

INVESTIGATION OF ENGINE PERFORMANCE AND EMISSION LEVEL OF SI ENGINE RUNNING WITH DIFFERENT RON FUEL GRADES

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Abstract—This paper discuss about engine performance and emission characteristic produced by gasoline vehicle by using different type of RON fuel grades and brands. This investigation involves engine performance test using chassis dynamometer and emission measurement with portable combustion analyzer. In the engine performance analysis, the engine first is tested using chassis dynamometer with different type of RON fuel grades (RON 95, RON97) from different manufacturers. Chassis dynamometer test will show the engine performance graph which includes power, torque and brake specific fuel consumption (BSFC). Next, the emission test is performed to validate and compare the data of emission level produced by vehicle. This emission test will run in condition of vehicle on idle and running by using chassis dynamometer with different type of RON fuel grades and brands. In this project the standard procedure of fuel and emission testing using chassis dynamometer have been successfully established. At the end of the project, results will show which type of RON fuel grades and brands produced higher engine performance, better fuel economy and less emission level. Further experimental test could be implemented utilizing engine dynamometer to obtain better result for fuel testing with improved instrumentation control.

Keywords—Fuel Testing, RON grade, Engine Performance, Emission Level, Light Duty Gasoline Engine.

I. INTRODUCTION

Two type of RON fuel grade are presently available in Malaysia namely RON 95 and RON 97. The RON 95 fuel had been introduced for local consumption due to the rapid rising of fossil fuel around the year 2008. RON 97 fuel still remains in the market with a higher price. Consumer prefers to use the RON 95 fuel mainly due to its lower price. However, the impact of using different RON grade fuel to various automobile remains unknown. There are so many rumors and speculative argument all over Malaysia about the exact short term, medium term and long term impact of using this lower RON grade fuel to the vehicle. Therefore, this project was initiated to provide some insight of the engine performance in term of Power, Torque, Fuel consumption and emission produce by using different RON grade fuel. This can be achieved by using chassis dynamometer. Emission test will be conducted using portable combustion analyzer and the data will analyze and conclusion will be drawn to show which type of fuel RON and brands have high performance and less emission level.

II. OBJECTIVES

The objectives for this project include:

- To compare the performance of engine with different types of RON fuel grades and brands.
- To compare the emission level from vehicle by using different types of RON fuel grades and brands
- To develop the standard of procedure of fuel testing by using chassis dynamometer.

III. PROJECT SCOPE AND LIMITATION

The scopes of this project involved the analysis of engine performance from the graph tabulated in chassis dynamometer data logging software. This data should be in term of power, torque and brake specific fuel consumption. The emission produce by various manufacturers with different RON grade fuel will be analyzed as well. Three manufacturers are chosen with both RON 95 and RON 97 grade fuel and the test matrix was design to run the experimental test matrix.

Limitation exists in this investigation due to the nature of test chassis dynamometer could perform. This includes the non steady state test since for the chassis dynamometer test, the engine speed need to be rapidly increased to show the engine power, torque and fuel consumption.

IV. LITERATURE REVIEW

The Research Octane Number (RON) is a number that is being assigned to different grades of fuel to present its capability to resist auto-ignition or known as knocking. RON is determined by running the fuel in a test engine with a variable compression ratio under controlled condition, and the result is compare with mixtures of iso-octane and n-heptane. In other words, it is a rating used to measure a fuels knocking resistance in spark-ignition internal combustion engines. The lower of RON the easier it becomes for fuels to ignite in engine. Therefore, the fuels with a higher octane number will eliminate knocking for higher compression ratio and gain more power in the engine.

Below are the some basic about available fuel:

a) Unleaded Petrol (ULP)

Unleaded Petrol or ULP has a Research Octane Number (RON) of between 91 and 93. Vehicles that use ULP operates with a catalytic converter because of the emitted gasses from exhaust are too high.

b) Premium Unleaded Petrol (PULP)

This premium petrol is a special blend of petrol with a higher octane rating which can produce higher engine power. So it gives more performance to the vehicle as well as knock-free performance and assisting the vehicle to run at its optimum. PULP has a Research Octane Number (RON) of 95 or 96.

c) Ultra Premium Unleaded Petrol (UPLUP)

Ultra means ultimate or it is a fuel have high octane unleaded fuel that maximizes engine power and performance. The fuel burns cleanly as well as producing less pollution. UPULP which has a RON of 98 commonly recommended for imported high performance vehicles.

A. Dynamometer

Dynamometer are used to measure torque and power over the engine operating ranges of speed and load. This can be achieved by using various methods to absorb the energy output of the engine, all of which eventually ends up as heat. Several kinds of dynamometer are common, some of them being referred to as “brakes” or “brake dynamometer” where there are dry friction brake dynamometer, hydraulic or water brake dynamometer and eddy current dynamometer. The dynamometer applies a resistance to the engine. If the dynamometer is connected to the engine’s output shaft it is referred to as an Engine Dynamometer. When the dynamometer is connected to the vehicle’s drive shaft it is called a Chassis Dynamometer. The force exerted on the dynamometer housing is resisted by a strain measuring device. (H.W. Gitano Briggs, 2010)

A dynamometer particularly suited for rapid testing of internal combustion engines coming off an engine assembly line where in a driving connection is established from a flexible drive plate on the engine crankshaft to the dynamometer input shaft by means of an adapter which includes a conventional friction disc sub-assembly of an automobile manual transmission clutch to absorb excessive torque pulse of the engines and a thrust bearing mounted on the dynamometer input shaft between a collar keyed to the dynamometer input shaft and the dynamometer housing, so that axial thrust loads are applied to the dynamometer input shaft. (G. J. Wolschlager, 1984 U.S. Patent)

B. Emission

Emissions is the emitted gasses result by the combustion of fuel such as natural gas, petrol and diesel. This study will focus more on gasoline engine emission with the main species of interest is CO. Emission gasses discharge

through exhaust pipe to the atmosphere. These emissions pollute the environment and contribute to global warming, acid rain, smog, odors and respiratory problems. The major causes of these emissions are non-stoichiometric combustion, dissociation of nitrogen, and impurities in the fuel and air.

Most of the car manufactures today had established modern technology to reduce and control emissions level produced by their vehicles which are regulated by the geographically bias regulations such as Euro Standards, California Emissions, Tokyo retrofits and many others. Hybrid car and electric vehicle had been a preferred choice to achieve zero emissions cars for the future. The main species of emissions from a gasoline engine are:

- i) Hydrocarbons
- ii) Carbon Monoxides (CO)
- iii) Nitrogen Oxides (NO_x)
- iv) Particulate matter- Soot
- v) Sulfur Oxides (SO_x)
- vi) Volatile organic Compounds (VOCs)

V. METHODOLOGY

The methodology described here, reflect the implementation of the engine performance and emission characteristic test conducted in order to achieve the objectives defined earlier.

A. Chassis Dynamometer

In this project, chassis dynamometer is the primary equipment utilized to measure torque, power and brake specific fuel consumption over the engine operating range of speed and load as shown in figure 1. It is consider a simplified engine test procedure to analyze the performance of different RON fuel grades and brands. Using the chassis dynamometer eliminate the complication of high end instrumentation and control as presented in a typical engine dynamometer test equipment. Chassis dynamometer measure power delivered to the surface of the “drive roller” by the drive wheels. The vehicle was position tangential to the chassis dynamometer roller as shown in figure 2.



Figure 1. Strapped vehicle in Chassis Dynamometer Laboratory

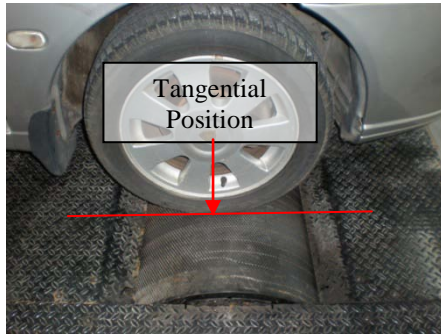


Figure 2. Tire Position on Chassis Dynamometer Drum

The roller in which the car wheel drive then runs the eddy current inside the roller and the output data is measured. Modern roller type chassis dynamometer system uses the Salvisberg roller, which improved traction and repeatability over smooth knurled drive rollers. (M.W., Salvisberg, 2002 U.S. Patent). The chassis dynamometer can be fixed or portable. The disadvantage of chassis dynamometer is the power lost in the drive train because the power not delivered directly from flywheel of engine but from tire rolling.

In the Engine Performance Testing Laboratory, UTeM, the chassis dynamometer had a single roller which can support testing for 2WD vehicles only. The vehicle is driven on rolls, while a dynamometer stimulates the inertia of the vehicle as well as the drag and friction on the vehicle (road load). The vehicle parameters need to be entered in computer using the chassis dynamometer software. The parameter includes altitude, atmospheric pressure, engine displacement and the gear ratio of the tested vehicle. Driver controlled the vehicle by pressing the accelerator pedal to the maximum rpm shown by the vehicle speedometer (redline limit). The data output display on computer will show the graph of performance of the vehicle. A sample of graph from a trial run showing engine power (kW) on the left y-axis and torque (Nm) on the right axis against Speed (km/hr) in x-axis as shown in figure 3

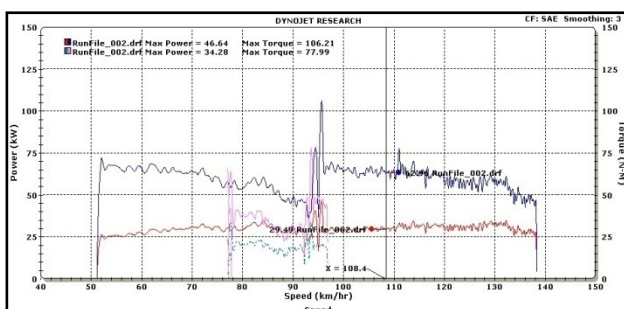


Figure 3. Sample Result from Chassis Dynamometer Trial Run



Figure 3. Bacharach Portable Combustion Analyzer (PCA 3)
 (Source: <http://www.bacharach-inc.com/pca3.htm>)

B. Portable Combustion Analyzer

This project will use Portable Combustion Analyzer manufacturer by Bacharach Incorporated to measure the amount of gas emission level produced by vehicle with different type of RON grades and fuel brands as shown in figure 3. Combustion analysis is a part of a process intended to improve fuel economy, reduce undesirable exhaust emissions and improve the safety of fuel burning equipment. Combustion analysis begins with the measurement of flue gas concentration and gas temperature, and many include the measurement of draft pressure and soot level. (TSI Incorporated, 2004).

The portable automobile exhaust emission analyzer is a device that can measure the gas emissions of both gasoline and diesel fuelled vehicle instantaneously or over a limited period of time. For gasoline fuelled vehicle, the device detects and displays the amount of the following air pollutants, namely, hydrocarbons (HC), carbon monoxide (CO), and nitrous oxides (NO_x). The portable emission analyzer consists of sensor, input devices, a microcontroller and a LCD displays.

VI. EXPERIMENTAL PROJECT FLOW

A. Archival Research

Various resources have been utilized from text book, patent library, and internet sources, conferences and journals paper. Journal and conferences sources give mostly the theory and facts about fuel RON, chassis dynamometer and portable combustion analyzer. While from book resources, the information that gained are about Internal Combustion Engine working principle, detail facts about engine parameter and emissions produced by vehicle. Therefore, from the information obtained, the project descriptions could be improved.

B. Experimental Research

Experimental research section in this project will discuss on type of testing use in this study. There are two types of testing done, which are engine performance using chassis dynamometer and emission test using portable combustion analyzer.

C. Development of Standard Fuel Testing using Chassis Dynamometer

This experiment will be carried out using two types of RON fuel grades which are RON 95 and RON 97 from three fuel manufacturers. In the first stage, three custom fuel tanks are fabricated to run this experiment which represents the three types of fuel brands. A PROTON WAJA 1600 c.c. will be use as the test vehicle in chassis dynamometer to quantify the different performance of fuel. As stated in the objective of this experiment is to compare performance of engine with different type of fuel RON and fuel brands, therefore, the parameters which are very important for the engine performances are, torque, power and engine revolution per minute (RPM).

D. Fuel tank Preparation

Experiment was conducted using three types of fuel tank which represent to three types of fuel brands. Below are the steps in preparation of fuel tank. Apparatus needed includes three fuel approved containers with capacity of ten liters each, fuel hoses, fuel tank pump, cutter, permanent marker and vernier caliper.

E. Chassis Dynamometer Setting

- Prepare testing car's PROTON WAJA; make sure the car in good condition.
- Enter car into the Engine Performance Testing Laboratory and drive wheels are park on the chassis dynamometer.
- Enter vehicle parameters into the computer (Vehicle redline speed limit, vehicle mass, type of fuel, model of car and vehicle tire size).
- Connect all data cable at Data Acquisition System port.
- The chassis of car is strapped with hardness at rear and front of car.
- An inductive pickup is clipped onto spark plug wire (oil coil wire) and ground wire is attached at body of car.
- Put fan in front of car engine to prevent it from overheating.
- Custom fuel tank (Fuel A or Fuel B or Fuel C) is connected with fuel hose to the fuel hose of car.
- Start testing by ramming the accelerator to the redline limit.
- Observe and print out the output data on the WinPEP7 software.
- Repeat step 8, use different of tank and RON fuel grades, analyze the output data.

- Analyze graph of horsepower and torque vs. engine RPM, air fuel ratio vs. RPM or any desire output from computer.
- Evaluate and describe the relation of the output result from the graph.
- Compare and discuss the testing result data for fuel RON 95 and 97 with three types of fuel brands

VII. CONCLUSION

As this paper is a partial progress of this investigation, the experimental test procedure for measuring engine performance and emission have been successfully established. This procedure will be utilized to further obtain the main objectives of the investigation. The performance and emission level of different fuel RON grades and fuel brands will give some indication of which fuel brand is the best and which RON grades is better for engine performance as well low emissions level. Analysis result and discussion will be presented in future paper.

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