Investigation of Jet Noise Reduction in Exhaust Nozzle of Turbofan Engine

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Abstract— **This project mainly focuses on the reduction of jet noise in the exhaust nozzle of turbofan engine. Reduction of noise in the exhaust system is done by attaching chevrons and using tabs. Investigation have been carried out on chevron nozzle to assess the importance of chevron parameters such as the number of chevron like (chevron count) and the tab mixing characteristics of co-flow jet. The result illustrate that by careful interaction of chevron and tabs parameters substantial noise reduction can be achieved. The sound pressure level (SPL) can be calculated from that we can determined the noise level at nozzle exit section. After assessing the chevron parameters we are going to modify the chevron shapes as tabs in order to get maximum noise reduction along with negligible thrust loss. Combination of chevrons with tabs is based on aspect of increasing the mixing of cold jet and the hot jet in order to decrease the noise emission. ANSYS-Fluent is a commercial CFD code which is used for performing the different simulation. The simulation results are evaluated to find out nozzle noise level in the engine exhaust system.**

Keywords— **chevron nozzle, chevron nozzle with tabs, separate analysis, comparative analysis.**

I. INTRODUCTION

Jet noise is widely recognized to be one of the most impacts of aviation and an environment issue for those living close to airports as well as further a field under the main arrival and departure tracks. Aircraft noise is noise pollution produced by any aircraft or its components, during various phases of a flight, on the ground while parked, while taxing, during takeoff, departure and arrival path, and during landing. There are three categories of noise by an aircraft, they are aerodynamic noise, engine and other mechanical noise, noise from aircraft system. Many passive devices such as chevrons or tabs, reduce noise through enhanced mixing of jet. Engine noise is one of the major part to the overall sound level as aircraft operate near airport. Turbofan engine are commonly used on commercial transports due to their advantage in performance. Engine noise sources come from the fan (including stator), the exhaust (also referred as jet), the compressor, the combustor, and the turbine. Tabs are severe protrusions into the flow at the nozzle exit plane. Chevrons are also protrusions, but of much less severity than the tabs. The aggressive mixing produced by the tabs greatly reduced low-frequency noise, but with the penalty of tab-induced high frequency noise. Chevrons, which provided a more balanced approach to mixing, reduced low-frequency noise without significant chevron-induced high frequency noise. The noise emitted by a jet engine has many sources. These include, in the gas turbine engine fans, compressor, combustor, turbine and propelling jets. Formula used for calculating noise level are: conservation of mass

$\dot{m}=\rho AV=\text{constant}$

$SPL=20x\log_{10}(p/p_{ref})$ in dB

$P_{ref}=20x10^{-6}$ pa

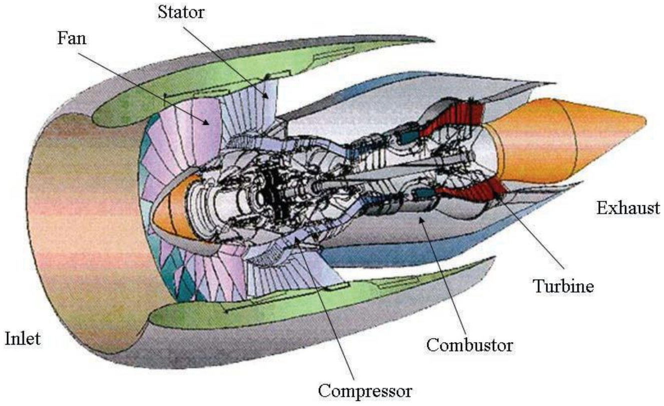

Fig.1. turbofan engine

A) HEALTH EFFECTS OF NOISE

There are several health problems of sound level. Noise levels can create stress, and other anti-social behaviors.

- Hearing impairment
- Hypertension
- Heart disease
- Sleep disturbance
- Affect memory

Noise with aircraft does not only affect people on the ground, but also those within the aircraft (e.g. flight crew, cabin crew, and the passengers).

II. NOZZLE DESIGN AND COMPUTIONAL WORK

A. *CATIA model of nozzle*

The present cone, chevron, and the chevron with tab model is created using CATIA CAD V5R19 in 3D by particular parameters. The cone model is created in 3D, the chevron model with different count, and those chevron model with tab also created in 3D.

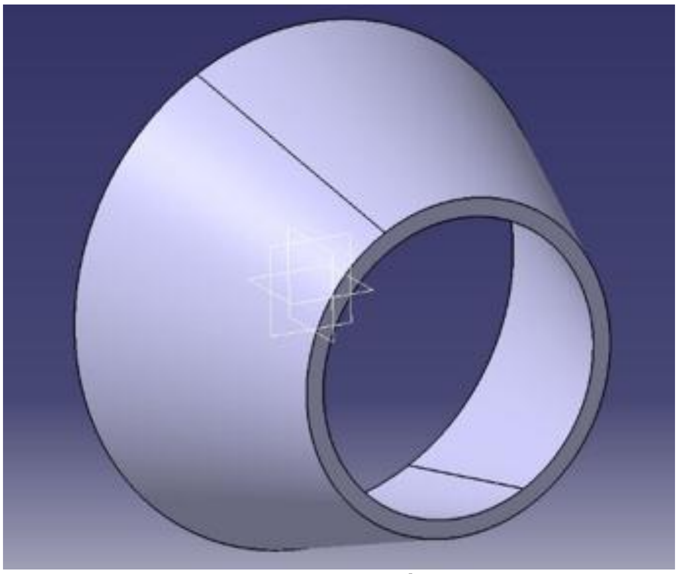

Fig 1. Cone nozzle

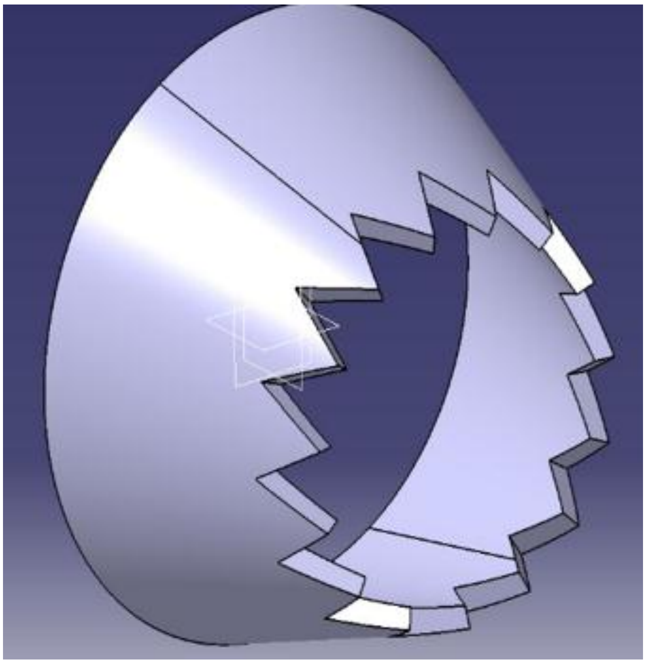

Fig.2. chevron 15

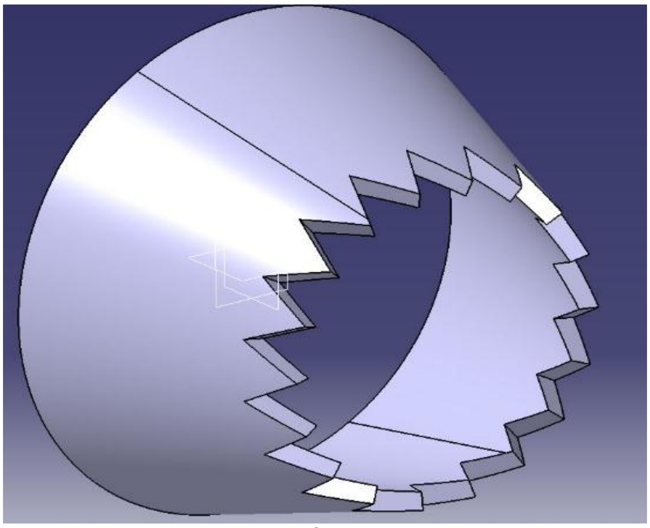

Fig.3. chevron 18

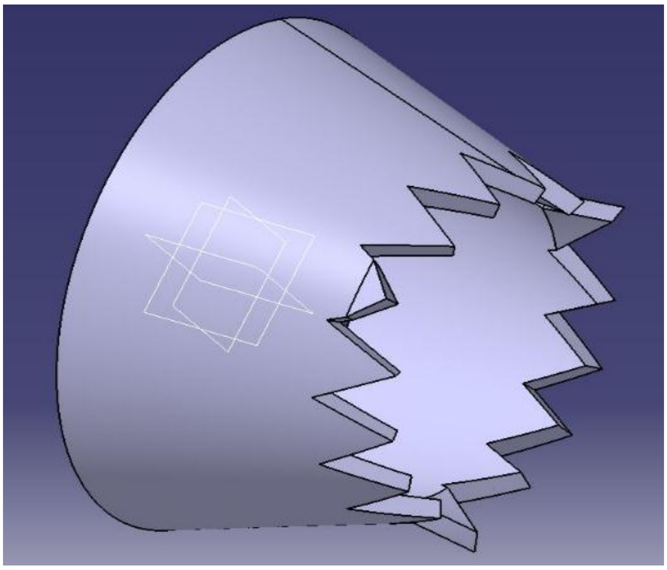

Fig.4. Chevron 15 with tab

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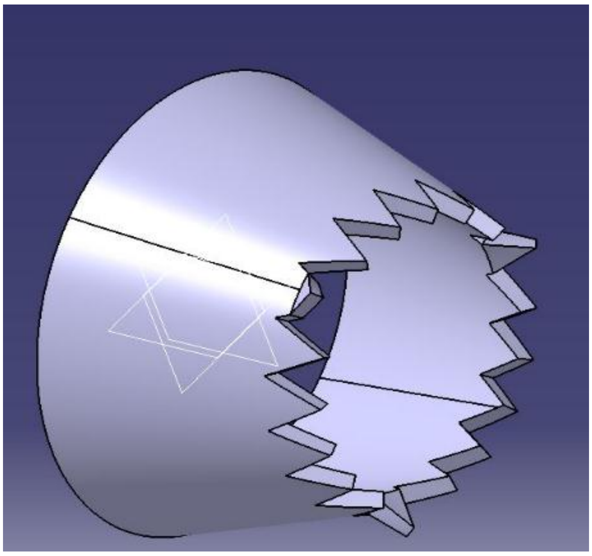

Fig.5. chevron 18 with tab

A. Meshing analysis

In this project HYPER MESH V13.0 is used for meshing. The model is imported from CATIA and generate mesh by giving particular properties. Each model is separately imported and meshed with created domain. Cone, chevron, and chevron with tab model are meshed in 3D. In these model mesh type trias and CFD tetramesh is used in the properties.

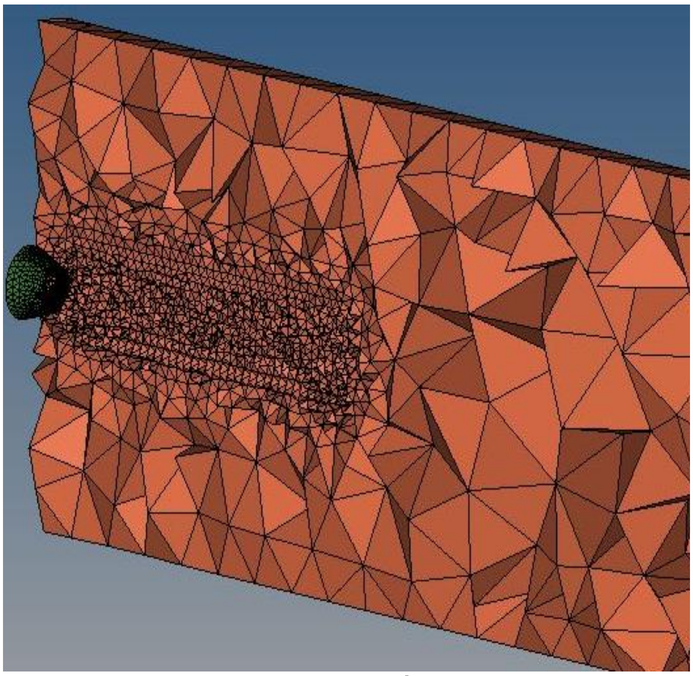

Fig.6. cone mesh

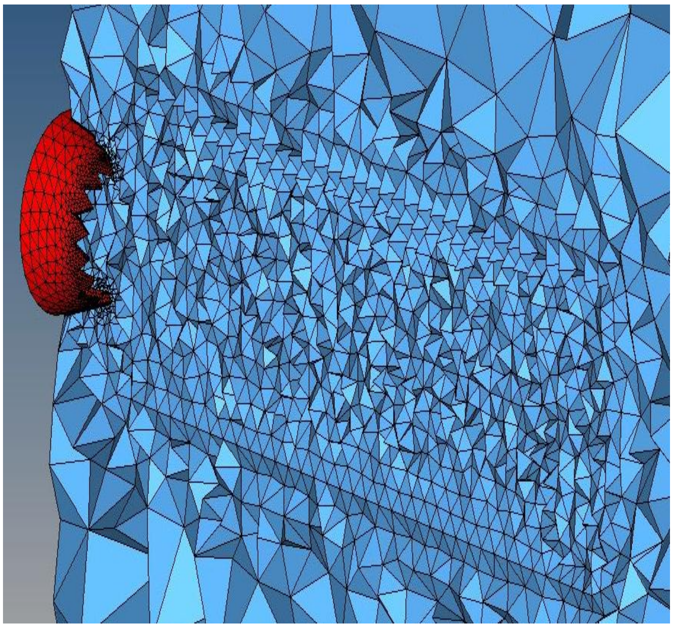

Fig.7. chevron 15

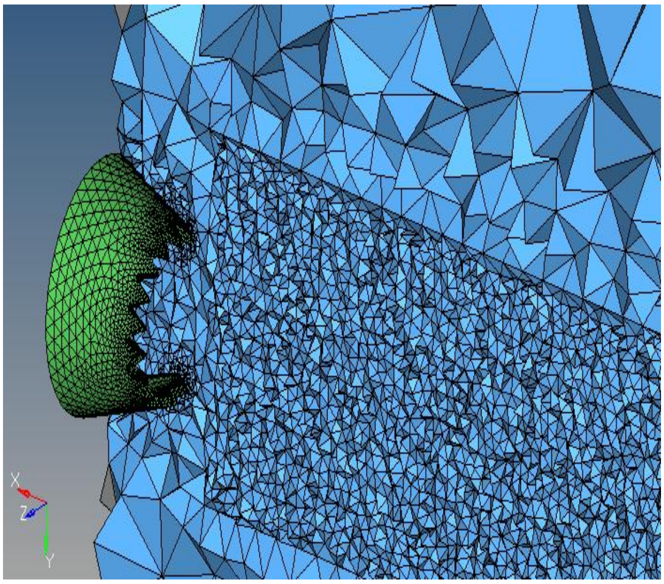

Fig.8. chevron 18

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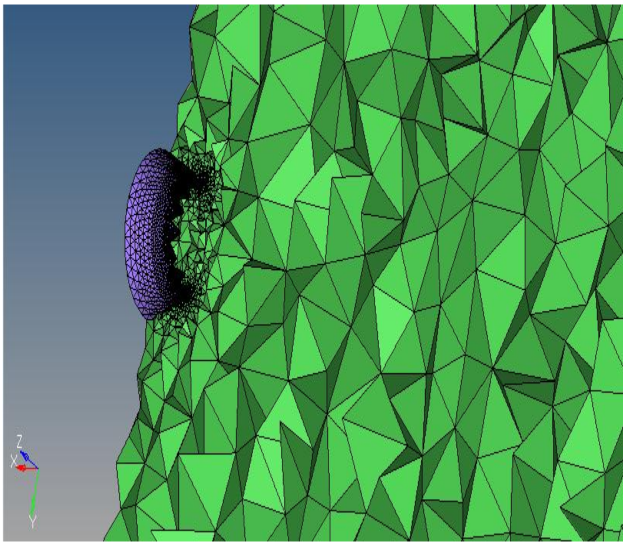

Fig.9. chevron 15 with tab mesh

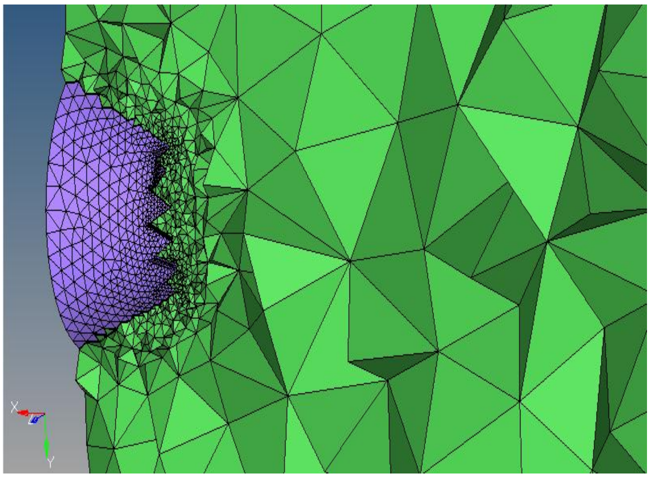

Fig.10. chevron 18 with tab mesh

C.CFD Analysis of the model

In this project, ANSYS-FLUENT 15 is used to test the model and also acoustical testing has done. In the testing viscous model K-EPSILON is used for material. Number of iteration 1000 is done for run the model.

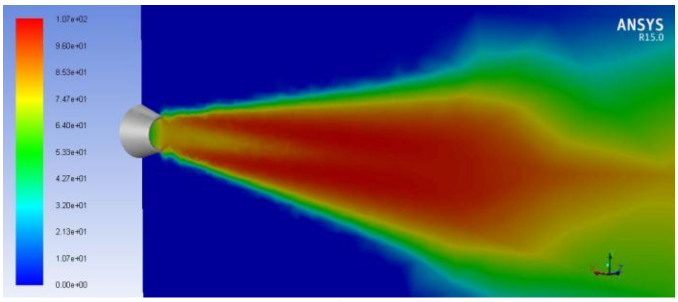

Fig 11. DB of cone nozzle

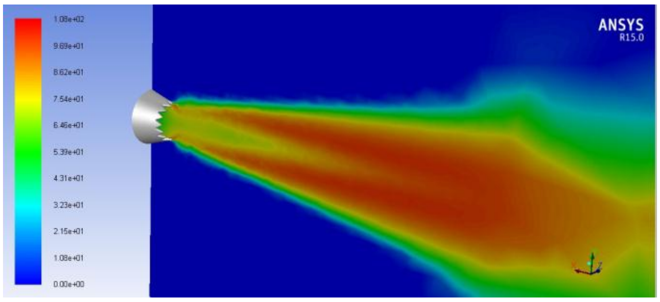

Fig 12. DB of chevron 15 nozzle

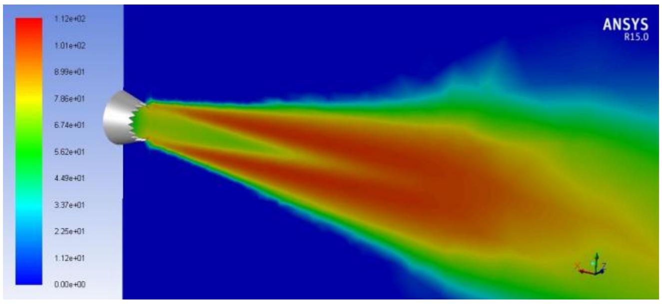

Fig 13. DB of Chevron 18 nozzle

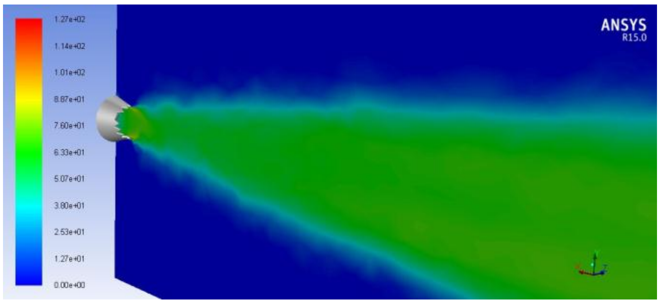

Fig 14: DB of Chevron 15 with tab nozzle

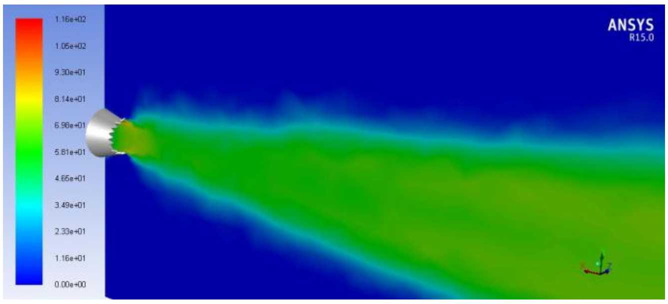

Fig 15: DB of Chevron 18 with tab nozzle

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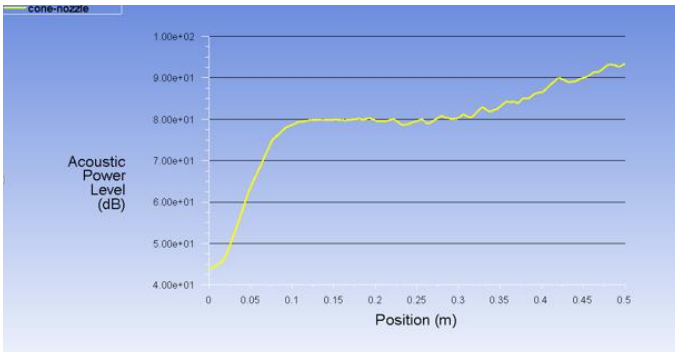
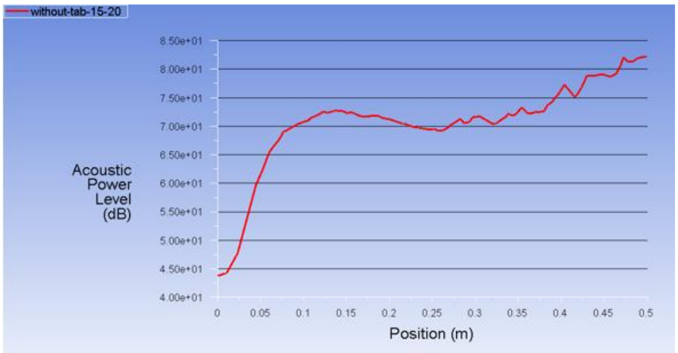
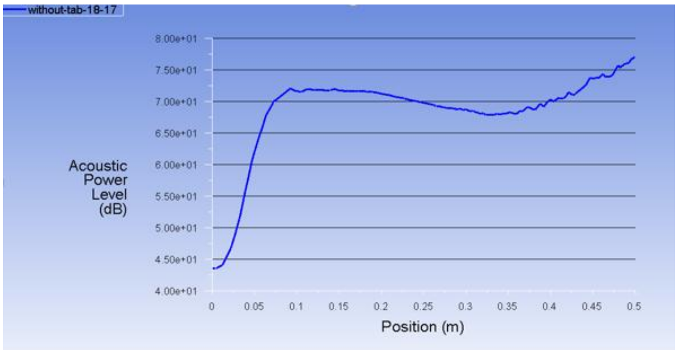
D. Graphical representation



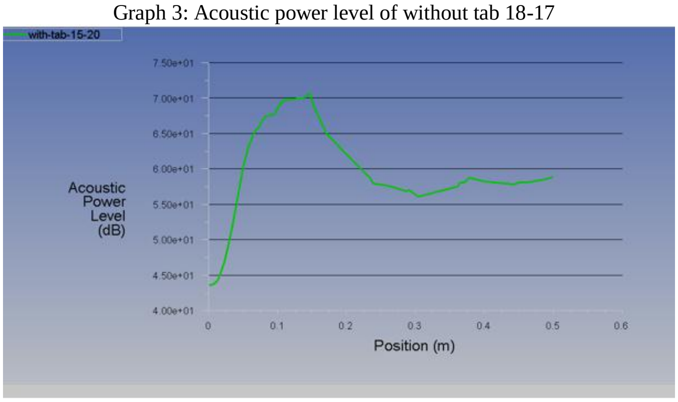
Graph 1: Acoustical power level of cone nozzle



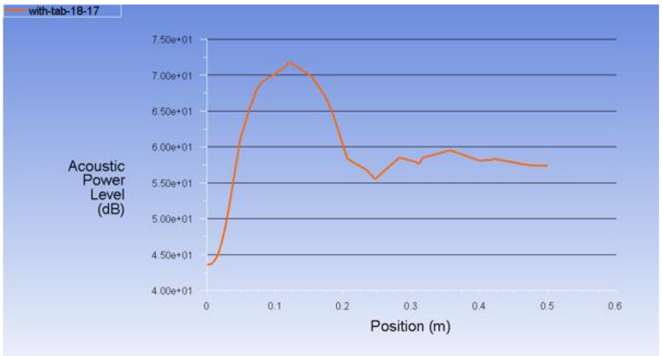
Graph 2: Acoustic power level of without tab 15-20



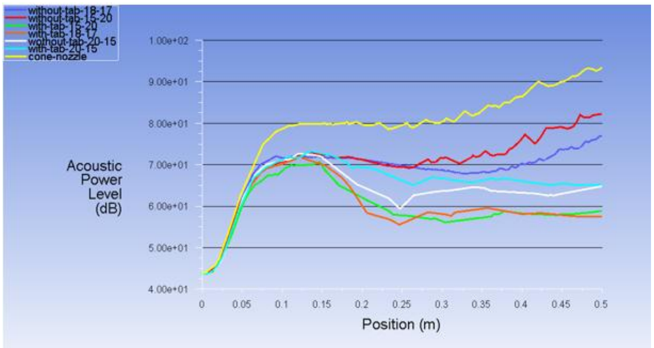
Graph 3: Acoustic power level of without tab 18-17



Graph 4: Acoustic power level with tab 15-20



Graph 5: Acoustic power level with tab 18-17



Graph 6: Comparative Graph of all the nozzle

III. RESULT AND DISCUSSIONS

Thus the result shows graphically acoustical test of the model and hence proved that increasing of chevrons with combine of few tabs is good reduction of noise emission at the nozzle exit of turbofan engine.

REFERENCE	SPL
Cone nozzle	84.774
15,20 chevron nozzle	28.673048
18,17 chevron nozzle	26.445432
15,20 chevron with tab	18.325193
18,17 chevron with tab	16.791677

IV.CONCLUSION

From the above graph it is evident that chevrons 18 with three tabs and chevrons 15 with three tabs is comparatively efficient in reduction of noise emission at the nozzle exit. It state that increasing chevrons count by mixing of few tabs is crucial and contribute of reduction of noise at the nozzle exit.

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