LONGITUDINAL AERODYNAMIC PERFORMANCE OF AN AIRCRAFT MODEL

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“I declare this report is on my own work except for summary and quotes that I have mentioned its sources”

Signature	: ………………………
Name of author	: ………………………
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To my beloved family

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ABSTRAK

Kajian ini dijalankan untuk memeriksa kesan variasi sudut serang dan sudut elevator defleksi terhadap pekali daya angkat, pekali seretan dan pekali momen anggukan. Projek ini adalah pembelajaran awal untuk mendapatkan UAV hukum kontrol. Rumus kestabilan terbitan dalam arah longitudinal ditentukan. Kajian rancangan, mereka pesawat terbang pendukung dan mereka template sebelum menjalankan uji terowongan angin. Pesawat terbang model Piper J-3 Cub 4 digunakan untuk menguji dalam siaran terowongan angin kecepatan rendah. Eksperimen yang dilakukan pada kecepatan rendah juga disebut sebagai subsonik. Koefisien yang diperolehi daripada eksperimen akan diterapkan ke dalam rumus kestabilan terbitan. Perincian menerbit pekali daya angkat, pekali seretan, pekali momen anggukan and sifat-sifat longitudinal aerodynamic juga dapat belajar dalam kajian ini. Dalam eksperimen ini, elevator memberi efek yang tinggi bagi pesawat model ini. Sifat-sifat bagi pesawat model Piper J-3 Cub 4 ini telah ditentukan.

ABSTRACT

This study carried out to examine the effect of variation angle of attack and angle of elevator deflection on the lift coefficient, drag coefficient and pitching moment coefficient. This project is initial study to obtaining control law of UAV. The stability derivative equation in the longitudinal direction is determined. Test plan, design aircraft model support and templates to fix control surface angle are conducted before implement wind tunnel testing. An aircraft model Piper J-3 Cub 4 is used to test in closed circuit low speed wind tunnel in order to reach the objective of the project. The experiments are conducted at a constant low speed flow field which also called as subsonic. The experiment results of coefficients are applied into stability derivative equation for this aircraft model Piper J-3 Cub 4. The details to derive lift coefficient and pitching moment coefficient and basic of longitudinal aerodynamic characteristics were studies in this study. From the results, it is found that elevator contribute high effectiveness to this aircraft model Piper J-3 Cub 4. This aircraft model Piper J-3 Cub 4 longitudinal direction characteristics had been discovered.

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LIST OF SYMBOLS

Concise list of symbols in order of appearance:

F = Force (N)

P = Pressure (Pa or N/m^2)

A = Area surface (m^2)

L = Lift force

C_L = Lift coefficient

ρ = Air density

V = Velocity

C_L = Lift coefficient

C_D = Drag coefficient

C_m = Pitching moment coefficient

$\bar{c}$ = Aerodynamic mean chord

α = Angle of attack

L = Lift force

H = Ratio of pressure dynamic, which called as tail efficiency

V_H = Horizontal tail volume ratio

C_{m_0} = Total pitching moment coefficient

k_2-k_1 = Correction factor for the body fitness ratio

S = Wing reference area

W_f = Average width of the fuselage sections

α_{0_w} = Wing zero-lift angle relative to the fuselage reference line

i_f = Incidence of the fuselage camber line relative to the fuselage reference line at the center of each fuselage increment

Δx = Length of the fuselage increments

M_{cgw} = Wing contribution to the pitching moment at center gravity

M_{ac_w} = Wing contribution to the pitching moment at aerodynamic center

$C_{m_{cg_w}}$ = Wing contribution to the pitching moment coefficient at center gravity

$C_{m_{ac_w}}$ = Wing contribution to the pitching moment coefficient at aerodynamic center

L_w = Lift force at wing contribution

D_w = Drag force at wing contribution

Q_w = Pressure dynamic at wing contribution

C_{L_w} = Wing contribution to the lift force coefficient

C_{D_w} = Wing contribution to the drag force coefficient

$C_{L_{\alpha_w}}$ = Wing contribution to angle of attack lift force coefficient

$C_{m_{\alpha_w}}$ = Wing contribution to angle of attack pitching moment coefficient

$C_{m_{0_w}}$ =Wing contribution to zero angle of attack pitching moment coefficient

M_{cg_t} = Tail contribution to pitching moment at center gravity

M_{ac_t} = Tail contribution to pitching moment at aerodynamic center

$C_{m_{cg_t}}$ = Tail contribution to pitching moment coefficient at center gravity

L_t = Lift force at tail contribution

D_t = Drag force at tail contribution

Q_t = Pressure dynamic at tail contribution

C_{L_t} = Tail contribution to lift force coefficient

$C_{L_{\alpha_t}}$ = Tail contribution to angle of attack lift force coefficient

$C_{m_{\alpha_t}}$ = Tail contribution to angle of attack pitching moment coefficient

$C_{m_{0_t}}$ = Tail contribution to zero angle of attack pitching moment coefficient

M_t = Tail contribution to pitching moment

$C_{m_{\alpha_f}}$ = Fuselage contribution to angle of attack pitching moment coefficient

$C_{m_{0_f}}$ = Fuselage contribution to zero angle of attack pitching moment coefficient

$C_{L_{\delta e}}$ = Lift force coefficient of angle of elevator deflection

$C_{m_{\delta e}}$ = Pitching moment coefficient of angle of elevator deflection

T_c = Thrust coefficient

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CHAPTER 1

INTRODUCTION

1.1 Background Study

Interest in Unmanned-aerial-vehicles (UAVs) in recent years has increased significantly. These aircraft are useful for applications ranging from military to scientific research because of their ability to perform dangerous missions without risking human life. [1] UAV able to depart from one point and arrive another point automatically by setting the coordinate of depart and arrive. This project is the initial study to obtaining control law of UAV. The study of force and moment aerodynamic changes which affected by the control surface will be included in this thesis. Aircraft model Piper J-3 Cub 48 is utilized to analyze performance of control surface in the longitudinal direction. A theoretical stability control derivative will be found to determine the total pitching moment coefficient. The model will be tested with variation angle of attack and angle of elevator deflection. Close loop low speed wind tunnel is utilized to determine the effectiveness of longitudinal control surface and to evaluate force coefficient and moment coefficient.

1.2 Problem Statement

Development of an effective set of flight controls was a critical advance in the development of the aircraft since aircraft flight control plays important roles in adjusting and controlling the aircraft's flight attitude or aircraft performance. An aircraft free to rotate in three axes which perpendicular to each other and intersect at the plane's center of gravity. Whereas elevator is the primary control surface on an aircraft that controlling longitudinal direction motion. How effective of control surface influence aircraft attitude? Thus, this project will investigates and discuss about the performance of control surface especially in longitudinal of aircraft model Piper J-3 Cub 48.

1.3 Objectives

The main objective of this project is to study variation of lift, drag and pitching moment coefficient (C_L, C_D and C_m) function of angle of attack and elevator deflection in longitudinal direction and to determine stability derivatives of the aircraft model.

1.4 Scope

The investigation will focus on the longitudinal aerodynamic behavior especially lift, drag and pitching moment coefficient. This project also involves simplification of stability derivative equation with control surface coefficient. Aircraft model also will be tested at close loop low speed wind tunnel at UTM. The procedure setup and wind tunnel test plan have to be developed before testing. Data processing and analysis data also have included in this study.

1.5 Report Organization

In this report, five chapters are included. Chapter 1 covers introduction of the report, Chapter 2 covers longitudinal aerodynamic and theoretical stability control derivative, Chapter 3 covers methodology conducting wind tunnel testing, Chapter 4 covers data results, Chapter 5 covers data analysis and discussion, Chapter 6 covers conclusion and recommendation.

CHAPTER 2

LITERATURE REVIEW

2.1 Basic Aerodynamic

Aerodynamics is a branch of dynamics concerned with studying the motion of air, particularly when it interacts with a moving object. The common air moving object is space vehicle – airplane which is control in three dimensions. The three dimensions axes are known as 'body axes', x-axis, y-axis and z-axis. The motion of an airplane in the vertical plane involves three degrees of freedom, one rotational and two translational. The figure below shows stability axes and control surfaces of an aircraft.