UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS

JUDUL: **DESIGN OF A MECHANISM TO MIX BIOGAS WITH AIR IN COMPRESSION INTERNAL COMBUSTION ENGINE**

SESI PENGAJIAN: 2010/2011

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DESIGN OF A MECHANISM TO MIX BIOGAS WITH AIR IN COMPRESSION INTERNAL COMBUSTION ENGINE

AHMAD HAZURY BIN HAMID

BACHELOR OF ENGINEERING
UNIVERSITI MALAYSIA PAHANG

2010

UNIVERSITI MALAYSIA PAHANG

FACULTY OF MECHANICAL ENGINEERING

I certify that the project entitled "Design of a Mechanism to Mix Biogas With Air In Compression Internal Combustion Engine " is written by Ahmad Hazury Bin Hamid. I have examined the final copy of this project and in my opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering.

Mr. Ahmad Basirul Subha Alias

Examiner Signature

DESIGN OF A MECHANISM TO MIX BIOGAS WITH AIR IN COMPRESSION INTERNAL COMBUSTION ENGINE

AHMAD HAZURY HAMID

This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Mechanical Engineering (Automotive)

Faculty of Mechanical Engineering
Universiti Malaysia Pahang

DECEMBER, 2010

SUPERVISOR'S DECLARATION

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STUDENT'S DECLARATION

"All the trademark and copyrights use herein are property of their respective owner. References of information from other sources are quoted accordingly; otherwise the information presented in this report is solely work of the author."

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SECOND EXAMINER'S DECLARATION

I hereby declare that I have checked this project report and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering

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Position	: Lecturer
Date	: 6 December 2010

DEDICATION

Specially dedicated to

My beloved family, and those who have guided and inspired me

Throughout my journey of learning

ACKNOWLEDGEMENT

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Last but not least, my beloved family members who always stand by my side concerning the ups and downs of my life. Home is where I find comfort. Endless love.

ABSTRACT

Internal combustion engines burn fuel to create kinetic energy. The burning of fuel is basically the reaction of the fuel with the oxygen in the air. The amount of oxygen present in the cylinder is the limiting factor for the amount of fuel can be burnt. If there’s too much fuel present, not all fuel will be burnt and un-burnt fuel will be pushed out through the exhaust valve. When building an engine, it’s very important to know the air-fuel ratio at which exactly all the available oxygen is used to burn the fuel and all the fuel is burnt completely. This ratio is called the stoichiometric air-fuel ratio. This project has successfully design a venturi mixer and analyze design of pressure regulator that perform accurate state estimation achieving desired outputs with certain parameters setting. It helps identify the current operating state of the system on which, on certain condition can generate the accurate output.

ABSTRAK

Enjin pembakaran dalaman membakar bahan bakar untuk menghasilkan tenaga kinetik. Pembakaran bahan bakar pada dasarnya adalah reaksi bahan bakar dengan oksigen di udara. Jumlah ini oksigen di silinder adalah faktor sekatan untuk jumlah bahan bakar boleh dibakar. Jika ada bahan bakar ini terlalu banyak, tidak semua bahan bakar akan bahan bakar dibakar dan tidak terbakar akan terdorong keluar melalui injap buang. Ketika membina mesin, sangat penting untuk mengetahui perbandingan hawa-bahan bakar yang justru semua oksigen yang sedia digunakan untuk membakar bahan bakar dan semua bahan bakar terbakar sepenuhnya. Nisbah ini disebut nisbah udara-bahan bakar stoikiometri. Projek ini telah berjaya merancang sebuah mixer venturi dan menganalisa desain regulator tekanan yang melakukan estimasi state tepat mencapai keputusan yang dikehendaki dengan parameter tertentu tatacara. Ini membantu mengenalpasti status operasi saat ini sistem di mana, pada keadaan tertentu boleh menghasilkan output yang dikehendaki.

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LIST OF ABBREVIATIONS

A_c	Surface area
A	Area
J	Radius
m	Meter
V	Volume
h	Height
$\dot{m}$	Mass flow rate
ρ	Density
$\dot{v}$	Volume flow rate
v	Velocity
SG	Specific gravity
M	Mach number
T	Temperature
P	Pressure
NGV	Natural gas vehicle

CHAPTER 1

INTRODUCTION

1.1 PROJECT SYNOPSIS

Natural Gas Vehicle or NGV is a new concept of operating a vehicle engine by not using petrol or gasoline as fuel. These systems have been develop in the past years and are suitable for most type of cars. Methane as natural gas had also been use as biogas fuel. In general, this project is about using methane as fuel to operate an engine in a biogas system. A storage tank which located behind in the bonnet of a vehicle. This project involves designing 2 things which is a device to mix biogas with air compression internal combustion engine and also a mechanism to regulate the pressure and maintain constant. This project also includes calculating of a mechanism to mix biogas with air in compression internal combustion engine by using gas dynamic equations. This project is basically done in group which is divided to several parts to complete and run a biogas engine. This project focused on determines the value and ratio of biogas and air, and also the size of biogas tube and the venturi mixer dimension.

The project will be funded by student final year project funding, UMP short term project funding as well as sponsorship attained from industrial sponsors in terms of equipments, products and also monetary funding.

The project title is Design of a Mechanism to Mix Biogas with Air in Compression Internal Combustion Engine. The mechanism purpose is to control the flow of biogas and air into the engine to get the required ratio of biogas and air. Study on related subject and data are gather to find the best result possible. So it is able to regulate the pressure and keep the pressure maintain constant.

1.2 PROBLEM STATEMENT

Engine powered by biogas had been widely used in Europe. The purpose of using biogas as fuel is because it can reduce the use of petrol. Petrol will be extinct one day, therefore the prevention to replace it to another fuel is by using biogas as fuel. Biogas engine is not been widely use in our country, especially for vehicle. The development of biogas must be develop thoroughly for the future. Therefore, to design biogas engine, the parameters value such as its ratio of air and fuel need to be calculated. This value can determine the amount of biogas needed and finally design the mechanism to mix biogas with air in compression internal combustion engine. For final year project 1, it will focus on the calculation method to get the parameters needed. In final year project 2, the data for real engine can be used and therefore, can build the mechanism inside a real engine.

1.3 OBJECTIVES

This project aims to produce a design for pressure regulator and a venturi mixer. The design for venturi mixer will concentrate on gas dynamic equation. While the pressure regulator design will base on redesign a current product.

The objectives of this project are;

1.3.1. To design a device to mix biogas with air in compression internal combustion engine.

1.3.2. To design mechanism that will regulate and maintain the pressure constant.

1.4 SCOPE OF PROJECT

The scope involve will be specified to diesel engine using biogas as fuel. The design will be on mechanism that will regulate and maintain the pressure constant. Another design is for venturi mixer which is purpose to mix biogas with air, with suitable air to fuel ratio.

The scopes of this project are;

1.4.1. Specific to diesel engine using biogas as fuel.
1.4.2. Design regulator device to keep the biogas pressure constant.
1.4.3. Design a venturi mixer to mix biogas with air.
1.4.4. Calculate the air-fuel ratio using the dynamic equations.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION AND OVERVIEW

Internal combustion engines burn fuel to create kinetic energy. The burning of fuel is basically the reaction of the fuel with the oxygen in the air. The amount of oxygen present in the cylinder is the limiting factor for the amount of fuel can be burnt. If there's too much fuel present, not all fuel will be burnt and un-burnt fuel will be pushed out through the exhaust valve. When building an engine, it's very important to know the air-fuel ratio at which exactly all the available oxygen is used to burn the fuel and all the fuel is burnt completely. This ratio is called the stoichiometric air-fuel ratio**.** (John, James E., Gas Dynamic)

A device to mix biogas with air in an internal combustion engine is function to regulate the pressure, maintain and provide the amount of biogas needed by the engine. The mechanism control the flow of biogas which is transfer into the venturi by using a tube. The size of the tube need to be determine by using an engine specification data to calculate the value.

This project mostly used the related formula, therefore, the value to be used in the formula is selected based on the true value. The engine that have been selected show how to use its specification from starting and with several formula, the size of tube which transfer the biogas is determine. Figure 2.1 show the area to be calculated.

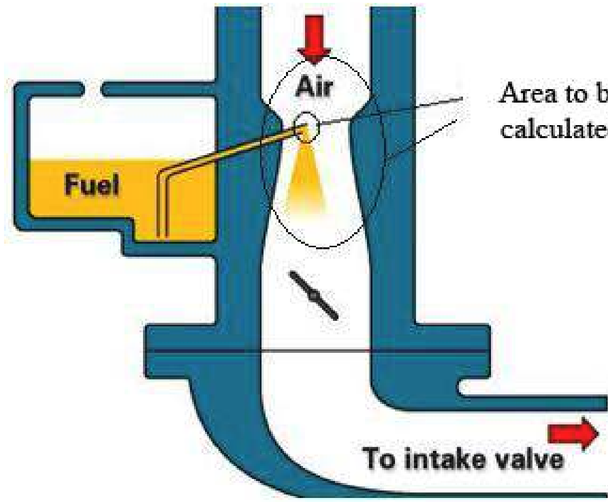

Figure 2.1 Venturi mixer and area to be calculated

Source: http://www.cdxetextbook.com/assocStudies/supScience/fuelSys/venturi.html

2.2 ENGINE SPECIFICATION

The engine specification is all the data of an engine used for a car. It can be obtain in a catalog selling car or from journals. From the engine specifications, all the parameter of the engine can be read from there. The engine selected to use in the calculation method are from Mitsubishi L200 Single Cab 4Work/4Life manual. The data from the engine specification is used in the equation to calculate the tube size. Figure 2.2 are the data from the engine.

Model		Single Cab 4Work/4Life Manual
Engine		
Engine type		
Fuel system		
Displacement	cc	2477
Bore/stroke	mm	91.1 x 95.0
Compression ratio		17.5
Maximum output	kW (bhp) at rpm	100 (134)/4000
Maximum torque Man	Nm (lb.ft) at rpm	314 (231)/2000
Auto	Nm (lb.ft) at rpm	–
Performance/Fuel Consumption/Emissions		
Maximum speed	mph (kph)	103 (167)
Acceleration 0-62 mph	secs	14.6
Fuel type		Diesel
lts/100km (mpg)	Urban mode	10.3 (27.4)
	Extra urban mode	7.3 (38.7)
	Combined	8.4 (33.6)
CO_2 emissions	g/km	225

Figure 2.2 Engine specifications for Mitsubishi L200 engine

Source: http://www.l200.org.uk/information/technical.php

From figure 2.2, the value that being used in the calculation are engine Maximum torque and Bore/stroke.

2.3 GAS DYNAMIC EQUATIONS

Gas dynamic addresses on compressible flows in which a gaseous continuous phase is seeded with droplets or particles and in which it is necessary to evaluate the relative motion between the disperse and continuous phases for a variety of possible reasons. In many such flows, the motivation is the erosion of the flow boundaries by particles or drops and this is directly related to the relative motion. In other cases, the purpose is to evaluate the change in the performance of the system or device. Still another motivations the desire to evaluate changes in the instability boundaries caused by the presence of the disperse phase. (Source: John, James E., Gas Dynamic)

Gas dynamics is a branch of fluid dynamics concerned with studying the motion of gases and its consequent effects. Gas dynamics combines the principles of fluid mechanics and thermodynamics. This study often concentrates on the behavior of gases flowing at speeds comparable to the speed of sound. (Source: John, James E., Gas Dynamic)

There are several equation used to calculated from the beginning until getting the value of the tube. The equation includes the Bernoulli equation, mass flow rate, volume flow rate, heat transfer rate, Mach number, and also the combustion equation.

2.3.1 Area, Volume, and Surface Area Equation

All the calculation above used for the cylinder or piston of the engine. The equation are;

$$A_c = \pi j^2 \tag{1}$$

Surface area, (1), where j is the radius of the cylinder.
SI units for surface area is m^2.

$$V = \pi j^2 \times h \tag{2}$$

Volume, (2), where j is the radius and h is the height of the cylinder or the stroke.
SI units for volume is m^3.

$$A = 2\pi j^2 + 2\pi jh \tag{3}$$

Area, (3), where j is the radius and h is the height of the cylinder.
SI units for surface area is m^2.

2.3.2 Mass Flowrate Equation

The number of kilograms of mass that flow past a given cross sectional area per second. In a pipe this becomes;

$$\dot{m} = \rho\dot{v} = \rho A v \quad (4)$$

$$\dot{m} = \frac{dm}{dt} \quad (5)$$

SI Units for mass flow rate is kg/sec.

In this project, the formula used for mass flow rate is simplified into;

$$\dot{m} = v\rho \quad (6)$$

2.3.3 Volume Flow Rate Equation

The volume of fluid that flows past a given cross sectional area per second.

$$\dot{V} = Av \quad (7)$$

Units for Volume Flow Rate (m^3/s).

Since there are no fixed mass to define as the system of focus in fluid flow problems, the flow of a small volume of the fluid can be used as useful concept to focus on as it move around in space. If the fluid is incompressible, for example. its density does not change as the substance flows along, then the volume flow rate follows a conservation of volume. The volume that flows in must flow out. (John, James E., Gas Dynamic)

$$\dot{V} = \frac{d(Ax)}{dt} = A\frac{dx}{dt} = Av \quad (8)$$

2.3.4 Bernoulli Equation

A statement of the conservation of energy in a form useful for solving problems involving fluids. For a non-viscous, incompressible fluid in steady flow, the sum of pressure, potential and kinetic energies per unit volume is constant at any point. A special form of the Euler's equation derived along a fluid flow streamline is often called the Bernoulli Equation.

The Bernoulli equations used in this project are;

`

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2 \quad (9)$$

In which the two sided in the equation are the Biogas digester (inlet) and venturi tube (outlet).

2.3.5 Mach Number

The criterion for the type of flow is Mach number, a non dimensional parameter defined by

$$M = \frac{V}{a} \quad (10)$$

The Mach number is the ratio of the speed of the gas divided by the local speed of sound. Because, as we have seen, the speed of sound depends upon thermodynamic variables of pressure, density or temperature, its value changes throughout the flow field as these variables change. (John, James E., Gas Dynamic)

The mass-flow rate at cross-sectional area A can be expressed in terms of stagnation pressure and temperature. It is useful to determine the Mach number corresponding to the maximum value of F(γ,M) because it will reveal the maximum flow rate for given values of p_o, T_o, and A. (John, James E., Gas Dynamic)

For a perfect gas with constant specific heats;

$$\dot{m} = \frac{p}{RT} MA \sqrt[2]{\gamma RT} \qquad (11)$$

Where

$$p = \frac{p_o}{\left(1+\frac{\gamma-1}{2}M^2\right)^{\gamma/(\gamma-1)}} \qquad (12)$$

And

$$T = \frac{T_o}{1+\frac{\gamma-1}{2}M^2} \qquad (13)$$

Thus

$$\dot{m} = \frac{p_o}{\sqrt[2]{RT_o}} A \sqrt[2]{\gamma} M \left(1 + \frac{\gamma-1}{2} M^2\right)^{-\frac{\gamma+1}{2(\gamma-1)}} \qquad (14)$$

For isentropic flow, in which p_o and T_o are both constant, the cross-sectional area A can be related directly to Mach number. Select the area at which M=1 as a reference area. Call this area A*. For steady flow, the mass-flow rate is constant through a variable-area channel. Thus the flow rate area A, say, $\dot{m}_A$, is equal to the mass flow rate at A*, say, $\dot{m}_{A*}$. (John, James E., Gas Dynamic)

$$\frac{A}{A*} = \frac{F(\gamma,1)}{F(\gamma,M)} \qquad (15)$$

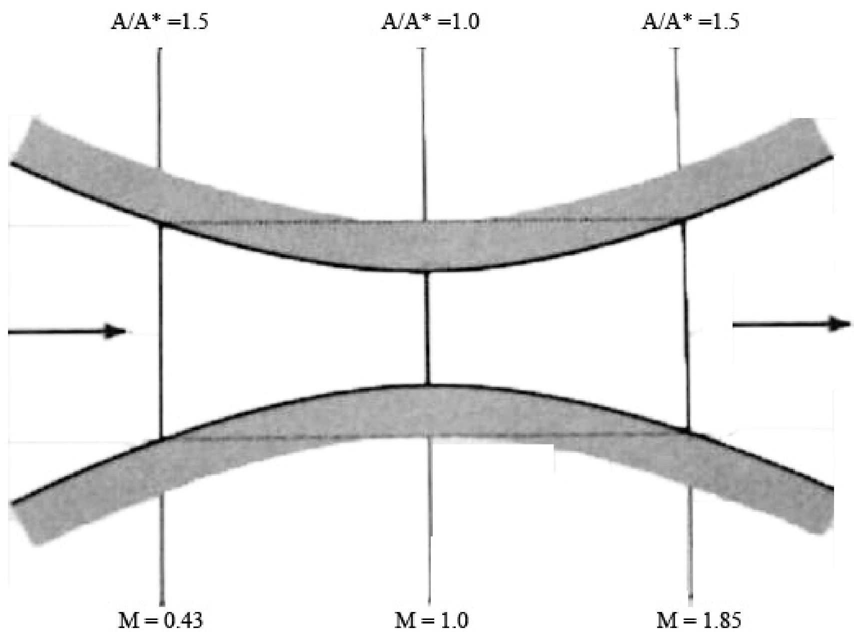

Figure 2.3 Area ratio and Mach number in a duct

Source: John, James E., Gas Dynamic

2.3.6 Combustion Equation

In order to operate a heat engine we need a hot source together with a cold sink. Occasionally these occur together in nature example such as geothermal sites or solar powered engines, but usually the heat source has to be artificially provided. The most common way of doing this is by the combustion of a fuel. (A. Cengal, Yunus., Heat and Mass Transfer)

To explain how to calculate the combustion equation, example show the step. Say we have a fuel that is 80% CH_4 (methane) and 20% C_2H_6 (ethane) by volume (UK natural gas) . We could choose any quantity of fuel but for convenience we shall use 1 kmole, which can be written as :-

(0.8 CH_4 + 0.2 C_2H_6)

Let us say that this mixes with Y kmoles of air and that the combustion processes go to completion.
Now air is - 79% N_2 & 21% O_2

Therefore 1 kmole of air may be written as :-
(0.79 N_2 + 0.21 O_2)

We may therefore write a combustion equation :-
(0.8 CH_4 + 0.2 C_2H_6) + Y(0.79 N_2 + 0.21 O_2)
(the reactants)

a CO_2 + b H_2O + c O_2 + d N_2
(the products of complete combustion)

Source: John, James E., Gas Dynamic

CHAPTER 3

METHODOLOGY

3.1 PROJECT FLOW

The project starts with understanding the project title given by the supervisor. This process includes consulting supervisor to gain the expected outcome and range of project to be made. When the expected outcome is cleared, further information will be gather from sources such as journals and books, and also from the internet. The understanding of project will be focusing on Design of a Mechanism to Mix Biogas with Air in Compression Internal Combustion Engine.

Collecting data is where the process of gather information is continued by finding the why and how this project should be design. If there is an existing design, the new design should be better and solving the problem of the old one. After the problems have been solved, the new design of the regulator should come out. Theoretical method such as formulas is used to determine certain values such as inlet and outlet size dimension.

After gathering all the relevant information, the project undergoes design process. In this step, the design of new regulator should be made base on the information's and related findings. Experimental on the design will be made to reassure the design is according to the theory. Finally, the improvement can determine.

All the above information will be made into the report, where all materials from beginning will be. The report writing process will be guided by the UMP final year project report writing. This process also included the preparation of slide for the final presentation.

The project ended after the submission of the report and the slide presentation has been presented.

3.2 THEREOTICAL METHOD

Theoretical method is the process to determine the dimension of venturi mixer. The exact figure can refer to figure 2.1 in chapter 2. To design a pressure regulator, determining the dimension of the outlet is important because pressure regulator process work when high pressure from storage tank went through the regulator. This is where pressure regulator function, it regulate the high pressure to low pressure before entering the valve. If there is no pressure regulator, pressure at around 150bar to 250bar entering the mixer will damage the component and engine part. Formulas used are as mention on chapter 2.

To do the theoretical calculation, some parameters need to gather. As in this case, the top speed and bore/stroke from Mitsubishi L200 Single Cab 4Work/4Life manual transmission is use (refer to chapter 2 figures 2.2). The value used is to determine certain value and can be changed to other value according to the vehicle.

3.2.1 Calculation Method

The calculation will focus on gas dynamic equations which had been mention in chapter 2. All the related equation to use in the calculation method can be refer in literature review section. The purpose of this method is to get the value for throat area, venturi area, and also the inlet tube area. Figure 3.1 show the exact picture on the area mention.

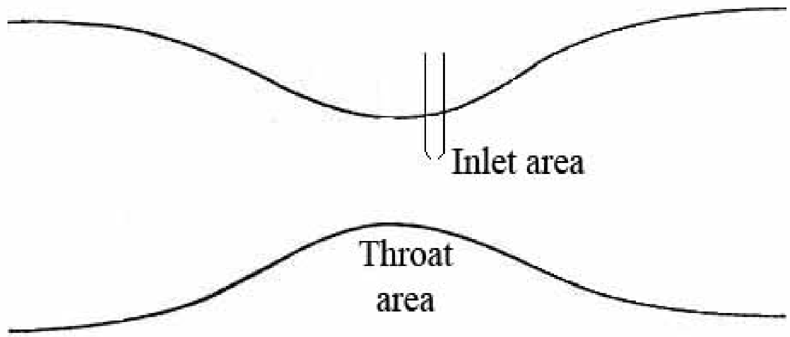

Figure 3.1: Venturi mixer to be design

From the data of vehicle Mitsubishi L200 Single Cab 4Work/4Life manual transmission in figure 2.2, the bore size is 0.0911m. A_c is the surface area. The bore is divided by 2 to get the radius. Therefore;

$$\text{Surface area}, A_c = \pi j^2 \quad = \pi(0.04555)^2$$
$$= 6.518 \times 10^{-3} m^2$$

After that, the value of volume is calculated as below.

$$\text{Volume}, V = \pi j^2 \times h \quad = (6.518 \times 10^{-3})(0.095)$$
$$= 619.228 \times 10^{-6} m^3$$

Calculation for total area of cylinder.

$$\text{Area, A} = 2\pi j^2 + 2\pi jh$$
$$= (2 \times \pi \times 0.04555^2) + (2 \times \pi \times 0.04555 \times 0.095)$$
$$= 0.0402 m^2$$

From figure 2.2, the maximum torque for manual transmission is 2000rpm. For a 4-stroke engine, angular rpm is divided by 2. Thus, in second it will be 16.67 round per second.

$$\text{Volume flow rate, } \dot{v} = vA_c$$
$$= (16.67)(6.518 \times 10^{-3})$$
$$= 0.1086\ m^3/s$$

Using the specific gravity formula to get the value of air density to find the mass flow rate of air.

$$\text{Specific Gravity, SG} = \frac{\rho_{air}}{\rho_{water}}$$
$$\rho_{air} = (SG)(\rho_{water})$$
$$= (0.0013)(998)$$
$$= 1.2974\ kg/m^3$$

$$\dot{m}_{air} = v \times \rho_{air}$$
$$= (16.67)(1.2974)$$
$$= 21.6276 \frac{kg}{s}$$

Combustion equation is used to get the ratio of air to fuel. Then the ratio is used to get the value of heat transfer rate for fuel which is the methane, followed by the mass flow rate of fuel. The step are show below.

Combustion equation

$$0.75CH_4 + 0.25CO_2 + 1.5O_2 + 1.5\left(\frac{79}{21}\right)N_2 \rightarrow CO_2 + 1.5H_2O + 1.5\left(\frac{79}{21}\right)N_2$$

$0.75CH_4$ and $0.25CO_2$ are the fuel. Hence, the total fuel weight is:

Carbon = 1 x 12mol
= 12 kg/kmol

Hydrogen = 3 x 1mol
= 3 kg/kmol

Oxygen = 0.5 x 16mol
= 8 kg/kmol

Total fuel weight $= 23\ kg$

$1.5O_2$ and $1.5\left(\frac{79}{21}\right)N_2$ are the air. Hence, the total air weight is:

Oxygen = 3 x 16mol
= 48

Nitrogen = $1.5\left(\frac{79}{21}\right)$ x 14mol x 2
= 158

Total Air weight $= 206\ kg$

Air fuel ratio is then 206/23 which equal to 8.9.

$$\frac{A}{F} = \frac{8.9}{1} \approx 9:1$$

$$\frac{1}{9} \times \frac{\dot{Q}_{fuel}}{\dot{Q}_{air}} = 0$$

$$\dot{m}_{fuel} = (16.67)(0.717)$$
$$= 11.9523 \frac{kg}{s}$$

From gas dynamic equation, the value need to be obtained is the area of the venturi where the curve happened.

$$\dot{m}_{air} = \frac{p}{RT} AM^2\sqrt{\gamma RT} \ ; \ \dot{m}_{air} = 21.6276 \frac{kg}{s}$$

$$P = 300 \frac{kN}{m^2}$$

$$R = 0.5182 \frac{kJ}{kg.K}$$

$$T = 298K$$

$$M = 1.0, 0.9, 0.8, 0.7$$

$$\gamma = 1.32$$

$\frac{A}{A^*}$ *is the area ratio*

For M= 1.0,

$A^* = 0.779\ m^2$

For M= 0.9,

$A = 0.962\ m^2$

$\frac{A}{A^*} = 1.234$

For M= 0.8

$A = 1.218\ m^2$

$\frac{A}{A^*} = 1.563$

For M= 0.7

$A = 1.591\ m^2$

$\frac{A}{A^*} = 2.042$

Bernoulli equation from 2 areas which is the storage tank that is before entering the pressure regulator is equal to the outlet of the pressure regulator. Simplified both side, the value for volume at the outlet is obtain. Finally, inserting the value of outlet volume into mass flow rate equation will get the area for the outlet tube. Therefore, the radius of tube is obtain.

Bernoulli equation

$$\frac{15000}{(0.717)(9.81)} = \frac{300}{(0.717)(9.81)} + \frac{v_2^2}{2(9.81)}$$

$$v_2 = 202.4949 \frac{m}{s}$$

$$\dot{m}_{fuel} = v_2 \times A$$

$$A = \frac{\dot{m}_{fuel}}{v_2}$$

$$= \frac{11.9523}{202.4949}$$

$$= 0.0590\ m^2$$

$$\pi j^2 = 0.0590\ m^2$$

$$j = 0.137\ m$$

3.3 PRESSURE REGULATOR FUNCTION

Pressure regulator as in figure 3.2 main function is to regulate pressure from high pressure to low pressure. The most common pressure regulator being used is for stove which is for cooking. It regulates pressure from the storage tank, and then supplies it to a valve that open and close the gas that come out.

Figure 3.2: Pressure regulator

The concept is almost the same as the Natural Gas Vehicle (NGV) system. The difference is the usage of each system. The cooking gas tank has lower pressure compare to the NGV storage tank. The maximum inlet pressure it can obtain is at 6bar where else the maximum pressure for NGV regulator is in the region of 240bar. The difference of value is really big.

The design chosen is to modify the current pressure regulator for cooking into an NGV pressure regulator. The gas flow through the pressure regulator is controlled mechanically by adjusting the screw that hold the spring in between the area of gas flow and the top of the regulator.

Basically, the size of the outlet tube for the pressure regulator can be retain by using the theoretical method. The ideal size using the theoretical method is for the specific flow of the gas through the pressure regulator. To control the flow, which is to increase the pressure out means increase the flow of the gas also. Therefore the adjusting screw purpose is to control it manually according to suitable amount of fuel supply to the mixer needed. Figure 3.3 show the screw adjuster at the pressure regulator.

Figure 3.3: Pressure regulator screw adjuster that control the inlet opening

3.4 PRESSURE REGULATOR DESIGN SPECIFICATION

The pressure regulator consists of several main parts. Each part has its function. Inlet tube in figure 3.4 is where the high pressure enters the pressure regulator. Fuel from high pressure storage tank will flow through this tube to regulate to lower pressure. An adapter is needed to connect the inlet tube because the tube has wall that protect and also to hold it adapter. The wall will hold the adapter tightly and avoid gas to flow beyond the wall. The body of the pressure regulator have 2 part, top and bottom. The top is slightly inserted into the bottom part and each side of the bottom part is clamp toward the top part. If there is any area that is not clamp tightly, it will allowed leakage. And when there is any leakage, pressure will not be regulate thoroughly.

Figure 3.4: Pressure regulator inlet tube for gas inlet

The outlet tube in figure 3.5 is where the gas comes out after being regulated inside the pressure regulator. The ideal size for the outlet can be determined by using the theoretical method. Since the theoretical method is the ideal value, the range for the outlet tube can still be consider. Therefore, the function of screw adjuster is used. Outlet tube shape is designed like stair shape purposely to lock with coupling and also tube lock.

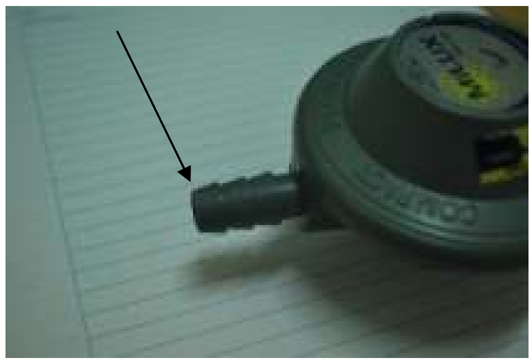

Figure 3.5: Pressure regulator outlet tube for gas outlet

On top of the pressure regulator is the cover as in figure 3.6. It is made of steel and lock by border of the pressure regulator body. Inside the cover is the part where control the flow of the gas through it.

Figure 3.6: Pressure regulator top cover to protect the equipment in it

Inside the cover, the first component is the screw adjuster in figure 3.3. This screw holds a spring below it. It can be adjusted into low or high according to spring response while there is flow through it by using screw driver. Screw adjuster also functions as limitation for the springs to rebound, where it holds the minimum pressure the spring can response on it.

The spring is position below the screw adjuster. Figure 3.7 show how the spring position. Beneath the spring is the part that hold together and response to the flow through it. When the gases enter this pressure regulator, the part below the spring will push the spring up. This spring will response and rebound into the screw adjuster.

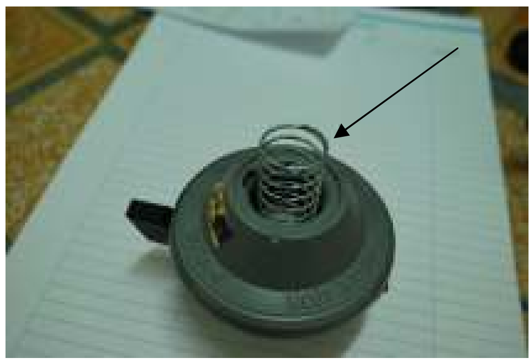

Figure 3.7: Pressure regulator spring that react to flow through it

Inside the top body, below the spring is where the part joins together. It consists of a diaphragm which attach to a screw. The purpose of this rubber diaphragm is to avoid any leakage of gas flowing through to the top. It makes sure the flow is direct through the inlet tube and out through outlet tube only. Any leakage will cause the gas flow value in and out of the pressure regulator to be inconsistent. When the flow enters the inlet tube, the diaphragm will spring back to the spring and hit the spring on top of it. Figure 3.8 is the diaphragm.

Figure 3.8: Pressure regulator diaphragm avoid any leakage of gas that flow through it

Below the rubber cover is a pressure regulator caliper, as in figure 3.9. It holds the screw that attach to the rubber cover. The caliper is join together to the body of the pressure regulator by a pin. This caliper is the first component that contact with the gas that flow through it. The pin connected to the caliper control the limit for the caliper to move up and down. When the gases enter the inlet tube, the caliper will detect the pressure and move the rubber cover that attach together with it upward.

Figure 3.9: Pressure regulator caliper will react as the door for inlet tube

CHAPTER 4

RESULTS AND DISCUSSION

4.1 THEORETICAL RESULT

From the calculation method, the goal is to find the area for the outlet pressure. The final value suitable for the outlet area is $j = 0.137\ m$. When the outlet area determine, the inlet area are also possible to calculate. There are certain condition need to be consider base on the calculation method which suitable for certain parameters only.

The dimensions for the venturi mixer also obtain from the Mach number equation. 10 different Mach number were made as parameters because the shape of venturi is width at both end and have necking at the center. This method can determine the area where the necking starts to grow bigger in dimension. Table 4.1 show the set of resulting data and figure 3.1 in chapter 3 is the venturi that measure..

Table 4.1: Theoretical result data for calculation method

Mach number (M)	Area (m^2)	Radius (m)
1.0	0.779	0.497
0.9	0.962	0.553
0.8	1.218	0.622
0.7	1.591	0.711
0.6	2.165	0.830
0.5	3.119	0.996
0.4	4.873	1.245
0.3	8.663	1.660
0.2	19.493	2.490
0.1	77.975	4.981

4.2 THEORETICAL RESULT DISCUSSION

In the calculation method, the parameters taken are from the engine specification. Therefore, for different type of engine we need to recalculate from the beginning to get the suitable outlet area. This means that for each different engine used, calculation need to start all over again. For example, the bore/stroke value will differ. The maximum speed limit will also differ.

Some value that used in the calculation is not in good accuracy. The theoretical methods only show the way to generate the exact equation to find the value. Values that need to pay close attention to in the Bernoulli equation are the pressure for inlet and outlet.

4.3 EXPERIMENTAL METHOD

Experimental method main purpose is to test and compare the difference between the inlet and outlet pressure value by changing the spring inside the pressure regulator. 2 types of spring will be use. Other component in the pressure regulator will remain standard. Experimental apparatus in this experiment are 10mm diameter hose, adapter and coupling, hose clip, pressure regulator, pressure gauge, and air compressor. The spring inside the regulator will be change to estimate the differences of both springs. Each spring will provide with air at 3bar, 6bar, and 9bar. Compressed air will be use to replace the methane gases.

Pressure gauges in figure 4.1 are among the most often used instruments in a plant. But because of their great numbers, attention to maintenance--and reliability--can be compromised. As a consequence, it is not uncommon in older plants to see many gauges and switches out of service. This is unfortunate because, if a plant is operated with a failed pressure switch, the safety of the plant may be compromised. Conversely, if a plant can operate safely while a gauge is defective, it shows that the gauge was not needed in the first place. Therefore, one goal of good process instrumentation design is to install fewer but more useful and more reliable pressure gauges and switches.

One way to reduce the number of gauges in a plant is to stop installing them on the basis of habit (such as placing a pressure gauge on the discharge of every pump). Instead, review the need for each device individually and install one only if there is a logical answer to the question. If a gauge only indicates that a pump is running, it is not needed, since one can hear and see that. If the gauge indicates the pressure (or pressure drop) in the process, that information is valuable only if one can do something about it (like cleaning a filter); otherwise it is useless. If one approaches the specification of pressure gauges with this mentality, the number of gauges used will be reduced. If a plant uses fewer, better gauges, reliability will increase.

Figure 4.1: Pressure gauge use to measure the pressure

4.3.1 Experimental Procedure

i. Apparatus is set starting from air compressor connected to a pressure gauge. A valve is used to connect the air compressor to the pressure gauge with some coupling and adapter. Purpose of pressure gauge is to measure the inlet pressure.
ii. From here, the compress air will go through the inlet of pressure regulator through a hose. Hose clip use to avoid any leakage.
iii. The outlet of pressure regulator will be connected to another pressure gauge by using a hose and hose clip. The flow will look like diagram below. See also figure 4.2.
iv. Open the valve a bit to check if there is any leakage through the connected hose and coupling. If there is any leakage, the hose and clip need to be adjust.
v. Open the valve and use the first pressure regulator to adjust the pressure at 3bar. Make sure at the end of the hose, the air is flow out from the hose.
vi. Measure the value of the outlet pressure at the second gauge.
vii. Repeat step 5 and 6 by setting the compress to 6bar and 9bar. Then repeat again with different spring.

Figure 4.2: Experimental setup with pressure gauge

4.4 EXPERIMENTAL RESULT

From the experiment, there are 2 type of spring use. A soft and a hard spring. Table 4.2 are the results from the experimental method.

Table 4.2: Experimental results data

Inlet pressure (Bar)	Soft spring (KPa)	Hard spring (KPa)
3	500	>500
6	650	500
9	1000	600

4.5 EXPERIMENTAL RESULT DISCUSSION

Base on the experimental result, the differences between both type of spring can be shown clearly in the graph below.

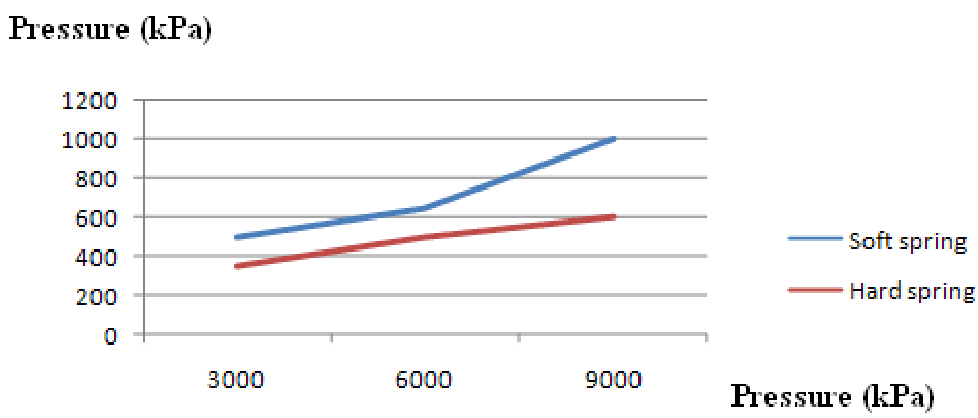

Figure 4.3: Experimental graph result for soft spring and hard spring

Soft spring seems to response well to pressure inlet. From the 3bar inlet pressure flow, the pressure regulator regulates it onto 500kPa. While for 6bar it regulate pressure to 650kPa. For 9bar, the spring seems to regulate it onto 1000kPa. For low pressure, the soft spring shows the consistency to regulate accordingly. But for high pressure such as 9bar, the graph is starting to increase highly.

Meanwhile, the use of hard spring show increasing of outlet pressure at slow rhyme. When 3bar inlet pressure flow through the pressure regulator, it regulate it until below 500kPa which is around 300-400kPa. For 6bar it regulate until 500kPa and 9bar it regulate until 600kPa. The consistency to regulate pressure at high value is suitable for hard spring compare to soft spring.

This experimental have certain problems that need to be improve to achieve better result. The pressure gauge use doesn't have the high accuracy needed, which can be shown in the result of hard spring. The inlet pressure for hard spring of 3bar result in pressure at lower than 500kPa. The gauge accuracy for pressure lower than 500kPa is hard to read. Length of pipe should not be too long, otherwise the pressure flow will not be accurate because long movement through the pipe. Pressure of air trap inside the pipe will also disturb the reading to get the accuracy.

CHAPTER 5

CONCLUSION

5.1 PROJECT SUMMARY

For the conclusion, the project to design of a mechanism to mix biogas with air in compression internal combustion engine achieves the objectives successfully. This project was done around fourteen week included the report**.** Pressure regulator designs are taken from a Liquid Petroleum Gas tank pressure regulator which some modification are made. The pressure regulator is control mechanically, which is by adjusting the screw adjuster.

The redesign pressure regulator can regulate pressure but the value of inlet pressure must be determined first. Practical aspect of using pure biogas to be test will encourage to a more specific details and value. The value for use in calculation method is possible to find as there is shown method on how to get the result. All steps and details are stated clearly.

Steps to producing a true regulator for a vehicle specifically a diesel engine should go through several testing and experimental to get the exact design. Pressure regulator is very important since it regulate high pressure to lower pressure and provide it to the engine. If the amount of fuel flow into the engine is not exact, it can harm and cause engine problem. Any leakage can also bring harm to the passenger and driver.

In theory a stoichiometric mixture has just enough air to completely burn the available fuel. In practice this is never quite achieved, due primarily to the very short time available in an internal combustion engine for each combustion cycle. Most of the combustion process completes in approximately 4-5 milliseconds at an engine speed of

6000 rpm. This is the time that elapses from when the spark is fired until the burning of the fuel air mix is essentially complete after some 80 degrees of crankshaft rotation. Catalytic converters are designed to work best when the exhaust gases passing through them show nearly perfect combustion has taken place. [John, James E., Gas Dynamic]

A stoichiometric mixture unfortunately burns very hot and can damage engine components if the engine is placed under high load at this fuel air mixture. Due to the high temperatures at this mixture, detonation of the fuel air mix shortly after maximum cylinder pressure is possible under high load. Detonation can cause serious engine damage as the uncontrolled burning of the fuel air mix can create very high pressures in the cylinder. As a consequence stoichiometric mixtures are only used under light load conditions. For acceleration and high load conditions, a richer mixture (lower air-fuel ratio) is used to produce cooler combustion products and thereby prevent detonation and overheating of the cylinder head. [John, James E., Gas Dynamic]

In order to be able to judge if an air-fuel mixture has the correct ratio of air to fuel, the stoichiometric air fuel ratio has to be known. If the composition of a fuel is known, this ratio can be calculated rather easily.

5.2 RECOMMENDATIONS

This project of designing a venturi tube is done without practical work or fabrication process. For recommendation, this project should proceed with further analysis and experiment. For example, this design can be tested by using software analysis to get the parameters such as air flow, stiffness and also its suitable dimension.

After analysis using the related software's, the next step can be done is to fabricate the product. This process can be achieve and not impossible because UMP have the machines and guide from staff can help to achieve this goal. Finally, after completing the fabrication process the experiment method to test the product can be made. From experimental method, comparison with software analysis can be made. It also can determine if the analysis from software is true or not.

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