THE STUDY OF CLOSE-COUPLED VERSUS UNDERFLOOR CATALYST EMISSION FOR PROTON PERSONA 1.6cc

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DECLARATION

I declare that this thesis entitled 'The Study of Close-Coupled versus Underfloor Catalyst Emission for Proton Persona 1.6' is the result of my own research except as cited in the references. The thesis has not been accepted to for any degree and is not currently submitted in candidature any other degree.

Signature	:	....
Name	:	....
Date	:	....

DEDICATION

To my beloved parent and for those who are always supporting me.

ABSTRACT

Time taken to activate catalytic converter of a car has been topic of interest for researcher due to stringent emission regulation. As many years pass through, the time taken for catalytic converter to activate has reduced as the discovery of various technological advancement especially in the era of Industrial Revolution 4.0. One of the technologies that led to improvement of heating on temperature of catalytic converter is by adding a heating element of the exhaust system called ‘Electrically Heated Catalyst’. This technology has been patented and been used on supercar, but not on ordinary vehicle due to cost constraint. This study will involve on the feasibility study of how fast it will heat the catalytic converter, the temperature before and after the installation of electric heated catalyst. The measurement of emission and temperature with or w/out EHC and EHC with air injection system will be recorded and analysed. The expected result would show how efficient this configuration in eliminating the initial time delay for catalyst light off. Based on result obtained, baseline HC emission measurement (without EHC and air injection) for close-coupled catalyst is better than baseline reading for underfloor catalyst, recorded its peak value at 270ppm at first 25 seconds and lowest value is recorded at 12ppm after 450 seconds for HC. While for underfloor catalyst, highest value of HC is recorded at 680ppm during the first 10 seconds and lowest value obtained is 147ppm at 380 seconds operation. For baseline CO emission reading, highest value obtained from close couple catalyst is 4.46% at the first 20 seconds and lowest value of 0.03% at 450 seconds operation. For emission reading with application of EHC and air injection, number of emission is reduced to 141ppm for HC and 6.4% for CO at 130 seconds operation.

ABSTRAK

Jumlah masa yang diperlukan untuk mengaktifkan penukar pemangkin kereta telah menjadi topik hangat para penyelidik oleh kerana peraturan pelepasan gas dari kenderaan yang telah diperketatkan. Sejak bertahun lalu, masa yang diperlukan untuk penukar pemangkin beroperasi semakin berkurangan dengan penemuan pelbagai kemajuan teknologi masa kini terutamany adalam era Revolusi Industri 4.0. Antara salah satu teknologi yang mampu meningkatkan suhu pada penukar pemangkin adalah dengan menggunakan teknologi pemangkin pemanas elektrik. Teknologi ini telah diguna secara meluas pada kenderaan berkuasa tetapi tidak digunakan pada kenderaan harian biasa akibat daripada kos pembuatan yang mahal. Kajian dalam projek ini melibatkan berapa cepat masa yang diperlukan penukar pemangkin untuk mencapai suhu ia bertindak tanpa atau dengan adanya penggunaan pemangkin pemanas elektrik pada kereta. Gas yang terhasil dari kereta tanpa atau termasuk pemangkin pemanas elektrik akan direkod dan dianalisis. Jangkaan keputusan dalam projek ini akan memaparkan kadar kebolehupayaan pemangkin pemanas elektrik dalam menghapus kelewatan penukar pemangkin untuk berfungsi sepenuhnya. Berdasarkan bacaan yang diperoleh, pengukuran pelepasan HC (tanpa EHC dan suntikan udara) untuk pemangkin rapat (CCC) adalah lebih baik daripada bacaan bacaan untuk pemangkin bawah lantai (Underfloor catalyst), mencatatkan nilai tertinggi pada 270ppm pada seawal 25 saat operasi dan nilai terendah dicatatkan pada 12ppm selepas 450 saat operasi. Untuk pemangkin bawah lantai, nilai tertinggi HC direkodkan pada 680ppm dalam tempoh 10 saat pertama dan nilai terendah yang diperoleh ialah 147ppm pada 380 saat operasi dijalankan. Untuk bacaan pelepasan CO asas pula, nilai tertinggi yang diperolehi daripada pemangkin pasangan rapat ialah 4.46% pada 20 saat pertama dan nilai terendah 0.03% pada 450 saat dijalankan. Untuk bacaan pelepasan dengan penggunaan EHC dengan suntikan udara, jumlah pelepasan dikurangkan kepada 141ppm untuk HC dan 6.4% untuk CO pada operasi 130 saat.

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LIST OF ABBREVIATION AND SYMBOL

No	Abbreviation/Symbol	Meaning
1	EHC	Electric Heated Catalyst
2	ECU	Electronic Controller Unit
3	DOHC	Double Over Head Cam
4	cc	Cubic centimetre
5	kW	Power, in kilowatt
6	HP	Power, in horsepower
7	Nm	Torque, in Newton meter
8	CVT	Continuous Variable Transmission
9	HC	Hydrocarbon
10	CO	Carbon Monoxide
11	O_2	Oxygen
12	°C	Temperature, in Celsius
13	ppm	Part per million
14	CCC	Close-coupled Catalyst

CHAPTER 1

1. INTRODUCTION

1.1. Project Background

To meet the future emission standard that structured by the international organisation, a modified catalytic converter is needed to achieve emission effectiveness produced by vehicles on the road. As the number of cars are increasing year by year, the rate of pollution in the air is reaching at critical level. As has been mostly discussed in the past, the heated catalytic converter seems to be the best solution to attain standard regulation of vehicle's emissions.

The usage of electrically heated catalyst is widely used in a high-performance car while in normal, daily-drive car the technology is not applied. In 1995, Alpina, a performance company for BMW model had introduced the first model of electric heated catalyst. This technology can be found on one of their model, Alpina B12 and can be found also in Toyota MRR2. For now, it is believed that most of average car on the road in not equipped with this technology. Thus, it is a satisfactory solution to equipped this electrically heated catalyst in a normal car because this kind of car is the most seen on the road.

Figure 1.1: Alpina B12

Although the development of electrically heated catalyst shows great result especially in vehicles emissions, but the durability and electrical energy required are still lacking. Researchers had run many years of test and experiment to make the heating element more reliable.

Catalytic converter is a device that control exhaust gas emission. Internal combustion engine produces a high pollution gas but with the aided of catalytic converter, it converts the gases into a less polluted gases. Catalytic converter is used and fitted in a car to comply with standard regulation of emission. This catalytic converter is equipped for both petrol and diesel engine cars.

Years by years, researcher has find so many ways to improve the catalytic to meet emission standard regulation. One of it is by installing an electric heater catalyst on the exhaust system and most of the catalyst is installed before the engine gas flow enter the catalytic converter. Electric heated catalyst is seeming to be a new way to overcome emission problem especially during cold-start. The electrified heating element will be powered either by secondary battery or just using the available resources. Temperature of the exhaust system in the early stage of cold stage will be higher than the temperature of exhaust system that is not equipped with this electric heated catalyst. Bear in mind that this kind of technology is only applicable for high-end cars and not in normal daily cars that people drive. Thus, the idea to equip this technology into average car is good and brilliant idea.

1.2. Problem Statement

The concern about environment pollution has driven people or organization about global warming and harmful effect of gases. This has pushed researcher to make invention that will help to reduce pollution of air. Cars is main the reason that air is polluted. Many years pass through, number of cars on the road keep increasing which by means may affect the quality of air because the gases that it produces.

During cold start, cars produces high pollution of gases and one of the gas is hydrocarbon. The reason of the high level of hydrocarbon is due to the catalytic converter that yet is not activated. For average car, it took at least 4 and a half minutes to activate it because in the early when the engine is started, the temperature of the exhaust system is low, and the catalytic converter is not working yet. Thus, that is the reason of why the level of gases is so high during cold start.

To solve this problem, an electric heater is created but there is another problem that need to consider, power supply. To run the electric heater, the task is to determine the least power that able to operate the electric heater and what is the most suitable power source that can be used from a car.

With the invention of this technology, it is hopefully that this technology can be equipped to normal daily car and consume less pollution to the air.

1.3. Objective

The objective that need to be achieved within this project are:

- To integrate E-Heater and air assisted injection system for emission measurement
- To design and calibrate E-Heated Catalyst and air assisted exhaust aftertreatment.
- To perform engine performance and emission measurement before and after e-heater and air injection system calibration.

1.4. Scope of Project

The scopes of project are as follow:

i. The car that will be involved in this project is Proton Persona 2016, with 1.6 litres engine.

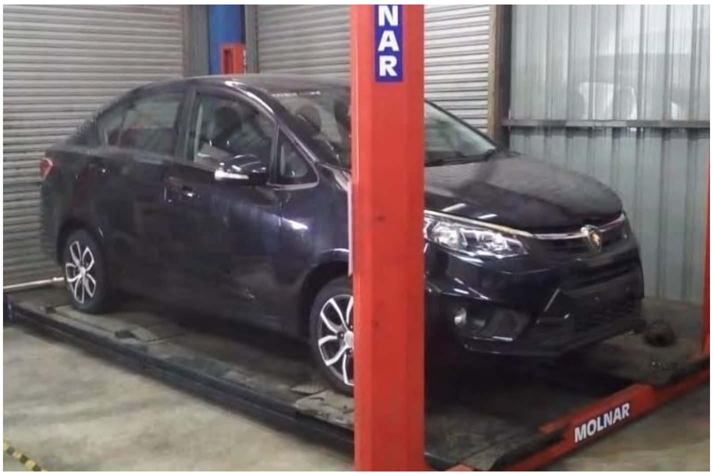

Figure 1.2: Proton Persona 1.6

ii. The electric heater is made from Emitec, model e-7710768-01.

Figure 1.3: Electric Heated Catalyst model e-7710768-01

iii. 4 unit of lambda sensors.

Figure 1.4: Lambda sensor

iv. EMS Gas Analyser

Figure 1.5: EMS Gas Analyser

v. Thermographic camera, model a655sc

Figure 1.6: FLIR model a655sc

vi. Thermocouple

Figure 1.7 : Exhaust gas Temperature Sensor Thermocouple, K Type

vii. Data logger

Figure 1.8 : Data Logger

viii. Air Injection System

Figure 1.9 : Secondary Air Injection System

CHAPTER 2

2. LITERATURE REVIEW

2.1. Catalytic Converter

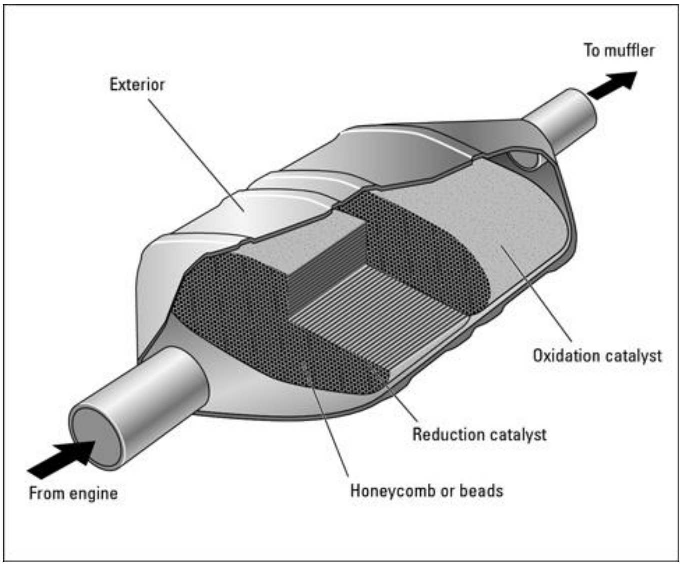

Figure 2.1: Catalytic Converter Internal

Internal combustion engine involving chemical process thus promoting air pollution. Approximately 30% of the total energy produced from engine is used to drive vehicle, 30% used by cooling system and remaining 40% released as heat through exhaust system [Su et. al 2013]. Catalytic converter is one of the efficient method, widely used in vehicles to overcome exhaust emission problem. Catalytic converter acts by converting harmful gases coming out from the engine such as Hydrocarbon (HC), Carbon Monoxide (CO), and Nitrous of Oxides (NOx) to a less harmful gases, Carbon Dioxide (CO_2), Nitrogen (N_2) and Oxygen (O_2) [Pardiwala et. al 2011]. Catalytic converter in fitted in exhaust system, between exhaust manifold and exhaust muffler. In most vehicle, they use either an underfloor three-way catalytic converter or close-coupled catalyst to reduce exhaust gas emission. Since close-coupled catalyst is positioned near with engine to reduce temperature drop while gases are flowing through the exhaust, thus close-coupled catalyst is more beneficial than underfloor three-way catalyst.

Figure 2.2: Close-coupled Catalytic Converter (Left) and Underfloor Catalytic Converter (Right)

The catalytic converter consists of 2 ceramic blocks. The first block is made from Platinum and Rhodium, Platinum and Palladium for second block. Inside catalytic converter, there are process of reduction and oxidation. Reduction process occurred on the second ceramic block while oxidation process occurred on the second ceramic block [Mukherjee et. al 2016]. Table below show conversion on gas emission through oxidation and reduction process.

Table 2.1: Oxidation process

$C_xH_{4x} + 2\times O_2$	$\rightarrow$	$xCO_2 + 2\times H_2O$
$2\times CO + O_2$	$\rightarrow$	$2\times CO_2$

Table 2.2: Reduction process

$C_xH_{4x} + 2\times O_2$	→	$xCO_2 + 2\times H_2O$
$2\times CO + O_2$	→	$2\times CO_2$
$2NO_x$	→	$N_2 + xO_2$

The activation of catalytic converter is highly depending on temperature. They will only operate when certain value of temperature is achieved. Catalytic converter can also age within time. When catalytic converter started to age with time, it will cause both reduction and oxidation process to be less react and less efficiency [Almeida et. al 2014]. Higher operation temperature of catalytic converter decreases storage capacity for oxygen and reducing conversion efficiencies, therefore, affecting its performance and increasing exhaust gas emission.