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Effect vibration characteristics in direct-injection engine with operated turpentine oil-diesel fuel blend

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Abstract

Turpentine oil, mainly derived from clove oil, shows strong potential as a diesel additive due to its oxygenated composition, improving combustion and reducing emissions. Despite its environmental advantages, limited application persists due to high production costs. This study investigates the effects of adding 0.2% turpentine oil to diesel fuel on engine vibration characteristics in a single-cylinder direct injection engine. Vibration was measured along three orthogonal axes (X, Y, and Z) under two engine loads (25% and 50%) and five speeds ranging from 1200 to 2000 rpm. Results revealed that turpentine-diesel blends consistently reduced vibration levels on the Y and Z axes. At 25% load, the lowest RMS vibration with turpentine additive occurred at 1400 rpm, while for pure diesel, it was at 1600 rpm. At 50% load, minimum vibration for both fuels was observed at 1400 rpm. The turpentine additive reduced vibration magnitudes by up to 11.3% on the Y axis and 9.6% on the Z axis compared to pure diesel. These findings support using turpentine oil as a viable additive to improve ride comfort and reduce engine-induced vibrations, offering reference data for future studies on alternative fuels.

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1. Introduction

Various fields of production and transportation have used many internal combustion engines. The advantages of diesel engines, such as flexibility, high energy efficiency and high stability in various operations, make them much in demand [1–4]. The dependence on fuel from petroleum on ICE engines worldwide has been pushed to shift to additive or renewable energy materials. This dependence has caused various unavoidable problems because conventional fuel has experienced scarcity in the past year due to increasing population demand and industrialization. So, scientists have been trying to find sustainable, renewable and environmentally friendly alternatives to fossil fuels. The depletion of

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petroleum fuels with increasingly stringent emission regulations has forced researchers to look for alternative renewable fuels or additives [5–7].

It was found that terpene compounds contained in clove oil (0.2%) were primarily responsible for forming a stable solution between the bio-additive and pure fuel, leading to rapid combustion and shorter ignition delay in engines fueled by clove oil fuel blends [8–11]. This data is interesting for further investigation on the influence of terpene compounds as combustion biofuel characteristics of diesel fuel on one-cylinder diesel engines. Turpentine oil is often referred to as a spirit of turpentine in the form of volatile liquid derived from the distillation of tree sap species belonging to the genus pine. Turpentine oil contains monoterpenes with C 10 carbon atoms. It is known that a diesel fuel with 5% pure turpentine oil could reduce smoke production and save fuel usage, as shown in the work by [12–15]. It was stated that 5% of oxidized turpentine oil was the most effective diesel fuel additive, as shown in the work by [16–19]. Turpentine oil is a clear liquid that is colourless (transparent), with a distinctive smell, and flammable [20–23]. In general, the physical and chemical properties of turpentine oil include a boiling point of 149–180 °C, insolubility in water, a density of 0.9, a flash point of 30–46 °C, and an auto-ignition temperature of 220–225 °C, as reported by the International Program on Chemical Safety and the European Commission [24–26]. Turpentine oil is generally composed of a mixture of unsaturated isomers and bicyclic hydrocarbons: α-pinen, β-pinen, and Δ-carene [21,27–29].

Biodiesel fuel has the advantage of being a diesel engine fuel. However, many alternative fuels, such as turpentine oil, can be used in diesel engines. Characteristics of vibration, combustion, emissions and performance produced by a machine are essential phenomena to study [30–33]. In the past few years, scientists have been trying to reduce vibrations sourced from machines because of the conditions for mechanical damage and the comfort of their passengers. Therefore, the automotive industry was forced to make various developments to meet customer demands for their products and to maintain increasingly high competition [34–37]. Researchers in this regard have investigated various vibrational behaviours sourced from internal combustion engines triggered by multiple fuels. Vibration behaviour on generator engines using hydroxyl (HHO) machines with a mixture of diesel-biodiesel fuel has been investigated by [38–41]. The experiment's results with the addition of HHO showed vibration acceleration on the engine block increased [38].

Meanwhile, different studies have also been investigated to measure noise and vibration characteristics from diesel engines using a mixture of diesel-biodiesel and natural gas fuels [42]. The results of experiments with the addition of biodiesel and natural gas show that engine vibration has decreased slightly. Investigation of combustion noise and emissions triggered by gasoline-diesel for compression ignition engines has also been discussed [43,44]. The vibrations in the compression ignition engine of biodiesel-petro diesel mixed fuel were analyzed by [45–48]. The results of their experiments with changes in the effects of biodiesel are influenced by engine speed [49]. Moreover, the vibration of diesel engines using a mixture of diesel-biodiesel fuel has also been investigated [50–53]. The use of fuel is to minimize the level of vibration that comes from the engine.

This study used a fuel blend consisting of pure diesel and 0.2% turpentine oil extracted from clove oil to operate a single-cylinder diesel engine. The primary objective was to evaluate the effect of this turpentine-diesel blend on engine vibration characteristics across three orthogonal axes. By comparing the vibration performance of the blend to that of conventional pure diesel, this study provides novel insight into the potential of turpentine oil as a bio-additive. The originality of this work lies in its experimental focus on the vibrational behaviour of engines using low-concentration turpentine blends, which has been rarely explored in prior studies, particularly at varying loads and engine speeds.

2. Methodology

This study measured the vibration characteristics of a single cylinder diesel engine using turpentine oil with pure diesel fuel. This experiment uses different engine speeds of 1200–1800 rpm with 200 rpm intervals at 25% engine load. The engine vibration is measured based on engine speed from two different fuels: turpentine-diesel oil and pure diesel.

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These experimental studies were performed on a diesel four-stroke, single-cylinder naturally aspirated direct injection engine (YANMAR F120M). The specifications of the diesel engine used in the experiment are presented in **Table 1**. Turpentine oil is mixed into pure diesel fuel in as much as 0.2% of every litre. Furthermore, as much as 3 litres of fuel mixing is prepared for each test. This experiment was carried out at 1200–1800 rpm at 25% and 50% engine load intervals of 200 rpm. A schematic experimental engine diagram is shown in **Figure 1**.

Table 1. Specifications of Engine

Description	Specification
Engine model	YANMAR TF120M
Engine type	diesel 4-stroke, one-cylinder engine
Bore x Stroke (mm)	92 × 96
Displacement (L)	0.638
Injection timing	17° BTDC
Compression ratio	17.7
Continuous output (HP)	7.82 kW at 2400 rpm
Rated output (HP)	8.94 kW at 2400 rpm

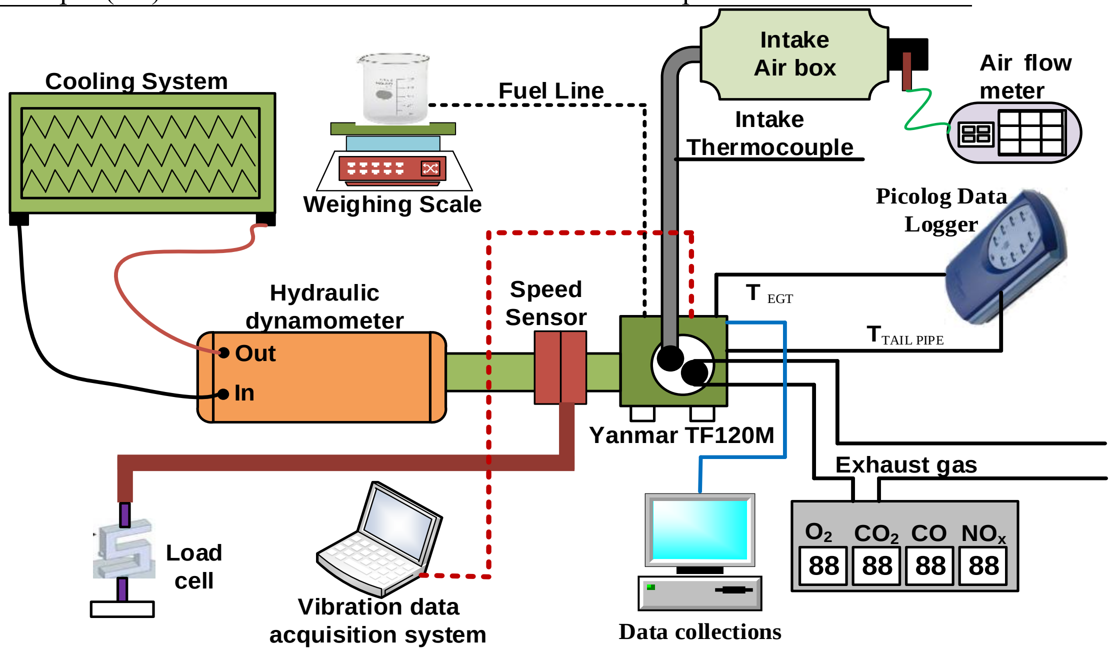

Figure 1: Schematic diagram engine

Vibration measurements in this experiment used the Accelerometer 3D Vibration Tester (VM-6380). This sensor is placed and bound to the engine. Data is recorded on three orthogonal axes (x-longitudinal, y-lateral, z-vertical axis). Vibration data is taken at different engine loads and speeds when using diesel fuel and turpentine additives. RMS value measures the results of vibrations related to the vibration level in the amplitude value associated with the wave history time. The formula below is used to measure the RMS value:

$$A_w \sqrt{\frac{1}{T}\int_O^T a_w^2\,(t)dt} \tag{1}$$

where a_w (m/s^2) is weighted acceleration, and T is the measurement time. A_{total} (acceleration of total vibration) can be described as a combination of three axes of acceleration and can be expressed by:

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$$a_{total} = \sqrt{a^2_{vertical} + a^2_{lateral} + a^2_{longitudinal}} \quad (2)$$

3. Result & Discussion

This experiment uses pure diesel fuel with turpentine additives at 25% and 50% engine loads with five different engine speeds, namely 1200, 1400, 1600, 1800 and 2000 rpm. The test results reported that the rest of the three vibrations were analyzed and compared between pure diesel fuel and after the addition of turpentine oil. Engine speed starts from 1200 to 2000 at intervals of 200 rpm for each load and fuel condition used.

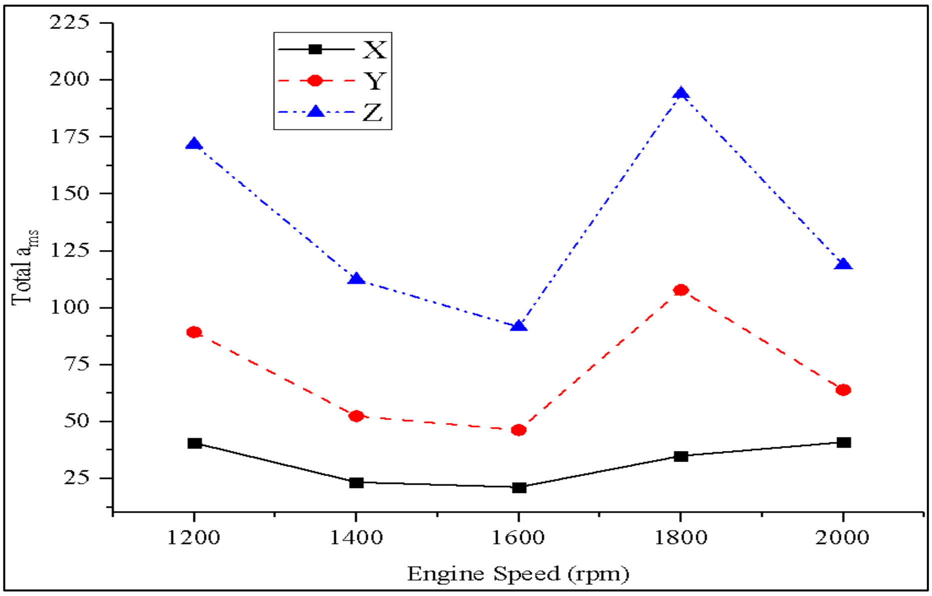

Figure 2: Total vibration at engine load 25% for diesel fuel

Figure 2 illustrates the total vibration acceleration (a_{rms}) measured along three orthogonal axes X (longitudinal), Y (lateral), and Z (vertical) at an engine load of 25% using pure diesel fuel, across engine speeds ranging from 1200 to 2000 rpm. The results show an apparent variation in vibration behaviour as a function of engine speed and axis direction. The Z-axis, representing vertical vibration, consistently exhibits the highest vibration levels compared to the other axes. The peak value on the Z-axis is recorded at 1800 rpm, reaching approximately 210 m/s^2, while the lowest Z-axis vibration occurs at 1600 rpm, at around 95 m/s^2. This trend is attributed to the up-and-down movement of the piston-cylinder system, which inherently generates stronger vertical oscillations.

The Y-axis (lateral vibration) shows a moderate level of vibration, with the lowest reading observed at 1600 rpm (≈45 m/s^2) and the highest at 1800 rpm (≈95 m/s^2). These fluctuations suggest the influence of engine imbalance and structural transmission effects during combustion. Meanwhile, the X-axis (longitudinal vibration) consistently reports the lowest vibration magnitudes, ranging from 20 m/s^2 at 1400 and 1600 rpm to a maximum of 40 m/s^2 at 1800 rpm. This indicates less vibrational energy is transmitted along the engine's longitudinal frame direction under light load conditions.

Overall, the data indicate that engine speed significantly influences vibration behaviour, with 1800 rpm yielding the highest vibration intensity across all axes, particularly in the vertical (Z) direction. This underscores the critical need to control engine operating conditions to minimize excessive vibration, especially in conventional diesel fuel light-load scenarios.

The z-axis is the arm with the highest value when measured because the cylinder moves up and down, resulting in vertical motion transmission to longitudinal by the crankshaft. Therefore, the highest value of the following arm is in the longitudinal direction. The lateral axis generally produces a lower

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vibration level. However, it depends on the equipment used and the engine changes or the transmission results from the other directions. The lowest vibration in the direction of the lateral axis is due to this phenomenon in the engine.

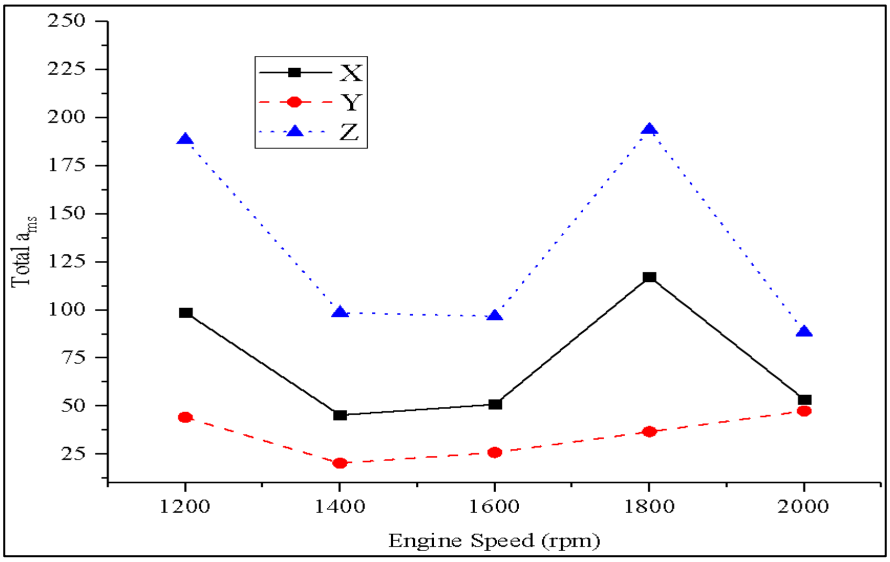

Figure 3: Total vibration at engine load 25% for turpentine oil

Figure 3 presents the total vibration acceleration (a_{rms}) measured along the X (longitudinal), Y (lateral), and Z (vertical) axes for a diesel engine operating at 25% load using a turpentine-diesel blend (0.2% turpentine) across engine speeds from 1200 to 2000 rpm. The results demonstrate significant differences in vibrational behaviour compared to pure diesel fuel. The Z-axis, representing vertical vibrations due to piston reciprocation, remains dominant across all engine speeds. The highest Z-axis vibration is recorded at 1800 rpm, reaching approximately 215 m/s^2, slightly higher than pure diesel at the same speed. However, the lowest Z-axis vibration under turpentine additive occurs at 1600 rpm, with a value of approximately 105 m/s^2 indicating a reduction from ≈175 m/s^2 at 1200 rpm.

On the Y-axis, which represents lateral vibrations, the turpentine blend shows notably lower values than pure diesel. The minimum vibration occurs at 1400 rpm with approximately 30 m/s^2, compared to around 50 m/s^2 for diesel. Even the peak Y-axis value for turpentine at 2000 rpm only reaches ≈50 m/s^2, whereas diesel reaches up to 90 m/s^2, highlighting a significant improvement in lateral vibration suppression. The X-axis (longitudinal) demonstrates a unique behaviour under turpentine combustion. The highest vibration is found at 1800 rpm, peaking at ≈115 m/s^2, considerably higher than diesel at the same point (≈40 m/s^2). This spike suggests that while turpentine improves lateral and vertical vibration, it may amplify vibrations in the longitudinal direction at specific operating speeds due to altered combustion dynamics or resonance.

In general, the use of turpentine as a diesel additive at 0.2% effectively reduces total vibration on the Y-axis by up to 40% and on the Z-axis by up to 10% at optimal engine speeds (1400–1600 rpm), compared to pure diesel. This supports the potential of turpentine additives in enhancing ride comfort and mechanical stability under light load conditions.

The following experiment was conducted at 50% engine load using pure diesel fuel with turpentine additives at different speeds. Pure diesel fuel produces the lowest vibration on the X axis at a speed of 1400 rpm, which is different when the engine load is 25%, whereas the lowest vibration is obtained at 1600 rpm. Meanwhile, using turpentine as an additive for 50% engine load produces vibrations at an engine speed of 1400 rpm. This result is almost the same as when the experiment was conducted at 25% engine load.

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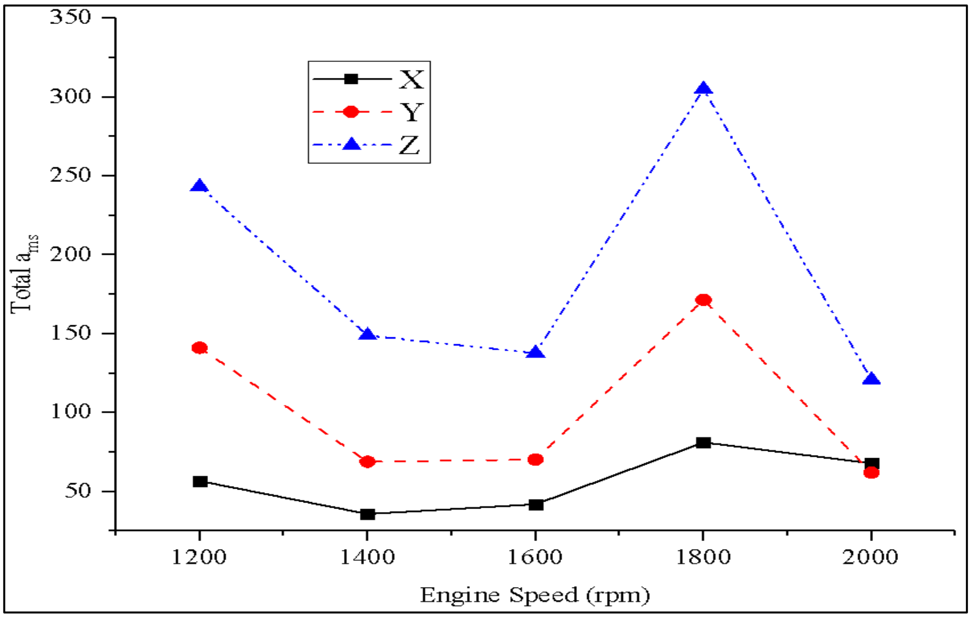

Figure 4: Total vibration at engine load 50% for diesel fuel

Figure 4 depicts the total vibration acceleration (a_{rms}) along the X (longitudinal), Y (lateral), and Z (vertical) axes of a diesel engine operating at 50% engine load using pure diesel fuel, across speeds ranging from 1200 to 2000 rpm. Compared to the 25% load, the increase in load amplifies the vibration levels across all axes. The Z-axis again shows the highest vibration intensities, consistent with the vertical forces induced by piston motion. The peak Z-axis vibration is observed at 1800 rpm, reaching approximately 320 m/s², over 50% higher than the corresponding value at 25% load. The lowest Z-axis vibration at this load is at 1600 rpm, with a value of approximately 140 m/s².
The Y-axis vibration also demonstrates a pronounced increase. The highest vibration occurs at 1800 rpm, with a reading of ≈165 m/s², while the lowest is at 1400 rpm, approximately 65 m/s². This trend indicates a clear correlation between increased engine load and lateral vibrational response, likely caused by higher fuel injection pressures and combustion forces. On the X-axis, vibration levels remain the lowest among the three axes, ranging from ≈35 m/s² at 1400 rpm to a peak of ≈75 m/s² at 1800 rpm. Despite this, the increase from light to medium load still results in a notable rise in longitudinal vibration, likely due to more significant torque fluctuations along the crankshaft axis. At 50% engine load, pure diesel fuel generates significantly higher vibration levels compared to 25% load, with Z-axis peaks rising above 300 m/s² and Y-axis vibration increasing by nearly 85% at some engine speeds. These results reinforce the importance of vibration-damping strategies, especially under moderate-to-high load conditions in diesel engines.
The result of the overall engine speed tested and the highest level of engine vibration acceleration was obtained from using pure diesel fuel for the Y and Z axes. However, the highest value for the X-axis was found on turpentine additive fuel. From the overall fuel sample and engine speed for the two loads tested, the highest vibration values were recorded at 1200 and 1800 rpm. Engine vibration is also strongly influenced by the speed and engine load given. The higher the engine speed and load, the higher the engine vibration level. However, adding 0.2% turpentine oil to the diesel can reduce the vibration acceleration rate for the growth of Y and Z. The higher oxygen content of turpentine oil positively affects the quality of combustion in the engine. Therefore, turpentine additive fuel can reduce engine ignition delay with pure diesel fuel. Reducing the ignition time delayed in the combustion phase cannot be controlled. The advantage of this relationship is that the peak point of pressure is getting closer to the 0° crank angle. The engine vibration is decreased because it is caused by more ignition time and combustion.

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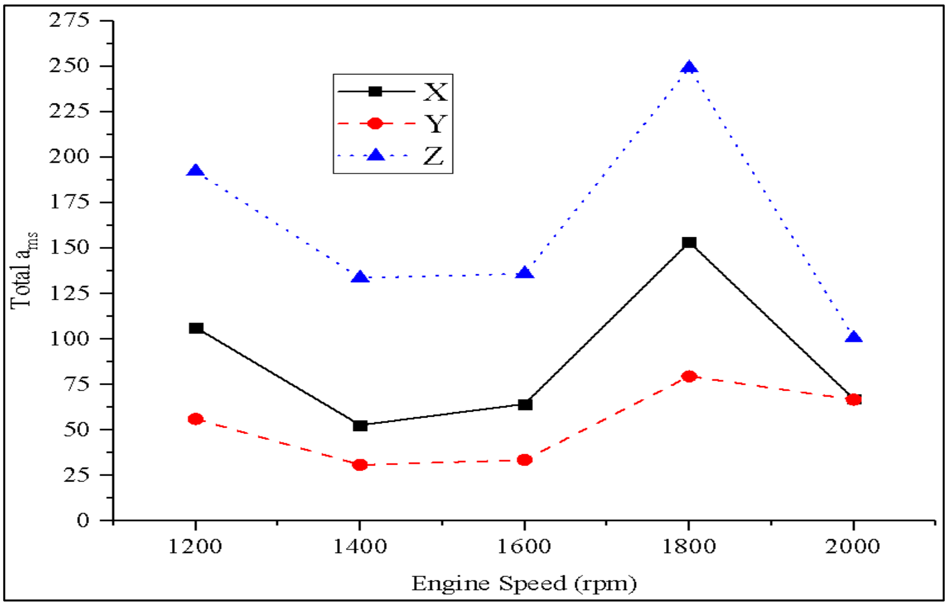

Figure 5: Total vibration at engine load 50% for turpentine oil

Figure 5 presents the total vibration acceleration (a_{rms}) of a diesel engine fueled with a 0.2% turpentine-diesel blend under 50% engine load across five engine speeds from 1200 to 2000 rpm. The vibrations were recorded along three orthogonal directions: X (longitudinal), Y (lateral), and Z (vertical). The Z-axis continues to exhibit the highest vibration amplitudes due to its alignment with the engine's piston motion. The maximum Z-axis vibration is observed at 1800 rpm, reaching ≈245 m/s², which is ~23.4% lower than the corresponding value for pure diesel (≈320 m/s²). The lowest Z-axis vibration is recorded at 1400–1600 rpm, hovering around 135 m/s², showing a consistent suppression compared to diesel fuel at the same speeds.

The Y-axis vibrations remain moderate and show notable improvement over pure diesel. At 1400 rpm, the minimum vibration is recorded at just ≈30 m/s², whereas the highest value, occurring at 1800 rpm, is ≈80 m/s². These values reflect an approximate 51.5% reduction in lateral vibration compared to diesel at peak speed (1800 rpm). For the X-axis, which captures longitudinal vibration, the data show a distinct increase with engine speed. Again, The maximum is 1800 rpm, measuring ≈150 m/s², about 2× higher than the diesel case (≈75 m/s²). This indicates that while turpentine improves lateral and vertical stability, it may intensify longitudinal oscillations at certain engine speeds due to altered combustion dynamics or mass imbalance effects.

Overall, using turpentine-diesel blends at 50% load reduces vibrations significantly along the Y-axis (up to 50%) and Z-axis (up to 23%) while increasing X-axis vibration at higher speeds. These findings suggest that turpentine can improve ride comfort and structural stability, particularly in the lateral and vertical domains.

4. Conclusion

This study experimentally investigated the vibration characteristics of a single-cylinder direct injection diesel engine operated with a 0.2% turpentine oil–diesel fuel blend, compared to pure diesel fuel. Vibration data were measured across three orthogonal axes (X, Y, Z) under two engine loads (25% and 50%) and five engine speeds ranging from 1200 to 2000 rpm. The key findings can be summarized as follows:

1. Engine vibration is significantly influenced by load and speed. At higher engine loads (50%), overall vibration levels increased substantially across all axes. For instance, the highest vibration using pure diesel at 50% load occurred at 1800 rpm on the Z-axis, reaching ≈320 m/s², compared to ≈210 m/s² at 25%.

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2. Adding turpentine oil effectively reduced vibrations in the Y and Z directions. At 25% load, the turpentine blend reduced lateral (Y-axis) vibration by up to 44% (from ≈90 m/s^2 to ≈50 m/s^2) and vertical (Z-axis) vibration by up to 10% compared to pure diesel. Similar trends were observed at 50% load, where the Y-axis vibration was reduced by ≈51.5% and the Z-axis by ≈23.4% at peak engine speeds.
3. However, longitudinal vibration (X-axis) increased with the turpentine blend, particularly at higher speeds. At 50% load and 1800 rpm, X-axis vibration with turpentine fuel reached ≈150 m/s^2, compared to ≈75 m/s^2 with pure diesel—an increase of 100%.
4. The optimal vibration reduction occurred at mid-range engine speeds (1400–1600 rpm), where both the Y and Z-axis vibrations were lowest for turpentine-diesel blends.

The study confirms that a low concentration (0.2%) of turpentine oil as a diesel additive can reduce harmful vibrations in critical directions (lateral and vertical), thereby improving mechanical stability and ride comfort. These findings provide strong evidence for applying turpentine oil as a vibration-reducing bio-additive in diesel engines and serve as a reference for future research involving different additive ratios, engine types, and combustion strategies.

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References

[1] E. Tosun, K. Aydin, S.S. Merola, A. Irimescu, Estimation of operational parameters for a direct injection turbocharged spark ignition engine by using regression analysis and artificial neural network, Therm. Sci. 21 (2017) 401–412.

[2] S.S. Hoseini, G. Najafi, B. Ghobadian, R. Mamat, N.A.C. Sidik, W.H. Azmi, The effect of combustion management on diesel engine emissions fueled with biodiesel-diesel blends, Renew. Sustain. Energy Rev. 73 (2017) 307–331. https://doi.org/10.1016/j.rser.2017.01.088.

[3] M. Muhibbuddin, Y. Muchlis, A. Syarif, H.A. Jalaludin, One-dimensional Simulation of Industrial Diesel Engine, Int. J. Automot. Transp. Eng. 1 (2025) 10–16.

[4] M. Nizar, S. Yana, B. Bahagia, A.F. Yusop, Renewable energy integration and management: Bibliometric analysis and application of advanced technologies, Int. J. Automot. Transp. Eng. 1 (2025) 17–40.

[5] K. Ayd, M. Ozcanl, Vibration , noise and exhaust emissions analyses of an unmodified compression ignition engine fuelled with low sulphur diesel and biodiesel blends with hydrogen addition, 1 (2016) 0–9. https://doi.org/10.1016/j.ijhydene.2016.03.179.

[6] A.S. Ramadhas, S. Jayaraj, C. Muraleedharan, K. Padmakumari, Artificial neural networks used for the prediction of the cetane number of biodiesel, Renew. Energy. 31 (2006) 2524–2533.

[7] E. Tosun, T. Ozgur, C. Ozgur, M. Ozcanli, H. Serin, K. Aydin, Comparative analysis of various modelling techniques for emission prediction of diesel engine fueled by diesel fuel with nanoparticle additives, Eur. Mech. Sci. 1 (2017) 15–23.

[8] A. Kadarohman, F. Hernani Khoerunisa, R.M. Astuti, Potency of clove oil and turpentine oil as a diesel fuel bioadditives and their performance on one cylinder engine, in: Proc. Int. Semin. Chem., 2008: pp. 30–31.

[9] R.E. Sardjono, F. Khoerunnisa, S.M. Rosdi, Y. Muchlis, Optimization of Engine Performance and Emissions with Fusel Oil Blends: A Response Surface Analysis on Speed and Throttle Parameters, Int. J. Automot. Transp. Eng. 1 (2025) 70–80.

[10] M.I. Maulana, S.M. Rosdi, A. Sudrajad, Performance Analysis of Ethanol and Fusel Oil Blends in RON95 Gasoline Engine, Int. J. Automot. Transp. Eng. 1 (2025) 81–91.

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[11] S.M. Rosdi, M.H.M. Yasin, N. Khayum, M.I. Maulana, Effect of Ethanol-Gasoline Blends on In-Cylinder Pressure and Brake-Specific Fuel Consumption at Various Engine Speeds, Int. J. Automot. Transp. Eng. 1 (2025) 92–100.

[12] P. Dubey, R. Gupta, Effects of dual bio-fuel (Jatropha biodiesel and turpentine oil) on a single cylinder naturally aspirated diesel engine without EGR, Appl. Therm. Eng. 115 (2017) 1137–1147. https://doi.org/10.1016/j.applthermaleng.2016.12.125.

[13] S.M. Rosdi, M.F. Ghazali, A.F. Yusop, Optimization of Engine Performance and Emissions Using Ethanol-Fusel Oil Blends: A Response Surface Methodology, Int. J. Automot. Transp. Eng. 1 (2025) 41–51.

[14] Y. Muchlis, A. Efriyo, S.M. Rosdi, A. Syarif, Effect of Fuel Blends on In-Cylinder Pressure and Combustion Characteristics in a Compression Ignition Engine, Int. J. Automot. Transp. Eng. 1 (2025) 52–58.

[15] Y. Muchlis, A. Efriyo, S.M. Rosdi, A. Syarif, A.M. Leman, Optimization of Fuel Blends for Improved Combustion Efficiency and Reduced Emissions in Internal Combustion Engines, Int. J. Automot. Transp. Eng. 1 (2025) 59–67.

[16] B. Guntoro, D. Woro Hastuti, S. Nurtini, The Relationship Between Leadership Type, Work Motivation, Training of Employee, and Physical Work Environment Toward Employee's Performance of Fastfood Company in Yogyakarta Indonesia, Glob. Adv. Res. J. Manag. Bus. Stud. 5 (2016) 18–25.

[17] O. Arpa, R. Yumrutas, M.H. Alma, Effects of turpentine and gasoline-like fuel obtained from waste lubrication oil on engine performance and exhaust emission, Energy. 35 (2010) 3603–3613. https://doi.org/10.1016/j.energy.2010.04.050.

[18] S.M. Rosdi, G. Maghfirah, E. Erdiwansyah, S. Syafrizal, M. Muhibbuddin, Bibliometric Study of Renewable Energy Technology Development: Application of VOSviewer in Identifying Global Trends, Int. J. Sci. Adv. Technol. 1 (2025) 71–80.

[19] M. Muhtadin, S.M. Rosdi, M. Faisal, E. Erdiwansyah, M. Mahyudin, Analysis of NOx, HC, and CO Emission Prediction in Internal Combustion Engines by Statistical Regression and ANOVA Methods, Int. J. Simulation, Optim. Model. 1 (2025) 94–102.

[20] R. Yumrutaş, M.H. Alma, H. Özcan, Ö. Kaşka, Investigation of purified sulfate turpentine on engine performance and exhaust emission, Fuel. 87 (2008) 252–259. https://doi.org/10.1016/j.fuel.2007.04.019.

[21] H. Sastrohamidjojo, Kimia minyak atsiri, Univ. Gadjah Mada, Yogyakarta. (2004).

[22] H.A. Jalaludin, M.K. Kamarulzaman, A. Sudrajad, S.M. Rosdi, E. Erdiwansyah, Engine Performance Analysis Based on Speed and Throttle Through Simulation, Int. J. Simulation, Optim. Model. 1 (2025) 86–93.

[23] M. Muhibbuddin, M.A. Hamidi, D.F. Fitriyana, Bibliometric Analysis of Renewable Energy Technologies Using VOSviewer: Mapping Innovations and Applications, Int. J. Sci. Adv. Technol. 1 (2025) 81–91.

[24] O.M. de la Santé, International programme on chemical safety, Environ. Heal. Criteria. 101 (1992).

[25] P. Selvakumar, W. Maawa, R. Rusiyanto, Hybrid Grid System as a Solution for Renewable Energy Integration: A Case Study, Int. J. Sci. Adv. Technol. 1 (2025) 62–70.

[26] N. Khayum, R. Goyal, M. Kamal, Finite Element Modelling and Optimisation of Structural Components for Lightweight Automotive Design, Int. J. Simulation, Optim. Model. 1 (2025) 78–85.

[27] I. Iqbal, S.M. Rosdi, M. Muhtadin, E. Erdiwansyah, M. Faisal, Optimisation of combustion parameters in turbocharged engines using computational fluid dynamics modelling, Int. J. Simulation, Optim. Model. 1 (2025) 63–69.

[28] H. Pranoto, R. Rusiyanto, D.F. Fitriyana, Sustainable Wastewater Management in Sumedang: Design, Treatment Technologies, and Resource Recovery, Int. J. Sci. Adv. Technol. 1 (2025) 38–46.

[29] M.A. Rosli, J. Xiaoxia, Z. Shuai, Machine Learning-Driven Optimisation of Aerodynamic Designs for High-Performance Vehicles, Int. J. Simulation, Optim. Model. 1 (2025) 43–53.

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[30] A. Keskin, The influence of ethanol-gasoline blends on spark ignition engine vibration characteristics and noise emissions, Energy Sources, Part A Recover. Util. Environ. Eff. 32 (2010) 1851–1860. https://doi.org/10.1080/15567030902804749.
[31] A. Keskin, M. Gürü, The effects of ethanol and propanol additions into unleaded gasoline on exhaust and noise emissions of a spark ignition engine, Energy Sources, Part A Recover. Util. Environ. Eff. 33 (2011) 2194–2205.
[32] C.H.E.W.A.N.M. NOOR, F. Arif, D. Rusirawan, Optimising Engine Performance and Emission Characteristics Through Advanced Simulation Techniques, Int. J. Simulation, Optim. Model. 1 (2025) 10–20.
[33] F. Almardhiyah, M. Mahidin, F. Fauzi, F. Abnisa, K. Khairil, Optimization of Aceh Low-Rank Coal Upgrading Process with Combination of Heating Media to Reduce Water Content through Response Surface Method, Int. J. Sci. Adv. Technol. 1 (2025) 29–37.
[34] E. Uludamar, E. Tosun, K. Aydın, Experimental and regression analysis of noise and vibration of a compression ignition engine fuelled with various biodiesels, Fuel. 177 (2016) 326–333. https://doi.org/10.1016/j.fuel.2016.03.028.
[35] A. Gani, S. Saisa, M. Muhtadin, B. Bahagia, E. Erdiwansyah, Y. Lisafitri, Optimisation of home grid-connected photovoltaic systems: performance analysis and energy implications, Int. J. Eng. Technol. 1 (2025) 63–74.
[36] M.F. Ghazali, S.M. Rosdi, Erdiwansyah, R. Mamat, Effect of the ethanol-fusel oil mixture on combustion stability, efficiency, and engine performance, Results Eng. 25 (2025) 104273. https://doi.org/https://doi.org/10.1016/j.rineng.2025.104273.
[37] B. Bahagia, M. Nizar, M.H.M. Yasin, S.M. Rosdi, M. Faisal, Advancements in Communication and Information Technologies for Smart Energy Systems and Renewable Energy Transition: A Review, Int. J. Eng. Technol. 1 (2025) 1–29.
[38] E. Uludamar, E. Tosun, G. Tüccar, Ş. Yıldızhan, A. Çalık, S. Yıldırım, H. Serin, M. Özcanlı, Evaluation of vibration characteristics of a hydroxyl (HHO) gas generator installed diesel engine fuelled with different diesel–biodiesel blends, Int. J. Hydrogen Energy. 42 (2017) 23352–23360.
[39] S.M.M. Rosdi, Erdiwansyah, M.F. Ghazali, R. Mamat, Evaluation of engine performance and emissions using blends of gasoline, ethanol, and fusel oil, Case Stud. Chem. Environ. Eng. 11 (2025) 101065. https://doi.org/https://doi.org/10.1016/j.cscee.2024.101065.
[40] D. Li, M. Ikram, J. Xiaoxia, A brief overview of the physical layer test system: Development of an IoTbased energy storage and electrical energy distribution system, Int. J. Eng. Technol. 1 (2025) 131–140.
[41] R.A. Alenezi, A.M. Norkhizan, R. Mamat, Erdiwansyah, G. Najafi, M. Mazlan, Investigating the contribution of carbon nanotubes and diesel-biodiesel blends to emission and combustion characteristics of diesel engine, Fuel. 285 (2021) 119046. https://doi.org/https://doi.org/10.1016/j.fuel.2020.119046.
[42] K. Çelebi, E. Uludamar, E. Tosun, Ş. Yıldızhan, K. Aydın, M. Özcanlı, Experimental and artificial neural network approach of noise and vibration characteristic of an unmodified diesel engine fuelled with conventional diesel, and biodiesel blends with natural gas addition, Fuel. 197 (2017) 159–173. https://doi.org/https://doi.org/10.1016/j.fuel.2017.01.113.
[43] W. Sumbodo, M. Yasar, M.I. Maulana, A. Khalid, Heavy Metal Analysis in Biocoke Fuel Derived from Empty Fruit Bunch (EFB) Waste, Int. J. Energy Environ. 1 (2025) 17–23.
[44] A.J. Torregrosa, A. Broatch, R. Novella, J. Gomez-Soriano, L.F. Mónico, Impact of gasoline and Diesel blends on combustion noise and pollutant emissions in Premixed Charge Compression Ignition engines, Energy. 137 (2017) 58–68.
[45] A. Taghizadeh-Alisaraei, B. Ghobadian, T. Tavakoli-Hashjin, S.S. Mohtasebi, Vibration analysis of a diesel engine using biodiesel and petrodiesel fuel blends, Fuel. 102 (2012) 414–422.
[46] M.S.M. Sani, R. Mamat, F. Khoerunnisa, A.R. Rajkumar, N.F.D. Razak, R.E. Sardjono, Vibration analysis of the engine using biofuel blends: a review, in: MATEC Web Conf., EDP Sciences, 2018: p. 1010.
[47] C. Efremov, S. Kumarasamy, Optimisation of Microgrid by HOMER Pro Software Design:

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Innovative Approach and Performance Evaluation, Int. J. Eng. Technol. 1 (2025) 120–130.
[48] R.A. Alenezi, Erdiwansyah, R. Mamat, A.M. Norkhizan, G. Najafi, The effect of fusel-biodiesel blends on the emissions and performance of a single cylinder diesel engine, Fuel. 279 (2020) 118438. https://doi.org/https://doi.org/10.1016/j.fuel.2020.118438.
[49] A. Taghizadeh-Alisaraei, B. Ghobadian, T. Tavakoli-Hashjin, S.S. Mohtasebi, Vibration analysis of a diesel engine using biodiesel and petrodiesel fuel blends, Fuel. 102 (2012) 414–422. https://doi.org/10.1016/j.fuel.2012.06.109.
[50] A.T. B. Heidary, S. R. Hassan-beygi, B. Ghobadian, Vibration analysis of a small diesel engine using diesel-biodiesel fuel blends, Agric. Eng. Int. J. 15 (2013) 117–126.
[51] G. Maghfirah, A.F. Yusop, Z. Zulkifli, Using VOSviewer for Renewable Energy Literature Analysis: Mapping Technology and Policy-Related Research, Int. J. Eng. Technol. 1 (2025) 83–89.
[52] A. Gani, M. Mahidin, E. Erdiwansyah, R.E. Sardjono, D. Mokhtar, Techno-Economic Assessment of Renewable Energy Integration in On-Grid Microgrids, Int. J. Energy Environ. 1 (2025) 24–30.
[53] A. Gani, Erdiwansyah, E. Munawar, Mahidin, R. Mamat, S.M. Rosdi, Investigation of the potential biomass waste source for biocoke production in Indonesia: A review, Energy Reports. 10 (2023) 2417–2438. https://doi.org/https://doi.org/10.1016/j.egyr.2023.09.065.

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