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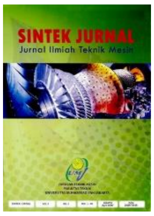

INCREASING THE PERFORMANCE OF DIESEL MOTORS BY INCREASING THE TEMPERATURE OF THE DIESEL

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ABSTRACT

This research aims to enhance the efficiency of diesel engines by optimizing the combustion process. One of the key factors in engine efficiency is the quality of the fuel-air mixture inside the combustion chamber. Imperfect combustion leads to high fuel consumption and low engine performance. Therefore, this study employs an experimental research method to investigate the influence of preheating the diesel fuel before entering the high-pressure pump on the formation of finer fuel mist particles and a more homogenous fuel-air mixing process. A series of experiments were conducted in this research by varying the temperature of the preheated diesel fuel and measuring relevant parameters related to combustion and engine performance. The results of this study demonstrate that preheating the diesel fuel before it enters the high-pressure pump leads to an improvement in the quality of the fuel-air mixture and enhances combustion efficiency. As a consequence, there is an increase in engine power and a reduction in optimal fuel consumption. In conclusion, the use of preheated diesel fuel to enhance the combustion process can be an effective solution to optimize the performance of diesel engines and reduce fuel consumption. This research contributes significantly to finding alternatives to address the issue of high fuel consumption in diesel engine-based vehicles.

Keywords: diesel engines; combustion process; engine efficiency; fuel-air mixture; combustion chamber

1. INTRODUCTION

The diesel engine was invented by Rudolf Christian Karl Diesel. Rudolf better known as Rudolf Diesel, who was born on March 18, 1858 in Paris. Diesel engines are also used as the main propulsion engines on board. diesel motors on board are very important, wherein the diesel motors in operation are aimed at smooth sailing operations. One of the supports to start the operation of a diesel engine is air [1].

The diesel engine is the main propulsion system that is widely used for both transportation and stationary drives. Known as high-efficiency internal combustion engines, the use of diesel engines is also growing in the automotive sector, including for the transportation of goods, tractors, bulldozers, power generators in small villages, emergency generators, etc. Low-speed diesel engines can operate on almost any liquid fuel. This class of diesel engines has a rotation of no more than 2500 revolutions per minute (rpm) and usually only has 1 piston so the power capacity produced is 5 to 30 horsepower (HP). This machine is usually used for fixed loads (stationary) and assembled with one or several units [2].

Combustion in a diesel engine often cannot take place perfectly. Amount of ingredients fuel in the combustion chamber that is not by the requirements, the fuel injection process is not good or the process of mixing fuel with air in the combustion chamber is often the cause of an incomplete combustion process [2].

To overcome this problem, diesel fuel is heated before being injected into the combustion chamber to reduce its viscosity so that later after being injected into the combustion chamber it can form finer grains and produce a more homogeneous fuel-air mixture. After that, a test was carried out on a diesel engine to see how the changes occurred in the performance of the motor if it was carried out heating of the fuel used to produce greater power and more efficient fuel consumption compared to before modification. [3].

In thermodynamics, it is stated that entropy production is always created during the combustion process and will affect the performance of a heat engine such as a diesel fuel engine. So that the performance of a diesel engine will change if there is a change in the initial state level to the end of the process that occurs in the cylinder. Variables that affect performance such as engine power, rpm, load, pressure, combustion temperature, AFR, and fuel type. Energy is defined as the theoretical maximum work that can be achieved when interacting systems reach equilibrium. The energy of a system is defined as the maximum amount of work that can be obtained from that system when it reaches thermal, mechanical, and chemical equilibrium [4].

The diesel engine invented by Rudolf Diesel 1892 which is a compression ignition engine which has been widely used today . While the patent was obtained on February 23, 1893 related to Design Methods for Combustion Engines. Diesel engines are, in principle, energy converters that convert chemically bound fuel energy into mechanical energy (effective work) by supplying the heat released by combustion in an engine to a thermodynamic cycle [5].

The performance levels of diesel engines are influenced by a changing fuel inlet temperature. With high fuel temperatures it causes high injection pressure resulting in shorter ignition delays which ultimately affect engine performance . At present, diesel engines are getting attention because in addition to fuel efficiency also due to the engine in accordance with the reference that has been given and does not inhibit the combustion process that it can produce optimal [5].

In an internal combustion engine, the combustion process is a chemical reaction that takes place very quickly between fuel and oxygen which generates heat resulting in high gas pressure and temperature. The need for oxygen for combustion is obtained from air which requires a mixture of oxygen and nitrogen, as well as several other gases with relatively small and negligible percentages. The chemical reaction between the fuel and the oxygen obtained from the air will produce combustion products whose composition depends on the quality of the combustion that occurs [6].

Diesel uses an automatic ignition system, which automatically ignites when there is a diesel supply at the end of the compression stroke. So what about the ignition timing? In a way, the ignition system and fuel system in a diesel engine are located in one. That's because to carry out combustion, it is also triggered by diesel coming out of the combustion chamber. So that the diesel fuel system is the beginning. [7].

In general, combustion in a diesel engine occurs when the end of the compression stroke, diesel fuel blows through the private injectors into the combustion chamber. So that the high temperature will burn the diesel mist which is affected by a fairly strong expansion. The working technique, when the engine is started, there is a flow of diesel fuel from the tank to the injection pump. Inside the injection pump, there is a plunger and a barrel plunger that regulates the volume of diesel which will then come out through the injector. When the ignition timing is reached, the plunger will suddenly push the diesel fuel. So that the diesel comes out through the injector which has a fairly small hole. This small hole is what makes diesel fuel able to fog up [6].

Diesel Engine Cooling System There are 2 kinds of cooling systems: Radiator: Using a pressurized radiator which is generally widely used. Inside the radiator the water moves down, having been cooled by the fan. The downward movement results from an increase in specific gravity due to a decrease in temperature. The cooling water absorbs heat due to combustion from the cylinder liner, cylinder head and all heat due to the friction of all moving part components. Cooling water will move upwards after absorbing heat and its specific gravity becomes smaller and will then be cooled by the fan, thus circulating water naturally cools the engine [8].

Hopper: Unlike the radiator type, the hopper type does not use a fan. The volume of water filled into the hopper is far more than the type of radiator. It has a wide 'mouth' as a hole for water filling, a seat for the cooling water filter which also functions as a seat for the water float (water level indicator) and at the same time as an estuary for releasing hot steam from cooling water [8].

The diesel engine is a machine whose internal combustion engine is the choice of many internal combustion engine users for their vehicles because of its superior fuel efficiency. As an effect of increasingly stringent regulations on environmental pollution, diesel engines have become an option for using internal-combustion engine systems. We encounter this internal combustion engine in several existing transportation systems such as: car systems, ships, portable power generators, buses, tractors and others. One of the advantages of the diesel engine is that the combustion system uses compression-ignition, which does not require a spark plug. In Diesel Fuel Motor one of the most important systems is the fuel flow system [9].

A diesel motor cannot work from rest to working condition, because the working medium, in this case combustion gas, is not available when the motor is not working. Then the motor must be driven by an external energy source. Medium speed diesel motors and low speed diesel motors are started by means of compressed air, which is specially passed through valves located in the cylinder cover [5].

Filling the cylinder during the working stroke of the cylinder in question. The air is stored in the air bottle which volume is enough to start the motor several times without increasing the air pumping. An installation with a driving motor must be able to be started 12 times in succession alternately for forward and reverse rotation without adding [6].

Pumping again. In diesel engines, the combustion process is a chemical reaction that takes place very quickly between fuel and oxygen which generates heat resulting in high gas pressure and temperature. The need for oxygen for the combustion process is obtained from air which requires a mixture of oxygen and nitrogen, as well as several other gases with relatively small and negligible percentages. The chemical reaction between the fuel and the oxygen obtained from the air will produce products of combustion whose composition depends on the quality of the combustion that is taking place [9].

In fact, combustion in a diesel engine often cannot take place perfectly. The amount of fuel in the combustion chamber that is not in accordance with the requirements, the fuel injection process is not good or the process of mixing fuel with air in the combustion chamber is often the cause of incomplete combustion process [10].

To overcome this problem, diesel fuel is heated before being injected into the combustion chamber to reduce its viscosity so that later after being injected into the combustion chamber it can form finer grains and produce a more homogeneous fuel-air mixture. After that, a test was carried out on a diesel engine to see how changes occur in the performance of the motor if the fuel used is heated to produce greater power and more efficient fuel consumption compared to before the modification [11].

2. METHODS

The research method used is an experimental research. in this experiment using an Isuzu diesel engine - Direct Injection. method in which researchers directly conduct experiments to see causal differences from the treatment givenExperimental Research Method Steps

a. Preparation

As a first step, this research includes experimental design, from the design to be used, variables, procedures, and others.

b. Research Implementation

The steps to do something by being treated according to the experimental design.

c. Processing and Analysis Stage

Data analysis in this experimental research is a step in interpreting the experimental results that have been carried out. The research data is first presented through tables or charts, then the researchers process and analyze the data from this study by applying the data processing techniques to be used, including statistical formulas. Increase the motor rotation in stages 1000 rpm, 1300 rpm, 1600 rpm, 1900 rpm, 2200 rpm, 2500 rpm and 2800 rpm.

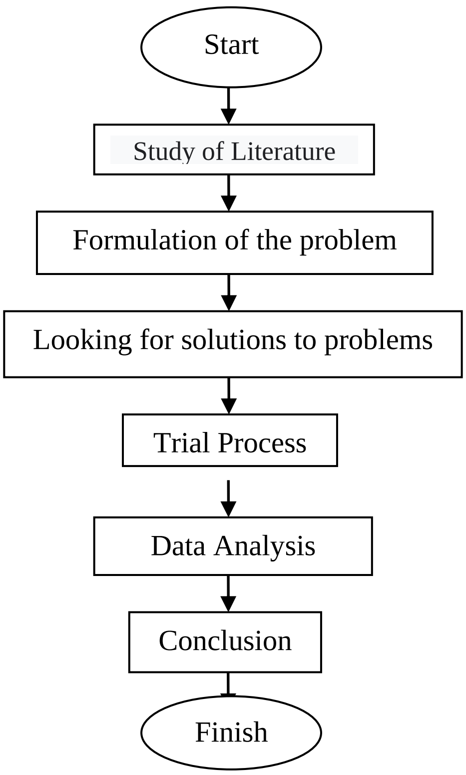

Figure 1. Research Flowchart

3. RESULTS AND DISCUSSION

3.1 Trial Tools

Table 1. Diesel Engine Specifications

No	Motor diesel Isuzu - *Direct Injection*	
1.	Model / type	4JA1, 4 cylinder, OHV diesel
2.	Machine Type	Four-stroke, top valve, water cooling
3.	Combustion chamber type	Direct intake
4.	Liner cylinder type	Dry-type chrome-plated, stainless steel
5.	Sistem gigi timing	Timing gear system
6.	Number of cylinders	4
7.	Centerline x steps	93 mm x 92 mm (3.66 in x 3.62 in)
8.	Number of piston rings	2 compression rings and 1 oil ring.
9.	Cylinder fill	2499 cm^3 (152.4 in^3)
10.	Comparison of cold compression (against 1)	18.4
11.	Compression pressure	31 kg/cm / 441 psi
12.	The sequence of fuel injection	1 - 3 - 4 - 2
13.	Fuel ignition timing	12 ° sebelum TMA
14.	Stationary rotation	750 rpm
15.	Maximum power	86 Ps / 3900 rpm
16.	Maximum power	86 Ps / 3900 rpm
17	Maximum torque	17,5 kg.m / 2300 rpm

This solar heater consists of a tube that has 1 inlet and 1 outlet, and there is a heating element mounted on the bottom and is also equipped with a temperature measuring sensor which is placed near the outlet pipe in the tube which is then connected to a signal conditioning circuit. so that the magnitude of the measurement can be read on a digital multimeter that is used as a display.

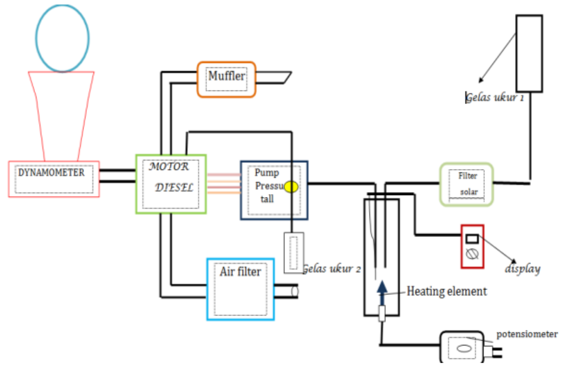

Figure 2. Equipment Series

The power measured by the dynamometer can be calculated using the formula.

$$BHP = \frac{2P\ P\ R\ Nd}{X}\ (dk) \qquad (1)$$

Where:
BHP= brake horse power (dk)
P = dynamometer action force (Newtons)
R = dynamometer arm length (m)
Nd = motor rotation (rpm)
X = conversion factor

While the average effective pressure (Brake Mean Effective Pressure) which is the average pressure acting on the piston during the work, step can be calculated based on the formula

$$bmep = \frac{0{,}45\ N\ Z}{A\ L\ i\ Nd}(\text{kg/cm}^2) \qquad (2)$$

Where:
N = shaft horsepower (dk)
A = piston cross-sectional area (m)
L = piston stroke length (m)
i = number of cylinders
Z = 1 for 2 stroke motors
Z = 2 for 4 stroke motors

The relationship between BHP and bmep is as follows $BHP = \frac{bmep\ lV_{sil}Np}{X}$

Where:

V_{sil} = Piston displacement volume

$$\frac{P}{4} D^2 L$$

Np = number of work steps per minute

= i. Nd/Z

Effisiensi Thermis (Brake Thermal Efficiency)

Thermal efficiency is defined as efficiency utilization of heat from fuel to be converted into mechanical work. Thermic efficiency can be calculated by the equation.

$$\eta_{th} = \frac{641{,}567}{sfc.LHV} \text{ X } 100\% \qquad (3)$$

Where:

η_{th} = Effisiensi thermis (%)

LHV = Low Heating Value in kcal/kg.

The calorific value of the bottom combustion can be calculated

with the equation:

$$LHV = (\ 16610 + 40.\ °API\ )\ .\ 555{,}361552\ \frac{kal}{kg} \qquad (4)$$

Where:

$$°API = \frac{141{,}5}{SG_{solar}\ (60^0\ F)} \qquad (5)$$

by SG_{SOLAR} = specific gravity solar = 0,815

Initial temperature (T_a)

$$T_a = \frac{T_0 + \Delta T_W + (\gamma r + Tr)}{1 + \gamma r} \qquad (6)$$

Where:
T_a = initial temperature (^{0}K)
T_0 = outside air temperature (^{0}K)
Tr= exhaust gas temperature (^{0}K)
γr= spent gas coefficient (0,04)
ΔT_W = air rise

Final Temperature

$$Ta = Ta \text{ x } \varepsilon^{n1-1} \qquad (7)$$

Where:
T_a = initial temperature (^{0}K)
ε= compression ratio
n_1 = polytropic coefficient

3.2 Trial Procedure

Experimental procedures adopted in data collection:

a. Before starting the motor, a check is carried out on the lubricating oil, cooling water, fuel and all other experimental equipment.
b. Turn on the motor at idle rotation of 850 rpm for 5 minutes so that the motor reaches its working condition.
c. Open the water inlet faucet to the dynamometer with water pressure between 3 - 4 bar, braking position at 0%.
d. Record data regarding motor rotation, diesel temperature, amount of diesel return flow in measuring cup 2, and fuel consumption time for 50 ml in measuring cup 1 and the dynamometer action force.
e. Increase the braking position up to 30% and left constant.
f. Increase the motor rotation in stages 1000 rpm, 1300 rpm, 1600 rpm, 1900 rpm, 2200 rpm, 2500 rpm and 2800 rpm.
g. Once again, record data regarding motor rotation, diesel temperature, amount of diesel return flow in measuring cup 2, fuel consumption time for 50 ml in measuring cup 1 and the dynamometer action force for each change in motor rotation.
h. After step 7 is completed, the load is reduced until it reaches 0%, and the motor rotation is reduced until its idle rotation, then turns off the water inlet pumpdynamometer then the motor is turned off and left until the temperature drops to 30°C.
i. After the temperature of the motor is 30°C, the motor is turned on again and the experiment is repeated starting from step 3 with the diesel temperature being raised 10°C and kept constant.
j. This temperature increase is carried out until a decrease in motor power is seen or when the temperature is high enough but it still does not show a decrease in power.
k. After the test is completed, the load is released by returning the braking position to 0%, then the motor rotation is returned to idle speed again.

From the figure 2 and 3 it appears that the solar temperature changes Will be accompanied by changes in torque and motor power, and it is seen that increasing the temperature of diesel fuel will increase the torque and power of the motor.

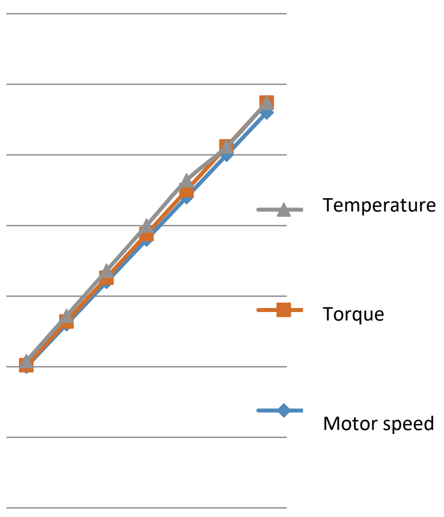

Figure 2. Torque Graph for the Rotation function at several temperatures

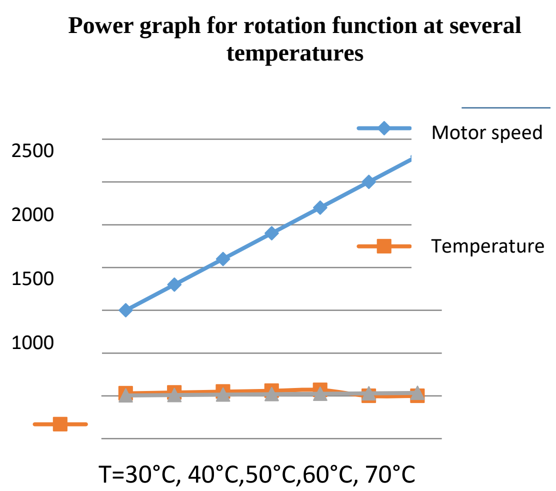

Figure 3. Power graph for rotation function at several temperatures

Theoretically, it can be explained that this increase is due to the heating of diesel fuel which results in a decrease in the viscosity/viscosity of diesel fuel so that when it is injected into the combustion chamber it can form finer fuel mist granules, under these conditions the process of mixing fuel with air will be smoother. homogeneous so that the fuel will burn more easily and cause the percentage of fuel burned to increase. With the greater amount of fuel burned, the increase the pressure that occurs in the resulting combustion chamber combustion will enlarge which in turn will increase the torque and power generated by the combustion engine.

The increase in power that occurs does not continue with an increase in temperature, as shown in the table that the increase in motor power only occurs until the diesel reaches a temperature of 30°C and the rest of the diesel continues to increase the temperature, the power generated by the motor is smaller when compared to when using diesel which is 30°C. This decrease can occur because increasing the temperature of diesel fuel will cause diesel fuel to become more flammable it will shorten the period of preparation for combustion (ignition delay). The preparation period for combustion can be defined as the preparation time of the fuel measured from the time of injection of the fuel until the fuel reaches its self-ignition condition (220 °C). Increasing the temperature of the diesel

Will cause diesel fuel to reach its ignition state more quickly. This change in power is not very visible at motor rotation below 1900 rpm of its overlapping curves, however for motor speed higher than 1900 rpm this change seems to be getting bigger marked by a tendency for the curves to be farther apart.

This shows a tendency that the use of heated diesel will have a greater effect on higher engine speed, bearing in mind that at higher engine speeds, faster-burning fuel is required due to the limited time available for shorter combustion.In this case, it is also necessary to pay attention to the time start of fuel injection as it nears the end of the compression stroke, and this must be adjusted to the length of the combustion preparation period.

If period preparation for combustion is too short while when the fuel is injected far enough before the piston reaches Top Dead Point (TDC), the peak pressure due to fuel combustion will occur before the piston reaches TDC, this is a disadvantage because the explosive power that should be used to push the piston on the stroke expansion/work is reduced because some are wasted when the piston has not reached TDC, besides that if the pressure increase in the combustion chamber is too great to exceed the strength of the motor construction. Problem that can arise if the tool is not can produce solar output with temperatures as expected so this is one of its weaknesses. suggestions for further researchers Solar heating systems can only occur when there is water the radiator is hot enough, so when the water the radiator still doesn't heat the system yet can work. This can be overcome with use of electric solar heaters (using heating element)

4. CONCLUSION

Currently this type of solar heater there are many on the market with use the heat from the radiator water. Problem that can arise is if the tool is not can produce solar output with the temperature as expected. So that there needs to be a change to the design of the tool. One way that can be done is to create a by–radiator water pass before entering the heater. Then by installing the faucet In this channel, you can adjust how much the flow rate of the hot water volume through the heater can be adjusted so that the output temperature of the diesel fuel can be varied as needed.

After heating the diesel fuel on the Isuzu diesel engine, it turned out to bring several changes to torque, power, specific fuel consumption, and thermal efficiency. Changes in the temperature of diesel fuel that will be injected into the combustion chamber of a diesel engine will affect its torque, power, specific fuel consumption, and thermal efficiency. Based on this study, the most ideal diesel temperature for Isuzu diesel motors to produce an increase in power and an optimal decrease in sfc prices is based on this study, namely the rotation range from 1300 rpm to 2800 rpm is 50°C, which results in an average power increase of 4 .8% and an average decrease in SFC of 25.4% when compared to without diesel heating (T diesel = 30°C) .comparison with previous research lies in setting idle speed, torque, diesel temperature, setting the water intake valve.

Problem that can arise if the tool is not can produce solar output with temperatures as expected so this is one of its weaknesses. suggestions for further researchers Solar heating systems can only occur when there is water the radiator is hot enough, so when the water the radiator still doesn't heat the system yet can work. This can be overcome with use of electric solar heaters (using heating element), thereby heating solar can be done without depending on radiator water temperature. And will be more even better if it is also equipped with the system control that can adjust the output temperature solar according to what we need when we do the experiment.

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REFERENCES

[1] Arismunandar, W. (1988). Penggerak Mula Motor Bakar Torak. Edisi ke-4. Penerbit ITB, Bandung.

[2] Murdieono, S. N. Aklis, & M. Eng. (2017). Kinerja Mesin Diesel Dengan Bahan Bakar Minyak Hasil Pirolisis Sampah Plastik. Jurnal Teknik Mesin Universitas Muhammadiyah Jember, 4(6).

[3] Muchlisinalahuddin D. (2016). AnalisisPrestasiMesin Motor Bakar Diesel Type Pauss Model 175A UntukBahanBakar Solar Dan Bio Solar. JurnalTeknikMesinUniversitasSebelasMaret, 6(1), 16–24.

[4] Kumar, P., Singh, S., &Thipse, S. S. (2015). Effect of fuel injection pressure and combustion chamber temperature on the performance and emission characteristics of a diesel engine. Procedia Materials Science, 10, 704-709.

[5] Nagar, et al. (2015). A Comparative Experimental Study Between The Biodiesels Of Jatropha And Palm Oils Based On Their Performance And Emissions In A Four Stroke Diesel Engine. Department Of Mechanical Engineering, Thapar University, Patiala 147 004, India, 24(2).

[6] Abdel-Rehim, H. M., & Saleh, S. H. (2017). Effect of intake air temperature on the performance and emissions characteristics of a diesel engine. Alexandria Engineering Journal, 56(2), 209-215.

[7] Jackson, L., & Thomas D Morton. (2000). General Engineering knowledge for Marine Engineers. Adlard Coles Nautical, London.

[8] Kim, D. S., Choi, S. B., & Kwon, S. C. (2013). Effect of fuel injection temperature on combustion and emissions characteristics in a diesel engine. Applied Energy, 107, 192-197.

[9] Kasiraman, G., Nagalingam, B., &Balakrishnan, M. (2012). Performance, emission and combustion improvements in a direct injection diesel engine using cashew nut shell oil as fuel with camphor oil blending. Energy, 47(1), 116–124.

[10] Rakopoulos, S. C., Rakopoulos, C. D., Giakoumis, E. G., Andritsakis, E. C., &Dimaratos, A. M. (2013). Experimental investigation of the effect of fuel temperature on diesel engine performance and emissions. Energy Conversion and Management, 74, 1-12.

[11] Obert, E. F. (1973). Internal Combustion Engine and Air Pollution. New York: Harper and Row Publisher.