Design & Analysis of Wedge Nozzle to Absorb the Sound Emission from the Jet Exhaust

T. Anbarasan[1] V. Keerthivasan[2] R. Anand Kumar[3] V. Krishna Priya[4]
[1]Head of Department [2]Assistant Professor [3,4]UG Scholar
[1,2,3,4]Department of Aeronautical Engineering
[1,2,3,4]Parisutham Institute of Technology & Science, Thanjavur, Tamilnadu, India

Abstract— The paper mainly focuses on the absorption of jet noise by installing a new active nozzle on the rear side of the jet exhaust. The nozzle is designed with wedge shaped reflectors on the interior wall of the nozzle to absorb the sound emission effectively. Analysis will be monitored from the absorber point of view on various points along the reference co-ordinate system (0º ,45º ,90º from the jet exhaust). Finally, the results of nozzle with wedge installation will be compared with the nozzle without wedge installation and chevron results. The results illustrate that by installing wedge nozzle at the exhaust section substantial noise absorption can be achieved with negligible thrust loss. 3D Modeling will be done by using SOLIDWORKS, Acoustic field and Flow field analysis will be investigated by using ANSYS-fluent.

Key words: Jet Noise, Sound Absorption, Chevron nozzle, Nozzle with wedge, Nozzle without Wedge, Acoustic Power Level (db), Velocity (m/s)

I. INTRODUCTION

The sound pollution is becoming a big hoax to the present human beings. There are tremendous amount of source for noise pollution .In that the aviation noise is an inevitable one, particularly the noise production from the jet engine during its operation. The noise emitted by a jet engine has many sources, they are

- Fan
- Compressor
- Combustor
- Turbine
- Propelling jets

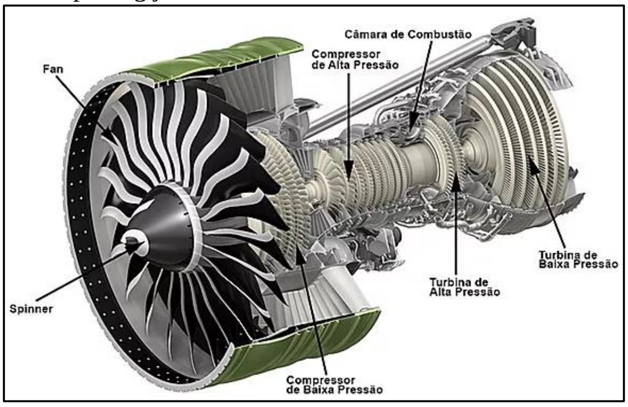

Fig. 1: Turbofan Engine

The propelling jet produces noise which is caused by shearing of exhaust jet plume at high velocity with the surrounding still (low velocity) air. Eddies are the reason for noise production in subsonic case and the Mach wave is the reason in supersonic case. There are many passive existing solutions to attenuate sound produced by propelling jet like chevron, which are mainly focuses to encourage the mixing between hot and cold gas.

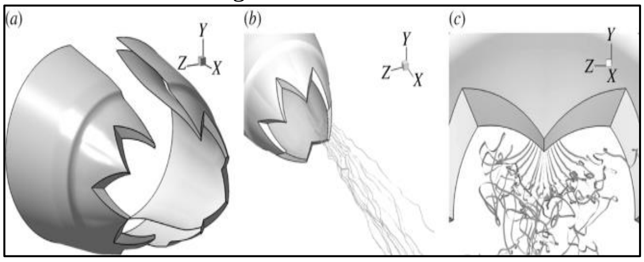

Fig. 2: Chevron Design

Chevron design is made by engineers to reduce the jet noise by increasing the mixing which is happened by generating vortices on the shearing layer of hot and cold gas. The chevron can give good results in attenuation of sound by having appropriate dimensions and number of counts.

This project focuses to reduce jet noise by installing active wedge nozzle.

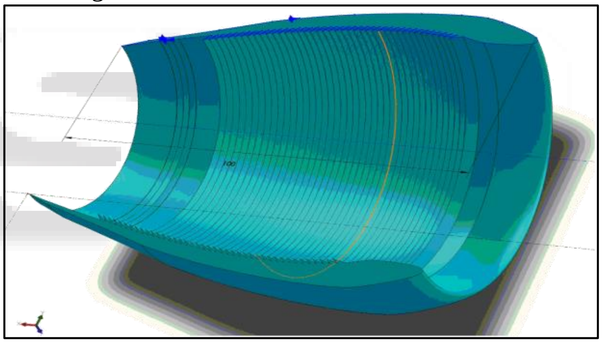

Fig. 3: Cross Section of Wedge Nozzle

Here, the principle of wedge nozzle is reflection and absorption. The noise emission from the propelling jet is propagated in all direction. The wedge nozzle is installed at the rear side of jet engine.

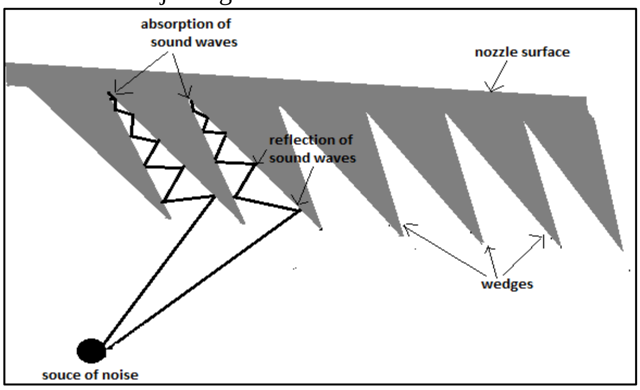

Fig. 4: Principle of Sound Absorption

The sound waves are reflected by the wedge design incorporated at the interior side of the wedge nozzle and it's absorbed.

II. COMPUTATIONAL WORK

A. 3D Model

3d model of chevron nozzle and nozzle with wedge and without wedge has been designed with SOLIDWORKS. SOLIDWORKS is a solid modeling computer aided design (CAD) and mechanical design automation application that lets designers quickly sketch out ideas, experiment with features and dimensions, and produce models and detailed drawing.

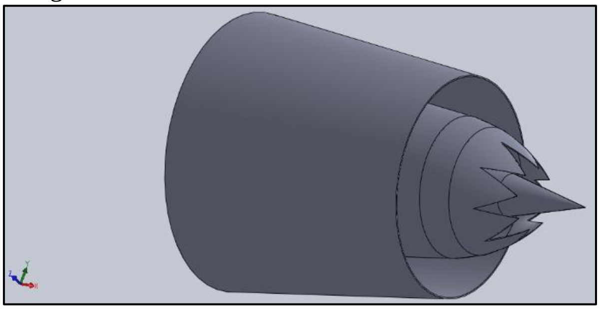

Fig. 5: Chevron Nozzle

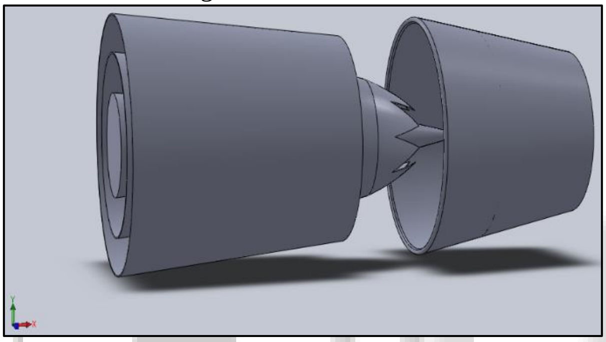

Fig. 6: Nozzle Installation without Wedge

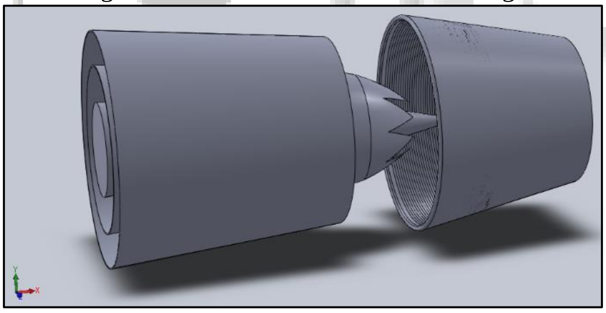

Fig. 7: Nozzle Installation with Wedge

B. Analysis

ANSYS-FLUENT is high performance computational fluid dynamic software (CFD) tool that delivers reliable and accurate solutions quickly and robustly across a wide range of CFD and multi physics applications and is used to model flow turbulence , heat transfer and reactions for industrial applications.

It is a powerful tool that concludes the noise resulting from unsteady pressure fluctuation to solve acoustical simulation. So the sound and flow analysis has been done on ANSYS-FLUENT software.

Hot inlet	250 m/s
Cold inlet	120 m/s

Table 1: Velocity Boundary Conditions

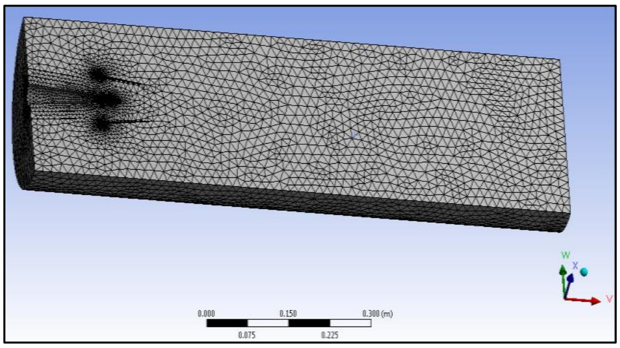

Fig. 8: Wedge Nozzle Meshing With Air Boundary

File Type	FLUENT
File Version	14.5.0
Viscous Model	K-Epsilon

Table 2: Viscous Model

Domain	Nodes	Elements
Air	26840	124950
Domain	Boundaries	
Air	Boundary - cold inlet	
	Type	VELOCITY-INLET
	Boundary - far field	
	Type	WALL
	Boundary - hot inlet	
	Type	VELOCITY-INLET
	Boundary - outlet	
	Type	PRESSURE-OUTLET
	Boundary - symmetry	
	Type	SYMMETRY
	Boundary - wall solid	
	Type	WALL

Table 3: Mesh Conditions

III. RESULTS

A. Contours of Acoustic Power Level (db)

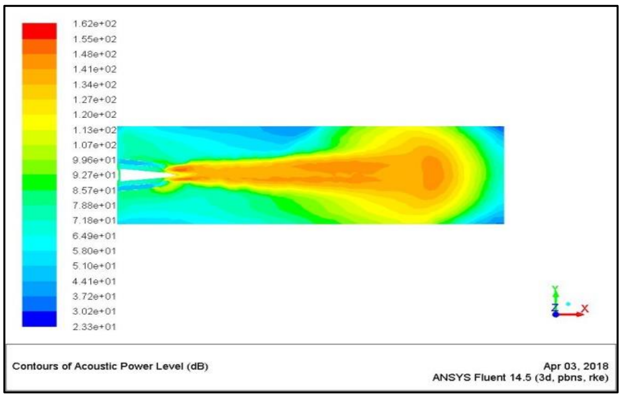

Fig. 9: Chevron Nozzle

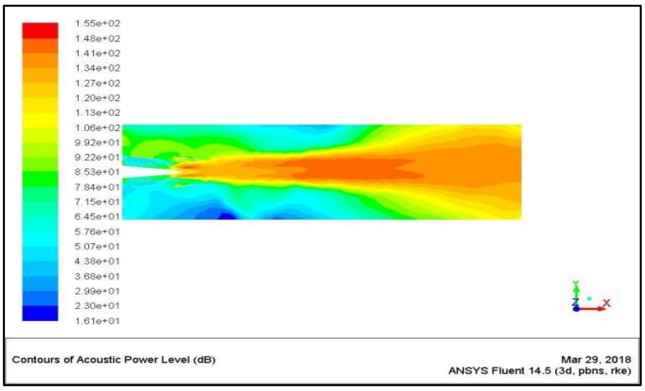

Fig. 10: Nozzle without Wedge

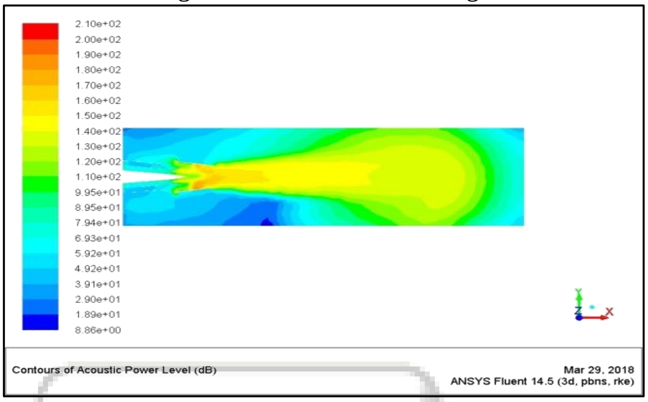

Fig. 11: Nozzle with Wedge

B. Contours of Velocity Magnitude (m/s)

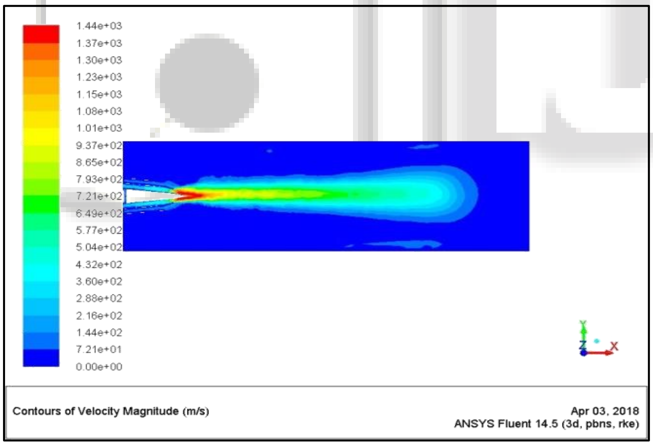

Fig. 12: Chevron Nozzle

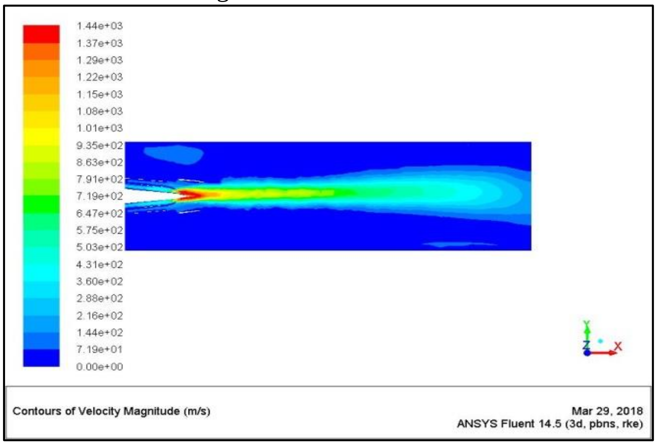

Fig. 13: Nozzle without Wedge

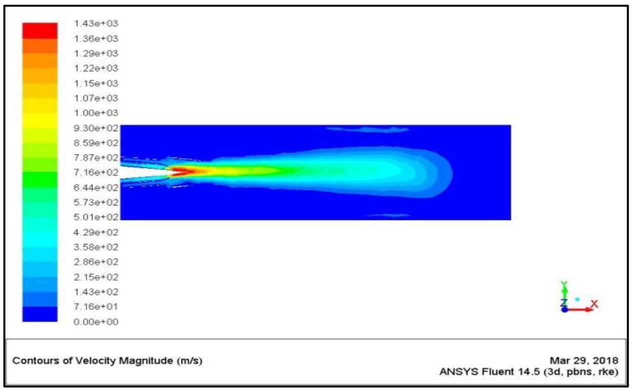

Fig. 14: Nozzle with Wedge

C. Graph Results of Acoustic Power Level

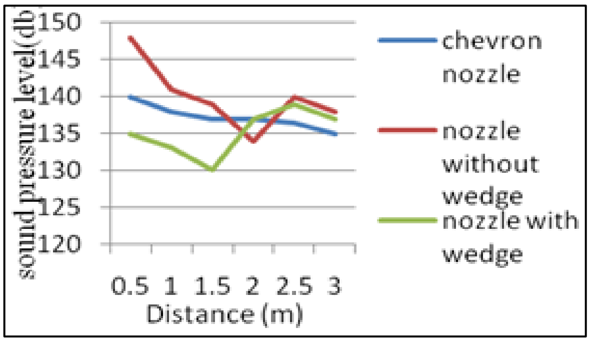

Fig. 15: 0° along the Jet Exhaust

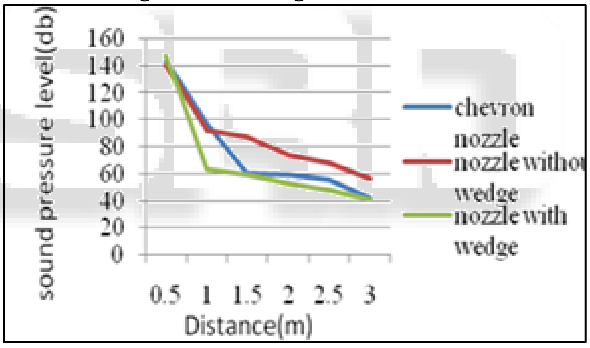

Fig. 16: 45° from the Jet Exhaust

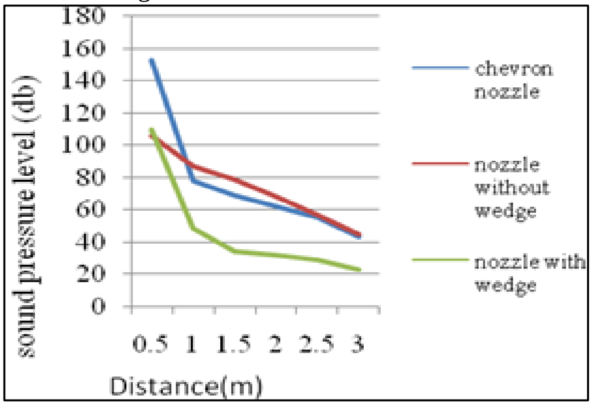

Fig. 17: 90° from the Jet Exhaust

D. Graph Result of Jet Velocity Magnitude

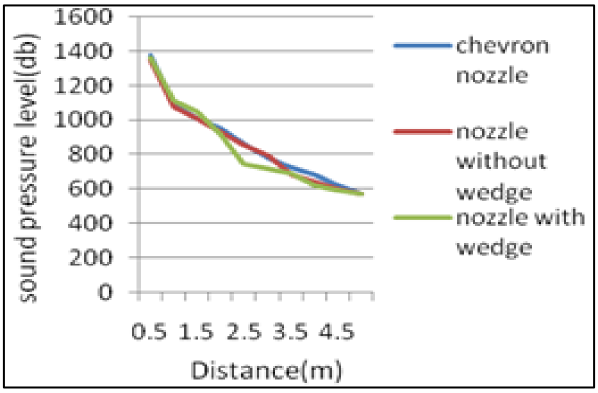

Fig. 18: Velocity in Exhaust

IV. CONCLUSION

We had studied and analyzed about the acoustic power level (db) through the different nozzle installations (1.chevron nozzle 2.Nozzle without wedge 3.Nozzle with wedge) at high velocities and relative constituents for the objective of engine noise reduction. We had accounted three cases of turbofan engine nozzle design configurations with suitable conditions and we had applied appropriate boundary conditions for all three cases and had got precise acoustic power analyzed results. Subsequently, we had compared all flow property values and significance of acoustic power variation for all cases by using the chart. The CFD results clearly shows that the acoustic power level(db) is absorbed around the wedge nozzle is 13db along jet exhaust , 45db normal to jet exhaust and 29db of sound is absorbed at 45° to the direction of jet exhaust. Conclusively, installation of wedge nozzle has given a better performance with superior acoustic power absorption with negligible thrust loss. The results shown that the Case 3 (Nozzle with wedge) design absorbs the sound pressure waves more competently than other two cases.

REFERENCES

[1] Carl H. Gerhold and lorenzo R. Clak," Database of Inlet and Exhaust Noise Shielding for Wedge Shaped Airframe" April 2001.
[2] Mr.Donald Bartlett "The Effects Of Using Noise Reduction Turbofan Engine Nozzle Designs On a Turbojet Engine "December 2016.
[3] Rebecca S. Shupe, Khairul B Zaman, Dimitri Papamoschou "Effect of Wedge Shaped Deflectors on Flow Fields of Dual Stream Jets" January 2007.
[4] John M Seiner, Bernard j Jansen and Nathan Murray "Noise Suppression of a Supersonic Model Twin Jet Nacelle".
[5] R J Astley, An agarwal, K R Holland, P F K Joseph "predicting and reducing aircraft noise" July 2007.
[6] James R Debonis "RANS Analysis of turbofan nozzle with wedge deflector for noise reduction".

