Analysis and Modification of Motorbike Silencer Exhaust System for Noise Reduction

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Abstract:- In this new era, noise pollution is very high. The one reason for this noise pollution is noise or sound which is generated by the exhaust system of the motorbike. So, it is necessary to reduce the noise from the exhaust of the motorbike. In this, original silencer reverse engineering has done and analyse it then three modification model of the silencer with it analysis are done and from that results one modified silencer are selected and forward for the manufacturing. After fabrication of the silencer, two tests are conducted. First, the test is conducted with original silencer then it is conducted with modified silencer. From that data, transmission loss of original and modified silencer are calculated and compare it. From that, noise reduced to 5DB. Also, flow velocity of exhaust gas in original silencer and modified silencer are also measured. In that, conclusion is that flow of modified is increase by 11% to original silencer and also PUC of modified silencer are check and it is in limit as per the PUC norms.

Keywords:- Noise Pollution; Motorbike; Exhaust System; Transmission Loss; Noise Attenuation;

I. INTRODUCTION

Sound is described as a propagating disturbance through a physical or elastic medium (like air, water or gas). In a modern city life, sound is as irritating not pleasant or useful. Such unpleasant or unwanted sound is called as noise. In other words, noise is the wrong sound in the wrong place and at wrong time. Silencers are the device or mechanical equipment which are specially use for attenuation of noise. Its purpose is to reduce the noise. Silencer are used in all sectors like automotive industries for vehicles, aeronautic industries, food industries for ventilation, oil and gas plant and power generation plants, etc. in all these sectors silencers are used for reduction of noise.

Using baffles in exhaust mufflers is known to improve their transmission loss [26]. The current scenario of high growth rate of automobile usage, the automobile industry is forced to adopt the government emission norms to keep the environment green [27]. The problem of noise reduction and protection is a formidable challenge for the design and operation of such units. One of the ways for noise reduction is a muffler installation [28].

As we known, motorcycles are very essential for the people for the work. And for today era, noise pollution is a one and important factor for the human being and the environment. And as it is mention above silencer play an essential role in it.

So, the primary objective is to analyse and modify the silencer. The main purpose is to reduce the noise from the motorcycle exhaust. To test in the actual conditions to determine its actual results of noise.

II. RESEARCH METHODOLOGIES

A. Mathematical equations:
In this, some formula are used to determine the transmission loss and to convert sound pressure level into sound power level. For analysis and testing, transmission loss is essential and its formula is:

$$TL = 10log_{10}\frac{W_i}{W_t} \dots (1)$$

Where,
TL = Transmission Loss
W_i = Sound Power Level of Incident in watts
W_t = Sound Power Level of transmission in watts (For original and modified)
And to determine the sound power, formula is:

$$L_W = 10log_{10}\left(\frac{W}{W_{ref}}\right) \dots (2)$$

Where,
W = Sound Power Level in Watt for original silencer and modified silencer and also for incident sound
W_{ref} = Reference Sound Power = 1×10^{-12} Watt
When, sound is measure, it is in the form of sound pressure level. To convert it into sound power level, use this formula:

$$L_w = L_P + 10log_{10}(S) \dots (3)$$

Where,
L_W = Sound Power Level
S = Surface area of imaginary sphere = $4\pi r^2$
r = Distance from the point of sound source (inlet port) to the point of the imaginary surface (outlet port)

B. Analysis of original silencer:
In this, Hero Honda CD100SS silencer is selected for analysis, modification and testing. Figure 1 shows the silencer of the Hero Honda CD100SS.

Fig.1. Silencer of hero honda CD100SS

In that, it contains catalyst converter, diffused pipe, baffle plate, resonator pipe. These all components are totally inside the expansion chamber. The function of the silencer is like a diffusive silencer with resonator. As the exhaust manifold is not the part of the silencer or it is a separate part from the expansion chamber, so we have not considered it for the analysis. But, as catalyst converter is the internal part of the silencer, so we have considered it. For modelling of original silencer, dimensions of each component are taken by using vernier calliper and measuring tape. For modelling, ProE/Creo software is used. Figure 2 shows modelling of the original silencer in cut section.
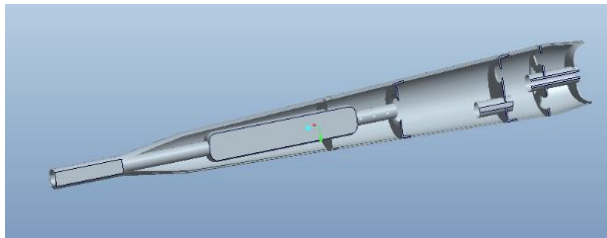

Fig.2. Cut section of original silencer

After modelling, model is analysing in Ansys software. For analysis of transmission loss, harmonic acoustic section for analysis of transmission loss in the silencer. Data for gas and steel for analysis are mention below:

Properties	Values	Units
Density	1.161	kg/m^3
Isotropic Thermal Conductivity	0.0263	W/m^{0}K
Specific Heat at Constant Pressure	1.007	KJ/kg^{0}K
Viscosity	0.896	N.sec/m^2

Table.1. Data of exhaust gas

Properties	Values	Units
Density	7850	kg/m^3
Isotropic Thermal Conductivity	0.1622	W/m^{0}K
Specific Heat at Constant Pressure	1.1635×10^{-03}	KJ/kg^{0}K

Table.2. Data of mild steel

After these data, analyzing gets started. After discretization of the model, boundary conditions are set that is frequency range from 0-100Hz at 10 intervals and set its input and output port. After that, solutions are given for transmission loss and start analyzing. Results of the analysis are as shown in figure 3.
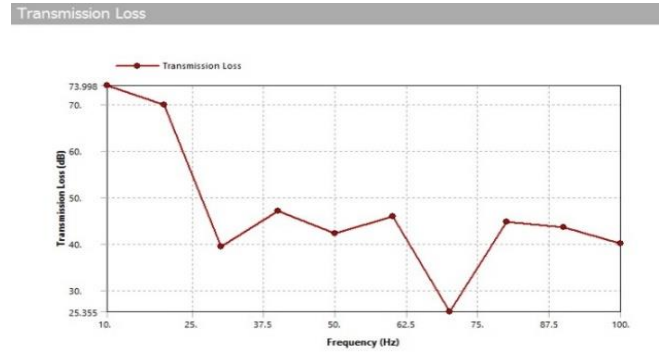

Fig.3. Graph of transmission loss vs frequency of original silencer

C. Analysis of modified silencer:
After the analysis of original silencer, three modified silencer are created and analyse it. In that, first modification is done by removing the resonator unit from the original silencer which as shown in figure 4.
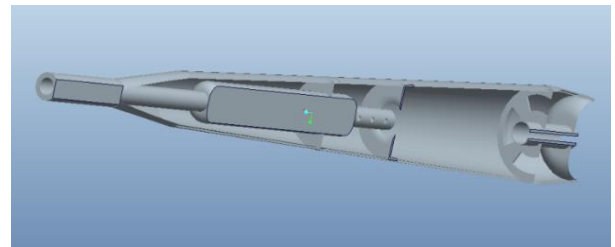

Fig.4. Cut section of modified 1 silencer

In second modification, diffuse plate is removed instead of resonator unit which is as shown in figure 5.
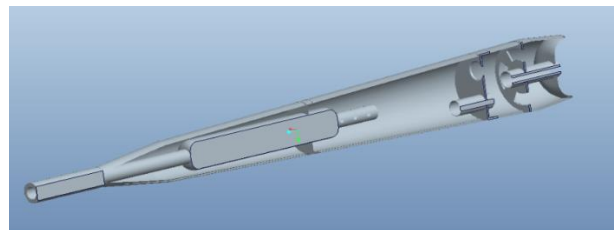

Fig.5. Cut section of modified 2 silencers

In last modification, both resonator unit and diffuse plate are removed which is as shown in figure 6.
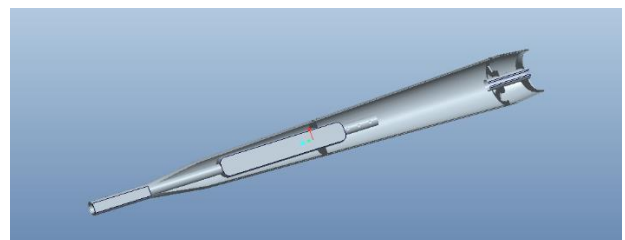

Fig.6. Cut section of modified 3 silencers

So, three modified models are analysed from that, transmission loss of modified 3 silencer is higher than other two and original silencer. So, modified 3 silencers are selected for the testing.
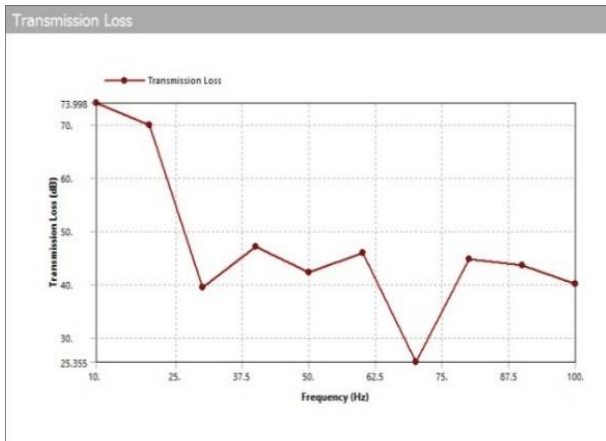
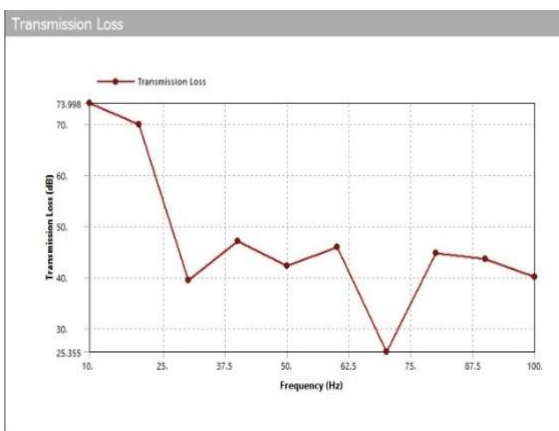Fig.7. Graph on transmission loss vs frequency on modified
1 silencer

Fig.8. Graph on transmission loss vs frequency on modified
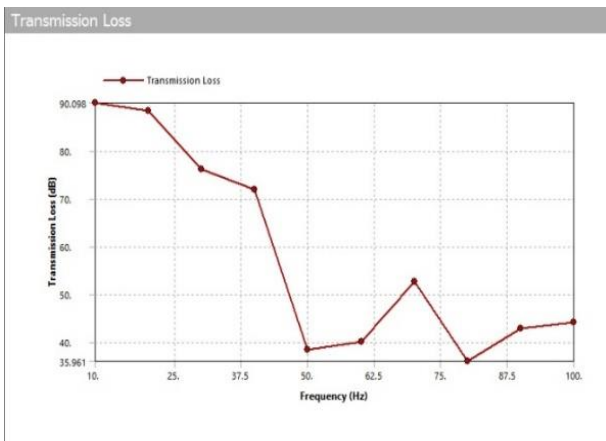2 silencers

Fig.9. Graph on transmission loss vs frequency on modified
3 silencers

D. Manufacturing of modified silencer:

As the model 3 is selected for the modification, it is undergo manufacturing. In that, manufacturing is nothing but to remove the resonator unit and diffuse plate. By using gas cutter, resonator unit and diffuse plate are removed.

Fig.10. Silencer after cutting the components

After removing the components, weld the cover plate which was cut by using oxy-acetylene welding and modified silencer are installed in the bike.

Fig.11. Modified silencer install in bike

E. Experimentation/Test:

Testing is conduct on the original silencer and modified silencer. First test is conduct on the original silencer then on modified silencer. Also, test is conducted on non-silencer to get the incident sound. Live test are conducted or it is also called field test, the test which is conduct on the actual environment to determine the actual noise in the environment from the silencer. Below there are some requirements are mention for conduction of test.

In this, two instruments are used for testing; first it is sound level meter and second is anemometer. Sound level meter are used for measuring of noise which is coming out from the engine and the silencer and anemometer are used for measuring flow velocity of the exhaust gas which is coming out from the silencer.

Fig.12. Sound Level Meter

Fig.13. Anemometer

Here, bike is run at test site at different speed. At different speed, sound and flow are measured by seating on the backside and facing opposite to rider side. So, the readings and results are mention in next chapter.

III. RESULTS AND DISCUSSION

After the conduction of test in original and modified silencer, readings of sound are found on the both the silencer.

The noise of the environment = 70.4 DB

Here, observation table of original silencer and modified silencer are shown below and readings are on the basis of speed of the vehicle.

Sr. No.	Speed (km/hr)	Sound (DB)
1	0/Idle	86.9
2	10	96.9
3	20	97.8
4	30	98.6
5	40	100.4
6	50	102.8

Table.3. Observation tables of original silencer

Sr. No.	Speed (km/hr)	Sound (DB)
1	0/Idle	78.3
2	10	93.7
3	20	93.8
4	30	95.1
5	40	95.7
6	50	96.2

Table.4. Observation tables of modified silencer

Also, the sound of exhaust gas without silencer is measure and their observation tables are mention below.

Sr. No.	Speed (km/hr)	Sound (DB)
1	0/Idle	106.5
2	10	124
3	20	126.1
4	30	128.9
5	40	130.2
6	50	132.4

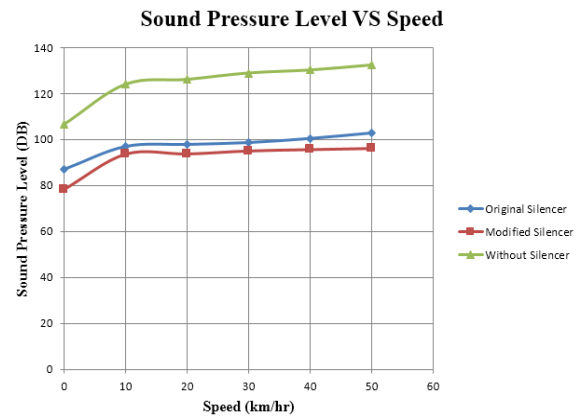Table.5. Observation tables of incident sound

Fig.14. Graph of sound pressure level vs speed of the silencers

All the readings are the sound pressure level. From the above table, it is found that, the noise reading is the combine of sound of exhaust gas of the silencer and the environmental sound. So, the subtracted the total sound with the environment sounds by using formula of subtraction of decibel. The formula is as shown below:

$$L_P = 10log_{10}\left[10^{(L_{P1}/10)} - 10^{(L_{P2}/10)}\right] \dots (4)$$

Where,
L_P = Particular Sound Pressure Level
L_{P1} = Combine Sound Pressure Level
L_{P2} = Environmental Sound Pressure Level

The table of the subtracted sound pressure level of original, modified and without silencer is mention below.

Sr. No.	Speed (km/hr)	Subtracted Sound Pressure Level (DB)		
		Original Silencer	Modified Silencer	Without Silencer
1	0/Idle	86.8	77.5	106.4
2	10	96.8	93.6	123.9
3	20	97.7	93.7	126
4	30	98.5	95	128.8
5	40	100.3	95.6	130.1
6	50	102.7	96.1	132.3

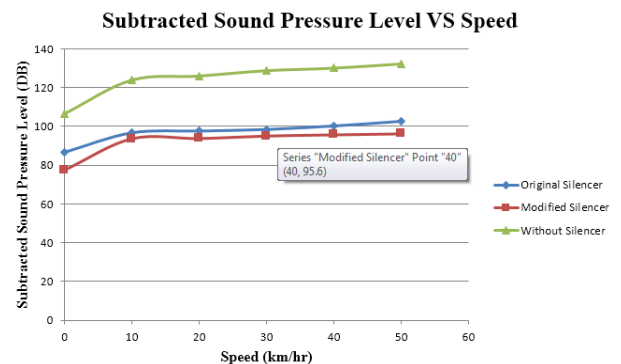Table.6. Calculated values of subtracted sound pressure level of each silencer

Fig.15. Graph of subtracted sound pressure level vs speed of the silencers

By using equation (1), (2) and (3), we have found the transmission loss of original and modified silencer.

Sr. No.	Speed (km/hr)	Transmission Loss (DB)
1	0/Idle	19.59
2	10	27.1
3	20	28.29
4	30	30.29
5	40	29.8
6	50	29.59

Table.7. Transmission loss of original silencer

Sr. No.	Speed (km/hr)	Transmission Loss (DB)
1	0/Idle	28.89
2	10	30.29
3	20	32.31
4	30	33.8
5	40	34.5
6	50	36.2

Table.8. Transmission loss of modified silencer

From these two results, graph of transmission loss vs speed of the vehicle to compare the results and the results are as shown in figure 14.
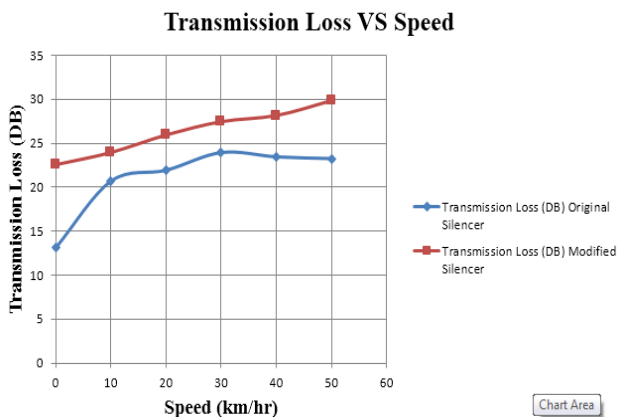

Fig.16. Transmission loss vs speed of original and modified silencer

From the above graph, it is found out that noise is reduced properly in the modified silencer. To determine whether the noise are in the limit of 100 DB or not average sound pressure level are calculated. The formula for this is:

$$L_{avg} = 10 log_{10} \left[\frac{1}{n} \sum_{n=1}^{n} 10^{(L_{pn}/10)} \right] \ldots (5)$$

Where,
L_{avg} = Average Sound Pressure Level in DB
n = Number of sound pressure level measured
L_{pn} = n^{th} number of sound pressure level

From the equation (5), the average sound pressure level of original silencer is 100.85 DB which is beyond the limit of 100 DB but the average sound pressure level of modified silencer is 96 DB which is lower than 100 DB. So, noise is reduced to 5 DB.

Also, flow of exhaust gas is measure in original and modified silencer that readings are shown below.

Environmental air flow = 2.6 m/sec

Sr. No.	Speed (km/hr)	Flow Velocity (m/sec)
1	0/Idle	4
2	10	1.5
3	20	2.1
4	30	2.4
5	40	5.7
6	50	2.9

Table.9. Flow velocity of exhaust gas of original silencer

Sr. No.	Speed (km/hr)	Flow Velocity (m/sec)
1	0/Idle	5
2	10	2.5
3	20	3.1
4	30	3.4
5	40	7.7
6	50	3.9

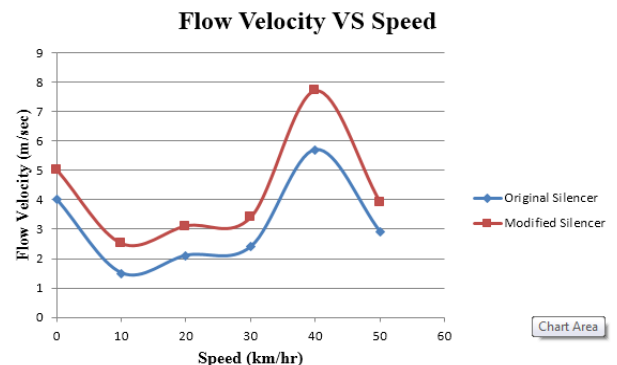Table.10. Flow velocity of exhaust gas of modified silencer

Fig.16. Graph of flow velocity vs speed of original and modified silencer

From these tables, we have found that flow of the modified silencer has increase by 11%.

IV. CONCLUSION

So, the original silencer is analyse and from that three modified silencer are model and again analyse it. After analyzing, the model is selected and put it for the manufacturing and done the test in the field. From the test, noise test is conduct on original and modified silencer. After the test, transmission loss is calculated and average sound pressure level. From that, it is conclude that from the test results, noise is reduce to 5DB and all the sound which are measure at different speed, all the sound levels are below the 100 DB as per the standard norms of the emission noise. So, noise is reduced to 5DB.

Also, test of the flow velocity of the exhaust gas of original and modified silencer and from that, it is conclude that flow velocity of the exhaust gas is increase upto 11%.

From this modification, sound of the silencer become smooth as compare to original silencer, so motorbike become smooth.

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