VIBRATION CONTROL OF A COUPLED CYLINDER UNDER ROTATIONAL MOTION

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JUNE 2015

SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Plant & Maintenance)"

Signature: ....

Supervisor: Dr. Roszaidi Ramlan

Date: ....

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This Report Is Submitted In Partial Fulfilment of Requirement For Degree of Bachelor of Mechanical Enginering (Plant & Maintenance)

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been dully acknowledge"

Signature: ....

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Date: ....

I dedicate my final year project to my family and my supervisor Dr. Roszaidi Ramlan. A special feeling of gratitude to my loving parents, Tainsing Somundoh and Lotimah Sogiloi whose encouragement and supported me throughout my degree. I will always appreciate all they have done.

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ABSTRACT

In oil drilling process, one the most destructive element is vibration. The phenomenon of vibration causes a lot of problem including drilling efficiency and even safety of the operators. Vibration suppression in drilling has been an ongoing study since years ago up until this century. Accurate prediction and controlling of the vibration problem is essential to achieve a more efficient and safer drilling operation. This research will focus on suppressing the vibration problem by studying the vibration characteristic of different physical parameters of the coupled cylinder and how to control them. Theoretical and experimental study was conducted to study this vibration problem. Theoretical study involves the analysis about the equation of motion of the coupled cylinder. The experimental study includes the investigation of effect of different parameters in a coupled cylinder which include load, rotational speed, cylinder's length, eccentricity, misalignment and different type of coupling. In this research, the line of drill pipes is characterized as coupled cylinder, the linkage as coupling, the rotary table as motor, and the drilling mud as load. The findings of this study lead to the understanding of the vibration characteristic of a coupled cylinder and hence the identifying the effective control method.

ABSTRAK

Dalam proses penggerudian minyak, salah satu elemen yang paling merosakkan adalah getaran. Fenomena getaran menyebabkan banyak masalah termasuk kecekapan penggerudian dan juga keselamatan pengendali. Penindasan getaran dalam penggerudian merupakan satu kajian yang sedang berlangsung sejak bertahun lalu sehingga abad ini. Ramalan yang tepat dan kawalanl masalah getaran adalah penting untuk mencapai operasi penggerudian yang lebih cekap dan lebih selamat. Kajian ini akan memberi tumpuan kepada mengurangkan masalah getaran dengan mengkaji ciri-ciri getaran pada parameter fizikal yang berbeza bagi silinder yang disambungkan dan bagaimana untuk mengawalnya. Kajian teori dan eksperimen telah dijalankan untuk mengkaji masalah getaran ini. Kajian teori melibatkan analisis tentang persamaan gerakan silinder yang disambung. Kajian eksperimen termasuk penyiasatan kesan parameter yang berbeza di dalam silinder yang disambung termasuk beban, kelajuan putaran, panjang silinder, kesipian, salah jajaran dan jenis penyambung yang berbeza. Dalam kajian ini, talian paip gerudi mempunyai ciri-ciri sebagai silinder yang disambumgkan pula, hubungan sebagai penyambung, meja berputar sebagai motor, dan lumpur penggerudian sebagai beban. Hasil kajian ini membawa kepada pemahaman ciri getaran silinder yang disambungkan dan seterusnya mengenal pasti kaedah kawalan yang berkesan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

f	=	Frequency
T	=	Period
t	=	Time
x	=	Displacement along x-axis
y	=	Displacement along y-axis
A	=	Amplitude
φ	=	Phase
ω	=	Angular frequency
e	=	Exponential
j	=	Imaginary
J_r	=	Inertial mass of rotary
J_b	=	Inertial mass of bit
J_1	=	Inertial mass of pipe 1
J_2	=	Inertial mass of pipe 2
d	=	Radius
$\mathbf{T}$	=	Transmissibility
T_m	=	Torque on motor
T_b	=	Torque on bit
T_r	=	Torque on rotary
θ	=	Angular displacement
$\dot{\theta}$	=	Angular velocity
$\ddot{\theta}$	=	Angular acceleration
m	=	Mass
c	=	Damping
k	=	Stiffness
ξ	=	Damping ratio
ω_n	=	Natural angular frequency

r	=	Ratio of angular frequency to natural angular frequency
F_f	=	Fluid force
F_b	=	Force on bit
F_x	=	Force on x direction
F_y	=	Force on y direction
F_N	=	Normal force
F_T	=	Tangential force
L	=	Length from inboard to outboard

LIST OF ABBREVIATIONS

RMS	-	Root mean square
BHA	-	Bottom hole assembly
ROP	-	Rate of penetration
PDC	-	Polycrystalline diamond compact

CHAPTER I

INTRODUCTION

This research is about the study of vibration control of a coupled cylinder under rotational motion as faced in oil drilling process. Oil drilling process is prone to many types of vibration problem. This research will lead to the understanding of the vibration problem and how to control them.

1.1 Problem Statement

The line of drill pipes in oil drilling process is subjected to three modes of vibration which are axial, radial and torsional. The real situation in oil drilling process was imitated in laboratory, where the rotary table, drill pipe, connection and drilling mud is characterised as the motor, cylinder or shaft, coupling and load respectively.

Axial vibrations, is a motion along the lengthwise axis of the cylinder. In drilling process, this is mostly due to the interaction between drilling bit and the hole bottom. This vibration is called ‘‘bitbounce’’. Axial vibration was introduced by introducing angular misalignment as this type of misalignment tends to create a strong vibration in axial direction.

Lateral vibrations, often caused by pipe eccentricity, leading to centripetal forces during rotation, named as drillstring whirl. This problem was imitated in the laboratory by introducing eccentric mass at the rotating coupled cylinder. Eccentric mass will generate centrifugal force which is in radial or lateral direction.

Torsional or rotational vibrations caused by nonlinear load magnitude. The rotational vibration of the cylinder characterized by alternating stops during which the pipe sticks and intervals of large angular velocity of the pipe. However, due to equipment availability restriction in the laboratory, only analytical analysis was conducted for this type of vibration.

Different physical parameters of the oil drilling equipment were also studied. That includes the effect of different parameters in a coupled cylinder which include load, rotational speed, cylinder's length, and different type of coupling.

1.2 Scope

The problem imitates the real problem during oil drilling process. Involve theoretical mechanical modelling of the dynamics of the coupled cylinders. A test will be fabricated and tested. The study will lead to understanding of what governs the good vibration control properties of the coupled structure. The study will also gain knowledge on how to control the vibration.

1.3 Objective

1. To study the vibration characteristics of a coupled cylinder.
2. To study the effect of coupling mechanism and how to control the vibration at the coupling.
3. To fabricate a test rig to investigate the vibration characteristic of coupled cylinder and performance of coupling.

CHAPTER II

LITERATURE REVIEW

In this chapter, all of information related to vibration analysis and control that used for the study of vibration characteristic of coupled cylinder under rotational motion was elaborated. Literature review is important process to get all information related to this research.

2.1 Fundamental of Vibration

According to Putra (2013a), Vibration is the motion of a particle or a body from a position of equilibrium. Vibration occurs when a system is moved from equilibrium position. The system will return to equilibrium position under the action of restoring forces such as the elastic forces, as for a mass attached to a spring, or gravitational forces, as for a simple pendulum. The system keeps moving back and forth across the equilibrium position.

Most vibrations are undesirable in machines and structures because they produce increased stresses, energy losses, causes added wear, increase bearing loads, induce fatigue, create passenger discomfort in vehicles, and absorb energy from the system. Vibration causes noise which creates discomfort and annoyance to human. In some field, vibration is found to be beneficial such as in tooth cleaning, massage chair, music instrument and energy harvesting.

Vibration is due to imperfection in machine or structure. The possible factors are imperfection in design process. Defect in manufacturing, installation or assembly cause the machine or structure to vibrate. Improper operation and maintenance also cause vibration problem. Rotating machines need proper balancing in order to prevent damage from vibrations.

2.2 Classification, Terminologies and Quantification of Vibration

Vibrations can be classified into three categories which are free, forced, and self-excited. Free vibration occurs with the absence of external force in the system. An external force that acts on the system causes forced vibrations. In this case, the exciting force continuously supplies energy to the system. Self-excited vibrations are periodic and deterministic oscillations. In contrast to forced vibrations, the exciting force is independent of the vibrations and can still persist even when the system is prevented from vibrating.

Below are some basic terminologies in vibration (Putra 2013b):

- Mass - store of kinetic energy
- Stiffness - store of potential (strain) energy
- Damping - dissipate energy
- Force - provide energy
- Amplitude - level of vibration from the equilibrium position (displacement, velocity, acceleration)
- Frequency - Frequency is the number of cycles repeated per second. The unit is Hertz (Hz)
- Phase - Angle difference between a measured point and a reference point

Quantification of vibration:

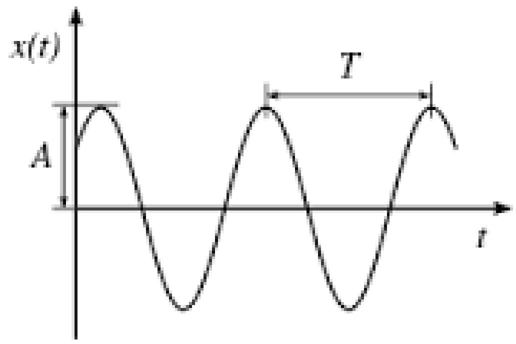

Figure 2.01: Amplitude and Period of Sinusoidal Wave (Putra 2013c)