

The Effect of Using Crankcase Emission Control System (CECS) Technology on Air-Fuel Equivalent Ratio and Carbon Monoxide Emissions in Four-Stroke Gasoline Engines

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ABSTRACT:

The test was conducted on a four-stroke gasoline engine with a rotation of 1000 rpm to 9000 rpm with an interval of 1000 rpm, using the Crankcase Emission Control System (CECS) which utilizes hot gas from the crankcase (crank chamber) that exits through the engine's breathing channel will mix with atmospheric air that has been filtered through the filter so that it becomes warm air and mixes with fuel which then the mixture flows into the combustion chamber. Then the vehicle was tested in stages. The first test was under standard conditions (without using CECS), and the second test with the use of CECS in the breathing channel. As a result of the leakage of hot gas in the gap between the piston and piston ring to the cylinder wall, the temperature in the crank chamber will increase. The observed things are the fuel supply time of 5 ml, the air-fuel equivalent ratio, and the concentration of carbon monoxide gas emissions. It turns out that the use of CECS can reduce the concentration of carbon monoxide quite significantly at 8000 rpm and 9000 rpm, respectively by 0.961% and 0.225%.

Keywords: : CECS, carbon monoxide, equivalent ratio, reduction, concentration

INTRODUCTION

A piston combustion engine is an engine that converts heat energy into mechanical work. In a piston combustion engine, heat energy is released through the combustion of a mixture of fuel and air in the combustion chamber. A homogeneous mixture of fuel and air is needed for the combustion process to be perfect. [4]

In this study, an experiment was conducted on the effect of the use of a crankcase emission control system (CECS) on the air-fuel equivalent ratio and exhaust emissions.

In an effort to reduce the percentage of toxic exhaust emissions in vehicles, various methods can be used, one of which is by maximizing the combustion process that occurs so that

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the combustion is perfect. Good combustion is greatly influenced by the condition of the air-fuel mixture that is formed. For that reason, this study will discuss CECS which functions to warm the air before entering the carburetor, and of course will affect the combustion process of the fuel and air mixture. [12]

The problems studied are as follows:

- How do standard conditions (without using CECS) affect the air-fuel equivalent ratio and exhaust gas composition of gasoline engines.
- How does the use of CECS affect the air-fuel equivalent ratio and exhaust gas composition of gasoline engines.

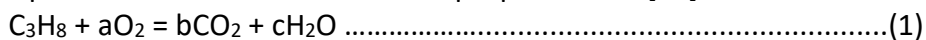
The carburization process is influenced by engine speed, fuel vaporization characteristics, intake air temperature and carburetor design. Modern high-speed engines have very limited time to form a mixture. Therefore, the flow rate of high-quality carburizing air (with high vapor content) at the fuel injection point must be increased. Another factor that ensures high-quality carburization in a short time is the presence of volatile HC in the fuel. Therefore, the characteristics of fuel vaporization indicate the need for efficient carburization, especially at high engine speeds.

An engine is usually operated at different speeds and loads. Therefore, the nature of the air-fuel mixture will be flowed into the combustion chamber. Fuel and air mix to form three types of mixtures, namely stoichiometric mixture, rich mixture, and lean mixture. A stoichiometric mixture is a mixture of air that is sufficient for complete combustion of a fuel. A rich mixture is a mixture that contains less air than a stoichiometric mixture. While a poor mixture is a mixture that contains more air than the stoichiometric mixture. This type of mixture can occur between a rich mixture and a lean mixture to continue the ignition preparation. This occurs at an air-fuel ratio of 19:1 to 9:1. [7]

Actually, the need for an air-fuel mixture at engine operating conditions varies from ideal conditions. Engine operation is truly successful if the carburetor can produce a mixture that meets the air-fuel ratio requirements at idle (rich mix), cruising (poor mix) and high power (rich mix). [7]

The relationship between the composition of the reactants (fuel and air) of the combustible mixture and the composition of the combustion products. This relationship only depends on the conservation of mass of each chemical element in the fuel and air, only a proportional fuel and air composition is required.

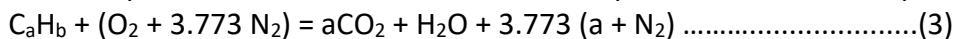
If sufficient oxygen is available, HC fuel can be perfectly oxidized. The carbon in the fuel is then converted into carbon dioxide CO_2 and water vapor H_2O . Consider the chemical equation for the perfect combustion of 1 mole of propane C_3H_8 : [13]



Given $b = 3$, $c = 4$ and $a = 5$, the equation above becomes:



Air contains nitrogen, but the reaction effect is not significant, the combustion products are at low temperatures. In general, the perfect combustion of HC fuel is from the average molecular composition of CaHb with air. The overall perfect combustion equation is:



Equation (3) shows the stoichiometric (theoretical) proportions of fuel and air, that is, just enough oxygen to convert all the fuel into complete oxidation products. The stoichiometric ratio of air - fuel or fuel - air to the fuel composition. From equation (3) we obtain:

$$= \left(\frac{A}{F}\right)_s = \left(\frac{F}{A}\right)_s^{-1} = \frac{(1 + \frac{y}{4})(32 + 3,773 \times 28,16)}{12,011 + 1,008y} = \frac{34,56(4 + y)}{12,011 + 1,008y} \dots\dots\dots (4)$$

The composition of combustion products differs significantly for fuel-lean and fuel-rich mixtures; Since the stoichiometric fuel - air ratio depends on the fuel composition, the actual fuel - air ratio to the stoichiometric fuel - air ratio is more of an information parameter for the definition of the mixture composition. The fuel-air equivalent ratio is: [9,11]

$$\Phi = \frac{(F/A)_{actual}}{(F/A)_{stoichiometric}} \dots\dots\dots (5)$$

The inverse of Φ is the relative ratio of air to fuel :

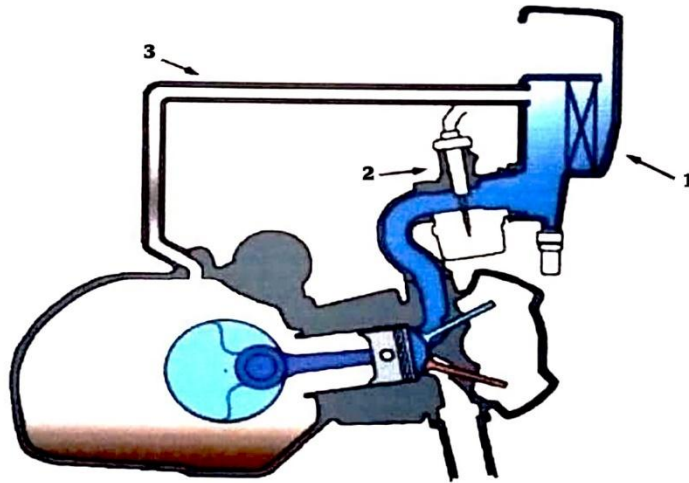
$$\lambda = \Phi^{-1} = \frac{(A/F)_{actual}}{(A/F)_{stoichiometric}}$$

- for lean mixture: $\Phi < 1, \lambda > 1$
- for stoichiometric mixture: $\Phi = \lambda = 1$
- for rich mixture: $\Phi > 1, \lambda < 1$

With the CECS technology that utilizes warm air from the engine's respiratory tract by channeling it back into the combustion chamber so that combustion is easier and can improve engine performance. [12], in addition, this technology can also reduce toxic gas emissions. The way this technology works is when the engine is operating, the piston moves up and down in the cylinder and performs a work cycle, especially when moving to the top dead center (TDC) which is carrying out the compression and combustion process/step, where at that time both valves are in the closed position, then the gas in the cylinder will be pushed and compressed by the piston, so that the pressure will increase and the gas will move in all directions, especially against the thrust of the piston movement, so that a small part of the gas will leak/exit into the crankcase due to leaks in the piston and piston ring against the cylinder wall (blowby), which then the gas will be utilized and circulated into the combustion chamber before passing through the air filter and then mixing with oxygen (from the outside air) so that it becomes warm air and then enters the combustion chamber because there is piston suction that previously passed through the carburetor and will be mixed with fuel (gasoline), so that both gases become gas that is already in the form of mist, then enters the combustion chamber and carries out the next combustion process. [10]

The image below shows the mechanism of CECS technology. The parts of CECS are 1. air filter, 2. carburetor, 3. breathing channel from the crankcase

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The leak referred to here is a gas leak or blast from the combustion chamber due to a leak in the piston and piston ring against the cylinder wall leading to the crankcase. The blast from this leak contains hydrocarbons (HC) of about 20% of the total HC content of the engine, and will increase by about if the piston ring is damaged (worn). In this gas blast, about 85% of the mixture from the carburetor is in the form of raw HC, the remaining 15% is burnt gas. [10].

RESEARCH METHODS

In this study, carbon monoxide (CO) gas emissions were measured against a standard engine without using a crankcase emission control system (CECS) and using CECS from the factory design results. The fuel used was gasoline fuel. The supporting equipment used in the study is as follows:

In this study, supporting equipment such as dynotest, image monitor, dynotest table, engine cooling blower, control panel, roller, motorcycle, tachometer and others were used.

The explanation related to the supporting equipment, test materials, and measuring instruments used in the study is as follows:

1. Dynotest / Dynamometer

Dynotest / Dynamometer is a tool used to measure power and torque on a motorcycle with Kowa Seiki Japan specifications.

2. Monitor

The image monitor is a display of a torque and power measurement program on a motorcycle.

3. Dynotest Table

The Dynotest Table functions as a motorcycle stand for torque and power testing.

4. Blower

The blower functions as an air blower to cool the motorcycle engine when the torque and power testing process is taking place.

5. Control Panel

The control panel functions as a place to operate the dynotest tools.

6. Roller

The roller functions as a reader of rotation, power, and torque on the motorcycle.

7. Test Machine

The test machine used is a Honda Megapro brand vehicle, a four-stroke gasoline engine type, with one cylinder. The engine has been assembled with test equipment, namely a roller as a load connected by a sensor to the spark plug cable which can be directly read automatically by the computer about the torque and power at the desired rotation.

8. Tachometer

A tachometer is a tool that functions to determine the engine rotation that occurs on the output shaft. The magnitude of the engine rotation can be directly read on the measuring scale with units of rotation per minute (rpm).

9. Stopwatch

A stopwatch is a tool used to determine the time required for the fuel supply during testing. In this case, the time in question is to determine how fast the fuel consumption time will be used in the experiment.

9. Burette

A burette is a tool used to measure the fuel supply during testing.

10. Gas Analyzer

A gas analyzer is a tool used to measure the percentage of exhaust gas composition

Exhaust Gas Emission Test

1. Preparation of the Test Site

- Temperature 20 – 40 0C; adjust to the specifications of the test equipment
- Smooth ventilation; air exchange affects air humidity
- Flat floor (not sloping); for engines using carburetors

2. Vehicle Preparation

- Normal engine working temperature (minimum 60 0C)
- Engine speed according to standard (vehicle specifications)
- All engine loads are turned off (lights, etc.)
- Check the exhaust gas channel, the exhaust must not leak

3. Test Equipment Preparation

- The tool has been calibrated for a maximum of 6 months
- Completed through the heating process
- There are no leaks in the system
- There are no errors (after auto diagnosis)
- Make sure the filter is clean (do a residual test)

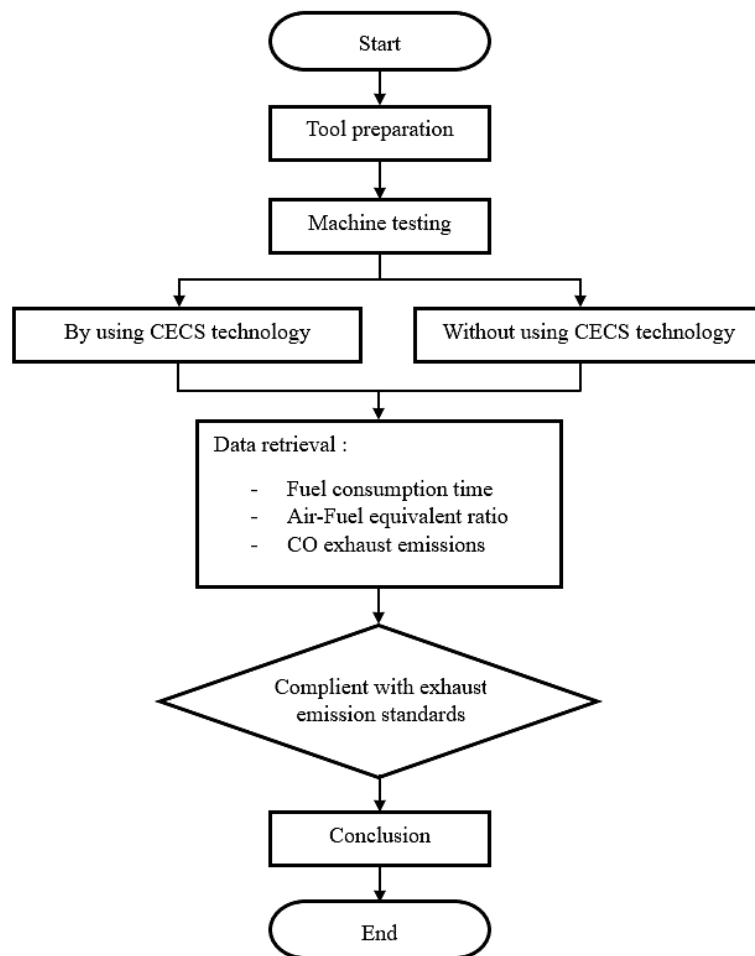
4. Testing Procedure

- Start the vehicle at stationary speed to warm up the engine to working temperature (\pm 60 - 80 0C)

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- Turn on the power of the test equipment (dynamometer / dyno test and gas analyzer) and other supporting tools (blower, etc.), then carry out testing according to the specified criteria with various speed variations
- When taking data, first the gas throttle is opened slowly until fully open until the desired engine speed is reached, this is done to collect data in the form of rotation that comes out on the computer that has been connected to the dynotest. To find out the exhaust emissions, the throttle gas is opened slowly until the desired rotation then insert the probe/sensor from the gas analyzer to the exhaust at least 30 cm, so that the exhaust gas composition will be directly visible on the gas analyzer monitor so that data is obtained from the test results. Testing and data collection are carried out 3 times in each rotation variation. At the same time, data on the time of fuel consumption of 5 ml and the equivalent ratio of air - fuel (λ) are also recorded
- Turn off the engine when the test is complete
- Testing is complete, all conditions return to their original state

Research Flow Diagram



RESULT AND DISCUSSION

CO Concentration

A good engine is expected to produce the smallest possible toxic exhaust emissions.

Table 1. Engine speed, fuel consumption time (t), A/F equivalent ratio (λ) and CO concentration

| Engine rotation [rpm] | Remarks | | | | | |
|--------------------------|------------------------|---------------------|--------|-----------|---------------------|--------|
| | Without CECS (standar) | | | With CECS | | |
| | Time [s] | Lamda (λ) | CO [%] | Time [s] | Lamda (λ) | CO [%] |
| 1000 | 82,78 | 1,043 | 6,436 | 84,9 | 1,044 | 6,559 |
| 2000 | 57,24 | 1,253 | 4,275 | 54,3 | 1,193 | 5,161 |
| 3000 | 39,64 | 1,128 | 4,846 | 40,28 | 1,56 | 5,244 |
| 4000 | 27,82 | 1,044 | 5,108 | 28,02 | 1,198 | 5,337 |
| 5000 | 22,97 | 0,973 | 5,364 | 23,15 | 1,044 | 5,403 |
| 6000 | 17,27 | 0,735 | 4,226 | 17,34 | 0,914 | 3,961 |
| 7000 | 14,01 | 0,949 | 3,017 | 14,13 | 0,862 | 2,188 |
| 8000 | 13,07 | 1,019 | 1,178 | 13,1 | 1,005 | 0,961 |
| 9000 | 11,42 | 1,124 | 0,255 | 11,67 | 1,129 | 0,225 |

But in reality, no engine actually produces CO₂ and H₂O from its combustion. Carbon monoxide is one of the significant toxic exhaust emissions produced by engines.

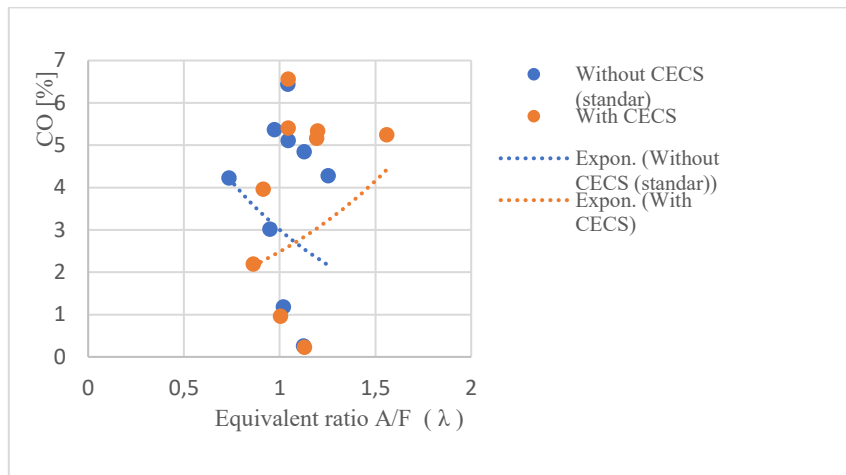


Figure 4. Relationship between CO concentration and A/F equivalent ratio

Figure 4 shows the relationship between carbon monoxide (CO) concentration and air-fuel equivalent ratio (A/F) of four-stroke vehicles with engine speed variations of 1000 to 9000 rpm, with an interval of 1000 rpm. This experiment was conducted on vehicles with standard

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conditions (without using CECS) and with conditions using CECS on the breathing channel (crankcase).

From the test results, the lowest CO concentration was obtained $\approx 0.225\%$ at engine speed of 9000 rpm, with or without using CECS, each with air-fuel equivalent ratio (λ) ≈ 1.124 and 1.129 . But the combustion that approaches the stoichiometric mixture ($\lambda \approx 1$) when the engine speed reaches 8000 rpm, each with an air-fuel equivalent ratio (λ) ≈ 1.005 and 1.019 , and each CO concentration is 0.961% and 1.178% respectively. From here it can be seen that by using CECS there is a significant reduction in CO concentration of 18.4% . So it can be assumed that when the engine speed reaches 8000 rpm it will reach the optimum engine power and specific fuel consumption. The richest mixture with an air-fuel equivalent ratio ≈ 0.735 (6000 rpm) compared to other conditions. The richest mixture with an air-fuel equivalent ratio ≈ 0.735 (6000 rpm) compared to other conditions. Meanwhile, the largest CO concentration is $\approx 6.559\%$ with an air-fuel equivalent ratio of ≈ 1.044 (1000 rpm rotation) and is said to be a poor mixture. The concentration of CO in the rich mixture in the exhaust gas is reduced stably along with the increase in the air-fuel equivalent ratio along with the increase in fuel in the engine speed range of $6000 \div 7000$ rpm. On the other hand, there is a fluctuating CO concentration in the lean mixture in the engine speed range of $1000 \div 4000$ rpm.

CONCLUSION

From the test results, it can be seen that the use of CECS technology at certain engine speeds can reduce carbon monoxide emissions. It turns out that the use of CECS produces a significant decrease in carbon monoxide concentration of 0.225% and at 9000 rpm engine speed, with or without using CECS (standard conditions), each with an air-fuel equivalent ratio (λ) ≈ 1.124 and 1.129 . Combustion approaching the stoichiometric mixture ($\lambda \approx 1$) when the engine speed reaches 8000 rpm, each with an air-fuel equivalent ratio (λ) ≈ 1.005 and 1.019 , and CO concentrations are 0.961% and 1.178% , respectively. The richest mixture with an air-fuel equivalent ratio ≈ 0.735 at an operating condition of 6000 rpm compared to other conditions.

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