ME5650 – ENGINEERING NOISE CONTROL

COURSE PROJECT REPORT

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NOISE REDUCTION IN HAIR DRYER

INTRODUCTION

Hair dryers are common electrical appliances used in households today. They are a handheld electromechanical device designed to blow cool or hot air over wet or damp hair in order to speed up the evaporation of water particles from the hair. It has a simplified structure, which mainly consists of an electric fan driven by a motor, heating coil consisting of an array of resistances and a gun shaped plastic casing that encloses them. However, the main drawback of the device is the amount of noise it creates, which causes a hindrance not only to the user but also to those around the user. A hair dryer can be compared to an aircraft engine in practice as both work in similar conditions. There is an intake of air i.e., suction facilitated by a fan, followed by work done on the air, i.e., heating of the air and its subsequent exhaust from the nozzle to do its job of drying the hair. In both the situations, the intake air has to pass through multiple sections undergoing unsteadiness, production of fluctuating forces on obstructions in its path and turbulence production, all of which become sources of noise. Acoustic measurements for a hair dryer are important primarily in the near field because of its proximity to the ear of its user. A person while using the hair dryer operates it at a distance of 1 inch to 6 inches from the hair dryer nozzle. Therefore, noise in the near field needs to be reduced

PROBLEM STATEMENT

Hair dryers are common electrical appliances, which produce sound pressure levels in the range of 60dB to 95dB at a distance of twelve inches from the source and such high noise levels could potentially lead to noise-induced hearing loss (NIHL). So we are taking hairdryer as our product and trying to reduce 4-5 dB in sound pressure level. The solution we are providing is by fixing a muffler in exhaust port of hair dryer.

WORKING PRINCIPLE

Most hair dryers consist of electric heating coils and a fan (usually powered by a universal motor). The heating element in most dryers is a bare, coiled Nichrome wire that is wrapped around mica insulators. Basically Nichrome is a resistor. A resistor resists the flow of electric energy, turning it into heat energy. Nichrome is used because of two important properties.

1. It is a poor conductor of electricity.
2. It does not oxidize when heated.

When you plug in the hair dryer the circuit first supplies power to the heating element the current then makes the DC Motor spin which turns the fan. The air flow generated by the fan is directed down the barrel of the hair dryer over and through the heating element the generated heat warms the air by forced convection and hot air streams out through the barrel.

PRODUCT SPECIFICATIONS

BENTAG NV 1290

Power consumption : 1000 Watts

Voltage required : 220 V

Supply line frequency : 50 Hz

COMPONENTS

- D.C Motor
- Heating element
- Bridge rectifier
- Switch
- Casing

CONVERSION OF A.C TO D.C SUPPLY : By using Bridge rectifier

Bridge rectifier is an electrical device that is used to convert alternating current in to direct current. The power supply available is 230volt A.C and by using rectifier we are converting to required D.C voltage.

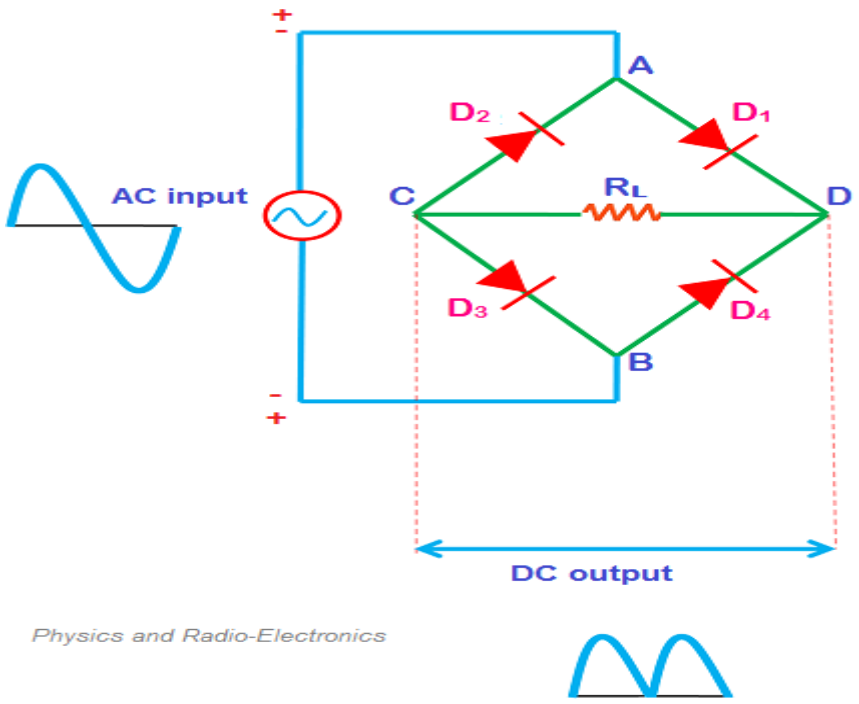


Fig: Bridge Rectifier

TEST CONDITIONS :

- Back Ground Room SPL = 47.1 dB , 37.3 dBA.
- Measurements are taken at a distance of 1 meter from the source at 1 meter of height.
- Time taken for measurements is 5 sec.

MEASUREMENTS :

FOR D.C MOTOR

- R.P.M of D.C Motor = 17230 RPM (Using Tachometer).
- Number of blades of Fan = 6.
- BPF = Number of blades * rpm / 60
  = 6*17230/60
  = 1723 Hz

PERFORMANCE AND GEOMETRIC MEASUREMENTS

- Volume flow rate = 0.2 m^3/min (Using hot wire anemometer)
- Mass flow rate = 0.004 kg/s
- Velocity of air = 3 m/s
- Diameter of exhaust = 3.8 cm

IDENTIFICATION OF NOISE SOURCES

- WITHOUT ENCLOSURE:-

For D.C Motor without Fan SPL = 71 dB.

For D.C Motor with Fan SPL = 74 dB.

- WITH ENCLOSURE :-

For D.C Motor with Fan, SPL =74 dB.

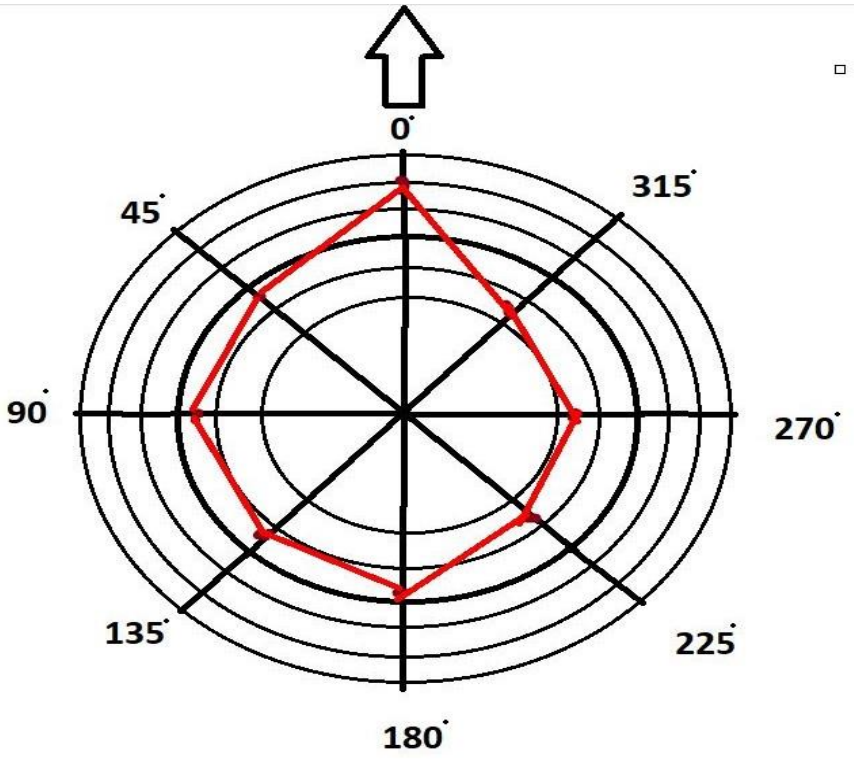
From acoustic measurements of hair dryer we identified that D.C motor with fan is the primary noise source.

TARGET SETTING

SOURCE RANKING

LP(TARGET) = 4 dB

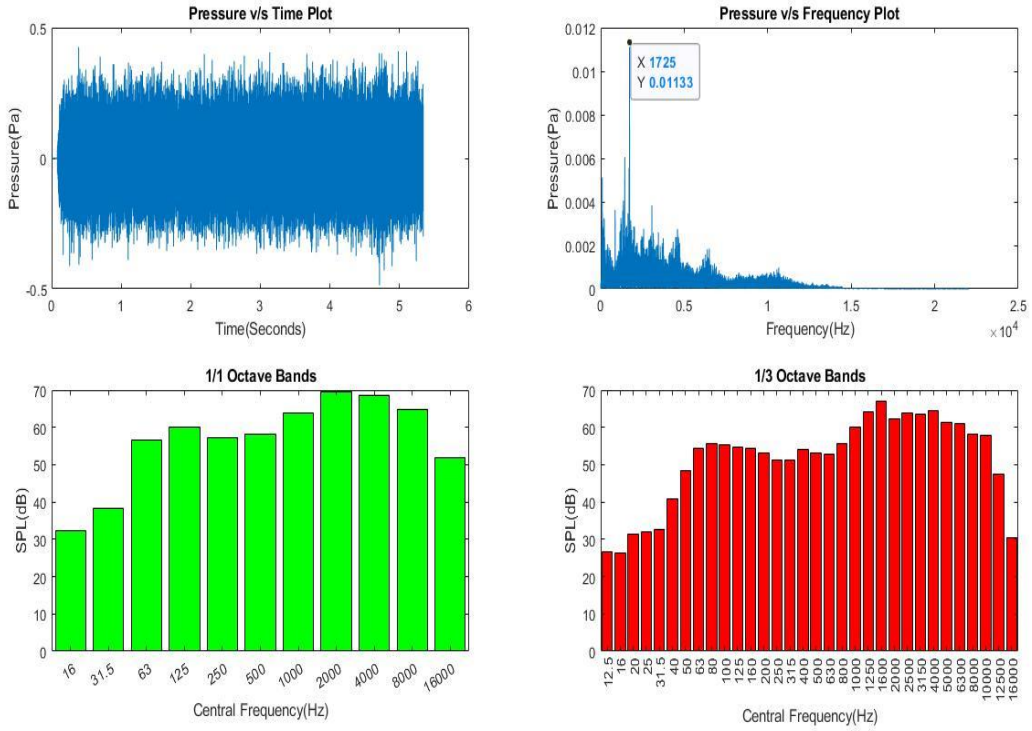
DIRECTIVITY CHART



DIRECTIVITY INDEX

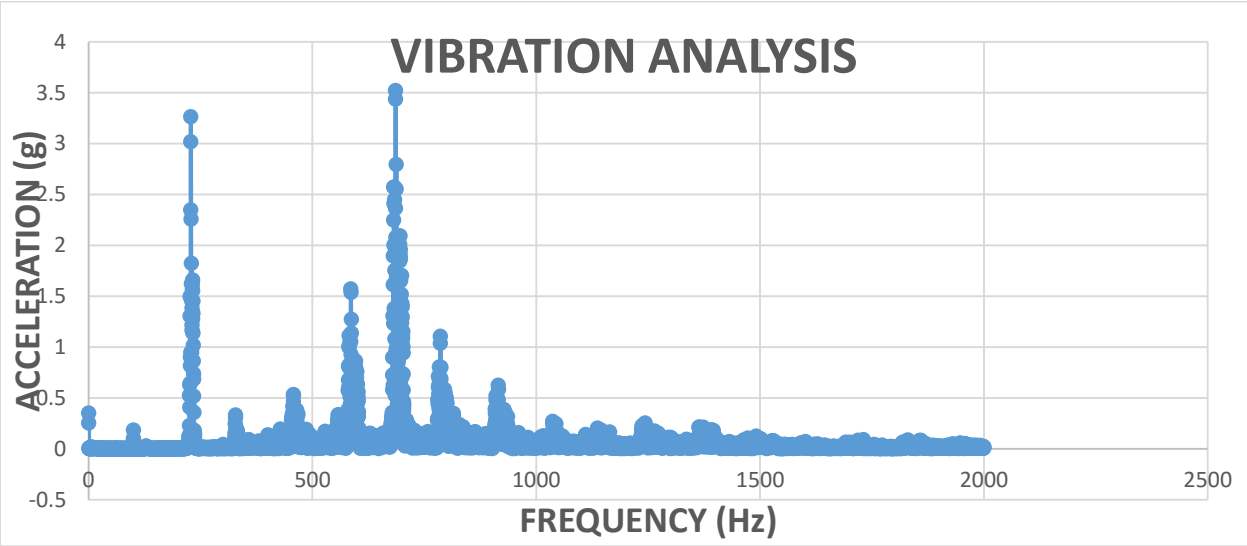
DIRECTION	SPL(dB)	DIRECTIVITY INDEX
0	74	3.4
45	69.6	-1
90	69.5	-1.1
135	69.0	-1.6
180	73.5	2.9
225	68.7	-1.9
270	68.1	-2.5
315	68.2	-2.4

FREQUENCY SPECTRUM AND OCTAVE SPECTRUM



VIBRATION ANALYSIS

EQUIPMENT USED – ACCELEROMETER



IDENTIFICATION OF PATHS

STRUCTURE BORNE NOISE :-

- vibration generated between brushes and commutator at a frequency of 100Hz and
  its Harmonics.
- Air gap between stator and rotor generates magnetic flux density, due to which vibrations are generated.

AIR BORNE NOISE:-

- Due to rotation of Fan air particles get disturbed from its mean position and noise is generated.
- We are getting peak value at 1725 Hz which is matching with blade passing frequency and another peak at second harmonic of BPF at 3440Hz.
- Due to Turbulence Broad band spectrum is observed**.**

NOISE REDUCTION TARGET SETTING

Noise reduction target = 4 dB

POSSIBLE SOLUTIONS :-

To reduce air borne noise

- Designing muffler at delivery part.
- Attaching enclosure at suction port.
- Since we are getting high frequency noise (1725Hz) . Acoustic material can be used effectively.

NOISE CONTROL METHOD

Muffler

They are used extensively on the intake as well as exhaust systems of the reciprocating internal combustion engines, compressors, fans, blowers, gas turbines, the heating ventilation and air-conditioning (HVAC) systems, high-pressure vents and safety valves.

Practically, the intake and/or exhaust (or discharge) systems of all flow machinery are fitted with mufflers.

Types of mufflers

- Active mufflers.
- Passive mufflers
  a) Reactive muffler - work on the principle of impedance mismatch.
  b) Dissipative muffler - converts it into heat as sound propagates through its absorptive passages.

DESIGN CONSIDERATIONS

- Adequate insertion loss so that the exhaust (or intake) noise is reduced to the level of the noise from other components of the engine (or compressor or fan, as the case may be), or as required by the environmental noise pollution limits.
- Minimal (or optimal) mean pressure drop so that the source machine does not have to work against undue or excessive back pressure. (This is particularly applicable to fans or blowers which would stall under excessive back pressure);
- Size restrictions, particularly under the vehicle.
- Weight restrictions.
- Durability, particularly in view of sharp thermal gradients in rain or on wet roads.
- Cost effectiveness is often the most important design criterion.

SELECTION OF MUFFLER

1. Reactive muffler is selected because it won't obstruct the flow of air and dissipate energy.
2. Reactive muffler works on principle of impedance mismatch by providing area change.
3. We are selecting the conical muffler because it will increase the performance of hair dryer by increasing the velocity of air at the end of muffler.

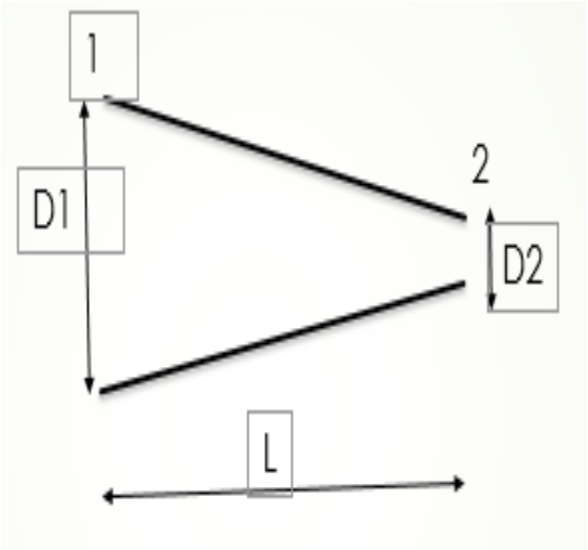
DESIGN CALCULATIONS

By using the pressure and velocity equations and boundary conditions for conical muffler we got Transfer matrix as below.

$$[T] = \begin{matrix} \frac{(e^{-jkl}+e^{jkl})}{2} & \frac{Y_2*(e^{jkl}-e^{jkl})}{2} \\ \frac{(e^{jkl}-e^{-jkl})}{2Y_1} & \frac{(e^{jkl}+e^{-jkl})*Y2}{2Y_1} \end{matrix}$$

By substituting each elements in transfer matrix to transmission loss equation we get

T.L = 10 log $\left[\frac{S_1}{S2} \times e^{2ikl}\right]$ dB.



For given

Diameter D1 = 3.8 cm (Diameter of Hair dryer delivery port)

TL = 4dB (expected)

Wave number k =w/c = 31.8 / m. (at frequency f =1723Hz)

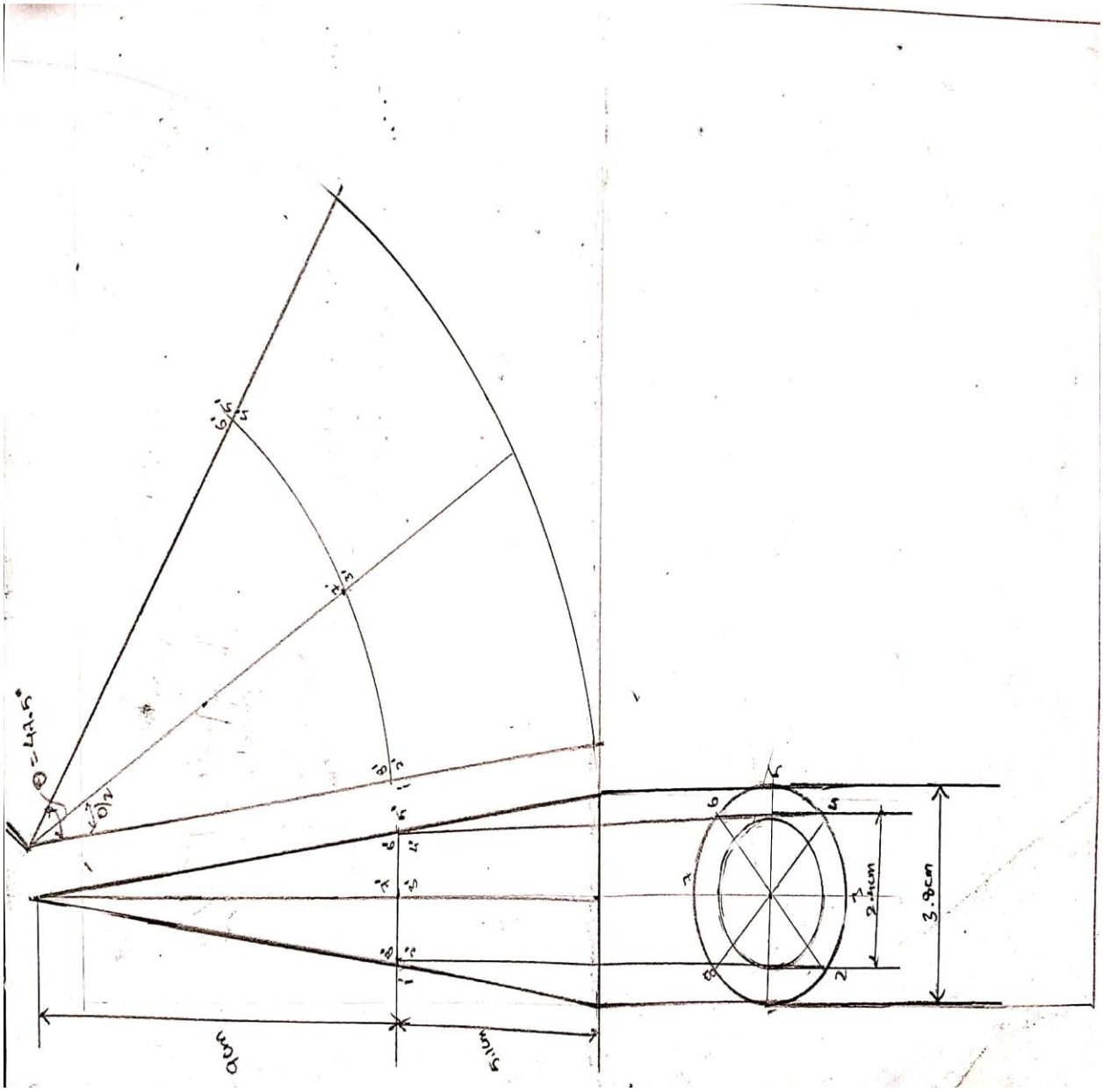
We found out the optimum diameter for minimum length as **D2 = 2.4 cm**

From geometry of hair dryer the angle is 8 degree

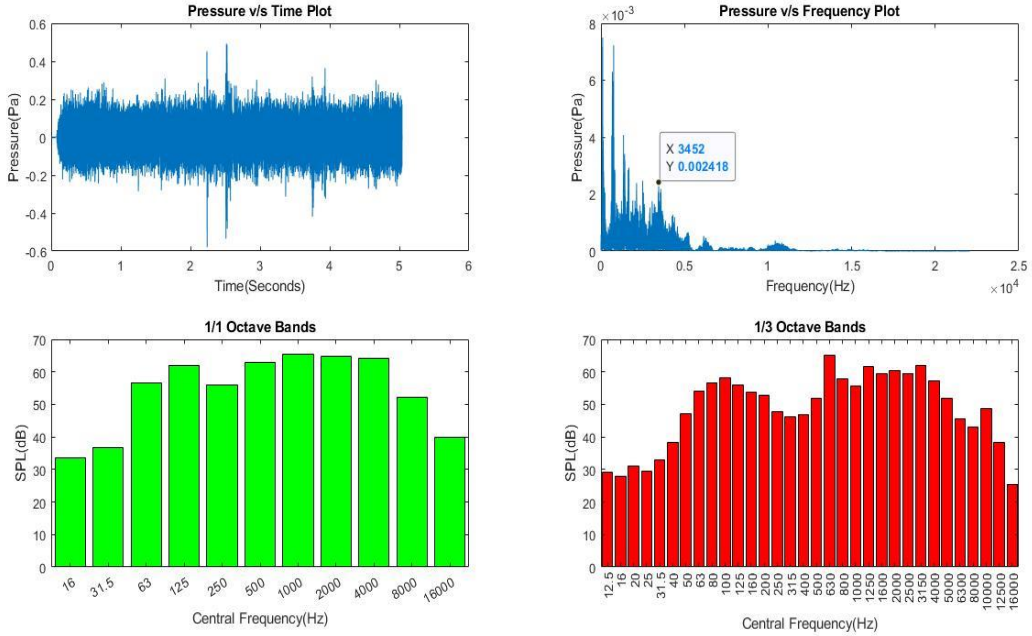
By doing geometric calculations,

Minimum length of muffler as **L=4.48cm.**

DEVELOPMENT OF CONICAL SURFACE

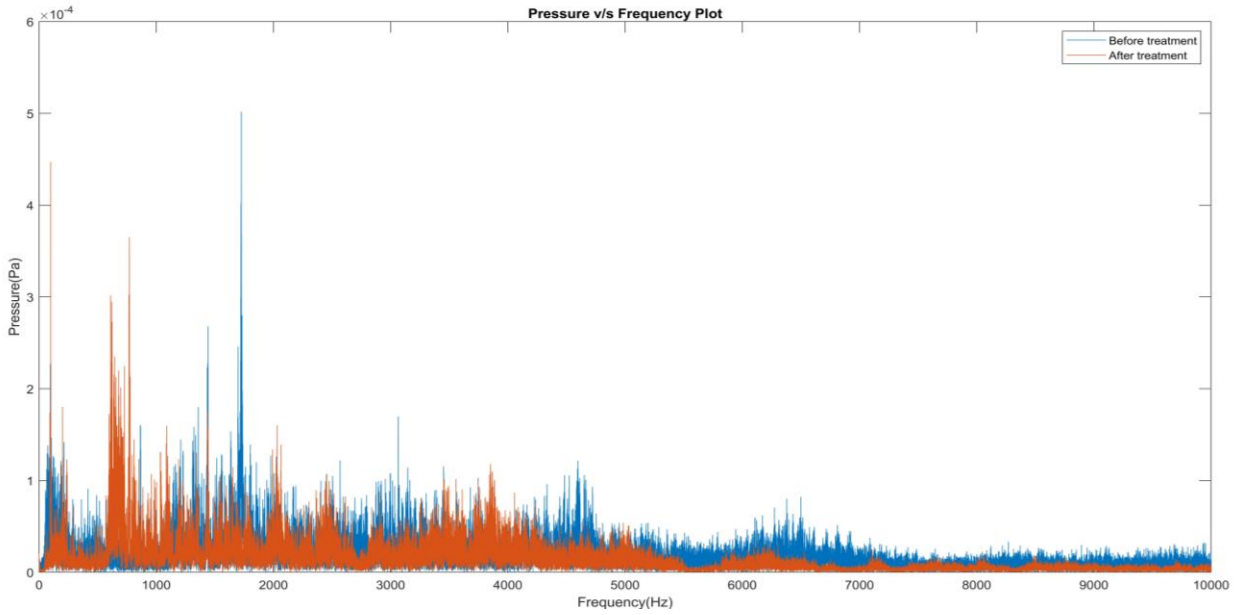


FREQUENCY AND OCTAVE SPECTRUM AFTER ATTACHING MUFFLER

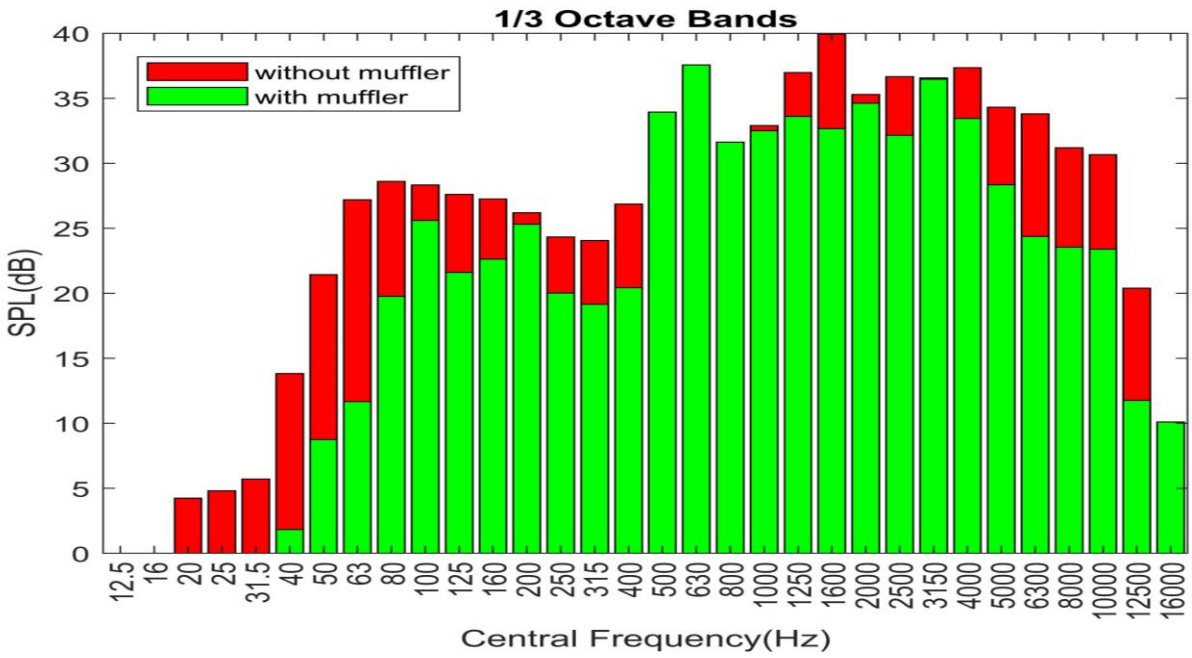


COMPARISON OF RESULTS

1. FREQUENCY SPECTRUM



2. 1/3 OCTAVE SPECTRUM



RESULTS AND OBSERVATIONS

- After attaching muffler total SPL = 71dB.
- Total noise reduction is 3 dB
- By attaching muffler peak in first BPF is eliminated.
- Amplitude of second BPF is reduced by 0.002 Pa.
- After attaching muffler we observed peaks at lower frequency range this is due to breakout noise.

FUTURE WORK

- As muffler surface is getting heated during operation, we will provide insulation by optimal thickness.
- Elimination of break out noise.

REFERANCE

1. Creative Means of Making Acoustic Measurements Inexpensively with Hair Dryer Noise Reduction as an Example (Conference Paper · June 2014)
2. Philippe K. and Pierre J., Hasselt, BE, European patent application for “Add on silencer for hairdryer”, Application number: 09177178.2, filed: November 26, 2009.
3. Altamore, N., United States patent for “Hair drying device with reduced sound emissions”, Patent Number: 6,148,537, Patent date: November 21, 2000.