Journal of Positive School Psychology
2022, Vol. 6, No. 3, 3853 –3860
http://journalppw.com

Prediction of Vibration and Noise Characteristics in 3 Cylinder Passenger Vehicle Through Experimental Investigation

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Abstract

Engine vibration in auto vehicles is one of the significant issues to be considered in the realm of surface vehicle which influences the ride solace, steadiness and drivability. Vibration Noise and Harshness (NVH) is one of the prevalent issues that is a moving errand to be tended to by the OEM Industries from the client see. As a wellspring of vibration and commotion boundaries, the accompanying variables like kinds of fuel utilized, game plan and tally of chamber, size of the motor, area of the motor mount, sort of motor mount material, kind of street on which the vehicle is running and vibration move ways. Numerous analysts have done different testing of the vibration and commotion in the trial test apparatus and few have led continuously working. Here in this undertaking, taking the vibration and commotion age issues in the car type traveller vehicles issue have been concentrated for our conversations principally during the inactive condition and low-speed movement of the vehicle and the street excitation wellspring of which the human solace is upset because of low-recurrence vibration and which prompts weakness and subsequently probes a three-chamber diesel motor car and four-chamber motor car has been chosen for the examination. Actually, the principle area of vibration perception and at five significant areas like the motor head, motor mount, motor body outline, vehicle seat leg and guiding wheel is chosen and the test work and similar investigation of the NVH issues were tended to.

Keywords : NVH, Motor Mount, vibration, excitation, vehicle

1. Introduction

In the surface vehicle on-street vehicles the driver and the travelers are continually encountering the vibration and clamor upsetting the solace, security and the drivability in all the three ways of the vehicle development. Vehicle producers have been continually investing amounts of energy in improving vehicle elements and ride comfort alongside other vehicle exhibitions. Different sorts of models of vehicle, seat and human body have been created to enhance the vehicle elements and ride comfort in the course of recent many years [1].

Diesel Engine vibrations can be named inside and outside vibrations. The inside vibrations are insinuated as the vibrations of internal fragments of the engine, provoked by the inertial force of moving parts and the variable squeezing component of start. The external vibrations are suggested as the vibrations of the entire engine system as a square, which is for the most part organized with the transmission case. The external vibrations are a result of lopsided second, inertial second, or variable-yield torsional power. The components that are liable for the vibration can be requested as the engine fuel used, number of chambers that is

gathered, kind of imbuement, and Engine mount that is supporting the engine that is fixed in the underside and the engine body [2]. Multi-chamber engines are used in applications where high power is required and it gives a favored situation of better balance of forces and minutes. The general arrangements used are 2-cylinder,3-chamber, 4-chamber, 5-chamber, 6-chamber and 8-chamber inline engines. On differentiating the inline and V-engine dependent on forces and minutes, from the vibration examination, it has been found that V-plan engines are better changed and consequently V-engine will give smooth action freed from commotion, vibration and severity unquestionably when appeared differently in relation to inline engine [3]. Ending demand influences changing of V-engine. Despite the way that it is more jumbled and not as smooth as the inline 6, the V-6 is more unbendable for a given weight, more limited and less slanted to torsional vibrations in the driving pole for a given dislodging. Ending demand impacts the balance, upheaval, vibration, flawlessness, and sound of the engine. The ending demand is the plan of power movement of each chamber in a multi chamber reacting engine. This is cultivated by beginning of the radiance interfaces a gas engine in the right solicitation, or by the gathering of fuel imbuement in a Diesel engine. When arranging an engine, Engines have even and odd ending demand. Engines that are regardless, ending will sound more smooth and predictable, while engines that are odd or unbalanced ending will have a burble or a throaty, growling sound in the engine note, and, dependent upon the driving pole arrangement, will consistently have more vibrations on account of the distinction in power transport [4]. Few investigators have considered the effects of vibration and racket in the engine using diverse fuel mixes. The results from some composing point by point that biodiesel blend powers showed to lessen vibration and uproar in engines when appeared differently in relation to unadulterated diesel. The effects of vibration and upheaval to some degree lessened while using biodiesel fuel when stood out from unadulterated diesel, considering the way that biodiesel has higher warmth levels than diesel [5]. Fischer-Tropsch diesel fuel joined from coal (CFT) is an elective fuel is blended in with diesel and were taken a stab at a CI engine to acquire vibration signals from the engine head and square. Taking into account the FFT and perpetual wavelet change (CWT) assessment, the effect of CFT on the vibration was thought of. The results demonstrated that the root mean square (RMS) assessments of the vibration signal decrease as the degree of CFT in the blends increases [6].

Table 1-Noise and Vibration

Sources of Noise	Frequency Ranges (Hz)
Combustion noise	500-8000
Piston slap	2000-8000
Valve operation	500-2000
Fan noise	200-2000
Intake flow noise	50-5000
Exhaust flow noise	50-5000
Injection pump operation	2000
Gear noise	4000

A trial was directed on VCR motors by Madhava varma indicating that the neem methyl oil has been tried for different burdens with consistent speed that has been understood that ignition actuated vibration is decreased when motor is worked with NME, instead of

diesel [7]. The above table 1. shows the different wellspring of clamor and recurrence ranges In a vehicle there are two unique classifications of transmission ways, identified with totally various instruments of energy transmission: structure-borne and air-borne ways. Normally in a vehicle, the construction borne clamor transmission way rules at low recurrence (<200 Hz) while the air-borne commotion transmission way overwhelms over 500 Hz . In the mid-recurrence range, both transmission ways have normally a similar degree of significance. The fundamental focuses of NVH trial methods are to decide the qualities of these two sorts of commotion in a vehicle, just as the transmission ways to driver and travelers. commotion planning strategies (sound force), acoustic holography and shaft shaping, Transfer Path Analysis, modular examination, request following are viewed as the most pertinent exploratory procedures to break down and distinguish NVH sources in a vehicle. Trial modular examination is another standard device in vehicle NVH advancement for deciding the unique qualities of a framework, and consequently for diminishing the danger of disappointment or unnecessarily high underlying vibration or sound pressing factor levels [8]. In time-recurrence investigation was performed on a 4 chamber direct infusion diesel motor to quantify the cylinder slap clamor showed because of the leeway between the cylinder and chamber square and three kinds of burning interaction estimated utilizing ECU and two arrangements of cylinder like the low commotion and high commotion uncovered that the vibrating recurrence of 2000 Hz is liable for the cylinder slap or more 3500 to 6500 Hz is answerable for the ignition cycle [9]. A non-fixed sign investigation procedure called as the time-recurrence dispersion technique for recognizing the commotion signal source in the CI motors is created to gauge the clamor boundaries like abundancy, recurrence and time and demonstrated it is been demonstrated that is more favorable position contrasted with the direct and bilinear recurrence dissemination strategy principally for checking the injector showing commotion [10]. the expectation of sound pressing factor level (SPL) of the inside commotion of the auto is determined for the four distinct excitations, for example, street excitation, mount excitation, motor excitation and wind excitation utilizing the half breed FE-SEA strategy and the accompanying boundaries, for example, the modular thickness, damping misfortune factor and coupling misfortune factor has been done [11].

2. Experimental setup and procedures

The three cylinder diesel engine of the above mentioned specification shown in table 2. And of measuring the vibration characteristics at the five location of engine head , engine mount , engine frame chassis, car seat leg and car steering rod as shown in Table 3. And the experimental graphs of the vibration characteristics with respect to the time domain analysis and frequency domain analysis showing the change of amplitude with respect to the time and frequency during the three different conditions like idle , 20kmph and 40 kmph and here we have shown the sample of the time domain values in Figure 1 to 5 and the frequency domain values shown in Figure 6 to 10. after this values the consolidated comparison of the vibration at the five location at the various speeds for which the figure 11 shows the frequency vs amplitude in engine head, figure 12 shows the frequency vs amplitude in engine mount, figure 13 shows the frequency vs amplitude in engine frame, figure 14 shows the frequency vs amplitude in engine car seat leg, figure 15 shows the frequency vs amplitude in car steering and fig.16 shows the noise values. It is been observed from the above figures the fluctuation of the vibration during the location at the seat and steering wheel is more and attention is required that this may be due to the transfer path and the road vibration which can be reduced by proper engine mounting

Table 2 Engine Specification of Three cylinder diesel engine – Model 2

Description	**specification**
Engine Description	1.2L U2 CRDi Diesel
Max Power	73.97bhp@4000rpm
Max Torque	190.25nm@1750-2250rpm
Cylinders	3, inline
Valve/cylinder	4,DOHC
Fuel type supply	Diesel / CRDi
Engine Displacement	1186 cc

Table.3 Vibration characteristics of Three-cylinder engine at various locations

Location /engine motion	Idle			20 kmph			40 kmph		
Engine Head	Frequency (Hz)	Amplitude (g)	Noise (db)	Frequency (Hz)	Amplitude (g)	Noise (db)	Frequency (Hz)	Amplitude (g)	Noise (dba)
	19.53	0.223	76.14	24.4	0.202	77.0	36.62	0.178	78.81
	41.50	0.105		48.53	0.102		73.24	0.0838	
	61.04	0.059		73.24	0.0616		109.9	0.0586	
Engine mount	19.53	0.108	76.14	24.41	0.0803	77	24.41	0.0658	78.81
	41.50	0.0425		48.83	0.0362		51.27	0.142	
	61.04	0.022		70.80	0.021		75.68	0.0209	
Engine Frame	19.53	0.009	76.14	24.14	0.126	77	24.41	0.009	78.81
	26.86	0.015		48.83	0.004	77	36.62	0.013	
	41.50	0.005		97.66	0.003		48.83	0.006	
Car Seat leg	21.97	0.0098	50.76	24.41	0.013	56.12	24.41	0.0091	58.68
	41.50	0.003		48.83	0.0016		36.62	0.0014	
	61.04	0.004		97.66	0.002		48.83	0.005	
Car steering rod	41.50	0.0183	50.76	24.41	0.0086	56.12	36.62	0.0107	58.68
	61.04	0.0059		48.83	0.0029		48.63	0.0046	
	88.03	0.004		97.66	0.015		73.24	0.062	

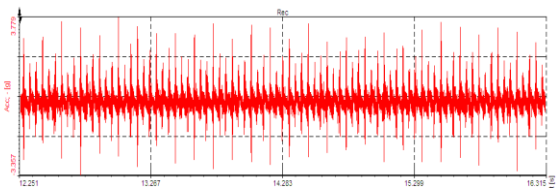

Fig. 1 Time(t) Vs Amplitude(g) at Engine head

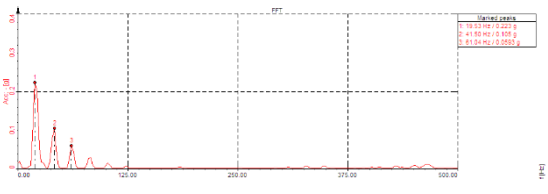

Fig. 6 Frequency Vs Amplitude(g) at Engine head

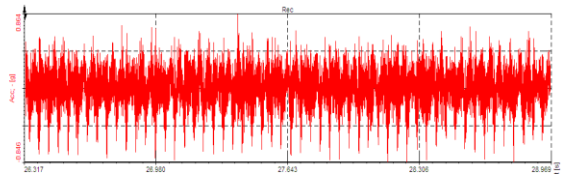

Fig.2 Time(t) Vs Amplitude(g) at Engine mount

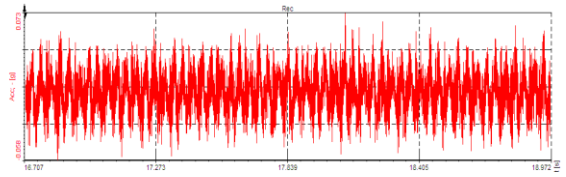

Fig. 3 Time(t) Vs Amplitude(g) at Engine frame

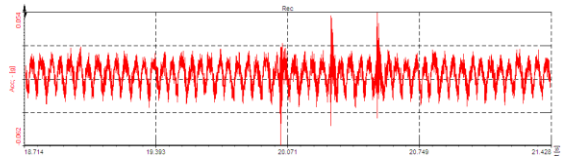

Fig. 4 Time(t) Vs Amplitude(g) at car seat leg

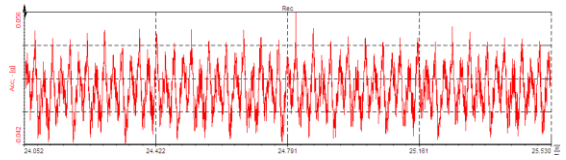

Fig. 5 Time(t) Vs Amplitude(g) at car steering

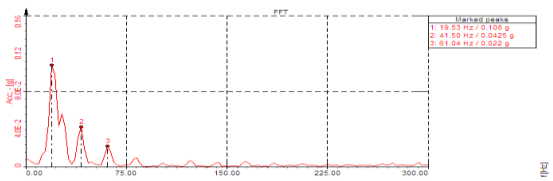

Fig. 7 Frequency Vs Amplitude(g) at Engine mount

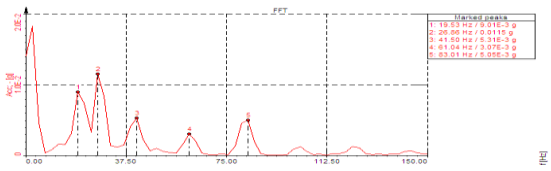

Fig. 8 Frequency Vs Amplitude(g) at Engine frame

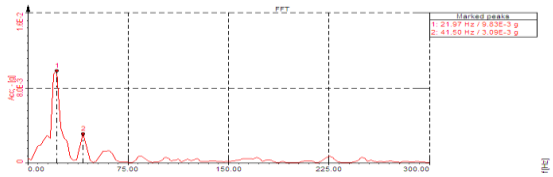

Fig. 9 Frequency Vs Amplitude(g) at car seat leg

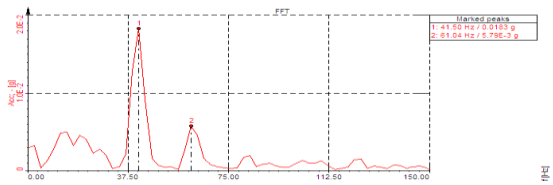

Fig. 10 Frequency Vs Amplitude(g) at car steering

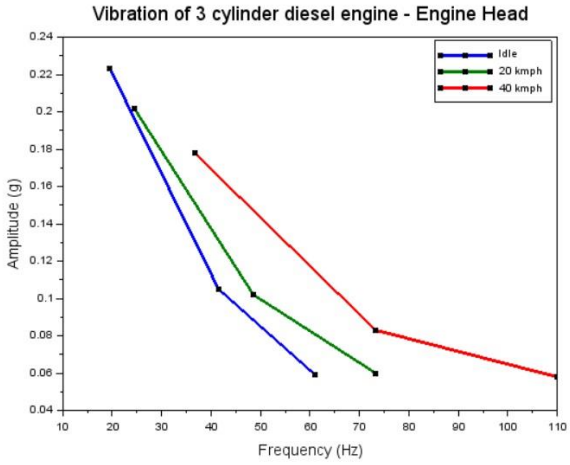

Fig.11 Frequency Vs Amplitude comparison at engine

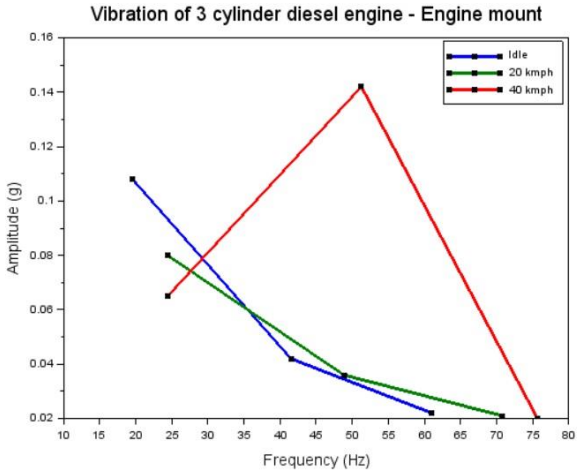

Fig.12 Frequency Vs Amplitude comparison at engine mount

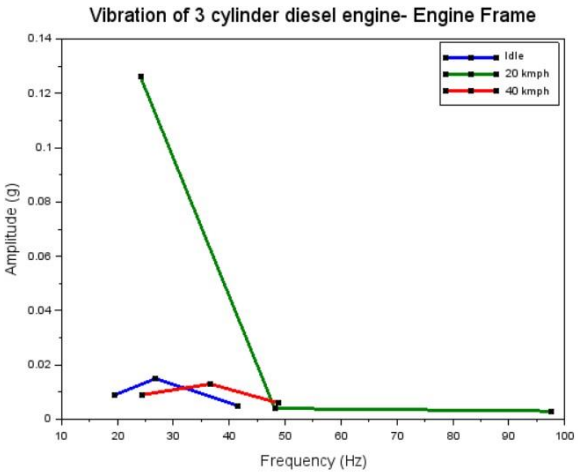

Fig.13 Frequency Vs Amplitude comparison at engine frame

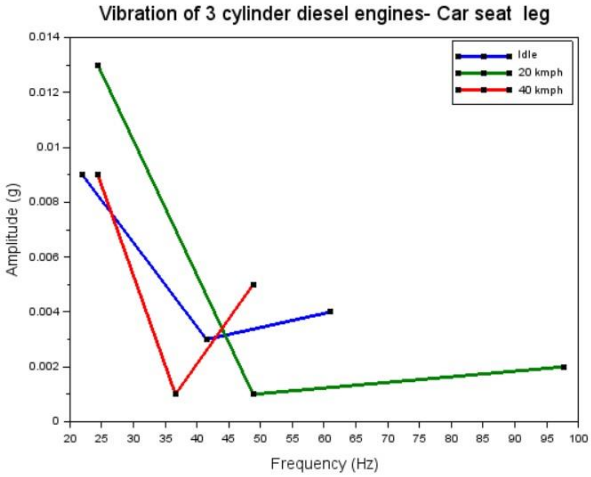

Fig.14 Frequency Vs Amplitude comparison at car seat

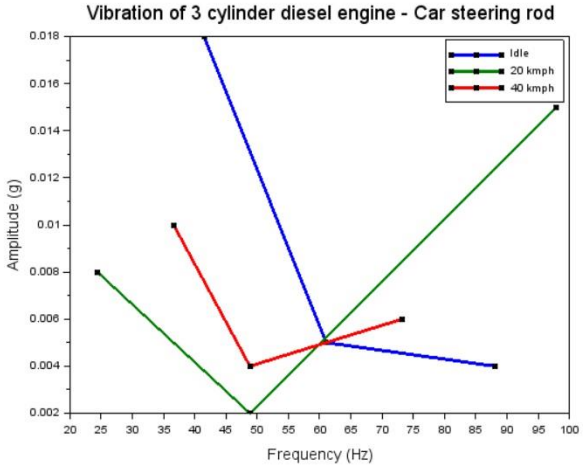

Fig.15 Frequency Vs Amplitude comparison at car steering

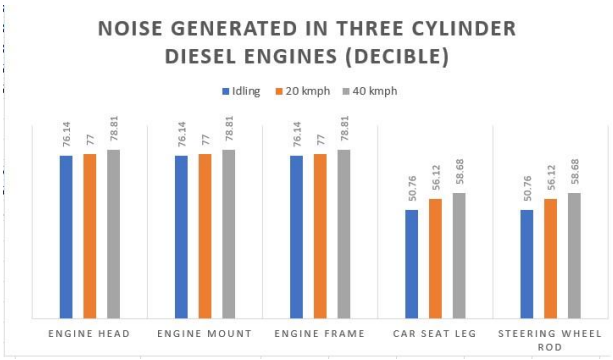

Fig.16 Comparison of noise generated in various locations

3. Conclusion and future work

From the experimental investigation and comparison of the vibration that is generated in the four cylinder and three cylinder diesel engine sedan at the locations of engine head, engine mount , engine chassis frame, car seat leg and steering rod it is observed that the low frequency are dominating at the idle and low speed of the vehicle and makes much discomfort especially when compared to the four cylinder diesel engine the vibration and noise generated at the car seat and the steering wheel are more and fluctuating which makes the fatigue issue to the vehicle and the passengers it is also observed that the three cylinder diesel engine is creating more noise due to its unbalancing issues which is observed from the vibration at the engine mount and it is suggested that a better engine mount can be fixed at the proper location to counter act the unbalanced force in which the engine mount design and its material characteristics may be improved by proving better dynamic properties like the stiffness and damping coefficient.

The following suggestion are listed for better vehicle comfort and NVH issues

1. The proper engine mount may be selected with better mechanical and dynamic properties
2. Proper support at the critical location may be recommended
3. The nonlinear properties which is one of the main material properties of the engine mount can be considered for vibration isolation in diesel engines
4. Instead of three-cylinder, four-cylinder diesel engines with compact power output is recommended for better combustion process and firing order which gives rise to the reciprocating and rotating unbalances of the engines.

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