Faculty of Mechanical Engineering

UTILIZATION OF ELECTRICAL HEATER UNIT AND SECONDARY AIR INJECTION INTO UNDERBODY CATALYST FOR REDUCTION OF EXHAUST GAS EMISSION

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UTILIZATION OF ELECTRICAL HEATER UNIT AND SECONDARY AIR INJECTION INTO UNDERBODY CATALYST FOR REDUCTION OF EXHAUST GAS EMISSION

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A thesis submitted

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DECLARATION

"I hereby declare that the work in this whole report is my own except for the summaries and quotations which have been duly acknowledged"

Signature : …….

Author : Raja Nazirul Mubin Bin Raja Ismail

Date : …….

SUPERVISOR APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Mechanical Engineering (with Honours).

Signature : ……

Supervisor Name : Associate Professor Dr. Noreffendy bin Tamaldin

Date : ……

DEDICATION

To my beloved family

To a very supportive and respected supervisor

To UTeM staff

&

To my friends

ABSTRACT

Exhaust gas emission plays an important role in maintaining the index of clean air and human health. It is important to reduce the emission of these harmful gases such as hydrocarbon (HC), carbon monoxide (CO) and nitrogen oxide (NOx). In that matter, it is believed that most of these gases comes from emission of automobile exhausts and factories as a product of engine combustion. The implant of three ways catalyst somewhat helps in reducing toxic gases emission by converting them into less toxic gas such as nitrogen gas (N_2), carbon dioxide (CO_2) and water (H_2O) droplet. The catalytic converter takes into effect once it reaches the light-off temperature around 450K. As it takes sometimes before the catalytic converter to reaches its light-off temperature for effective conversion of toxic gases, a few alternatives had been made including bringing catalytic converter closer to the exhaust manifold so that it can exploit hot gas emitted from the engine, installation of secondary air system to enrich oxygen gas, O_2 content for facilitating HC burning and the use of electrically heated element (EHC) to speed up catalyst activation time. The use of EHC to reduce the time taken for the catalytic converter somehow seems one of the best alternatives as it can supply an instant heat to the catalyst for activation before the work changes to the heat supply by the exhaust gas temperature emitted from the engine combustion. However, placing catalyst further from the combustion chamber outlet and the blow of air from secondary air injection system had reduce the exhaust gas temperature and causing a longer the light-off

time thus reduce the heat received by the catalyst for catalyst activation. Further optimization is needed to improve the efficiency of EHC in term of time and temperature so that the exhaust emission meets the current regulated emission standard.

ABSTRAK

Pelepasan gas ekzos berperanan penting dalam mengekalkan indeks kebersihan udara dan kesihatan manusia. Harus diketahui bahawa sangat penting untuk mengurangkan pelepasan gas yang berbahaya seperti hidrokarbon (HC), karbon monoksida (CO) dan nitrogen oksida (NOx). Oleh yang demikian, penghasilan gas-gas ini dipercayai berpunca dari ekzos-ekzos kenderaan dan kilang-kilang hasil daripada pembakaran di dalam enjin. Pemasangan 'three ways catalyst' (TWC) dilihat dapat membantu dalam mengurangkan pelepasan gas-gas berbahaya dengan menukarkan gas-gas ini kepada yang kurang berbahaya seperti gas nitrogen (N_2), karbon dioksida (CO_2) dan titisan air (H_2O). 'Catalytic converter' ini hanya akan berfungsi apabila mencapai suhu pengaktifannya sekitar 450K. Memandangkan tempoh masa yang panjang diperlukan sebelum 'catalytic converter' mencapai suhu pengaktifan, beberapa alternatif telah dibuat termasuklah mendekatkan 'catalytic converter' dengan manifold ekzos supaya suhu gas tinggi yang keluar dari enjin hasil dari pembakaran dapat dimanfaatkan, pemasangan sistem udara kedua untuk memperkayakan kandungan gas oksigen,, O_2 bagi kemudahan pembakaran HC dan juga penggunaan 'electricaly heated catalyst' (EHC) untuk mengurangkan jangka masa pengaktifan pemangkin. Penggunaan EHC dilihat sebagai salah satu alternatif terbaik memandangkan EHC dapat membekalkan haba dengan kadar segera kepada pemangkin sebelum tugas memanaskan pemangkin beralih kepada haba yang terhasil dari pembakaran dalam enjin. Walaubagaimanapun, meletakkan

pemangkin lebih jauh dari salur keluar ruang pembakaran dan tiupan angin oleh sistem suntikan angin kedua telah mengurangkan suhu gas ekzos dan menyebabkan tempoh yang lebih lama diambil untuk pemangkin mencapai suhu pengaktifan. Pengoptimuman selanjutnya diperlukan untuk meningkatkan kadar kecekapan EHC dari segi masa dan suhu supaya pelepasan ekzos memenuhi piawaian pelepasan semasa yang terkawal.

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LIST OF ABBREVIATIONS

^{o}C	-	Degree Celsius
^{o}F	-	Degree Fahrenheit
GDI	-	Gasoline Direct Injection
EHC	-	Electrical Heated Catalyst
TWC	-	Three Ways Catalyst
CCC	-	Close Couple Catalyst
mK	-	Millikelvin
ms	-	Millisecond
ppm	-	Part per million
HC	-	Hydrocarbon
CO	-	Carbon Monoxide
NOx	-	Nitrogen Oxide
CO_2	-	Carbon Dioxide
N_2	-	Nitrogen gas
O_2	-	Oxygen gas
MΩ	-	Mega Ohm
mV	-	Millivolt
μm	-	Micrometre

CHAPTER 1

INTRODUCTION

1.1. Background Research

Exhaust gas emission standard had become stricter from day to day thus require a more efficient of harmful gases converter and lower exhaust greenhouse gases emission from vehicle (Chang, Chen, Koo, Rieck, & Blakeman, 2014). USA and Europe legislature future target requirement of exhaust emission reduction by motorcar pushes automobile industry to unstoppably refine the current technology (Pfalzgraf et al., 1995). High technology engine comes with higher fuel efficiency manage to decrease the emission of toxic gases (Chang et al., 2014). This system controlling the gases emission demand needs of catalyst to operate smoothly under cold start and normal condition operation at low temperature (Chang et al., 2014). A good and high-quality exhaust system plays an importance role in producing a high-performance vehicle with low emission. In addition, the performance of the converter during cold starts influenced by exhaust gas transition with electrically heated catalyst, secondary air injections and gasoline burner installation are a few options available alternative to do the work (Powertrain-india, 2016). A high reduction of exhaust gas during cold start of an engine is an indicator of exhaust with high quality emission system.

An electrically heating catalyst is the appliance that was introduce as a heating element that help to reduce exhaust gas reduction during cold start. It helps in burning of hydrocarbon gas to achieve optimum performance.

1.2. Problem Statement

Cold start is one of the main problems occur in nowadays vehicle as the catalytic converter require high temperature before reaching its light-off temperature. The gas emitted from the exhaust consist of hydrocarbon (HC), carbon monoxide (CO) and nitrogen oxide (NOx) which were harmful to the environment as it still not being treated and filtered by catalytic converter that was less functional below its light-off temperature. These untreated gases will cause pollution and not good for human health. There are several designs produced to improve the light-off temperature including by bringing the catalyst closer to the engine so that it can exploit higher exhaust gas temperature.

1.3. Objectives

1. To evaluate E-heater power requirement and recommend suitable placement position along the exhaust system.
2. To design and develop air assisted system to support E-heater application in exhaust.
3. To perform engine performance and emission measurement before and after E-heater air injection system.

1.4. Scopes

1. Emitec e-heater limited to its power specification up to maximum 10V and 300 Amp
2. The position of air assisted will be limited within the existing exhaust system which provide simple mechanism for air assisted.
3. The engine performance and emission will be performed on a 1.6 litre Proton Persona gasoline engine.

CHAPTER 2

LITERATURE RIVIEW

This section will describe about the previous founding related to the title of studies. The source of references can be from any trusted party including video illustration.

2.1. THREE WAYS CATALYST (TWC)

TWC is a catalyst used to reduce of Hydrocarbon (HC), Carbon Monoxide (CO) and Nitrogen Oxide (NOx) emitted from exhaust (Chang et al., 2014).

Three way catalyst (TWC), Figure 1, is a device used as a converter of toxic gas produced during engine combustion into less toxic gas (Sankararaj, 2013). The reaction occurs in TWC convert Hydrocarbons (HC), Carbon Monoxide (CO) and Nitrogen Oxide (NOx) into less harm element likes water (H_2O), Nitrogen gas (N_2) and Carbon Dioxide (CO_2) (Sankararaj, 2013).

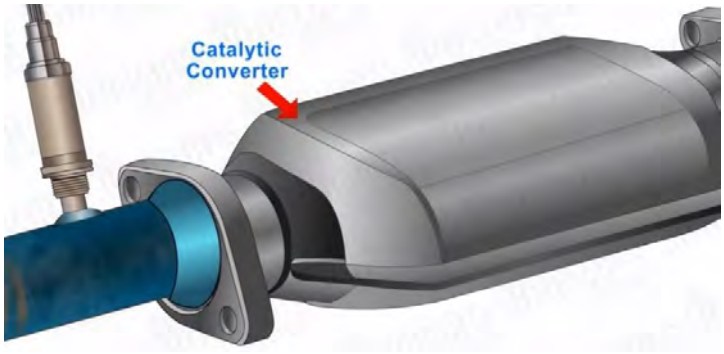

Figure 1 Three Ways Catalytic Converter ("How Car Exhaust System Works," 2013)

TWC consist of two ceramic blocks of micro ducts with platinum (Pt) and rhodium (Rh) is at the first ceramic block called as reduction catalyst followed by platinum (Pt) and palladium (Pd) at the second ceramic block as the oxidation catalyst shown in Figure 2 (Sankararaj, 2013).

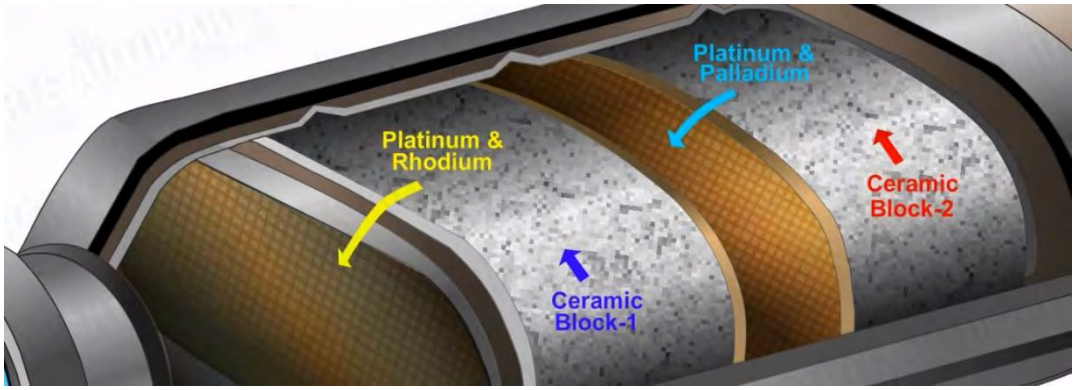

Figure 2 Two Ceramic Blocks ("How Car Exhaust System Works," 2013)

The exhaust gases carrying harmful gas entering the first block causing the catalyst to react with nitrogen oxides that pass through it (Sankararaj, 2013).

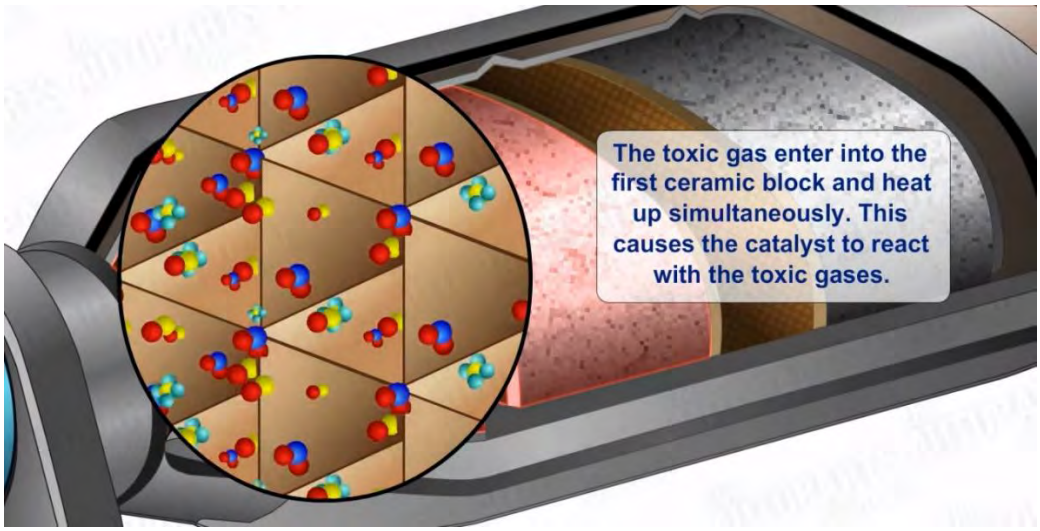

Figure 3 First Block Reaction ("How Car Exhaust System Works," 2013)

The reaction of nitrogen oxide with catalyst producing nitrogen gas, N_2 and oxygen gas, O_2, Figure 4 (Sankararaj, 2013).

$$2NO_2 \rightarrow N_2 + 2O_2.$$

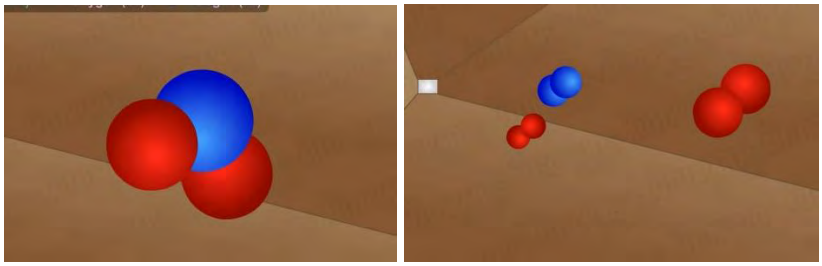

Figure 4 Reaction in first Ceramic Block ("How Car Exhaust System Works," 2013)

The reacted gases, N_2 and O_2 along with the other gases CO and HC were then exit first ceramic block and being sent to second ceramic block of oxidation catalyst containing platinum (Pt) and palladium (Pd) (Sankararaj, 2013).

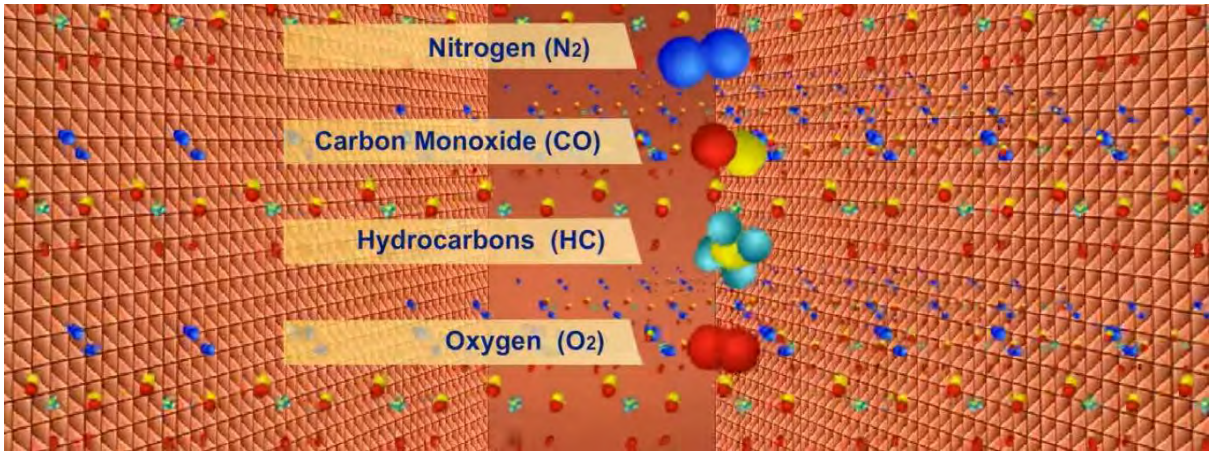

Figure 5 Gases Enter the Second Ceramic Block ("How Car Exhaust System Works," 2013)

The reaction of carbon monoxide, CO and oxygen gas,O_2, Figure 6 taken place inside the oxidation catalyst block producing carbon dioxide, CO_2 (Sankararaj, 2013).

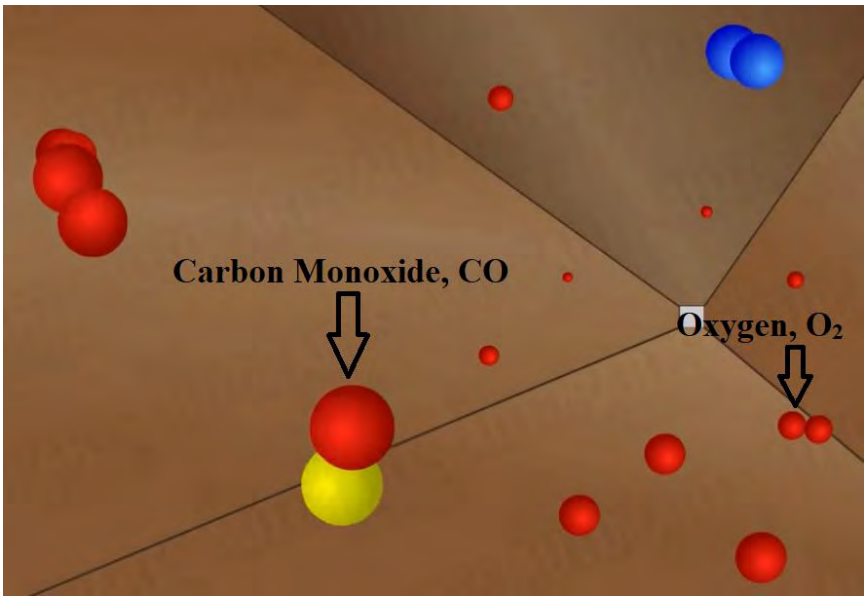

Figure 6 CO and O_2 Reaction ("How Car Exhaust System Works," 2013)

The reaction takes place producing CO_2 as shown in Figure 7.

$$2CO + O_2 \rightarrow 2CO_2$$

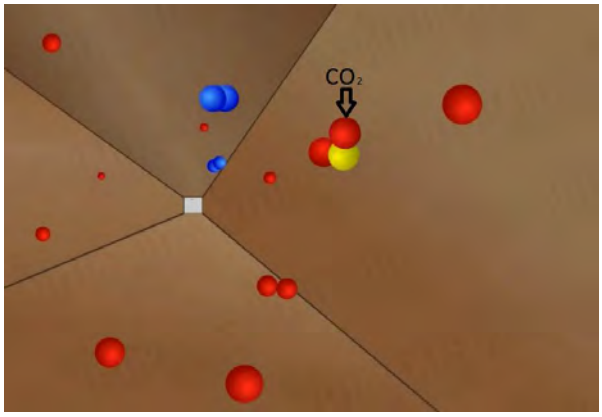

Figure 7 Carbon Dioxide Produced ("How Car Exhaust System Works," 2013)

Hydrocarbon, HC that pass through second ceramic block also under go reaction with O_2 as shown in Figure 8 (Sankararaj, 2013).

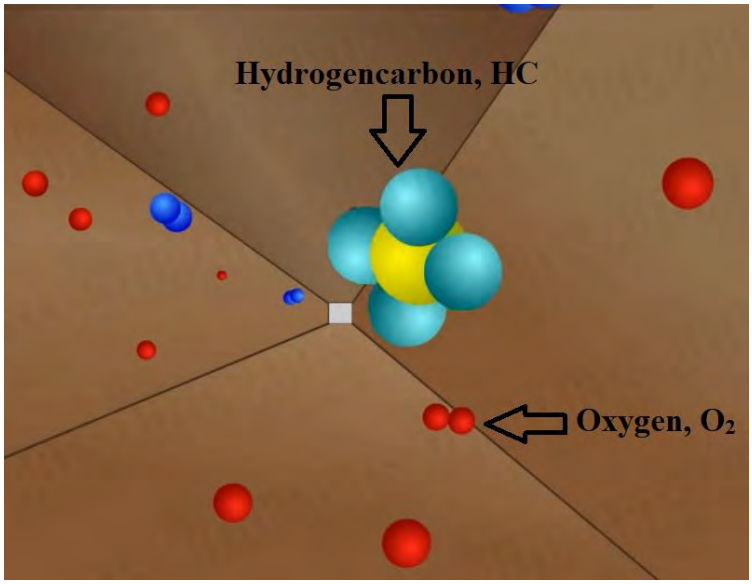

Figure 8 Hydrocarbon Reaction ("How Car Exhaust System Works," 2013)

This reaction thus producing water and carbon dioxide, Figure 9.

$$HC + O_2 \rightarrow H_2O + CO_2$$

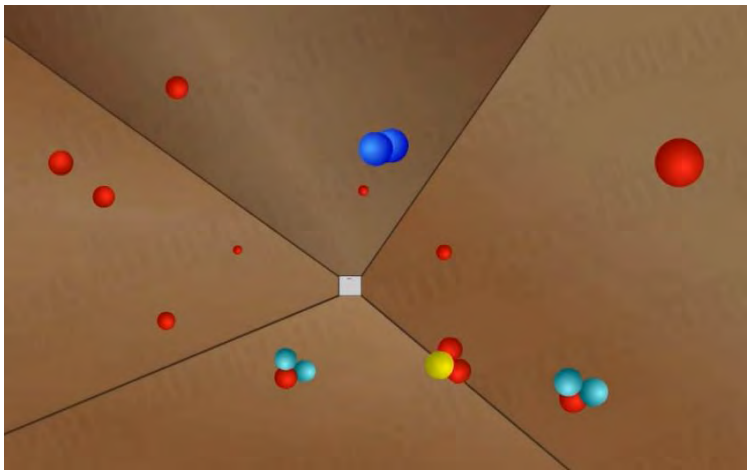

Figure 9 Formation of H_2O and CO_2 ("How Car Exhaust System Works," 2013)

At the end of the process occur inside the TWC, the less toxic gases was produced. Those gas are CO_2, N_2 and H_2O as illustrated in Figure 10 (Sankararaj, 2013).