Noise and Vibration Sources in Engines (Part II)

Dr. **Sunny NARAYAN**[1*], Dr. **Vipul GUPTA**[2]

[1] Mechanical engineering department, Qassim University, Saudi Arabia

[2] Mechanical engineering department, Indus University, India

* rarekv@gmail.com

Abstract: *There are several sources of Noise and vibrations in automotive engines which must be controlled for proper working of engines. Combustion and motion-based noise are two important sources of noise. This work focuses on these two aspects of NVH resources. The presented work may provide important aspect of diagnosis methodology of engines.*

Keywords: *Acoustics, Noise, Vibration, Automotive*

1. Introduction

Noise and vibration testing of combustion engine is key in planning of design of automotive systems [1, 2, 3]. Noise emissions from vehicle is of structure borne noise and air borne type. Air based noise due to acoustic path is called air borne noise, whereas structural path based with vibrational energy is structure borne noise. The structural noise has low frequency ranges, whereas the air borne has higher ranges. Various investigations take into account the following aspects:

A. Overall sound pressure levels.
B. Identification of various sources.
C. Analysis of transfer paths and mechanisms.
D. Subjective and objective investigations.

2. Combustion based noise

Combustion based is transferred to surroundings from top surface of cylinder, walls and connecting rod. This depends on the rate of gas pressure rise. Structural attenuation plays a crucial role. Higher stiffness of parts leads to higher values of resonant frequencies.

Knocking is also an important source of noise. Reduction in the ignition delay period may lead to lower values of combustion noise. Higher compression ratios, intake air pressure and exhaust gas recirculation can also prove beneficial to reduce noise [4-10]. AVL noise meter, wavelet-based noise meters and, decomposition of cylinder pressure has proved to be effective techniques to analyze noise [11-13].

3. Piston skirt assembly noise

Tickling noise, piston slapping and rattle noise are three major sources in piston skirt. Piston slapping noise or piston secondary motion noise has a major contribution in diesel engines as shown in figure no 1 [14-18].
Major factors that influence this motion include:
A) Side thrust force-lower speeds, low piston masses and higher crank radius to connecting rod length ratio can reduce this force and hence resulting slapping noise [19].
B) Moments of forces - lower inertia, piston pin and crankshaft offsets, supply of the lubrication may help to reduce piston motion [20].
C)Distance of travel of skirt before striking liner wall- smaller lateral gap between piston skirt-to-bore can help to reduce the lateral motion.
D)Oil damping force -sufficient oil in skirt can help to reduce slapping noise significantly [20].
E) Damping and stiffness of parts–impacts of soft piston skirt causes lesser noise emissions due to

larger deformations.

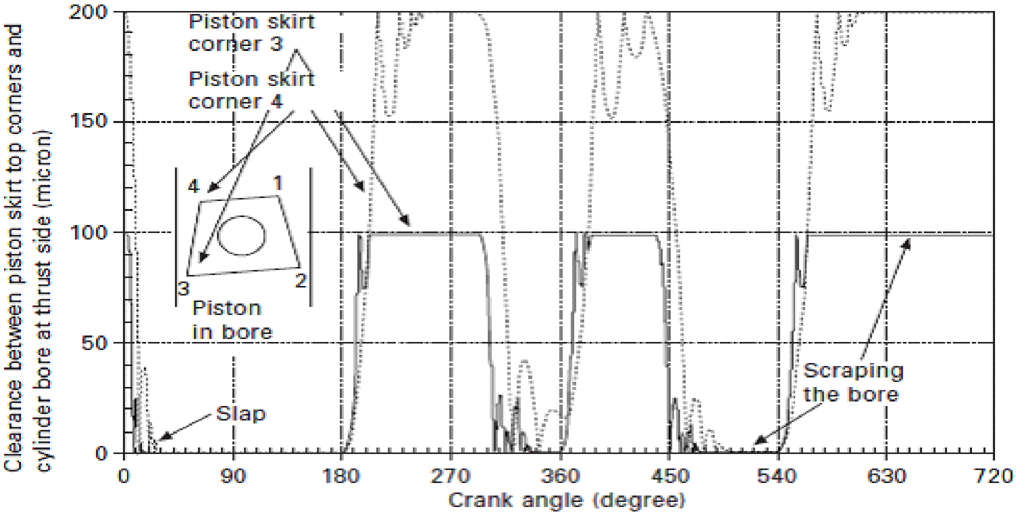

Fig. 1. Piston slapping motion [18]

4. Valve train noise

This type of high frequency noise includes following three major excitation sources:
A) Acceleration of cam- opening and closure of cam causes higher frequency vibrations.
B) Valve impacts - impulsive impacts during operation of valve as well as bouncing noise at higher speeds.
C) Frictional vibrations-This noise is observed at lower speed ranges.

5. Gear train noise

The rattling noise during transmissions is major cause of concern that is caused by non-uniform torque from crank train to drive train causes rattle noise in gears. Clearances, thermal expansions, tooth deflection and tolerances cause whining noise. This noise depends on the number of teeth, size of teeth and magnitude of torsional inputs.

6. Crank train and engine block vibrations

Torsional vibrations in the crank shaft and thin sections of engine block are important sources of noise and vibrations.

7. Flow noise

Lower frequency range intake flow noise is due to fluctuations in flow of charge at ducts and is dependent on valve area and engine speed. Turbocharging noise also forms an important part of aerodynamic noise.

8. Bearing noise

Bearings present in the crankshaft and connecting rod have clearances which are likely to generate as seen in figure no 2 [1-13].

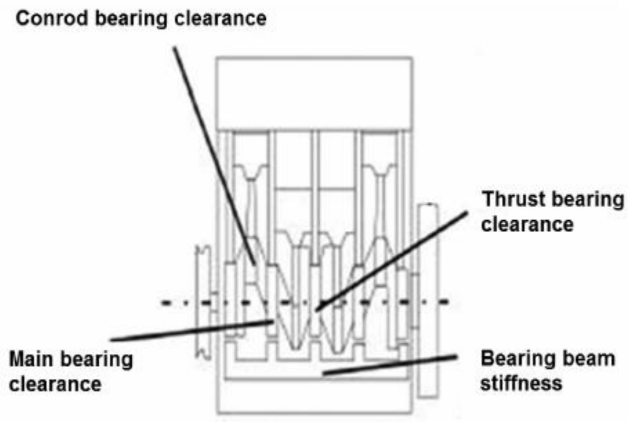

Fig. 2. Sources of Bearing noise [3]

Optimization of clearances, crank shaft damper and flexible flywheel design are effective ways to control this noise.

9. Belt and chain noise

Meshing impact and polygon effect depends on speed and number of meshing teeth as shown in figure no 3 [13-20].

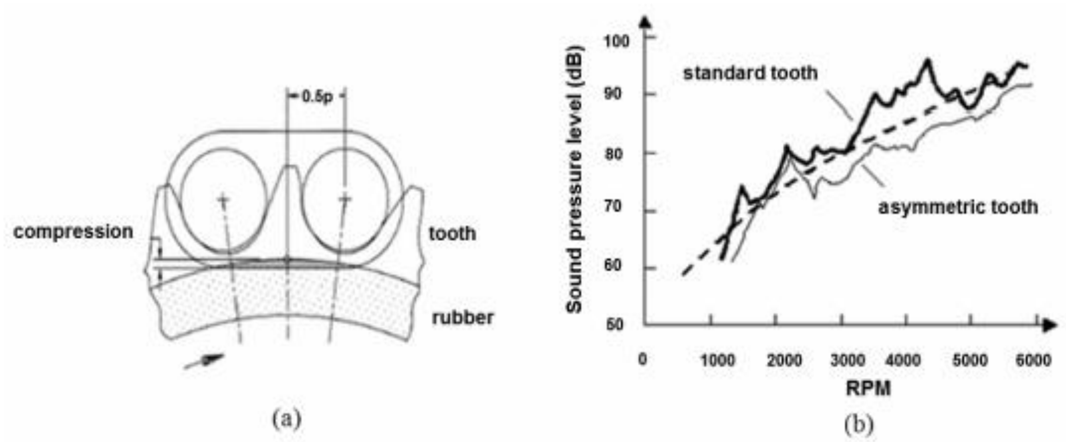

Fig. 3. Timing belt and its noise spectrum [3]

Use of rubber ring sprocket in chain sprocket can help to reduce this noise. Combustion engines also have transmission belts systems that have several modes of vibrations as seen from figure no 4,5.

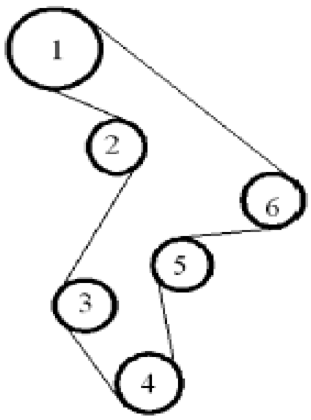

Fig. 4. Timing belt system [3]

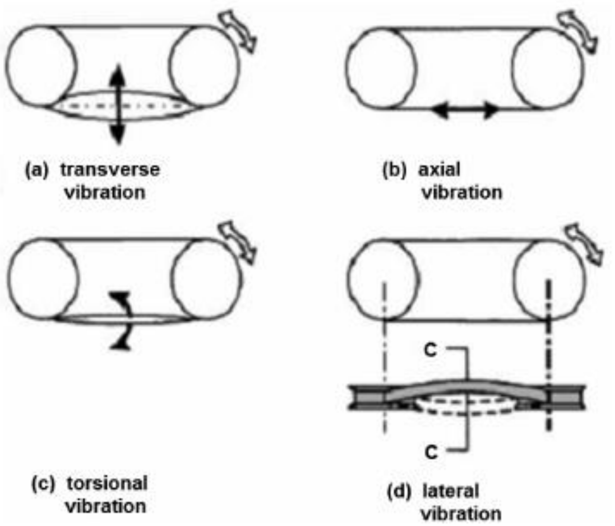

Fig. 5. Timing belt distortions [3]

10. Conclusion

Figure no 6 shows mechanism for generation and transmission of noise sources in an engine.

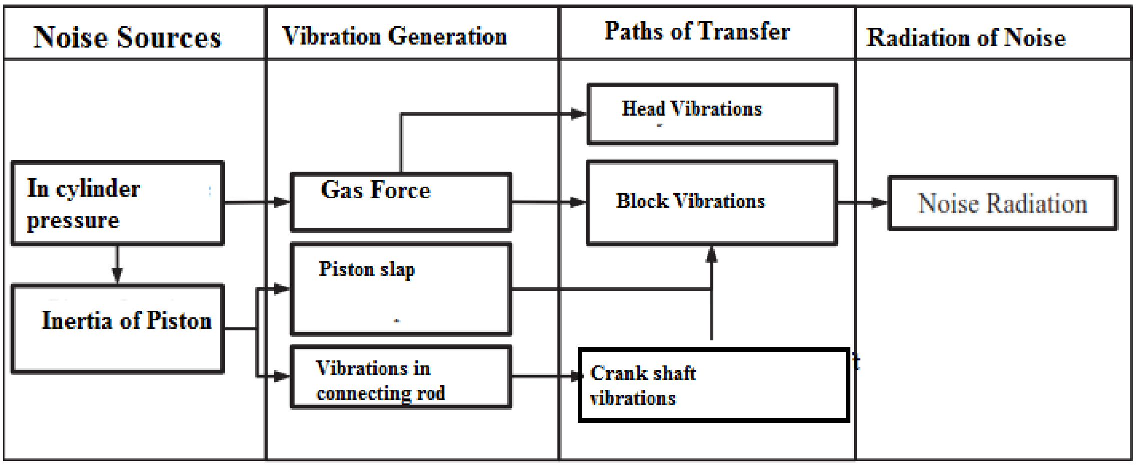

Fig. 6. Mechanism of noise generation [3]

As obvious from the above figures, the combustion-based noise and motion-based noise have major contributions, hence it is necessary to focus on these aspects of engine acoustics.

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