THERMAL ANALYSIS OF VEHICLE ENGINE

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A report submitted in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering with Automotive Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2008

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive

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STUDENT'S DECLARATION

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

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TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF SYMBOLS

q	Heat transfer rate
k	Thermal conductivity
A	Surface area
ΔT	Temperature gradient
Δx	Distance
Ts	Surface temperature
$T\infty$	Ambient temperature
Lf	Load factor
Sf	Scale factor
T_{Ref}	Time dependence reference temperature
Cp	Specific heat
ρ	Density
dT/dt	Temperature change versus time

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ABSTRACT

This thesis deals with thermal analysis in internal combustion engine. The objective of this thesis is to develop finite element model of combustion chamber for thermal analysis, to obtain the temperature distribution in combustion chamber and its surrounding component, and to determine localized temperature region in the engine. Finite element method (FEM) was employed to develop computational model to analyze the temperature distribution in the engine components and to identify the critical temperature in the components. Computational domain consists of combustion chamber as major part and its surrounding components such as valves, and exhaust port and water jacket. Two types of combustion process were modelled: Spark ignition engine and compression ignition engine. 2-dimensional (2D) simplified models was developed using general-purpose FE code, ALGOR. The element type was 2D element. Material properties were taken from ALGOR library. Heat convection due to the presence of water was defined by convection coefficient. Thermal load due to combustion was defined to all nodes of combustion chamber. The finite element models were analyzed using the thermal transient heat transfer analysis. The finite element model was validated by comparing the maximum temperature at the piston surface with the published result. The results were found to be agreeable. The computed results indicate that the exhaust part may reach the highest maximum temperature in the engine after combustion occurred. In SI engine, the critical component in thermal effect is the cylinder head and for the CI engine is at the piston bowl. Furthermore, the material used to construct the engine part strongly influences the temperature distribution in the engine. Therefore, the performance of the engine at very high temperature can be improved by changing material and design of component. From the analysis, the capability of diesel engine to resist thermal contact is higher compare to gasoline engine because of using higher thermal resistance material with suitable shape and geometry design.

ABSTRAK

Tesis ini membincangkan tentang analisis terma dalam enjin pembakaran dalam. Objektif tesis ini adalah untuk membangunkan model elemen terhad kebuk pembakaran untuk analisis terma, untuk mendapatkan agihan suhu dalam kebuk pembakaran dan komponennya yang sekeliling, dan untuk menentukan tempatkan rantau suhu dalam enjin. Kaedah unsur terhingga (FEM) telah diapplikasikan untuk melaksanakan model berkompiter untuk menganalisis agihan suhu dalam komponen enjin dan mengenalpasti suhu genting dalam komponen-komponen. Model kebuk pembakaran maya terdiri daripada satu bahagian utama iaitu kebuk pembakaran dan komponen-komponennya yang sekeliling seperti injap, pangkalan ekzos dan jaket air. 2 dimensi model kebuk pembakaran telah dimodelkan iaitu : Enjin cucuhan bunga api dan enjin cucuhan mampatan. 2 dimensi (2D) model-model yang dipermudah adalah dibangunkan menggunakan kod FE, ALGOR. Jenis unsur adalah unsur 2D. Ciri-ciri bahan telah dilakukan daripada perpustakaan ALGOR. Perolakan haba disebabkan oleh kehadiran air adalah ditakrifkan oleh pekali perolakan. Muatan terma disebabkan oleh pembakaran adalah ditakrifkan kepada semua nodus kebuk pembakaran. Model-model elemen terhad dianalisis menggunakan pemindahan haba sementara yang terma. Model elemen terhad disahkan dengan membandingkan suhu maksimum di permukaan omboh dengan hasil kajian lepas. Data-data yang diperolehi telah didapati berketepatan dengan rujukan. Keputusan kajian menunjukkan bahagian ekzos boleh mencapai suhu maksimum tertinggi dalam pembakaran sehabis enjin berlaku. Dalam enjin SI, componen paling kritikal dalam kesan haba adalah pada kepala silinder dan untuk enjin CI adalah di mangkuk omboh. Tambahan pula, bahan yang digunakan untuk membina bahagian enjin Sangay mempengaruhi agihan suhu dalam enjin. Oleh itu, prestasi enjin di suhu tinggi sebenar boleh diperbaiki oleh perubahan bahan dan reka bentuk komponen. Daripada analisis, keupayaan enjin diesel untuk menentang kesan terma adalah lebih tinggi berbandingan enjin gasolin disebabkan penggunaan bahan rintangan haba yang lebih tinggi dengan rekaan bentuk dan geometri yang sesuai.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Vehicle or automobile engines are major part that contributes to mean of transportation. Researcher in automotive field have emphasized on improvement of engine design since long fuel economy and environmental impact from transportation become a global concern. Research focus, to name a few, include bio-fuel cell, spark-free operating, hybrid – engine, and electric engine. Methodology in these researches depends on large amount of experiments. Recently, few researchers took their attention to applying numerical tools like finite element method to improve engine design as experimental works are costly and time consuming. [1]

Among the numerical tools, finite element method has been widely used to develop computational models in a variety of field due to being benchmark and its advantages. Some of the advantages are: variety of material model and complex boundary condition can be modeled. Major finite element codes to date are ABAQUS, ANSYS and ALGOR. [2]

1.2 Problem Statement

Vehicle engines are still now considered not-well-improved from the view point of fuel economy and environmental impact. One reason of high fuel consumption and pollution is that quarter of energy is wasted as heat. It is beneficial if possible to reuse this heat lost to gain more power and also to reduce amount of fuel consumption. In order to solve this case, knowledge of temperature distribution in the engine is important to be known.

1.2 Objective

a) To develop finite element model of internal combustion engine for thermal analysis
b) To obtain the temperature distribution in internal combustion engine and its neighborhood
c) To determine localized temperature region in the engine

1.3 Scope of study

Finite element code	-	ALGOR
Analysis	-	Thermal transient heat transfer analysis
Engine	-	Petrol spark-ignition engine and Diesel engine
	-	Design will focus combustion chamber and its surrounding component
Model validation	-	Temperature distribution will be compare with published result

1.4 Thesis Organization

This thesis consists of five chapters including chapter 1. Chapter 1 introduces the project background, objective, scope for this research. Chapter 2 is basically about literature review and previous study related to this research. The methodology and result discussion has been explained in chapter 3 and 4 respectively. Finally, chapter 5 is conclusion and recommendation part for this study.

References

[1] NASA technical briefs, 2004

[2] Finite element analysis of element problems using different displacement, Wilson E.A. (1970)

[3] Process of Heat Transfer, Principle and Application, Serth R.W (2007)

[4] Internal Combustion Engine Fundamentals, John B Heywood (1988)

[5] Effect of copper and silicon content on mechanical properties in Al–Cu–Si–Mg alloys, Muzaffer Zeren (2003)

[6] ALGOR V16 Library, (2004)

[7] An Analysis of the Finite Element Method, Gilbert S., George Fix (1973)

[8] Early Finite Element Research at Berkeley, Edward L. Wilson (2007)

[9] Controlled Temperature Combustion Engine, Charles L Gray, (2002)

[10] Properties and Selection: Irons, Steels and High Performance Alloy, ASM Handbook, vol. 1, ASM International, 1990.

[11] Piston thermal deformation and friction considerations, SAE Paper 820086, Li C.H. (1982)

[12] Thermal analysis of an SI engine piston using different combustion boundary condition treatments, V Esfahanian (2005)

[13] Finite element simulation of a twin-cam 16-valve cylinder structure, Finite Element Analysis. Chyuan S.W. (2000)

[14] Design and analysis of gasket sealing of cylinder head under engine operation conditions, Chang Chun Lee (2004)

[15] Modeling of heat conduction within chamber walls for multidimensional internal combustion engine simulation, Int. J. Heat Mass Transfer 41 ,859–869, Yong L., Reitz R.D. (1998).