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Calculation of Exhaust Gas Heat Produce for Ron 95, Ron97 and Vpower Racing Base Fuels use in Internal Combustion Engines

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ABSTRACT:

The purpose of this study is to identify and analyse the calculation of exhaust gas heat produce (EGHP) in internal combustion engine (ICE) based on three types of fuel used specifically Petrol Ron 95, Petrol Ron 97 and Vpower racing base. The experimental test rig has used 1.6 CamPro Proton engine with 1561cc capacity and dynamometer. The calculation has used the basic formula of heat transfer equation and heat loss through the exhaust that included the mass flow rate of exhaust gas, specific heat of exhaust gas and temperature gradient. The exhaust temperature of ICE is generally in range from 400°C to 600°C and exhaust gas heat transfer affects the emissions burn-up in the exhaust system. This contributes significantly to the engine requirement. The experimental data was statistically analysed to identify the unknown parameter. High correlation of data variables can be determined based on the heat loss produced or EGHP. This also has significance by using different types of fuel in ICE.

KEYWORDS:

Exhaust gas; Heat produce; Internal combustion engine; Fuel system; Proton engine

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1. Introduction

Around 90% of Malaysia's electricity generation depends on fossil fuel such as coal, oil and natural gas [3-4]. Prediction reported that around 82% of electricity was generated by fossil fuels in 2015 [3, 5]. Burning fossil fuels, mostly hydrocarbon oil and coal, produces a large amount of air pollutants. The air pollutants are harmful to global environment. The increasing risk of global warming and climate change has increased more stringent policy and debate of world global environment issues [5-6]. For this time and future, this take times to look into the solution of energy crisis, created by fossil fuels without changing the climate behaviour. Geographically, Malaysia is situated in region of tropical and humid climate, which delivers easy access to a diversity of renewable energy sources. The government of Malaysia has initiated renewable energy policies to encourage industries and individuals to employ renewable energy powered system in power application [7]. Looking to the future, Malaysia's main demand for energy is expected to triple by 2030 [1], reflecting growth in living standards. Most of the growth in energy consumption is expected to come from fossil fuel consumption, which has raised concern about the effect of Malaysia's growth on the environment [7-8].

Exhaust Gas Heat Produce (EGHP) uses similar concept as the thermodynamics cycle a steam power plant [2, 9, 10] (Figs. 3 and 4). The steam power plant continuously converts the energy stored in fossil fuels (coal, oil, natural gas) or fossil (uranium, thorium) into shaft works and ultimately into electricity [11]. Stijepovic et al [12] have studied the organic Rankine cycle system and compared with conventional cycle, including the prospect of generating power from low temperature heat sources. EGHP is a guideline for researcher to make improvement in heat source, especially for Internal Combustion Engine (ICE) technology. Many of the EGHP or organic Rankine cycle research reports the solution of the organic fluids as the main issue in the organic Rankine cycle application for particular heat source [2-13]. In ICE only about 1/3 of the fuel combustion energy is converted into useful work to drive the vehicle and its accessory loads [14-15]. Nearly 40% of heat energy is wasted with engine exhaust gases [16]. If the waste heat of an ICE is mainly from exhaust gas, the engine cooling system can be recovered and the engine efficiency will be improved [17]. Furthermore, global warming will be decreased due to better engine efficiency.

2. Methods

The EGHP is calculated as a function of both the temperature and the mass flow rate of exhaust gas using,

$$\dot{Q}_E = \dot{m}_E \times Cp \times \Delta T \quad (1)$$

Where $\dot{Q}_E$ is the heat loss through the exhaust (kJ/s or kW). $\dot{m}_E$ is the mass flow rate of exhaust gas (kg/s), *Cp* is the specific heat of exhaust gas (kJ/kg°C), Q_E is the rate of net heat transfer into or out of the control volume and ΔT is the temperature gradient (°K). Most often, the energy balance relation is used for steady-flow system [18]. For a steady-flow system with one inlet and one exit, the rate of mass flow into the control volume must be equal to the rate of mass flow out of it. When the changes in kinetic and potential energies are negligible, which is usually the case, and there is no work interaction, the energy balance for such a steady-flow system reduces. The exhaust temperature of ICE is generally in range of 400°C-600°C and exhaust gas heat transfer effect emissions burn-up in the exhaust system and it contributes significantly to the engine requirement [19-21]. Engine and dynamometer specifications are given in Table 1. The experiment was carried out at Automotive Lab Engg., UiTM, Shah Alam. Fig. 1 shows the test setup of 1.6 CamPro Proton engine. The experiment is focussed on using three types of fuel namely Petrol Ron 95, Ron 97 and Vpower racing base.

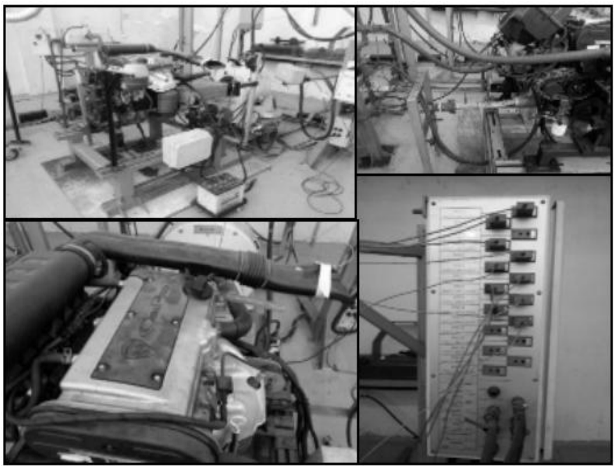

Fig. 1: Test setup of 1.6 CamPro Proton ICE and dynamometer

Table 1: 1.6 CamPro Proton ICE & dynamometer specifications

Name	Specification
Engine capacity	1561cc
Compression ratio	10:1
Valve mechanism	16-Valve DOHC
Bore	76mm
Stroke	73.4mm
Max output (/rpm)	82 kW/6000
Max torque (/rpm)	148 Nm/4500
Density fuel (Ron 95,Ron 97 and Vpower racing base)	0.725-0.780
Density air fuel	1.167kg/m^3

3. Results and discussions

Table 2 shows the calculated EGHP percentages based on the experiments using fuel Ron 95, Ron 97 and Vpower racing base fuel. The Table shows that value of heat produce or heat loss through the exhaust (kJ/s) by comparison with power (kW) and output (rpm) to describe the performance of automobile engines [19-21]. Fig. 2 shows the graphs of heat loss and power versus the exhaust temperature outlet from ICE 1.6 CamPro proton engine dynamometer test rig setup for different fuel types used. Fig. 3 shows the heat loss and power versus output in rpm performance of ICE 1.6 CamPro proton engine dynamometer based on three types of fuel. Fig. 4 shows the overall EGHP by percentage heat loss versus heat produce and based on Petrol Ron 95, Ron 97 and Vpower racing base fuels.

Table 2: Result calculation EGHP base fuel Ron 95

N (rpm)	Power (kW)	base fuel Ron 95		base fuel Ron 97		Vpower base fuel	
		Q_E (kJ/s)	% Heat prod.	Q_E (kJ/s)	% Heat prod.	Q_E (kJ/s)	% Heat prod.
1499	15.9	9.74	36.97	8.24	33.16	9.08	36.35
2003	21.8	13.50	37.09	11.92	34.23	13.17	37.67
2494	31.0	18.10	36.72	16.88	35.10	18.55	37.44
2997	33.5	23.66	41.32	22.89	40.52	24.62	42.36
3509	42.3	30.65	41.17	30.31	40.90	31.75	42.88
4008	51.7	38.86	43.10	39.11	43.26	40.26	43.78
4501	57.6	45.06	43.85	45.55	44.12	46.34	44.59
4997	58.9	49.99	45.78	50.28	45.93	50.85	46.33
5495	64.5	56.54	46.71	56.92	46.88	57.40	47.09

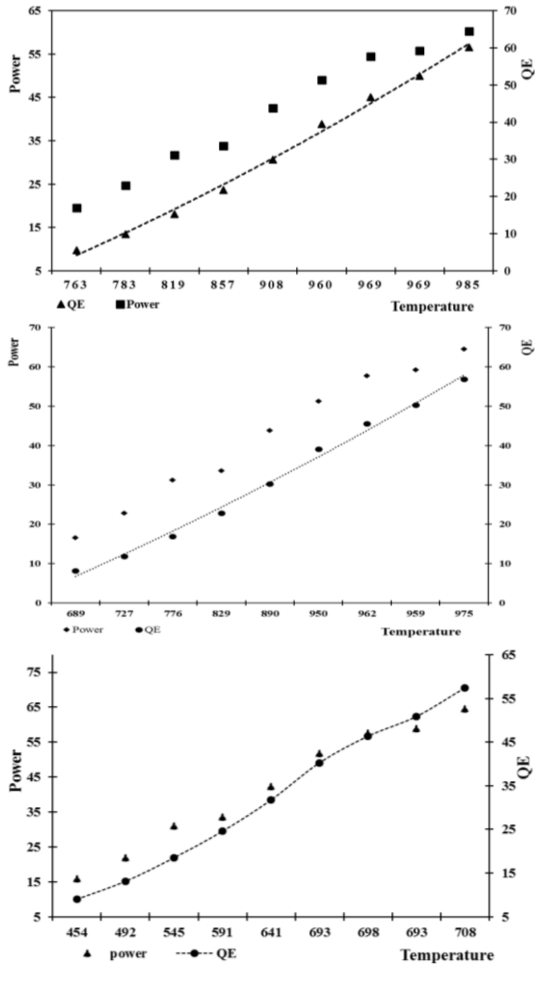

Fig. 2: Heat loss and power vs. Exhaust temperature outlet, Fuel types – Ron 95 (top), Ron 97 (middle) and Vpower (bottom)

From Zukarnian Zakaria and Hishamudin Md. Som (2001), to find the free correlation effect from another variable, partial correlation is the best way for any ordinal data analysis [22]. Table 5 shows the statistical analysis of partial correlations on the measured value of heat loss or EGHP between each other fuels. It shows that there is a high correlation of data variables, i.e. within the range (0.90-1.00) between the two variables.

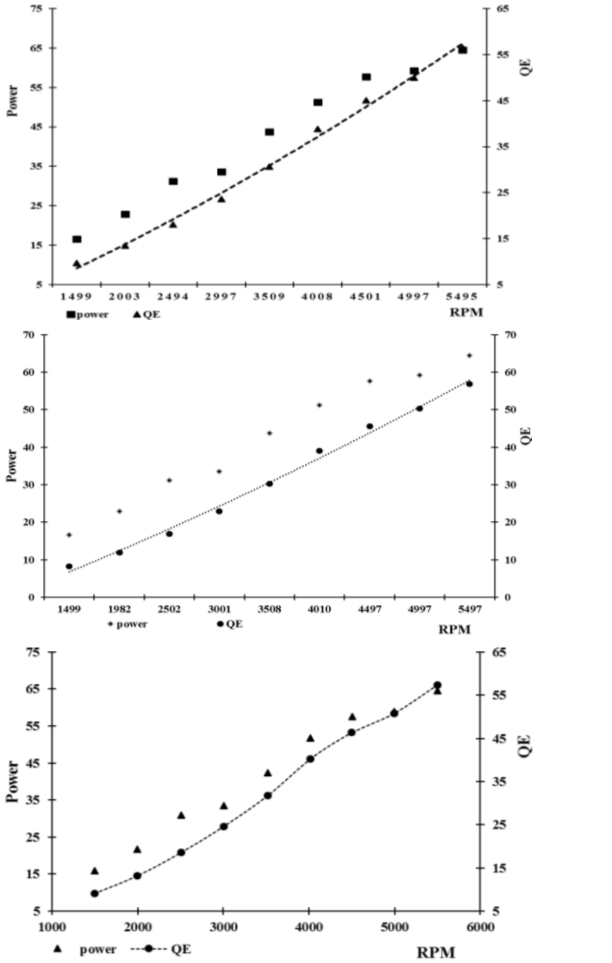

Fig. 3: Heat loss and power vs. Output in rpm, Fuel types – Ron 95 (top), Ron 97 (middle) and Vpower (bottom)

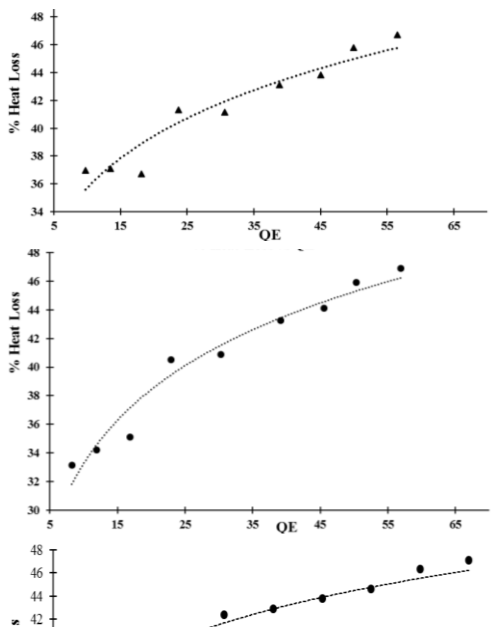

Fig. 4: % Heat loss vs. Heat loss produce, Fuel types – Ron 95 (top), Ron 97 (middle) and Vpower (bottom)

From nonparametric Friedman Test analysis, the obtained significant value is 0.013, which is less than 5%. This means that this hypothesis shows significance by using different types of fuels to measure heat loss produce or EGHP in ICE. If the significant value is more than 5%, null hypothesis is accepted. In other words, that is no significance by using different fuel types to measure the heat loss produce or EGHP in ICE [22].

Table 5: Statistical analysis: Correlation based on two variables

Correlations with measured				
Control variables		Ron 95	Ron 97	Vpower
rpm	Ron 95	1.000	0.987	0.942
	Ron 97	0.987	1.000	0.982
	Vpower	0.942	0.982	1.000

4. Conclusions

This research has detailed the calculation of EGHP in ICE based on three types of fuel – Petrol Ron 95, Ron97 and Vpower. The value of heat loss produce can be determined by calculating the basic formula of heat loss through the exhaust. The exhaust flow convective heat transfer rates are the largest in the entire cycle due to very high gas velocities developed during the exhaust blow down process and due to the high gas temperature inside the engine cylinder [19, 20]. High correlation of data variables can be determined based on heat loss produce or EGHP has shown significance using different types of fuel in ICE.

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