International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 03 | Mar -2020 ISSN: 2582-3930

EFFECT OF DIMPLED SURFACE ON AIRCRAFT WING

L Abinaya
Excel Engineering College

S Prashanth
Excel Engineering College

Dr. P karunakaran
Excel Engineering College

ABSTRACT

Drag coefficient decreasing and the enhanced aerodynamic efficiency in the airfoil which contains dimples will have similarly fewer drag than the apparent airfoil. Then by Introducing dimples at the wing of the aircraft which will form the turbulence by forming the vortices which will delay the boundary layer split leading to reduction of pressure drag and likewise extend in the angle of stall. And improve the aircraft maneuverability by delaying the go with the flow split point at stall and by decreasing the drag by the application of the dimple effect over surface of the aircraft wing.

Keywords: *Drag, Dimples , Stall, and Lift , etc*

1. OBJECTIVE

The main objective is to reduce the drag coefficient and improve the lift coefficient, So that the aerodynamic efficiency will improve.By this changes in wing surface design flow separation will be postponed slightly. Angle of stall can also increase slightly from 12° to 16°.

2. DESIGN METHOD

In the design method we are using circular dimples for aircraft wings even though there are many kinds of dimples shapes available . We have chosen a circular dimple model because most of the other shapes are creating a coefficient of drag even though producing lift. But in this circular dimple coefficient of drag creation is less than most of the design, and NACA 4415 airfoil have been chosen for our project because that the airfoil will have less coefficient of lift value and high coefficient of drag value and we made dimple.

3. METHODOLOGY

Dimpled surface wing was generated by using the CATIA V5R17 modelling software. Then the ANSYS simulations for the available aircraft wing was carried out and the results of velocity streamlines and pressure at outlet are plotted. And analysis is done using ANSYS solver, the simulations are carried out for aircraft wing with dimples with different dimple depth and diameter.

4. DESIGN CALCULATION

Designing is the most Concentrated For this project. There are many kinds of dimples shapes available that we have chosen as a circular dimple model because most of the other shapes are creating a coefficient of drag even though producing lift. But in this circular dimple coefficient of drag creation is less than most of the design, so that we are creating circular dimple as a modelled dimple. There in reference they have already said that the hexagonal design dimple will be good in production in coefficient of lift but that creates more coefficient of drag. They already concluded that the other kind of dimple pattern can be used in wing for better performance.

While selecting dimple as in circular shape there are many consequences faced in that selection, there are many depth and diameter shapes available. Also spacing is the main factor used in this design calculations. The number of dimples also needed to be considered for this design. This is the factors and problems faced in this design calculations.

4.1 Design Calculations:

The variation of the dimple depth and diameter plays a vital role in changing value of coefficient of lift and coefficient of drag value, so that the different size dimple depth and diameter are used in this airfoil design as following models,

Depth -0.5mm Diameter -4 mm

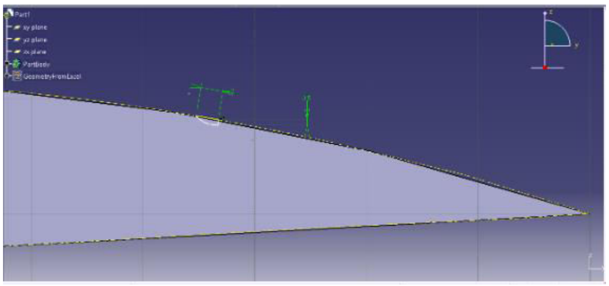


Figure 1 NACA 4415 model 1

Depth -0.5mm Diameter -5mm

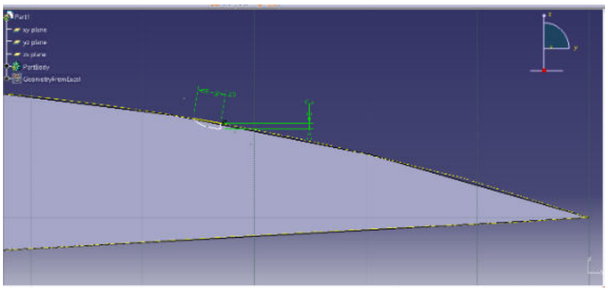


Figure 2 NACA 4415 model 2

Depth -0.5mm Diameter -6mm

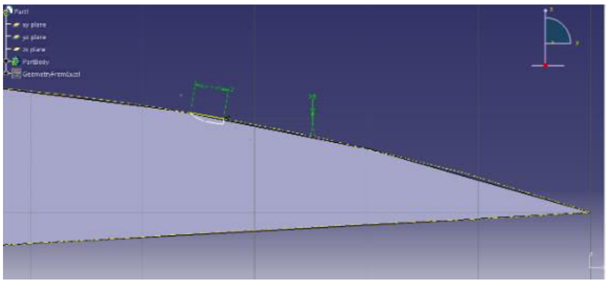
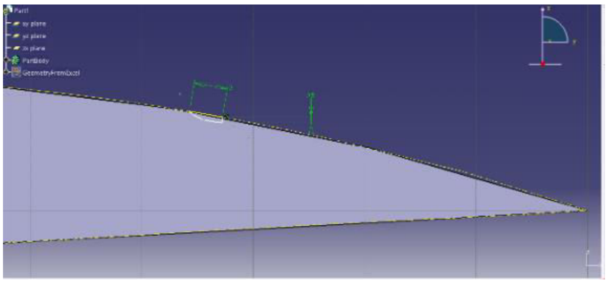


Figure 3 NACA 4415 model 3

Depth -0.75mm Diameter -4 mm



Depth -0.75mm Diameter -5 mm

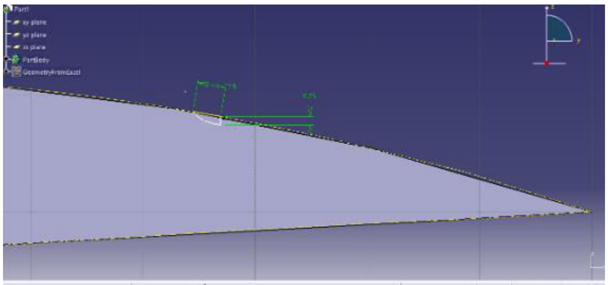


Figure 5 NACA 4415 model 5

Depth -0.75mm Diameter -6 mm

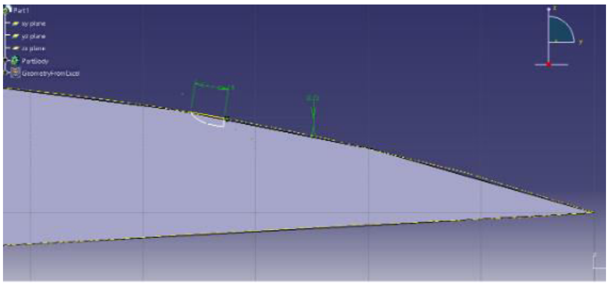


Figure 6 NACA 4415 model 6

Number of Dimple 29 Spacing between dimples 7 mm

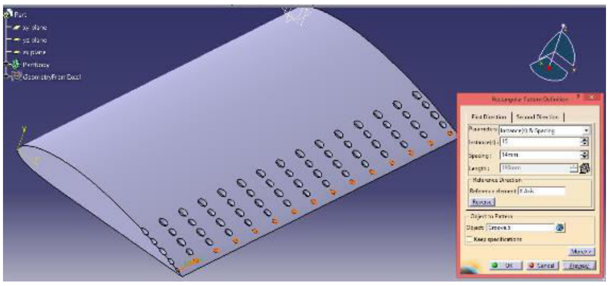


Figure 7 NACA 4415 model 7

4.2 Inflation:

Inflation is useful for CFD boundary layer resolution, electromagnetic air gap resolution or resolving high stress concentrations for structures.The following sections provide the high-level steps to follow to assign inflation depending on the selected mesh method The Smooth Transition option uses the local tetrahedral element size to compute each local initial height and total height so that the rate of volume change is smooth. Each triangle that is being inflated will have an initial height that is computed with respect to its area, averaged at the nodes. This means that for a uniform mesh, the initial heights will be roughly the same, while for a varying mesh, the initial heights will vary.In analysis part there are many analysis done with the above mentioned different designs. The comparative studies among the different kind of dimples and depth is calculated and shown below in analysis diagram,

Analysis report for single row dimpled surface wingFigure

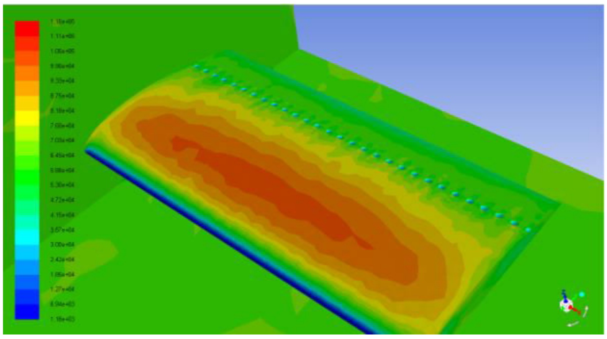


Figure 8 Dynamic pressure analysis for single row

5. ANALYTICAL CALCULATION

5.1 Analytical Calculation

For single row dimple CLand CDis plotted by this drag and lift value is calculated by using the formulaFor Lift calculations,L=(12)□□^{2}□□LFor Drag calculations,D=(12)□□^{2}□□D

The above mentioned formula is used to calculate the amount of lift and drag For that

□=1.225□□/□^{3}
□=330□/□
□=□h□□□∗ □□□□□□□□

5.2 Lift Calculation

For dimple less wing
CL=0.0101L=(12)□□^{2}□□L=0.5*1.225*3302*(0.2*0.1)*0.0101
L=13.4736525Kgm/s
2L=13.4736525N
For single row dimple wing
CL=0.0130L=(12)□□^{2}□□L=0.5*1.225*3302*(0.2*0.1)*0.0130L=17.342325Kg m/s2L=17.342325NFor double row dimple wing
CL=0.0205L=(12)□□^{2}□□L=0.5*1.225*3302*(0.2*0.1)*0.0205L=27.3475125Kg m/s2L=27.3475125NFor triple row dimple wing
CL=0.0280L=(12)□□^{2}□□L=0.5*1.225*3302*(0.2*0.1)*0.0280L=37.3527Kg m/s2L=37.3527N

7.3 Drag Calculation

For Drag calculations,D=(12)□□^{2}□□DFor dimple less wing
CD=0.0075D=(12)□□^{2}□□D=0.5*1.225*3302*(0.2*0.1)*0.0075D=10.0051875Kg m/s2D=10.0051875NFor single row dimple wing
CD=0.0090D=(12)□□^{2}□□D=0.5*1.225*3302*(0.2*0.1)*0.0090D=12.006225Kg m/s2D=12.006225NFor double row dimple wing
CD=0.0130D=(12)□□^{2}□□D=0.5*1.225*3302*(0.2*0.1)*0.0130D=17.342325Kg m/s2D=17.342325NFor triple row dimple wing
CD=0.0175D=(12)□□^{2}□□D=0.5*1.225*3302*(0.2*0.1)*0.0175D=23.3454375Kg m/s2D=23.3454375N

6. EFFICIENCY IMPROVEMENT ANALYSIS

For single row;
CL of dimple less surface -CL dimple surface = 0.0130-0.0101CL = 0.0130−0.01010.0101
CL =0.287128712For double row;
CLof dimple less surface -dimple surface = 0.0205-0.0101CL = 0.0205−0.01010.0101
CL =1.0297027For triple row;
CL of dimple less surface -CLdimple surface = 0.0280-0.0101CL = 0.0280−0.01010.0101
CL =1.772277228

7. CONCLUSION

In the investigation it was observed that the dimpled surface aircraft wing is efficient than the normal dimple less surface aircraft wing.The increase in the number of dimples is resulting in the increase of the coefficient of lift

The purpose of this paper was to determine at which design will be able to increase the lift during the analysis so as to reduce coefficient of drag which in turn reduces drag by modifying the diameter, depth and spacing of the dimples on the wing surface. Hence, a dimpled surface wing is then modelled in CATIA V5 R-17 and analysis was carried out in FLUENT for the same with different design models. It was found out that the efficiency of the dimpled surface wing is slightly higher than the dimple less surface wing.

8. ACKNOWLEDGEMENT

We thank **Mr. S. SARAVANAN B.E** (Aeronautical Engineer) Founder of Nulinz Education Private Limited, Mettur Dam. and Author of Intelligent Method Of Flight Datas Recording Using Satellite Communication by Avoiding the Search of Blackbox, with **GNANASEKARAN C, GOKULNATH S and JEBASTIN S** of Excel Engineering College For their Support,Guidance throughout the project.

4. REFERENCES

[1] Flow structures and heat transfer over a single dimple using hybridURANS-LES methods Johann Turnow, Robert Kasper and Nikolai Kornev July, 2017
[2]AERODYNAMIC EFFECT OF 3D PATTERN ON AIRFOILXiao Yu Wang, Sooyoung Lee,Pilkee Kim and Jongwon Seok 6 February 1997
[3] Aerodynamic Analysis of Dimple Effect on Aircraft Wing E. Livya, G. Anitha, P. Vall Vol:9, No:2, 2015
[4] A Review on Aerodynamic Behavior of Airfoil when Surface ModifiedAmit Kumar Saraf, Dr. Mahendra Pratap Singh, Dr. Tejsingh ChouhanMarch-2016