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SIMULATION OF NOISE SUPPRESSION USING PASSIVE TECHNIQUES IN AIRCRAFT ENGINES

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Abstract: Among the various environmental concerns, the aircraft noise item has been constantly growing in importance over the past years. Measures for its reduction at the source as well its mitigation around airports must take into account aspects of medicine and technical design as well as legal and land use planning aspects. While the flow speed becomes above the Mach 0.6, there is a need to suppression the noise level. Noise reduction techniques can be broadly classified as passive and active methods. Passive control involves reducing the radiated noise by energy absorption, while the active method involves reducing source strength or modifying acoustic field in the flow to obtain noise reduction. Our study mainly focusing on the usage of optimized passive control devices for the given flow field, Small scale pins and vortex generators placing at span wise causing the disturbance in the flow. The study has been carried out at varying angles ($\alpha = 0^0, 30^0, 45^0$) and in height from $h/\delta = 1$ to 5, where δ is the height of the incoming boundary layer. The purposes of the investigation are to be characterizing the flow-field for flow visualization and pressure recovery measurements. The pressure, Velocity and acoustic variation along the model was also studied computationally by installing tab in our model.

Index Terms: Passive and active method, mitigation, suppression

1.INTRODUCTION

Aircraft noise, after roadway traffic, is the second largest source of environmental noise pollution and therefore of considerable concern to urban areas surrounding most major airports (Smith, 2004). With the advances made in aerospace technology, air transportation is being used much more frequently than in the past and this continuing growth in the popularity of air travel has led to predictions by European aircraft manufacturer, Airbus, of an increase in global air passengers by almost 4.9% a year, with the freight industry also expected to grow by 5.8% annually. High levels of growth over the past decades have led to an increase in noise intensity around airport communities and have been met by stringent aircraft regulations and noise certification requirements to suppress them (Smith, 2004). In the light of this, the field of aero acoustics has attracted much attention, with aircraft noise reduction becoming one of the most important areas of research. The International Civil Aviation Organization (ICAO) imposes regulations that limit the maximum noise exposure from aircraft at three crucial positions during its flight envelope (Jenkinson et al. 1999). For certification purposes these are: below the approach, to the side-line of the runway and under the take-off path of the aircraft. The noise measurement location for the approach phase is situated at ground level 2 km from the start of the runway below the approach trajectory of the aircraft. During the aircraft acceleration phase for take-off, the measurement point is 450m to the side-line of the runway, with the departure measuring point being just below the take-off path of the aircraft at approximately 6.5 km from the start of the runway. The 1 noise limit for each of the three measurement points varies with respect to the aircraft take-off mass, but stands at a maximum allowable limit for aircraft heavier than 270 tonnes at 108 EPNdB (Jenkinson et al. 1999), which is the effective perceived noise level in decibels having taken into account the duration to its exposure and distance from its source (RAeS, 2004). The airframe noise sources generally include flap and wing trailing edges, flap and slat side edges, landing gears, cavities, spoilers, component inter action noise and sources associated with the fuselage and wing turbulent boundary layers (see their view by Crighton4 summarizing the early airframe noise research. Among these noise sources, landing gears and high-lift devices including slat and flap were identified as the two major airframe noise contributors. Further investigations on scaled models of the set two major-noise-source airframe components give the understanding of noise source mechanism that the airframe aerodynamic noise is normally caused by flow separation of bluff body and unsteady interactions between aerodynamic surface and turbulent flows, as shown in Fig. 1.

Fig 1 Flow separation and fluid-structure unsteady interaction on high-lift devices and landing gear of an aircraft causing the airframe aerodynamic noise

2.REVIEW OF LITERATURE

"Aeroacoustic Analysis of Fan Noise Reduction With Increased Bypass Nozzle Area" by Richard P. Woodward, Christopher E. Hughes, and Gary G. Pod boy, Glenn Research Center, Cleveland, Ohio stated that, An advanced model turbofan was tested in the NASA Glenn 9-by 15-Foot Low Speed Wind Tunnel (9 by 15 LSWT) to explore far field acoustic effects of increased bypass nozzle area. This fan stage test was part of the NASA Glenn Fan Broadband Source Diagnostic Test, second entry (SDT2) which acquired aero acoustic results over a range of test conditions. The baseline nozzle was sized to produce maximum stage performance at cruise condition. However, the wind tunnel testing is conducted near sea level condition. Therefore, in order to simulate and obtain performance at other operating conditions, two additional nozzles were designed and tested–one with +5 percent increase in weight flow (+5.4 percent increase in nozzle area compared with the baseline nozzle), sized to simulate the performance at the stage design point (takeoff) condition, and the other with a +7.5 percent increase in weight flow (+10.9 percent increase in nozzle area) sized for maximum weight flow with a fixed nozzle at sea level condition.

"Optimal control of aero acoustic noise generated by cylinder vortex interaction" published by S.S. Collis, K. Ghayour and M. Heinkenschloss. This paper presents an optimal control formulation and solution for an idealized Blade Vortex Interaction (BVI) problem. This problem consists of the interaction of an inviscid vortex pair with a circular cylinder in a steady Mach 0.3 uniform flow with wall-normal velocity used as control on the cylinder surface. This model problem captures the fundamental noise generation process of the BVI phenomena while mitigating many of the complexities of the full rotorcraft problem. The optimal control problem is solved using a gradient based method where gradient information is computed from a continuous ad joint analysis of the governing unsteady Euler equations. The BVI wave packet is targeted by defining an objective function that measures the square amplitude of pressure fluctuations in an observation region over a time interval of interest.

Project objective

Among the various environmental concerns, the aircraft noise item has been constantly growing in importance over the past years. While the flow speed becomes above the Mach 0.6, there is a need to suppression the noise level. Our study mainly focusing on the usage of optimized passive control devices for the given flow field, Small scale pins and vortex generators placing at span wise causing the disturbance in the flow. The study has been carried out at varying elevation angles ($\alpha = 0^{o}, 30^{o}, 45^{o}$) and in height from $h/\delta = 1$ to 5, where δ is the height of the incoming boundary layer. For computational work, the setup model was created and drawn in CATIAV5 and they were meshed in ICEMCFD. This model was read in to CFX where flow boundary conditions were applied and the discretized Navier-Stokes equations were solved numerically. In this the flow frequency is analyzed by changing the velocities. Various parameters has been analyzed and measured under various velocity ranges and the results were obtained using CFX.

3.Methodology

The methodology we employed to carry out this project is shown in the flow chart below.

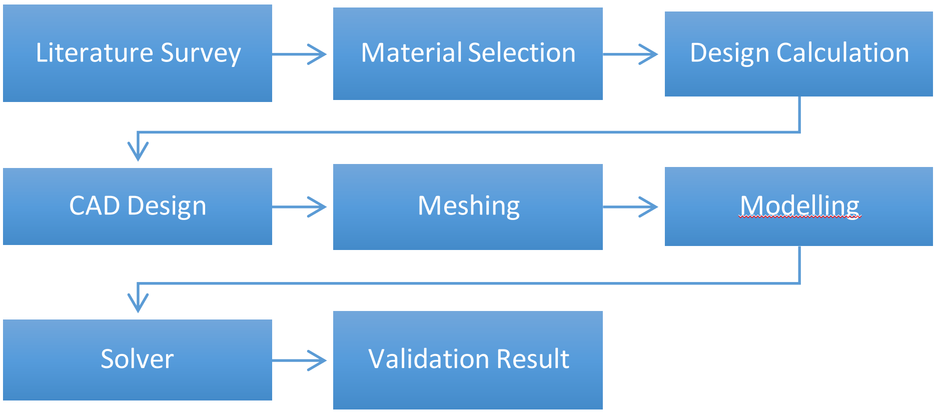


Fig 2: Methodology

Modelling

In this project work the model was designed using CATIA V5 Designing software. **CATIA** (an acronym of **computer aided three-dimensional interactive application)**, is a multi-platform software suite for computer aided design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE), PLM and 3D, developed by the French company Dassault Systems.

Commonly referred to as a 3D Product Lifecycle Management software suite, CATIA supports multiple stages of product development (CAX), including conceptualization, design (CAD), engineering (CAE) and manufacturing (CAM). CATIA facilitates collaborative engineering across disciplines around its 3DEXPERIENCE platform, including surfacing & shape design, electrical, fluid and electronic systems design, mechanical engineering and systems engineering.

CATIA facilitates the design of electronic, electrical, and distributed systems such as fluid and HVAC systems, all the way to the production of documentation for manufacturers.

4.Computational Model

Geometry

The models which were designed for this computational analysis are shown in the following figures.

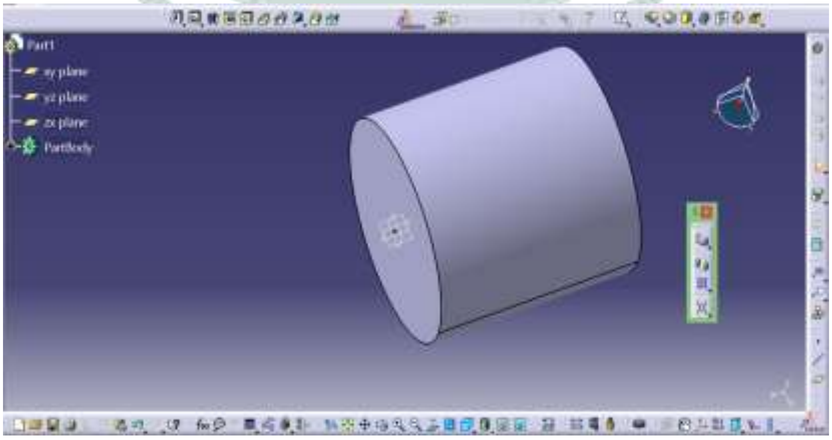


Fig 3: Cad Model

Meshing is process of discretizing a whole volume in to numerous nodes. So that we could analyze the changes occurred in each nodes while applying any external forces. The mesh type selected here was tetra, since the structure is a complicated structure and the numbers of nodes details are given below

Number of nodes 10388
Number of elements 1336653
Mesh type Tetra

The following figure shows the wireframe mesh of the whole model

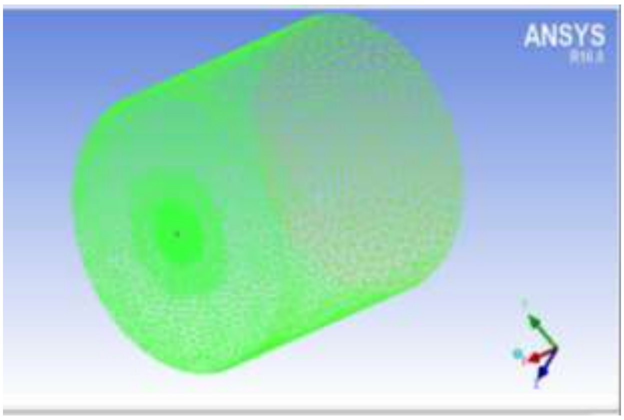


Fig: 4 Meshed wireframe model

The following figure shows the 3D meshed model

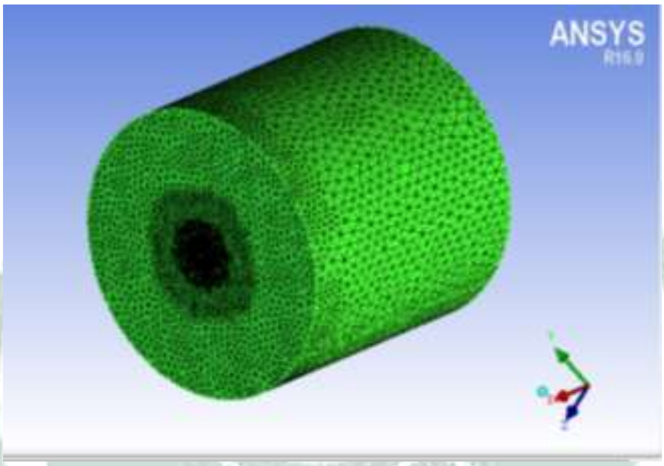


Fig: 5 Meshed 3D model

The following figure shows the wireframe and 3D meshed model of the inserted tab to reduce the acoustic effects.

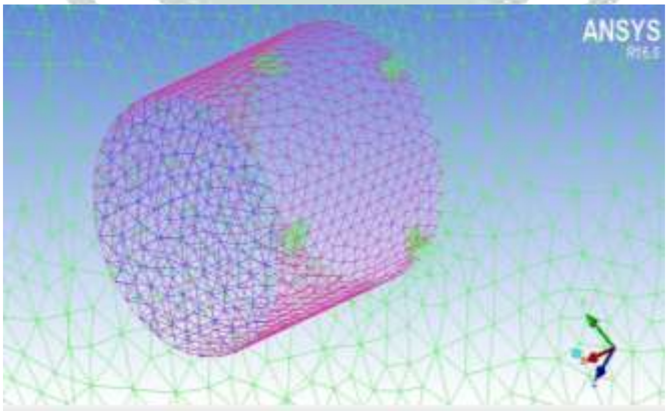


Fig: 6 Wireframe meshing over control tab

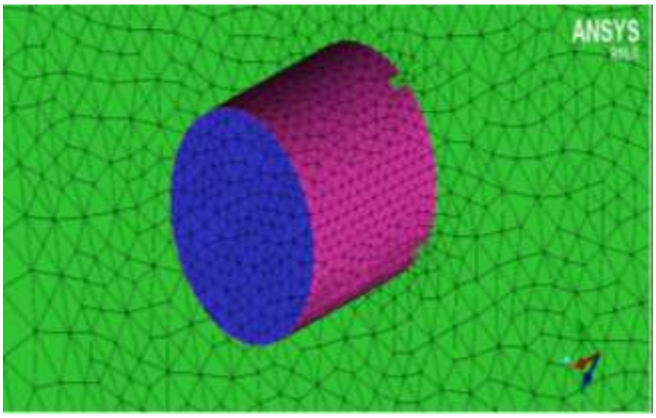


Fig: 7 3D meshing over control tab

5. RESULTS AND DISCUSSIONS

Solver

Using ICEMCFD software the model has been meshed and the boundary conditions were applied. We are exporting this meshed model to the solver to get the mixing pattern and velocity distribution pattern results. The solver we choose to find these results is ANSYS CFX.

The Model was designed in CATIA and then imported to the working field of ICEMCFD. Using ICEMCFD software the model has been meshed and the boundary conditions were applied. We are exporting this meshed model to the solver to get the mixing pattern and velocity distribution pattern results. The solver we choose to find these results is ANSYS CFX.

ANSYS, Inc. is an American Computer-aided engineering software developer headquartered south of Pittsburgh in Cecil Township, Pennsylvania, and United States. Ansys publishes engineering analysis software across a range of disciplines including finite element analysis, structural analysis, computational fluid dynamics, explicit and implicit methods, and heat transfer.

Pressure contour:

At 0 degree:

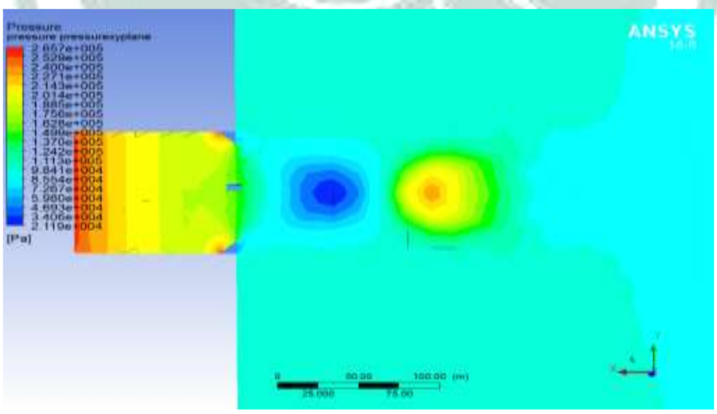


Fig: 8 Pressure contour at 0 degree

At 30 degree:

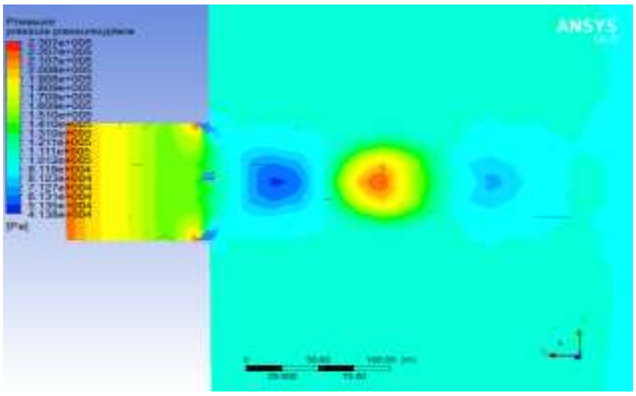


Fig: 9 Pressure contour at 30 degree

At 45 degree:

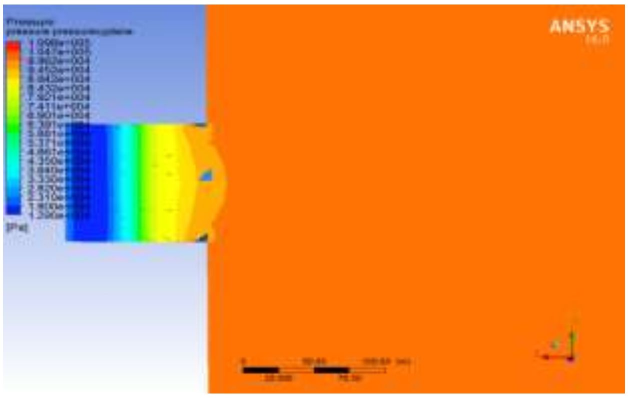


Fig: 10 Pressure contour at 45 degree

Velocity contour:
At 0 degree:

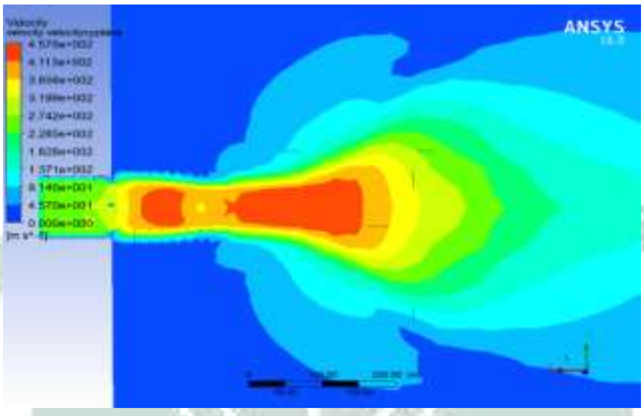


Fig: 11 Velocity contour at 0 degree

At 30 degree:

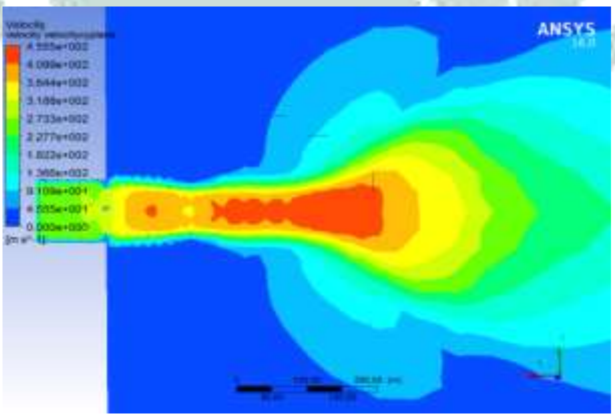


Fig: 12 Velocity contour at 30 degree

At 45 degree:

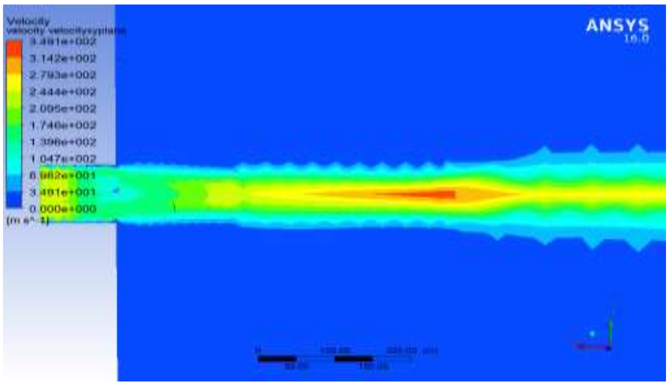


Fig: 13 Velocity contour at 45 degree

Acoustic Power contour at lb:

At 0 degree:

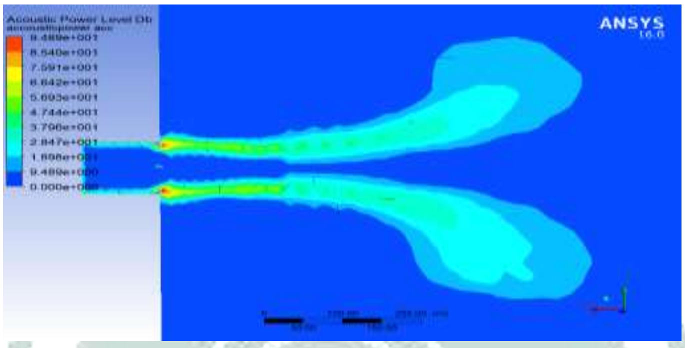


Fig: 14 Acoustic Power contour at 0 degree

At 30 degree:

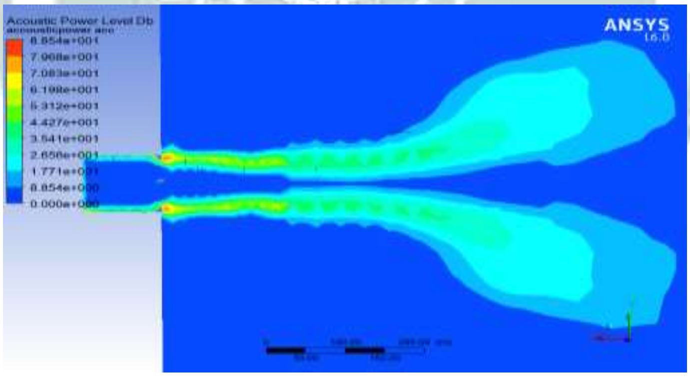


Fig: 15 Acoustic Power contour at 30 degree

At 45 degree:

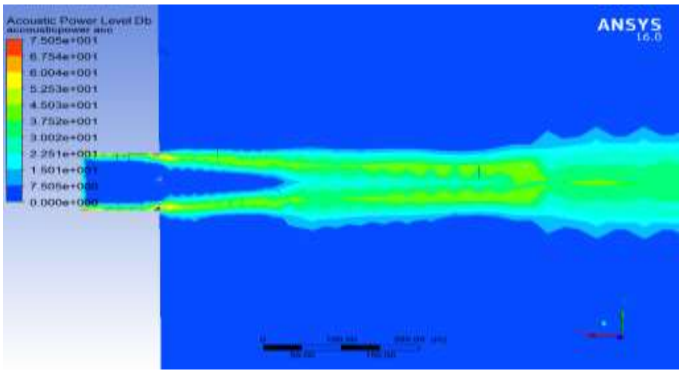


Fig: 16 Acoustic Power contour at 45 degree

Acoustic contour:

At 0 degree:

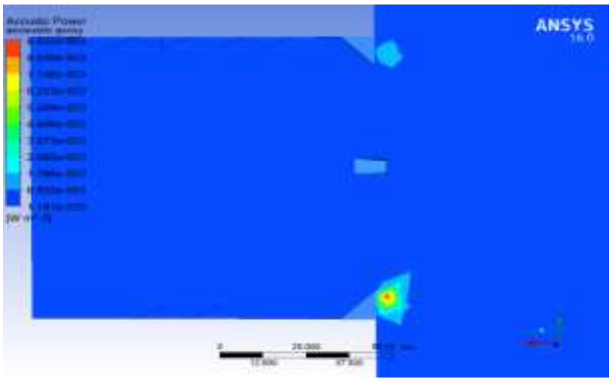


Fig: 17 Acoustic contours at 0 degree

At 30 degree:

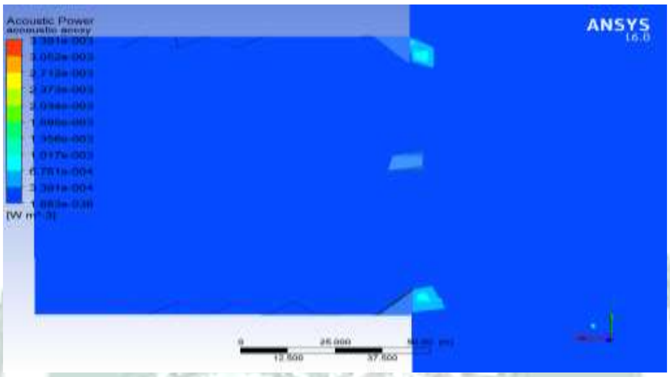


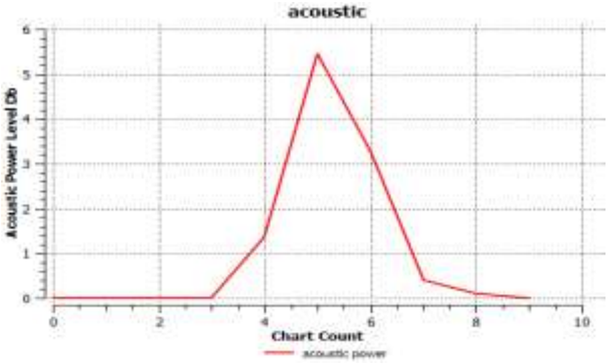
Fig: 18 Acoustic contours at 30 degree

At 45 degree:

Fig: 19 Acoustic contours at 45 degree

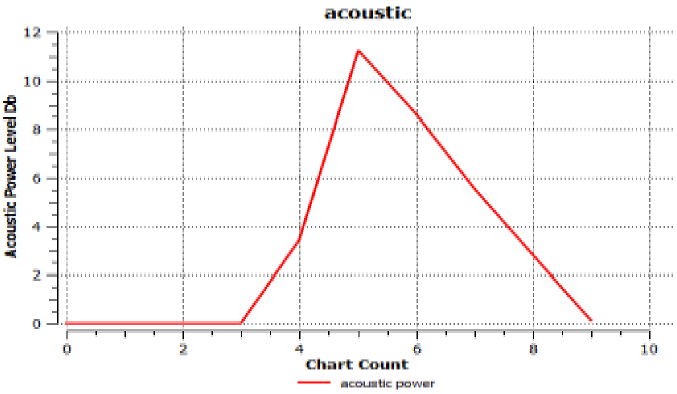
Acoustic Power plot:

At 0 degree:



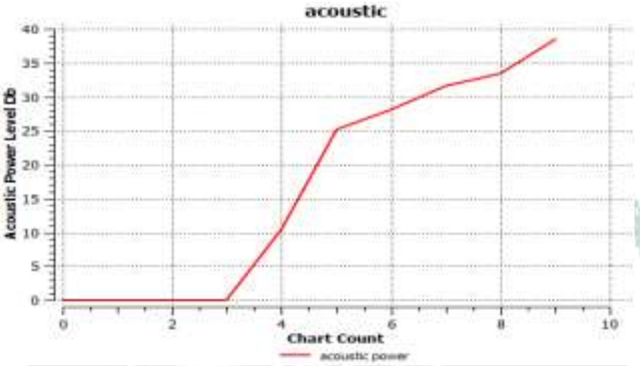
Graph 1 Acoustic Power Plots at 0 degree

At 30 degree:



Graph 2 Acoustic Power Plots at 30 degree

At 45 degree:



Graph 3 Acoustic Power Plots at 45 degree

When we compared our obtained results with standard models without tabs it shows efficient reduction in acoustic effects.

6. CONCLUSION

Aircraft noise, after roadway traffic, is the second largest source of environmental noise pollution and therefore of considerable concern to urban areas surrounding most major airports (Smith, 2004). With the advances made in aerospace technology, air transportation is being used much more frequently than in the past and this continuing growth in the popularity of air travel has led to predictions by European aircraft manufacturer, Airbus, of an increase in global air passengers by almost 4.9% a year, with the freight industry also expected to grow by 5.8% annually. High levels of growth over the past decades have led to an increase in noise intensity around airport communities and have been met by stringent aircraft regulations and noise certification requirements to suppress them. In the light of this, the field of aero acoustics has attracted much attention, with aircraft noise reduction becoming one of the most important areas of research. Among the various environmental concerns, the aircraft noise item has been constantly growing in importance over the past years. Measures for its reduction at the source as well its mitigation around airports must take into account aspects of medicine and technical design as well as legal and land use planning aspects. While the flow speed becomes above the Mach 0.6, there is a need to suppression the noise level. Noise reduction techniques can be broadly classified as passive and active methods. Passive control involves reducing the radiated noise by energy absorption, while the active method involves reducing source strength or modifying acoustic field in the flow to obtain noise reduction. Our study mainly focusing on the usage of optimized passive control devices for the given flow field, Small scale pins and vortex generators placing at span wise causing the disturbance in the flow. The study has been carried out at varying elevation angles and in height from h/δ = 1 to 5, where δ is the height of the incoming boundary layer. The purposes of the investigation are to be characterizing the flow-field for flow visualization and pressure recovery measurements.When we compared our obtained results with standard models without tabs it shows efficient reduction in acoustic effects.

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