Research Paper Engineering

Performance Analysis Diesel Engine Silencer Design

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ABSTRACT

This paper is focuses on reduction in exhaust noise coming from diesel engine silencer. Till today so many changes have been made to make silencer more compact and more silent. Various types of fibrous materials are available in market which is used in a silencer as a muffler. Glass wool, Rock wool, Mineral wool etc. are some of their examples. I have used fiberfrax S96 fibrous material which has high noise absorption coefficient and high temperature resistance. Using this material in silencer of Indica DLS car I found that noise was reduced around 4 to 5dBA. According to BIS vehicle which has power to mass ratio is in between 25<PMR<=50, noise level must be less than 74dBA. Noise measurement was with Indica DLS silencer was average 53dBA where by using fiberfrax S96 it was reduced and the result that 48dBA.

KEYWORDS

Diesel engine silencer design, Diesel engine technical specification, Fibrous materials, Properties of fibrous materials.

Introduction:-

Fibrous materials are materials which basically used for applications where there is must need to absorb sound. Fibrous materials have good sound absorbing coefficient that they are very useful in silencers and in building constructions where there is must need to reduce sound level. There is various sound absorbing materials basically used which has high sound absorbing coefficient.

Various Types of Fibrous Materials:-

1. Acoustic Belt
2. Acoustic tiles
3. Asbestos, Sprayed
4. Brickwork painted
5. Brickwork unpainted
6. Cork sheet
7. Fiber board on battens (Synthetic Fiber)
8. Hardwood
9. Mineral Wool
10. Plaster walls
11. Glass wool

Properties of a Glass Wool:-

Temperature Range: Glass wool is suitable for applications ranging from minus 195 degree Celsius to plus 230 degree Celsius.

For special applications up to 450 degree. Aluminium foil facing is suitable up to 120 degree Celsius.

Chemical Stability: Glass wool is chemically inert. Application does not cause or accelerate corrosion. Glass wool is rot proof and odourless. Fire Safety: Glass wool is non-combustible in accordance with BS 476 incombustible, extremely low spread of flame, non emission of dense smoke and toxic gases, on depletion of oxygen (high oxygen index70%).

Biological: Glass wool is inorganic. Does not encourage growth of fungi and vermin.

Sound Absorption Coefficient:-

The absorbing coefficient can be mathematically presented as follows:

$$\alpha = 1 - \frac{I_R}{I_I}$$

Where α, I_R and I_I are the sound absorption coefficient, one-sided intensity of the reflected sound and the one-sided intensity of the incident sound, respectively.

Total Room Sound Absorption The total sound absorption in a room can be expressed as:

$$A = S_1 \alpha_1 + S_2 \alpha_2 + .. + Sn \alpha_n = \sum S_i \alpha_i$$

where

A = the absorption of the room (m^2 Sabine)
S_n = area of the actual surface (m^2)
α_n = absorption coefficient of the actual surface
Mean Absorption Coefficient

The mean absorption coefficient for the room can be expressed as:

$a_m = A / S$
where,
a_m = mean absorption coefficient
A = the absorption of the room (m^2)
S = total surface in the room (m^2)

Experimentation Data According to BIS
Some BIS standards for noise measurement:-

1. Maximum limit for sound level must be according to their Power to Mass Ratio. Below table shows that maximum limits of sound level according to power to mass ratio of vehicle.

Maximum Limits of Sound level:-

Category	Power to Mass Ratio	Limit Value in dBA
First	PMR<25	73
Second	25<PMR<=50	74
Third	PMR>50	77

PMR= [Pn ÷ (mkerb + 75)] * 1000
Where: - Pn = Net power
mkerb = numerical value of kerb mass in kg.

2. The apparatus used for measuring the sound pressure level

shall be a sound level meter or equivalent measuring system meeting the requirements of Class 1 instruments.

3. The background noise (including any wind noise) shall be at least 10 dB(A) below the A weighted sound pressure level produced by the vehicle under test. If the difference between the background sound pressure level and the measured sound pressure level is between 10 dB(A) and 15 dB(A), in order to calculate the test result the appropriate correction shall be subtracted from the readings on the sound level meter.

Correction applied to individual measured test value:-

Background sound pressure level difference to measured sound pressure level, in dB	10	11	12	13	14	>=15
Correction, in dB(A)	0.5	0.4	0.3	0.2	0.1	0.0

4. The distance of microphone shall be 7.5 ±0.05 m and the microphones shall be located 1.2 ± 0.02 m above the ground level.

5. The vehicle is tested in a constant speed test.

Indica DLS silencer internal design change:-
Material used was fiberfrax "S 96" just like used in scooter's specimen silencer. According to BIS standard PMR of Indica DLS is less than 50.

PMR= [Pn ÷ (mkerb + 75)] * 1000
Where: - Pn = Net power=53.5 ps at 5500 rpm
mkerb = numerical value of kerb mass in kg.=1000 kg
PMR= [53.5/ (1000+75)]*1000 = 49.78

According to BIS standard sound level limit it falls in second category. So that sound level limit should be 74 dBA or less than it.

Fig.4.1 Indica DLS existing diesel silencer

Fig.4.2 Indica DLS proposed silencer design with fiberfrax S96

4.3 Application of proposed Design:-
1. To reduce Noise level
2. To reduce air pollution
3. Temperature control
4. Energy conservation

4.4 Advantages and Disadvantages:-

❖ **Advantages:-**
- Better noise absorption coefficient gives maximum reduction in sound coming from silencer.
- Modification can be easily done in silencer
- Sustainable to high temperature
- Cooling consumes less time
- Does not shrink
- Resistance to corrosion
- Resistance to fire

❖ **Disadvantages:-**
- There may be a chance of increase in back pressure
- There may be a chance of increase of carbon deposit in silencer

3.5 Experimental Data for Indica DLS:-

1. Noise level with silencer:-

Distance (Meter)	Noise level (dB A)				
1	54.1	53.9	54.2	54.3	53.9
2	53.5	53.4	53.4	53.2	52.9
3	52.4	52.4	52.5	52.6	52.4

Average: - At 1 m: - 54.08dBA Total Average: -53.26dBA
2 m: - 53.28dBA
3 m: - 52.43dBA

2. Noise level with proposed silencer:-

Distance (Meter)	Noise level (dB A)				
1	48.8	48.4	48.7	48.6	48.6
2	48.1	47.9	47.9	48.2	48.2
3	47.7	47.6	47.5	47.6	47.6

Average: - At 1 m: - 48.62dBA Total Average: -48.09dBA
2 m: - 48.06dBA
3 m: - 47.6dBA

Conclusion
Experimental data shows that the material named fiberfrax S96 fibrous material used inside the chamber of Indica DLS silencer gives the better noise reduction than the existing design of Indica DLS silencer. High Sound absorption coefficient of fiberfrax S96 results in a maximum noise reduction. Specimen design of scooter silencer was also results effective that in scooter exhaust noise reduced around 3dBA. Using fiberfrax S96 inside silencer I got that the noise level was reduced up to 4 to 5 dBA. Actually exhaust noise produced by Indica DLS's silencer was average 53dBA. By using fiberfrax S96 as a muffler inside silencer it was reduced up to 4 to 5dBA and average noise level was 48dBA.

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