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# TEST REPORT

| REPORT NO. : | 2014MA0330 | PAGE: | 1 OF 20 |
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| | | |
|---|---|---|
| Applicant | : | BAE INTERNATIONAL INC. SDN. BHD.<br>Level 21.03 Plaza Pengkalan,<br>3rd Mile Jalan Ipoh,<br>51100 Kuala Lumpur. Malaysia |
| For | : | HAI-O ENTERPRISE BERHAD<br>Wisma Hai-O, Lot 11995, Batu 2, Jalan Kapar<br>41400 Klang, Selangor. |
| Manufacturer | : | BAE TRADING SDN. BHD.<br>No. 9 Jalan 14/108C,<br>Taman Sungai Besi Industrial Area,<br>57100 Kuala Lumpur. Malaysia |
| Product | : | JTX Airtracker |
| Reference Standard/ Method of test | : | Evaluation of Spark Ignition Engine Performance and Emission Using JTX Airtracker. |
| Description of sample/ Description of Test Specimen | : | Brand : JTX<br>Product Name: Airtracker |
| Date Received of Complete Application | : | 28th April 2014 |
| Job No. | : | J20141390330 |
| Description of Test Results/ Overall Test Result | : | The test results of the submitted test sample is described from Page 3 of this report |
| Issued date | : | 16 JUL 2014 |
| Approved Signatory | | |

(MOHD ALIF MOHD YUSOFF)
Testing Executive

(HAJI MOHD ADZHAR AHMAD)
Head
Mechanical & Automotive Section (MAST)
Testing Services Department

SIRIM QAS INTERNATIONAL SDN BHD Mechanical & Automotive Section

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7.2 The Test Report shall not be amended, changed, varied or modified in any manner whatsoever by the Applicant or otherwise.

7.3 If the Test Report is to be furnished to any third party or to the public, each such Test Report shall be furnished in full, legible and in its entirety.

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a) Informing and placing a notice in the media;
b) Obtaining an injunction from Court (cost on a solicitor-client basis to be borne by the Applicant);
c) Refusing to accept any further Product for Testing Services from the Applicant or whosoever related to the Applicant, whether subsidiary or otherwise;
d) Instructing the Applicant to withdraw and recall the advertisement, statement or document in question and advertise a clarification and apology to SIRIM QAS International, SIRIM and/or other SIRIM's subsidiaries twice in a national publication of SIRIM QAS International's choice at the Applicant's sole cost; and
e) Informing or lodging a report pertaining the Applicant's Test Report with the relevant authorities.

7.8 In the event of an investigation from any third party concerning the Applicant's Test Report, SIRIM QAS International may disclose the same for purposes of such investigation.

7.9 If such approval is obtained from the Managing Director of SIRIM QAS International, the Applicant may only include the phrase. "A sample of this product has been tested by SIRIM QAS International... (Test Report No) ... (dated) .... (for what test) ... (to which standard)" or such similar words which stress that only the Sample was actually tested.

7.10 Certified true copies of the Test Report may be issued upon request by the Applicant upon payment of the relevant fee.

**General Information:**

1. All tests were conducted and witnessed at the address below:

   AUTOMOTIVE DEVELOPMENT CENTRE (ADC)
   Faculty of Mechanical Engineering
   Universiti Teknologi Malaysia (UTM)
   Johor. Malaysia

2. The test was conducted on the 23$^{th}$ to 24$^{th}$ June 2014.

## 1.0 INTRODUCTION

The test work was conducted to determine the performance and emission of a device called JTX Airtracker (hereafter refer as Airtracker, supplied by BAE International Inc. Sdn. Bhd.) on an a reference engine.

The claims by the client pertaining to the product are the improvement of the following parameters;

1.1 Engine performance i.e. engine torque ($\tau$) and engine brake power (BP).

1.2 Brake specific fuel consumption (BSFC).

1.3 Brake thermal efficiency ($\eta_{bth}$)

1.4 Emission gases i.e. oxides of nitrogen ($NO_X$), hydrocarbon (HC), carbon monoxide (CO), oxygen ($O_2$), carbon dioxide ($CO_2$).

The scope of work undertaken by Automotive Development Centre (ADC) and Witness by SIRIM QAS Personnel to is to evaluate claim (1.1), (1.2), (1.3), and (1.4) when the engine is run at (i) standard engine condition benchmarked with (ii) a similar engine fitted with Airtracker.

At this juncture as of how this device operates and influence the engine is only known to the company concerned. ADC is tasked to observe the influence of this device upon the performance and emission of the test engine.

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## 2.0 PRODUCT REVIEW

Figure 1 shows the product (Airtracker) as supplied by BAE International Inc. Sdn. Bhd.


Figure 1: Airtracker.

JTX-Airtracker is adhered to the cover of the air filter compartment of the vehicle's engine. As claimed by the company, it instantly provides additional energy and oxygen to the air inlet flow of airstreams and transforms the molecules of oxygen into smaller bundles of molecule structure. The device is said to contain a renewable greentech energy that is embedded inside the product. Figure 2 shows the installation procedure of IPS to the engine tested.

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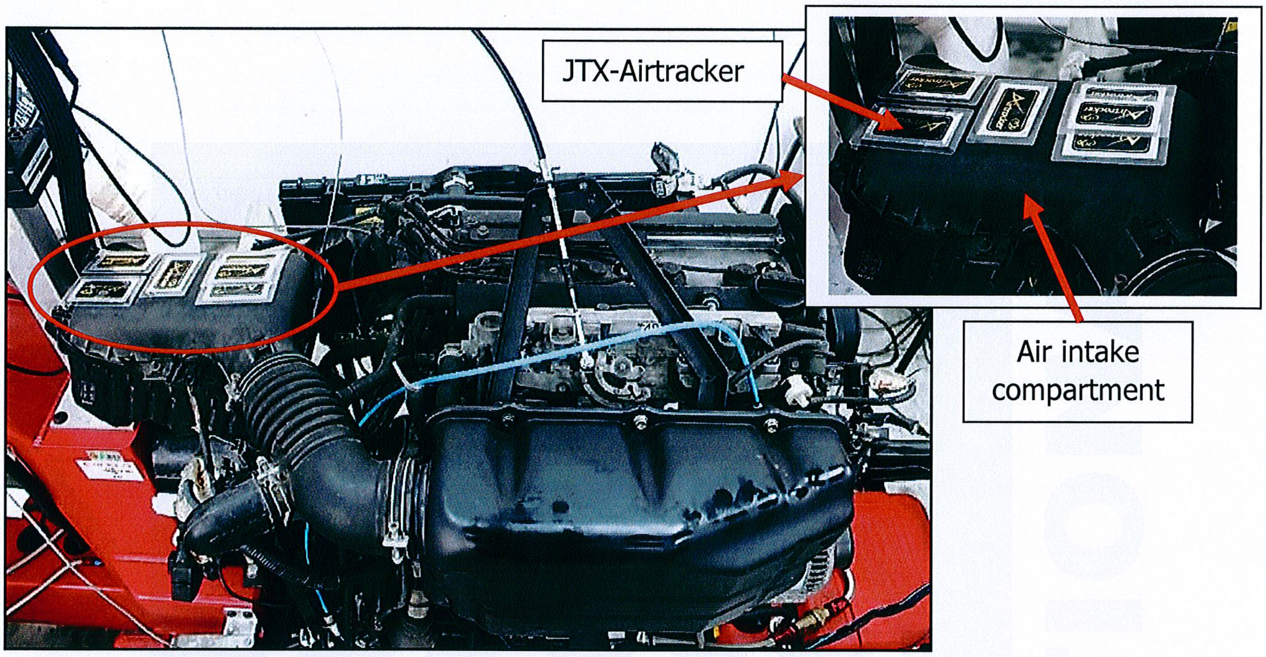


Figure 2: The Airtracker was installed on the air intake compartment.

**3.0 DURATION**

The overall duration i.e. from preparation to completion of the experimental program was carried out from 23rd-24th June 2014.

**4.0 TEST EQUIPMENTS**

The engine and test equipments used for this experimental work are:

4.1 Spark ignition engine (Toyota 4AGE, 1.6 liter)
The spark ignition engine is used for comparative engine performance assessment, as shown in Figure 3. The engine is not equipped with a catalytic converter which the output gases measured are the actual by-products of combustion in the exhaust of the engine. Table 1 exhibits the specifications of the tested engine.

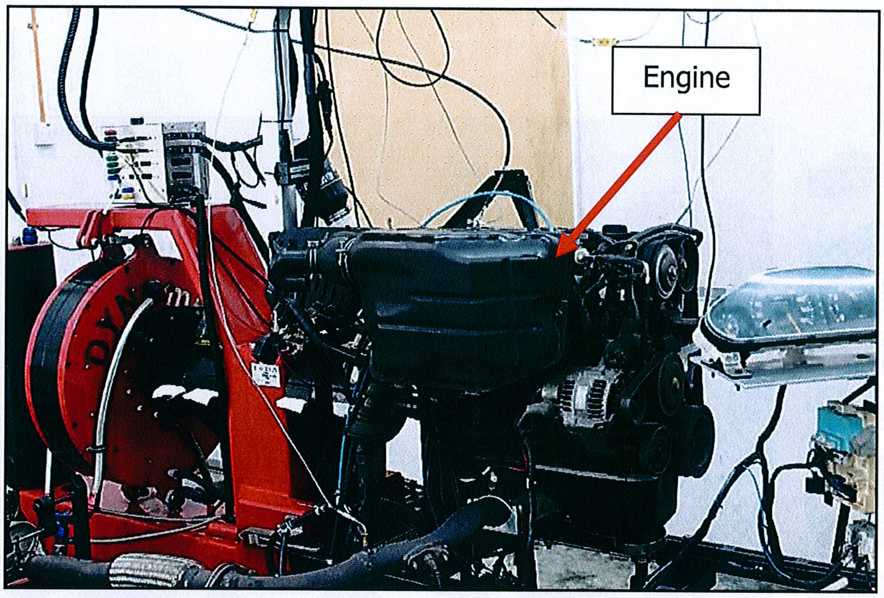


Figure 3: Toyota 4AGE, 1.6 liter gasoline engine.

Table 1: Engine specifications.

| | |
|---|---|
| Engine name: | Toyota 4AGE |
| Engine capacity: | 1.6 liter |
| Compression ratio: | 11.1:1 |
| Valve train: | 20 Valves |
| Power: | 123 kW @ 7800 rpm |
| Torque: | 163 Nm @ 5600 rpm |

4.2 Eddy current dynamometer (Dynomite)

The dynamometer is coupled directly to engine. The dynamometer will exert load on the engine in order to measure the engine torque produced (refer to Figure 4)

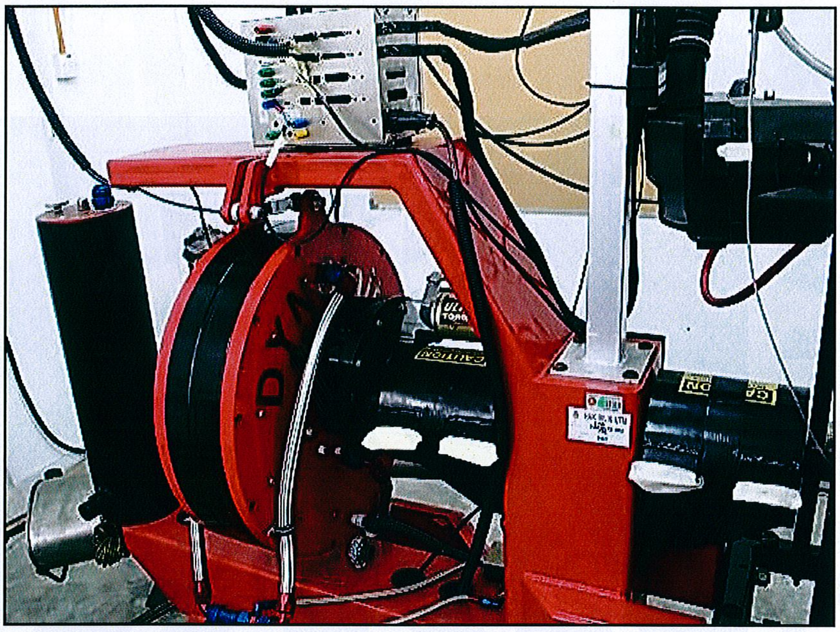

Figure 4: Dynomite eddy current dynamometer.

4.3 Fuel flow meter (Ono Sokki)

The flow meter is installed in the fuel line to measure the net fuel flow rate consumed by the engine. Figure 5 (a) and (b) show the fuel consumption components used.


(a) Fuel flow detector (b) Fuel flowmeter

Figure 5: Fuel measuring components.

4.4 Emission gas analyzer (EMS)

The EMS (Figure 6) is used to measure exhaust gas constituents namely oxygen ($O_2$), carbon dioxide ($CO_2$), nitrogen oxide ($NO_X$), hydrocarbon (HC) and carbon monoxide (CO).

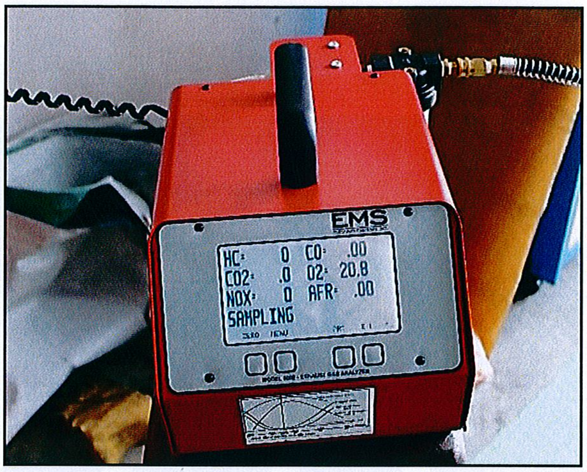


Figure 6: Emission gas analyzer (EMS).

4.5 Dyno-Max software

The function of this software is to log-in the appropriate parameter automatically to the data logger for post experiment processing (Figure 7).

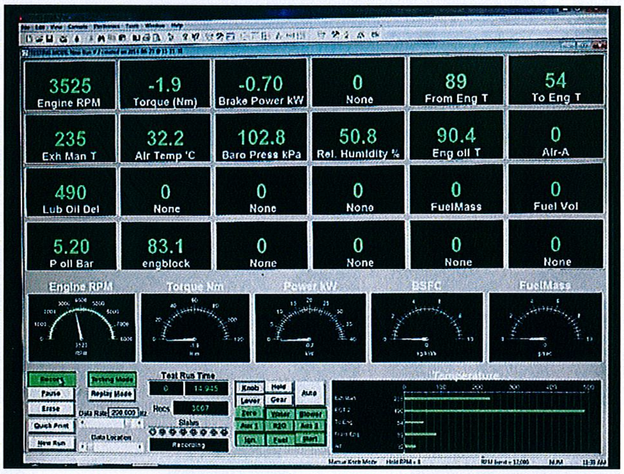


Figure 7: Dyno-Max software display.

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## 5.0 TEST PROCEDURES

The testing was done at variable speed (constant throttle with 18% open throttle) which was based on the BS 5514 procedures laid out for engine performance test. The standard engine performance characteristics (without Airtracker) are used as the base data. Then the engine has been installed with Airtracker supplied by the client. The same test condition was set and run.

The details of the test procedures are:

a) Standard condition (without Airtracker)

I. The engine was run under idling speed until it was stable and all the required parameters were noted as reference (e.g. fuel consumption and emissions).

II. The engine was run under idling speed until it was stable and all the required parameters were noted as reference (e.g. fuel consumption and emissions).

III. Then, the engine speed was set at 3500 rpm (18% open throttle).

IV. The required parameters (e.g. torque and brake power) were logged in automatically by the Dyno-Max software. The emission and fuel consumption data were recorded manually.

V. For the subsequent set of data, the engine speed was decreased by an interval of 500 rpm by applying load (increase load) to the engine via the dynamometer. The test was repeated until the engine speed reaches 1000 rpm. Step (iii) was repeated.

VI. Once this was done, the applied load was released until it reaches minimum torque and at the same time the engine speed was decreased until it reaches idling speed.

b) Airtracker condition

(i) The engine was installed with Airtracker and run under idling speed for 3 hours and 30 minutes.
(ii) Then, all the required parameters were noted as reference (e.g. fuel consumption and emissions) at idling condition when the engine was stable.
(iii) Next, the engine speed was set at 3500 rpm (18% open throttle).
(iv) The required parameters (e.g. torque and brake power) were logged in automatically by the Dyno-Max software. The emission and fuel consumption data were recorded manually.
(v) For the subsequent set of data, the engine speed was decreased by an interval of 500 rpm by applying load (increase load) to the engine via the dynamometer. The test was repeated until the engine speed reaches 1000 rpm. Step (iv) was repeated.
(vi) Once this was done, the applied load was released until it reaches minimum torque and at the same time the engine speed was decreased until it reaches idling speed.

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## 6.0 RESULTS AND DISCUSSIONS

### 6.1 Engine Performance Test

#### 6.1.1 Torque ($\tau$)

Torque is normally measured with a dynamometer. It is a measure of the engine's ability to do work.

Figure 8 shows the graph of torque against engine speed before and after using Airtracker. The torque produced by the engine after the air intake treated with Airtracker is always higher compared to the standard engine. This is a positive increment of the engine's torque by an average of 9.30%.

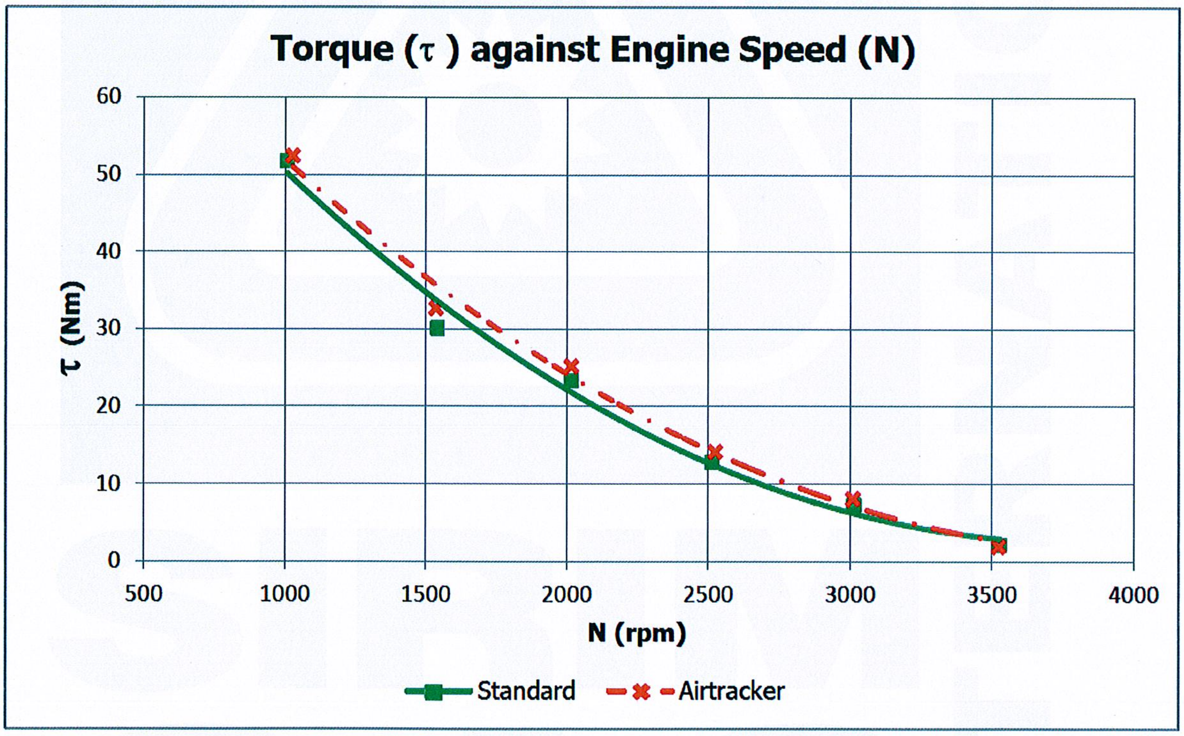


Figure 8: Graph of torque against engine speed.



#### 6.1.2 Brake Power (BP)

Brake Power (BP) is a measure of power output produced by the engine. The BP is being derived from the torque and engine speed measurements.

Figure 9 exhibits the graph of BP against engine speed. For the engine installed with Airtracker, BP indicates an overall higher value (ranging from 1000 – 3000 rpm), with the average gain of 9.28%.

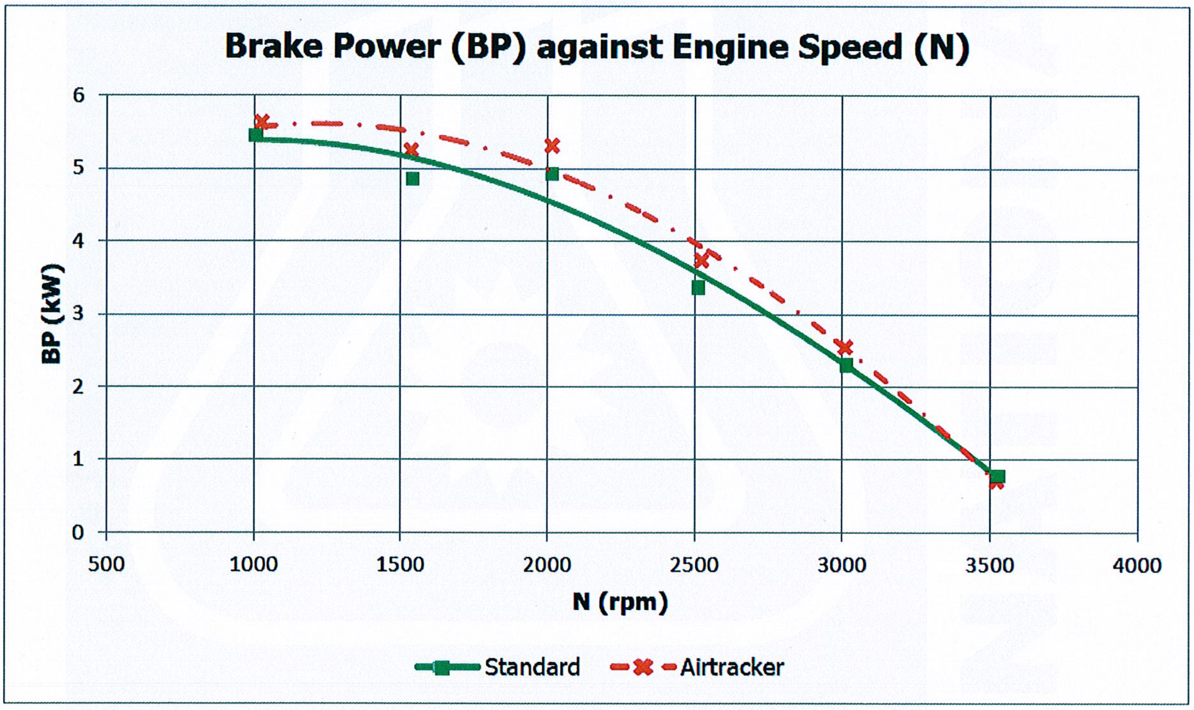


Figure 9: Graph of brake power against engine speed.

### 6.1.3 Brake Specific Fuel Consumption (BSFC)

BSFC is a measure of the fuel efficiency of a reciprocating engine. It is the rate of fuel consumption divided by the power produced. BSFC indicates the level of fuel economy during engine operation.

Figure 10 illustrates the graph of BSFC against engine speed. For the engine equipped with Airtracker, the BSFC is noted to decrease at the average of 10.89% at all engine speeds. With the decrease in the value of BSFC, naturally the fuel consumption will be decreased. This is an encouraging sign improvement of the engine's fuel consumption.

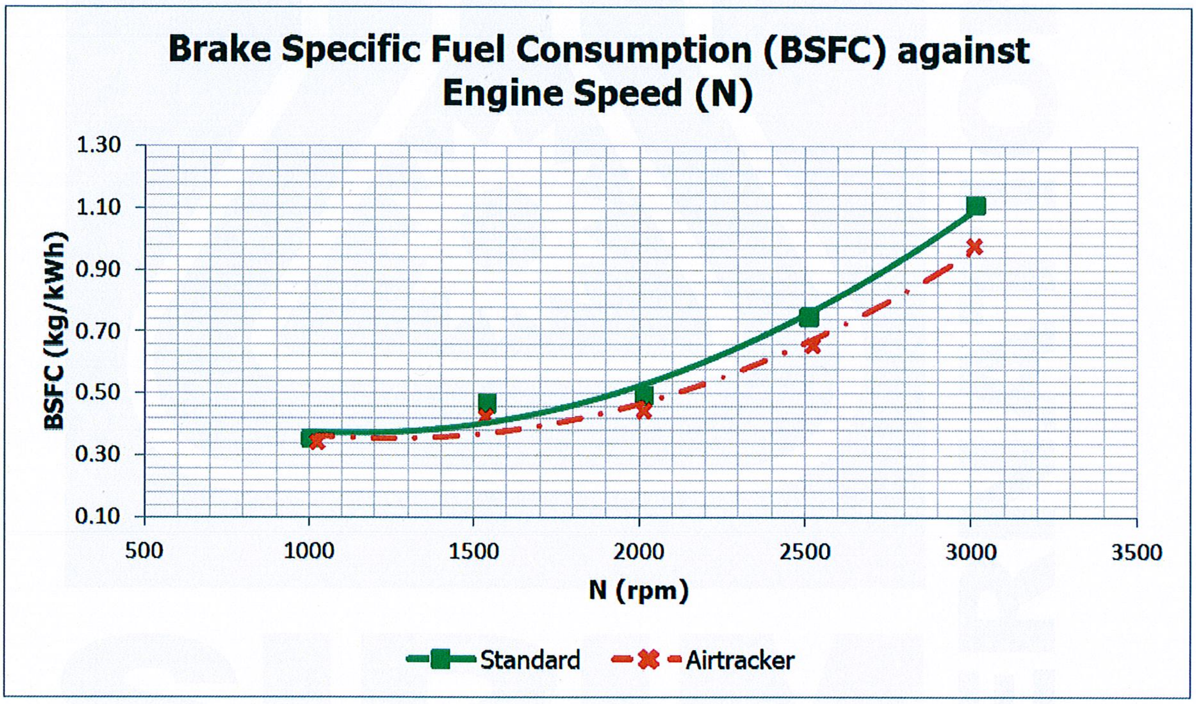


Figure 10: Graph of BSFC against engine speed.

### 6.1.4 Brake Thermal Efficiency ($\eta_{bth}$)

Brake thermal efficiency is a measure of the efficiency of the engine to produce brake power from the amount of fuel being supplied.

Figure 11 shows the graph of brake thermal efficiency against engine speed. For the engine retrofitted with Airtracker, it shows the positive impact in which the brake thermal efficiency is increased at the average of 10.51% (at the engine speed of 1000 – 3000 rpm).

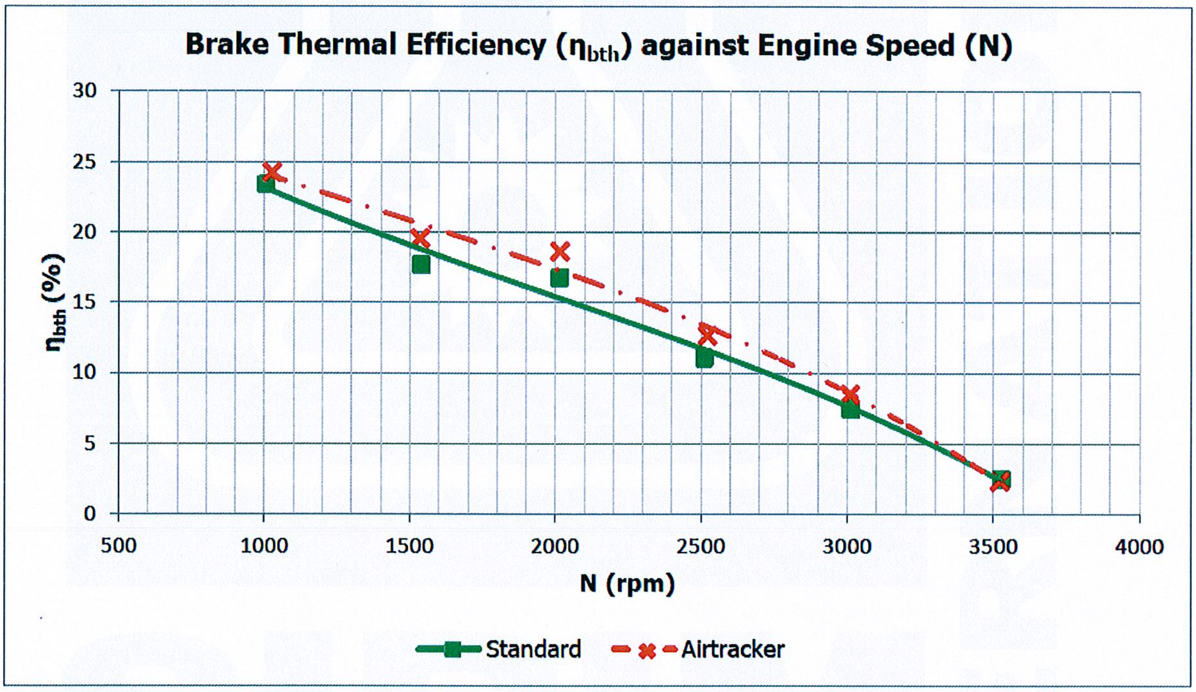


Figure 11: Graph of brake thermal efficiency against engine speed.

## 6.2 Emission gases

### 6.2.1 Oxygen ($O_2$) and Carbon Dioxide ($CO_2$)

Oxygen ($O_2$) constituent of the exhaust gas shows excess of air (lean mixture) is present during combustion and this can lead to the formation of Oxides of Nitrogen (air consists of $O_2$ and $N_2$) and heat loss. The higher $O_2$ concentration in the exhaust gas shows the excess air occurred during the combustion process. The carbon dioxide ($CO_2$) concentration indicates a product of complete combustion; however the gas will contribute toward global warming.

Figure 12 illustrates the graph of $O_2$ and $CO_2$ against engine speed for the tested engine before and after the used of Airtracker. The used of Airtracker does not give noticeable difference in $O_2$ and $CO_2$ constituents.

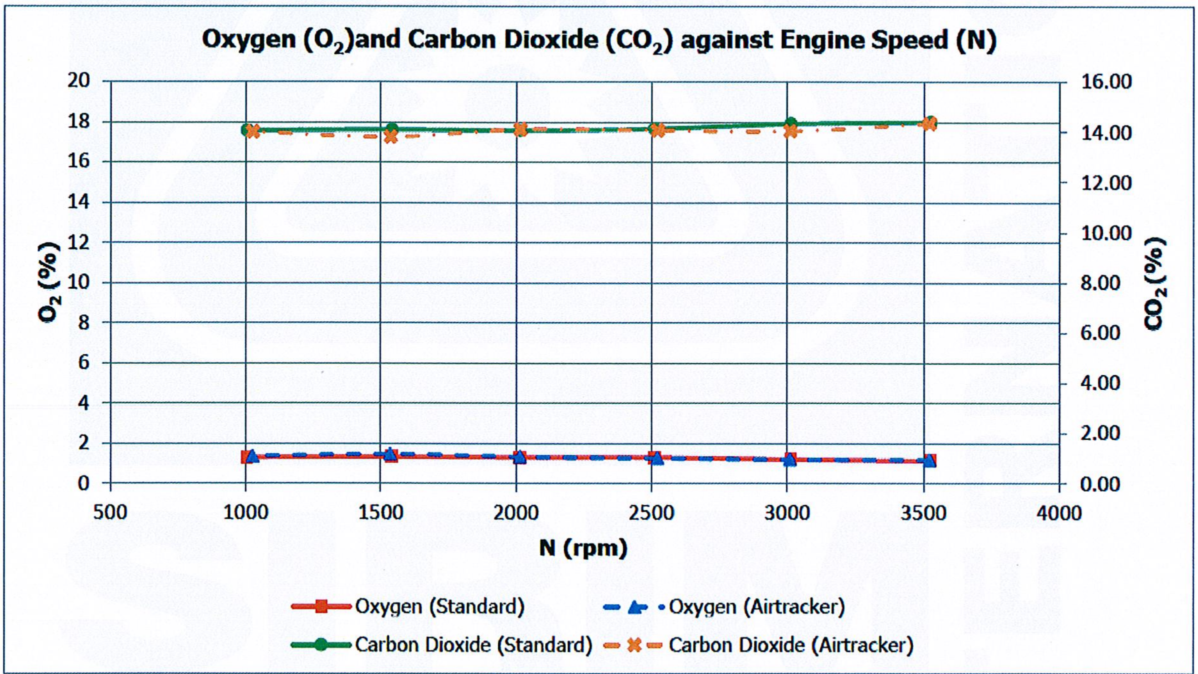


Figure 12: Graph of oxygen and carbon dioxide against engine speed.

### 6.2.2 Oxides of Nitrogen ($NO_X$)

Oxides of nitrogen ($NO_X$) emission is directly proportional to combustion temperature in internal combustion engines. High cylinder temperature which occurs during the combustion process can cause nitrogen react with oxygen to form $NO_X$. It is the source of air pollution called smog and ultimately may cause of acid rain and is classified as carcinogenic.

Figure 13 shows the graph of $NO_X$ against engine speed. As the engine installed with Airtracker, the graph shows $NO_X$ was decreased at the average of 8.39% at all engine speeds condition except for 3000 rpm. The reduction also up to 13.49% when the engine operated with Airtracker at the engine speed of 1000 rpm. This is positive improvement of the $NO_X$ emission of the engine.

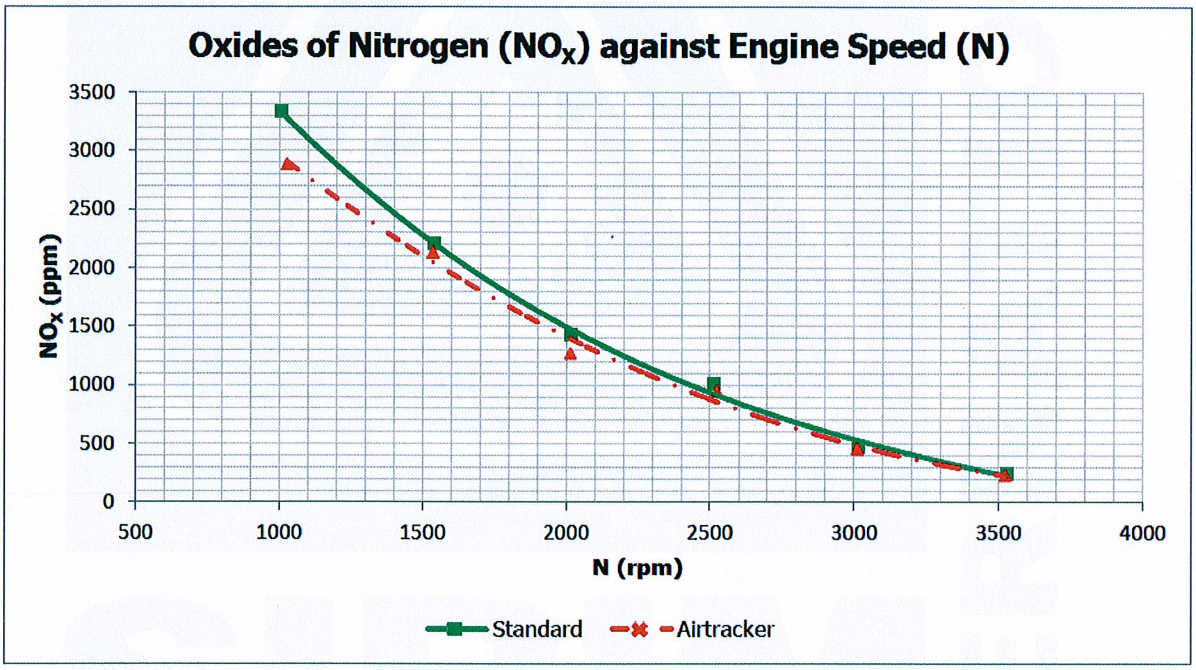


Figure 13: Graph of oxides of nitrogen against engine speed.

The $NO_X$ level was observed to reduce due to the reduction of the engine's combustion temperature. This reduction was detected through the exhaust manifold temperature and engine block temperature of the engine equipped with Airtracker which is noted to be lower than the standard engine condition. Figure 14 and 15 exhibit the graph of both temperatures against engine speed.

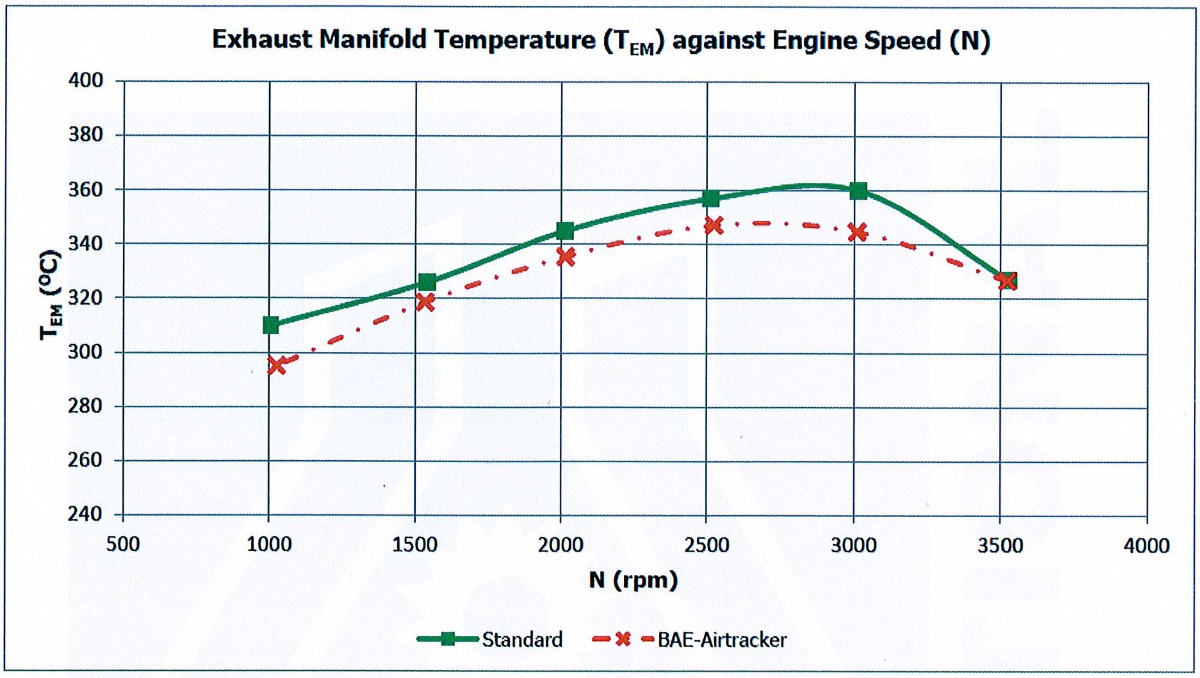


Figure 14: Graph of exhaust manifold temperature against engine speed

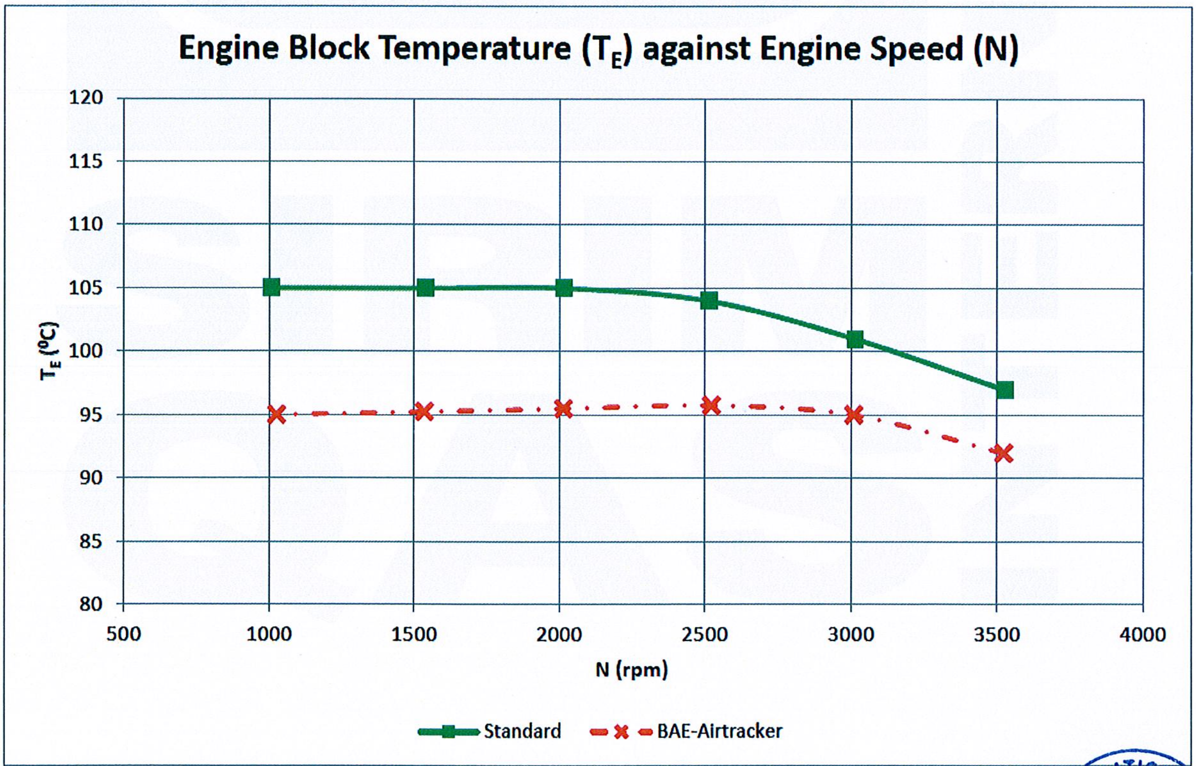


Figure 15: Graph of engine block temperature against engine speed

### 6.2.3 Carbon Monoxide (CO) and Hydrocarbon (HC)

Carbon monoxide (CO) emission is a product of incomplete combustion and occurs when carbon in the fuel is partially oxidized rather than fully oxidize to $CO_2$. It is also a high toxicity gas. Hydrocarbon (HC) constituent indicates the fuel molecules in the engine do not burn (or burn only partially) and can this may result in soot and particulate being formed.

Figure 16 and 17 illustrate the graph of CO and HC respectively against engine speed. The used of Airtracker shows the CO is decreased at the average of 4.04% compared to standard condition.

For the HC constituent, the graph shows the positive improvement of the gas emission for the engine operated with the installation of Airtracker at the average of 15.12%. The decreased of the HC emission and the increment of the torque value of the engine installed with

Airtracker, the results indicate the engine has better combustion compared to standard condition.

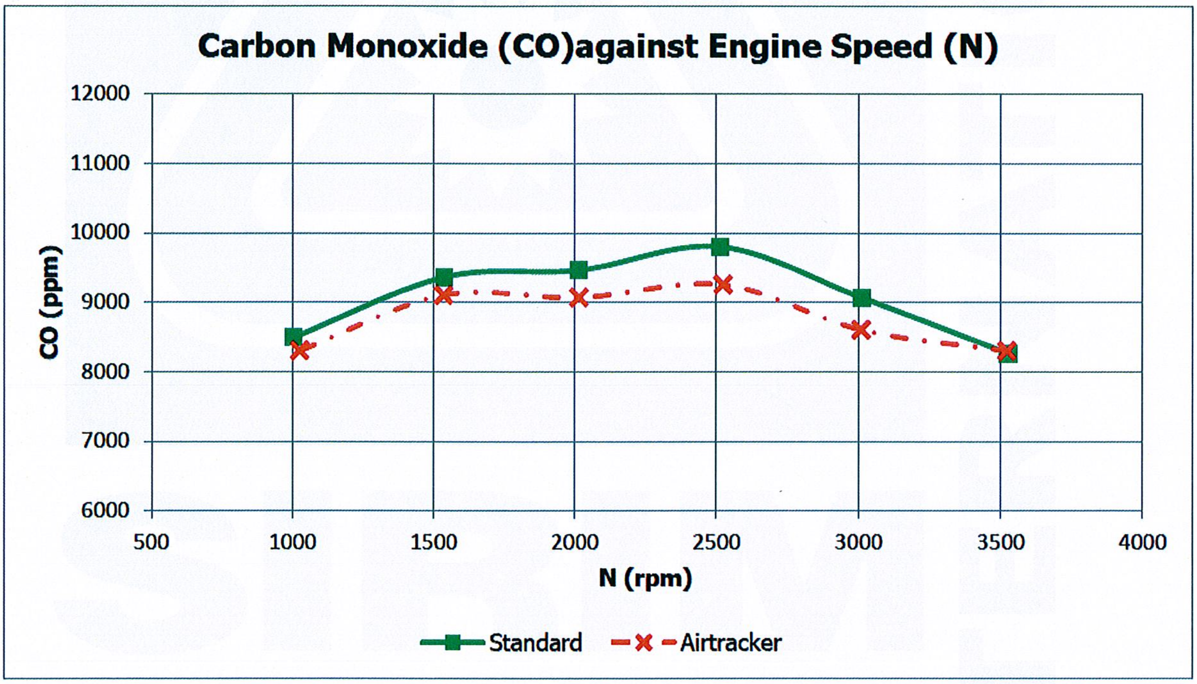


Figure 16: Graph of carbon monoxide against engine speed.

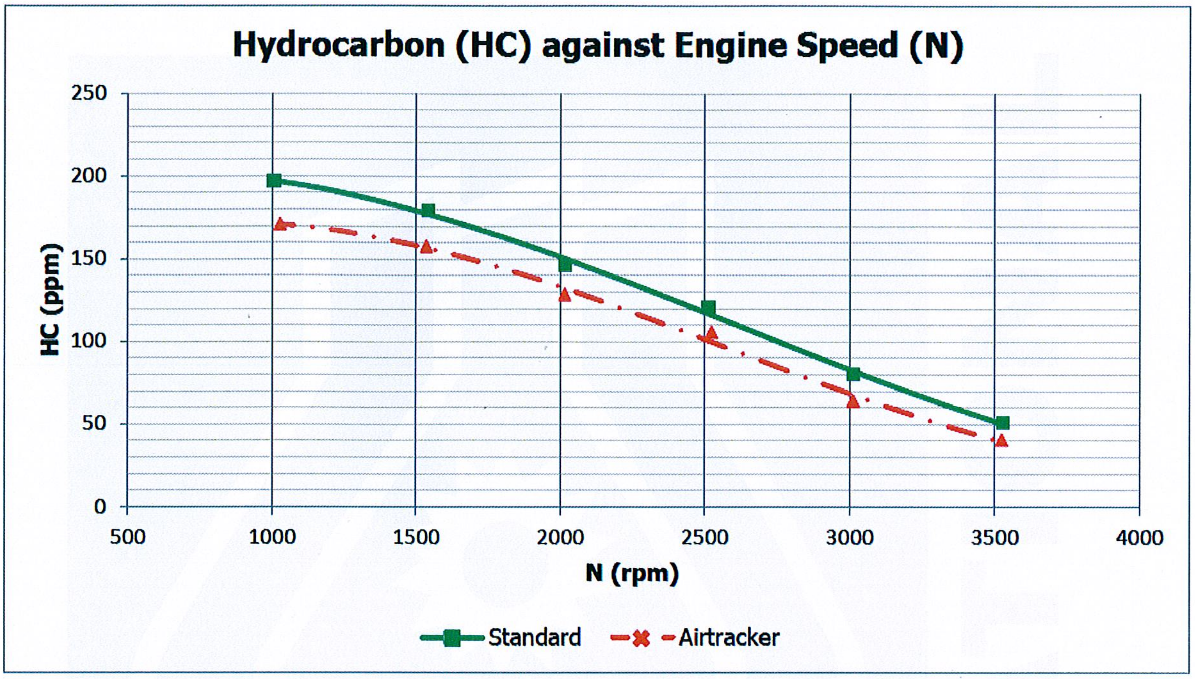


Figure 17: Graph of Hydrocarbon against Engine Speed.

## 7.0 CONCLUSIONS

The salient points of this test work are derived as follows:

(a) The results show improvement of the spark ignition engine performance for torque and BP when the engine equipped with Airtracker. The average improvement of the torque and BP are 18.28% and 17.89% respectively when the engine runs at 1000 – 3000 rpm.

As conclusions, $\tau_{Airtracker} > \tau_{standard}$ and $\mathbf{BP_{Airtracker}} > \mathbf{BP_{standard}}$

(b) When the engine is run with Airtracker, it shows positive improvement on the engine's BSFC which reduced at the average of 10.89%. This indicates fuel consumption improvement.

This can be concluded $\mathbf{BSFC_{Airtracker}} < \mathbf{BSFC_{standard}}$

(c) Brake thermal efficiency ($\eta_{bth}$) indicates encouraging improvement for the engine's treated with Airtracker at the average of 10.51% (at the engine speed of 1000 – 3000 rpm).

The conclusion of this analysis is, $\eta_{bth\ Airtracker} > \eta_{bth\ standard}$

(d) The $O_2$ and $CO_2$ gases of both engine conditions do not give noticeable differences. This result indicates the engine installed with Airtracker does not have any adverse effect on the concentration of exhaust gas constituents ($O_2$ and $CO_2$).

(e) The used of Airtracker will decrease $NO_X$, CO and HC emissions at the average of 8.39%, 4.04% and 15.12% respectively compared to standard engine condition.

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**APPENDIX**

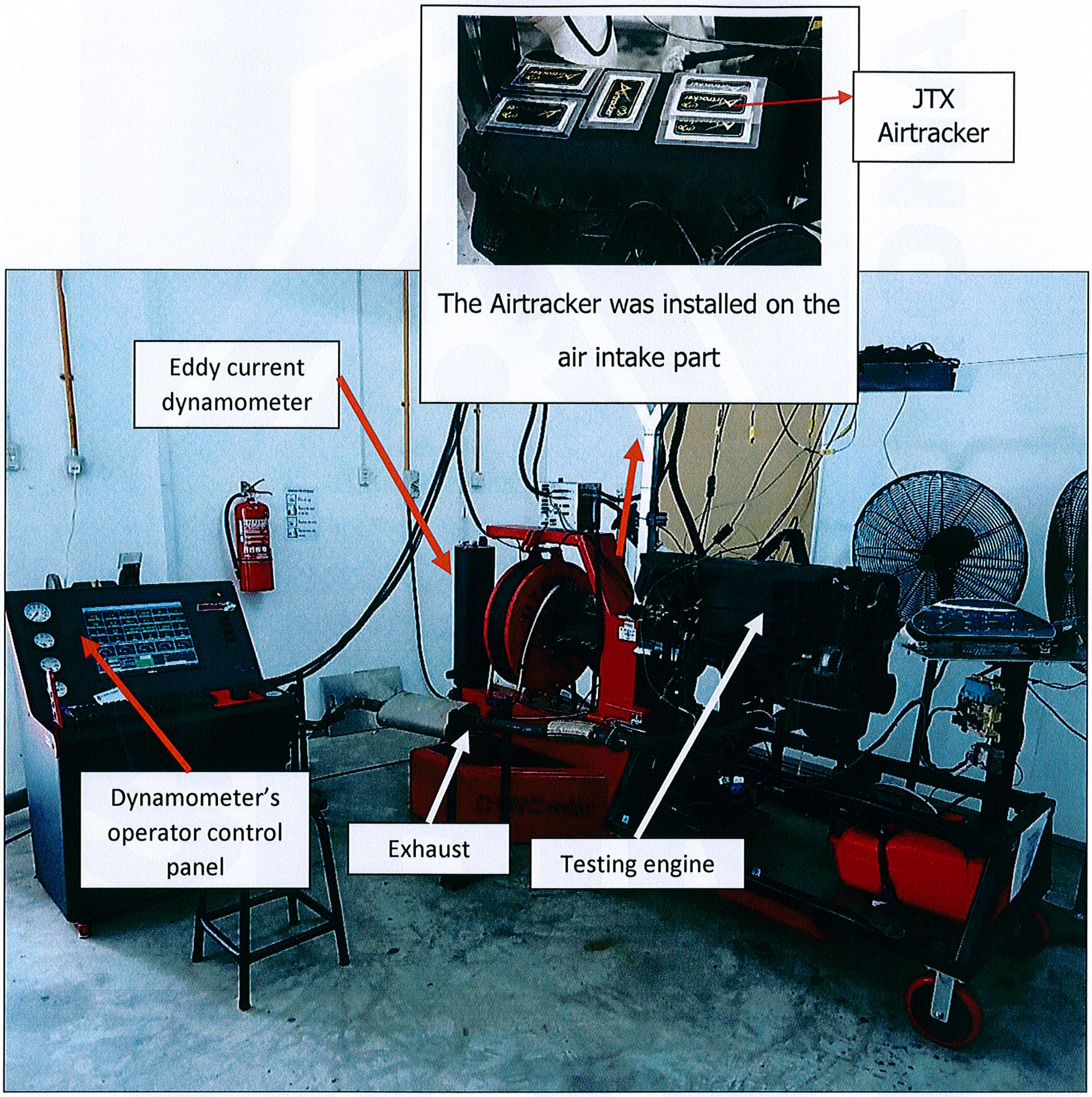


Figure 18: Engine testing testbed