Ice Accretion Effect On An Aerofoil Using Wind Tunnel: An Experimental Approach

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ABSTRACT
Aerodynamic wind tunnel tests were directed to consider the impacts of different ice gradual additions on the streamlined execution of a 36-inch harmony, two-dimensional business fly airfoil. Eight diverse ice shape setups were tried. Four were castings produced using molds of ice shapes accumulated in an icing air stream. Two were made utilizing computationally smoothed drawings of two of the ice shapes accumulated in the icing burrow. These smoothed profiles were then reached out in the range savvy course to frame a two dimensional ice shape. The current work centers around the streamlined presentation of a twin horn frosted airfoil. Twin horn frosted wooden layer is created out of delicate wood material which is mounted onto a NACA 0018 Airfoil which is reasonable to check inside the 30cm×30cm test part of low speed structure with various approaches from - 20˚ to 20˚ for an addition of 5˚. Tests are done to discover how static pressing factor dispersion, drag and lift varieties over Blank Airfoil and Twin Horn Iced Airfoil are differing. Crude information from the construction is prepared and pressing factor, lift and drag coefficients are determined utilizing numerical conditions. The deliberate information results were thought about for the instance of clear and twin horn frosted airfoil.

Key words: Accretion, AOA, Aerofoil, Wind Tunnel, Coefficient of Pressure, Coefficient of Drag, Coefficient of Lift

I. INTRODUCTION

A stall is a condition in optimal design and aeronautics wherein the approach increments past a specific point to such an extent that lift starts to diminish. The point at which this happens is called basic approach.

In liquid elements, a slow down is a decrease in the lift coefficient produced by a foil as approach increments. This happens when the basic approach of the foil is surpassed. The basic approach is normally around 15 degrees, however it might differ altogether relying upon the liquid, foil, and Reynolds number.

Slow down is characterized as an abrupt decrease in the lift produced by an airfoil when the basic approach is reached or surpassed. A slow down is a condition in optimal design and avionics wherein the approach increments past a specific point to such an extent that lift starts to diminish. The point at which this happens is called basic approach. This basic point is needy upon the airfoil area or profile of the wing, its angle proportion, and different elements, yet is regularly in the scope of 8 to 20 degrees comparative with the approaching breeze ("relative breeze") for most subsonic airfoils. The basic approach is the approach on the lift coefficient versus approach bend at which the greatest lift coefficient happens.

1.1. ICING SEVERITY

The term 'icing seriousness' is basically about the rate at which critical ice growth happens. The portrayals of super cooled water beads so far have been as far as their size. These similar measurements are significant - commonplace shower beads have a distance across multiple times that of average cloud drops and regular downpour drops have a breadth multiple times that of normal cloud drops. Size as portrayed by measurement is, however, not what is important most regarding the potential for ice gradual addition through sway. What truly has the effect is the volume (or mass) of water contained in a drop since this is the thing that controls the measure of water which will affect the airplane and furthermore how far rearward of the wind current stagnation point in front of a main edge surface that drops will strike the airplane. This last point is of extensive significance since huge drops may affect a long ways past the main edges in regions which are not enemy of frosted or deiced and may likewise go to ice as they are streaming rearward in contact with the surface at first hit.

1.2. TWIN HORN SHAPE

The above interaction prompts a lopsided conveyance of water drop impacts on the main edge. It is effectively possible that those which are directly in the center would not be diverted

definitely and would affect rather on the upper and lower sides of the main edge.

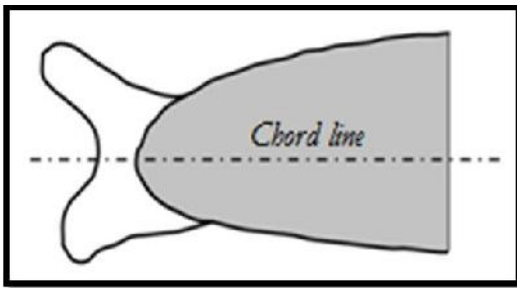


Fig 1.2: Development of twin horn shape

This beginnings the twofold horn shape, which is a different interaction and which is additionally upgraded by slam impact. Be that as it may, if the drops are exceptionally substantial, as on account of freezing precipitation, diversion is restricted, and ice gradual addition happens in a bend shape.

1.3. ICING ENVIRONMENT

The appropriation of super cooled water beads and ice inside a cloud changes with temperature. As a rule, the biggest super cooled drops are found at temperatures just underneath 0ºC, for example at heights simply over the freezing level (FZL). The size of the super cooled drops will in general diminish with diminishing temperatures or potentially expanding elevation.

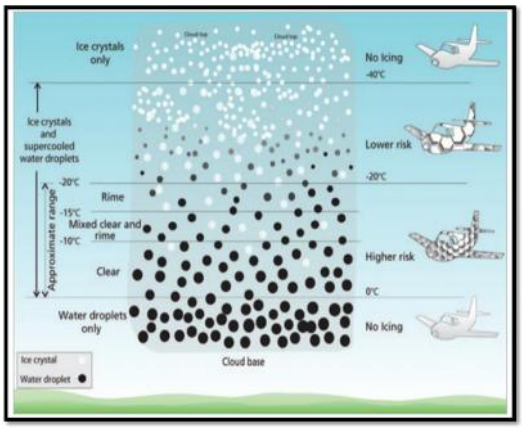


Fig 1.3: Icing Environment

Figure 1.3 subjectively shows the four kinds of ice shapes with the vertical pivot addressing expanded two-dimensionality and the even hub addressing expanding stream unsettling influence (and thusly corruption in streamlined execution). Harshness is in the lower left corner as the most 3D shape with low to direct unsettling influence of the stream field. Stream insightful, horn, and length shrewd edge ice are for the most part more 2D and have expanding streamlined impact from stream savvy ice with the least to traverse astute edge with the biggest impact. The circles addressing the various shapes cover addressing the way that a few shapes have qualities of more than one sort.

1.1. EFFECTS OF ICING

Ice on an airfoil changes its properties, decreasing lift and expanding haul for a given approach. Ice on a propeller edge decreases the productivity of the propeller and diminishes push. What's more, the heaviness of the ice builds the airplane weight and accordingly the lift required. Since for a given velocity the approach should be expanded to give the vital lift, the basic (slowing down) point is reached at a higher velocity than when ice is absent.

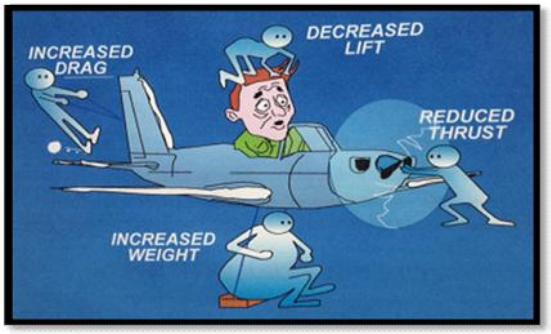


Fig 1.4: Effect of icing

II.EXPERIMENTAL SETUP

Tests are done in an air stream. In this investigation Altech open circuit air stream is intended for use in understudy Engineering labs and other mechanical and Government research offices. This Wind Tunnel can be utilized to consider the pressing factor circulation, lift and drag qualities of airfoils, chamber and so forth Reynolds number up to 25, 00,000 can be accomplished with this passage.

The targets of the current work are as per the following:

Twin horn frosted wooden layer is displayed.

Wooden Twin Horn Iced layer is made by utilizing carpentry devices and mounted it onto a NACA 0018 Airfoil.

Experiments were led in air stream for both the Blank and Twin Horn Iced Airfoils

Static pressure coefficients are noted by estimating pressure conveyance on the surfaces of both the test models.

Relationship is accomplished between the coefficient of pressing factor and the non-dimensional distance along the harmony length and results for both the test models are looked at.

Calculate drag and lift coefficients by estimating drag and lift power.

To accomplish connection between the coefficients of drag and lift and various approaches and to think about the outcomes for both the test models.

III. NACA0018 AIRFOIL

A model of NACA0018 airfoil has been chosen for this investigation in which there are two kinds of airfoils. One is NACA 0018 airfoil with a harmony of 16 cm, a range of 30cm and greatest thickness 2.9cm with openings of 12 number of each 1mm distance across are bored on the upper and lower surface of the airfoil. Adaptable cylinders are fixed at these 12 areas and associated with multi-tube manometer for estimation of static pressing factor dissemination and the other airfoil with a harmony of 16cm, a range of 25cm and greatest thickness of 2.9cm for estimating drag and lift power.

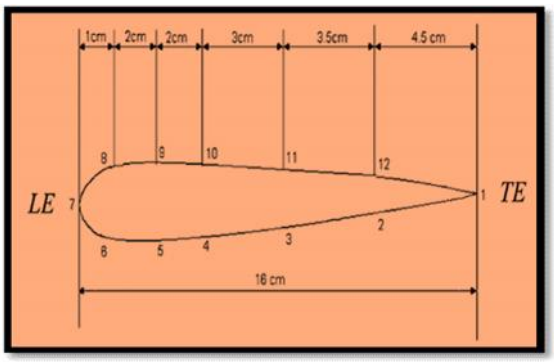


Fig 3.3: Position of the sensors along the chord

IV.TWIN HORN ICED AEROFOIL

The Twin Horn Iced Airfoil is framed by mounting a twin horn frosted wooden layer on NACA 0018 Airfoil. The twin horn frosted wooden layer is made by following two stages

1. Design of Twin Horn Iced wooden layer in Auto CAD

2. Fabrication of Twin Horn Iced wooden layer utilizing wood

Plan of Twin Horn Iced wooden layer

The plan of the twin horn frosted wooden layer incorporates

Import the Co-ordinates of NACA 0018 airfoil from Airfoil devices

The NACA 0018 Airfoil Co-ordinates are imported from Airfoil devices to .txt record and afterward traded to Excel.

Create CAD record in Auto CAD

The NACA 0018 Airfoil Co-ordinates are traded from Excel to AUTO CAD to get required airfoil.

Fig 4.1: Twin Horn Iced layer

Fabrication of Twin Horn Iced wooden layer

When the CAD model was made, a model of twin horn frosted wooden layer was made in the carpentry. The twin-horn frosted wooden layer comprised of delicate wood with 25 cm length. At the point when the ice layer was finished, it was mounted onto a NACA 0018 airfoil.

V.WIND TUNNEL TESTS

The Blank and Twin Horn Iced Airfoils are tried in air stream. During experimentation, right off the bat the clear airfoil is put in the test part of the air stream with changing approach and afterward after clear airfoil is supplanted with Twin Horn Iced Airfoil with changing approach.

Fig 5.1 : Position of Twin Horn Ice Aerofoil

S.No	AOA α (Deg)	Blank Airfoil		Twin Horn Iced Airfoil	
		F_D (kgf)	F_L (kgf)	F_D (kgf)	F_L (kgf)
1	-20	-0.89	-0.68	-0.65	-1.18
2	-15	-0.77	-0.87	-0.37	-1.32
3	-10	-0.6	-0.66	-0.26	-1.1
4	-5	-0.37	-0.25	-0.09	-0.49
5	0	-0.22	0.08	-0.05	-0.1
6	5	-0.37	0.44	-0.15	0.05
7	10	-0.54	0.76	-0.31	0.31
8	15	-0.71	0.94	-0.44	0.39
9	20	-1.03	0.45	-0.62	0.12

Table 1.1 : Drag and Lift Force for Blank and Twin Horn Iced Airfoil

VI.MODEL CALCULATIONS

The drag coefficient, lift coefficient and pressure coefficient values are determined using the following relations for blank and twin horn iced airfoil.

For Blank Airfoil:

Angle of attack (α) =0^0

Difference of manometer reading in Pitot tube, (q) =2.8 cm

The air flow velocity is determined from Pitot tube using the equation

$$V = 13\sqrt{q} = 13\sqrt{2.8} = 20.95 \text{ m/s}$$

Chord=16 cm=0.16 m

Span=25 cm=0.25 m

Area, A=chord length ×span=0.16×0.25=0.04 m^2

Air density=1.225 kg/m^3

$$C_D = \frac{F_D}{\frac{1}{2} \rho_{air} V^2 A} = -0.018 \quad C_L = \frac{F_L}{\frac{1}{2} \rho_{air} V^2 A} = 6.902 \times 10^{-3}$$

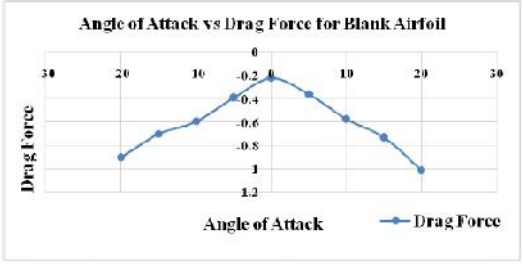
Atmospheric pressure, P_{atm}=17.5 cm of water

Difference of manometer reading in Pitot tube (q) =4.2 cm

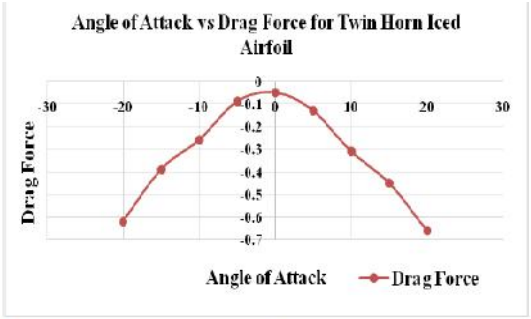
Static pressure, P=18.4 cm of water

$$C_P = \frac{P_{atm} - P}{q} = \frac{17.5 - 18.4}{4.2} = -0.2142$$

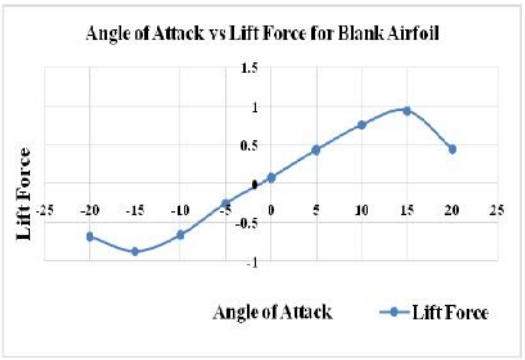
VII. RESULTS



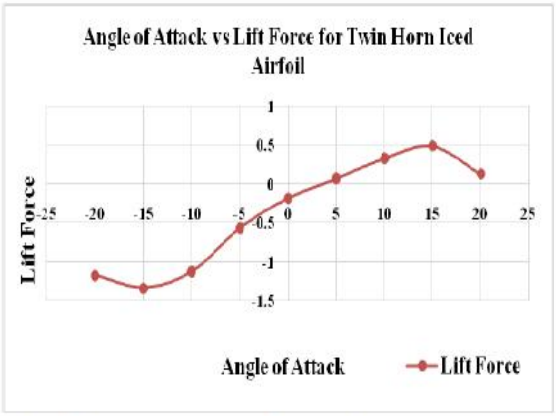
Graph 1: Angle of attack vs Drag Force for Blank Airfoil



Graph 2: Angle of attack vs Drag Force for Twin Horn Iced Airfoil



Graph 3: Angle of attack vs Lift Force for Blank Airfoil



Graph 4: Angle of attack vs Lift Force for Twin Horn Iced Airfoil

VIII.CONCLUSION

For twin horn frosted airfoil, the most extreme drag power is - 0.05 kgf in any event estimation of lift power is - 1.34 kgf at α=-150.The static pressing factor dispersion is changing along the non-dimensional distance. Cp esteems are diminishing from LE on lower surface and expanding on side for twin horn frosted airfoil in contrast with clear airfoil. The presentation of a clear airfoil end up being altogether better in contrast with a twin horn frosted airfoil.

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