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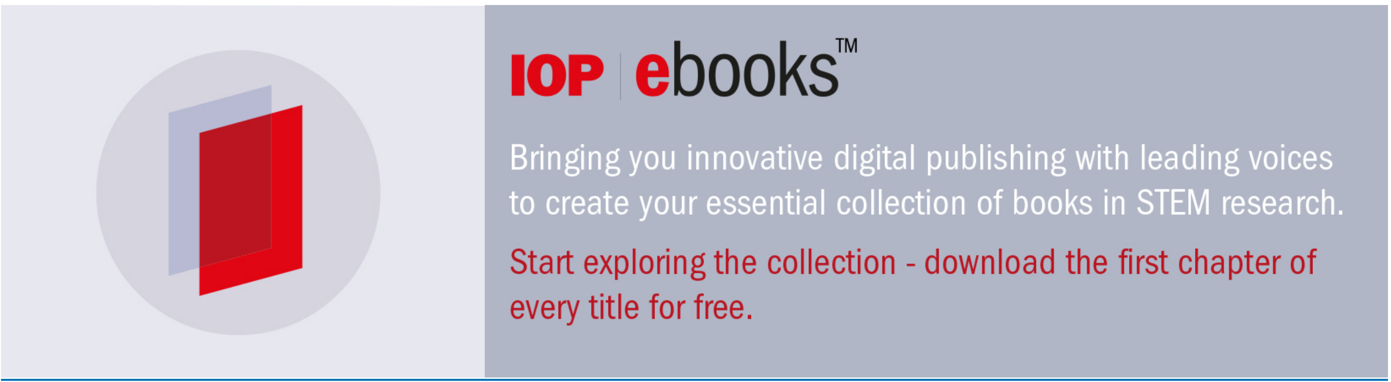

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Experimental investigation of vibrations and noise characterization for spark ignition engine

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Abstract. An experimental study was carried out for measuring vibrations, noise and combustion characteristics associated correlations using a four-cylinder spark ignition engine. This study aims to investigate the effects of vibrations and noise on spark-polishing machines that are triggered by pure gasoline. This test runs at 15% engine load and 20% with engine speed 1000-2200 rpm at intervals of 300 rpm. The measurement of engine vibration in pistonic uses PCB Piezotronics ICP® Accelerometer (352C22). Overall tests that have been carried out for 20% loads at 1900 and 2200 maximum vibrations, the velocity is 0.214 and 0.234, compared to 0.617 and 0.562 for 15% loads. From the results of engine vibration analysis, it can be reported that increasing engine speed and the load is given engine vibration can significantly decrease. Generally, noise increases for all samples tested; however, reduced noise is recorded when speed and engine load increase. This observation is also consistent with other observations related to vibration and combustion noise, heat release rates, and ignition delays.

1. Introduction

Various automotive industries are now increasingly competing to tie the quality of production, especially on personal vehicle engines and public transportation. All over the world, from cities to remote villages have used both small vehicles and large-bodied vehicles. In recent years the demand for vehicles has increased. Given the ever-increasing demand for the engine, it provides competition for the automotive industry to provide comfort to passengers, be more efficient, less polluting, cheaper, and friendly to the environment. In this context, a comprehensive investigation is important to do both fuel use and repairs to the combustion engine, so that vibration, noise and engine spray characteristics can be reduced. In this study, the relationship between the engine combustion process and its spray characteristics with vibration and noise was investigated.

Various scientists have tried and researched the properties of combustion, sprays, vibrations and noise sourced from internal combustion engines. They are starting from the use of fuel until the addition of engine material has been carried out. Currently, a lot of research into the effects of vibration and engine noise using fuel is done on diesel engines. Very little in the literature of investigation of vibration and noise is carried out on spark ignition engines. Besides, many vibration and noise investigations are carried out of the effects of using various fuels. Several researchers in recent years have studied investigations into the performance of spark ignition engines using alcoholic fuels such as ethanol. However, the effect of vibration and noise on the combustion engine uses very little fuel. Vibration in the engine is a fluctuation in the mechanical system or equilibrium position in the engine. If engine

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vibration is not controlled, it can cause safety to the occupants[1-2]. Besides, too much vibration also causes noise in the vehicle. The formation of engine vibration is caused by several structures such as engine speed, load, oil viscosity and the properties of the fuel used.

The process for calculating engine combustion optimisation is used from variations in the value of vibration, load, ignition and ignition time. This process, serves to increase fuel consumption, emissions and noise. Therefore, several attempts have been made to reduce engine vibration characteristics. Investigation of the effects of vibration and noise characteristics triggered by diesel-petrodiesel fuel has been carried out [3]. This test is carried out on a four-cylinder engine that has been modified from natural gas-gasoline fuel. The results of tests carried out can reduce vibration and noise and reduce carbon monoxide and hydrocarbon emissions. Investigation of vibrations and noise triggered by biodiesel Karanja fuel has also been carried out by [4]. The highest engine combustion noise is found in the 20% biodiesel mixture. The highest level of vibration is also found in Karanja-biodiesel at 20%. This is due to shorter combustion duration, higher heat release and increased ignition delays. The vibration and noise characteristic effects triggered by ethanol-gasoline blended fuels have been studied by [5]. The results of this experiment show vibrations and noise increased at 1500 and 2500 rpm. This increase is due to oxygen content and latent heat which is higher than the fuel mixture of ethanol-gasoline. While in studies with different vibration and noise characteristics on diesel engines using a diesel-biodiesel blend has been investigated [6]. This experiment was carried out on four-cylinder and four-stroke compression ignition engines.

Furthermore, the effect of vibration on the engine triggered by natural gas fuel is correlated with combustion pressure [7]. The results of this investigation show that the vibrations produced exceed mechanical vibration. Experiments on Genset machines using diesel-n-butanol mixed fuel to measure vibration and noise have been studied [8-10]. The test results can be reported that when the engine load is low, the vibration and noise are slightly better. However, when the engine load is high the vibration and noise increase. Correlation between vibrations, noise with engine combustion is very strong. Testing with methanol-gasoline fuel which is run on a spark ignition engine to evaluate engine vibration has been discussed [11]. This result shows the highest vibration obtained at the engine speed of 1000 and 1300 rpm for gasoline fuel. While the highest vibration of methanol-gasoline is recorded at engine speeds of 1600 and 1900 rpm. Furthermore, research on noise and vibration has been studied by several researchers [12–21]. However, in general, their analysis applies to diesel engines with various fuel mixtures.

The main aim of this study is to investigate the effects of vibrations and noise on spark-ignition engine that are triggered by pure gasoline. This test runs at 15% engine load and 20% with engine speed 1000-2200 rpm at intervals of 300 rpm. Vibration analysis using PCB Piezotronics ICP® Accelerometer (352C22). This tool is used to measure the level of the frequency spectrum and vibration in the spark ignition engine. Analysis of vibration values and engine noise is taken at each engine load and speed.

2. Experimental apparatus and procedure

Spark ignition engine four-cylinder, four-stroke was used as an experimental tool in this study. The specifications of this machine as shown in Table 1. Test parameters for data collection were obtained from engine loads of 15% and 20% with engine speeds of 1000 to 2200 rpm at intervals of 300 rpm. Before the engine data collection is heated first to normalize the vibration and noise on the engine. Schematic machine diagrams in this study are shown in Figure 1.

Table 1. Specifications for engine

Descriptions	Engine
Engine type	Mitsubishi 4G93 SOHC
Bore stroke	81.D mm x 89.0 mm
Number of cylinder	4 (1st cylinder is instrumented)
Fuel injection type	MCI-Multi (Electronically Controlled Multi-point) fuel injection
Piston displacement	1.834 L
CR	9.5:1
Max power	86 kw@5500 rpm
Max torque	161 nm@4500 rpm

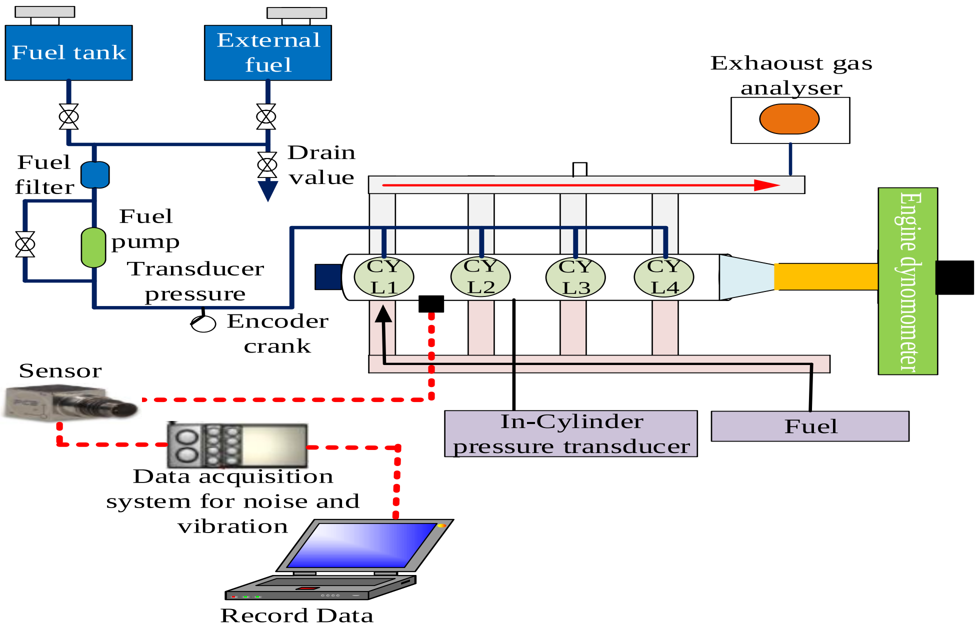

Fig. 1. Schematic diagram for engine setup

Fig. 2. Engine experiment

3. Result and Discussion

As explained in the previous section, the vibration and noise signals measured for engine acceleration are critical parameters for comparing the vibration signals from the spark ignition engine at 15% and 20% loads with different engine speeds. Figure 3 to 7 illustrate the vibration acceleration signal in two cycles for 15% and 20% engine loads at different speeds. Vibration signals generated from the engine have a relationship with the combustion event and valve opening/closing in the engine. From the results of this analysis, it can be noted that engine vibration decreases when the load and engine speed increase is shown in Figure 6 and 7. The maximum value for engine loads is 20% at speeds of 1900 and 2200 rpm at 0.214% and 0.234% lower compared to 15% engine load around 0.0617% and 0.562%. The reason for this is that the engine combustion level is getting higher, so that vibration acceleration is healthier than the lower engine speed. However, the reverse vibration signal increases when the engine speed is lower. Engine load which increases with low engine speed results in increased vibration on the engine as shown in Figure 3-5.

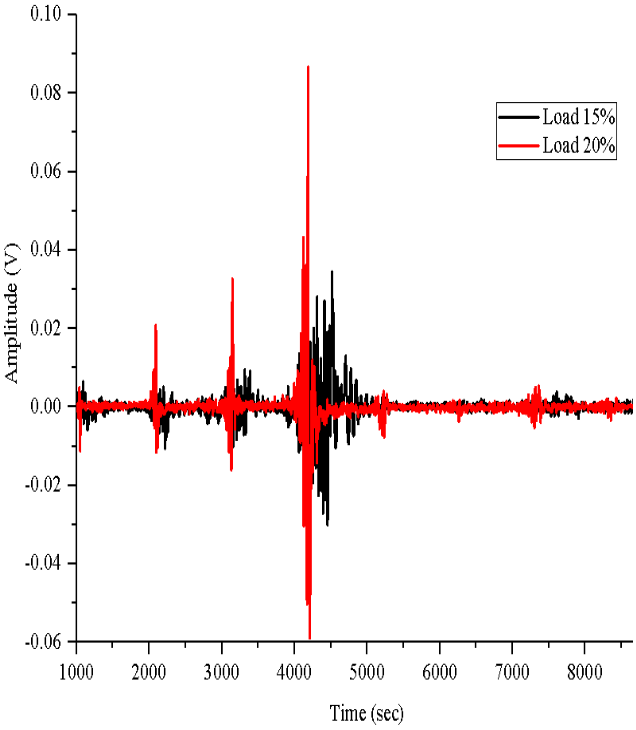

Fig. 3. Time domain signal of vibration acceleration at 1000 rpm

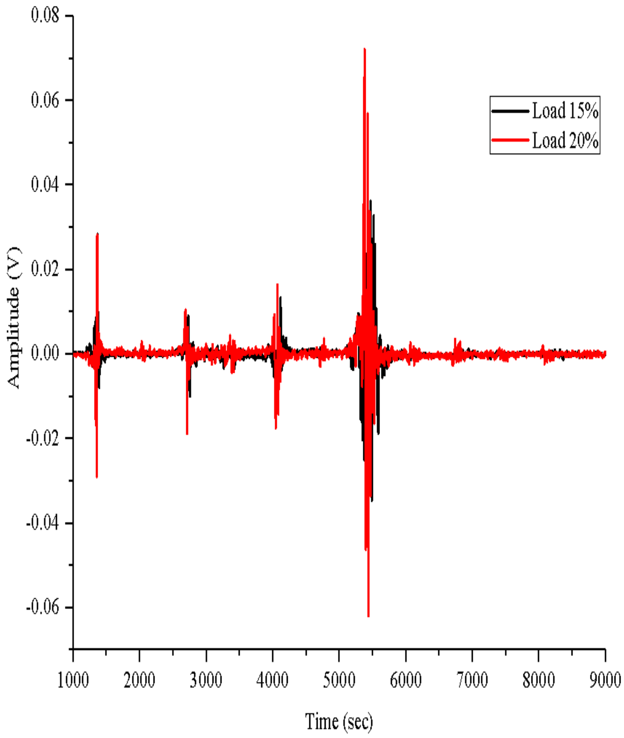

Fig. 4.Time domain signal of vibration acceleration at 1300 rpm

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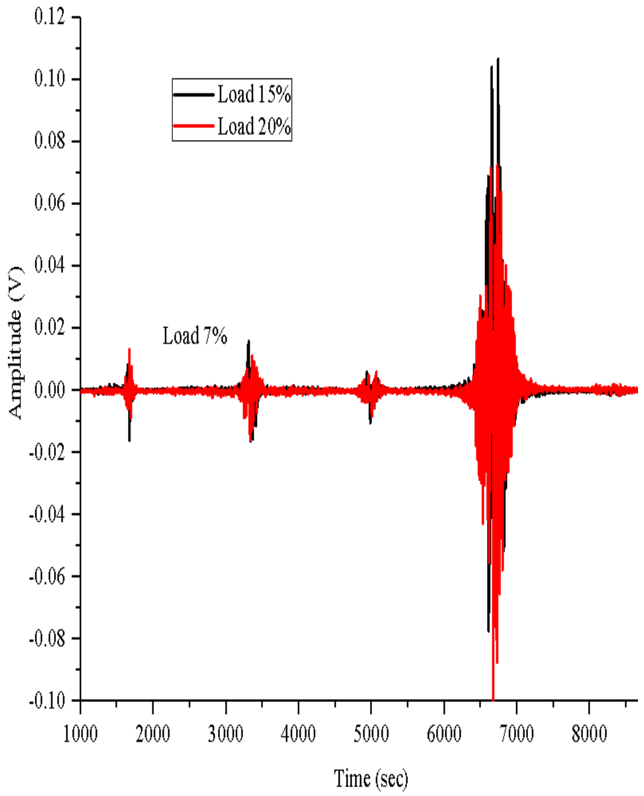

Fig. 5. Time domain signal of vibration acceleration at 1600 rpm

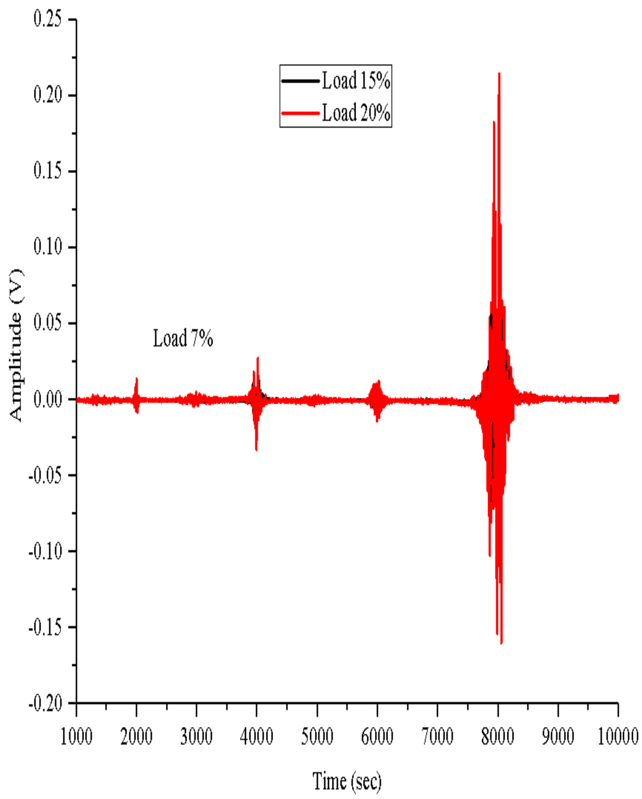

Fig. 6. Time domain signal of vibration acceleration at 1900 rpm

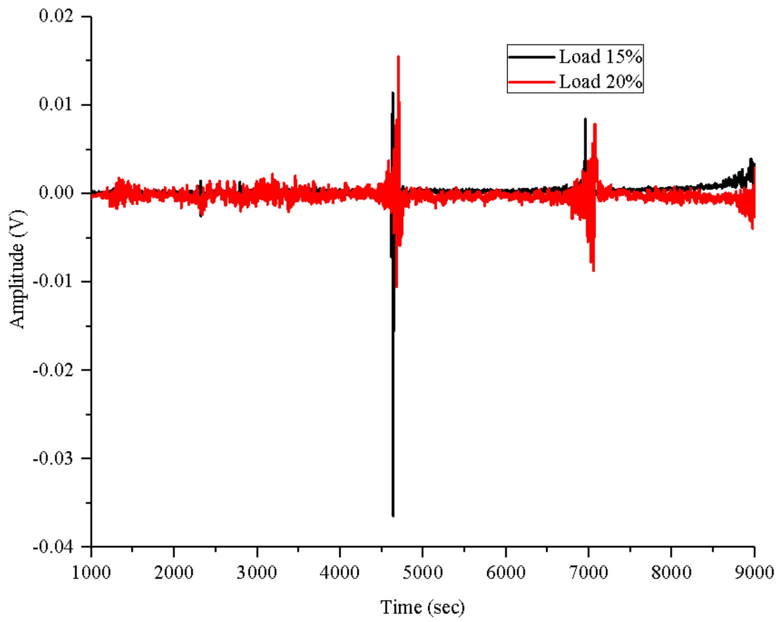

Fig. 7. Time domain signal of vibration acceleration at 2200 rpm

The maximum vibration value for engine speed 1300 and 1600 at a load of 20% is around 0.0812% and 0.174% compared to 0.0392% and 0.157% for a capacity of 15%. So that at the speed of this machine is very vulnerable to the emergence of unwanted engine vibrations. However, when the speed is lower as in Fig. 3, vibration is lower for higher loads than for low engine loads.

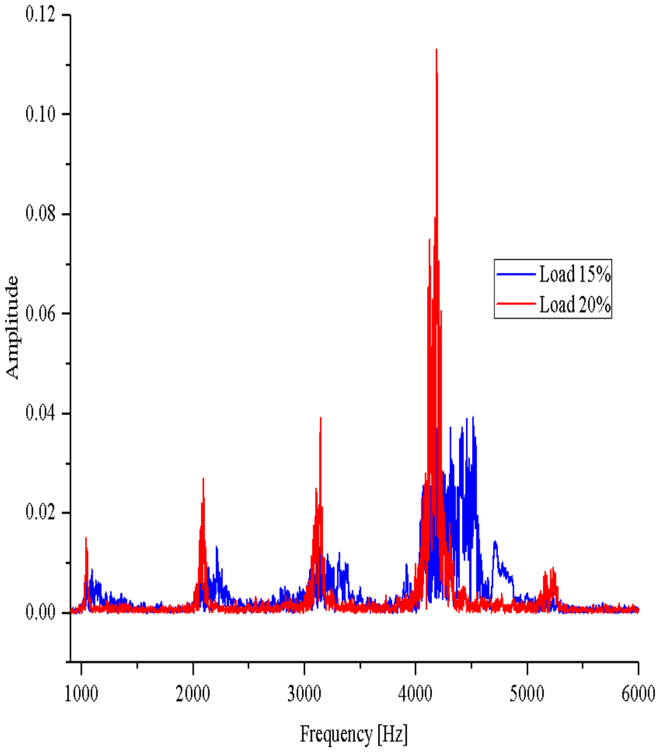

Fig. 8. Frequency spectra of the engine vibrations at 1000 rpm

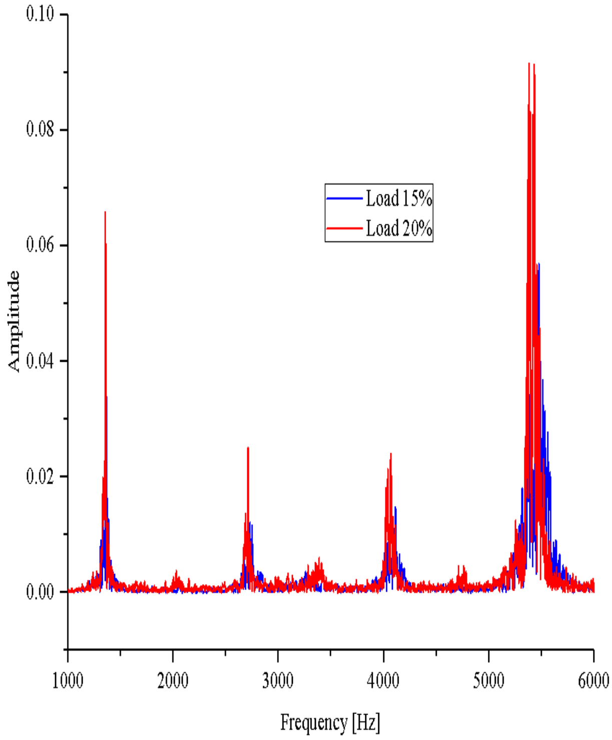

Fig. 9. Frequency spectra of the engine vibrations at 1300 rpm

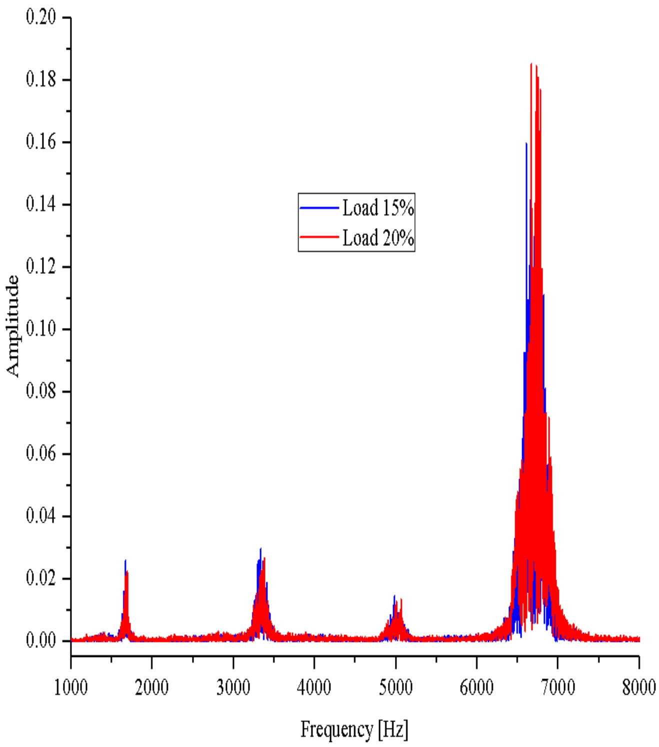

Fig. 10. Frequency spectra of the engine vibrations at 1600 rpm

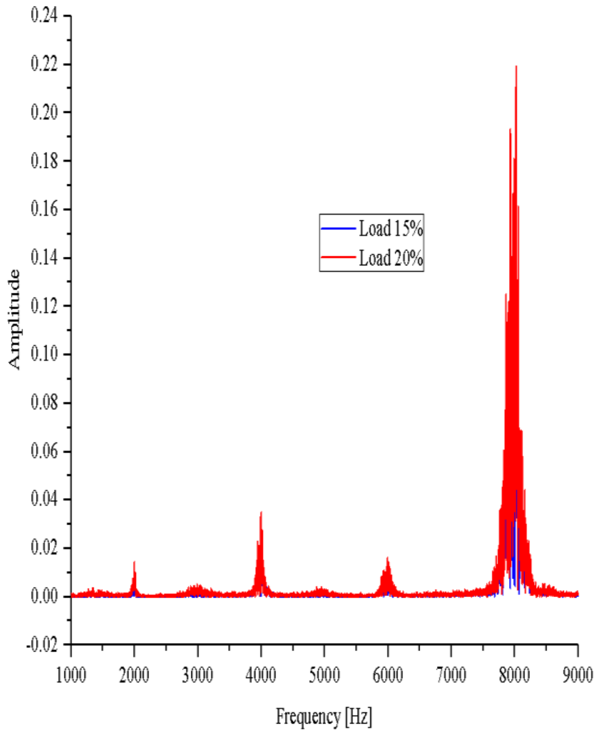

Fig. 11. Frequency spectra of the engine vibrations at 1900 rpm

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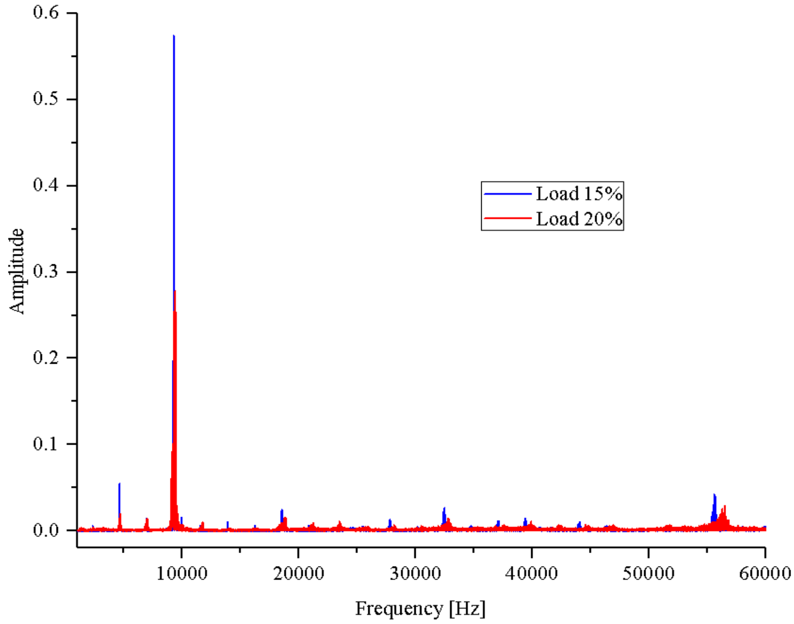

Fig. 12. Frequency spectra of the engine vibrations at 2200 rpm

Fig. 8-12, is the result of the frequency spectra obtained from engine vibrations for engine loads of 15% and 20%. The overall results tested show that the vibration level increases at low and medium engine speeds. However, at high loads and speeds, the vibration generated by the engine decreases as shown in Fig. 12. The characteristics of engine vibration are very significant where at high speeds the maximum frequency value is around 0.3 Hz compared to 0.6 Hz at lower loads. The results of the tests that have been carried out show the highest vibrations of data at engine speeds of 1900 and 1600 rpm with a frequency level of 0.23 Hz and 0.19 Hz respectively.

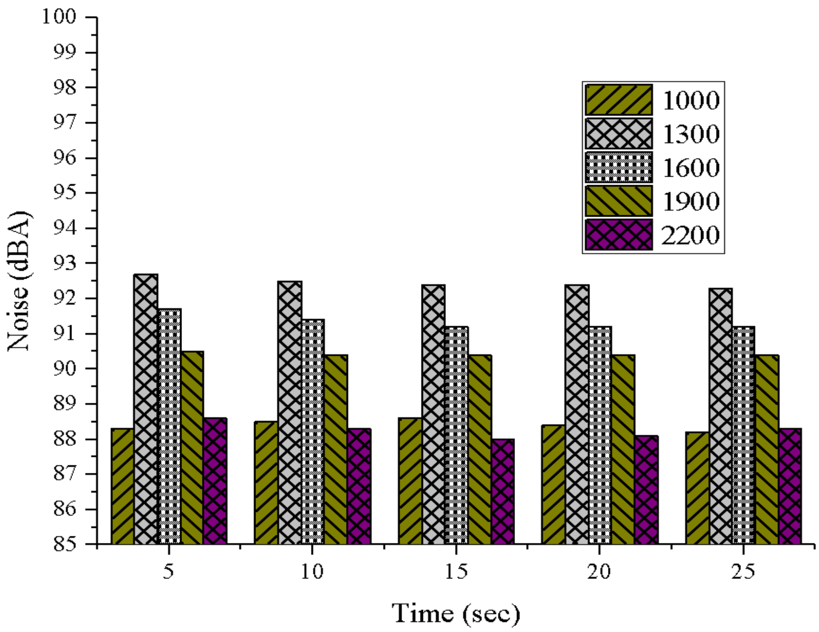

Fig. 13. Average of noise values of different speed at engine load 15%

The engine combustion noise decreases recorded at low speed and high speed shown in Fig. 13. The highest sound is obtained at a speed of 1300 rpm for each second measured. While for 10, 15 and 20 seconds the lowest noise is stared at the speed of 2200 rpm compared to the speed of 1000 rpm. However, at 5 and 25 the lowest noise is obtained at a speed of 1000 rpm. Similar results were found by [5]. Where the results of their tests reported that engine combustion noise for each sample tested experienced an increasing trend.

The increased engine speed and load can reduce engine combustion noise as shown in Fig. 14. The lowest noise is noted when the engine speed reaches 2200 rpm for each second compared to the overall engine speed tested. While the highest noise level is recorded at the engine speed of 1600 rpm. In general, the level of vibration and noise from the results of the analysis carried out on spark ignition engines with a load of 15% and 20% shows an increasing trend. Similar results found by [5]. Where the results of engine operation using ethanol-gasoline fuel increase from the results of the entire sample tested. While the results of experiments conducted by [4], the use of Karanja-Biodiesel 20% can increase engine vibration. Thus, engine vibration increases at low and medium speeds. However, reverse engine vibration decreases when engine speed increases in this study.

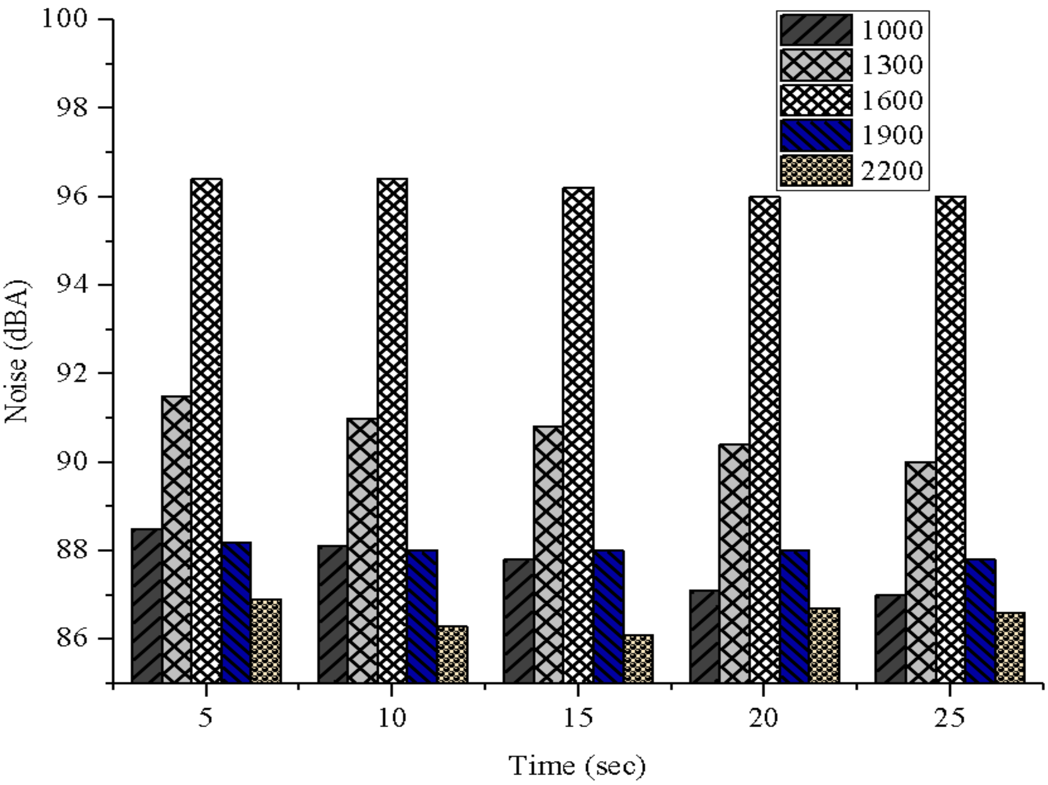

Fig. 14. Average of noise values of different speed at engine load 20%

4. Conclusion

This study focuses on measuring the vibration acceleration rate of combustion spark ignition engines with loads of 15% and 20% and different engine speeds. Based on the results of testing of the two engine loads given, the increased engine speed and load can reduce the vibration level in the engine. Decreasing engine vibration is recorded at speeds of 1900 and 2200 rpm for a load of 20% compared to a load of 15%. Overall tests that have been carried out for 20% loads at 1900 and 2200 maximum vibrations, the velocity is 0.214 and 0.234, compared to 0.617 and 0.562 for 15% loads. From the results of engine vibration analysis, it can be reported that increasing engine speed and the load is given engine vibration can significantly decrease. Meanwhile, engine noise generally decreases when engine speed and load increase. Of the two engine loads tested the lowest sound was recorded at the engine load of 20% for the overall engine speed compared to the engine load of 15%. Moreover, these results indicate a substantial relationship between combustion with vibration and noise originating from the engine.

Acknowledgments
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References
[1] Hussey M 1983 Fundamentals of mechanical vibrations *Macmillan*
[2] Rao SS and Yap FF 2014 Mechanical Vibrations Ed. 4 *Prentice Hall Upper Saddle River*
[3] Taghizadeh-Alisaraei A, Ghobadian B, Tavakoli-Hashjin T, Mohtasebi SS. 2012 Vibration analysis of a diesel engine using biodiesel and petrodiesel fuel blends *Fuel* 102 414–422.
[4] Patel C, Agarwal A K, Tiwari N, Lee S, Lee C S and Park S 2016 Combustion, noise, vibrations and spray characterization for Karanja biodiesel fuelled engine *Appl Therm Eng* 106 506–517.
[5] Keskin A. 2010 The influence of ethanol-gasoline blends on spark ignition engine vibration characteristics and noise emissions *Energy Sources, Part A Recover Util Environ Eff* 32 1851–60.
[6] Ayd K and Ozcanl M 2016 Vibration, noise and exhaust emissions analyses of an unmodified compression ignition engine fuelled with low sulphur diesel and biodiesel blends with hydrogen addition *International Journal of Hydrogen Energy* 41(26) 11481-11490.
[7] Hunt S 2016 Engine Vibration of a Compressed Natural Gas Engine as an effect of Combustion *Electronic Theses and Dissertations* 5734.
[8] Sani M S M, Rahman M M , Baharom M Z and Zaman I 2015 Sound Intensity Mapping of an Engine Dynamometer *International Journal of Automotive and Mechanical Engineering (IJAME)* **11** 2820-9
[9] Satsangi D P and Tiwari N 2018 Experimental investigation on combustion, noise, vibrations, performance and emissions characteristics of diesel/n-butanol blends driven genset engine *Fuel* 221 44–60.
[10] Razak N F D, Sani M S M, Azmi W H and Zhang B 2017 Noise and vibration analysis for automotive radiator cooling fan *IOP Conf. Ser. Mater. Sci. Eng.* 257 012083
[11] Gravalos I, Moshou D and Gialamas T 2011Vibration Effects on Spark Ignition Engine Fuelled with Methanol and Ethanol Gasoline Blends *Journal of Agricultural Machinery Science* 7(4) 367–372.
[12] Erdiwansyah, Sani M.S.M, Mamat R, Khoerunnisa F, Rajkumar A R and Razak N F D 2018 Vibration Analysis of the Engine Using Biofuel Blends: A Review *MATEC Web Conf 225*.
[13] Heidary B, Hassan-Beygi S R, Ghobadian B, Taghizadeh A 2013 Vibration analysis of a small diesel engine using diesel-biodiesel fuel blends *Agric Eng Int J* 15 117–126.
[14] Yıldırım H, Çınar A, Şayli H and Köylü H 2015 Vibration and noise analysis of an engine fuelled with diesel and biodiesel blends *International Conference on Advances in Mechanical Engineering* Instanbul.
[15] Mirnezami S V, Hassan Beygi S R, Ghobadian B, Abdollahzade R and Ahmadian H 2014 Effect of diesel-biodiesel blends on user vibration transmissibility of riding power tiller through user body *The 21st International Congress on Sound and Vibration* Beijing.
[16] Taghizadeh-alisaraei A, Ghobadian B, Tavakoli-hashjin T 2016 Characterization of the engine's combustion-vibration using diesel and biodiesel fuel blends by time-frequency methods : A case study *Renew Energy* 95 422–432.
[17] Sani M S M, Zaman I and Rahman M M 2015 Analysis of Split Air Conditioner Noise using Sound Intensity Mapping *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 9(1) 28-33.

[18] Uludamar E, Tosun E, Tüccar G, Yıldızhan Ş, Çalık A and Yıldırım S, 2017 Evaluation of vibration characteristics of a hydroxyl (HHO) gas generator installed diesel engine fuelled with different diesel–biodiesel blends *Int J Hydrogen Energy* 42 23352–60.

[19] Sani M S M, Rahimi M A F A and Mohamed D 2019 Sound Intensity Mapping of Two Stroke Engine by Using Hemispherical Surface Coordinate Arrangement *IOP Conf. Ser. Mater. Sci. Eng.* 506 012060

[20] Ravi M, Vijaya Kumar K C K and Murugesan A 2015 Certain investigations on the performance of emission, vibration and noise characteristics of C.I engine using biogas and biodiesel as alternate fuel *Int J PharmTech Res* 8 11–9.

[21] Razak N F D, Sani M S M, Azmi W H and Zhang B 2019 The Effect of Change in Flowrate on Power Spectral Density (PSD) of Automotive Radiator System for Flow-Induced Vibration Monitoring *IOP Conf. Ser. Mater. Sci. Eng.* 469 012101.