Design and Analysis of Airfoil with Different Shapedimples

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ABSTRACT

Dimple plates are widely used for construction and vehicles, especiallycar bodies, trains, and aircraft wings. The dimples surface helps to overcome turbulent airflow around vehicles, thereby delaying the separation point and producing fewer vertices and drag. This study aims to predict the pressure distribution occurring over the airfoil with dimple. The test is carried out with Computational Fluid Dynamic (CFD) FLUENT program. Aerodynamic efficiency can be improved by adding dimples, vortex generator, suction effect on boundary layer and more. Research shows that adding dimples on the airfoil does improve the aerodynamic efficiency by delaying the separation of the flow. The purpose of this project is to identify whether adding different shapes of dimples on the surface of the standard NACA 63-412 airfoil will improve the aerodynamic efficiency. The main outcome of this research is to provide the different shapes of dimples which provides the better aerodynamic efficiency at different configurations of placing the dimple were also studied in this project. There is a decrease in the pressure coefficient. This decrease occurs due to changes in flow characteristics.

Keywords:(Airfoil, NACA 63-412, Dimple for different shapes, Flow properties)

1. SCOPE OF WORK

Aircraft performance improvement can also be obtained through trailing edge optimization, control of the shock boundary layer interaction and of boundary layer separation. The drag coefficient of an object does not always remain the same as speed is changed. These changes in drag come about because the way the air behaves changes as speed and size are changed.

Drag on an aircraft can be broadly classified into profile drag and induced drag. Additionally drag due to the formation of shock wave also takes the role which is called as wave drag. By reducing the profile drag the total drag can be reduced. Improving the aerodynamic shape for commercial aircraft reduces the operating cost. This improvement can be gained by concentrating on reducing the drag of an aircraft. Reducing the drag may lead to stall during landing.

2. NATURE AND SCOPE OF STUDY

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3.CONCEPT OF SURFACE MODIFICATION BY DIMPLES IN GOLF BALL

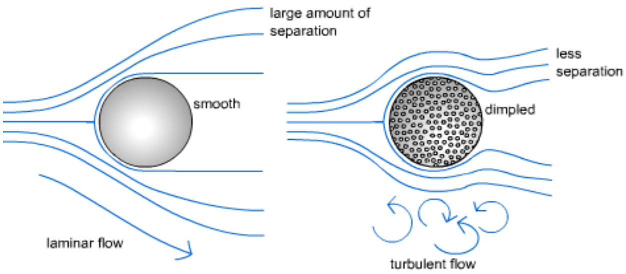
1. When a golf ball is analyzed dimples on the ball

seems to reduce thevortex formation as well as the drag over the body. The main reasoning fordimples on the golf balls is about bluff body aerodynamics and boundarylayers. A boundary layer is the air formed immediately around the object inairflow nearer to the surface of the body, the air moves with the body, sohe relative airflow velocity is zero. From there, it increases, so that a fewmillimetres from the surface, the airflow velocity is almost identical to theairflow velocity infinitely far away from the bodyTwo main types of boundary layers formed are.Turbulent boundary layer Laminar boundary layer

4. CONCEPT OF SURFACE MODIFICATION BY DIMPLES IN GOLF BALL

1. In a laminar layer, the air moves mainly parallel to each other shearing In a turbulent layer, the air moves randomly in all direction and also cross-flow. The end result is that the turbulent boundary layer has much more momentum close to the surface, but takes much more distance for the flow to reach thefree-stream velocity

5. FLOW OVER GOLF BALL WITH AND WITHOUT DIMPLE



- The objective of the project are:Comparison of airfoil with different shapes of dimples on upper surface and without dimples to visualize its effects.Comparison of following shapes of dimple on airfoil ;

Semi-
spherical
Parabolic
Elliptic
Triangular
Square
Hexagonal

Comparison of co-efficient of lift and co-efficient of drag for dimpled airfoil at 0°,2°,3°,4°,6°,8°,12°,16° angle of attack.

Comparison of L/D ratio of above airfoil and 3D modelling of airfoil which provides better L/D ratio

7. LITERATURE SURVEY

.Effect of Dimple on Aerodynamic Behaviour of Airfoil Rao &Sampath,

Surface modification was done to improve performance of airfoil. Here NACA4412 airfoil was modified with dimple and cylinders. Dimples of two sizes at different location were simulated. Dimples near trailing edge gave good result. Five different experiments were performed with various sizes of dimples and cylinders. But it was noticed that dimples on airfoil showed better result in terms of efficiency of the airfoil

Effect of Dimple on Aerodynamic Behaviour of Airfoil A.Dhiliban, 2013

Turbulent in rear side leads to pressure drag. In this smooth airfoil was compared with rough airfoil. Roughness was created on both upper and lower surface towards the trailing edge. For the simulation, velocity of the air was kept constant (100m/s) with k-ε std turbulent model. Overall performance of the airfoil was increased on

Effect of Dimple on Aerodynamic Behaviour of Airfoil Faruqui, Albari, Md.Emrn, &Ferdaus, 2013

Efficiency of the airfoil can be increased by many ways i.e. flow control method or adaptive technology. Here the flow control method is used. Naca 4315 airfoil was used on CFD tools. Two different models were tested, one was smooth airfoil and other was with bumpy surface on upper side of the airfoil. The bump was generated at 80% of chord length toward trailing edge. The flow separation starts near 9 degree angle of attack in smooth airfoil. From this it was noticed that there was a drastic change in results of bumpy surfaced airfoil.

Effect of Dimple on Aerodynamic Behaviour of Airfoil Srivastav, 2012

This study was done on the basis of dimples on the golf ball. This says that drag on golf ball can be reduced by dimples so on this basis author thought that drag could also be reduced if this theory is applied on airfoils.

I.

8.DESIGN AND DOMAIN SETUP

The design was done by using ANSYS in this design NACA 63412 series airfoil was chosen for analysis; because it is used in real time purpose, so by analyzing this would to applicable for practical application Dimples of 0.05 C of Diameter and cord length of 100mm designed using software along the upper surface of airfoil for delaying separation of flow & decreasing the drag. The dimple is placed at 20% of chord length from the leading edge as the flow separation starts here. The analysis is done on six different shapes of dimple:

Semi-

spherical

Triangular

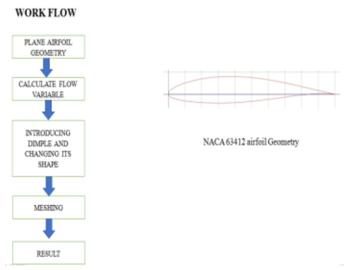
Square

Hexagonal

Parabolic

Elliptic

9.METHODOLOGY



Table

AOA [degree]	L/D RATIO FOR DIFFERENT SHAPES OF DIMPLE						
	WITHOUT DIMPLE	SEMI-SPHERICAL	PARABOLIC	SQUARE	HEXAGONAL	TRIANGULAR	ELLIPTICAL
0	21.18663	17.64634	21.18704	18.36235	20.30928	18.13158707	17.2139571
2	38.49569	31.37729	38.49467	30.50659	34.15851	31.61942477	29.09842328
3	42.95083	35.11081	42.9502	33.86169	40.0019	36.40957905	28.93996849
4	46.87042	38.78227	46.87131	38.57384	43.6217	40.96585603	47.84662479
6	43.96332	32.11771	43.96509	37.86726	41.3974	35.05775975	42.14235278
8	39.25006	12.09042	33.52416	32.59207	38.54199	39.01538741	37.39148453
12	39.10826	9.985386	30.42453	4.772003	29.69762	12.25135669	7.306393356
16	17.62959	1.670415	17.62917	3.173928	2.037073	6.007014311	2.990426407

11. CONCLUTION

The analysis of flat plate solar dryers for agricultural products underscores their significant potential in addressing post-harvest losses, enhancing food security, and promoting sustainable agriculture practices.
Through the examination of various parameters such as efficiency, cost-effectiveness, and environmental impact, it is evident that flat plate solar dryers offer a viable solution for reducing moisture content in agricultural produce while minimizing energy consumption.
The findings highlight the importance of optimizing design, orientation, and operational parameters to maximize performance and overall effectiveness.

12. ACKNOWLEDGEMENT

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13. REFERENCE

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Effect of Dimple on Aerodynamic Behaviour of Airfoil Faruqui, Albari, Md.Emrn, &Ferdaus, 2013

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Effect of Dimple on Aerodynamic Behaviour of Airfoil Rao &Sampath,

Design and Analysis of Vortex Generator and Dimple over an Airfoil Surface to Improve Aircraft Performance Sonia Chalia, Manish Kumar Bharti