International Journal of Modern Engineering Research (IJMER)

www.ijmer.com Vol.1, Issue2, pp-242-246 ISSN: 2249-6645

Review and Diagnostics of noise and vibrations in automobiles

Prof. Deulgaonkar V.R[1], Prof.Dr.Kallurkar S.P[2,] Prof.Dr. Mattani A.G [3]

[1](Department of Mechanical Engineering, MMCOE, Pune, University of Pune,)
[2](A.G.Patil Institute of Technology, Solapur, University of Solapur India)
[3](Department of Mechanical Engineering, Govt.COE Amravati, Sant Gadge Baba Amravati University, India)

ABSTRACT

The present work describes various automotive noise & vibration sources and their contribution. Noise and vibration reduction technique is studied through energy flow path. Various international and Indian standards for vehicles consider two types of noise measurement i.e. pass by noise and stationary noise. This paper discusses the appropriateness of SN test for in use vehicle. A methodology for interior noise source identification and its analysis is descried. Two vehicles of same class but of different makes were compared and evaluated for interior noise and vibration levels. The effectiveness of the firewall, silencers and engine mounts are checked and compared. The correlation between pressure and vibration levels of different sources with acoustical and structure transfer path are studied. Basic causes, design guidelines and validation techniques using lab simulation and data acquisition are discussed. Application of damping technology using viscous materials to control noise and vibration in vehicles is described.

Keywords - E*nergy flow path*, Noise, *Stationary Noise*, Vibrations.

INTRODUCTION

Sound is a propagating type of energy traveling through a medium with particular velocity. The unwanted sound is noise. Vibration is the variation or displacement of a body with respect to specific reference position with time when displacement is alternatively greater or smaller than reference. Harshness is defined as vibration perceived actually and audibly produced by interaction of the tyre with road irregularities and vibrations of the structure and components. [1]. A significant part of the world energy consumption is related to transportation. The wide use of automobile vehicles causes detrimental effects on the surrounding environment. The 20-25% of the total greenhouse gas emission in industrialized countries is generated by transportation [2]. The transportation noise is one of the major sources of noise exposure in residential areas and causes substantial annoyance during night. Considering this, many countries have enocked legislation limiting the noise levels in residential areas. Various international and Indian Standards for vehicles consider two types of noise measurement viz. passby noise (PBN) and stationary Noise (SN).The oil thickness plays a major role in determining the engine's vibration characteristics [3-4].The acceptance criterion of any vehicle in terms of user comfort depends on the vehicle interior noise and vibration characteristics. The levels of sound energy and structural excitation inside the vehicle compartment measures the amount of annoyance in terms of quality and comfort. For vehicle interior noise identification and treatment, quantification of noise sources by determining the sound power contribution from each vehicle component, acoustic leakages inside the vehicle body panel, vibrations during gear shifting at lever and steering wheel vibrations needs to be identified, because interior noise in a vehicle has a major impact on customers perception of operation, performance and quality [5]. In the highly competitive global automotive market the need to develop high quality products and achieve product excellence in all areas to obtain market leadership is critical.

1. Sources of Noise & Vibrations in Automobile

Interior noise in any vehicle reduces the users ride comfort. For today's compact era the trend towards compact power units is substantially increased resulting in vehicles running at higher level of noise and vibrations.

1.1 Engine**:**

Vibrations in engine are generated due to the reciprocating mechanism used for converting the energy into rotary motion. The forces producing the engine vibrations are: Combustion, Reciprocating and Rotational Forces. A downward force is generated during combustion stroke on the piston which due to geometrical construction of connecting rod and crankshaft generates a torque around crankshaft axis. Torsional vibrations are generated due to

the torque variations. A multi-cylinder engine can be compared with a system of masses rotating on a single crankshaft in single and different planes. The primary & secondary forces as well as couples generate vibrations due to reciprocating unbalance. Significant inertia effects are generated due to small unbalance of rotating masses in high speed engines. Rotating unbalance generates unacceptable levels of vibrations and stresses in individual and supporting structures

1.2 Noise Sources**:**

Various noise sources in an automobile are induction noise, exhaust noise, noise from accessories, and noise radiation from engine sources. Induction noise is due to opening and closing of valves. In cylinder on opening the valve, the inlet air column is set into oscillation due to intense pressure thump. Closing of the inlet valve produces forced undamped vibrations. Exhaust noise exists when exhaust valve opens and releases gas into exhaust system. Various accessories used generate unwanted sound. In this category engine fan is the main source of noise. It is used in addition to radiator for cooling, and operated by air during ride. Pressure fluctuations result in generation of noise. Transient vibrations are induced by periodic and aperiodic distortion of engine due to combustion processes. Figure 2 shows Propagation of tyre noise of an automobile at frequency of 600 Hz. Alternating inertia loads and mechanical impacts of the engine mechanism produces noise. Often it is very difficult to sort out which force is the cause of excitation of engine structure. Table 1 shows the percentage contribution of sources of the total noise.

Table 1. Percent contribution of sources to total noise

Sr.No	Source	% Contribution
i.	Engine	22 to 30
ii.	Exhaust system	25 to 35
iii.	Intake system	05 to 15
iv.	Fan and cooling system	07 to 15
v.	Transmission	12 to 15
vi.	Tyres	09 to 15

1.3 Driveline Sources

Noise and vibration in driveline are a consequence power transmission from engine to wheels. Mechanical layout of front wheel drive and propeller shaft of rear wheel drive is the sources of noise and vibration in respective automobiles. The various sources are transmission gear noise, drive and propeller shaft, axle noise, tyre noise, aerodynamic noise, wind noise and interior noise. Generation of noise & vibrations from gears results due to improper bending dynamics of gear tooth and both torsional and bending characteristics of shafts. Propeller shaft generates excitation at elemental speeds. Due to large coupling angles, universal joints generate excitation. Also most of modern vehicles induct constant velocity coupling at the centre of two piece propeller shaft results into noise. Axle noise is due to response of rear axle to vibration generated by meshing action of the axle gear set. The so generated noise is annoying even at squat levels in passenger compartment of the vehicle. Tyre noise is due to tribology between tyre and road. Mechanics of tyre noise generation may be combination of squash vibration (primary noise source) exists due to rough road surface, tread squirm results lateral vibrations and generates noise spectra. Slick/aerodynamic noise is generated by chaotic flow of air around the tyre contributes to the tyre noise. Tyre is excited by several means, which include non-uniform wear, radial or lateral run-out, road roughness, road surface irregularities, road surface discontinuities that induces impacts, bumps etc, which contribute to noise and vibration of automobiles. Wind noise is superficial and is experienced at the interior of vehicle. Flow of air over the exterior of vehicle and the flow of air into and out of the cabin arising from imperfect sealing of door frames and glasses are the causes of wind noise generation. Ample number window and door seals ensure successful wind noise control. Fig. 1 shows various noise/vibration sources.

Interior noise is a prominent acceptance criterion of any vehicle in terms of comfort at the interior part. To identify interior sources of noise and diagnose them, the noise sources are quantified by determining sound power contribution from each vehicle component, panel acoustic leakages, panel vibrations gear shifting, and steering wheel vibrations. Engine being the main source of noise, the noise from the engine is transmitted in two ways viz. direct infiltration & structural vibrations. Improper sealing, holes in lower dashboards, complicated geometry, worn out engine mounts leads noise from engine to reach directly into the cabin. Structural vibrations are due to rings in exhaust systems. These vibrations are transferred from engine to body through drive shafts supported on bearings, rear axle etc. Table 2 depicts engine noise, vibration phenomenon and sources. Table 3 presents the permissible noise levels according to EU directive 96/20 EC

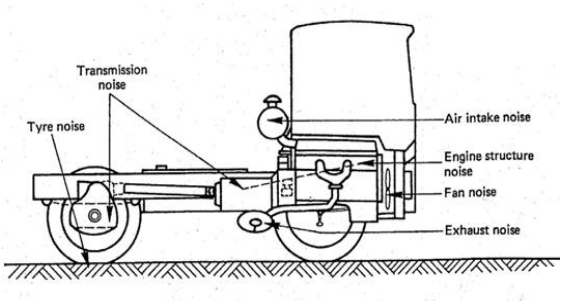

Figure 1 Various vehicle noise /vibration sources

www.ijmer.com Vol.1, Issue2, pp-242-246 ISSN: 2249-6645

Figure2. Propagation of tyre noise of an automobile at frequency of 600 Hz

2. Noise control/reduction techniques

The following techniques are proposed as under

2.1 Energy Flow Path technique

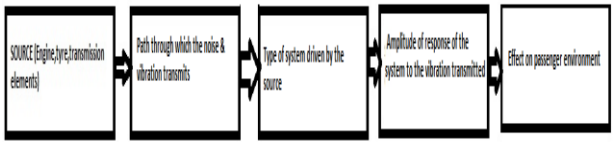

Figure3. Energy flow path diagram showing the propagation of energy (noise/vibration) from source to rider/passenger

Fig.3 shown above depicts the flow of noise and vibration through various stages from source to destination. The transmission path properties are determined by the vibration modes of the structure. Outer surface properties also influence the sound propagation. The ways in which the final engine noise radiation may be influenced or controlled are reduction at the source of combustion forces and mechanical forces, reduction of vibration transmission between the source and the outer surface, reduction of the sound radiation of the outer surface, control or reduction of combustion pressures, reduction of piston slap by redesign of the piston and cylinder or by oil film injection, gear and bearing noise are reduced by improved design e.g. gear tooth profiles and bearing clearances, more advanced redesigns can be made involving extensive simulation the dynamics using finite element modeling. Fig. 4 shows the noise and vibration reduction technique.

Table 2 Engine noise, vibration phenomenon and sources

Sr.No	Phenomenon	Source
i.	Noise during idling	High compression and cylinder pressure.
ii.	Thriving Noise	Low order harmonics of inertia forces in multi-cylinder engines
iii.	Engine component reverberation	Harmonics of gas and inertia forces during respective compression and power strokes.
iv.	Vehicle component reverberation	Harmonics of gas and inertia forces.
v.	Airborne sound of engine	Mechanical impacts, combustion noise.

Table 3 Allowable sound level for road vehicles according to EU directive 96/20 EC

Sr.No	Type of Vehicle	Sound level dB (A)
i.	Personal car	74
ii.	Bus and truck weighing between3.5 to 2 tones and below	76
iii.	Bus with total weight above 3.5 ton and engine power below 15kW	78
iv.	Bus and truck weighing in between 2 to 3.5 to ton.	77
v.	For engine power 150kW or above	80

Figure 4 Noise and vibration reduction technique through flow path.

2.2 Exhaust and Intake Noise Control

Exhaust and intake system noise originates, from the pressure fluctuations of the engine and additional flow generated noise. Control of noise generation at the source involves making changes to the combustion process, which influences engine performance and exhaust gas emissions. So mufflers or silencers were used placed in a flow duct to prevent sound from reaching the openings of the duct. Reactive silencers do this by reflecting sound back towards the source while absorptive silencers attenuate sound using absorbing material Basic requirements for a modern exhaust systems; compact outer geometry, sufficient attenuation and low pressure drop.

2.3 Vibration Damping

Use of viscoelastic materials enhance the damping in a structure in three different ways viz. free layer damping treatment, constrained layer damping treatment, tuned viscoelastic damping treatment. The damping material is either sprayed on the structure or bonded using a pressure-sensitive adhesive in free layer damping. An interesting feature of the free-layer treatment is that the damping performance is independent of the mode shape of vibration. Constrained-layer damping includes a sandwich of two outer elastic layers with a viscoelastic material as the core. This damping is more effective than the free-layer design as more energy is consumed and dissipated into heat in the work done by the shearing mode within the viscoelastic layer. The TVDs are applicable to reduce vibration/noise associated with a single frequency or a narrow band of frequencies. Properly tuned TVDs eliminate an unwanted resonance by splitting the original peak into two, one below

and one above the resonance frequency of the original system.

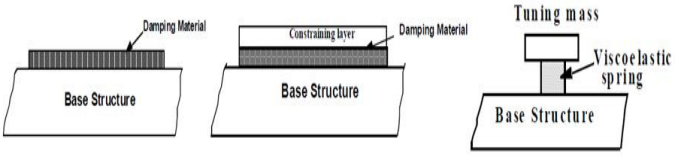

Figure5. Free Layer Damping, Constrained Layer Damping and tuned viscoelastic damping treatments

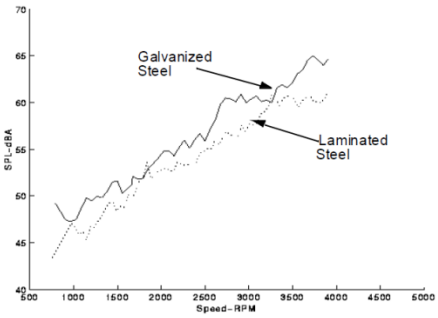

Figure6. Distinction of sound pressure level at driver's ear for a car equipped with regular and damped oil pans

CONCLUSION

Various sources of vibration from engine to driveline are identified and a detailed analysis of the cause is carried to influence the vibration characteristics of automobile. Engine vibration sources resulting from various forces viz: Combustion, reciprocating and rotational is reduced by using in-plane and two plane balancing methods. Method to reduce the rotating and reciprocating unbalance is gives the designer a means to influence the noise and vibration characteristics. The contribution of each vibration source and its reduction technique is focused here. The noise sources; their contribution and the engine related noise and vibration phenomenon in the vehicle is tabulated. An attempt is made to co-relate the noise and vibration sources and further methods to reduce the same are provided which reduces the noise and vibration and improve vehicle ride comfort characteristics. The energy flow method's four stages are used as a benchmark to reduce any vibration problems in automobiles arising from the random as well linear vibrations. It also helps in identification of the proper flow of vibrations and noise.

Noise one of the major concerns is taken care of here by identifying various noise sources and techniques to reduce the same are discussed which improves the vehicle ride quality and comfort level of passenger Interior noise is the major concern and is required to be taken care at the design stage itself. To reduce the vehicle interior noise manufactures prefer placement of sound absorbing materials, proper sealing of all openings and cavities present in the vehicle. Use of viscoelastic materials for damping vibrations is given, it is to be remembered that the use of these viscoelastic materials improves the damping properties of damper and are used in structures that are not primary load carrying members. For load carrying members, the design should first satisfy the strength and stiffness requirements over damping benefits. The noise limits for in-use vehicles are legislated as; highest noise levels permitted are 103 dB (A) as compared to the noise level of 96db (A) observed in new vehicles. Countries which have implemented similar requirements are Japan, New Zealand, California as well as USA under federal Motor Carrier Safety, Administration (FMCSA). [3].A detailed investigation regarding noise, vibration and their sources is very much essential to gratify the market and be a pioneer in automotive world. Further step is of identification of BSR problems and their reduction techniques.

REFERENCES

1. Raju.S, ARAI Pune, Workshop on Noise, vibration and harshness for automotive engineering, 2004, 123- *139.*
2. Herman V Auleraer, Noise and vibration characteristics of low emission vehicles. Keynote paper, *51-62.*
3. Karanath N.V. and Raju .S, Investigation of relation between stationary and pass by noise for new in use vehicle, *SAE paper No. 2005-26-051. ARAI Pune, 623-629.*
4.Nayak N. Reddy P.V, Aghav Y, Navtej Singh Sohi and A.D. Dani A.D.,Study of Engine vibration due to piston slop on single cylinder High powered Engine,Kirloskar Oil Engines Ltd. Pune, India, *SAE paper 2005-26-046, pp. 581-588.*
5.Mahale P.S, KalsuleD.J, A. Muthukumar A and Raju S, Vehicle interior noise source identification and analysis for benchmarking,ARAI Pune. *SAE paper 2005-26-048,592-603*
6. Gosavi S.S, Automotive Buzz, Squeak and Rattle (BSR) detection and prevention,TATA technologies Ltd, *ARAI Pune, 661-667.*
7. Rao M.D, Dept. of Mech. Engg. Mechanics, Michigan Technological University, Houghton, Michigan & 9931 USA 2001. Recent applications of viscoelastic damping for noise control in automobiles and commercial airplanes.
8.Gabiniemic J, Gatt J,Cerrato G. – Jay (Tecumesh products research laboratory) Automatic detection of BSR events. (Magna Automotive Testing).
9. Nashif A.D, Jones D.I.G and Henderson J.P *Vibration Damping, New York: 1985 John Wiley and Sons.*
10.Soovere J., Drake M.L and Miller V.R vibration Damping workshop Proceedings *1984* ,AFWAL-TR-84-3064 publications by Air force Wright aeronautical Laboratories, *Wright-Patterson Air Force Base, Ohio,* VV-

1-VV-10, a design guide for damping of aerospace structures.
11.Kung.S.W., and Singh R., Development of approximate methods for analysis of patch damping and design concepts. *Journal of Sound and vibration 219, 1999 785-812*

www.ijmer.com Vol.1, Issue2, pp-242-246 ISSN: 2249-6645

12. Vydra E.J and Shorgen J.P. Noise and noise reducing materials. *Society of Automotive Engineers, 1993 Paper No 931267.*
13.Kerwin E.M.Damping of flexural waves by a constrained viscoelastic layer. *Journal of the Acoustical Society of America 31 1959, 952-962.*
14. Lilley K.M, Fasse M.J and Weber P.E 2001. "A comparison of NVH treatments for vehicle floorplan applications". SAE paper No.2001-01-1464.
15. Hussaini A,Designing an interior waterborne coating for use in automotive paint shops to replace sound deadening pads. *SAE paper no. 2001-01-1391. 2001*