UNIVERSITI PUTRA MALAYSIA

ENGINE DOWNSIZING SIMULATION BASED ON LOW RPM VARIABLE VALVE TIMING SYSTEM

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By

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Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

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Chairman : Assoc. Prof. Surjatin Wiriadidjaja, PhD, Ir
Faculty : Engineering

Downsizing an engine has proven to be one of an effective way to reduce emissions and fuel consumption. Theoretically, when an engine is running at high speed, maximum overlapping between the intake and exhaust valve is needed for a lean 'breathing' of the engine. But when an engine is running at lighter speed and load, these maximum overlapping techniques may be useful to be use to lessen the engine's fuel consumptions and emissions. To optimize these 'breathing' of the engine, it requires a different set of valve timing at different speed. This is due to the fact that as the speed increases, the duration of intake valve to have more fresh air decreases and combusted gas may not exit the chamber in time. Therefore, varying the intake timing of an engine could help produce higher power and, if applied to smaller and lighter engine, it could result in a lower fuel consumption as well. In this particular research that has been conducted through simulations and complemented by experimental works, it has been realized that downsizing an engine together with the implementation of variable valve timing is able to generate similar power with an increase in volumetric efficiency, while slightly lowering fuel consumption. As reported by many researchers, the variable valve timing method is indeed proven for improved fuel economy, lower emissions and higher torque under any operating condition.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

SIMULASI PENGURANGAN SAIZ ENGINE BERDASARKAN INJAP PEMASAAN BOLEH UBAH PADA KELAJUAN RENDAH

Oleh

AINUL ANIYAH SABARUDDIN

Disember 2015

Pengerusi : Prof Madya Surjatin Wiriadidjaja, PhD, Ir
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Pengurangan saiz enjin telah terbukti sebagai salah satu cara untuk mengurangkan pengeluaran serta penggunaan bahan api. Secara teori, apabila sesebuah enjin bergerak pada kelajuan yang tinggi, pertindihan injap yang maksimum pada injap pengambilan dan injap pengeluaran ekzos adalah amat diperlukan untuk memastikan ratio udara dan minyak berada pada tahap yang baik untuk menghasil kuasa yang besar. Tetapi, semasa enjin berada dalam kelajuan dan muatan yang rendah, pertindihan injap secara maksimum ini boleh digunakan sebagai cara untuk megurangkan penggunaan bahan api. Kepelbagaian injap yang berlainan masa pada kelajuan yang berbeza diperlukan enjin untuk "pernafasan" enjin yang optimum. Ini kerana apabila kelajuanenin bertambah, tempoh pengambilan udara baru dan tempoh pengeluaran gas yang telah terbakar akan menjadi lebih singkat. Kesuntukan masa ini akan menyebabkan kurangnya pengambilan udara yang bersih serta menyebabkan tidak kesemua gas yang telah dalam proses pembakaran sempat dikeluarkan. Dalam kajian ini, kesan penguranan saiz enjin bersertakan teknik pemasaan bolehubah injap ini untuk menjanakan kuasa setanding dengan kuasa enjin yang lebih besar darinya. Oleh itu, dengan adanya teknik ini, penjimatan bahan api dan kuasa yang lebih besar mampu dihasilkan.

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Thank you.

I certify that a Thesis Examination Committee has met on 4 December 2015 to conduct the final examination of Ainul Aniyah bt Sabaruddin on her thesis entitled "Engine Downsizing Simulation Based on Low Rpm Variable Valve Timing System" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the Degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATONS

RPM	Revolution Per Minute
PCM	Powertrain Control Module
TDC	Top Dead Center
BDC	Bottom Dead Center
AFR	Air Fuel Ratio
EGR	Exhaust Gas Recirculation
IVO	Intake Valve Open
IVC	Intake Valve Closing
EVO	Exhaust Valve Open
EVC	Exhaust Valve Closing
VVT	Variable Valve Timing
OF	Overlapping Factor
PVO	Positive Valve Overlapping
NOx	Nitrogen Oxide
HC	Hydrocarbon
CO	Carbon Oxide

CHAPTER ONE

INTRODUCTION

Originally the basic form of gasoline engines is not as efficient as it is today. According to the U.S Department of Energy (EPA), out of the power combusted in gasoline engine, only about 15% of it are converted into mechanical energy to power up a car. Due to heat and friction about 62% of the energy lost and according to Environmental Protection Agency (EPA, 2015) about 17% of energy lost in idle state. With current finding and technologies, modern car engines are now able to work a lot more efficient.

In improving an engine's performance such as to make it more powerful it would require a better and more efficient combustion. Combustion occurs with two important thing that is the air and fuel. By having more fuel alone will not make the engine go faster. Both of the air and fuel is relatively needed together. One of the factor that influence the power of an engine is the lean mixture of its air-fuel ratio. The leaner the mixture is, the bigger power it could produce. Hence it can be said that it has a direct affect to an engine's performance. The air and fuel ratio of the engine give a proportionally effect to the engine's performance and power. Thus, helping the engine to get a leaner mixture of air and fuel could help in improving the combustion made by the engine. One of the way of helping an engine to have a leaner mixture is by advancing its intake valve timing for a longer period to suck in more fresh air for a better combustion.

1.1 Problem Statement

Over the years since in 1940's an aircraft internal combustion engine design has been remotely the same. Changes and improvements may have been done on the materials or fuels, but the basic form of the engine itself remained the same. One of desired characteristic of an engine is to be light but yet powerful enough to drive the plane up to the air. Over time since then, technologies has improved aircraft's engine in variious specs such as, the size, material and the the of fuel used. As most aircraft nowadays used turbines but light weight aircraft still used the same four stroke engine concept till this day. The focus of this thesis is to theoretically downsize an engine but yet powered it up with a variable valve timing technology.

It is a desirable thing for any automotive manufacturers especially in aviation to have lessen the weight of its engine. In automobile, one of effective way to lessen an engine's weight is to downsized them but either reducing the combustion cylinder size or by reducing the number of cylinders existing in the engine itself. Of course by only do that, smaller engine means smaller power compared to the bigger ones. In modern days, most downsized engines it accompanied or attached with turbocharger os supercharger to help the engine to gain leaner mixture for a more powerful and

desriable output with less fuel. Other than downsizing, there is another techniques to provide longer time for more air for the engine for leaner air-fuel mixture that is via variable valve timing.

Valve timing techniques can affects many aspects of an engine's performance such as fuel consumption and engine emissions. Variable valve timing is one of a common technology used in normal automotive engine whereby it give out an amazing power but normally has only been focusd and used for high speed, approximately about 6000RPM. Aircraft engine however, normally fly with the range of 2000RPM to 4000RPM.

Thus, in this study, simulation of a downsized piston will be carry out together with variable valve timing with power output as normal aspirated non variable valve engine in low speed.

1.2 Objective

The objective of this study is to study how the normal aspirated piston work and then to create a simple engine profile for a simulation based on the same engine to see the effect of downsizing an engine to its power. This study will also implement the variable valve timing system to the engine simulation to see the possibilities of making the variable valve timing could provide greater output with lower fuel usage in low RPM ranging from 2500RPM to 4000RPM.

1.3 Scope Of Study

The scopes of this project are:

I. To downsize the size of an engine by reducing thecombustions chamber size
II. To see effects of differentiating valve timing and engine displacement in term of its power, volumetric eefficiency and fuel
III. To vary different sets of cam on a reduced sized engine with low RPM ranging from 2500RPM to 4000RPM
IV. To see the power curve produced by number III

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