Experimental Investigation of Effect of Multiple wings

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Abstract- An experimental study was performed to investigate the lift and drag coefficient of multiple wing. Most of the previous works carried out to increase the lift force and reduce the drag force having the more efficient and effective design. The aim of this project is to investigate the effect of multiple wings on lift and drag force. To perform this investigation a model of multiple wings is constructed and experiments were conducted in subsonic wind tunnel. The model of NACA 0012 symmetric airfoil with chord length of 21cm, maximum thickness 0.12cm, span length 21cm was selected for tri- plane configurations. The aerodynamic characteristics were examined placing multiple wings 12cm apart at low speed condition with various angles of attack like 0, 5,10,15,20 degrees for all the tri plane configurations. The ideal and experimental lift and drag coefficient is measured based on the experimental data. From this experimental investigation it shows that the coefficient of pressure and lift, both are increased with the angle of attack, on the other hand, drag coefficient is slightly decreased.

Index Terms— Tri-plane, Aerodynamic characteristics, Multiple wing, Lift coefficient

INTRODUCTION

An experimental study is performed to investigate the lift and drag coefficient of multiple wing. Most of the previous work was carried out to increased the lift force and reduce the drag force to create the more efficient and effective design. To perform this investigation a model of multiple wings were constructed and experiments were carried out in subsonic wind tunnel. The major aerodynamic principle focused on this project is a symmetric airfoil does not generate lift at a zero angle of attack. Another fundamental principle is that lift is created over an airfoil by the pressure differences over the top and bottom surfaces of the airfoil. Drag over an airfoil is caused by drag due to lift, skin friction, as well as pressure. The drag due to lift is caused by the tip vortices of the airfoil not extending to the walls of the wind tunnel and allowing the high pressure to interact with the relative low pressures along the top surface of the airfoil causing a loss in lift. The drag caused skin friction is due to the molecules passing over the surface of the airfoil and some sticking to the surface in the no slip condition. The pressure drag is created by the stagnation point in the front of an airfoil which impedes the flow of the fluid over the airfoil. Lift and the coefficient of lift are relevant to this experiment since in a purely theoretical environment, a symmetric airfoil will generate zero lift due to a zero value for lift coefficient at zero degree angle of attack. The relevance of drag and the coefficient of drag within this particular experiment are that the minimum values for drag and the coefficient of drag are at an angle of attack of zero degree for a symmetric airfoil. At the experiment, the profile of lift and drag along the length of the airfoil begins at near zero at the root of the leading edge and increases to a maximum at the tip The aerodynamic characteristics were examined placing multiple wings 12cm apart at low speed condition with various angles of attack like 0, 5,10,15,20 degrees for all the tri plane configurations [1-3].

MODEL CONSTRUCTION

A model of multiple wing consists of 3 airfoil, chord length 21cm, maximum thickness 0.12cm and span is also 21cm mounted 12cm one above the other. Material used to construct airfoil is Gamari Wood" Scientific Name is (*Gmelina Arborea*). Three airfoils are attached with 2 acrylic board with 12cm gap. Each of the airfoil model is prepared with care to maintain proper accuracy. The airfoil model was drilled at the middle section having the 20 pressure taping points. Then the vinyl tube pipe were attached each of the pressure taping point.

Fig. 1. *3D model of NACA 0012 profile*

Total of 60 pressure taping point were created for the measurement of pressure. Then three airfoils on each side mounted each other 12cm apart by drilling the two acrylic boards. For experimental investigation of the various angles of attack there are five drilling into the acrylic board in the leading edge of airfoil. Each of drilling hole are 50 gap, to create 0, 5,10,15,20 degree. Then models placed in the closed type test section of low scale large noise subsonic wind tunnel apparatus existing in aerodynamics lab. [8-10]

Fig. 2. *Photograph of Complete Model of multiple wing before installing the Wind Tunnel (front view)*

FORMULATION

Coefficient of pressure were calculated using the following formula:

Coefficient of pressure,

$$C_p = \frac{p - p_\infty}{q_\infty} \quad (1)$$

$$C_p = \frac{p - p_\infty}{\frac{1}{2}\rho_\infty V_\infty^2} \quad (2)$$

Cp is the difference between local static pressure and free stream static pressure, non-dimensional zed by the free stream dynamic pressure. From the equation, the value of the Cp is found and lifts and drag coefficient are calculated by integrating the pressure over the wing [6].

Co-efficient of lift,

$$C_L = \frac{1}{c}\int_0^c (C_{p,l} - C_{p,u})dx \quad (3)$$

Coefficient of drag,

$$C_d = \frac{1}{c}\int_0^c (C_{p,l} - C_{p,u})\frac{dy}{dx} \quad (4)$$

In this experiment the angle of attack are chosen 0, 5, 10, 15 and 20^0 and the free steam velocity is 25 m/s.

EXPERIMENTAL

The experiment were carried out on a low scale large noise wind tunnel apparatus in aerodynamics lab. The size of the test section is (1×1×1) m^3 subsonic wind tunnel. Figure 3 shows the photographic view of the experimental set up. A high speed fan is used to simulate the airfoil though the tunnel. The models of multiple wings are mounted on the test section with help of the screw clamp. Furthermore, it would to support the inflatable wing a desirable attitude in these tunnel experiments. Since the vertical part of the aerodynamic force produces the lifting force necessary to suspend the load. The main interest is to examine the aerodynamic characteristics of the model. The model was placed into the middle section supported by a frame. The lift and drag force is calculated from the data collected from the experiment. Since the pressure distribution on each surface is expected to be symmetrical pressure only one side is measured using vinyl tube and pressure measuring sensor. An airfoil develops lift through generally lower pressures above the wing and higher below with respect to the pressure of the approaching air. The overall pressure distribution can be measured with small tubes embedded in the wing leading to a suitable pressure transducer. The laboratory model is equipped with 20 pressure openings. The openings are located at 0, 4.75, 9.52, 14.28, 19.04, 23.08, 28.57, 33.33, 38.09, 42.85, 47.61, 52.38, 57.14, 61.90, 66.66, 71.42, 76.61, 80.95, 85.71, 90.47, and 95.23 percent chord on both upper and lower surfaces.[7,10]. The flow is incompressible and subsonic. The free stream airflow is kept at 25 m/s and the effect of temperature is neglected.

Fig. 3. *Photograph of the experimental setup of multiple wing*

EXPERIMENTAL RESULTS

The experimental data was recorded for different angles of attack from 0° to 200 with 5° interval. The lift and drag coefficients have been calculated from the experimental data based on the consideration of 2-D aero foil. Fig.4 shows the ideal and experimental lift coefficient with various angles of attack.

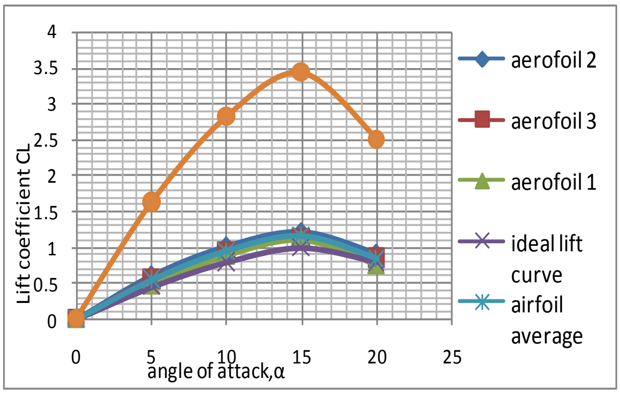

Figure 4: Ideal & Experimental lift coefficient with various angle of attack

From the graph it shows that the ideal and experimental lift coefficient of multiple wing have five angle of attack viz. 0, 5, 10, 15, 20 degree. Almost for all the angle of attack the lift coefficient is quiet same. From the graph it is shown that the lift coefficient of airfoil-1 is increased linearly with angle of attack and after that lift coefficient decreases with further increasing the angle of attack. The lift coefficient graph is almost straight line for each frequency up to 5degree angle of attack. Here flow is fully attached with wing surface. After 5 degree angle of attack a curvature deflection is created and again increases lift coefficient rapidly and reaches the maximum point at surrounding 15 degree angle of attack. After the maximum point of lift coefficient at angle of attack 15 degree, the values of lift coefficient C_L get decreasing. It is the stall point. After stall point a dead flow region is created and flow is unable to re-attach with wing surface. At 20 degree angle of attack the lift coefficient gradually decreased [7,10].

Also from the graph it is seen that the lift coefficient of airfoil-3 is increases linearly with increasing angle of attack and after that lift coefficient decreases with increasing angle of attack. In air foil-2 the highest lift coefficient is obtain and the value of the lift coefficient is 1. It is the pick value of the multiple airfoils. The overall lift coefficient is increasing at the angle of attack 15 degree. After 20 degree angle of attack the lift coefficient rapidly decreased. In the Fig.4 the orange curve is the summation of the 3 airfoil lift coefficient and comparing with the actual curve it can be concluded that the overall lift coefficient is increased with angle of attack and overall lift is much higher than the actual lift.

Comparing the ideal and experimental lift curves, it shows that the overall lift coefficient increased up to certain angle of attack and then decreased [5,6].

Fig.6 represents the ideal and experimental drag coefficient with various angles of attack.

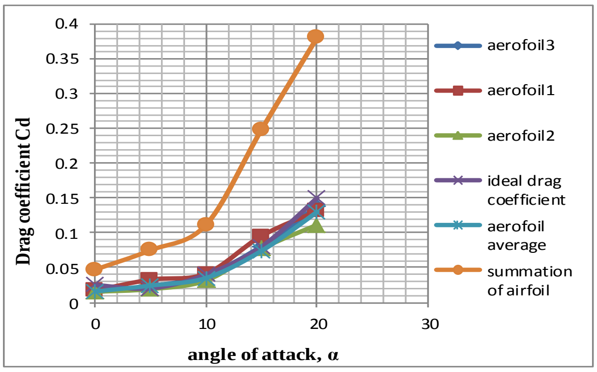

Figure 5: Ideal & Experimental drag coefficient various angle of attack

From the graph it shows that ideal and experimental drag coefficient of multiple wing have five angle of attack viz. 0, 5, 10, 15, 20 degrees. In the airfoil-1 the drag coefficient is increased linearly with increasing angle of attack and after that drag coefficient increased rapidly with increasing angle of attack. The drag coefficient curve is almost linear for each frequency up to 5 degree angle of attack. Here flow is fully attached with wing surface. After 5 degree angle of attack a curvature deflection is created and again increases drag coefficient rapidly and reaches the maximum point at surrounding 20 degree angle of attack. After the maximum point of lift coefficient at angle of attack 20 degrees. From the graph of airfoil-3 it is seen that the drag coefficient of airfoil-3 is increased linearly with increasing angle of attack and after that drag coefficient rapidly increased with increasing angle of attack. For air foil-2 the lowest drag coefficient is obtain the value of the drag coefficient is 0.111. It is the lowest value of the multiple airfoils. The overall drag coefficient is decreasing so the total drag is decreased. By comparing ideal and experimental drag curves it exhibit that the overall drag coefficient is decreased and it is efficient to using multiple air foil NACA 0012 [7].

Fig.6 represents the ratio of lift and drag coefficient with various angles of attack.

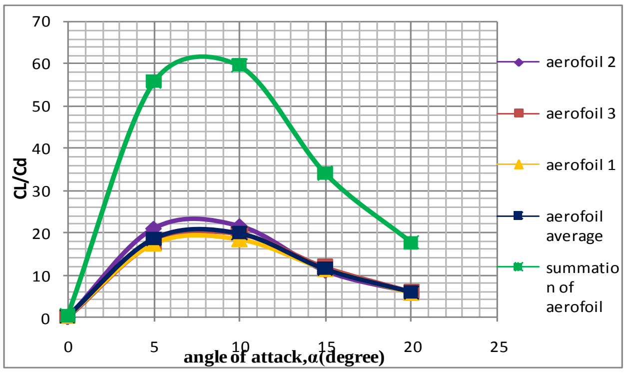

Figure 6: Ratio of lift and drag coefficient with various angle of attack

From the fig.6 it is shown that the C_L/C_d of airfoil- 1 is increases linearly with increasing angle of attack and after that C_L/C_d decreases rapidly with increasing angle of attack. The ratio of C_L/C_d curve is almost linear for each frequency up to 5 degree angle of attack. Here flow is fully attached with wing surface. After 5 degree angle of attack a curvature deflection is created and again C_L/C_d decreases rapidly and reaches the lowest point at surrounding 20 degree angle of attack. Also for the airfoil-3 C_L/C_d is increases linearly with increasing angle of attack and after that C_L/C_d decreases with increasing angle of attack. For air foil 2 the highest peak point C_L/C_d is obtain and the value of the lift coefficient is 23. It is the pick value of the multiple airfoils. The C_L/C_d is increasing at the angle of attack 10 degree. At angle of the 20 C_L/C_d rapidly decreases. From the overall investigation it shows that the overall lift coefficient is increased and drag coefficient is decreased.

CONCLUSION

An experimental study was carried out to investigate the lift and drag coefficient of multiple wing. From the experimental investigation it can be concluded that tri-plane can significantly enhanced the lift coefficient with increasing the angle of attack and decreases the drag coefficient. The design mechanism shows that uniform and more power full flow could be generated along the slot of the airfoil. The device is excellent to investigate the lift and drag coefficient. The experimental data shows that the coefficient of pressure as well as coefficient of lift is increased with increasing angle of attack, drag coefficient is slightly decreased.

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