

Noise and Vibration Sources in Engines (Part I)

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Abstract: Noise and vibrations from automotive systems form important benchmarks for customers' choice. These have determinant effect on shelf life of engines. Hence it is important to study sources and properties of these noise and vibration sources. The presented work discusses various noise and vibration sources found in an automotive system.

Keywords: Acoustics, Noise, Vibration, Automotive

1. Introduction

Combustion engines are major sources of power for various automotive as well as machinery. About one fifth of the total energy consumption in U.S.A. goes towards operating these engines [1-5]. Figure 1 summarizes Sales of diesel engines-based vehicles.

US Sales of Diesel Vehicles

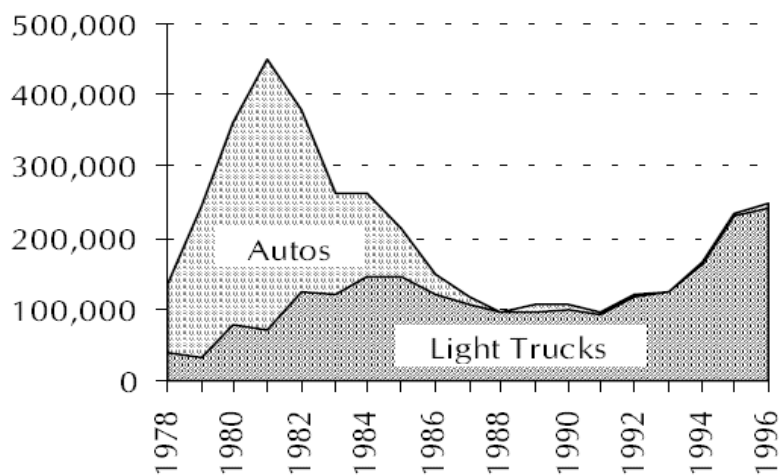


Fig. 1. Sales of various diesel engine-based automobiles

Gasoline engines use spark ignition system for fuel combustion as compared to with diesel engines (that use compression ignition. Diesel engines have higher compression ratios, thus allowing Combustion to take place away from chamber walls. In addition, there are various losses in petrol engines. Hence efficiency of gasoline engines is lesser when compared with diesel engines [6-10]. These factors have led to growing interest of automotive makers in diesel engines. Table no 1 shows the market share of diesel engines based automotive in U.S.A.

Table 1: Major Diesel engine car makers

Automotive Make	Engine Make	Market Share
Hino	Hino	100%
Freightliner	Cummins	62.3%
	Detroit Diesel	37.0%
	Mercedes Benz	0.7%
International	Cummins	7.2%
	Navistar	92.8%
Volvo	Cummins	13.6%
	Volvo	86.4%
Western Star	Cummins	21.2%
	Detroit Diesel	78.8%
Mack	Cummins	6.0%
	Mack	94.0%
Peterbilt	Cummins	65.2%
	PACCAR	34.8%

2. Summary of various sources of noise

Vehicle noise and vibrations can have a bad effect on overall performance of automobiles. These aspects also form important benchmarks for perception of customers while choosing a vehicle as parameters of comfort levels and vehicle reliability. A layout of vehicle consists of several units like power train, chassis, heating, ventilation and air conditioning systems (HVAC) as well as various electronics systems as shown in figure 2,3 [11-20].

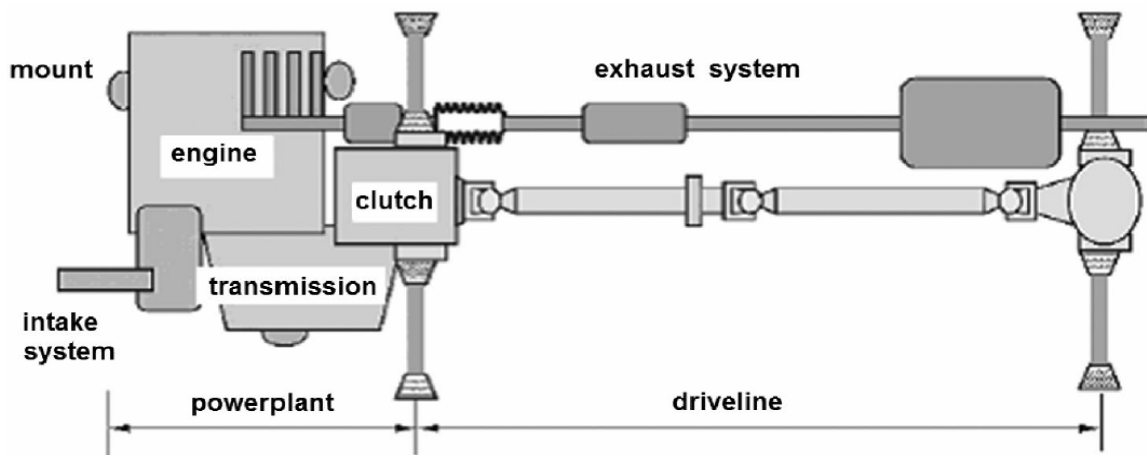


Fig. 2. Powertrain

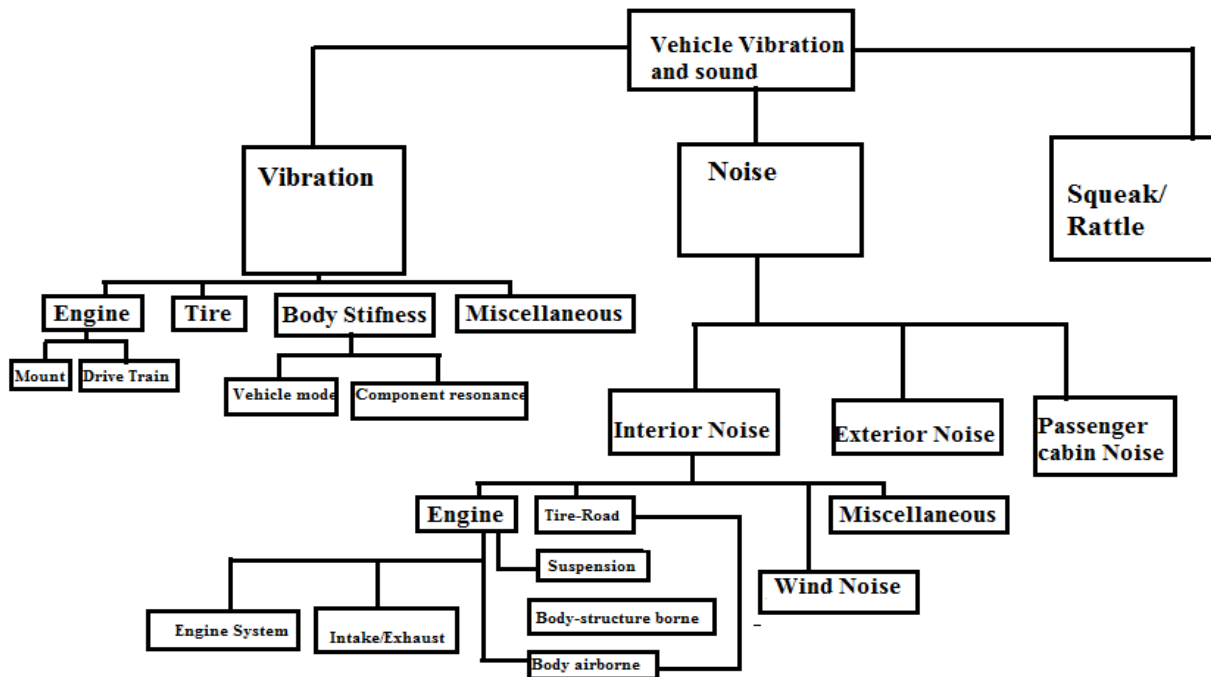


Fig. 3. Noise and vibration sources

Combustion noise is generated as an impulsive pressure wave [20]. The intensity of this noise depends on square of in cylinder pressure developed. Mechanical based noise includes piston motion, bearing misalignment noise, cam and oil pump noise [20]. Flow based noise includes aerodynamic noise due to motion of fan. Table 2 summarizes various sources with their frequency ranges [20].

Table 2: Frequency ranges of various noise sources

Source	Frequency range	Effecting factor
Combustion based Noise	500-8000Hz	In cylinder pressure
Piston Noise	2000-8000Hz	Speed, design
Valve Noise	500-2000Hz	Valve ,Engine
Fan Noise	200-2000Hz	Speed, Blades
Intake Noise	50-5000Hz	Flow
Exhaust Noise	50-5000Hz	Flow
Injection Pump Noise	2000Hz	Pump design
Gear operation noise	4000Hz	Speed, Teeth

3. Quantification

Various methods used include:

- a) **lead covering method**- This method includes measurement of noise emissions from engine using selective covering of engine parts with lead.
- b) **vibration method**-The sound power level of engine ($L_w[A]$) can be expressed in terms of acoustic impedance (ρc), surface velocity (u), radiation efficiency (σ) and surface area (S) by following relationship:

$$L_w[A]= 10*\log(\rho c)+10*\log(S)+10* \log(\sigma)+10*\log (u) \tag{1}$$

c) Spectro- filters

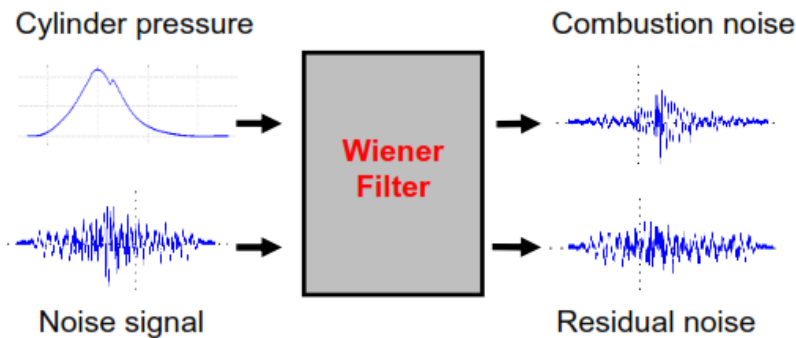


Fig. 4. Application of Wiener filter

Input response $P(t)$ giving a single output response $C(t)$ as seen from figure 4. The impulse response function has been denoted by $H(t)$. The system is corrupted by external component $M(t)$.

$$C(t) = C_1(t) + C_2(t) \quad (2)$$

4. Summary

Car industry had turnover of about 1 Trillion U.S.\$ [20]. Attributes such as durability and serviceability require a vehicle to be in service for certain period of time. In the present work summarizes sources, properties and methods of quantification of various sources of noise and vibrations in combustion engines. The discussed methodology can be useful for early fault detection and hence help in effective condition monitoring of an engine.

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