e-ISSN: 2548-060X

International Journal of Energy Applications and Technologies

journal homepage: www.dergipark.gov.tr/ijeat

Original Research Article

Effect of iridium spark plug gap on emission, noise, vibration of an internal combustion engine

hosted by Turkish JournalPark ACADEMIC

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ARTICLE INFO

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Received May 7, 2019
Accepted June 29, 2019

Published by Editorial Board Members of IJEAT

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doi: 10.31593/ijeat.561307

ABSTRACT

The most important factors affecting comfort and performance in motor vehicles are; The exhaust gases generated by the internal combustion engine are noise and vibration. The effect of these factors can be reduced thanks to the fully efficient and regular operation of the engine. The most important part affecting the efficient operation of the spark plug ignition engine is the spark plug. Spark plug failure; emission, noise and vibration values increase. These negative effects reduce vehicle comfort and increase travel costs; it also causes more damage to nature. Vehicles are designed and manufactured to ensure optimum operating parameters during production. However, changes in these parameters occur as the vehicle is used and different types of parts are used during maintenance. In this study, spark plug nail spacing; Emission, noise and vibration effects and determination of optimum nail spacing. In the experiments, iridium spark plug was used as ignition spark type. The spark plugs wear out because the engine fires continuously during operation. This wear increases the distance between the center electrode and the electrode cap and changes the resulting spark quality. According to the experiments; When the iridium spark plug nail spacing is 0.8 mm, the noise is optimum at different revolutions, the vibrations in the 0.9 mm nail spacing increase at low revolutions, and the hydrocarbon value is minimized at high revolutions in the 0.8 mm spark plug nail spacing.

Keywords: iridium spark plug; internal combustion engine; noise; emission; vibration

1. Introduction

Comfort is one of foremost among the factors that affect automobile preferences of current consumers. Comfort levels of vehicles have increased considerably with the development of technology. In the vehicles, there are several factors affecting driving comfort negatively. These factors are mainly stemming from emissions, noise and vibration produced from internal combustion engines. Completely extinguishing of these factors are impossible in recent conditions. However, the producers have been conducting several R&D studies to reduce these factors, and producing current automobiles with minimum emission, noise and vibration.

Besides of negative effects on driving comfort, incomplete combustion, non-available air-fuel mixtures, and exhaust gases generated in the engine threaten human health and environment. At the big cities, one important reason of air pollution is poisonous exhaust gases from internal combustion engines. Density and features of pollution change depend on types of engine, process, settings, fuel compounds and environmental atmospheric conditions. [1-2].

There are several factors causing air pollution, but exhaust gases compose more than half of other pollutants. The composition of these pollutant gases contain unburned hydrocarbons such as paraffin, olefins and aromatics partially

burned hydrocarbons such as aldehydes, ketones, carboxylic acids, and some lead compounds such as CO, NOx, SCb and particulate matters [3]. Hydrocarbon emissions that take part in the compounds and are found as suspension cause of negative effects on living organisms and respiratory system as reacting with nitrogen oxide and constituting a smog layer that is called ‘’photochemical smog’’. Hydrocarbons are emissions that are released to atmosphere no incineration or partially burned due to nonhomogeneous temperature distribution in a cylinder, air-fuel ratio, low compression and valve overlay. For this reason, controlling of emission have a great importance in vehicles. An engine vehicle with no emission control can make unfavorable to a person's daily 15 m^3 fresh air requirement in as little as 10 minutes. Nitrogen oxide originated from exhaust gases combine with hemoglobin in the blood. It constitutes nitric acid as combining with moisture on lungs and its effect will be low due to amount of consisted acid that has low concentration. However, it can become a danger for persons with respiratory disease. Emissions in regard to affecting human health negatively change as respiratory times and amount of taking. In respect to this, three different concentrations are defined and danger limits are as follows [5].

1.If it is stayed in an ambient that include 100 ppm carbon monoxide, dull headaches are observed.

2.If it is stayed in an ambient that include 500 ppm carbon monoxide, sharp headaches, dizziness and faint are observed.

3. On the place that contain 2000 ppm and higher amount of carbon monoxide, respiration fading, blackout and dead are seen [4-6, 7-8].

On the basis of the European Union, international agreements have been made for reducing of emissions about protection health of nature and human. Enterprises make many R&D studies to reduce emission values in the light of these agreements. Nowadays, even if emission of harmful gases has been decreased, it is not in a sufficient level. In this case, there are some significant developments. For instance, exhaust gases in the internal combustion engines are controlled with catalytic converters, exhaust gas recirculation (EGR), crankcase ventilation, fuel evaporation and thermal exhaust reactors. In addition to these, there are particle filter in diesel engines. NO_X, HC and CO emissions that released result of burned in internal combustion engines are reduced by 90% and 95% using three ways catalytic converters and converted to harmless N_2, CO_2 and H_2O gases. In the gasoline engines, a design of direct injection engine, poor-mixed combustion graded filling engines, minimizing engine sizes on the last time and application of overfill systems to prevent power loss in small stroke engines take a part among these technologies. However, the technological studies for reducing emissions increase vehicles cost significantly. Besides, these technological developments in the case of emission; especially, determining the standard value for the newly produced vehicles from developed countries is another precaution. In this case, emission values of vehicles are tried to bring under control with taking measurements on certain intervals during using vehicles. However, in recent years, the emission measurement stations in Turkey have been given to private enterprises and the economic concerns of these enterprises may cause the measurements to not reflect the reality and the emission values to be higher than the standard value. This situation, besides damaging the nature and human health, vehicle users who might not aware to the situation that is increased the fuel consumption, only want to take the official trading and ensure the sufficiency [5-9].

Besides air pollution that is originated from vehicles; one of the growing problems developing and especially developed countries is the noise pollution caused by traffic [13-14]. Noise is defined as the unpleasant, undesirable, disturbing sound that is faced in many areas of human life. Imposed voice is such disturbing as for that how it is meaningless, violent, irregular and abrupt. However, every voice is not noise; the voice is named as noise, depends on the psychological condition of the person imposed to sound as well as the violent of the sound, its treble and continuity. In addition to this, it is clear that many types of sounds are accepted as noise by everyone [11]. Several physiological effects of noise on human health are determined such as muscle stresses, stress, increased blood pressure, changes in heart rate and blood circulation, pupil growth and insomnia. In addition, noise may have an important effect to emerge diseases of migraine, ulcer, gastritis etc. Result of vehicles movements; noise that originate air friction come from engine, rack, hood, braking, contact between wheels and surface of way constitutes. Besides these, exhaust system that is designed unwell is a source of noise [15]. Ratio of exhaust noise to total noise emitted from vehicles, it is known 40% as well as depending on types of silencer and the vehicle [12].

Sound from vehicles engine is an important source of noise. Sudden pressure impact that cause combustion event on engine cylinder, cause of oscillation to cylinder walls and engine side walls. This oscillation that formed in different pieces of engine, cause of air pressure oscillations and forming sounds. The main reasons of engine vibrations are pressure forces with result of combustion, disorders of engine pieces that worked with accelerate, the centrifugal force generated by the flywheel and its movements on the valve mechanism. Strain forces created from unbalanced movements in linear and cyclic accelerated, cause to increase engine vibration. Flexibility of pieces, intervals between pieces and non-regular contact are another reason of engine vibration [5-8].

Extinction of vibrations in internal combustion engines is impossible, but decreasing vibration is possible. Especially,

advances on material technology affect engine vibrations positively. Besides this; for decreasing vibration and voices on vehicles to minimum level; there are some precaution that have to taken such as decreasing amount of engine revolution numbers, increasing number of cylinder and thickening engine body. But, these precautions are not preferred by consumers and producers for some reasons; fuel consuming, performance and extra manufacturing costs [6-7-10].

In this study, the effect of iridium spark plug gap on emission, noise, and vibration of an internal combustion engine is experimentally investigated, and accordingly the optimum plug gap is determined. In the experiment, a Tofaş group engine that have 1581 cc volume, carrying a sound absorber in exhaust system, an exhaust gas emission measuring device, a noise level measuring device, and acceleration meter are used. Remaining parts of this work are organized as follow: in Section 2, the material and method are given; in Section 3, the findings are presented; in Section4, the results and discussion have been given.

2. Material and Method

Iridium spark plugs are known to provide better combustion potential than standards spark plugs. On the other hand, these spark plugs are more costly than the others. These spark plugs used in the new generation vehicles are also used for old engines in markets frequently. In the spark ignited engines, the spark plugs are abraded in a certain quantity during engine operation. This abrasion changes spark quality as increasing distance between electrode center and electrode cap. Changing of quality of spark cause of some critical changes in engine operation. The iridium spark plug was selected to the motor used in the study and the original spark plug was adjusted to the nail gap (0.80 mm).

In the study, BOSH BEA 250 exhaust-emission measuring device depicted in the Figure 1 is used to realize emission measurements.

To measure the noise from the engine, CEM DT-8820 sounds level measuring device that is calibrated from OMKA calibration center seen in the Figure 2 is used. Values are determined as decibel (dBA). For noise measurements, the meter is fixed at a distance of 1.5 m from the noise center. Measurements were made indoors.

In the experiments, a model of PCE-VD3 acceleration measuring device, which is seen in Figure 3, is used to measure vibration data produced by the engine. The device is a miniature universal data recording device that has integrated triaxle (X, Y, Z axes) acceleration sensor. Internal sensor of the device have ±18 measurements interval per axes and it is measured in axes of X, Y, Z and four different types of acceleration with g unit. Vibration data are recorded by a personal computer. Vibration data are recorded automatically for a 500 ms time interval from the software.

Fig. 1. Exhaust-emission measuring device

Fig. 2. Noise level measuring device

Fig. 3. Acceleration measuring device

Period of measurements is accepted to be 30 sec for every choose engine revolution. After every measurement, values of average and maximum combining acceleration are recorded.

The experiments were carried out with Tofaş group engine that have 1581 cc volume and carry a sound absorber in exhaust system. The engine was located on a fixed table. The iridium spark plug mounted on the motor during the experiment is shown in Figure 4b. The experiments were carried out in a 23°C workshop environment. After the engine has been set to operating temperature, the data is saved.

International Journal of Energy Applications and Technologies, Year 2019, Vol. 6, No. 2, pp. 44-48

(a)

(b)

Fig. 4. a) Spark plug combustion engine and experimental setup, and b)Iridium spark plug

3. Findings

Figure 5 illustrates the amount of hydrocarbons produced by the engine running at different revolutions and different spark plug intervals. According to the results of the experiment; The amount of hydrocarbons was measured in the original spark plug nail spacing (0.8mm), HC 2098 ppm at 1000 rpm. When the speed is increased, 2335 ppm is measured at 2000 rpm. A decrease of 3000, 3500 and 4000 rpm HC was observed.

0.7 mm spark plug nail spacing; HC 1859 ppm was measured at 1000 rpm. When the number of revolutions is increased, an increase in the amount of HC has been observed at 1500-2000 rpm. A decrease in HC was observed at 3500 and 4000 rpm. 0.9 mm spark plug nail spacing; HC at 2700 ppm was measured at 1000 rpm. When the speed is increased, 1648 ppm is measured at 1500 rpm. When HC is considered as a fuel that has not achieved combustion, it can be concluded that the combustion is of poor quality due to the increased amount of HC.

Figure 6 shows the noise values produced by the engine at different revolutions and different spark plug nail clearances. A noise value of 53 dBA at 1000 rpm and a noise value of 59 dBA at 4000 rpm were determined in the 0.8 mm spark plug nail spacing. 0.7 mm spark plug nail spacing; A noise level of 77 dBA at 1000 rpm and a noise level of 87 dBA at 4000 rpm were determined. 0.9 mm spark plug nail spacing; 75 dBA noise at 1000 rpm and 89 dBA noise at 4000 rpm were determined. The lowest total noise values were found in the original spark plug nail range.

Figure 7 shows the vibration data generated by the engine at different operating speeds and different spark plug nail intervals. When the data were evaluated, 1.71g vibration value at 1000 rpm and 4.44g vibration value at 4000 rpm were determined in 0.8 mm spark plug nail spacing. 0.7 mm spark plug nail spacing; A vibration value of 1,87g at 1000 rpm and a vibration value of 3.96g at 4000 rpm were determined. 0.9 mm spark plug nail spacing; A vibration value of 1.87g at 1000 rpm and a vibration value of 3.63g at 4000 rpm were determined.

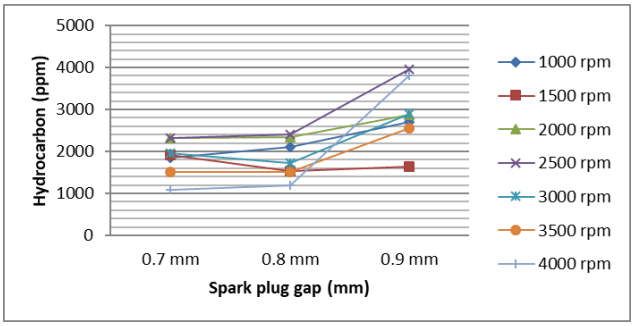

Fig. 5. Spark plug gap, relation of the spark plug gap and corresponding hydrocarbon emission

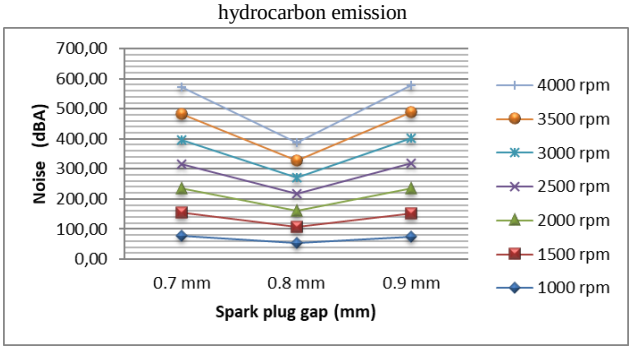

Fig. 6. Relation of spark plug gap, revolution and noise

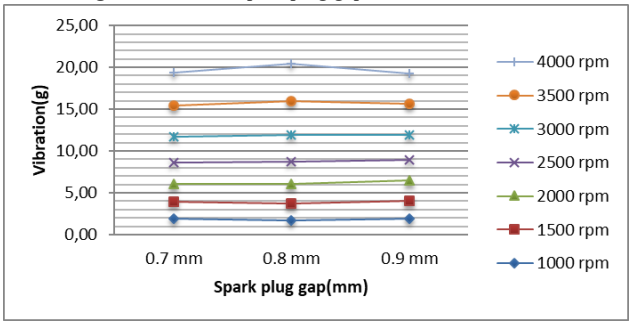

Fig. 7. Relation of spark plug gap, revolution and vibration [16]

4. Result and Discussion

In the study; the effect of iridium spark plug gap on emission, noise, and vibration of an internal combustion engine is experimentally investigated, and accordingly the optimum plug gap is determined. According to the results of the experiments; it was observed that when the spark plug gap and number of revolution increased, the vibration and noise increased respectively; otherwise, the exhaust emission (HC) value varied depending on the value of spark plug gap. The findings obtained are briefly presented in below.

a) The HC values, at the original plug gap (0.8 mm) and high revolutions, generally decreased. It is determined that an increase in the spark plug gap (in 0.9 mm) increased the HC value. High HC value implies a worse combustion that causes to release more harmful matter to environment, and to increase the fuel consumption. For this reason, it is suggested that users who make their maintenance on time are more advantageous in terms of both economic and comfort aspects.

b) As for the noise values, the engine constitutes less noise at original spark plug gap (0.8 mm).

c) As for the vibration values, the minimum vibration was observed at 2500-3000 rpm.

The most important point to take into consideration during maintenance of vehicles is to use spark plug that has true features. In addition, a new spark plug, even it is bought newly, the plug gap of the spark plug must be controlled with a feeler gauge. Unequal spark plug gaps might cause engine to run irregularly, decreasing of performance, and increasing of fuel consumption. A clear indicator of a engine failure can be considered to be fluctuation in idle revolution and vibration of engine. In the future works; values of performance and emission at more spark plug gap and revolutions in detail, and thus, the correlation between the performance and emission values could be investigated.

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