



Mahindra 2 Wheelers

Prediction And Control Of Transmission Loss To Improve Motorcycle Muffler Sound

Ulhas Mohite

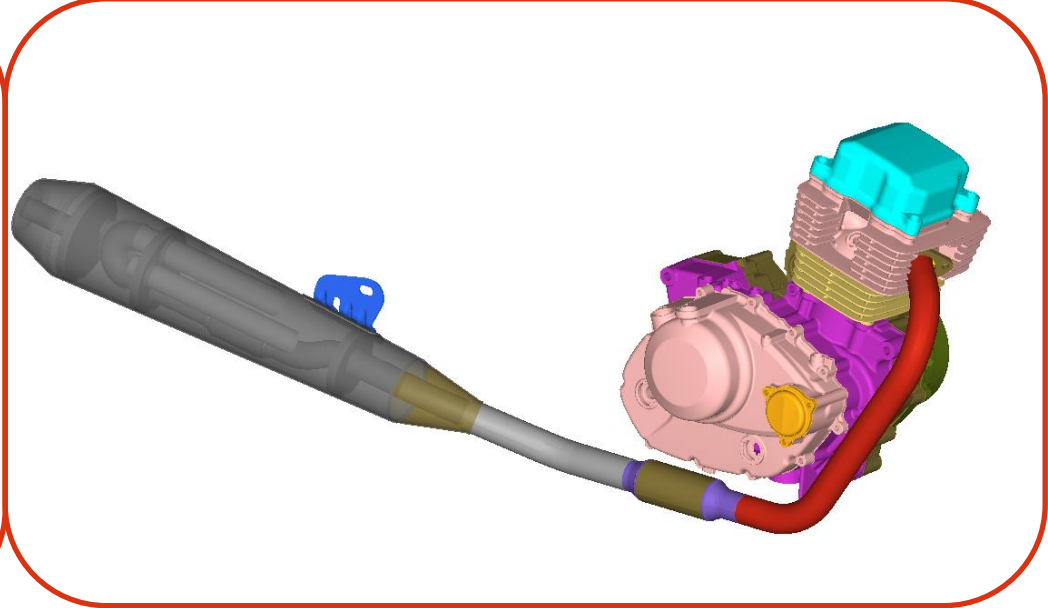
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COMSOL
CONFERENCE
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Motorcycle Exhaust system



Requirements of Automotive Muffler

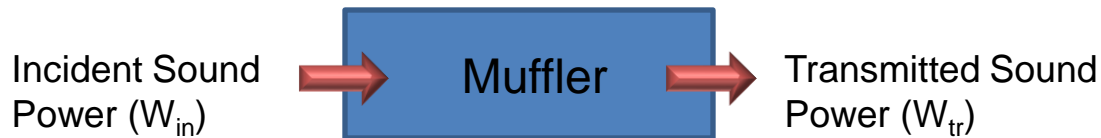
- Attenuate engine exhaust noise
- Provide low back pressure
- Meet pass by noise
- Space constraint
- Cost

- Exhaust sound is important for motorcycles
- Measures of performance of muffler

- Transmission Loss
- Insertion Loss
- Noise reduction

Transmission Loss

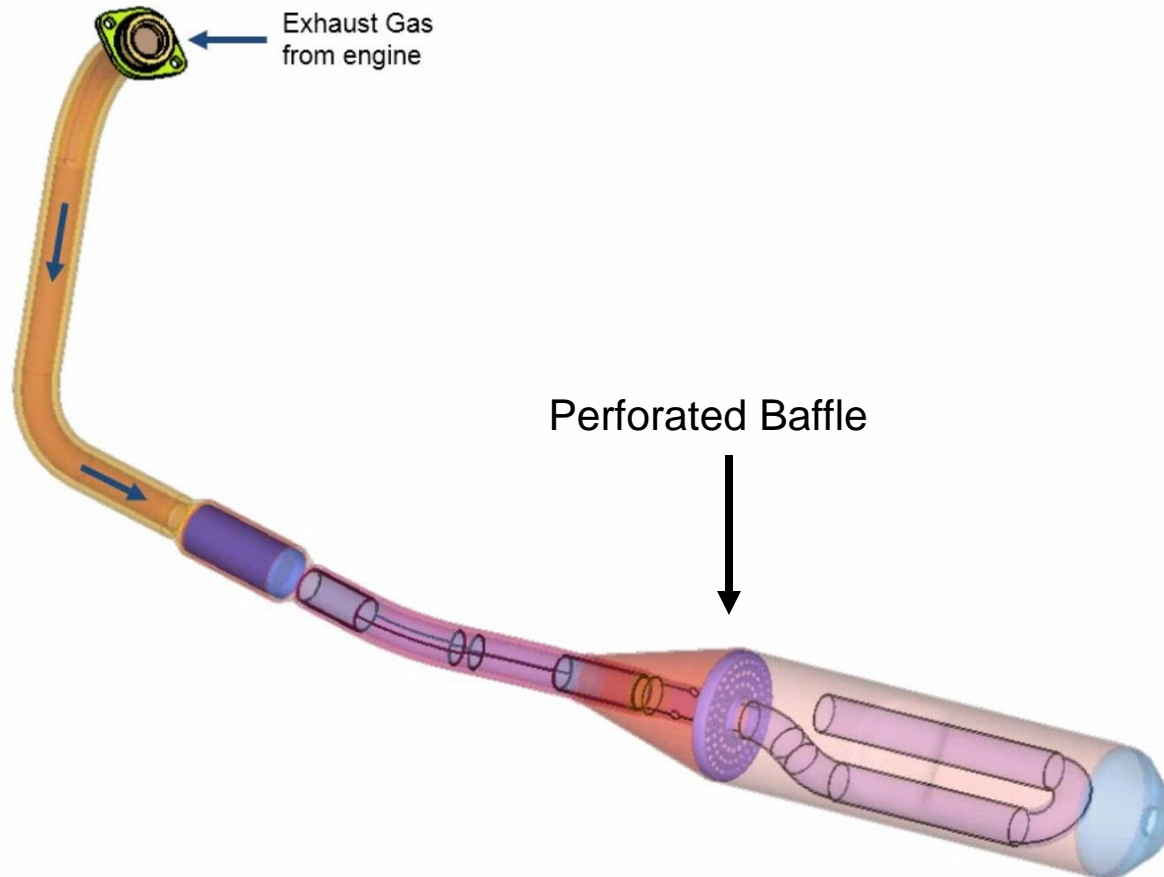
- Transmission loss (TL) is the ratio between acoustical power incident and power transmitted downstream of muffler into anechoic termination



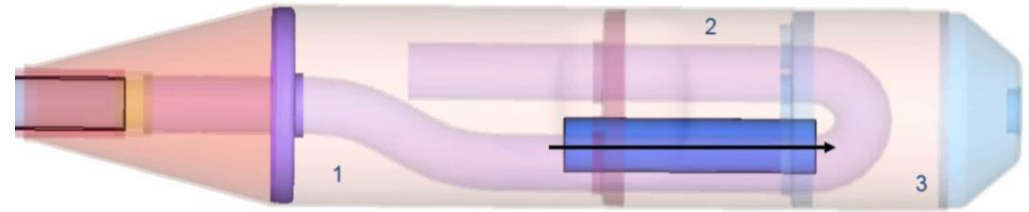
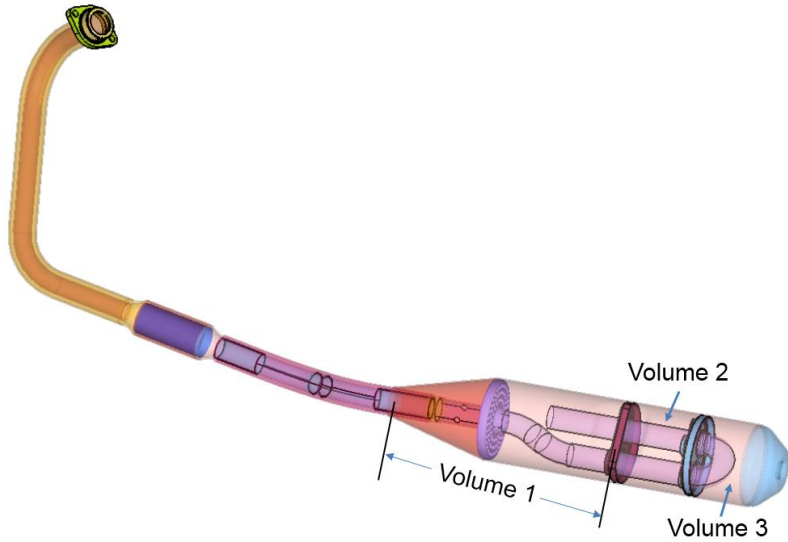
$$TL = 10 \cdot \log_{10} \left(\frac{W_{in}}{W_{tr}} \right)$$

- TL can be predicted from known physical parameters of muffler
- It is a property of a “muffler only “ so used as a design criteria

Gas flow inside muffler

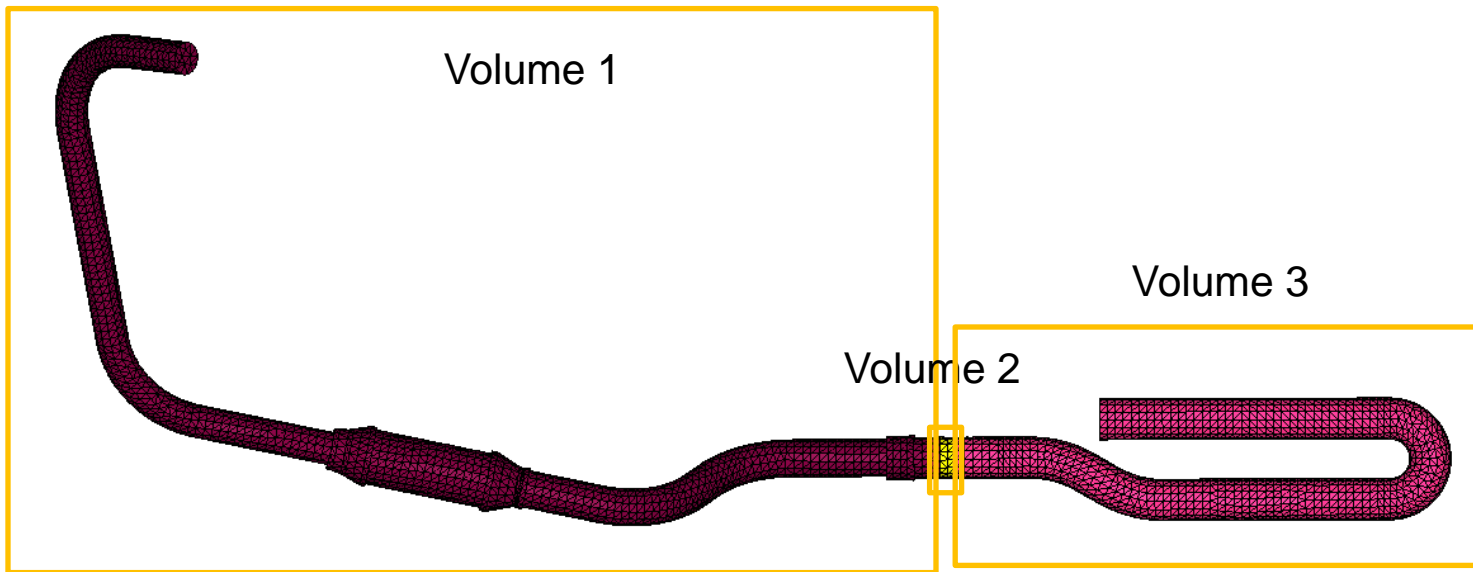
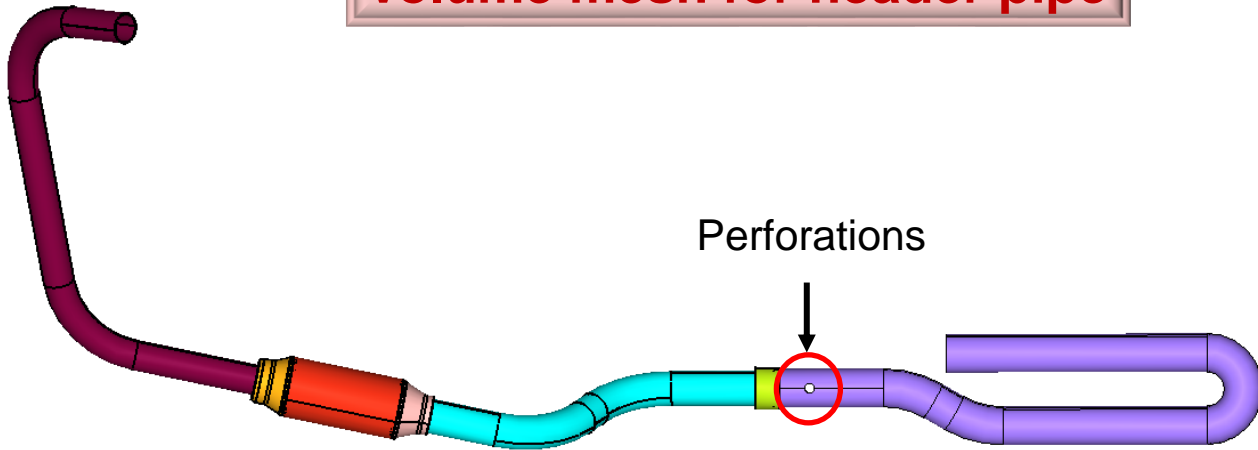


Gas flow inside muffler

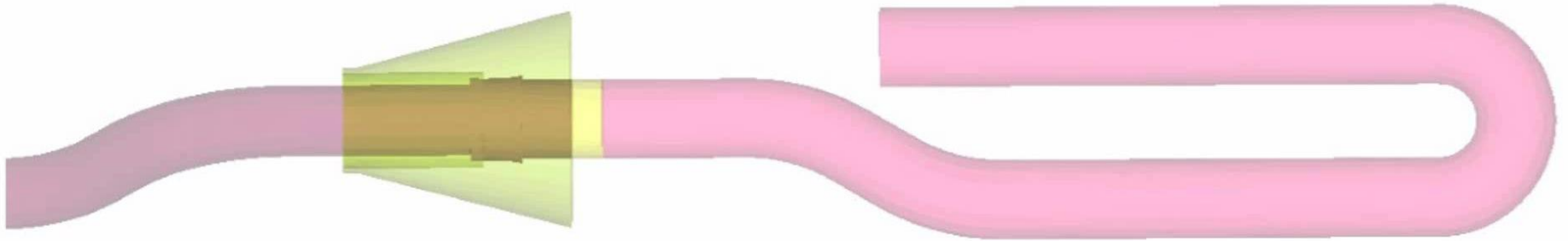


Flow from Volume 1 to Volume 3

Volume mesh for header pipe

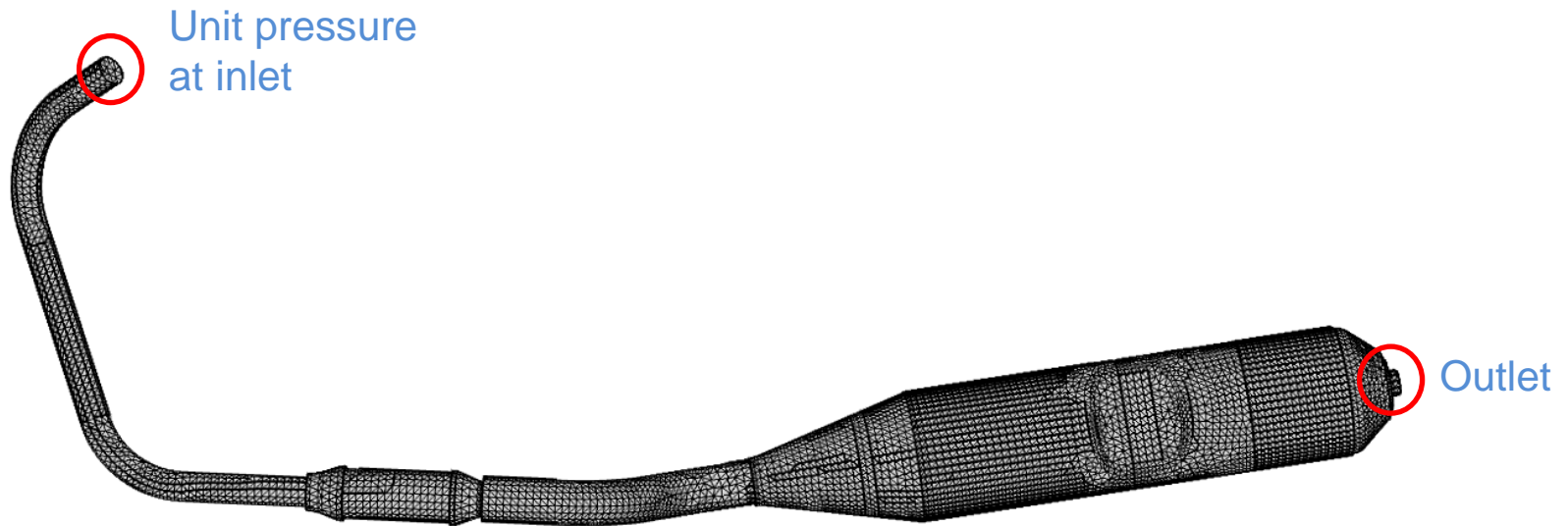


Volume mesh for different regions of muffler



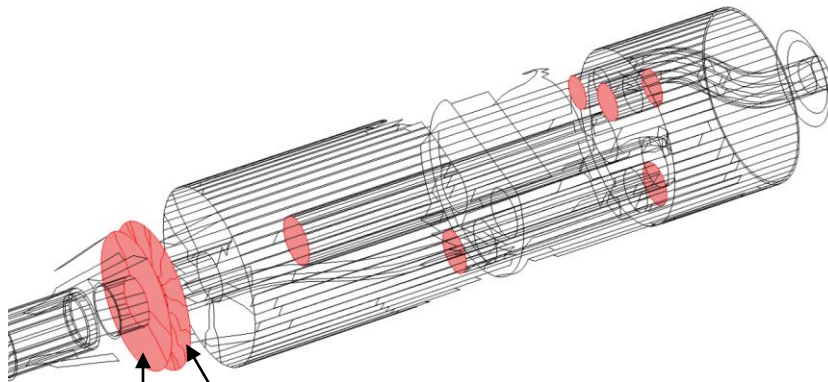
COMSOL Model Setup

Volume mesh for different regions are imported in COMSOL



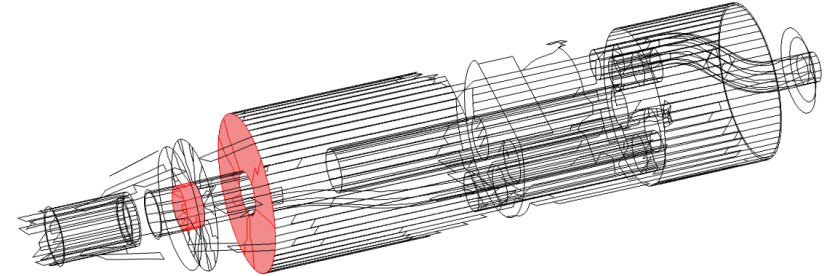
Plane wave radiation condition is applied to both inlet and outlet boundaries

Continuity Boundary Condition



Continuity BC adjacent to perforations on pipe

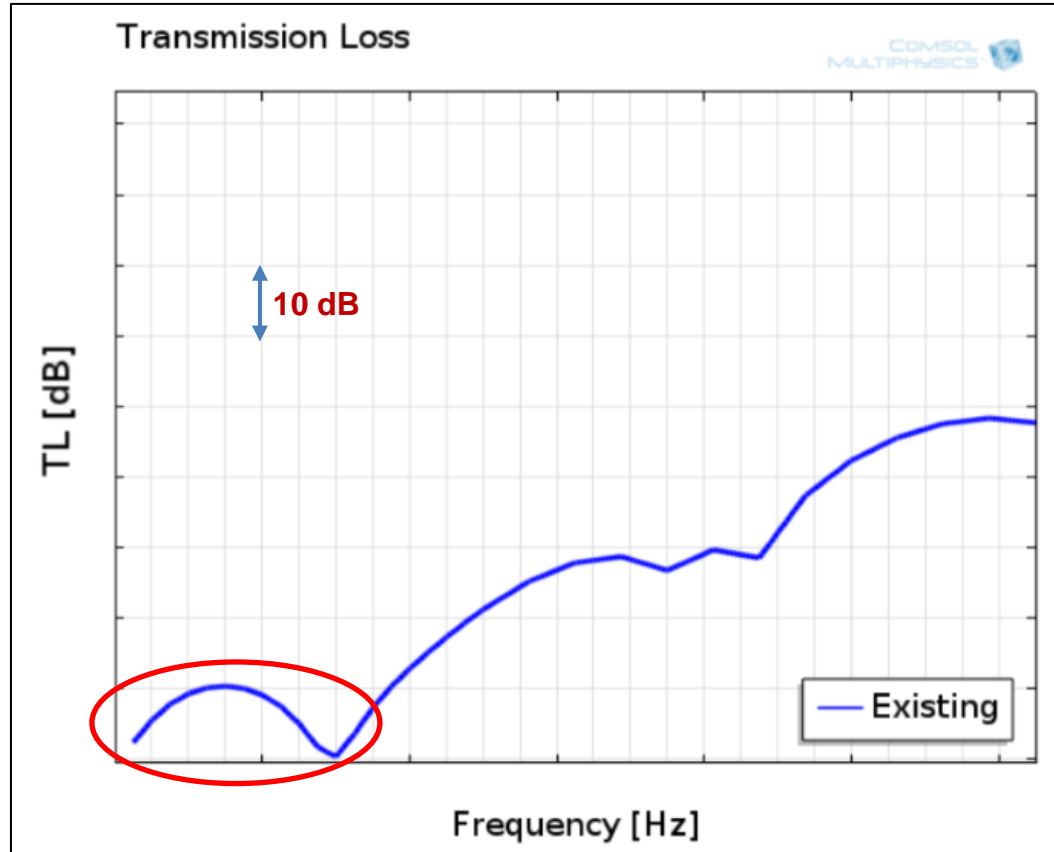
Perforations on pipe and baffle



Inputs required:

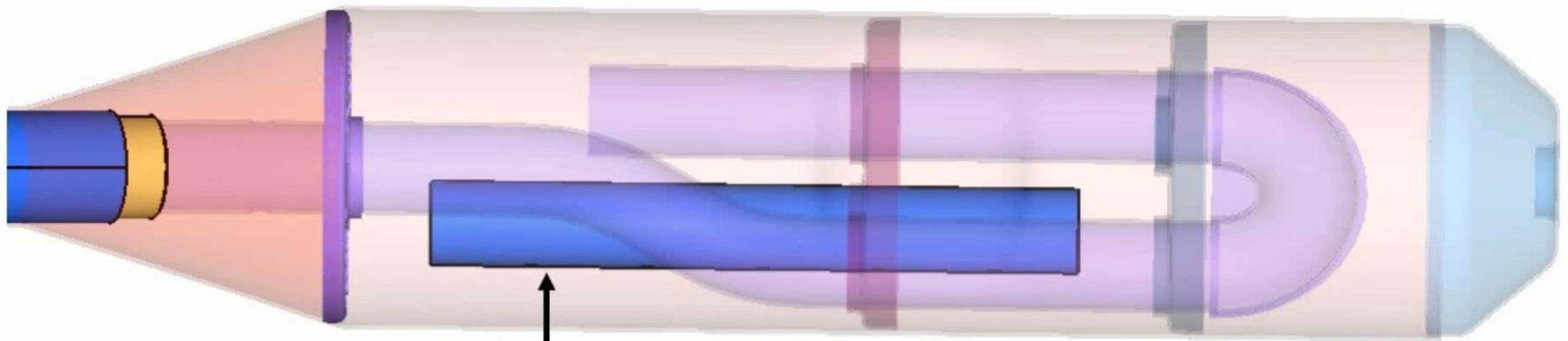
1. **Area Porosity** - holes fraction of the boundary surface area
2. **Baffle/Pipe thickness**
3. **Hole Diameter**

Transmission Loss of Muffler



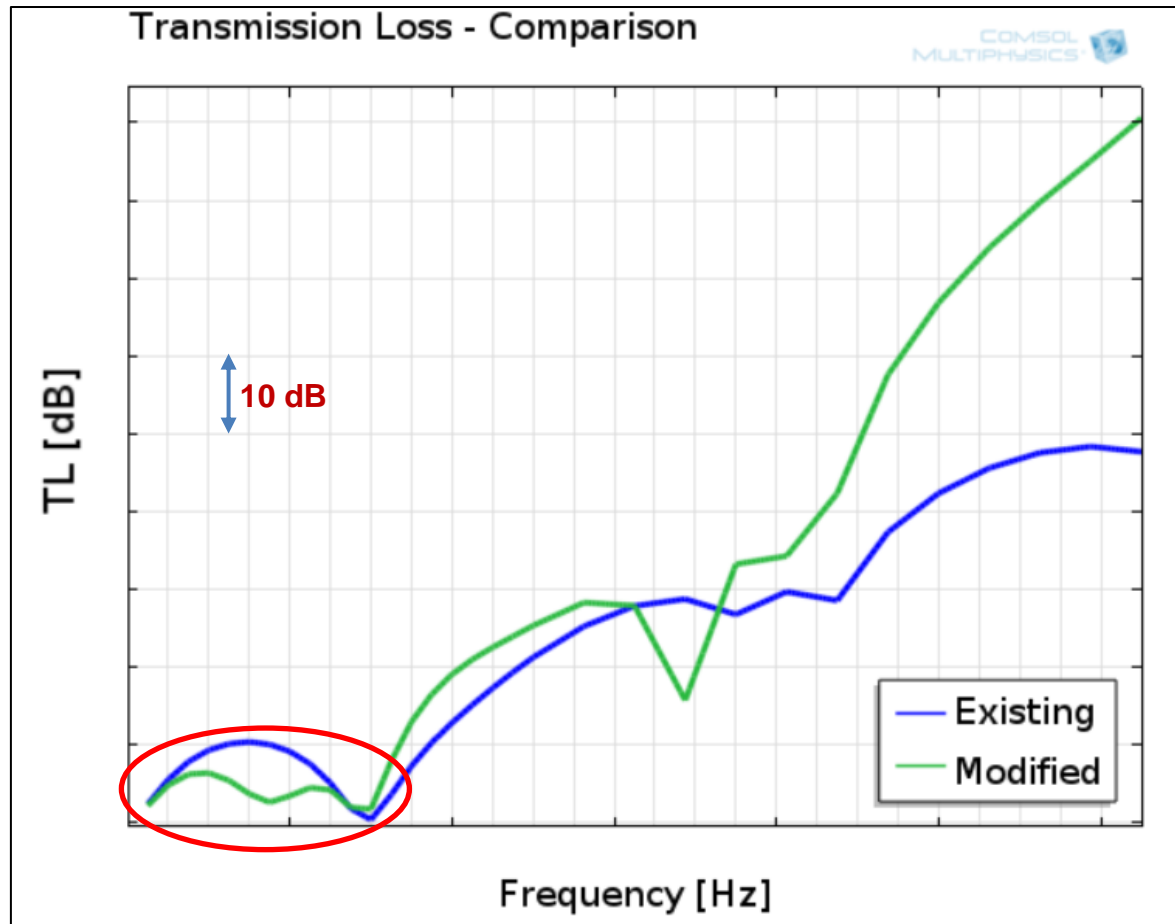
- Noise levels for the existing muffler at engine idling condition were recorded in testing
- Increase in noise levels at low frequencies was desired

Modified Muffler



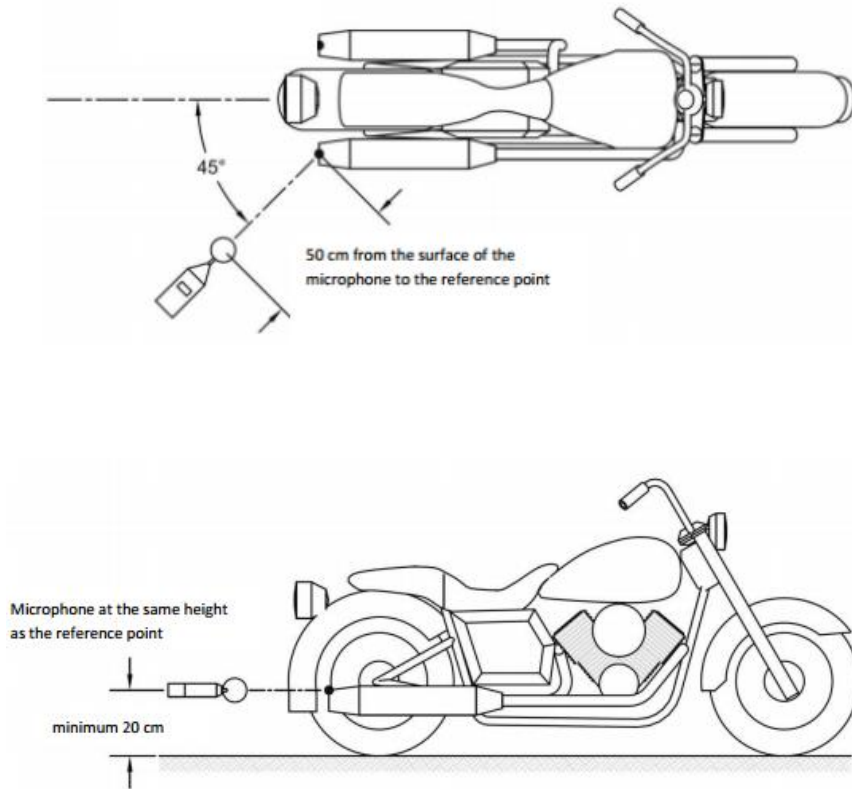
Pipe length increased

TL Comparison: **Existing v/s Modified**

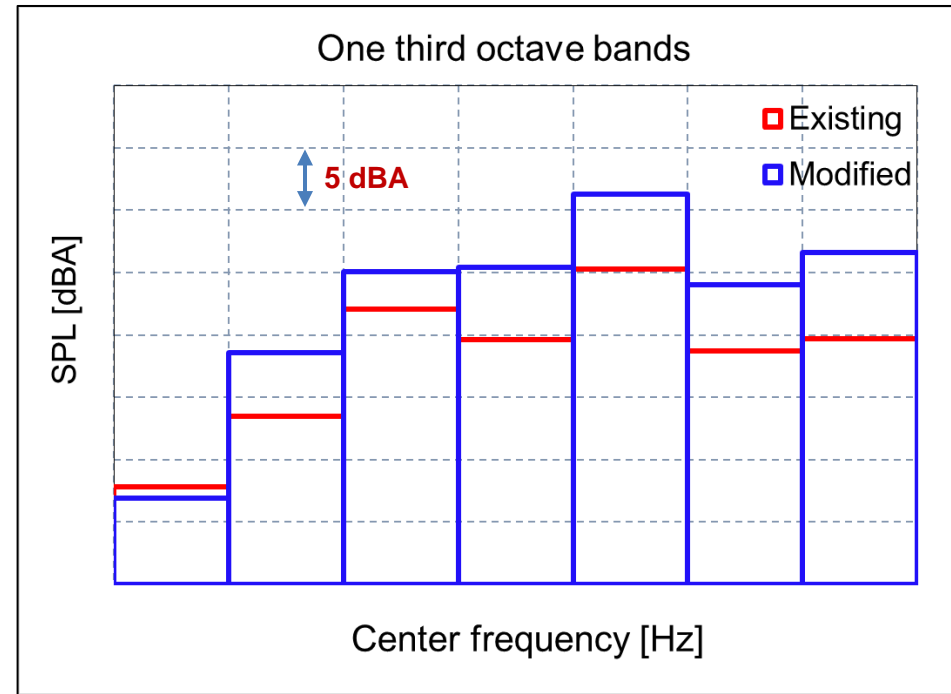


- With modified muffler, transmission loss at low frequencies is reduced

Tail pipe noise measurement



SPL Comparison: Existing v/s Modified

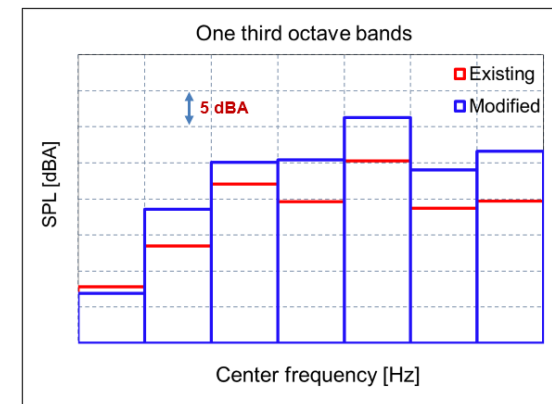
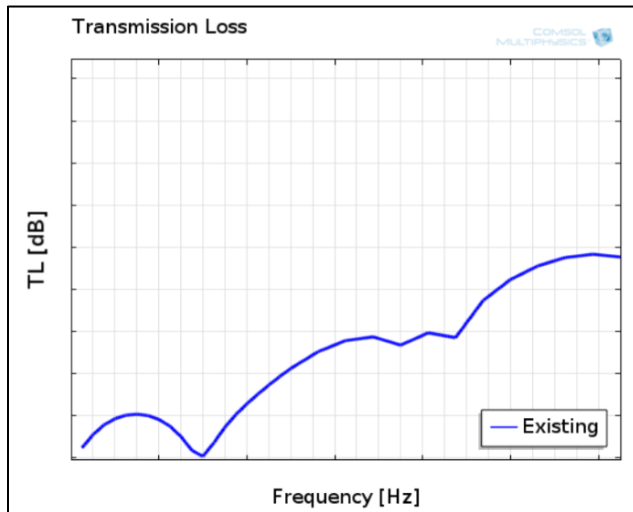
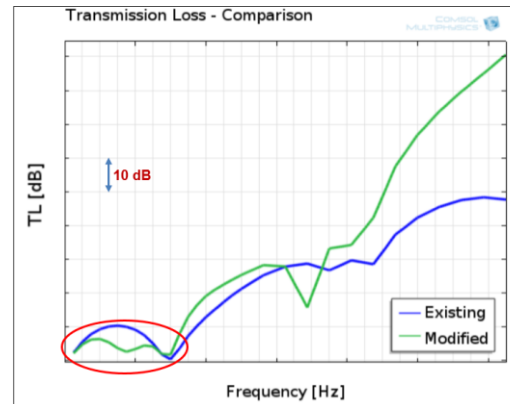
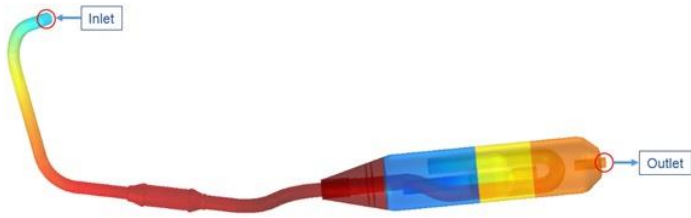


- With modified muffler, desired increase in noise levels at low frequencies is achieved

Conclusion

Transmission loss for a muffler of single cylinder motorcycle engine is predicted using COMSOL

Based on analysis results, modifications in muffler can be carried out in the design stage to achieve desired noise levels

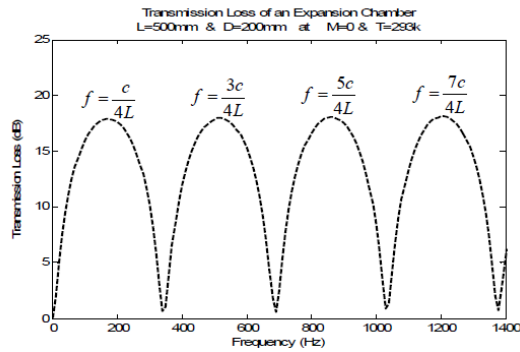


This approach results in savings in terms of cost and reduction in product development time

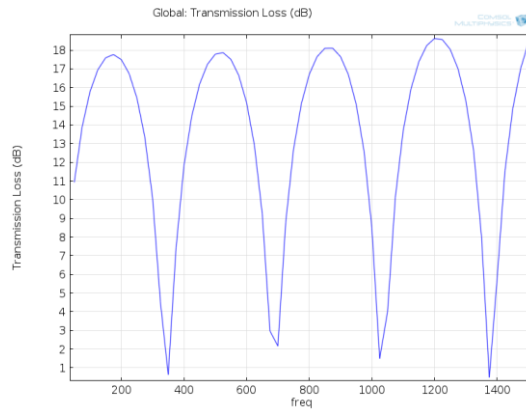
THANK YOU

Simple Expansion Chamber

Test results



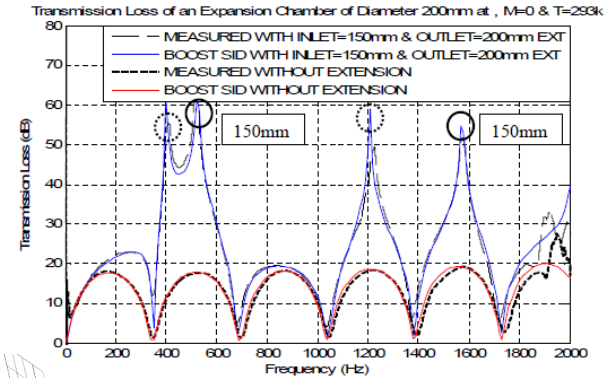
Analysis results



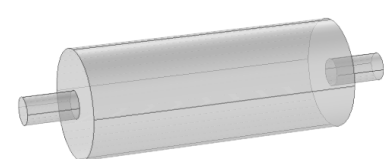
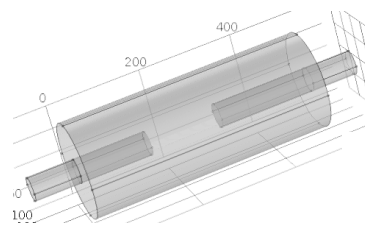
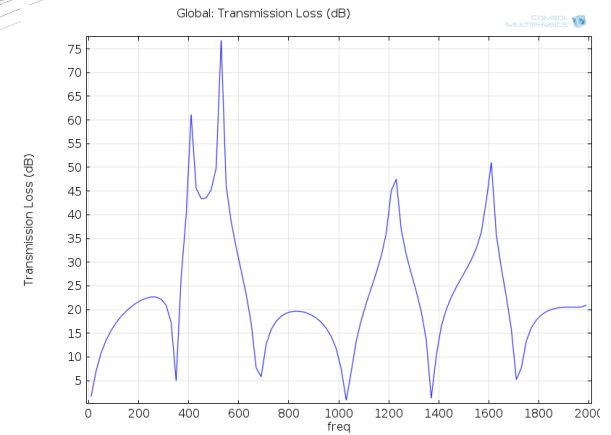
Analysis results match well with the test results

Expansion Chambers with extensions

Test results

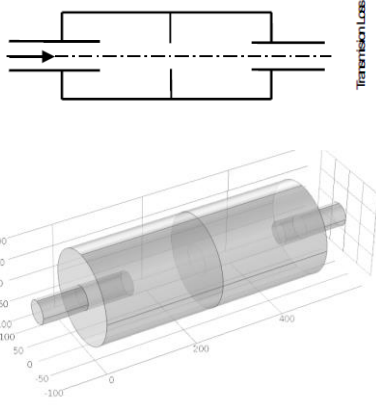
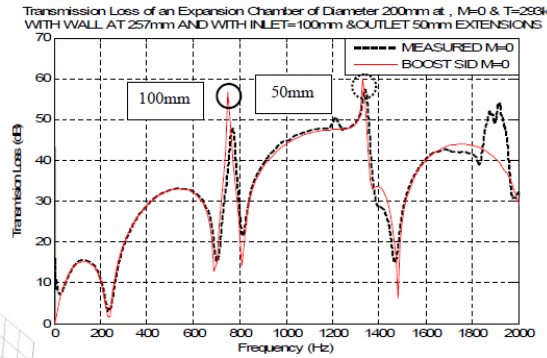


Analysis results

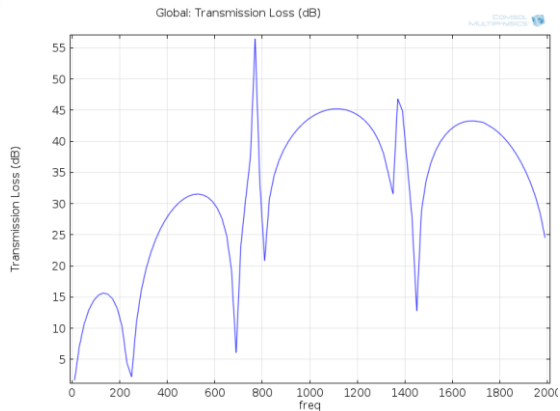


Expansion Chambers with Walls and Extensions

Test results

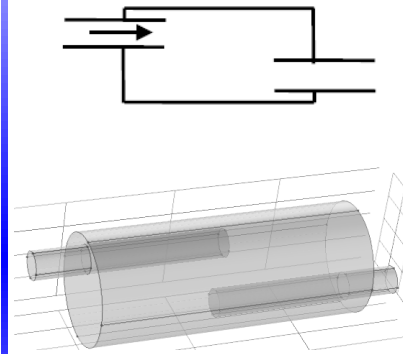
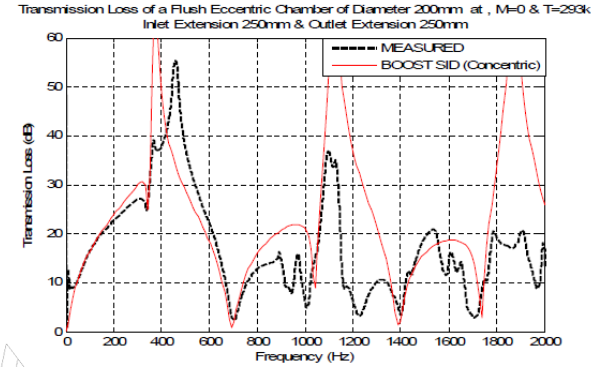


Analysis results

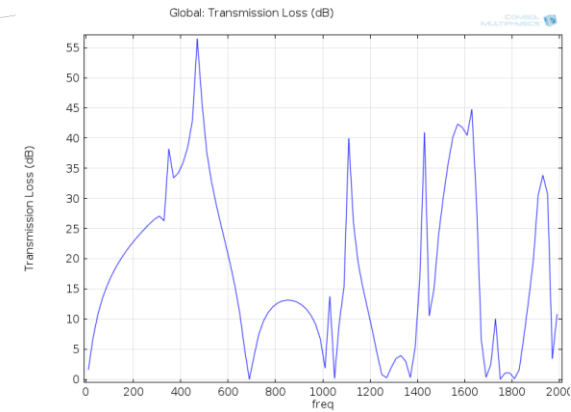


Mufflers with Flush Eccentric Inlet and Outlet Pipes

Test results



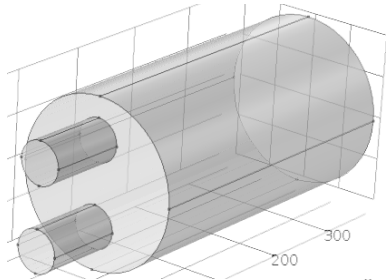
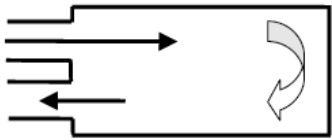
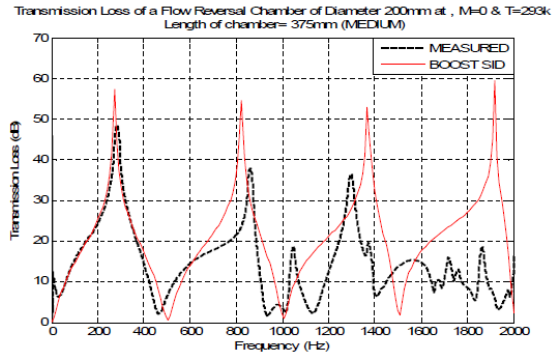
Analysis results



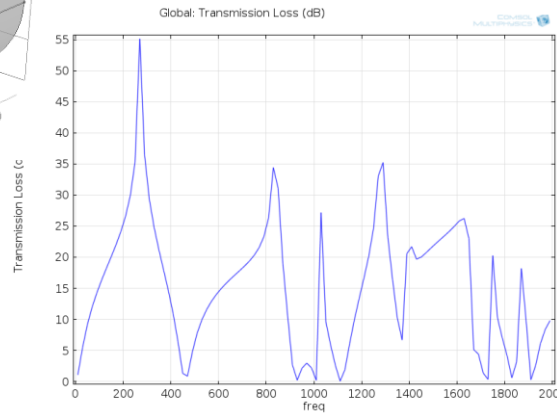
Analysis results match well with the test results

Mufflers with Flow Reversal

Test results



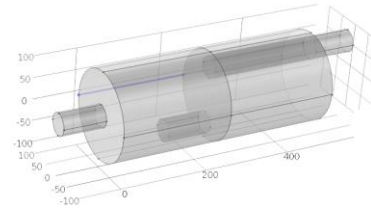
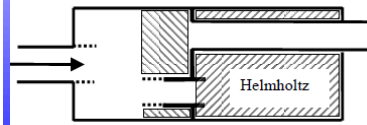
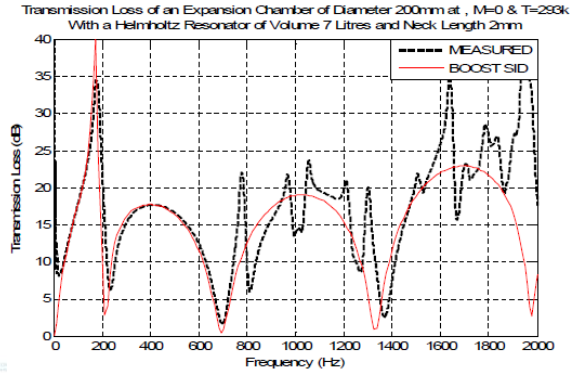
Analysis results



Analysis results match well with the test results

Helmholtz Resonator

Test results



Analysis results

