2
LITERATURE REVIEW

2.1 DRILL STRING CHARACTERISTIC

A drill string is use to transmit the rotation of the rotary table or top drive to the bit and to serve as a conduit for the drilling fluid [2]. The drill string is hollow steel cylinder where the drilling fluid can be pumped down into the formation through that hollow section while being circulated back up through the annulus which the void between the drill string and the wellbore. In addition, the drill string is consists of two main parts, the drill pipe and drill collar. The drill pipes are the major portion of the drill string. It is commonly made out steel and butt-welded tool joints at each end. The tool joints provide a means for fastening the individuals of pipe together. The pipe is upset at both ends to reinforce the ends of pipe. Meanwhile, the drill collar which is heavier than standard drill pipes are design for guiding, stabilizing and providing the weight on the bit [3].

The following are the major functions of drill string in conventional rotary drilling operations:

- Transmit rotary motion from the surface to a drill bit.
- Conveys drilling fluid to the bottom of wellbore.
- Produces weight on bit for effective drilling action.
- Provides control of borehole direction.

2.2 VIBRATION OF THE DRILL STRING

Generally, an extensive vibration of the drill string will lead to the failure and damages of the tools. The vibration can create fatigue damage by inducing repeated cyclic bending stress on the drill string [2]. The vibration also will create high impact loads to the drill string resulting in drill pipe twist-off and washout, and downhole component failures. Theoretically, the drill string is subjected to into three basic vibration mode which are axial, lateral and torsional vibration. The axial vibration or longitudinal is the motion of the drill string in its own axis. Meanwhile, the lateral vibration or transverse motion is the side-to-side motion of the drill string. Lastly, the torsional vibration is the motion causing the string to periodically torque up and spin free [2].

Lateral vibration is the most important vibration mode of the drill string. This kind of vibration is responsible for most of the downhole tool and drill string failures. The lateral vibration can occur at the bottom hole assembly (BHA), the bit and drill pipes. Impacts of the BHA against the wellbore wall generate high shock load and high cyclic bending stress resulting in measurement while drilling (MWD) equipment, motor and BHA component failures. Furthermore, the impacts on the drill pipe can cause wear in drill pipes, twist-off and washout. As the bit also is connected to the drill string, the vibration will affect the bit as well. The impacts on the bit can lead to premature drill damage. One of the main causes of the lateral vibration is resonance. The resonance occurs when the rotary speed is too close to natural frequencies of the BHA. The resonance would result to self-excited high magnitude vibration. Apart from the resonance, the BHA eccentricity and buckling also can cause the high magnitude of lateral vibration. In one of the previous research, Lee[4] had found parametric resonance in mud drilling and air drilling after modeling the lateral vibration of BHA while induced by bit and formation interaction. Using some fins on drill collar may reduce the lateral vibration and prevent buckling as well.

In the axial vibration of the drill string, it will lead the bit to repeatedly lift of and impact the bottom of the wellbore, thus resulting in large weight on bit fluctuations. The high impact load from the axial vibration can damage the drill bit, drill string or the surface hoisting equipment.

The torsional vibration can be defined as a non uniform bit rotation in which the bit stops rotating momentarily at regular intervals. That is why it causes the string to periodically toque up and spins free as mention before. The typical environment for torsional vibration or stick slip high angle wells with aggressive PDC bits and high weight on bit, when the downhole frictional torque exceeds the rotary torque. The torsional vibration of the drill string had been studied before. Khuleif[5] had studied using torsional and vibration of drill string using both Lagrangian approach and the finite element method. In his model, he found out the neutral point position on the natural frequency of drill string. Common failures resulted by the torsional vibration are bit damage, connection over torque and drill string twist-off. A few solutions to torsional vibration may include reducing drill string torque through working in the better hole cleaning.

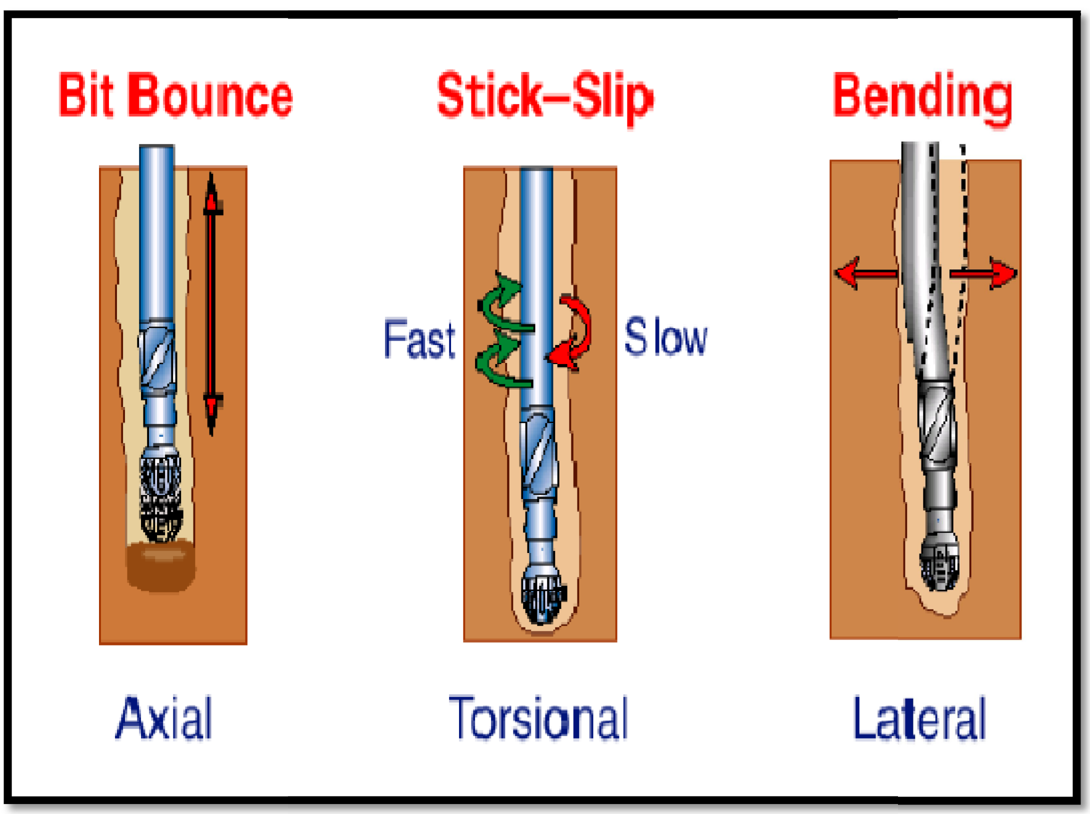


Figure 1: Drill string failure and its direction

2.3 THE EFFECT OF DRILLING MUD FLOW RATE AND WEIGHT ON BIT

Drilling mud is used to cool the drill bit and transmit the carved rock back to the surface [6]. It is flows from the hollow section of the drill pipe and the drill collar to the end of the hole. However, the drilling mud flow rate provides significant effects on stability and vibration of drill string. The drilling mud flow rate will affect the drill string in term of the natural frequency and vibrational amplitude. The increase of the drilling mud flow rate will result in decrease of natural frequencies and the amplitude as well. Thus increasing the drilling mud flow rate causes more damping in the lateral vibration of drill string.

For the past few years, there are many researches had studied the effect of drilling mud to the drill string. Paidoussis[7] had developed a theoretical model for dynamics of a hanging tubular cantilever conveying fluid downward. According to Paidoussis, after exiting from the free end, the drilling mud or fluid was pushed upwards in the outer annular region contained by the cantilever and a rigid cylindrical channel. His model was similar to a drill string with a floating fluid-powered drill bit. He analyzed the linear stability of a drill string without weigh on bit and found critical flow rate of a drilling mud. However, the drilling mud could also stabilize the drill string after the second natural frequency is vanished. It is show in an analytical formulation but this effort did not occur in the drilling process because of the huge amount of drilling mud that needed.

For the case of weight on bit, the drill string will experienced changing in natural frequency and vibrational amplitude, which same as the effect of drilling mud flow rate. As the weight on bit increase, the natural frequency decrease, while the vibrational amplitude is increase [6]. Exposure of this kind situation to the drill string will result in failures or damages. The weight on bit is the difference of weight force of the part of the drill string below the neutral point and the buoyancy force of drilling mud. In some cases, the increase of weight on bit is encouraged as it can enhance the rate of the penetration of drill bit thus making the drilling process faster. However, it may lead to buckling of the drill string which causes permanent contact of drill string with the wall of the wellbore and leads to failure in both of them. As point out by Ghasemloonia[8], as the weight on bit nears the buckling load, the first natural frequency approaches zero. It is obvious that in the presence of large amount of axial force, natural frequencies decrease in compression and increase in tension load of the drill string.

2.4 THE STABILITY OF THE DRILL STRING

In many years, theoretical analysis of stability of drill strings has been performed by many authors. In the paper written by Elsayed[9], he use an alternative, cost-effective approach to representing the drill string in the laboratory using active circuits. In the paper, it presents the stability equations and shows their dependence on the Frequency Response Function (FRF). Elsayed also prove that only the negative component of the frequency response function is relevant to stability. Finally, he concluded by developing a stability diagram using an assumed bit interacting with the active circuit model showing the utility of this approach. The stability diagram is essentially plot of bit diameter against the bit speed at the threshold of stability. This threshold can be defined as the bit diameter at each speed above which vibration tend to grow with the time until saturation occurs. This saturation limits the maximum amplitude of vibration and results from excessive axial bit movement. When the bit moves above the rock surface, the cutting force is momentarily reduced to zero. This will affect the bit by limiting vibration amplitude. Conversely, if the bit diameter is below the threshold of stability at the chosen speed, vibration tends to die out. However, during the stability threshold, vibration tends to remain unchanged. His methodology delineated in his paper can be used in the analysis of drill string dynamics, such as the design of shock absorbers placed above the drill bit thus that will be resulted in minimize bit vibration and failure.
In the end, he had come out the result of bit force versus the time to further analyze the stability of the drill string as below;

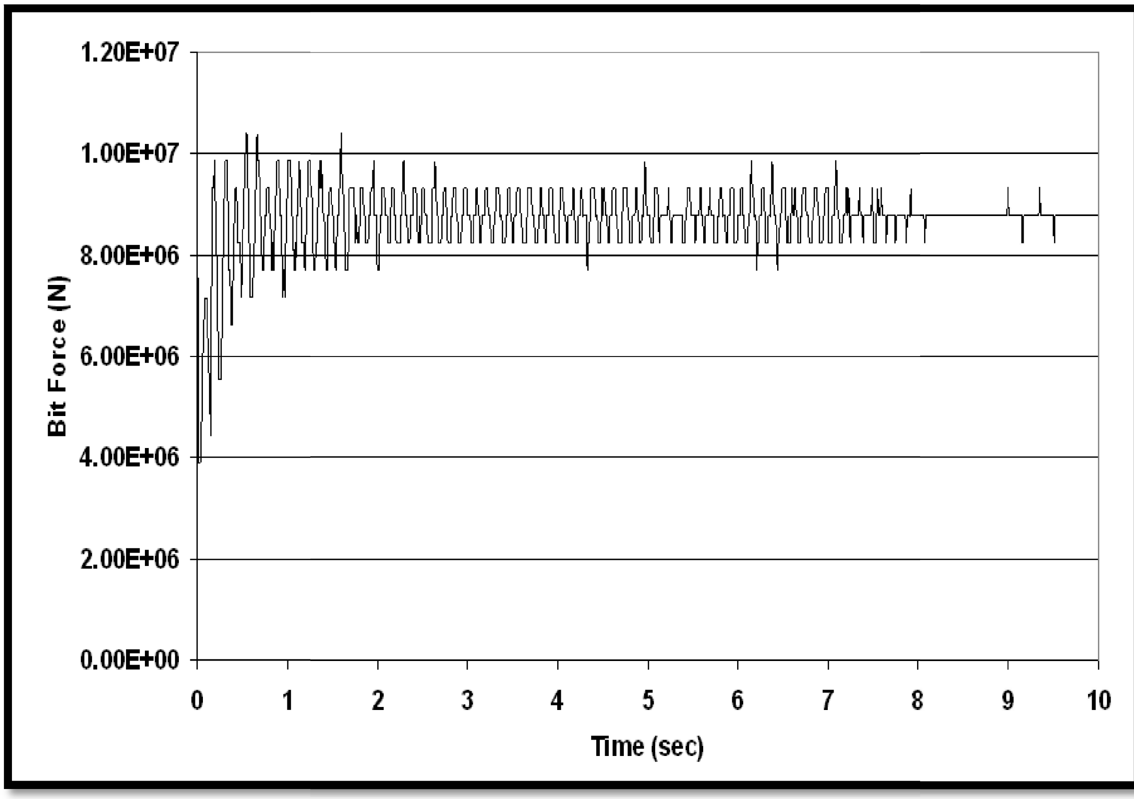


Figure 2 : Bit vibration in stable drill string

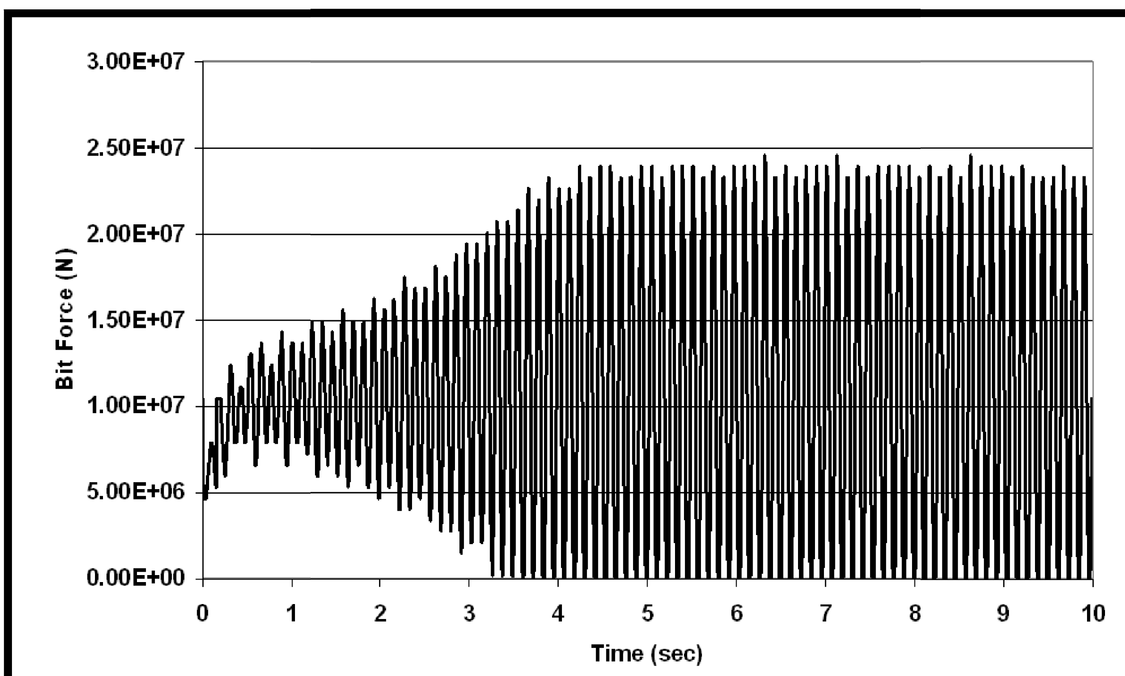


Figure 3 : Bit vibration in unstable drill string

Based on the Elsayed's result above, it is safe to assume that when a stable drill string is achieved, the bit force will be constant throughout the whole drilling process. Meanwhile, when an unstable drill string had occurred, the force of the bit is varies. The result of Elsayed's research can be used in order to improve the drill string and control the force of the bit as well. The weight on bit and the force of formation will have to take a look closely as this parameter is related with the force that will subjected by the bit to the formation.

2.5 DRILL STRING ANALYTICAL OVERVIEW

A drill string can be considered to be a slender beam that consists of two main parts [8]. The thin lightweight upper part can be called as the drill pipe and the thicker heavier section at the bottom is compromised of drill collars. The weight of the drill collars provides enough axial loads to maintain a certain amount of weight on bit.

The bottom hole assembly components are attached to the end of the drill collars. A drill string is under tension in the upper part and under compression in the collar section. It is desired that the drill pipe never undergoes compression and mostly drill collars are under compression. This phenomenon is controlled through mud hydrostatic effects in the drilling process. In the paper written by Ghasemloonia (2010), he modeled the vibration behavior of drill collars at the point of contact with wellbore. Therefore, the assumed model for this part is a beam, which is under compression as stated above. The gap between drill collars and the borehole wall is reduced with stabilizers, which assist the drill collars to keep centralized.

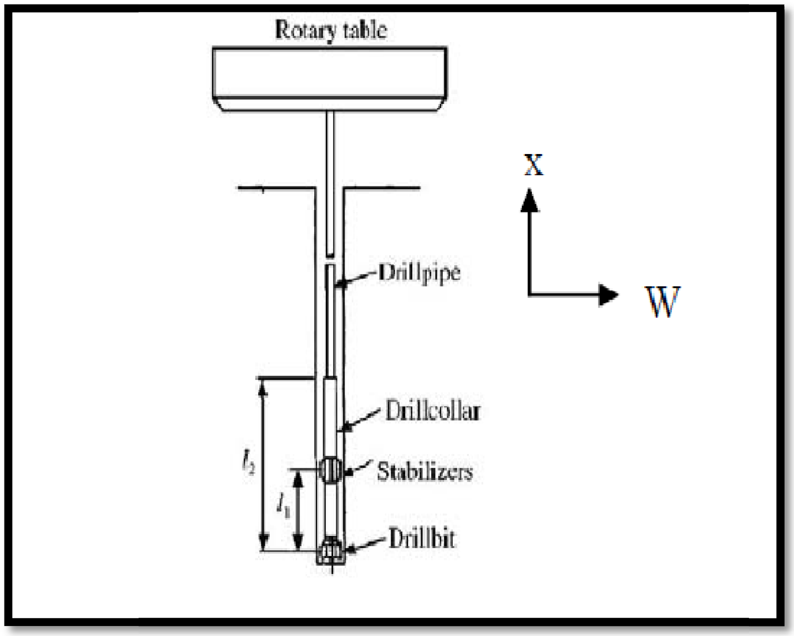


Figure 4 : Schematic view of drill string

This simple illustrated schematic view of drill string can be used to further understand on the drill string. That is the reason why the drill string can assumed as a beam. The outcome of this assumption, Ghaseemlonia (2010) manage to derive a calculation in order to analyze the vibration of drill string under the weight on bit.

As a result from previous assumption, the Euler-Bernoulli beam under axial compression load is assumed in this paper as well [8]. The boundary condition in the lower point of the drill string, which is the bit, is assumed as simply supported for transverse motion, since it has the ability to move downward and is ideally restricted from moving laterally. While the upper part of the beam which the top of collars is also considered as a supported constraint, due to the fact that the drill pipe restricts to its lateral motion.

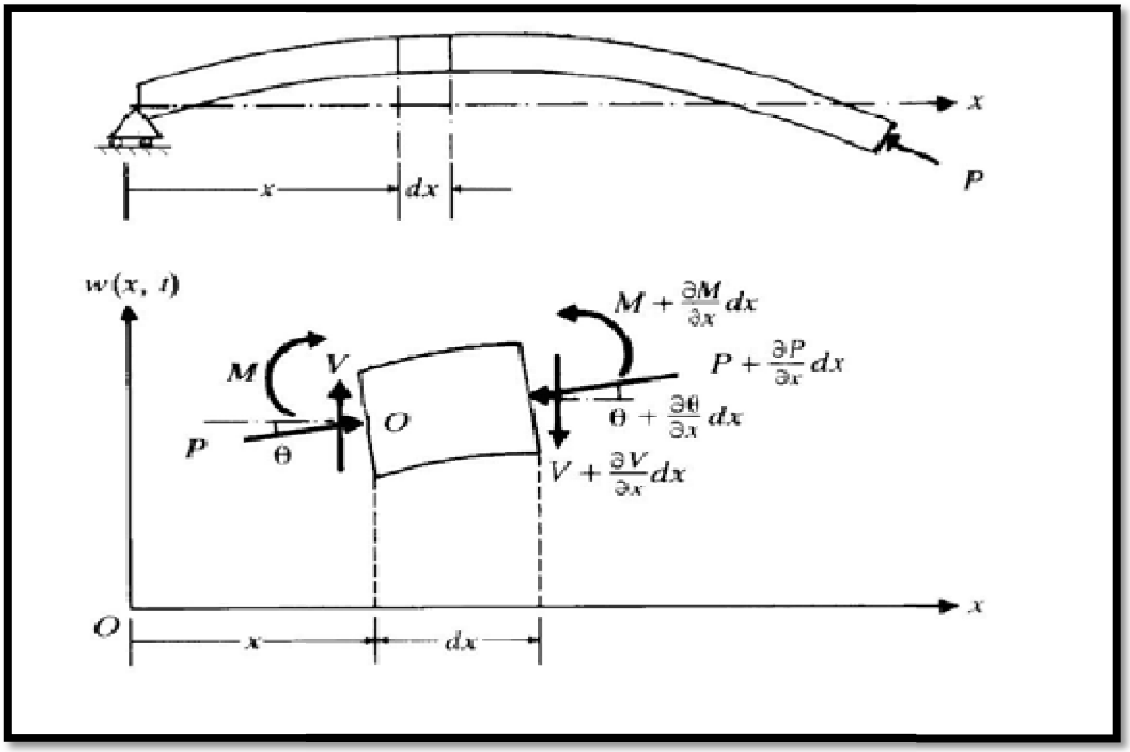
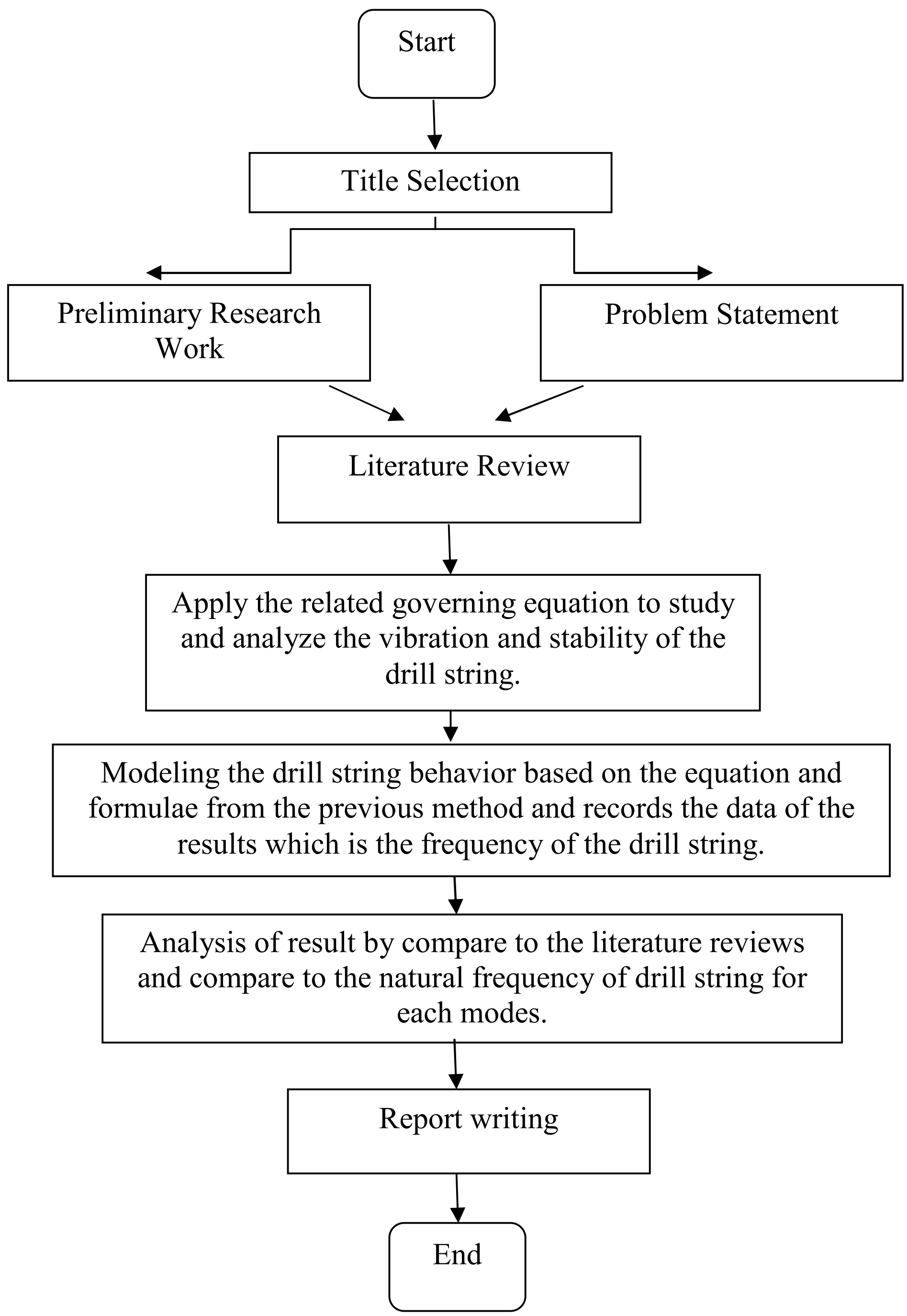


Figure 5: Schematic view of the Euler-Bernoulli beam under compression load and the equation involve

CHAPTER 3
METHODOLOGY

3.1 PROJECT FLOW CHART



3.2 PROJECT ACTIVITIES

In previous FYP 1, the author has to understand and familiarize on mechanism the drill string which includes the design and the component of the drill string. This initial activities need to be done and understand completely as it will continue during FYP 2.

After obtain the desired input of value based on studies during FYP 1, the work will proceed to model the drill string behavior subjected to its vibration and stability. In modeling phase, the author would use the software to simulate the drill string behavior.

In summarize for the work that will be doing in FYP 2, the work will be focusing on the software usage including designing, analyzing and simulation only. The purpose of CATIA software is to design the drill string including bottom hole assembly based on the gathered data.

Meanwhile, the ANSYS software is used for the purpose of simulate the drill string, then solve it, and obtain the nature vibration frequencies. These results can provide the drilling work with very useful parameters, so that any drilling work can accord these data to control the drill string system and avoid the phenomena of the drill string resonance. For the model of drill string, the main factors that affect drill string vibration can be considered, the subordinate factors are ignored. Before the analysis of drill string vibration, the hypothesis can be made as follows:

i. The drill string is along the axis of well hole during drilling
ii. The effect of drilling liquid and the friction of drill string and well hole are not considered, the various damping can be neglected
iii. The tie-in and dog-leg are ignored. The stiffness coefficient of the steel wire in the well mouth is 9.81×106.

The initial data that will be used in modeling the drill string already been gathered. The analysis type is liner, elastic, isotropic material. For the system of drill string, the material properties that will be used as follows;

i. Elastic model is 2.06*10^11,
ii. Poisson's ratio is 0.3,
iii. Density is 7850Kg/m3

For the nature vibration analysis, the model type is pipe59, the key point at well mouth is fixed, its displacement is zero and weight of bit acted on the bottom of drill string is 80~100KN. The data result that will gain from different height of drill string also will be observed. However, all of these parameters could changes during the modeling process in order to obtain more satisfy result.

The author applied mathematical method also to have more understanding regarding the studies title. Mathematical method means using a certain equation to calculate or find the value that desire. In this thesis, value that needs to be calculated is the natural frequency of the drill string. According to Timoshenko (1974), the solution to equations of motion for a vibrating bar gives the following equation for natural frequencies of axial modes,

$$f = \frac{i}{4L}\sqrt{\frac{E}{p}}, i = 1,3,5... \quad (3.1)$$

Or,

$$f = \frac{iv_a}{4L} \quad (3.2)$$

Since the speed of a compression wave in steel is 5134 m/s, the natural frequency of fundamental drill string axial mode is,

$$f = \frac{4212}{L} \text{ cycles/sec} \quad (3.3)$$

Similarly, the natural frequency of torsional mode is,

$$f = \frac{1}{4L}\sqrt{\frac{G}{p}} \qquad (3.4)$$

Or,

$$f = \frac{v_\theta}{4L} \qquad (3.5)$$

Since the speed of shear wave in steel us 3246 m/s, the natural frequency of the fundamental drill string torsional mode is,

$$f = \frac{2662}{L} \text{ cycles/sec} \qquad (3.6)$$

These equations can be used to find the value of natural frequency for each vibration mode and compare to the frequency that obtained for different parameter. The value of natural frequency can be found at the Chapter 4 later in this report.

3.3 PROJECT GANTT CHART

No.	**Detail/Week**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Mid-Semester Break**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	**Selection of Project Topic** • Discuss with the supervisor about the topics offered															
2	**Preliminary research on the drill string** • Listing down the component and function of drill string • Listing down the failure of drill string caused by vibration • Research on literature review based on the same topic															
3	**Extended Proposal Preparation**															
4	**Submission of Extended Proposal**															
5	**Proposal Defence**															
6	• **Continue research on related topic** • **Familiarizing with the software/tool that will be used (CATIA and ANSYS)**															
7	**Submission of Interim Draft Report**															
8	**Submission of Interim Report**															

Table 1: FYP 1 Project Gantt Chart

No.	Detail/Week	1	2	3	4	5	6	7	Mid-Semester Break	8	9	10	11	12	13	14
1	**Drill string system design** • Based on data gathered															
2	**Modeling the drill string behavior** • Using ANSYS software															
3	**Retrieve the result of modeling work** • Redo the modeling if necessary • Interpret the result • Discussion the result with supervisor															
4	**Preparation of Progress Report**															
5	**Submission of Progress Report**															
6	**Preparation of Pre-EDX**															
7	**Pre-EDX**															
8	**Submission of Draft Report**															
9	**Submission of Dissertation (soft bound)**															
10	**Submission of Technical Paper**															
11	**Oral Presentation**															
12	**Submission of Project Dissertation (hard bound)**															

Table 2 : FYP 2 Project Gantt Chart

3.4 SOFTWARE/TOOLS/EQUIPMENT REQUIRED

The listed below is the softwares that had been used in order to finish the thesis of analyze the stability and vibration of the drill string.

SOFTWARE	DESCRIPTION
CATIA	• Design the drill string system based on gathered data to have better understanding on drill string system.
ANSYS	• Modeling the drill string behavior and analyze its vibration.

Table 3 : Software required

CHAPTER 4
RESULT AND DISCUSSION

4.1 THE EFFECT OF ROTARY SPEED

n	1	2	3	4	5	6	7	8	9	10
rpm	30	60	90	120	150	180	210	240	270	300
***f*(Hz)**	0.515	1.024	1.514	2.008	2.535	3.010	3.500	4.033	4.567	5.019

Table 4: The frequency of drill string for axial vibration

n	1	2	3	4	5	6	7	8	9	10
rpm	30	60	90	120	150	180	210	240	270	300
***f*(Hz)**	0.263	0.432	0.601	0.770	0.939	1.108	1.277	1.446	1.615	1.784

Table 5: The frequency of drill string for torsional vibration

n= Number of set sample
f= Frequency
rpm= Revolution per minute of drill string

The Table 4 show the data of nature frequency of axial vibration of the drill string when the rotary speed of drill string is different in the straight well. The data from the straight well is important in order to understand the study of vibration of the drill string at basic fundamental. As mention by Chunjie and Tie[2009], the frequency of axial vibration at 150 rpm rotary speed is closed to its nature frequency based on equation that have been mention in methodologies part (Eq 3.3). As the rotary speed of drill string increase, the frequency of drill string for axial vibration will increase as well. Thus, this situation in any real time drilling work must be avoided by ensure that rotary speed do not exceed 150 rpm. The continuation of drilling work when it is exceed its nature frequency, the stronger axial vibration would occur which will cause many drilling accidents such as bit bouncing, fatigue of bit and drilling tool rupture.

During the drilling engineering of deep and straight well, with the depth of well is increasing, the drill string stiffness will decrease and drill string presents itself losing stability. As the drill string is on the situation of resonance, drill string will be collapsed or damaged. The result of drill string for axial vibration is important to the drilling works.

In the Table 5 shows the torsional vibration of drill string. The behavior of drill string is almost the same as axial vibration. As the rotary speed of drill string increase, the frequency of torsional vibration will increase as well. The reason of torsional vibration is that axes of drill string deviates from the axes of well hole and at the same time, the drill string keeps close to the wall of borehole. When drilling work is in progress, the table rotary should keeps away from the nature frequency of torsional vibration to avoid the resonance. If there is resonance of drill string in torsional vibration, one of the possibilities that might be occurs is sticking-slip situation [11]. Figure 8 and Figure 9 below show the relation of axial and torsional vibration with the rotary speed of the drill string.

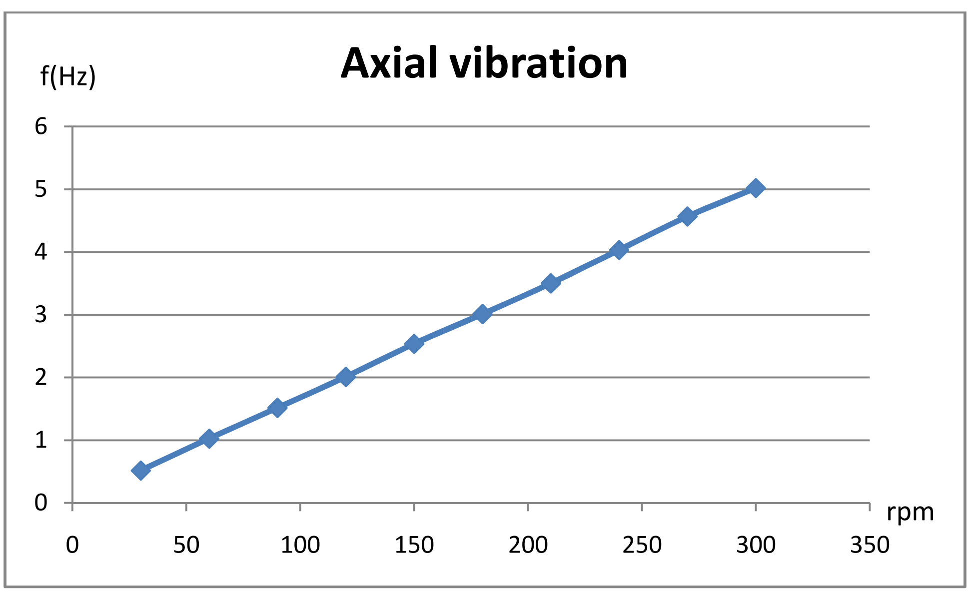


Figure 6 : The relation of axial frequency with rotary speed

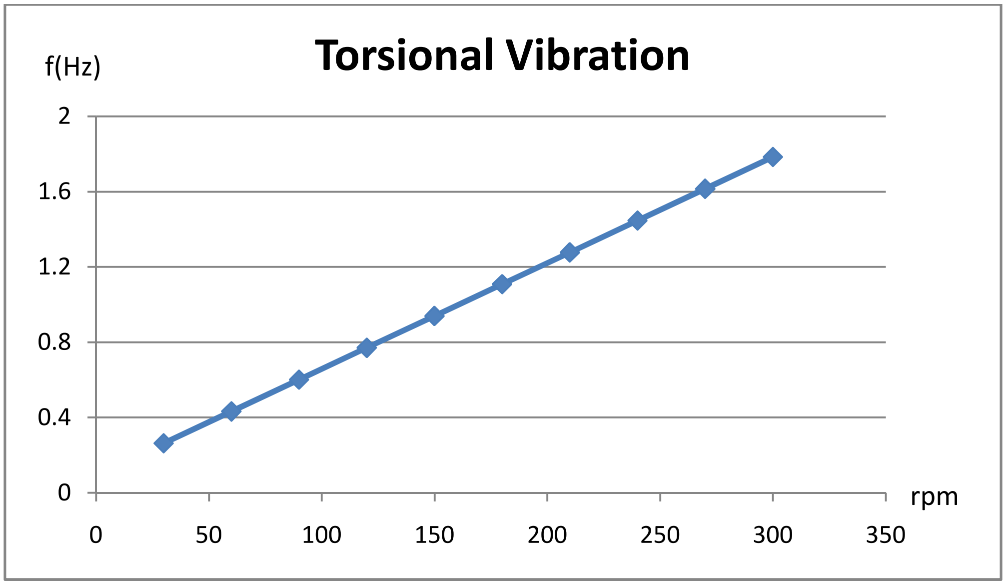


Figure 7 : The relation of torsional frequency with the rotary speed

After doing some comparison with the data in literature review, the result is valid. All the data that had been produced is close to the result data of literature review for both axial and torsional vibration modes.

4.2 THE EFFECT OF THE LENGTH OF DRILL STRING

L (m)	Frequency of drill string (Hz)					
	Rpm=30	Rpm=60	Rpm=90	Rpm=120	Rpm=150	Rpm=180
500	2.1277	6.8284	11.712	16.749	21.852	26.999
1000	1.1505	3.5153	5.9948	8.5579	11.467	13.798
1500	0.76655	2.3138	3.8931	5.5050	7.142	8.7965

Table 6: The frequency of drill string for axial vibration

The length depth of drill string in the well can affect the stability and vibration of the drill string. Table 6 shows the situation of drill string axial vibration of the six sets of the vibration of straight well part in three different depths. Here, L is the length of drill string, at different rotary speed, show the frequency of each length that drill string experienced. The results show that the length of drill string has great effect to drill string vibration. As the length of drill string increase, the frequency of drill string is decrease at the same rotary speed of drill string. However, at the same length of drill string, the frequency of drill string is increase with the increasing of rotary speed. The results are important to drilling worker, if the frequency of drill string vibration is close to its nature frequency, drill string will be in the situation of resonance, and the drill string system will fatigue quickly. The choice of type of bit also should accord to the requirement of the stratum, but different bit has different affect to dynamic behavior of drill string. For example, if the three-teeth bit is used during drilling, when rotary table speed is 77.8rpm, drill string will acute vibration with frequency 3.89Hz by using Eq 3.3, the drill string is in the strong vibration state, thus this situation must be avoided. The axial frequency of drill string varies with the length of drill string it is shown in Figure 10. The figure shows that the relation of frequency of the axial vibration with the length of drill string.

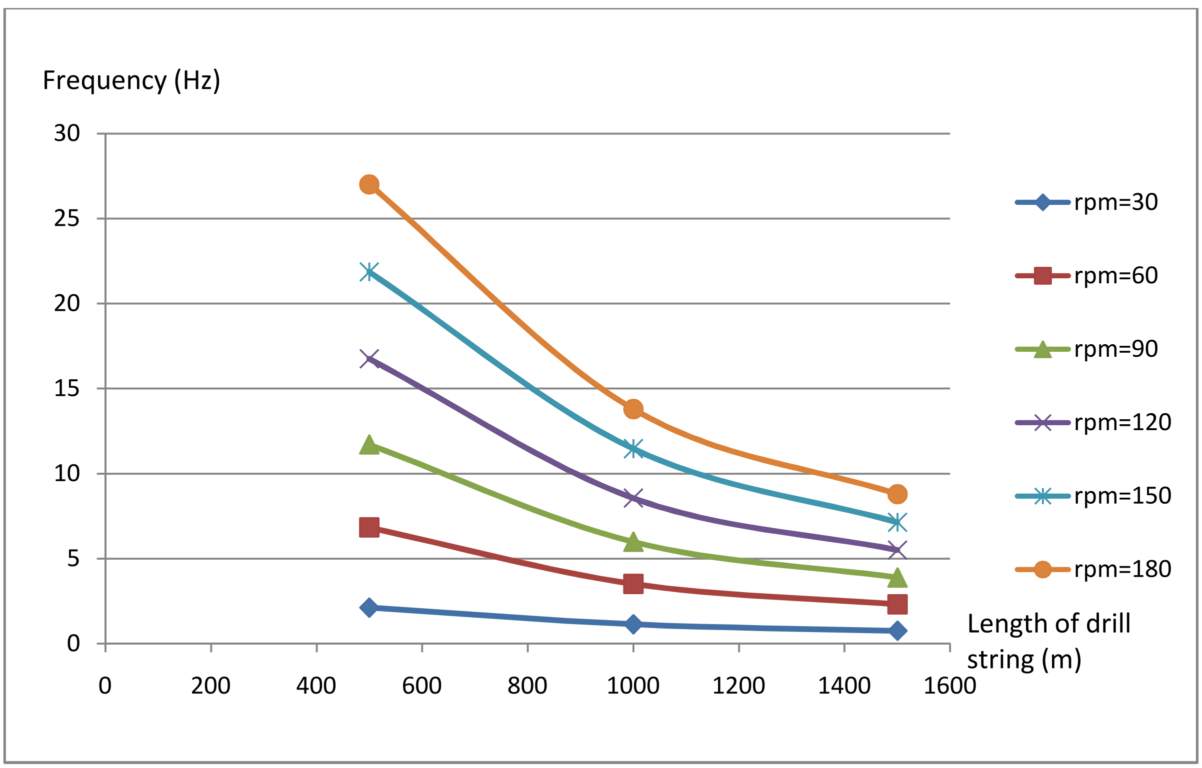


Figure 8 : The relation of axial frequency with the length of drill string

L (m)	Frequency of drill string (Hz)					
	Rpm=30	**Rpm=60**	**Rpm=90**	**Rpm=120**	**Rpm=150**	**Rpm=180**
500	1.183	3.9029	6.9029	10.167	13.407	16.676
1000	0.64967	2.0625	3.6174	5.2376	6.8836	8.5378
1500	0.44494	1.3653	2.3377	3.3459	4.3739	5.4127

Table 7: The frequency of drill string for torsional vibration

The torsional vibration frequency of drill string is showed in Table 7. The result shows that there are similarities of data pattern between torsional frequency and axial frequency. As the length of drill string increase, the frequency of drill string is decrease at the set number of n. However, at the same length of drill string, the frequency of drill string is increase with the increasing of the set number n. It can be seen as shows in Figure 11 below. Some results are close to the frequency of rotary table in practice situation, these results must be paid attention. For example, we consider the situation that the length of drill string is 1500m, if vibration that will induced by drill string is 2.33 Hz, the drill string will be in the state of resonance due to closed to its natural frequency which is 2.50 Hz (Eq 3.6). The drill string will move like a torsion pendulum, causing the drill string to fatigue or tear.

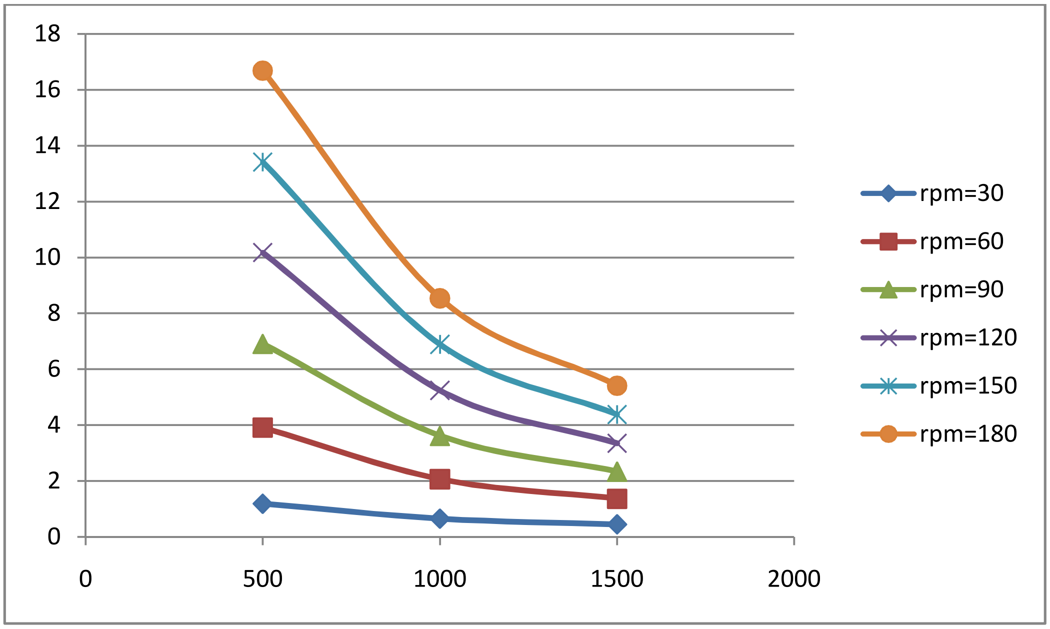


Figure 9 : The relation of torsional frequency with the length of drill string

For all the result and data that had been produced for the case study for the effect of the length of the drill string, it shows that data can be considers as a valid data. All these data are closed with the literature review that had been studied including the relation for both axial and torsional vibration modes of the drill string.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

This study meets its objective which is aiming to analyze the stability and vibration of the drill string. Improving the stability and vibration drill string is essential as it will significantly increase the performance and duration of the drill string. At the same time, it also will reduce the components failures of the drill string which always occur when an extensive vibration is subjected to the drill string. Thus, minimized the vibration of the drill string will always be the main priority in every drilling work.

Based on analysis of data gathering and all the result that had been obtained, it can be concluded that stability and vibration of the drill string depend on the self-excitation of the drill string itself. The value of the frequency of the drill string experienced is so important in this study. The drill string will started to fatigue or break when the frequency of the drill string having is close to its natural frequency. The reason for this is when the frequency of drill string vibration is near to its natural frequency, the drill string will be in resonance situation. The resonance would result to self-excited high magnitude vibration. That is when failure of drill string started to occur.

In this thesis, two types of vibration modes in two cases had been studied. These two vibration modes are axial and torsional modes. First case is on how the rotary speed can affect the vibration of the drill string. Based on the analysis, both modes of drill string will experience increase of frequency when the rotary speed is increasing as well. Thus, it will lead to the frequency of the drill string to close with its natural frequency which at the end, the drill string is in resonance situation. In the second case, the study is about on how the length of drill string affecting the frequency of the drill strings itself. The result and analysis show it is similar with the first case. As the length of the drill string increase, the frequency of the drill string experienced is increase as well. However, as the frequency of the drill string increase, it means the drill string will closed to its natural frequency. When the drill string reached its natural frequency, the drill string will be in resonance and the failure of the drill string will start to occur.

As for recommendation based on the finding that had been made, the technique of vibration control should be utilized fully. The vibration control technique can be used either to increase or to decrease the vibration force in drill string. The three basic techniques for reducing the magnitude of drill string vibration are changing the force frequency to the drill string, increase or apply the damping to the drill string and eliminate source of excitation to the drill string. All of these techniques aim to reduce frequency that the drill string will experienced so it will prevent the drill string from exceed beyond its natural frequency. The frequency of drill string needs to monitor closely during the drilling work to prevent the drill string from resonance as the resonance will result to self-excited high magnitude of vibration to the drill string, which lead to drill string failure.

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