FLUID STRUCTURAL INTERFACE ANALYSIS OF GAS FLOW IN OIL AND GAS TRANSMISSION PIPE

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A report submitted in partial fulfillment of the requirements
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I certify that the project entitled "Fluid Structural Interface Analysis of Gas Flow in Oil and Gas Transmission Pipe" is written by Yap Huey Tyng. I have examined the final copy of this report and in my opinion, it is fully adequate in terms of language standard, and report formatting requirement for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project report and in my opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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Dedicated to my parents and my family

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ABSTRACT

A solution interface of fluid structural problems which are the coupling Computational Fluid Dynamics (CFD) analysis has become more tractable through the accessibility of High Performance Computing. Mainly, with the demand of reducing the vibration problem which contributed from the coupling interaction between the fluid flow and the structure, the Fluid Structural Interface (FSI) analysis is performed to find out the stress and strain of the structure. A pipeline test rig is built in lab scale for accuracy correlation purpose by studying the dynamics characteristic and response of the structure. The pipeline is measured and analyzed in order to observe its dynamics characteristic through modal analysis. The result from ANSYS Modal Analysis is then correlated with the result from measurement analysis. It has been found that the accuracy of the results can be up more than 90%. The computational model that passed the accuracy comparison is then been analyzed to obtain the stress and strain of the structure through ANSYS Transient Structural and CFX coupling analysis. The results indicate that the pipeline test rig is having a maximum stress of 20.9kPa and maximum strain of $5x10^{6}$. Results from ANSYS Modal Analysis show that the reliability of the computational model and ANSYS FSI analysis can determine the stress and strain which are occurring on the pipeline system.

ABSTRAK

Penyelesaian kepada masalah struktur antara muka bendalir merupakan gandingan analisis komputasi dinamik bendalir (CFD), telah menjadi lebih senang dilakukan melalui kebolehcapaian komputer berprestasi tinggi. Permintaan mengurangkan masalah getaran yang terutama terhasil daripada interaksi gandingan antara aliran bendalir dan struktur, Analisis Interaksi Antara Cecair dan Struktur (FSI) dikaji untuk mengetahui ketegangan dan tekanan daripada struktur. Ujian paip sistem yang dihasilkan dalam makmal bertujuan untuk korelasi ketepatan dengan mengkaji ciri-ciri dinamik dan tindak balas pada struktur. Pengukuran dan analisis pada pipeline diperhatikan untuk mengetahui ciri-ciri dinamik melalui analisis mod. Hasil daripada analisis mod ANSYS mempunyai kaitan dengan keputusan analisis pengukuran. Didapati bahawa ketepatan keputusan boleh dinaikan lebih daripada 90%. Model pengiraan komputer yang melepasi perbandingan ketepatan kemudiannya akan dianalisis untuk mendapatkan tekanan dan ketegangan struktur melalui Struktur *Transient* ANSYS dan gandingan analisis CFX. Keputusan menunjukkan bahawa rig ujian paip mempunyai tekanan maksimum 20.9kPa, ketegangan yang maksimum daripada 5×10^6. Keputusan menunjukkan bahawa daripada analisis mod ANSYS boleh menentukan kebolehpercayaan model pengiraan dan analisis ANSYS FSI dalam menentukan tekanan dan ketegangan yang berlaku pada sistem paip.

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ω	Natural frequency
ε	Total strain, Bandwidth parameter
σ	True stress, local stress
A	Cross-sectional area
B	Weight correction factor
E	Young's Modulus
D	Outside Diameter of Pipe
I	Moment of intertia
k	Radius of gyration
l	Length
P	Concentrated weight
W	Weight

LIST OF ABBREVIATIONS

ASME	American Society of Mechanical Engineering
CAD	Computer Aided Design
CFD	Computational Fluid Dynamics
DAQ	Data Acquisition
EIA	Energy Information Administration
FEA	Finite Element Analysis
FSI	Fluid-Structure Interaction (FSI)
HSE	Health and Safety Executive
ODS	Operating Deflection Shape
PVC	Polyvinyl Chloride

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Oil and gas provide about 60 % of the world's primary fuel. According to U.S Energy Information Administration (EIA), there are about 3229.25 billion cubic meters of natural gas consumption and 87,084.3 thousand barrels per day of oil supply in year 2011 and the demand is increasing every year.

Oil and gas refinery process plant is a continuous process where the product is made by passing materials through different pieces of specialized equipment; each a piece of equipment ideally operates in a single steady state and performs one dedicated processing function. The output product of this process appears in a continuous flow. To transfer the oil and gas, pipeline is the most common equipment to be used.

Oil and gas transmission pipe usually operate at high pressures to allow high transportation rates. They are designed, built and operated to well-established standards and laws because they products carried can pose a significant hazard to the surrounding population and environment.

However, as other structure, they are records shown that the pipelines fail and one of the main reasons is due to vibration. Piping vibration can be an annoying problem which can consume unnecessary maintenance activity and can affect pumping system performance as well as endurance. A data published by Health & Safety Executive (HSE), United Kingdom shows that the offshore in the United Kingdom Sector of the North Sea, fatigue or vibration failures account for 21 % of all hydrocarbon releases. Although overall statistics are not available for onshore oil and gas plant facilities, available data for individual plants indicates that in Western Europe, between 10 % and 15 % pipe work failures are caused by vibration. To clearly identify the problem due to vibration, a study is going to be done to investigate dynamics characteristics and response of the pipeline by using Fluid-Structure Interaction (FSI) software.

Fluid-Structure Interaction (FSI) is where fluid flow exerts pressure on a solid structure causing it to deform in the structure and it perturbs the initial fluid flow. Fluid-structure interactions can be stable or oscillatory. In oscillatory interactions, the strain induced in the solid structure causes it to move such that the source of strain is reduced and the structure returns to its former state only for the process to repeat.

Typically, a fluid-transient code is used to determine pressures and flow velocities which are used as input to a structural dynamics code. This called uncoupled or one way approach but it has severe limitation because it neglects crucial interactions between the liquid and the pipe. Therefore, this project is going to utilize coupled Fluid-Structure Interaction (FSI) to study the interaction between the dynamic response of the structure and the gas flow in the pipe. The FSI software is going to be used in this project is ANSYS. ANSYS can perform two-way FSI simulations through the coupling system. The coupling system can perform the simulation for both the effect of the fluid flow to the pipelines and the pipeline deformation to the fluid flow.

1.2 PROBLEM STATEMENT

As the vibration is always the main concern to the oil and gas industry especially to the transmission pipe to transfer the products due to its potential to cause failure to the structure. Is there a way to detect the pattern of the vibration to detect the potential of failure of structure due to vibration?

Most of the analysis is doing only one way which is either to the transmission pipe or the fluid flow. However, there is interaction between the structure and the fluid and they influence each other as they are in contact. How is the interaction between the structure and the fluid flow?

1.3 PROJECT OBJECTIVES

- To study the coupled fluid-structure interfacing of Oil and Gas transmission pipeline using FSI
- To correlate the simulation result with the experimental measurement result

1.4 SCOPE OF PROJECT

- To design and build a lab scale transmission pipeline
- To perform simulation with Fluid-Structure Interaction (FSI) software
- To compare the simulation result with the measurement of the real structure result
- To investigate the dynamic characteristics and response of the transmission pipe

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