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 (Automotive)(Honours)"

Signature : .....
Supervisor : DR. MUSTHAFAH BIN MOHD TAHIR
Date : JUNE 2015

ENGINE PERFORMANCE ANALYSIS USING GT-POWER SOFTWARE

KHAIRIL AMRI BIN MUHAMAD TAJUDDIN

This report is submitted in accordance with requirement for the Bachelor of Mechanical Engineering (Automotive)(Hons.)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

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DECLARATION

"I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledged."

Signature : KHAIRIL AMRI .....

Author : KHAIRIL AMRI BIN MUHAMAD TAJUDDIN

Date : JUNE 2015

DEDICATION

This thesis is dedicated to

my beloved father and mother

APPRECIATION

Firstly, I am grateful to Allah s.w.t, the most gracious and most merciful for His blessing, grace and guidance in order for me to complete this 'Projek Sarjana Muda'.

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ABSTRAK

Perisian konvensional GT-Power digunakan untuk mensimulasikan enjin petrol silinder tunggal. Enjin petrol diasimilasikan oleh perisian untuk mengkaji prestasi enjin apabila enjin tersebut beroperasi dengan Gas Asli Mampat (CNG) sebagai bahan api alternatif dan kesan prestasinya terhadap enjin petrol yang menggunakan simulasi komputer GT-Power. Gas Asli Mampat (CNG) telah lama digunakan dalam industri dan juga untuk automotif tugas ringan. Pengeluar enjin dan kenderaan semakin melibatkan diri dalam pembangunan peralatan enjin asal, terutamanya untuk aplikasi penggantian petrol, walaupun masih ramai yang menganggap bahawa permintaan terhad dan tersebar untuk mewajarkan pengeluaran berskala besar. Model enjin petrol empat lejang telah dibangunkan menggunakan model perisian GT-Power dengan pengukuran untuk semua komponennya. Keputusan hasil dari simulasi dibandingkan dengan data dari hasil eksperimen daripada enjin petrol Robin EY20-D yang beroperasi menggunakan bahan api dari petrol dan juga CNG. Dimensi enjin sebenar seperti 'bore', 'stroke', diameter paip pengambilan dan diameter ekzos diukur. Antara data seperti nisbah mampatan, penghubung rod panjang dan nilai penyuntik bahan api adalah berdasarkan kepada risalah data enjin. Dimensi dan parameter enjin dimasukkan ke dalam 'pop up table'. Simulasi pada keadaan beban penuh telah dijalankan bagi enjin yang beroperasi menggunakan petrol dan juga bahan api CNG. Pengiraan telah dijalankan ke atas model yang menggunakan bahan api mono CNG dan juga bahan api mono petrol untuk mengetahui prestasi enjin dengan bahan api yang berbeza. Keputusan simulasi dibandingkan dengan data untuk bahan bakar petrol dan juga bahan bakar CNG. Eksperimen telah menggunakan brek air pam hidraulik yang bertindak sebagai dinamometer. Simulasi dan eksperimen telah dijalankan untuk menyiasat parameter prestasi enjin seperti tekanan silinder, tork, kuasa, kecekapan isi padu dan Brek Penggunaan Bahan

Api Khusus (BSFC). Keputusan menunjukkan bahawa petrol mempunyai kuasa yang lebih, tork dan Brek Penggunaan Bahan Api Khusus (BSFC) daripada CNG tetapi kecekapan isi padu bagi CNG adalah tidak sebanyak petrol.

ABSTRACT

The conventional software of GT-Power is used to simulate a single cylinder gasoline engine. The gasoline engine is simulated to study the engine performance when the engine is operating with Compressed Natural Gas (CNG) as alternative fuel and its performance effect on the gasoline engine using GT-Power computational simulation. The Compressed Natural Gas (CNG) has long been used in industries and light-duty automotive engine because it is less expensive. Engine and vehicle manufacturers are increasingly involved in the development of original engine equipment, especially for gasoline replacement applications, although many still regard the demand as to limited and dispersed to warrant large-scale manufacture. The CNG four stroke gasoline engine model was developed using GT-Power computational model with measurement for all of its components. The simulation results were compared with the data from the experimental result from the gasoline engine Robin EY20D engine operating with gasoline fuel and CNG fuel. The actual engine dimensions such as bore, stroke, intake pipe diameter and exhaust diameter were measured. Some of the data such as compression ratio, connecting rod length and fuel injector properties was based on the engine data sheet. The engine dimension and parameter are inserted into the software pop up table. The simulations were conducted at full load condition for the engine operating with gasoline and CNG fuel. The computational model was run using mono CNG fuel and mono gasoline fuel to know the engine performance with difference fuel. The simulation results were compared with the data for the gasoline fuel and also the CNG fuel. The experiment has been using water brake hydraulic pump act as a dynamometer. The simulation and experiment was performed to investigate engine performance parameters such as cylinder pressure, torque, power, volumetric efficiency and Brake Specific Fuel Consumption (BSFC). Results show gasoline is more power, torque and Brake Specific Fuel Consumption (BSFC) than CNG but volumetric efficiency for the CNG is not as much as gasoline.

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LIST OF SYMBOL

%	=	Percentage
$\overline{U}_p$	=	Average piston speed
$\dot{m}_a$	=	Steady state flow of air into the engine
$\dot{m}_f$	=	Rate of fuel into engine
$\dot{m}_{nf,i}$	=	Instantenous mass flow rate
$\dot{\omega}_{ct}$	=	Instantaneous cranktrain acceleration
A_p	=	Piston face area of all pistons
I_{ct}	=	Engine inertia
$T_b(t)$	=	Instantenous brake torque
V_{disp}	=	Dispalcement volume
$\dot{W}$	=	Work per cycle
W_b	=	Brake work
ρ_a	=	Density of air
ρ_{ref}	=	Density reference object pointed
avgrpm=		Engine speed (RPM)

bkw	=	Instantaneous brake power
bmep	=	Brake mean effective pressure
bpwr	=	Brake power
BSFC	=	Brake specific fuel consumption
btq	=	Brake torque
℃	=	Unit for temperature (degree Celsius)
cc	=	cubic centimetre (displacement)
cptq	=	Crank Pin Torque
fueltot	=	Fuel total
kg/m^3	=	Unit of density
kg/mol	=	kilogram/mol
Mass %	=	Mass percentage
mm	=	milimeter
N	=	engine speed
n	=	Number of revolutions per cycle
Nm	=	Newton metre (Torque)
stq	=	Shaft Torque
Vol %	=	Volume percentage
W	=	Work

LIST OF ABBREVIATION

BDC	=	Bottom Dead Centre
CI	=	Compressed Ignition
CNG	=	Compressed Natural Gas
CR	=	Compression Ratio
DI	=	Direct Injection
ICE	=	Internal Combustion Engine
kW	=	kilo Watt (Power)
LNG	=	Liquefied Natural Gas
MBT	=	Maximum Brake Torque
NGV	=	Natural Gas Vehicle
PSM	=	Projek Sarjana Muda
rpm	=	Revolution Per Minute
scfd	=	standard cubic feet per day
SI	=	Spark Ignition
TDC	=	Top Dead Centre
tsfc	=	trilion standard cubic feet

UMP = Universiti Malaysia Pahang

UTeM = Universiti Teknikal Malaysia Melaka

WOT = Wide Open Throttle

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CHAPTER I

INTRODUCTION

1.1 OVERVIEW

Nowadays, industry's development cycle of a new I-C (Internal Combustion) engine typically involves designing, building and testing. In this report, the engine performance parameters such as power, torque and mean effective pressure are studied when using gasoline and compressed natural gas (CNG) as fuel. A one dimensional GT-Power software, industrial grade engine simulation software has been used to simulate the engine model and to analyse the required parameters. The software was used in both design and an analysis mode with particular emphasis given to combustion chamber design (Joseph F. Kmec, 2009).

Takeshi Kato (2001) and Mardani Ali Sera (2003) said that the Compressed Natural Gas (CNG) has long been used in industries and stationary engines, but the application of CNG as a transport fuel has been considerably advanced over the last decade by the development of lightweight high-pressure storage cylinders. As the sequences of these studies, researches on CNG fuelled engine are also progressing throughout the world due to its potential as an alternative fuel for spark ignition (S.I) engine. The difference between the

operation of the conventional gasoline fuelled and the CNG-engine system arises from the physical and chemical properties of these two fuels. It is well known fact that petroleum fuels are liquid at room temperature and CNG remains in a gaseous state at much lower temperature (-161℃), CNG has a lower density but higher octane number than gasoline. It can easily operate in a high compression ratio and higher self/spontaneous ignition temperature makes it a safer fuel in case of leakage (L.M. Das, 2000). Table 1 represents the comparison between the physiochemical of CNG and that of the gasoline.

Table 1: Combustion related properties of gasoline and CNG.

(Source: M.U. Aslam(2006))

Properties	**Gasoline**	**CNG**
Motor octane number	86	119
Molar mass (kg/mol)	108	17.2
Carbon weight fraction (mass %)	86	73
Stoichiometric air fuel ratio (A/F)s	12.5	14.3
Stoichiometric mixture density (kg/m^3)	1.4	1.7
Lower heating value (MJ/kg)	42.5	46.9
Lower heating value of stoic. mixture (MJ/kg)	2.9	2.3
Flammability limits (vol % in air)	5.2	15.6
Spontaneous ignition temperature (℃)	512	633

Flyan (2002) said that energy policy and planning with the related orientation have become a very important public agendum of most developed and developing countries nowadays, as a result of which, the governments are encouraging the use of alternative fuels of petroleum oil in the automotive engines. When evaluating different alternative fuels one has to take account many aspects:

- Adequacy of fuel supply,
- Process efficiency,
- Ease of transparent and safety of storage,

- Modification needed in the distribution/refuelling network in the vehicle,
- Fuel compatibility with the vehicle engine (power, emission, ease of use, and durability of engine).

As a gas, CNG requires a different approach of fuel induction mechanism of all normal temperatures and pressures. This has resulted in an increased interest in the use of CNG as fuel for the internal combustion engines and hence CNG has now used to power vehicles of various ranges, starting from light delivery trucks to full urban buses and other varieties of applications (Klimstra, 1990).

1.2 PROBLEM STATEMENT

Rosli Abu Bakar (2001) said that natural gas has been used widely as an alternative fuel in internal combustion engine. Natural gas produces very low pollution and emission compared to gasoline. The main problem that hinders the mass implementation of CNG fueled vehicle in the market nowadays is its lower output due to losses in volumetric efficiency, low flame speed and absence of fuel evaporation which only has range of 40% - 50% gasoline engine power output.

The percentage volumetric efficiency losses because low of air-fuel intake and low energy density. Low fuel mixing will produce low power in the combustion chamber. Therefore, simulation in related software to model and analyze the data. The suggested software to model and to analyze the data is GT-Power software with the experimental data result.