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Original Research Article

Investigation of the effect of spark plug gap on vibration, noise and HC emission in a gasoline engine

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ABSTRACT

There are many factors that affect the operation of vehicle engines. Not working regularly of an engine causes a decrease in the performance; on the other hand, an increase in the fuel consumption, the vibration and the HC emission. These adverse impacts reduce vehicle comfort and increase travel costs, and also damage nature much more. Vehicles are normally designed in such a way that they provide optimum operating parameters. However, as the vehicle is used, these parameters negatively change. In this study, it has been experimentally investigated that the effects of spark plug gap on vibration, noise and HC emission in a gasoline engine. It is a fact that, the spark plug is abraded in a certain amount because it is continuously ignited. This abrasion increases the distance between the center electrode and the electrode head, and changes the quality of the composed spark. In experiments, it has been detected that, when the spark plug clearance and the number of revolutions are increased, the vibration and noise increase proportionally; on the other hand, the exhaust emission (HC) value increases at 0.7 mm, 0,8 mm and 1.0 mm plug gap and decreases at 0.9 mm plug gap. As a result, setting the standard spark plug gap in the gasoline engines to 0.9 mm instead of 0.7 mm can provide a significant reduction in exhaust emissions; thus, an improvement in performance can be achieved.

Keywords: Spark plug gap, Vibration, Noise, Emission

1. Introduction

Development of vehicle technology has increased the competition between the producers and correspondingly the level of comfort and safety of vehicles. There are many factors that affect the comfort and safety of the vehicle. Vibration, noise and emission can be considered as the most important factors.

Basic sources of vibration and noise in vehicles are vehicle engine, road surface and aerodynamic effects. It is observed that, the people who are exposed to these effects, have symptoms of distraction, stress, irritability and fatigue [1-2]. In this case, it increases the accident risk of the driver. The vibrations may cause failure of the systems on the vehicle by exposing to impact, material fatigue, friction and thermal stress. Failures due to the fatigue of the materials are among the most important results of the vibration [3,4]. Reducing the vibration makes it possible to reduce the noise level significantly [5].

The main causes of vibrations in vehicle motors are combustion forces resulting from combustion, irregularity of engine parts with accelerated motion, centrifugal force brought about by the flywheel, and movements in valve mechanism[6-7]. Coercion forces generated by unbalanced movements in linear and cyclically accelerated parts cause an increase in the motor vibration. Another reason of motor vibrations is the elasticity of the parts, the gap between the parts and the non-continuous contact [5,8].

The rapid pressure impulse caused by combustion in the engine cylinder causes the cylinder walls and engine flank walls to vibrate. These vibrations in different parts of the engine cause the pressure fluctuation and produce noise. It is impossible in today's technology to eliminate vibration in internal combustion engines; but it is possible to reduce it. Particularly, advances in material technology have a positive impact on motor vibration. In addition, optimizing the motor operation will also reduce the vibration. Besides; it is necessary that some measures need to be taken, for example, reducing the motor speed, increasing the number of cylinders and thickening the cylinder block to reduce to minimum these vibrations and sounds. However, that is not preferred by producers and users because of the imputed costs which will be added to fuel consumption, cost, performance, and purchase-sell cost. For this reason, vehicle manufacturers and users are resort to isolate the noise which is radiating from the motor [9-10].

One of the growing problems of developing and especially developed countries is the traffic noise [10-14]. Noise is defined as unpleasant, unwanted, uncomfortable sound. A noise is so disturbing as how insignificant, how violent, how irregular and how sudden. But every sound is not defined as noise. To define a sound as noise is not only dependent on the severity, shrillness, saturation and continuity of the voice. Also it changes according to the physical and mental state of the person who exposes to the sound. However, it is also clear that many sound types will be defined as noise by everyone without any doubt [11-12]. It has been determined that there are some physiological effects of noise on humans like muscle tension, stress, increase in blood pressure, change of heartbeat and blood circulation, eye infant growth and insomnia. Stress and insomnia are long-term effects of noise. Also it is asserted that noise may cause the emergence of diseases like migraine, ulcer and gastritis [12-13]. This noise, which is the result of the movements of the vehicles consists of some constituents like noises which have been caused by the engine, engine frame and vehicle body, braking and contact of the wheels with the road surface and air friction generated by the vehicle [11-14]. In other respects, an unwell-designed exhaust system is also an important noise source [14-15]. It is known that the quota of exhaust noise which is changing depending on the current vehicle and muffler type in total noise which is radiating from the vehicle is %40. For this reason, one of the important issues which are needed to be worked on is the exhaust system in order to reduce the noise radiating from motor vehicles [15].

Besides the noise pollution caused by vehicles; the gases produced as a result of combustion are also harmful to nature and human health. Especially, a large part of the air pollution in the cities is caused by the harmful gas from the internal combustion motor vehicles. Characteristics and concentrations of pollutants which are radiating from motor vehicles change depend on the engine type, engine setting, mode of use, fuel composition and atmospheric conditions [1]. Motor vehicles pollute the environment with gas, liquid and solid wastes which are resulted from exhaust emissions, fuel-oil vapor, lead compounds, asbestos and rubber powders, corrosion, corrosion and corrosion [2].

There are some matters in the compound of exhaust gases which constitute 75% of the total pollutants from motor vehicles; partially burnt hydrocarbons such as aldehydes, ketones, carboxylic acids, CO, NOx, SCb, lead compounds and particulates[3]. If the hydrocarbons are from exhausted; they are emissions that are partially burned due to faulty air-fuel ratio, low compression, valve thrust and inhomogeneous temperature distribution in the cylinder, or are left in the atmosphere without involvement in combustion. Hydrocarbon emissions suspended in the atmosphere cause adverse effects on the respiratory system and living things by reacting with nitrogen oxides to form a mist layer known as "photochemical cis-smog" [15]. A motor vehicle which has not emission control can make a person's 15 m^3 / day fresh air requirement inconvenient to breathe in as little as 10 minutes. Emissions vary according to respiratory duration and intake quantities in point of adverse effects of human health. In this regard, three different concentrations have been identified and hazard limits have been indicated [5]. If you stay in an environment containing 100 ppm carbon monoxide for a long time, you may notice slight headaches, severe headaches, dizziness and fainting in 500 ppm and respiratory weakness, loss of consciousness and death at 2000 ppm and above [6]. Nitrogen oxides combine with hemoglobin which are in the blood. It combines with moisture in the liver to form nitric acid, and the amount of acid formed is less effective due to the low concentration. However, they accumulate over time and pose danger for the people who suffer from respiratory tract diseases [7].

Although the emission of harmful gases has been reduced by the development of vehicle technologies, it is not at an adequate level. Today, exhaust emissions of an internal combustion engine are controlled with catalytic converters, exhaust gas recirculation (EGR), sump ventilation, fuel evaporation and thermal exhaust reactors. They are also available in particulate filters used in diesel engines. They are converted to harmless N_2, CO_2 and H_2O gas by reducing the NOx, HC and CO emissions which are combustion gases in the internal combustion engines to three-way catalytic converter. The harmful exhaust emissions from the three-way catalytic converters can be reduced to 90% to 95% and converted into harmless gases [8]. In the international agreements that the European Union is mainly based on; reduction of emissions, protection of nature and human health. These agreements are based on the European Union.

The companies are doing a lot of research to decrease the value of the emulsion. These technologies include the directly sprung engine design in which poor-mixed combustion in the gasoline engine, stepped filler motors, recent motor size reductions and the application of overfill systems to prevent power loss in small stroke engines [4]. However, these technological studies which are done to reduce the emissions increase the cost of the vehicle.

Another measure taken regarding emissions is that countries require emission values to a certain standard in order to allow the use of manufactured vehicles. During the utilization of vehicles, measurements are made at regular intervals to try to control the emission values of the vehicles [5].

In this study, it has been investigated that the effects of spark plug gap on vibration, noise and HC emission of gap in a gasoline engine. In the experiment, a Tofaş group motor with 1600 cc engine volume having a single muffler in the exhaust system, accelerometer, noise level measuring device, and exhaust gas emission measuring device are used. The rest of the work is organized as follows: Section 2 contains the material and method used in the experiment, Section 3 explains findings, Section 4 draws the conclusion and discussion.

2. Materials and Methods

The PCE-VD3 model accelerometer vibration device shown in Figure 1 was used in order to obtain the vibration data generated by the motor in the experiments. This device is a miniature universal data recorder with integrated triaxial (X, Y, Z axes) acceleration sensor. The internal sensor of this device has a measurement range of ± 18 per axis and as X, Y, Z axes and total resultant acceleration, four different acceleration types are measured in g units. Vibration data were recorded via a personal computer. Vibration data was automatically recorded by the software at a time of 500 ms. The measurement duration for each selected motor cycle was accepted as 15 s. At the end of each measurement, the average and maximum resultant acceleration values were recorded.

Figure 1. Accelerometer

The noise generated by the motor was calibrated by OMKA calibration center which is shown in Figure 2 and a CEM DT-8820 sound level meter is used. Values were determined as decibels (dBA). Noise measurements were recorded at a distance of 2.5 meters from the noise center. The only noise source was the engine because the measurements were made in a closed area.

Figure 2. Noise level meter

The exhaust gas emissions measurement device shown in Figure 3 was used to perform emission measurements in the study.

Figure 3. Exhaust gas analyser

The experiments were carried out with a Tofaş group motor with a 1600 cc engine volume which has a single muffler in its exhaust system as shown in Figure 4a. The motor was mounted on a metal box. The buckets mounted on the motor during the test were shown in Figure 4b. Experiments were carried out in a workplace whose temperature is 20 °C After the engine was brought to operating temperature, the data were recorded.

3. Results

Figure 5 shows the vibration data of the engine at different operating speeds and different spark plug gaps. When the data were evaluated, it was determined that the vibration at a spark plug gap of 0.8 mm and at 2000 rpm was 2.42 g.

Vibration was observed to be higher at other spark plug gap values. When a vehicle was assumed to run normally at 2000-2500 rpm it can be seen that the engine has a good quality combustion at the 0.8 mm spark plug gap and therefore the engine runs more stable because of its smooth operating.

a. Gasoline engine

b. Spark plug

Figure 4. The gasoline engine and spark plug used in the experiment

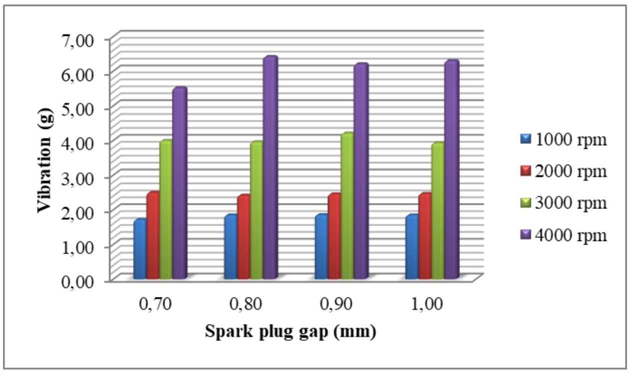

Figure 5. Vibration versus spark plug gap at different revolutions

Figure 6 shows the noise values that the engine produces at different speeds and spark plug gaps. At 2000 rpm, a noise level of 78.5 dBA was found. At 3000 rpm, the lowest noise value (81.7 dBA) was found at 0.7 mm spark plug gap.

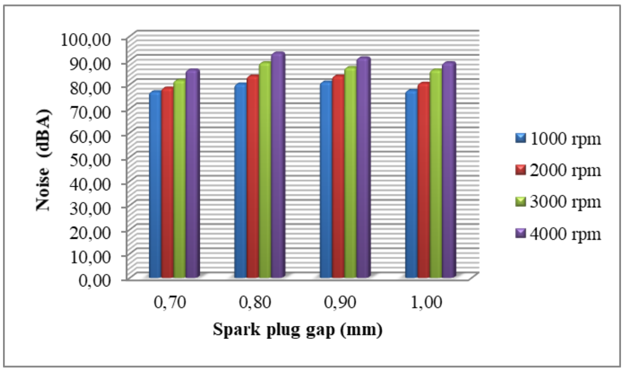

Figure 6. Noise versus spark plug gap at different revolutions

In Figure 7, the amounts of hydrocarbon (in ppm) produced by the engine operating at different spark plug gaps and speeds are shown. According to the results of the experiment; hydrocarbons amount was measured to be 1250 ppm HC at 1000 rpm and at the standard spark plug gap. When the speed is increased to 2000 rpm, it was measured to be 1800 ppm. A decrease in the HC was observed at the revolutions of 3000 and 4000 rpm.

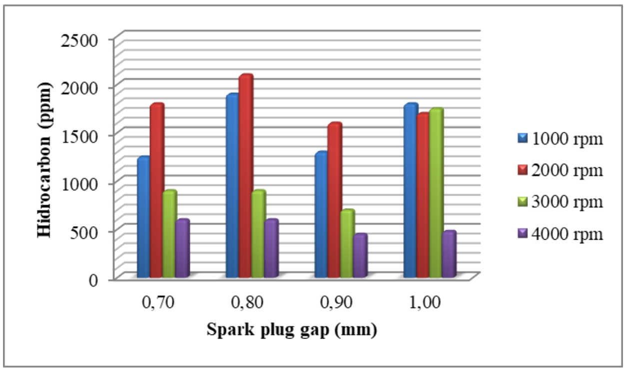

Figure 7. Hydrocarbon versus spark plug gap at different revolutions

At the 0.8 mm spark plug clearance, the HC was measured to be 1900 ppm at 1000 rpm. When the speed was increased to 2000 rpm, HC was measured to be 2100 ppm. A decrease in HC was observed at the revolutions of 3000 and 4000 rpm at 0.9 mm spark plug gap. When the speed was increased to 2000 rpm, HC was measured to be 1600 ppm; on the other hand, a decrease in HC was observed at the revolutions of 3000 and 4000 rpm. Similarly, at 1.0 mm spark plug gap, the HC amounts measured at 1000, 2000 and 4000 rpm was measured to be 1800, 1700 and 480 ppm respectively.

Consequently, because the average HC in the experiments decreases at the 0.9 mm spark plug gap we can conclude that there is a good combustion at this spark plug gap.

4. Conclusion

In this study, it has been investigated that the effects of spark plug gap on vibration, noise and HC emission in a gasoline engine. In experiments, it has been observed that, when the spark plug gap and the number of revolutions are increased, the vibration and noise increase proportionally; on the other hand, the exhaust emission (HC) value changes depending on spark plug gap. The findings are presented as detailed below. Increasing of spark plug gap,

a) Increased vibration values at 1000 rpm; but it is assumed that 0.8 mm spark plug gap is more suitable when the vehicle is operated between 2000 and 3000 rpm in daily use,
b) Generates less noise values at the original spark plug gap (0.7 mm) for all engine revolutions.
c) Increased the HC amount in general. An increase in the HC means that the combustion is incomplete or getting worse. If the combustion is poor, more harmful substances spread to the atmosphere and results in an increase in the fuel consumption. For this reason, it is suggested that the regular maintenance of the vehicles yields more advantageous in terms of economy and comfort.

The most important point in the car maintenance is that the suitable spark plug having equally spark gap must be used for a vehicle. Otherwise, the engine would not properly operate at idle or other revolutions. Another point herein is that that the total amount of HC measured in the original spark plug clearance (0.7 mm) is higher than the values measured in the 0.9 mm spark plug clearance. In the light of such information, it has been found that 0.9 mm spark plug gap is more suitable in terms of exhaust emission. The performance and emission values at different revolutions and spark plug gaps, and thus the correlation between performance and emission values can be investigated in future works.

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