DEVELOPMENT OF A COMPRESSED NATURAL GAS (CNG) MIXER FOR A TWO STROKE INTERNAL COMBUSTION ENGINE

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ABSTRACT

Compressed Natural Gas (CNG) has been accepted widely as an alternative to gasoline. More importantly the use of CNG in two stroke engines will drastically reduce the high emission output from these engines as these engines are widely used around the world. A conversion kit is used to apply the fuel in engines. A bi-fuel conversion system converts engines without much modification to other systems. They are normally produced for four stroke application. This kit has to be studied to be modified for two stroke application. The part that connects the engine to the kit is called a gaseous fuel mixer. This part mixes the air and fuel due to its venturi shape. A mixer provides fuel suction at different engine speeds due to pressure difference at the throat. The optimisation of the throat is important as a small throat will cause poor performance at high speeds while a large throat will reduce fuel suction. The smaller throat size creates higher velocity and lower pressure. This low pressure creates fuel suction into the mixer. The mixer was designed for a two stroke engine air flow. Computer aided design (CAD) and computational fluid dynamic (CFD) software were used as a tool for the design. The design is optimised for inlet and outlet angles, number and size of the hole at the throat circumference and also the throat size. The prototype design was manufactured based on optimised dimensions of the mixer that were obtained from CFD analysis. The mixer was validated to show that the CFD analysis was correct. Testing apparatus were used to do the validation. The apparatus consists of a laminar flow element (LFE), a smoke generator, a digital manometer and a gaseous flow meter. It was used to validate the flow pattern, pressure drop from the mixer and the air fuel ratio given by the mixer.

ABSTRAK

Gas Asli Termampat (CNG) telah diperaku i sebagai satu alternatif kepada petrol. Penggunaan gas in dalam enjin dua lejang mampu mengurangkan pengeluaran pencemaran tinggi dari enjin ini. Ini kerana penggunaan enjin dua lejang adalah banyak di dunia. Bahan api ini digunakan pada engine melalui kit penukaran. Penukaran enjin petrol ke CNG perlu dilakukan dengan modifikasi kecil pada enjin asal. Oleh itu, kit penukar CNG dwi-bahanapi digunakan. Unit ini dibuat lazimnya untuk enjin empat lejang, oleh itu, ia perl u dikaji bagi penggunaan dalam enjin dua lejang. Bahagian pada alat ini yang bersambung kepada enjin dinamakan sebagai pencampur bahanapi bergas. Ia menyebabkan gas bercampur pada bahagian yang berbentuk venturi. Pencampur ini memberikan sedutan gas kepada enjin pada halaju enjin yang berbeza disebabkan perbezaan tekanan pada bahagian yang dipanggil leher. Ubahsuai leher adalah penting bagi operasi alat ini. Ubahsuai leher adalah perlu kerana leher yang kecil akan menyebabkan prestasi enjin yang rendah pada kelajuan tinggi manakala leher yang besar tidak dapat memberi sedutan gas yang diperlukan. Tekanan rendah menyebabkan sedutan pada pencampur ini. Pencampur direkabentuk untuk aliran udara pada enjin dua lejang. Rekabentuk berbantukan computer (CAD) dan Dinamik Bendalir berbantukan computer (CFD) digunakan sebagai alat rekabentuk. Rekabentuk pencampur diubahsuai dengan menggunakan CFD pada sudut masukan dan keluaran, bila ngan lubang dan saiz lubang pada leher serta saiz leher itu sendiri. Prototaip dibuat berdasarkan dimensi pencampur yang diperolehi daripada analisis CFD. Untuk membuktikan analisis CFD pengesahan telah dilakukan. Peralatan ujikaji telah digunakan untuk melakukan pengesahan ini. Ia terdiri daripada elemen aliran laminar (LFE), penghasil asap, manometer digital dan meter aliran gas. Peralatan ini digunakan bagi tujuan pengesahan bentuk aliran, kejatuhan tekanan dan nisbah udara kepada bahan api yang diberi oleh pencampur ini.

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LIST OF SYMBOLS

AF	Air fuel ratio	-
A_1	Area in inlet	m^2
A_2	Area at throat	m^2
C_μ	Viscosity constant	-
C_v	Specific Heat	J/kgK
Dr	Delivery ratio	-
H_L	Losses in pipe	Pa
k	Turbulent kinetic energy	J/kg
$\dot{m}_1$	Inlet mass flow rate	kg/s
N	Engine speed	rpm
Q_a	Volumetric air flow rate	m^3/s
Q_1	Measured flow rate	m^3/s
Q_2	Actual flow rate	m^3/s
p_{atm}	Atmospheric pressure	Pa
Q_H	Heat source per unit volume	J/m^3
q_i	Diffusive heat flux	J/s
S_i	Mass distributed external force per unit mass	N/kg
U	Fluid velocity	m/s
v_1	Velocity at inlet	m/s
v_2	Velocity at throat	m/s
Δp	Pressure drop	Pa
ΔP_{air}	Pressure drop in the air cleaner	Pa
ΔP_u	Intake pressure drop upstream	Pa
ΔP_{thr}	Pressure drop across throttle	Pa

ΔP_{valve}	Pressure drop across intake valve	Pa
ρ_1	Air density at inlet	kg/m^3
f_μ	Turbulent viscosity factor.	-
δ_{ij}	Kronecker delta function	-
ε	Turbulent dissipation	J/s
θ	Angle	$^\circ$
τ_{ik}	Viscous shear stress tensor	Pa
μ	Dynamic viscosity	kg/m s
μ_l	Dynamic viscosity	kg/m s
μ_t	Turbulent eddy viscosity	kg/m s

CHAPTER 1

INTRODUCTION

Current trends in the automotive industry are ever changing especially regarding the usage of alternative fuels. The search for the best alternative fuel that produces the least amount of emission has sparked concerns to many researchers. Maxwell (1995) stated that many studies on alternative fuel have been carried out and researchers are looking at natural gas, liquefied petroleum gas (LPG), methanol, ethanol, and hydrogen. All of these fuels have their advantages and disadvantages which are cost, availability, environmental impact, usage in vehicle, safety and the acceptance by consumers.

Current fuel price inflation and also current oil crisis, drastic moves were taken by many countries to reduce petroleum usage and finding other alternatives to its usage. In developing countries, the concern of finding alternative fuels has started and already had become an issue. With gas reserves three times more than petroleum oil, Malaysia is increasingly turning its attention towards natural gas. The national petroleum company of Malaysia, PETRONAS has embarked on the Natural Gas for Vehicles (NGV) program where NGV dispensing facilities are available at some selected PETRONAS service stations, located in high traffic density areas of Kuala Lumpur and Johor Bahru. The government support for the NGV program was seen in 25% reduction on car road tax for using NGV as well as requiring new taxis in the Klang Valley to use CNG by engine conversion systems.

In automotive applications, natural gas can be used in three forms based on how the natural gas is stored. One of the most popular forms of natural gas is the compressed natural gas (CNG), which is natural gas in pressurised form. The other least popular methods of obtaining natural are liquefied natural gas and the absorption natural gas.

CNG is a good alternative to petrol and diesel. Consumers would easily accept this form of alternative as it has low operational cost due to subsidised price and its usage could provide cleaner engine emissions. The main reason behind CNG fuel being cleaner is that natural gas is principally comprise of 90% methane, which is the simplest form of hydrocarbon. Even so, the CNG fuel available today still lack in some qualities compared to petroleum fuel. For example, CNG fuelled engines normally possess lower engine performance compared to petrol.

The main reason is that CNG fuelling systems creates a lot of losses in terms of volumetric efficiency. This happens as CNG must be supplied to the engine through a mixing device before the mixture of CNG and air is drawn into the engine. This causes less fuel in the combustion chamber and reduces volumetric efficiency. Currently petrol fuelled engine are converted into a CNG fuelled engine by means of a fuel mixing device.

1.1 Problem Statement

Currently, there are no specific CNG mixers specifically designed for two stroke engines in the market. All of the conversion kits that are available for four stroke engines only. A proper CNG mixer should be designed for two stroke engine application. A supercharged 150 cc two stroke engine has been chosen for CNG conversion. Direct usage of a conventional four stroke engine CNG mixer for two stroke engines is not possible as they are too large a size for a small two stroke engine air requirements. The design of the mixer has to consider the whole range of engine operating condition in order to provide a complete view of its performance.

The existing four stroke engine CNG mixers are usually not properly refined and optimised to enable good air fuel mixing. In addition, the efficiency of the current mixer design is also an issue as it is designed for simplicity which only offers practicality but lack in efficient air flow performance throughout the engine speed. Therefore, a straight forward conversion is not possible.

1.2 Objectives

The objectives of the study are as follows:

1) To design a venturi burner type CNG mixer for a two stroke engine according to the engine's air requirement using CFD.
2) To fabricate the optimised prototype of the CNG mixer and test it on a flow bench machine.

1.3 Scope

The scopes of the research are as follows:

1) Preliminary design of the CNG mixer.
2) Optimising the CNG mixer design using CFD as a design tool .
3) Fabrication of the prototype CNG mixer.
4) Testing and validation of the CNG mixer design.

1.4 Methodology

A general methodology was followed in the research as indicated in the flow chart as shown in Figure 1.1:

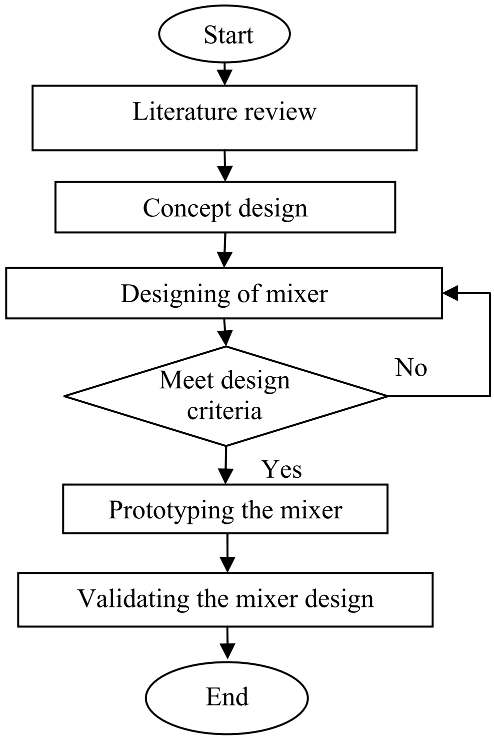

Figure 1.1 Methodology

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