JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

DESIGN OF NOISE ATTENUATED AIRCRAFT WITH DIMPLED WINGS

Rakesh Kumar Shah[1], M.G. Rajagopal[2], Bijay Kumar Sah[3], Nitesh Prasad Mandal[4], Sangmeshwar Pratap Patel[5]

[1,3,4,5]Final Year Aeronautical Engineering, Excel Engineering College
[2]Assistant Professor, Department of Aeronautical Engineering
Excel Engineering College, Tamil Nadu, India

---***---

Abstract - *The ever-present challenges in the aeronautical engineering industry are drag and noise reduction. Since, the aircrafts are powered by various types of propulsion and powerplant systems that can be either turboprop, turbofans, turbojet the noise produced by them differs depending upon their needs and requirements. Due to the continuous growth over the past few decades in the aviation industry, it is also expected that it will continue to undergo continuous growth over the upcoming few decades and several future demands may be increased for aerial transportation. Thus, it is broadly acknowledged that with the increasing demand of commercial aircraft for transportation there arises a lot of environmental issues, out of which noise pollution being the most notable cause that influences the human society. This paper presents the current methods along with our proposed technology that can be incorporated in a commercial aircraft in order to mitigate the noise pollution problem caused in the vicinity of airports also along with increment of aerodynamic efficiency by embedding dimples over the wing surface. Thus, this paper has explored solutions for two major affairs faced by present aviation industry and aircraft manufacturers.*

***Key Words*: Noise pollution, Noise reduction, Drag reduction, Aerodynamic efficiency, Dimples etc.**

1.INTRODUCTION

Over the past decades, various researches, experiments and studies have been conducted by researchers, aircraft manufacturers which provides the insights of seriousness caused by aircraft noise to human society and environment and have come up with the best possible solution for these problems of attenuating the noise produced by commercial aircraft by implementing of various recent noise reduction technologies such as fan flow deflectors, chevron nozzles etc. Also, at present, various types of modifications have been implemented so as to improve the aerodynamic efficiency of the aircraft, one of those modification which we have considered and implemented is dimple. In simple words, dimple can be defined as a slight natural project in the surface. There are mainly two types of dimples based on its projection side i.e., inward dimples and outward dimples. Through the in-depth study based on Golf ball theory, we came up with a new concept of introducing dimples on the surface of the wing. Further, we also decided to choose the best possible airfoil option for our wing that too from an already existing aircraft i.e., NACA 23015.Therefore, here through this paper we came up with a new concept of implementing two different ideas i.e., introducing dimples on the surface of the wing and also possible noise reduction technology to reduce the pressure drag and increase lift coefficient as compared to the simple airfoil along with noise attenuation.

2. LITERATURE SURVEY

Here, for the literature survey we have downloaded and studied separate research papers and articles of noise reduction technology and dimpled wing in order to get in-depth information regarding the noise mitigation and drag reduction mechanism so that we can easily incorporate them in our design model.

"*Computational Analysis Over NACA-23015 Airfoil for Flow Separation Delay using Passive Flow Separation Techniques*" by "*S. Ram Sai, K. Sai Priyanka, R. Sabari Vihar*" studied flow separation delay which involves methods using passive flow separation delay techniques. This report reviews the suction control over boundary layer method in depth there by making it easy to understand controlling of boundary layer separation. Analysis on Flow separation delay over NACA-23015 airfoil are conducted by varying velocity and Slots placement along the chord. This work helps further researchers in identifying and selecting the best position for suction Slots for better aerodynamic properties in designing a wing.

"*Flow Control over Airfoils using Different Shaped Dimples*" by "*Deepanshu Srivastav*" has studied to improve the maneuverability and performance of an aircraft by flow manipulation over the NACA0018 airfoil. In order to verify the effect of dimples, computational study has been made starting from 2D study of inward and outward dimpled airfoil. The dimples have increased the aerodynamic efficiency which therefore helps in improving the performance.

"*Flow Analysis around the Dimple Wing on Aircraft*" by "*Mohanasaravanan P S*" aims to design a wing with dimples on the upper surface of the wing and analyze the results using design software ICEM CFD and CFX in ANSYS. The results show an increase in the stall angle, flow separation point and decreases the pressure drag but skin friction point drag will increase due to attached flow over the surface of the wing. A comparative study is done which shows the variance in lift and drag of modified airfoil models with and without dimple over the wing surface at various angle of attack.

"*Technological Innovations for Noise Reduction in Turbofans and Airframes*" by "*Rakesh Kumar Shah, Dr. P. Karunakaran, Sumit Pandit, Nitesh Prasad Mandal and Pradeep Kandel*" discusses and analyzes the major principles involved in the jet noise and airframe noise production. We have also reviewed about various measures and innovations that have been done over the period for reducing airframe noise and exhaust noise. Some of the examples of the technology that has been presented here are chevrons, increasing by-pass ratio, incorporating greater number of stator vane count, increasing distance between rotor and stator etc. Thus, we believe that the work done in this paper will be particularly useful for the students, researchers to understand about reasons of aircraft noise production and also aid the researchers to incorporate modern innovative ideas for further reduction of aircraft noises.

"*Noise reduction by aircraft innovations*" by "*Ulf Michel*" studied and carried out a survey regarding sources of aircraft noise, assessments of achievements in aircraft noise reduction with the aid of certification noise levels, innovations in engines, current turbofan engines etc. He also concluded that Political support in form of continuous and lasting research funding is necessary and new engine concepts with large fuel savings potential will lead to a great challenge for noise research.

3. PROBLEM DEFINITION

All around the globe, many commercial aircraft and remarkable hours of flight is found to be going on, in daily bases and the only reason is the increase of congestions on the roadways and discomfort faced due to it. Thus, this is also one of the key reasons of the public for choosing aerial transportation means over road transport ones. On an average, almost all the commercial aircrafts produce and exceeds 140 decibels during takeoff which is far more than the audible range of human ears. Because of this reason, noise is considered to be one of the key problems linked to aviation industry since this unwanted noise leads to various health issues as well as negative social and economic effects. Some of the health issues that can be faced are sleep disturbance, community annoyance in and around the airport areas, cardiovascular diseases as well as mental health issues. It has been found that petitioners are protesting about various aspects of noise disturbance and inquiring for mitigation actions to be taken to unravel these issues. Not only this, but the pressure drag produced in the aircraft has significantly aided in reducing the aircraft's aerodynamic efficiency which also needs to be taken into consideration.

4.RESEARCH OBJECTIVES

The main research objectives of our project are listed below:

- ✓ To design and manufacture an alternative aerial transportation system to avoid noise pollution.
- ✓ By mitigating the level of noise pollution caused by aircrafts, it also caters to healthy and sound environment.
- ✓ To improve the current existing wing design of aircrafts by introducing dimples on its surfaces.
- ✓ To achieve enhanced and ecologically sound environment by improving aerodynamic efficiency and noise reduction methods in the aircrafts.

5. PROPOSED DESIGN FOR NOISE ATTENUATION

After a thorough study and detailed examination about aircraft noise and its main sources (turbofan engines and airframe as discussed in this paper) we came to a conclusion that various components need to be designed and improved in order to reduce noise produced from turbofan engines and airframes.

- ➢ The first one is deploying a fan flow deflector which is specially designed with the purpose to keep the exhaust coaxial but deflect the secondary (fan) flow through vanes or similar devices in the secondary flow path. It is mainly incorporated for reducing convective Mach number of turbulent eddies that generate intense downward and sideward sound radiation. The deflectors thicken the low-speed flow underneath the core jet, resulting in lower noise emission towards the ground.
- ➢ Similarly, another technology that can make significant contribution for noise reduction is Active noise control. It's working principle is just to produce a sound field that is exactly the mirror image of the offending sound. Hence, active noise cancels out the disturbance with the net result of significantly reduced sound.
- ➢ Combining Chevrons and Microjet together so as to use simultaneously. The combination of these methods is more beneficial than each method alone this is because of its unique feature of applying micro jets to the shear layer at the tip of chevrons.
- ➢ In the main landing gear, a porous cover to decelerate the airflow around the noise source between the wheels and its supporting frames can be designed and installed. Similarly, deflectors for the landing gear bay can also be applied along with landing gear mesh fairings.
- ➢ Porous devices along with flap edge noise reduction fins can be applied at the edge of flaps and tip of an aircraft flap so as to reduce flap side edge noise and airframe noise.
- ➢ Measures such as width reduction of slat gap can be implemented to reduce slat noise, further increasing of By-pass ratio.

6.PROPOSED DIMPLED WING DESIGN

The sole aim of this project is to study and analyze the effect of dimples on the surface of the wing and noise reduction technologies in the aircraft. Here we will broadly discuss the design of different models of airfoil and noise reduction methods that are implemented in our project work. This research consists of analysis of wing with normal NACA 23015 Series airfoil and with dimples over the same airfoil 's upper surface of the wing. Through the in-depth study it has been concluded that introducing a dimple at a specific position in an airfoil reduces the pressure drag at a specific angle of attack. Here, we have considered numerous dimples over the airfoil surface at a specific distance from the leading edge and analyzed its performance by alternating the velocity and angle of attack (AOA). For this, we have designed normal NACA 23015 airfoils, and the same airfoil with semi spherical dimples over its surface in SolidWorks.

The main reason for selecting semi spherical dimple is that because of its bluff body characteristic it can acquire some turbulent kinetic energy when placed in a flow separation regime can to stick to the surface and reduce drag since turbulent boundary layer flow has a larger momentum than ordinary laminar boundary layer and thereby delays the flow separation. The specifications of our proposed design of 3D model wing with dimples are given below in TABLE 1.

Airfoil Type	NACA 23015
Chord	100mm
Span of chord	25mm
Type of dimple	Semi Spherical dimple
Location of Dimples	8mm from the leading edge
Number of dimples	9
Diameter of dimples	1mm
Thickness/Extrusion of dimple	1mm
Centre to Centre distance between the dimples	2.5mm
Experimental Angle of Attack (AOA)	0,5,10,16 degrees
Velocity (m/s)	5,10,50
Material	Air

Table.1: Proposed Model Specifications

There are 2 models are created for the analysis:

1) The normal airfoil model with no dimples.

2) The airfoil with dimples on its upper surface.

6.1 SOLIDWORKS MODEL OF AIRFOIL

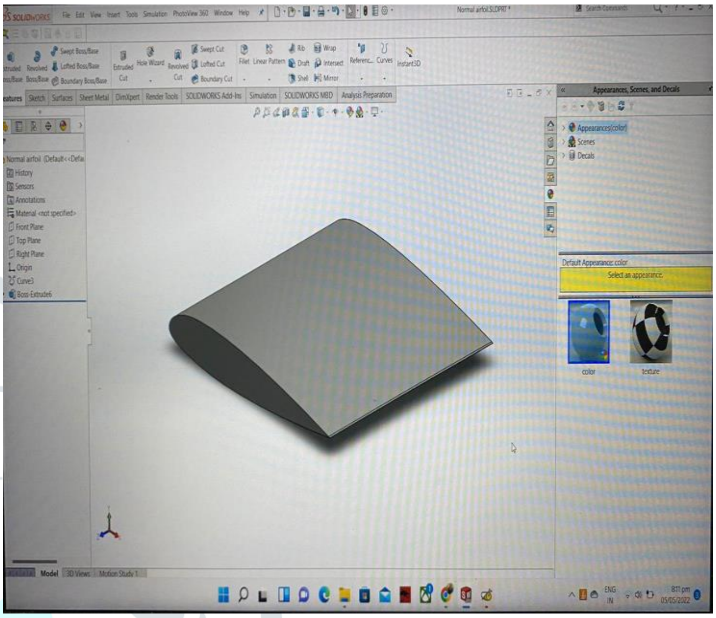


Fig.1: NACA 23015airfoil without dimple.

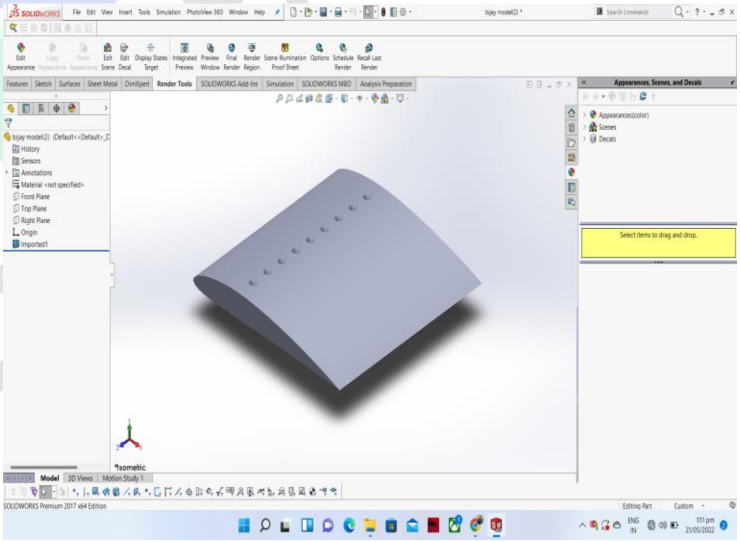


Fig.2: NACA 23015 airfoil with semi spherical dimple

6.2 ANALYSIS PARAMETERS

A parameter, generally, is any characteristic that can help in defining or classifying a system. A parameter is an element of a system that is useful, or critical, when identifying the system, or when evaluating its performance, status, condition, etc. Here, we have the following parameters in Table 2.

Table.2: Airfoil Specifications

S. No.	PARAMETERS	VALUES
1.	Chord length & Span length	100mm & 25mm
2.	Dimple radius	0.5mm
3.	Series Code	NACA 23015
4.	Experimental Angle of Attack (AOA)	0,5,10,16 (degrees)
5.	Material	Solid aluminum

6.3 MESHING CONDITIONS

Table.3: Meshing Conditions

S. No.	PARAMETERS	Type
1.	Method	Tetrahedral
2.	Patch	Independent
3.	Process	Medium

6.4 MESHING MODEL

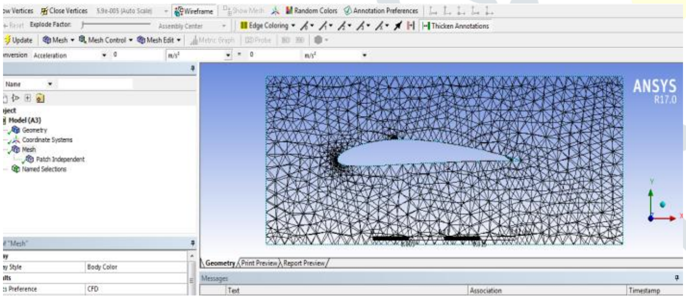


Fig.3: Meshing of Dimpled airfoil at 0 AOA

6.5 CALCULATIONS AND ANALYSIS

Various calculation parameters and values are required to obtain the accurate result. The various input required for analysis are in Table 4.

Table.4: Calculation Parameters

S.No.	PARAMETERS	VALUES/CONDITIONS
1.	Inlet Velocity	5,10,50 (m/s)
2.	Pressure	1 atm
3.	Gradient	Least squares cell based
4.	Pressure	Second order
5.	Momentum	First order upwind
6.	Turbulent Kinetic Energy	First order upwind
7.	No. of iterations	500
8.	Calculation model	k-epsilon
9.	Plots	C_L Vs AOA, C_D Vs AOA, C_L/C_D Vs AOA

7.RESULTS AND GRAPHS

7.1 Observation Table for Normal Airfoil without Dimple (C_d V_S AOA)

Table.5: C_d V_S AOA

AOA	5m/s	10m/s	50m/s
0	0.14151	0.01396	0.00846
5	0.03275	0.02177	0.01415
10	0.14203	0.04242	0.02841
16	0.15612	0.15204	0.06294

7.2 Observation Table for Normal Airfoil without Dimple (C_L Vs AOA)

Table.6: C_L Vs AOA

AOA	5m/s	10m/s	50m/s
0	0.07322	0.06948	0.05826
5	0.23373	0.22927	0.23373
10	0.22941	0.41647	0.46829
16	0.80093	0.80748	0.82596

7.3 Observation Table for Dimpled Airfoil (C_d Vs AOA)

Table.7: C_d Vs AOA

AOA	5m/s	10m/s	50m/s
0	0.023477	0.016218	0.00090542
5	0.032244	0.023645	0.017963
10	0.058915	0.043749	0.030325
16	0.19395	0.14835	0.085345

7.4 Observation Table for Dimpled Airfoil (C_L Vs AOA)

Table.8: C_L Vs AOA

AOA	5m/s	10m/s	50m/s
0	0.14025	0.16022	0.1808
5	0.34205	0.3804	0.4208
10	0.52922	0.58005	0.63935
16	0.88755	0.91745	0.94935

7.5 Plots of Normal Airfoil at 0 AOA

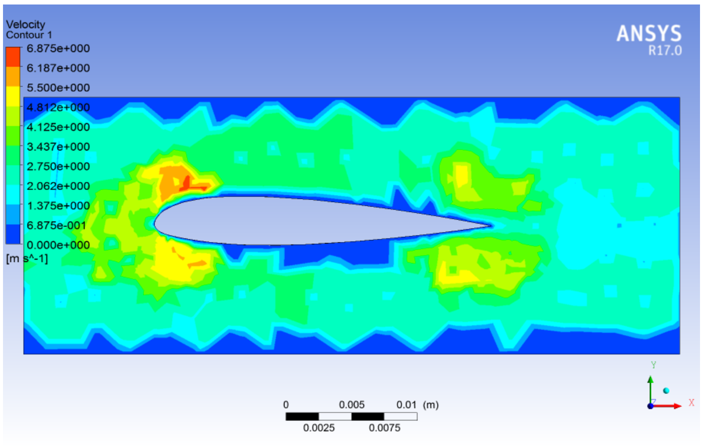


Fig.4: Velocity graph at 0 AOA(5m/s)

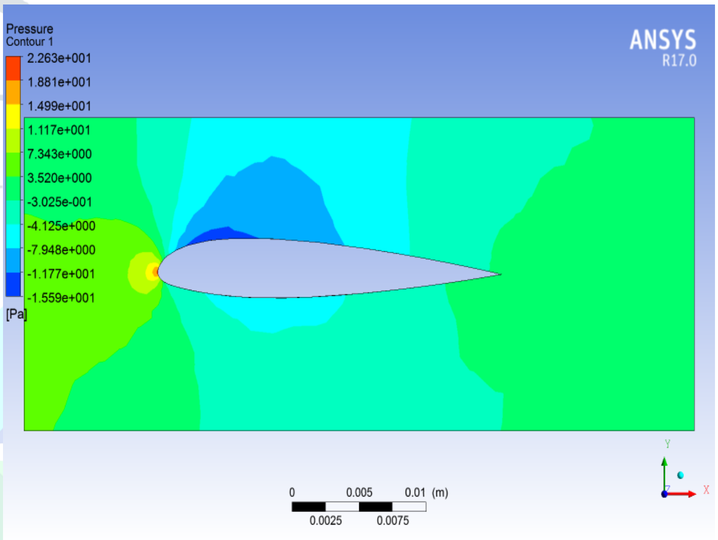


Fig.5: Pressure graph at 0 AOA(5m/s)

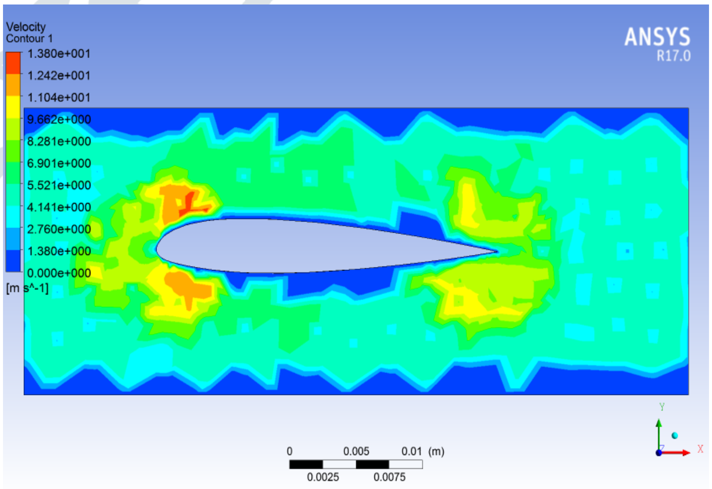


Fig.6: Velocity graph at 0 AOA (10m/s)

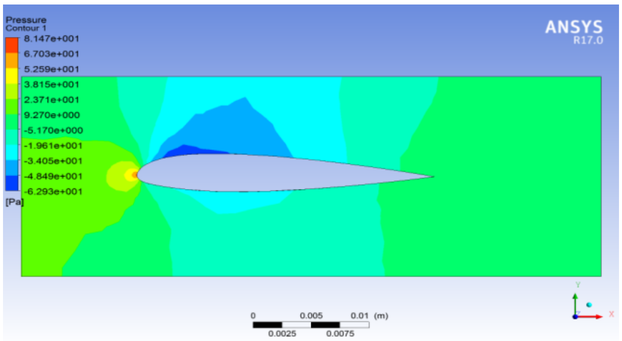


Fig.7: Pressure graph at 0 AOA (10m/s)

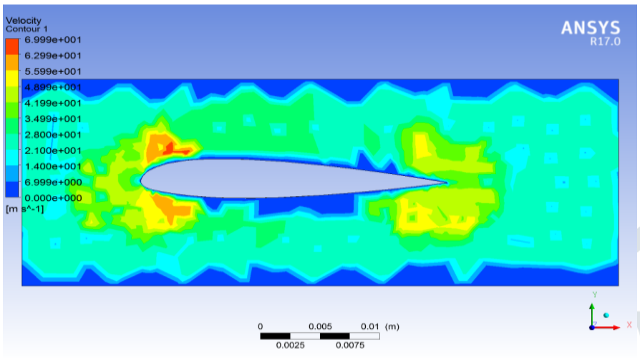


Fig.8: Velocity graph at 0 AOA (50m/s)

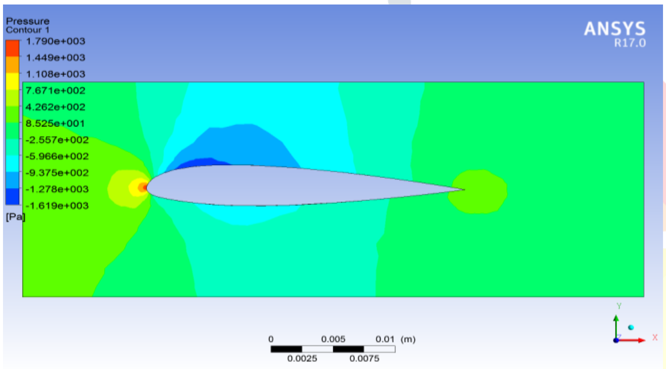


Fig.9: Pressure graph at 0 AOA (50m/s)

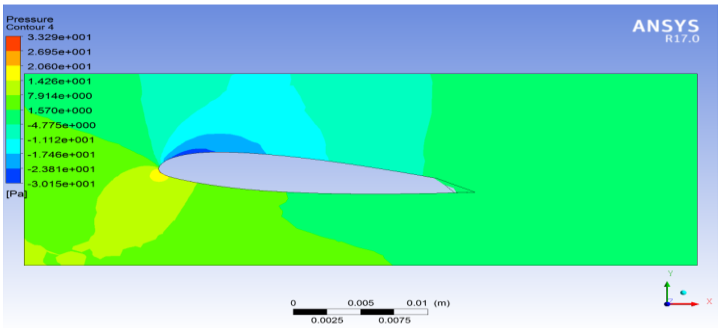


Fig.11: Pressure graph at 5 AOA (5m/s)

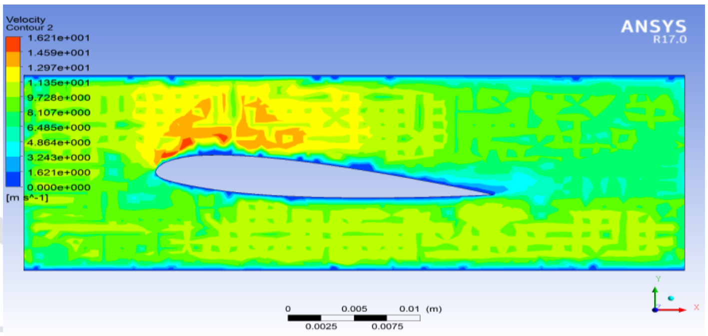


Fig.12: Velocity graph at 5 AOA (10m/s)

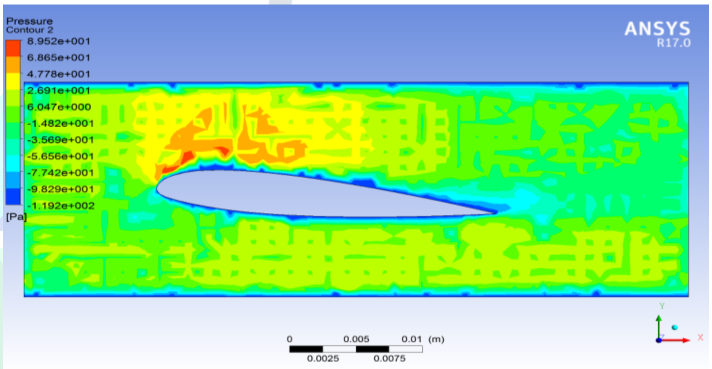


Fig.13: Pressure graph at 5 AOA (10m/s)

7.6 Plots of Normal Airfoil at 5 AOA

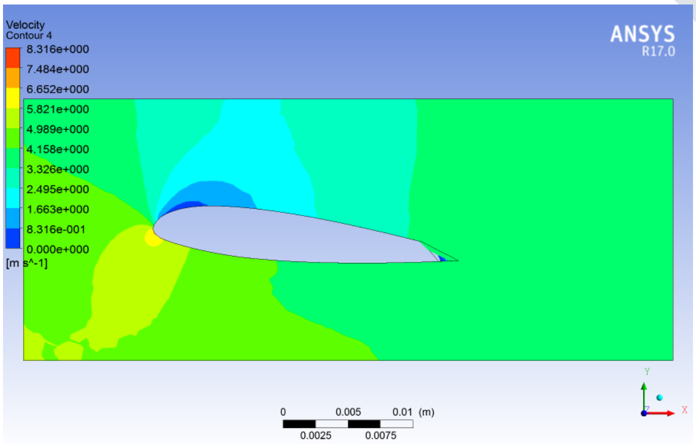


Fig.10: Velocity graph at 5 AOA (5m/s)

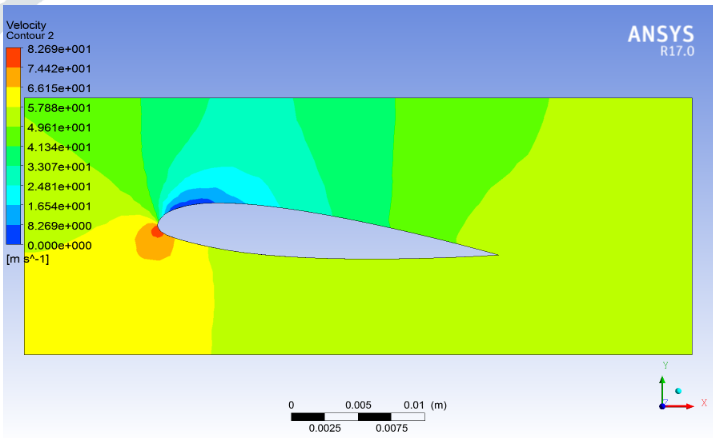


Fig.14: Velocity graph at 5 AOA (50m/s)

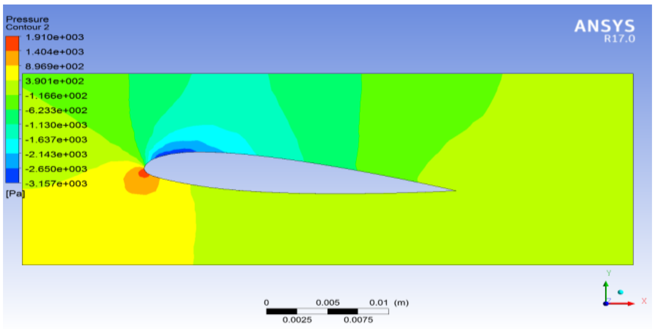


Fig.15: Pressure graph at 5 AOA (50m/s)

7.7 Plots of Normal Airfoil at 10 AOA

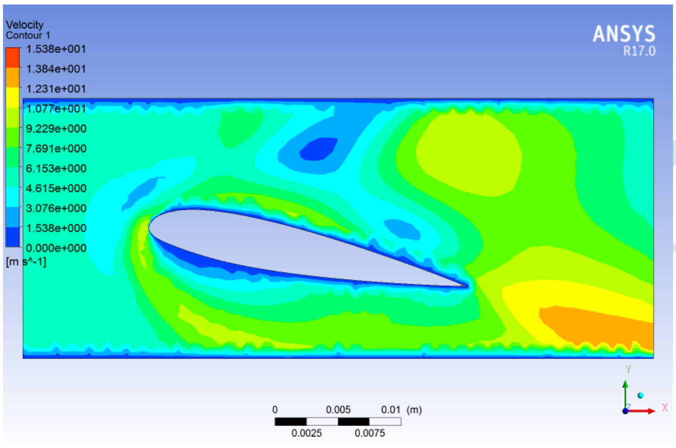


Fig.16: Velocity graph at 10 AOA (5m/s)

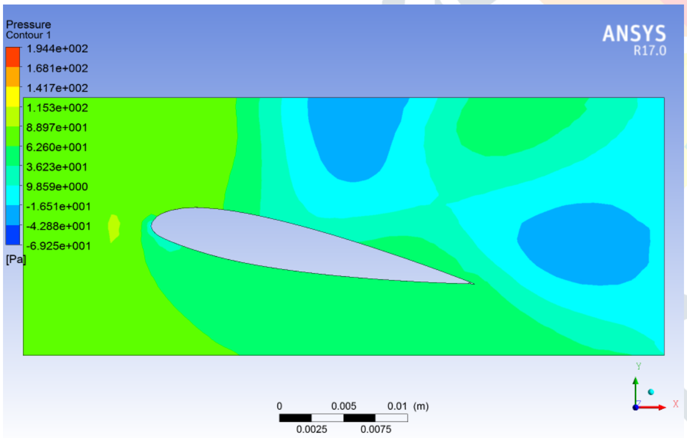


Fig.17: Pressure graph at 10 AOA (5m/s)

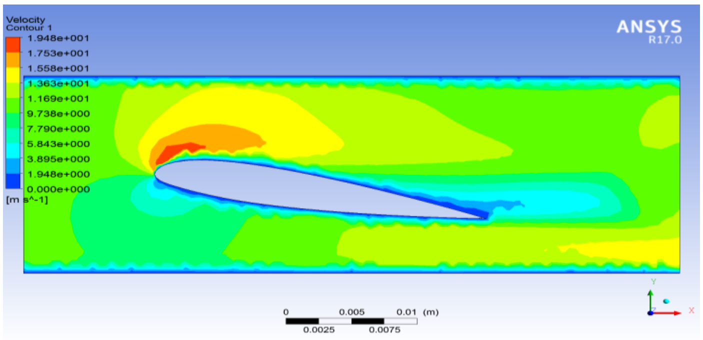


Fig.18: Velocity graph at 10 AOA (10m/s)

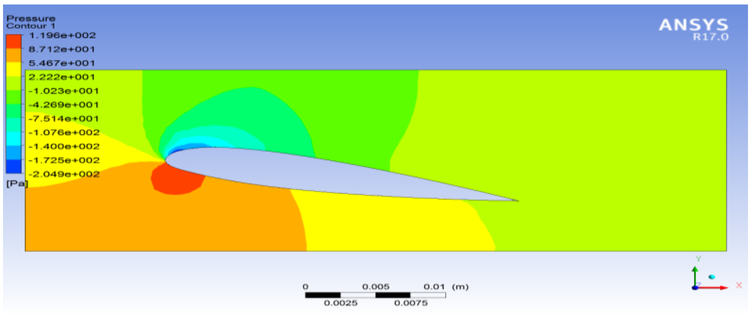


Fig.19: Pressure graph at 10 AOA (10m/s)

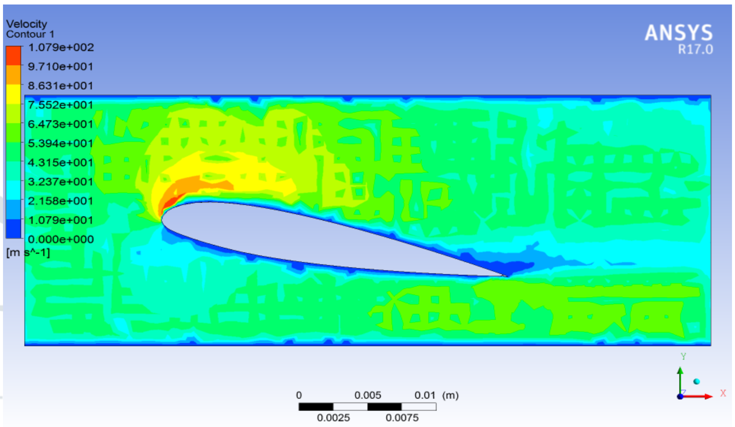


Fig.20: Velocity graph at 10 AOA (50m/s)

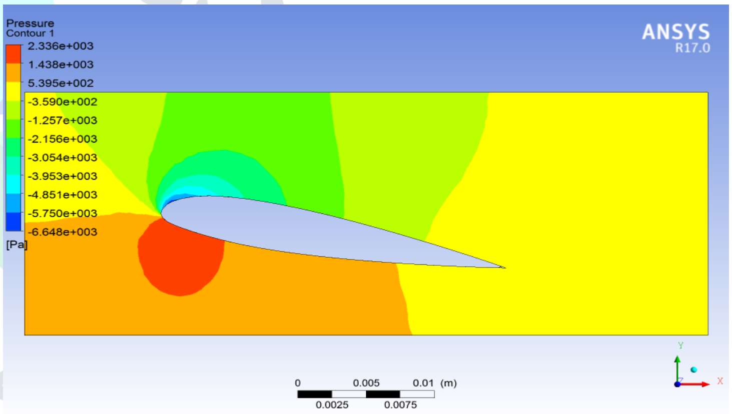


Fig.21: Pressure graph at 10 AOA (50m/s)

7.8 Plots of Normal Airfoil at 16 AOA

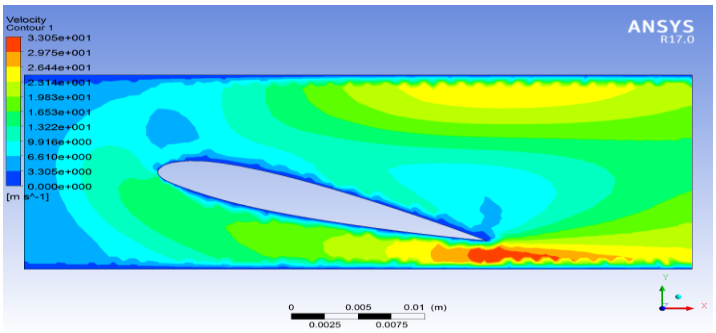


Fig.22: Velocity graph at 16 AOA (5m/s)

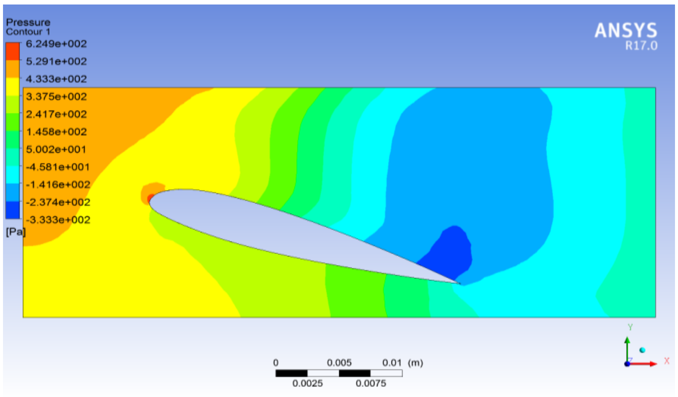


Fig.23: Pressure graph at 16 AOA (5m/s)

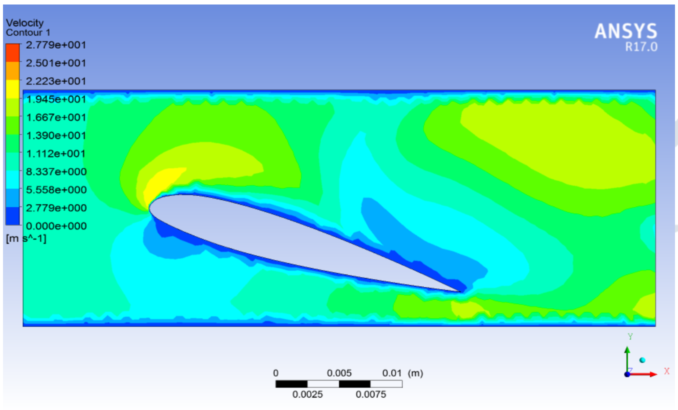


Fig.24: Velocity graph at 16 AOA (10m/s)

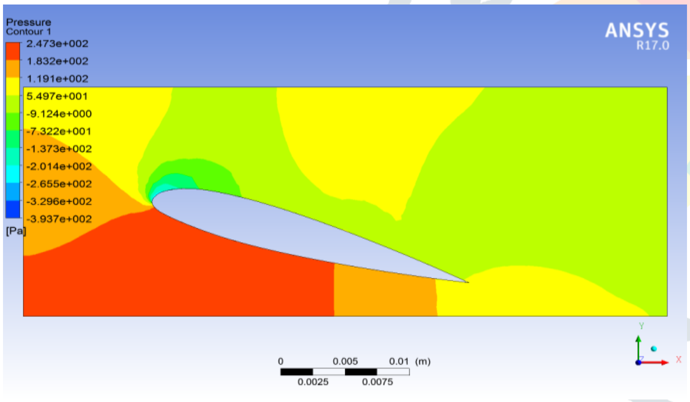


Fig.25: Pressure graph at 16 AOA (10m/s)

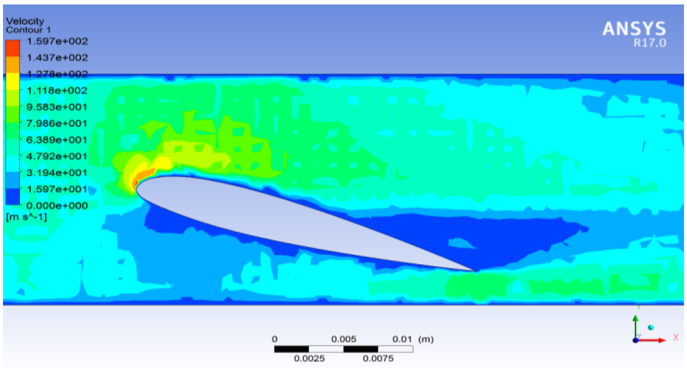


Fig.26: Velocity graph at 16 AOA (50m/s)

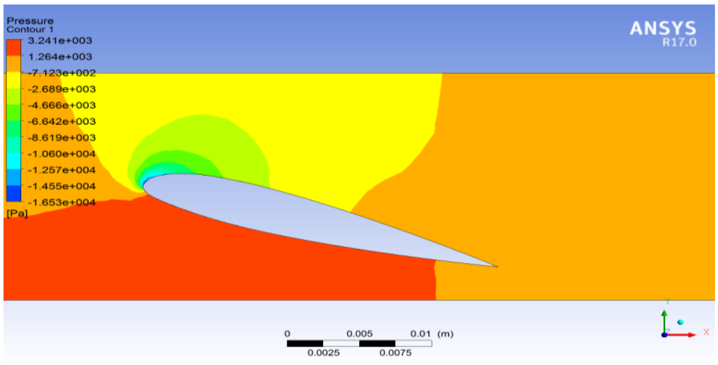
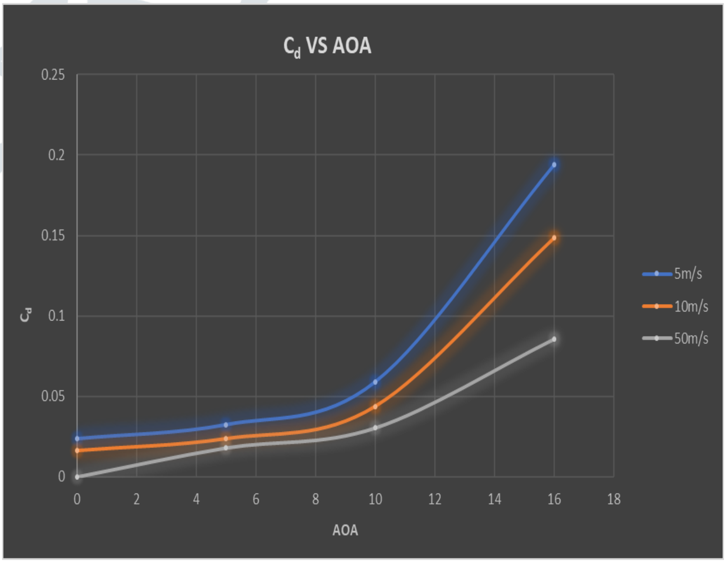


Fig.27: Pressure graph at 16 AOA (50m/s)

7.9 Graphs of Normal Airfoil (C_L V_s AOA and C_d V_s AOA)

Graph.1: C_L V_s AOA

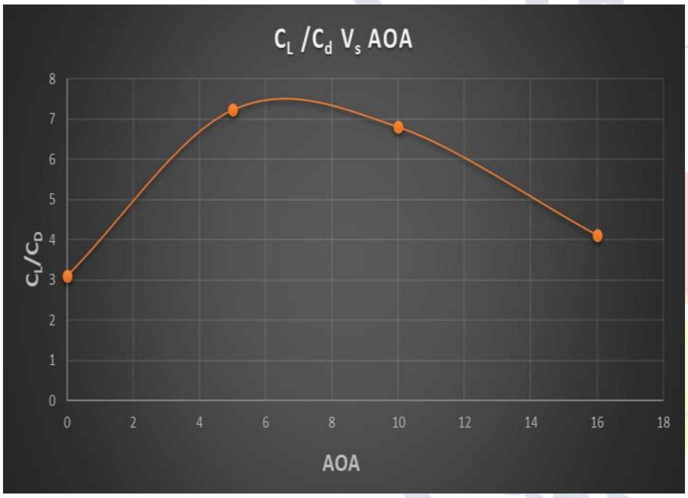


Graph.2: C_d V_s AOA

7.10 Table and Graph of Normal Airfoil (C_L / C_d Vs AOA)

AOA	5m/s	10m/s	50m/s
0	3.11	4.28	64.34
5	7.24	9.69	13.01
10	6.81	9.51	15.44
16	4.12	5.44	9.67

Table.9: C_L / C_d Vs AOA



Graph.3: C_L / C_d Vs AOA(5m/s)

8.PLOTS OF DIMPLED AIRFOIL

8.1 Plots of dimpled airfoil at 0 AOA

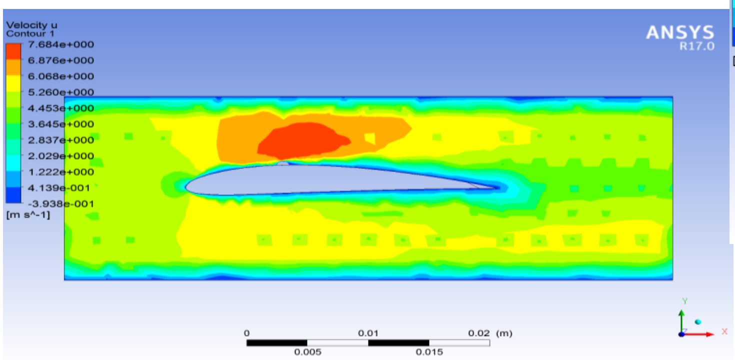


Fig.28: Velocity graph at 0 AOA (5m/s)

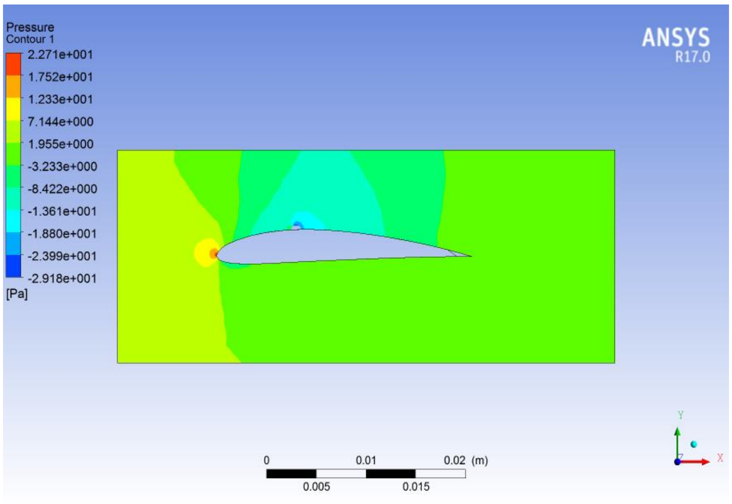


Fig.29: Pressure graph at 0 AOA (5m/s)

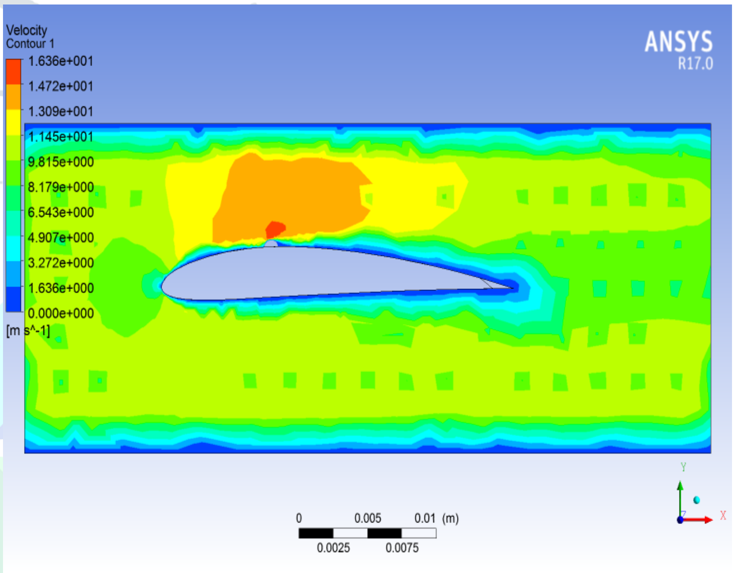


Fig.30: Velocity graph at 0 AOA (10m/s)

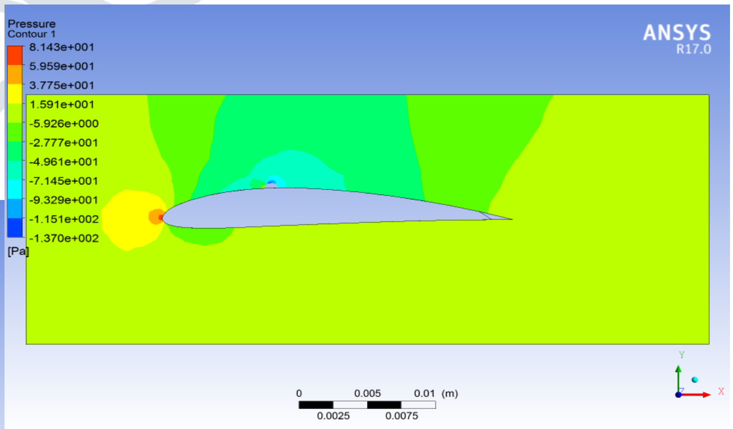


Fig.31: Pressure graph at 0 AOA (10m/s)

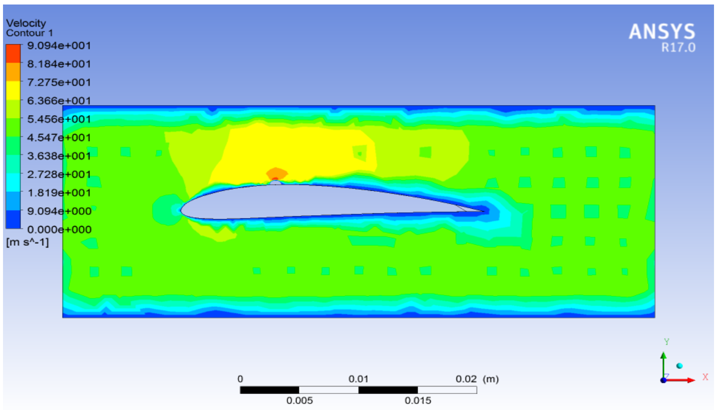


Fig.32: Velocity graph at 0 AOA (50m/s)

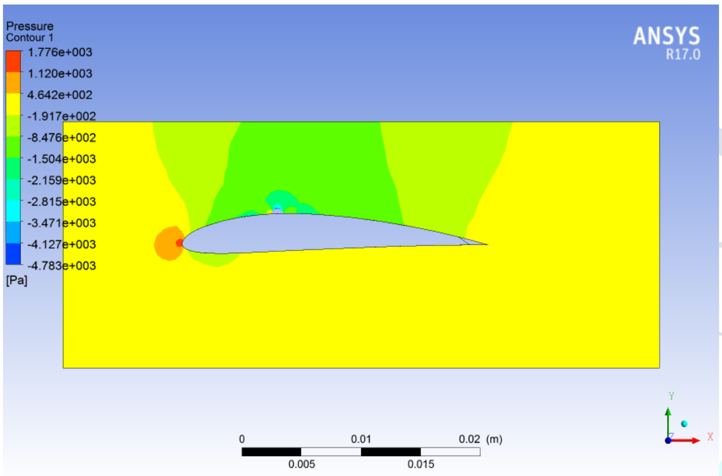


Fig.33: Pressure graph at 0 AOA (50m/s)

8.2 Plots of dimpled airfoil at 5 AOA

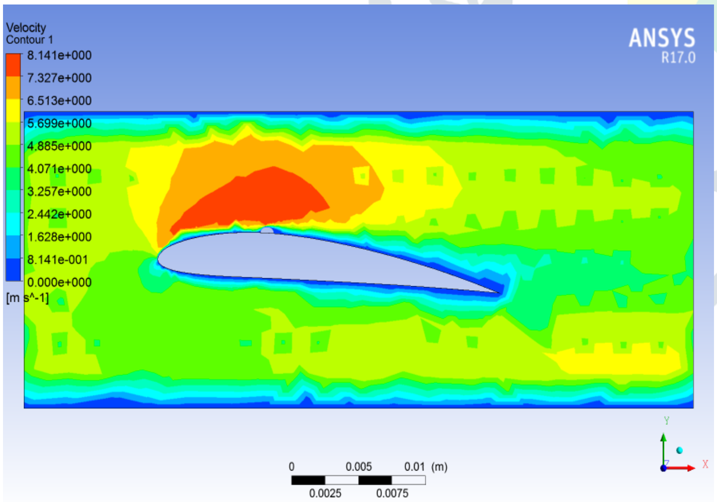


Fig.34: Velocity graph at 5 AOA (5m/s)

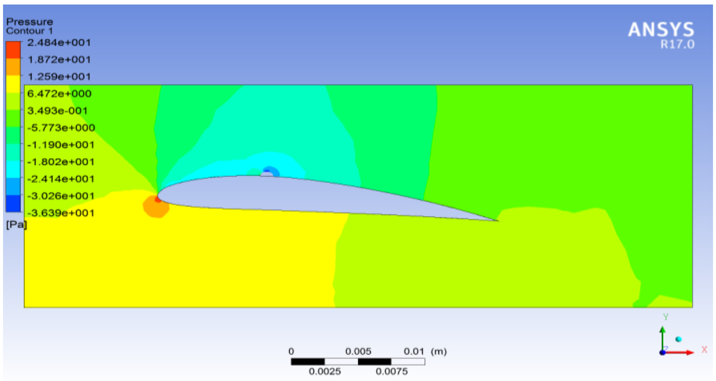


Fig.35: Pressure graph at 5 AOA (5m/s)

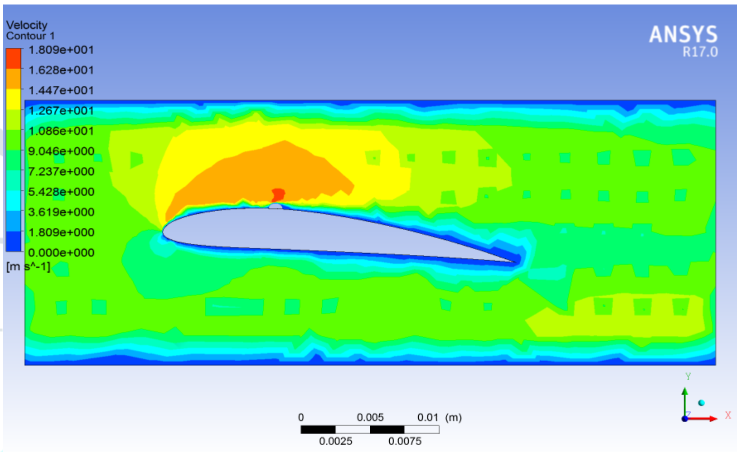


Fig.36: Velocity graph at 5 AOA (10m/s)

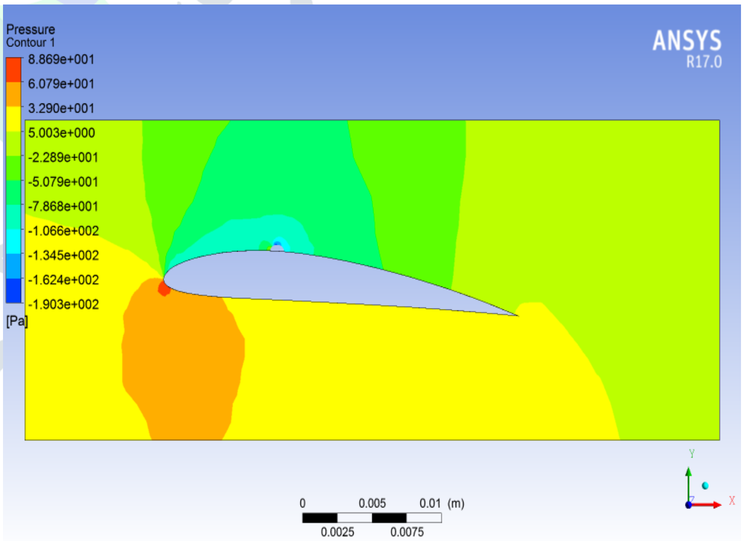


Fig.37: Pressure graph at 5 AOA (10m/s)

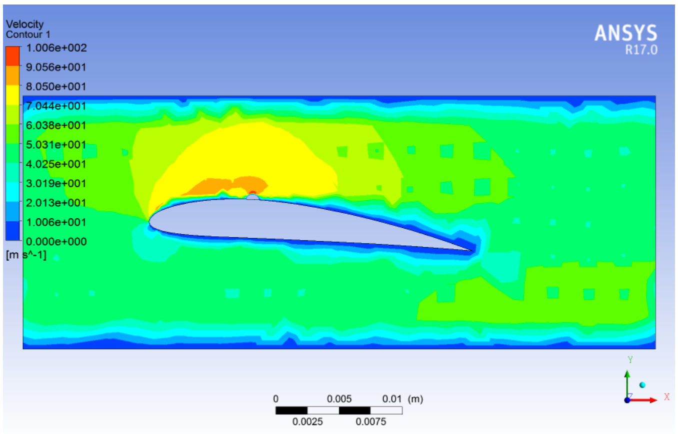


Fig.38: Velocity graph at 5 AOA (50m/s)

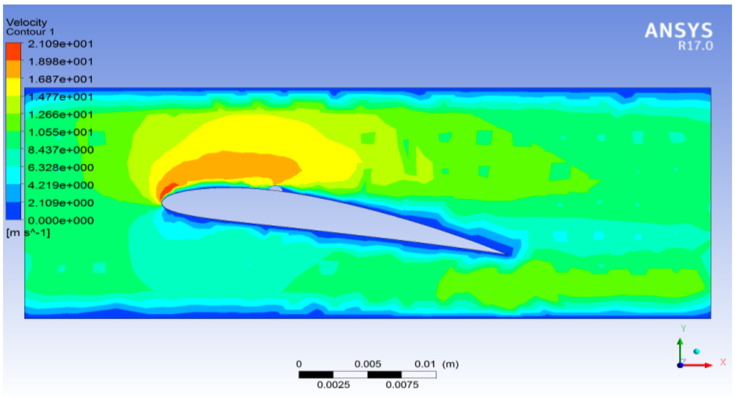


Fig.42: Velocity graph at 10 AOA (10m/s)

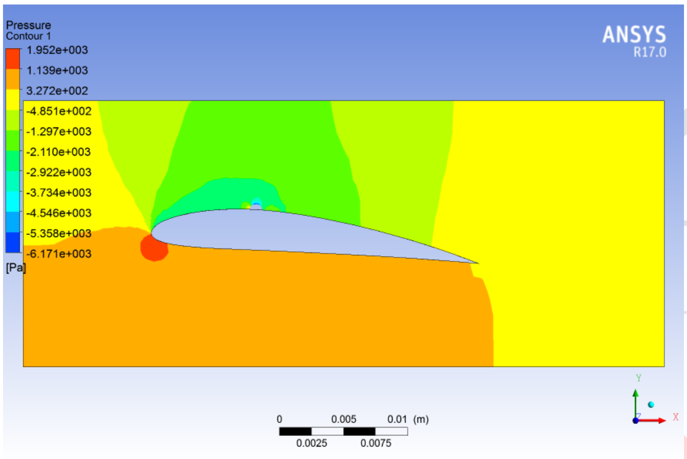


Fig.39: Pressure graph at 5 AOA (50m/s)

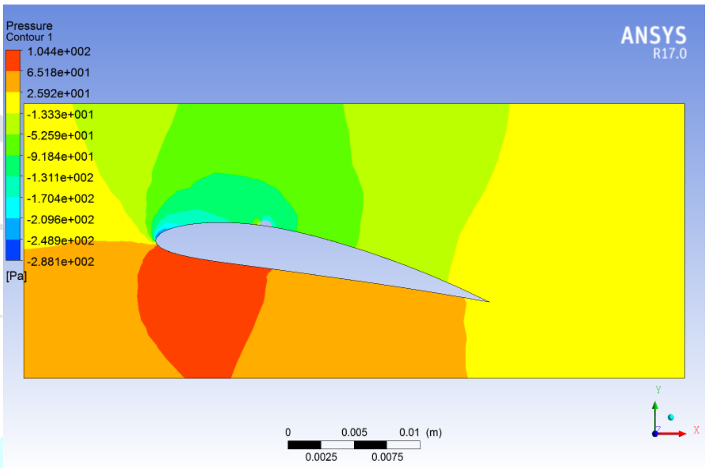


Fig.43: Pressure graph at 10 AOA (10m/s)

8.3 Plots of dimpled airfoil at 10 AOA

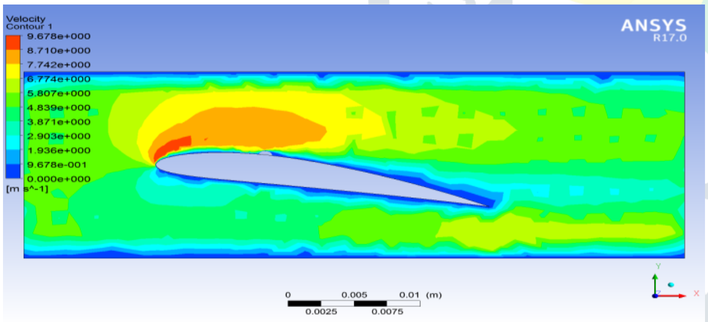


Fig.40: Velocity graph at 10 AOA (5m/s)

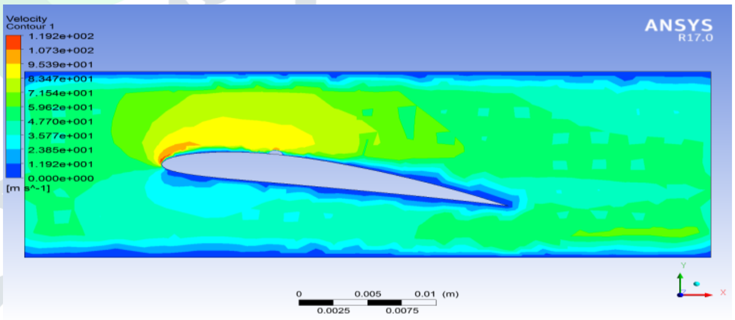


Fig.44: Velocity graph at 10 AOA (50m/s)

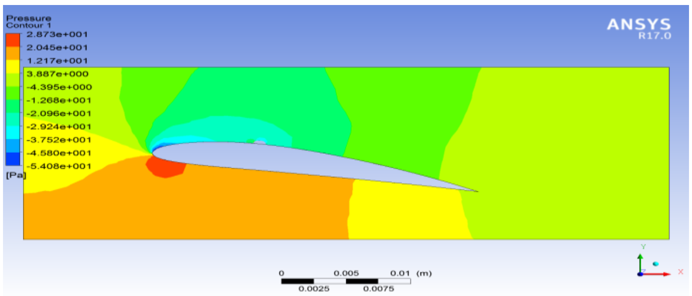


Fig.41: Pressure graph at 10 AOA (5m/s)

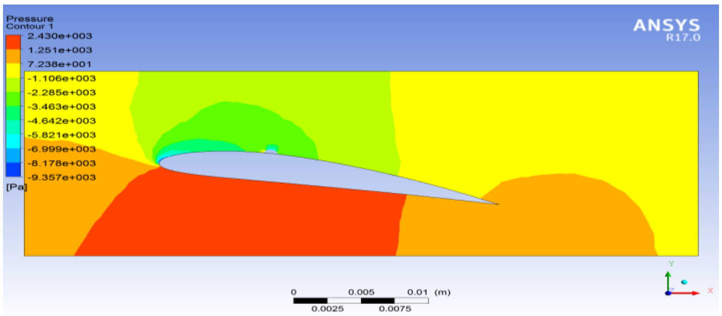


Fig.45: Pressure graph at 10 AOA (50m/s)

8.4 Plots of dimpled airfoil at 16 AOA

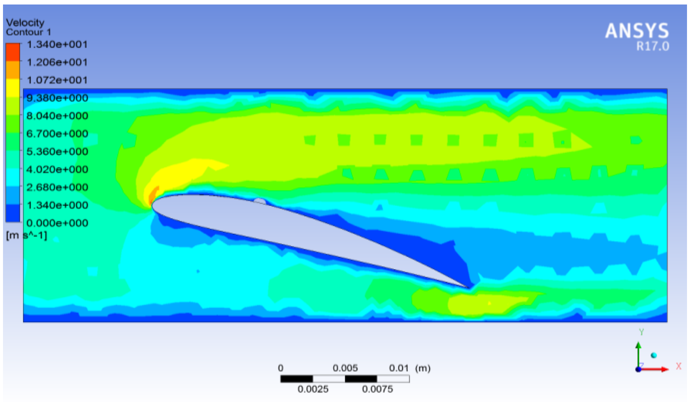


Fig.46: Velocity graph at 16AOA (5m/s)

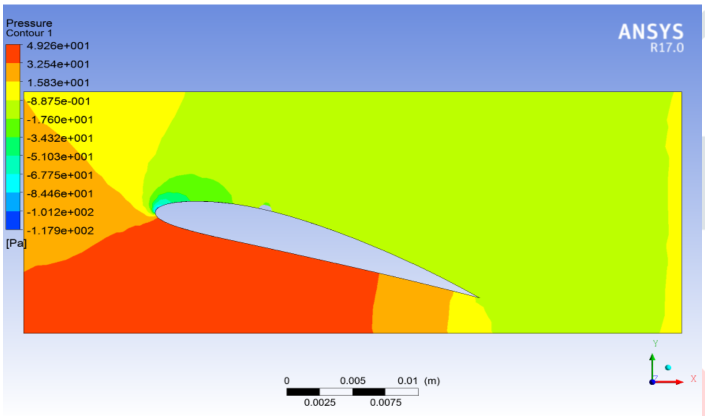


Fig.47: Pressure graph at 16AOA (5m/s)

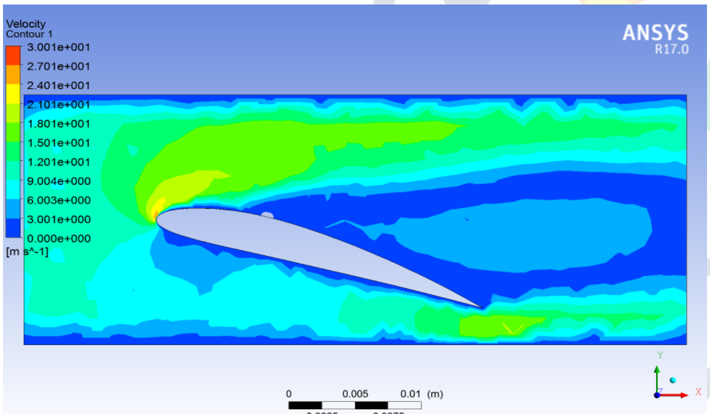


Fig.48: Velocity graph at 16 AOA (10m/s)

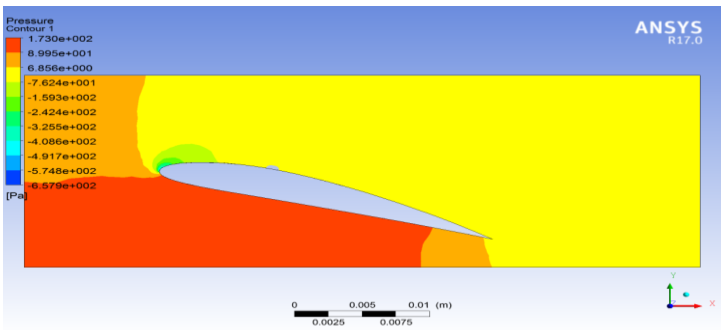


Fig.49: Pressure graph at 16 AOA (10m/s)

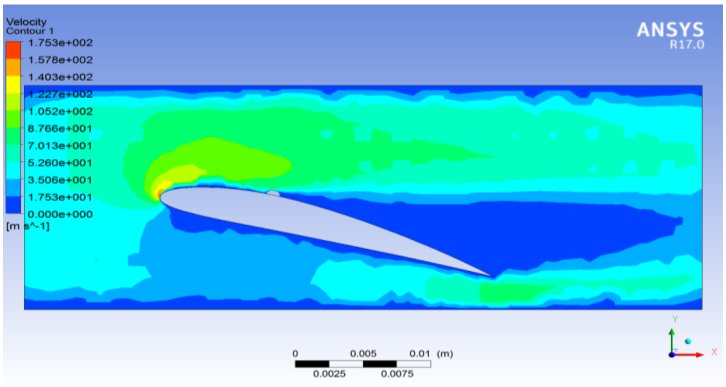


Fig.50: Velocity graph at 16 AOA (50m/s)

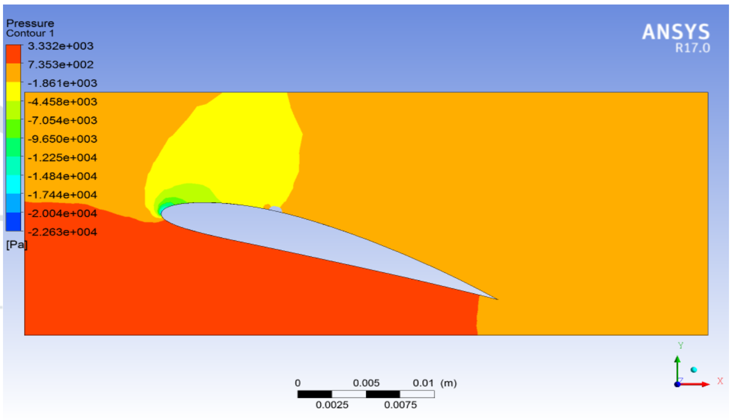
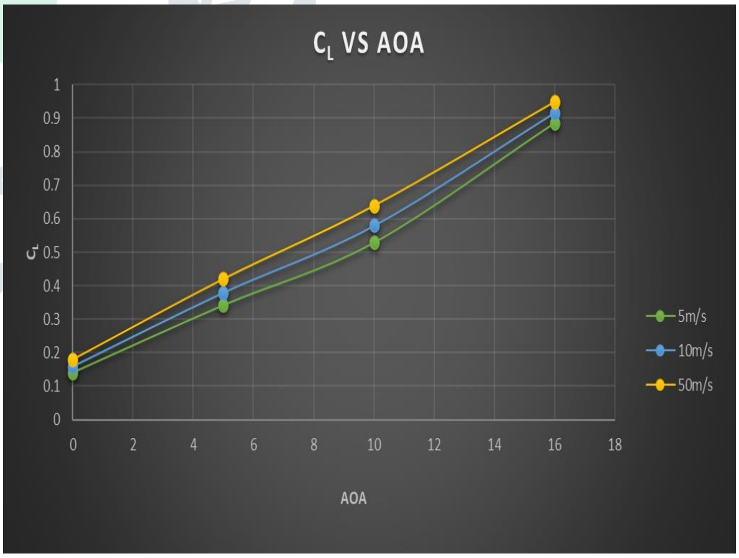
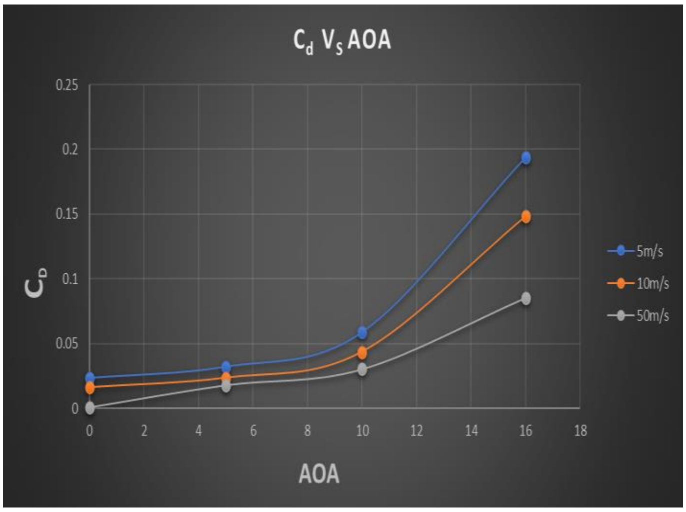


Fig.51: Pressure graph at 16 AOA (50m/s)

8.5 Graphs of Dimpled Airfoil (C_L Vs AOA and C_d Vs AOA)



Graph.4: C_L Vs AOA



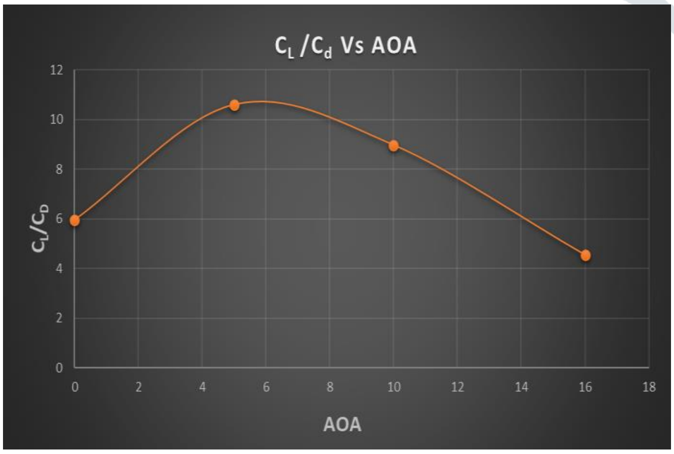
Graph.5: C_d V_S AOA

8.6 Table of Dimpled Airfoil (C_L/C_D V_S AOA)

AOA	5m/s	10m/s	50m/s
0	5.97	9.87	199.69
5	10.60	16.08	23.42
10	8.98	13.25	21.08
16	4.57	6.18	11.12

Table.10: C_L / C_d V_S AOA

8.7 Graph of Dimpled Airfoil (C_L/C_D V_S AOA)



Graph. 6: C_L /C_d V_S AOA(5m/s)

9. CONCLUSIONS

Through this project, we have discussed and analyzed the major principles involved in the noise production (jet and airframe noise)and drag production over a normal NACA 23015 airfoil .We have also reviewed about various measures and innovations that have been done over the period for reducing airframe noise and exhaust noise and tried our level best to solve these issues through our proposed design of incorporating active control methods, fan-flow deflectors, combined use of chevrons and microjets, along with deflectors in landing gears, increasing by-pass ratio, incorporating greater number of stator vane count, increasing distance between rotor and stator etc. Also, analysis was carried out for both normal and dimpled NACA 23015 airfoils at varied Angle of Attack (0,5,10,16) for different velocity (5,10,50 m/s) with semi-spherical dimple over the airfoil surface and was compared with the normal plain airfoil. The pressure distribution was found to be changed on the wing as compared to the normal plain airfoil. Thus, the comparison proved that embedding dimples over the wing surface increases the amount of lift produced with small increase in drag. From the tables (5,6,7,8,9 and 10) and graphs (3 and 6) we can clearly conclude that the lift produced increases by approximately 15% which is quite impressing and satisfactory. From above discussion it can also be concluded that the aircraft stall characteristics can be increased and hence, the maneuverability of the aircraft can be increased. Thus, we believe that the work done in this project will be particularly useful for the students, researchers, aircraft manufacturers to understand about reasons of aircraft noise production and also aid the researchers to incorporate modern innovative ideas for further reduction of aircraft noises along with the incorporation of dimples over the wing surface to reduce the drag produced and increase the aircraft's maneuverability.

FUTURE SCOPE OF THE PROJECT

The further step of this project can be continued by testing the airfoils with not only different types of outward dimples but also inward dimples and based on their aerodynamic performances, the better option can be chosen, or even a hybrid pattern can be tested for improved efficiency. Then, the second step would be to test these patterns on a wing in actual flight condition. For our study, we had taken only 3 velocities (5,10,50m/s) as the free stream velocity. This study can be extended to other higher free stream velocities. The effect of Angle of attack needs to explored for the change in further angle of attack as we have tested only up to 16 degrees. The dimples can be extended to other parts of an aircraft also if found to be useful.

ACKNOWLEDGEMENT

First of all, we would like to express our deepest gratitude, significant thanks and profound respect to our Project Guide Mr. M.G. Rajagopal for his praiseworthy guidance, valuable criticism and consolation all through the length of the research. We would like to express our special gratitude and thanks to our Project Coordinator Dr.P. Karunakaran and K. Vijay Babu for imparting their knowledge and expertise in this study. We are highly indebted to Dr.S.P. Venkatesan, Head of the Department, Department of Aeronautical Engineering, Excel Engineering College and also all the faculty members for their guidance and constant supervision as well as for providing necessary information regarding this research & also for their support in completing this endeavor. We might likewise want to give our earnest appreciation to all the companions and our colleagues, without which this exploration would be fragmented. We do thanks to almighty for keeping us healthy during the successful completion of this project.

REFERENCES

[1] Mohana Saravanan P S, Flow analysis around the dimple wing on aircraft, International Journal of Engineering Research Online, A peer Reviewed International Journal, Vol.3, No.2,2015.

[2] Technological Innovations for Noise Reduction in Turbofans and Airframes by Rakesh Kumar Shah, Dr. P. Karunakaran, Sumit Pandit, Nitesh Prasad Mandal and Pradeep Kandel available on www.jetir.org

[3] BhadriRajasai, Ravi Tej, Sindhu Srinath, Aerodynamic effect of Dimple on Aircraft Wings, Proc. of The Fourth Intl. Conf. On Advances in Mechanical, Aeronautical and Production Techniques - MAPT 2015.

[4] Choi KS. Effect of longitudinal pressure gradient on turbulent drag reduction with riblets. In: Coustols E, editor. Turbulence control by passive means. Dordrecht, Netherlands: Kluwer Academic, 1990

[5] Bogdanovic-Jovanovic, B. JasminaZivojin M. Stamenkovic and Milos M. Kocic, 2012 "Experimental and Numerical Investigation of flow around a sphere with dimples for various flow regimes," Thermal Science, Vol.16, No.4, pp.1013-102.

[6] ChannuRaju and P.R. Viswananth, 2001 "Base Drag Reduction Caused by Riblets on a GAW aerofoil", Journal of Aircraft Vol.No.6: Engineering Notes.

[7] DeepenshuSrivastav, (2012), "Flow Control Over Aerofoils Using Different Shaped Dimples", International Conference on Fluid Dynamics and Thermodynamics Technologies (FDTT) IPCSIT Vol.33 IACSIT Press, Singapore.

[8] Livya E, Anitha G, Valli P, Aerodynamic Analysis of Dimple Effect on Aircraft Wing, World Academy of Science, Engineering and Technology, International Journal of Mechanical, Aerospace, Industrial, Mechatronics and Manufacturing Engineering, Vol.9, No.2,2015.

[9] Saarang S. Mahamuni, A Review on study of Aerodynamic Characteristics of Dimple Effect on Wing, International Journal of Aerospace and Mechanical Engineering, Vol.2, No.4, July 2015.

[10] Jet Noise Reduction of Turbofan Engine by Notched Nozzle. Available on: http://www.sea-acustica.es

AUTHOR'S PROFILE

1) Mr. Rakesh Kumar Shah, currently pursuing Final year of Aeronautical Engineering at Excel Engineering College, Tamil Nadu, India. Has presented papers at many National and International level symposium and seminars, also published 5 Research papers in International Journals on Wing morphing technique, water scooping mechanism for Fire- fighting Aircraft, Noise attenuation technology in Turbojets, Battery durability and Thermal management system in Electric Vehicles and also assisted in more than 5 publications. Research interest includes Aerodynamics, Propulsion, Aircraft Model designing, Electric Vehicle, Robotics, Space Science etc.

Contact: rakeshkumarshah70@gmail.com

2)Mr.M.G.Rajagopal, Assistant Professor in department of Aeronautical Engineering. Pursuing research in the field of Aerodynamics. Having more than 7 years of teaching experience in Aeronautical Engineering. Published more than 15 papers in International Conferences and Journals. Also, into the research in Wind tunnel analysis.

Contact: mgrajagopal.eec@excelcolleges.com

3)Mr. Bijay Kumar Sah, currently pursuing Final year of Aeronautical Engineering at Excel Engineering College, Tamil Nadu, India. Has presented 5 papers at many National and International level symposium and seminars. Research Interest includes Aero modelling (RC and UAV) Aerodynamics, Aircraft and Rocket Propulsion, CFD, ANSYS, Composite materials etc.

Contact: sahbijay2001@gmail.com

4)Mr. Nitesh Prasad Mandal, currently pursuing final year of Aeronautical Engineering at Excel Engineering College, Tamilnadu, India. Has presented many papers in national level seminars and workshops. Research interest includes Propulsion, Aerodynamics, Structural Integration of the Aircraft and Aircraft modelling (RCs and UAVs). Also, into the research of Jet Engine optimizations.

Contact: npmandal68@gmail.com

5)Mr. Sangmeshwar Pratap Patel, currently pursuing final year of Aeronautical Engineering at Excel Engineering College, Tamilnadu, India. Has presented many papers in national level seminars and workshops. Research interest includes Propulsion, Aerodynamics, Aircraft modelling (RCs and UAVs).

Contact: gp9118048691@gmail.com