THERMODYNAMIC CYCLE ANALYSIS OF PULSE DETONATION ENGINE (PDE) BY BIOGAS

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Dedicated to

My family, my colleagues

&

Special dedication to

My beloved husband and parents

Who did not live to share the happiness in my achievements

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ABSTRACT

As the moving forward step parallel with the growing of modern technology, Pulse Detonation Engine is applying the high performance propulsion engine and power plant. PDE has the high theoretical thermodynamic efficiency which is nearly to the constant volume of combustion and also simplest in term of mechanical system used. By existing of the thermodynamic cycle analysis, there are some cycles are adopted from it, such as the Humphrey, ZND and Brayton. The mixture between hydrogen and methane with air are the main ingredient to make this PDE fully satisfies and the characteristic of detonation is calculate by using the CEA software and this model can be developing through Matlab. The thermal efficiency and frequency relationship is study between these mixtures.

ABSTRAK

Pulse Letupan Bahan Enjin sebagai pemangkin utama untuk merealisasikan matlamat ini. Ini adalah kerana sifat PDE yang mempunyai kecekapan termodinamik yang tinggi dimana nilai kecekapannya adalah hampir kepada nilai isipadu pembakaran yang sekata dan PDE juga menggunakan sistem mekanikal yang ringkas untuk berfungsi. Dengan kewujudan kitaran analisis termodinamik yang ideal, maka terdapat beberapa kitaran ynag diubah suai dan diterima pakai antaranya adalah kitaran Humphrey, ZND dan Brayton. Hidrogen dan metana adalah merupakan ramuan utama dalam memastikan PDE ini dapat dijalankan dan sifat letupan dikira menggunakan perisian CEA dan diguna pakai melalui Matlab. Kecekapan terma dan frekunsi diantara campuran ini dikaji dalam kajian ini.

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LIST OF SYMBOLS

C_p	-	Specific heat capacity at constant pressure
C_v	-	Specific heat at constant volume
h_0	-	Initial enthalphy
hi	-	Final enthalphy
P_1	-	Initial pressure
P_2	-	Final pressure
T_1	-	Initial temperature
T_2	-	Final temperature
U_1	-	Initial velocity
U_2	-	Final velocity
R	-	Gas constant
Q	-	Heat supply
ρ_1	-	Initial density
ρ_2	-	Final density
η	-	Efficiency

LIST OF ABBREVIATIONS

CEA	-	Chemical Equilibrium Applications
CJ	-	Chapman-Jouguet
DDT	-	Deflagration Detonation Transition
LHV	-	Low Heating Value
PDE	-	Pulse Detonation Engine
ZND	-	Zeldovich-von Nuemann –Doring

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Pulse detonation engine (PDE) is a new concept of propulsion system that is different with the other propulsion system normally based on deflagration combustion process. PDE is using detonation mode as it main combustion process.

The setup of PDE system consists of a series of inlet valves, a detonation tube, and an exit nozzle. This PDE setup actually is an unsteady device that uses a repetitive cycle to generate thrust. By referring to previous old system which is consist of lack accurate control systems with low response time and not comprehending the physic of flow, this influence the researches to stopped it by decade. PDE system have many advantages compared to conventional air breathing propulsion systems such as high thermal efficiency, high specific impulse, mechanical simplicity, low weight and low cost.

A cycle analysis is perform to show that the efficiency of a detonation cycle and the details of PDE will be discuss more in this thesis.

1.2 Research Objectives

The objective of the study is:

i. To focus on calculate the detonation speed of biogas such as hydrogen and methane by using CEA software and write the Matlab code which identify the ideal thermodynamic cycle for PDE system
ii. To identify the PDE frequency effect on thermodynamic efficiency.
iii. To compare the cycle analysis of detonation and deflagration.

Based on these advantages characteristic that can translate into propulsion systems possessing high performance, low development and life cycle costs, and new advanced mission capabilities, PDE becomes the good ways to move on. Realization of the potential of PDE technology, however, is hinder by the absence of fundamental understanding of detonation phenomena as well as some key specific system related issues. Therefore, this effort to mature PDE technology broadly addressed a number of research issues that crossed disciplinary boundaries in an integrated program.

1.3 Problem Statement

The PDE has the higher result of the thermodynamic efficiency of PDE system. The PDE has the speed range of Mach 0 -5 in specific thrust and fuel consumption over the conventional jet engines under the ideal situations. PDE also be test by using different kind of substance such as fuels, gases and liquids. By focusing the Biogas as the main input of PDE experiment in this study, the detonation speed can be calculate. The example of Biogas that will use is hydrogen and methane.

In represented revolution of technology, PDE consist of many advantages in cycle efficiency, hardware simplicity, operations and reliability. Based on these advantages characteristic that can translate into propulsion systems possessing high performance, low development and life cycle costs, and new advanced mission capabilities, PDE becomes the good ways to move on. Realization of the potential of PDE technology, however, is hinder by the absence of fundamental understanding of detonation phenomena as well as some key specific system related issues. Therefore, this effort to mature PDE technology broadly addressed a number of research issues that crossed disciplinary boundaries in an integrated program.

1.4 Scope of the Project

This research deals mainly with PDE in details. There are several Biogas use as a fuel such as hydrogen and methane. From this Biogas, the detonation speed can be calculate by using the CEA software. The concept of ideal thermodynamic cycle is the focus to analyse this PDE system. The complete thermodynamic equilibrium is used. In this paper the study, only cover the Humphrey, ZND and Brayton cycle in order to analyse the thermodynamic system. There is also the stoichiometric mixture use and assumption the cycle is ideal.

1.5 Thesis Outline

Chapter 1: Introduction

This chapter describes the research background of this thesis. The objective of this thesis also been started in this chapter.

Chapter 2: Literature Review

In this chapter, the item discussed is the related works and literature review that will supported this study.

Chapter 3: Methodology

The most significant chapter that is chapter 3 detailing on the research methodology variables and equations involved in the modelling and simulation part.

Data collection method and the accuracy of the result are been listed in that chapter.

Chapter 4: Result and Discussion

For this chapter, results from simulation done is list out and discussion is carry out for the result obtained**.**

Chapter 5: Conclusion and Recommendation

In this last chapter, the conclusion of the study and recommendations on future improvements for different gasifiying agents needed in this study.

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