UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OF ELECTRONIC FUEL INJECTOR TESTER FOR EDUCATIONAL PURPOSE

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Automotive Technology) with Hons

By

AUZAI BIN AMIT

B071410406

950329-01-6905

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I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality as a partial fulfilment of Bachelor of Mechanical Engineering Technology (Automotive Technology) (Hons.). The member of the supervisory is as follow:

…….

(Project Supervisor)

ABSTRAK

Laporan ini menerangkan reka bentuk penguji penyuntik bahan api elektronik dan analisis struktur kerangka badannya. CATIA V5R21 digunakan untuk mereka bentuk struktur bingkai badan dan penyambungan penguji penyuntik bahan api elektronik. Dalam bahagian laporan ini turut disertakan reka bentuk termasuk komponen sistem suntikan bahan api dan spesifikasinya. Untuk analisis, perisian solidThinking Inspire telah dipilih untuk menganalisis berdasarkan aplikasi analisis yang diingini. Analisis tekanan, faktor keselamatan dan anjakan akan dikeluarkan untuk menentukan kekuatan bingkai badan penukar penyuntik bahan api elektronik. Berat produk juga diambilkira. Hasil daripada akan ditinjau dan sebelum meneruskan untuk menyelesaikan reka bentuk.

ABSTRACT

This report describes the design of electronic fuel injector tester and its body frame structure analysis. CATIA V5R21 used to design the body frame structure and the assembly of the electronic fuel injector tester. In the part this paper, the design included the fuel injection system components and its specification. For the analysis, the solidThinking Inspire software has been chosen to analyse based on the analysis application. The analysis of stress, factor of safety and displacement will be issued to determine the strength of the body frame of the electronic fuel injector tester. The weight of the product is also taken into account. The result than will be review and before proceed to finalise the design.

DEDICATION

Special dedication to my beloved families especially my strong and gentle parents who taught me to trust in Allah, believe in hard work and that so much could be done with little. A special thanks to my friends and lecturer especially my supervisor who taught me to think understand and express. Without their inspiration and guidance, I would not be able to pass through the tiring and exhausting process of this search.

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Nowadays all modern petrol injection system uses indirect injection. A special pump sends the fuel under pressure from the fuel tank to the engine bay where still under pressure it is distributed individually to each cylinder. Depending on the particular system, the fuel is fired into either the inlet manifold or the inlet port via an injector. This works much like the spray nozzle of a hose, ensuring that the fuel comes out as a fine mist. The fuel mixes with the air passing through the inlet manifold or port and the fuel/air mixture enters the combustion chamber(Enright, 2015).

Some cars have multi-point fuel injection where each cylinder is fed by its own injector. This is complex and can be expensive. It is more common to have single-point injection where a single injector feeds all the cylinder or to have one injector to every two cylinders. The injectors through which the fuel is sprayed are screwed, nozzle-first, into either the inlet manifold or the cylinder head and are angled so that the spray of fuel is fired towards the inlet valve(Pimenta, 2010).

The injectors are one of two types, depending on the injection system. The first system uses continuous injection where the fuel is squirted into the inlet port all the time the engine is running. The injector simply acts as a spray nozzle to break up the fuel into a fine spray - it doesn't actually control the fuel flow. The amount of fuel sprayed is increased or decreased by a mechanical or electrical control unit - in other words, it is just like turning a tap on and off. The other popular system is timed injection (pulsed injection) where the fuel is delivered in bursts to coincide with the induction stroke of the cylinder. As with continuous injection, timed injection can also be controlled either mechanically or electronically.

The earliest systems were mechanically controlled. They are often called petrol injection (PI for short) and the fuel flow is controlled by a mechanical regulator assembly. These systems suffer from the drawbacks of being mechanically complex and having poor response to backing off the throttle. Mechanical systems have now been largely superseded by electronic fuel injection (EFi). This is thanks to the increasing reliability and decreasing costs of electronic control systems.

1.2 Problem Statement

Nowadays, there are certain vehicle face some symptoms due to dirty injector or clogging injector such as lean misfire, rough idle, hesitation and stumbling on light acceleration, a loss of power, and higher hydrocarbon (HC) and carbon monoxide (CO) emissions. These problems mostly being less concentrate for mostly the driver in Malaysia as the process of cleaning the injector may cost them a lot of money. Besides that, there are also issue of convenience to use the fuel injector tester in certain community such as education institute. Some of the problems are:

1 The cost of the fuel injector test machine is too expensive.
2 Students also hardly to understand how the system works.

1.3 Objectives

i. To design of fuel injector tester by using PDS scoring.

ii. To design the fuel injector tester that costing below than RM400.

iii. To design the fuel injector tester that can show the spray pattern.

1.4 Scope

The scope of this project is to develop a complete design of fuel injector tester. The design must be in the cost range which is RM400 and below. The design must be simple but can solve or function very well to achieve the objectives. The design will be start over after getting the optimize printed circuit board (PCB). Then, after completing the final design, it will be send over to be fabricate later.

This project does not cover the design of the injector tester circuit. In addition, this tester is designed only for gasoline fuel injection and for light vehicle only. Besides that, this design can only be use for testing the injector only and the servicing process is not included.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter reviews on the past research which includes the current knowledge including substantive findings as well as theoretical and methodological contributions to this project topic. Literature review is a secondary source and it is the basis for research in almost every academic area. Literature review can also help in making assessments related to the topic or finding a solution to the particular problems.

2.1 History of fuel injection

In 1893, Rudolph Diesel with Augsburg and Krupp try to develop an efficient internal combustion engine. Firstly, they tried to use powdered coal as fuel which they had been accumulating throughout the countryside. In this experiment, they failed as the engine exploded. Finally, they decided to use oil as the fuel and it turned out as success experiment. In that experiment, the oil was mechanically injected into the engine. The results were unsatisfactory, probably because of the crude injection equipment with large dead fuel volume, so that Dr Diesel resorted to using the compressed air equipment available from his coal dust experiments. His first tests with air injection proved so successful that this became the accepted method of injection for many years. Thus, early in the development of this new engine the importance of the fuel injection process on engine combustion was emphasized, and subsequent progress in diesel engine development has been largely dependent upon improvements in fuel injection (DeLuca, 2015).

2.2 Fuel Injection

Fuel injection is a system for mixing fuel with air in an internal combustion engine (Pimenta, 2010). This system provides an overall efficiency of fuel delivery and control of fuel quantity that cannot be achieved with a carburettor. As in a traditional carburettor, fuel is converted to a fine spray and mixed with air. However, where a traditional carburettor forces the incoming air through a venturi to pull the fuel into the air stream, a fuel injection system forces the fuel through nozzle under pressure to inject the fuel into the air stream without requiring a venturi.

On many earlier electronic injection systems (typically through until the early 1990s), the injectors were all opened at the same time (on four cylinder engines), which is referred to as 'simultaneous injection'. With six-cylinder engines the injectors were generally operated in two groups of three injectors; with eight-cylinder engines the injectors were operated in two groups of four; and with 12-cylinder engines there were four groups of three injectors. All of the injectors in a group would open and close at the same time. It was also usual for all of the injectors to be opened twice for every engine cycle, so half of the required quantity of fuel was delivered each time the injectors opened. On these older systems, the injector timing was therefore not perfect because, while one cylinder might have its injector opening when the inlet valve was open, on the rest of the cylinders, the inlet valves would be closed. The injected petrol would therefore be 'waiting' for a short period before it was drawn into the cylinder.

There are five types of fuel injection system which are Mechanical Fuel injection, Central Port Injection, Continuous Fuel Injection, Single Point Injection, Direct Injection and Multi Point Injection. Nowadays, most of the light vehicles use direct injection.

The modern electronic systems that cars are equipped with today utilize a number of sensors to monitor engine conditions. Sensors is basically can be defined as the tools that been used to obtain a data needed before being process and send them to the actuators. In this system, sensors are used to gain data such as quality of intake air, engine speed, engine temperature, idle to full load and intake air temperature. The data obtained than will be process by the Electronic Control Unit (ECU) before being send to the actuator which is fuel injection valves. The sensors that this system use is air flow sensor, engine speed sensor, throttle valve switch, engine temperature sensor and air temperature sensor.

Both sensors and electronic control unit (ECU) is essential to the system to accurately calculate the needed amount of fuel. Thus fuel injection can increase fuel efficiency and reduce

pollution. Basically, based on Figure, fuel injection system normally two sub systems which are electronic system and fuel system. In electronic system, they have three components which are injectors, Electrical components unit(ECU), and sensors while in fuel system they have four components which are fuel pump, fuel filter, fuel pressure regulator and fuel rail.

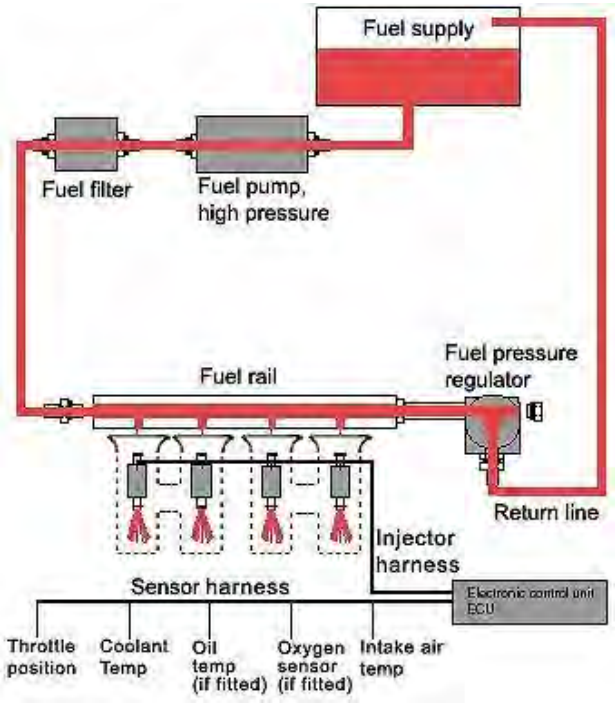

Figure 2.2: Gasoline Fuel Injection System

With modern systems the injectors are usually opened individually in sequence (to match the engine firing order), this is known as sequential injection. The injectors are typically opened just prior to the inlet valve opening. All the required fuel is therefore delivered in one 'opening' of the injector. However, there are occasions where a very large quantity of fuel is required, for example during full load acceleration, where the injectors can be opened twice for every operating cycle (half the fuel quantity is delivered at each opening). Although it is possible to use a signal from the ignition system to trigger sequential injection, many systems use separate sensors to identify one of the cylinders, for example cylinder number, the ECU then uses this signal as a master reference and operates the injectors in sequence at the appropriate times. The sensor is referred to as a 'cylinder identification sensor' or 'phase sensor' which are usually either inductive or Hall effect sensors.

The camshaft rotates once for every engine cycle (while the crankshaft rotates twice), so the cylinder identification sensor is usually located adjacent to the camshaft. Therefore, a single

trigger lug attached to the camshaft could then cause an inductive sensor to provide a single reference signal. Alternatively, a Hall effect rotor attached to the camshaft could have a single 'cut out', thus producing a single reference pulse. A crankshaft speed/position sensor provides the necessary crankshaft angle and speed information. Some systems used a trigger signal provided by a sensor attached to a spark plug lead. The sensor generated a small electrical pulse that was used by the ECU as the master reference signal.

It is claimed that direct injection, when compared with an equivalent engine with port injection, provides a decrease in fuel consumption in the region of 15% to 20%, while engine power is slightly improved. One other benefit is that direct injection systems require very rapid vaporisation of the petrol to enable it to mix quickly with the air. This rapid vaporisation is achieved through the use of high fuel pressures and a special injector nozzle design. Importantly, when a liquid vaporises, it has the effect of drawing heat from the surrounding air, i.e. it cools the surrounding air. Therefore, when fuel is injected into the cylinder, the vaporisation process reduces the temperature of the air in the cylinder, reducing the potential for combustion knock (which can occur if temperatures are too high).

2.3 Fuel Injection Testing Equipment

With the introduction of GDI, Gasoline Direct Injection, over the last few years, there have been developed software & adaptors that allow for the servicing of these expensive to replace the problem injectors. One of them is fuel injection testing equipment. This equipment mainly functions as to test the injector in several test to know the condition of the injector(Cooper, 1981). The tests are pressure test, leak-off test and spray test. This machine contains some components that are same to the real fuel injection system in vehicle such as fuel pump, fuel rail and fuel tank. This machine will be drive by the programmable board which has been programmed to act like the Electronic Control Unit (ECU) to control the whole system of this machine(Lusignan, 1998).

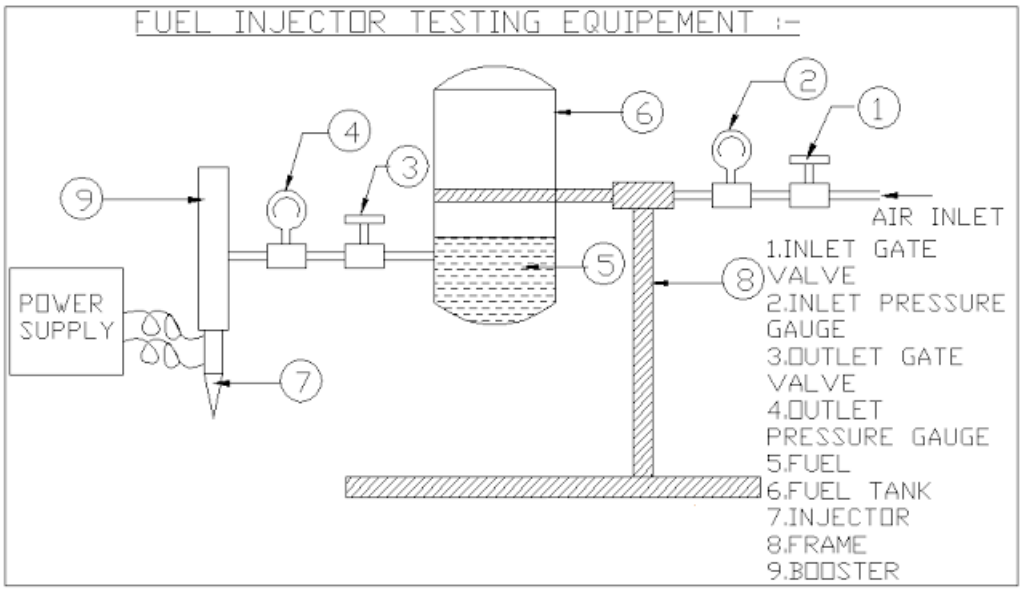

Figure 2.3: Fuel injector Testing Equipment

Based on **Figure 2.3**, the compressed air is given to the input supply of this fuel injector testing equipment. The inlet valve is opened and the inlet pressure is noted down. The fuel tank contains some amount of fuel to conduct the testing operation. The outlet gate valve is opened and the outlet pressure is noted down with the help of outlet pressure gauges. The fuel injector is fitted to the holder with the help of suitable arrangement. The 12V power supply is given to the fuel injector coil. The coil gets energized to open the nozzle hole so that the pressurized fuel sprayed by the injector nozzle. That sprayed pressure is noted to be analyse later.

2.4 Components in Fuel Injection Testing Equipment

The fuel injection system in vehicle are designed to ensure the efficiency of fuel delivery and control the quantity of fuel that could not be achieved with previous system which is carburettor. Fuel Injection Testing Equipment resemble exactly what the injection system in vehicle so that the testing process could be done easily and correctly(Desai, Pawaskar and Manchekar, 2015).

2.4.1 Injector

The injector is an electromechanical device that sprays fuel directly into combustion chamber, which is fed by a 12 volt supply from the ECM. The injector consists of a solenoid operated valve which is held in the closed position by a spring until the earth circuit is completed by the ECM. The injector normally consists of the nozzle, nozzle valve, spring and body as refer to **Figure 2.4.1**. When the electromagnetic field lifts the needle off its seat, fuel is delivered to the engine. The total lift on the needle is approximately 0.15 mm and has a reaction time around 1 millisecond.

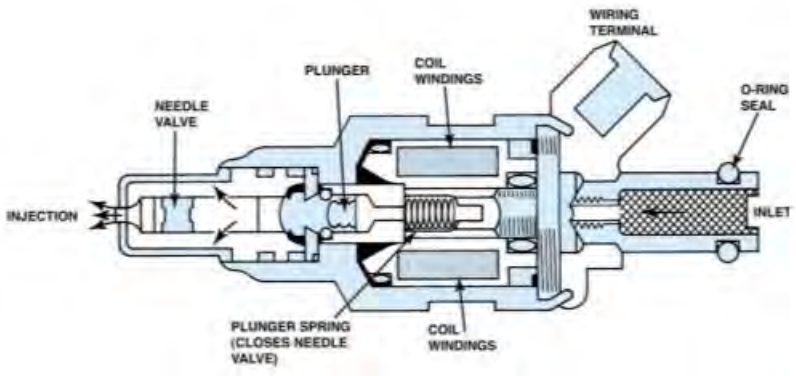

Figure 2.4.1:Injector

2.4.2 Electronic Component Unit (ECU)

An ECU contains a programmed memory, which, in an injection ECU, contains data on how much fuel should be injected under different operating conditions. In vehicle fuel injection system, when information is received from the sensors, the ECU refers to the programmed data and switches on the fuel injectors so that they deliver the required amount of petrol. Meanwhile, in this fuel injector testing machine, the ECU will be the programmable board that have been programmed earlier to act like ECU in vehicle fuel injection system. Below are the example of ECU and programmable board.

Figure 2.4.2.1:ECU

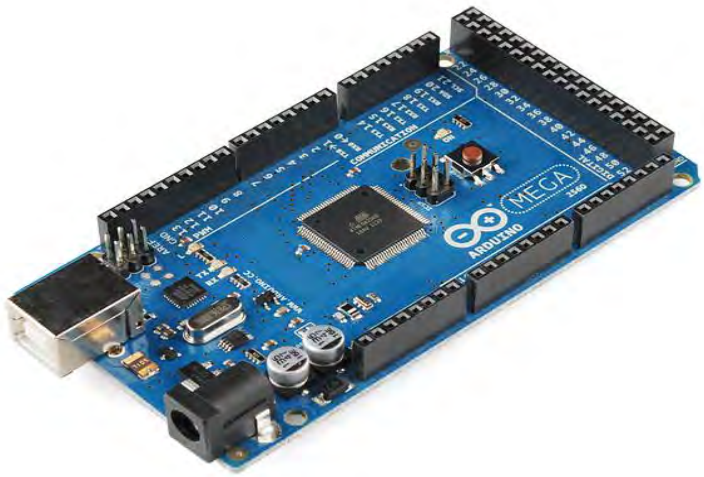

Figure 2.4.2.2: Programmable Board