MEASUREMENT OF DYNAMIC THRUST PRODUCED BY IMBALANCE PROPELLER

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A project report submitted in partial fulfillment of the

requirement for the award of degree of

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DECLARATION

I declare that this thesis entitled "Measurement of dynamic thrust produced by imbalance propeller" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : ZUNNURHAIRY BIN SEDEK

Date : DECEMBER 2018

DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

ACKNOWLEDGEMENT

In the name of Allah, Most Gracious and Most Merciful.

All praise to Allah S.W.T. that have given me strength and guide me to complete my Undergraduate Project (UGP) successfully. While making this thesis, I was involved with many people from different background, and gathered valuable knowledge. Greatest appreciation goes to my family who has been so tolerant and supports me all the time. Thanks for their encouragement, love and emotional support that had given to me.

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ABSTRACT

Accidents involving aircraft often occur in recent times. One of the causes is due to deterioration of propeller. This thesis focuses on the design, construction and validation of a system to test performance propeller and measurement dynamic thrust using Rcbenchmark software. The performance of new level of deterioration design is presented, in term of dynamic thrust and efficiency. The performance of level deterioration propeller divide to tree location, with every location have 3 gram mass. First level is at distance 7.5cm, second 5.0cm and the last 2.5cm from the central of propeller were analyzed. The result show conditional performance in thrust generated by every level position compare to control propeller. The experimental setup test stand was designed and constructed in which the propeller was mounted in a wind tunnel for dynamic testing, and the results were compared. From dynamic testing, the rotational speed of the propeller was held constant at regular intervals while the airspeed was increased from 0 to 20m/s. The coefficient of thrust, the coefficient of propeller power and the propeller efficiency were plotted versus the advance ratio for various rotational speeds. The thrust and torque were found to increase with rotational speed, propeller pitch and diameter, and decrease with airspeed.

ABSTRAK

Kemalangan yang melibatkan pesawat sering berlaku pada masa lalu. Salah satu penyebabnya adalah disebabkan oleh penurunan kipas. Tesis ini memberi tumpuan kepada reka bentuk, pembinaan dan pengesahan sistem untuk menguji kipas prestasi dan teras dinamik pengukuran menggunakan perisian Rcbenchmark. Prestasi reka bentuk kemerosotan baru dibentangkan, dari segi teras dan kecekapan dinamik. Prestasi terhadap kerosakan kipas terbahagi kepada tiga lokasi, dengan setiap lokasi mempunyai 3 gram jisim. Tahap pertama adalah pada jarak 7.5cm, kedua 5.0cm dan 2.5cm terakhir dari pusat kipas dianalisis. Hasilnya menunjukkan prestasi bersyarat dalam tujahan yang dijana oleh setiap kedudukan peringkat berbanding dengan mengawal kipas. Pendirian ujian persediaan eksperimen direka dan dibina di mana kipas dipasang di terowong angin untuk ujian dinamik, dan hasilnya dibandingkan. Dari ujian dinamik, kelajuan putaran kipasnya tetap pada jarak masa yang tetap sementara laju udara meningkat dari 0 hingga 20m / s. Pekali tujahan, koefisien kuasa kipas dan kecekapan kipas telah dirundingkan berbanding nisbah pendahuluan untuk pelbagai kelajuan putaran. Tujahan dan tork didapati meningkat dengan kelajuan putaran, padang baling-baling dan diameter, dan berkurang dengan kelajuan udara..

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UAVs	-	Unmanned Aerial Vehicles
C_P	-	Coefficientof Power
C_T	-	Coefficient of Thrust
D	-	Propeller Diameter, m
ρ	-	Density of air, kg/m^3
n	-	Propeller rotational speed, rev/sec
T	-	Thrust, N
P	-	Power, W
V	-	Air Velocity, m/s
RPM	-	Rotation per Minute
J	-	Advance Ratio
η	-	Propulsive Efficiency
R	-	Radius of Propeller

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Before the advent of the aircraft propulsion, a piston engine that guides the propeller to provide the thrust or movement required to power all aircraft. For this purpose the propeller has always been part of the aircraft. Some authorities have stated that propeller coming from China in the last few centuries as descendants of the windmills (Frank E. Hitchens 2015)

The propulsion system is very important today. It has become a major transportation in business and travel. But if the propulsion system is damaged small or bigger, it will have a big impact on the drivers and passengers. However, a major problem with this propulsion system is a propeller. Therefore, it is important to investigate the propeller performance to ensure that the design carries a reliable also that not that will cause problems with the engine and the flight system and consequently causing the accident.

1.2 Problem Statement

The deteriorated of propeller for aircraft can affect the unbalance and so on vibration. Propeller needs to be balanced to provide a substantial reduction in vibration and noise delivered and also reduce excessive damage to part and other engine components. Propeller imbalance can be divided into three categories which are static imbalance, dynamic imbalance and aerodynamic imbalance.

Propeller static imbalance happens when the center of gravity of the propeller does not coincide with the axis of rotation. If a propeller is placed between centers on frictionless rollers the heavy or weighted portion will rotate to the bottom immediately. This is corrected by adding or removing weight from the propeller. Static imbalance can cause a vibration to the propeller. Other problem is it can lead cracking of engines baffles and propeller cracks can cause poor handling the airplane.

Another type of propeller unbalance is aerodynamic unbalance results when the thrust of the blades is unequal. It’s happens when a blade pitch variance occurs from one blade to another during the rotational cycle. If one blade is grabbing more air than any one of the other blades a vibration will be felt. The effect cause instrument panel shaking and exhaust system cracks. The major effect from the aerodynamic unbalance is an accident.

1.3 Objective of Project

1. To design a measurement technique to remotely dynamic thrust.
2. To measure the performance of propulsion system.
3. To analyze the force production at different level of imbalance.

1.4 Scope of Project

1. Literature studies on the propulsion system used in UTM UAV known as CAMAR v3.

2. The experiment will be executed at wind speed ranging from 0 to 20m/s.

3. Other setting and nature of the experiment shall be relevant to CAMAR v3

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review is a portrayal of what have been distributed through books, articles and different sources which is applicable to a specific issue. Range of research giving a depiction, synopsis, and basic assessment of every work. The reason for literature review is to give an outline of significant literature published on a subject. A literature review can be only a basic summary of the sources, however for the most part has a hierarchical pattern and consolidates both synopsis and combination. It may give another elucidation of old material or join new with old understandings. Moreover, it gives a hypothetical base of the exploration and help the author determine the gist of the research.

2.2 Propeller categorize

A propeller is a device which transmits power by converting it into thrust for propulsion of a vehicle such as an aircraft, ship, or submarines though a fluid such as water or air by rotating two or more blades propeller at central shaft. A propeller creates forward thrust by pushing back on the air. (John T. Lowry.2001).

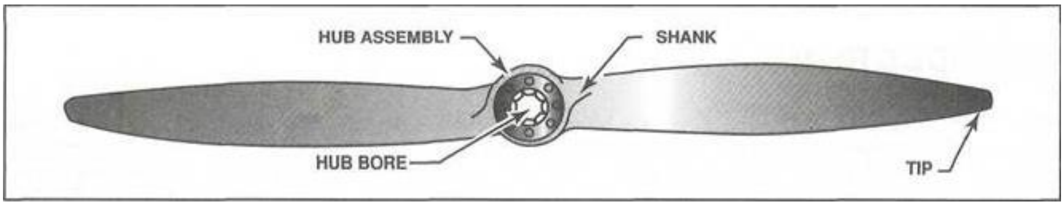

Figure 2.1: Propeller

2.3 Propeller work and the underlying working mechanism

All propeller systems produce thrust by imparting a change of momentum to a mass of air or propulsive fluid. Propellers operate by producing by relatively small change in velocity to a relatively large mass of air. These blades are made up of airfoils or also called blades elements with a twist distribution that gives the optimal power at some design condition. (Asselin Mario, 1965).

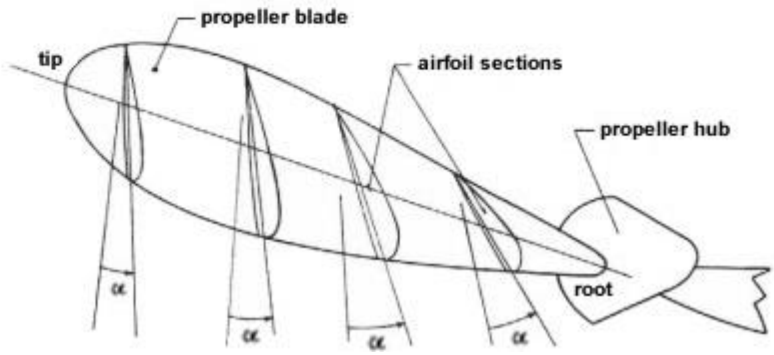

Figure 2.2: Propeller blades showing the part.

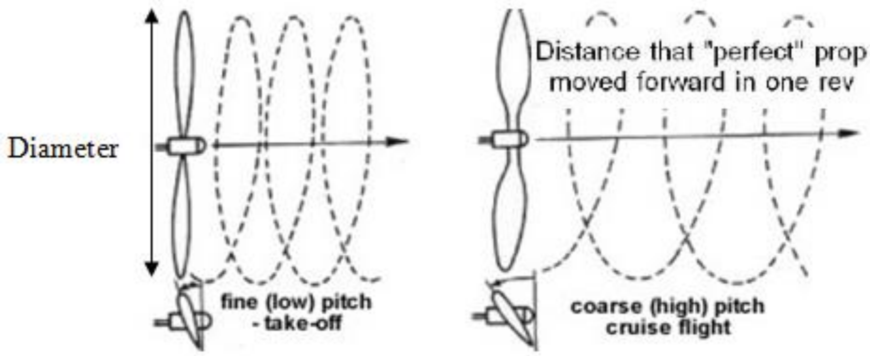

Figure 2.3: Diameter and Propeller pitch function.

2.4 Quantify the performance of propellers and its efficiency

The purpose of a propeller is to convert power which is delivered by a rotating shaft into thrust by accelerating a large mass of air to a higher velocity. The effectiveness of a propeller performs this conversion is known as efficiency. The propeller convert the engine torque into axial trust is measured by the propeller efficiency which in turn depends on several factors, namely the propeller diameter, solidity, number of blades and prop blade leading to name a few. (Frank E. Hitchens 2015).

Efficiency is therefore the best way to measure a propeller performance where efficiency is an important characteristic parameter of the propeller arising due to its rotation in the air. Thrust is a force that propels the aircraft through the air but efficiency is measure of how well the propeller success in achieving this objective. (Frank E. Hitchens 2015).

It is defined as;

$$\eta_P = \frac{C_T}{C_P} J \qquad (2.1)$$

$$J = \frac{V}{nD} \qquad (2.2)$$

When aircraft speed increases, the angle of attack seen by the prop blade of a fixed-pitch prop will decrease. That result limits the maximum efficiency of a fixed pitch prop to a single airspeed at a given RPM, as shown by the following plot of efficiency at different blade pitch angles (β) shows.

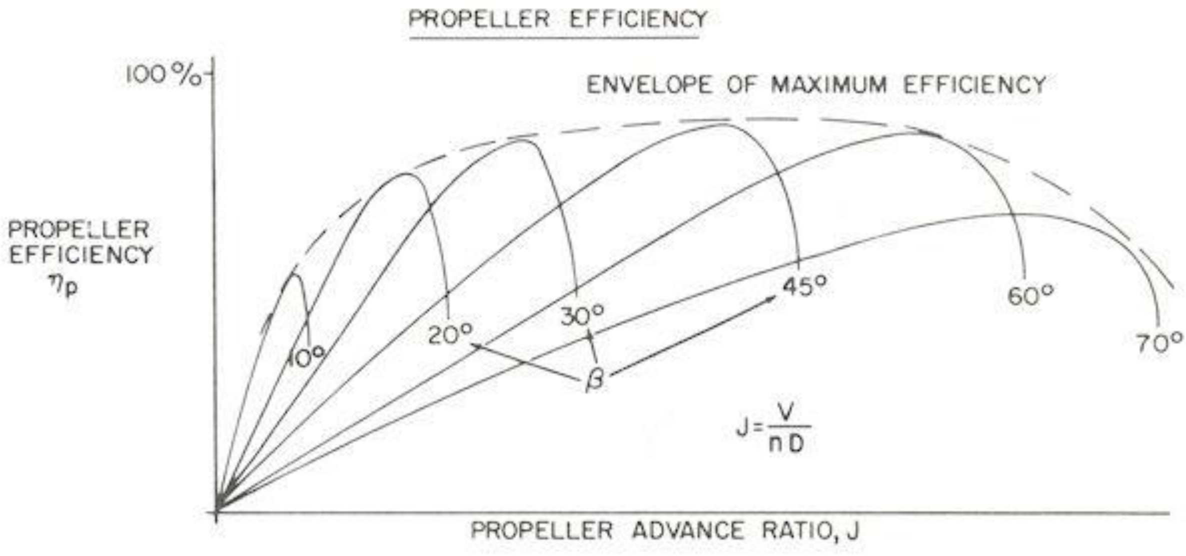

Figure 2.4: Propeller Efficiency

The curves in Figure 2.4 suggest that if the blade pitch could be varied in flight, the propeller efficiency could be very high for a wide range of operating conditions. Therefore, many propellers contain a mechanism in the hub to change the overall pitch of the blades in response to a servo command from a control system. That control system is typically a propeller which maintains propeller RPM at a pilot set value (within certain limits) regardless of aircraft speed or engine power setting.

2.5 Type of Propeller Deteriorated.

Many types or causes that lead to propeller deteriorated or propellers to fail to well performed. The usually of failures occur in the blade at the tip region, usually at the tip and often due to a crack initiator such as a pit, nick, or gouge. Despite a blade propeller failure can occur along any portion in propulsion system, particularly when nicks, scratches, corrosion, and cracks are present. Although during propeller inspection and routine maintenance it is important to inspect the entire blade. The severity of the damage determines the type of repairs required. Following that paragraphs describe some of the types of damage be found in propellers. (U.S Department of Transportation Federal Aviation Administration, 2005).

2.5.1 Surface Corrosion.

The loss of surface metal due to chemical or electro-chemical usually having a contrasting color and texture to the base metal. Figures 2.5 and 2.6 shows a surface corrosion which is generally results when the corrosion protection on a metal surface has been removed by erosion or by polishing. Consequently, removing paint, corrosion protection and polishing blades, is not recommended.

Figure 2.5: Polished Blade Surface Corrosion

2.5.2 Pitting

Pits consist of visible corrosion cavities extending inward from the metal surface. They can grow on the surface, under decals or under improperly installed de-ice boots.

Pitting can appear to be relatively minor - 0.010 inches deep - and still cause major problems since the pits could be a precursor to the initiation of cracks (see Figures 2.7)

Figure 2.6: Pitting

2.5.3 Intergranular Corrosion.

Intergranular corrosion occurs in grain boundaries. The presence of intergranular corrosion may be the result of the continued presence of moisture such as under a decal, in a fastener hole, or when anodize and paint protective barriers have been lost. Exfoliation is a form of intergranular corrosion that occurs more often in forgings or rolled sheets, and less often in castings. Exfoliation is sometimes visible as metal flaking and cracks on a blade leading edge (see Figure 2.7).

Figure 2.7: Exfoliation on the Blade Leading Edge

2.5.4 Nick

A sharp, notch-like displacement of metal usually found on leading and trailing edges. All nicks are potential crack starters (see Figure 2.8).

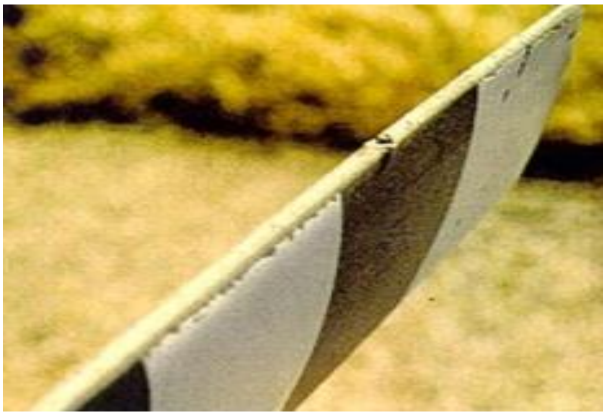

Figure 2.8: Blade Nick

2.5.5 Erosion

The loss of material from blade surface by the action of small particles such as sand or water and is usually present on the leading edge close to the tip. This damage destroys the blades' corrosion protection, which might lead to blade failure (see Figure 2.9).

Figure 2.9: Erosion on a Metal Blade

2.5.6 Cracks.

When found anywhere cracks in a propeller leads to immediate removal and detailed inspection. Cracks in propellers will be increase grow over time, and eventually till to failure (see Figure 2.10).

Figure 2.10: Blade Crack

2.5.7 Severe Damage.

the bigger propeller damage cause include a broad spectrum of damage, to severe ground impact damage.(see Figure 2.11)

Figure 2.11: Severe Damage

2.5.8 Fire Damage or Heat Damage.

Propellers have been exposed to fire or heat damage such as a hangar or engine fire. If instance of such an incident, propeller inspection must required . That aluminum propeller parts have been exposed to high temperatures (in excess of 93 °C), then the parts must be assumed to be airworthy. Composite propeller blades may have a lower temperature threshold for potential damage.

2.6 Consequences of using deteriorated propellers.

The using of deteriorated propellers can cause a several problems to the aircraft. Propeller failures indicate that failures occur across the entire spectrum of aircraft engine propeller combinations. The deteriorated propeller can affect the unbalance and vibration. The major problems can lead to an accident to the aircraft.

2.6.1 Vibration and Unbalance.

Propeller imbalance is a key problem on all aircraft used. Overcoming propeller imbalance is crucial to the efficient operating performance of thrust aircraft. Propeller imbalance can cause to excessive vibration which leads fatigue in aircraft components and afterward other structural failures. The negative effects of vibration not only for passenger discomfort but also excess fuel consumption.

Keeping vibration under control and monitoring its effects to predict potential failures requires significant expenditures results in increased labor and maintenance costs. Vibration also leads to poor handling and cause accident.

2.6.2 Example of accident due to deteriorated propeller

The deteriorated propeller can caused the accident of aircraft. The flight twin-engine Embraer 120 Brasilia turboprop crashed, killing five people, after almost four feet of a propeller blade snapped off in midflight, stopping the left engine. That created wind drag and an imbalance that ultimately brought down the plane. Investigators found small corrosion pits in the aluminum center where the break occurred". (The New York Times, Saturdays 26 1995).

Another case was according the news reported that Broken propeller caused the plane to lose power and crash near St. Mary's. Two people were injured. (WIBW News now.com, dated 6 November 2017).

2.7 Wind tunnel testing as a tool

Wind tunnel device for producing a controlled stream of air in order to study the effects of movement through air or resistance to moving air on models of aircraft. beside that methods to estimate propeller performance is to test the propeller. a fan draws the air through a duct. A test section of the wind tunnel duct is fitted with removable panels for access to allow model testing to be mounted safety in the flow. Furthermore probes connected to pressure transducer attach in wind tunnel to investigate flow speed. For work at model aircraft speeds and sizes it is particularly vital to keep the flow in the test section of the tunnel.(Martin Simons, 1994).

2.7.1 Open Loop Wind Tunnel

Tunnel of the open loop type draw air from the ambient environment and exhaust it back to the ambient after exiting the fan. Nonetheless are often affected by external weather, especially wind which can cause fluctuation in the flow speed through the tunnel.

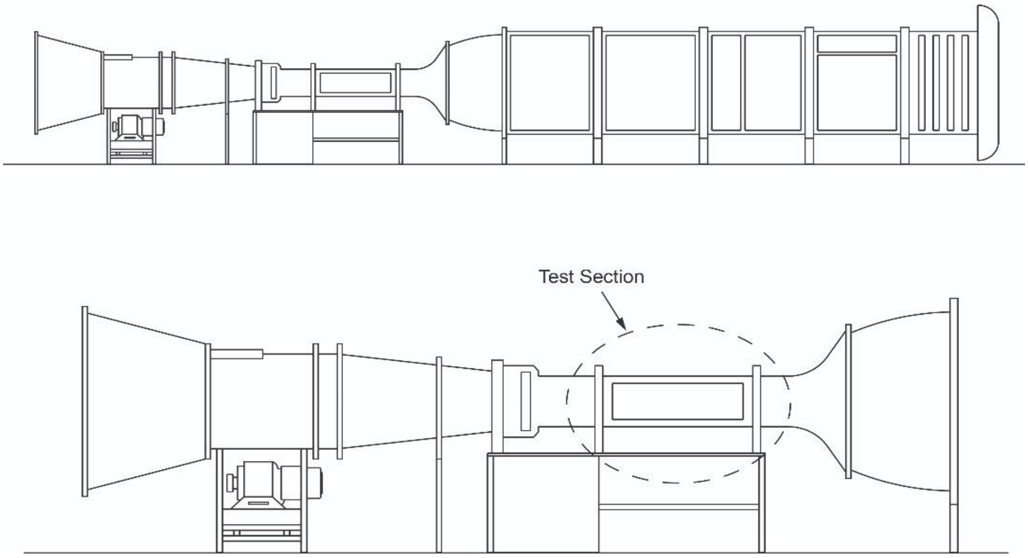

Figure 2.12: Open Loop Wind Tunnel

2.7.2 Closed Loop Wind Tunnel

The closed return type of tunnel is less subject to weather but because the same air is re-circulated to the intakes after passing the fan additional precaution are needed to prevent vortices from the fan blades persisting all the way through the tunnel. The closed-loop wind tunnel design delivers improved efficiency and generates less noise, but is more expensive and more difficult to manufacture.

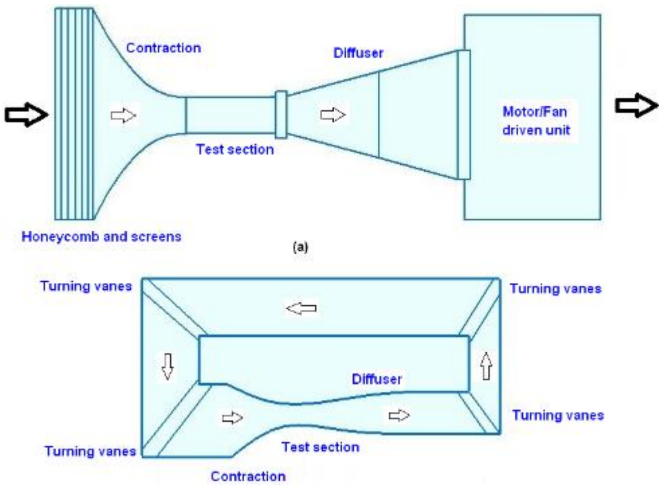

Figure 2.13: Closed Loop Wind Tunnel.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter gives an outline of research methods that were followed in the study. It provides information on the criteria for inclusion in the study. Research methodology describes the research design that was chosen for the purpose of this study. The instrument that was used for data collection is also described and the procedures that were followed to carry out this study are included. Data collected from the experiment shall be used for further analysis.

3.2 Propulsion system

3.2.1 Electric Motor

Basically, electric motors are electromechanical machines that convert electrical energy to mechanical energy power. The general power supply used in the UAVs is DC (Direct Current). Brushless DC motors (BLDC) feature high efficiency and excellent controllability. the magnetic fields resulted from the current generates, leads the coil assembly to rotate, as each coil is pushed away from the like pole and pulled toward the unlike pole of the fixed field.

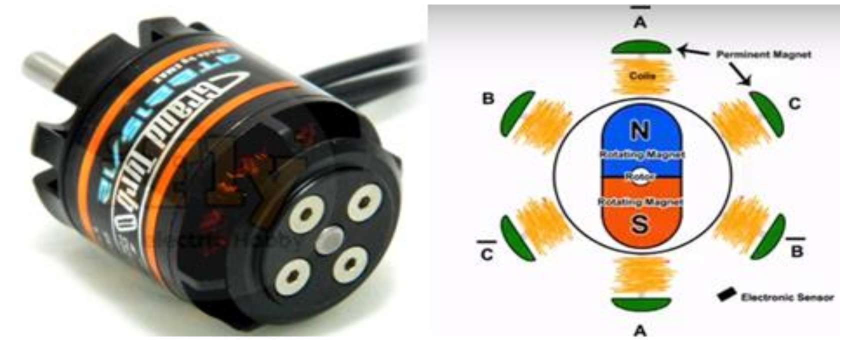

Figure 3.1: Brushless DC Motor

Specification for motor selected using for experimental from Emax , brand Grand Turbo, model number GT2215/12,Brushless Motor for RC Multicopters. Number of magnetic poles is 12.

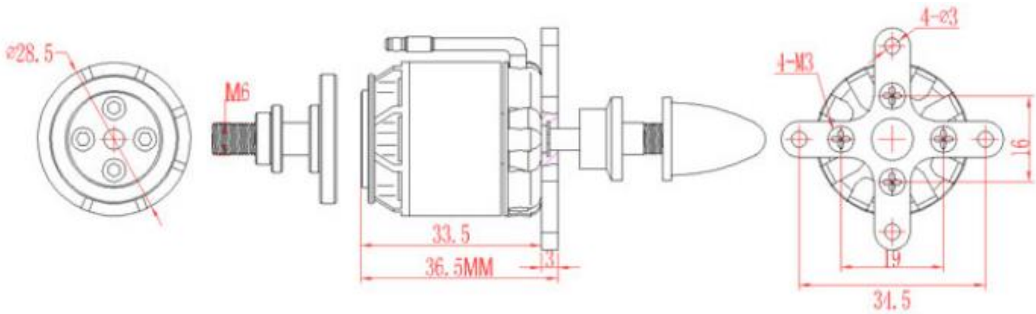

Figure 3.2: The detail drawing for motor selection.

Table 3.1: Motor description

No.Of cells	2-3xLi-Poly
Stator dimensions	22x15mm
Shaft diameter	4mm
Weight	70g/2.46oz
Recomended model weight	300-1100g
Recomended prop without gearbox	10x4.7 11x3.8

Model	Cell Count	RPM/V	Prop (APC)	RPM	MAX current (<60S)	Thrust
GT2215/12	3S	905	10x4.7	7450	15A	1000g 2.20lb
	3S	905	11x3.8	7000	18A	1050g 2.31lb
GT2215/09	3S	1180	10x4.7	8300	26A	1250g 2.76lb
	3S	1180	10x6	8850	24A	1140g 2.51lb

3.2.2 Electronic Speed Control (ESC)

Electronic Speed Controller (ESC) is an electronic circuit with the purpose to vary a servo motor speed. Its direction and possibly also to act as a dynamic brake of a brushless motor. The objective of electronic speed controllers is to create a balance between power available and power required. ESC also uses the PWM - Pulse Width Modulation signal for controlling the speed of the motor.

Table 3.2: Esc specification

Item	Continuous Current	Burst current(10S)	Li-xx Battery(cell)	Dimension (mm)L*W*H	Weight(g) wires Included	BEC(Linear)	Programmable
Budget 10A	10A	15A	1-3			1A/5V	YES
Budget 18A	18A	23A	2-3	55*30*15	24	2A/5V	YES
Budget 30A	30A	40A	2-4	60*30*15	24	2A/5V	YES
Budget 50A	50A	65A	2-5	70*35*20	38	3A/5V	YES

Figure 3.3: The ESC utilized to control the motor.

3.2.3 Lithium Polymer Battery (LiPo)

LiPo batteries short for Lithium Polymer are a type of rechargeable battery. LiPo provide high energy storage to weight ratios, are capable of safe fast discharges, have quick recharge times. Characteristics of lipo to understand are the battery's voltage and capacity. Normally typically noted in a short hand such as "3S-2200". In this example, "3S" denotes that the battery has tree cells in series. The nominal voltage of each cell is 3.7 volts (4.2v fully-charged), so the total pack voltage is 3 cells x 3.7v = 11.1v.

The second number denotes the capacity of the battery in milliamp-hours (mAh). A fully charged 2200mAh pack is rated to provide a current of 2200 milliamps (2.2 amps) for one hour before it is fully discharged. The value of capacity is completely independent of how many cells are in series.

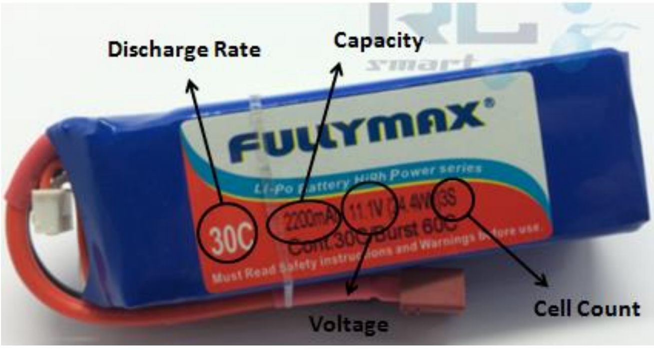

Figure 3.4: Lipo battery.

3.2.4 Propeller baseline

The propeller from emax, specification (EP-8040), material is plastic, type GWS have one propeller hole size 3mm, diameter 8 inch and 4 inch pitch = 5.5 gram mass.

Figure 3.5: GWS slow flyer 8’ x 4’ propeller control

3.2.5 Propeller imbalance

At the moment development of UAV increases, the demand for high efficiency propeller increase significantly. The main aim is to determine the efficiency of the propeller, which can be obtained testing experiment in dynamic thrust. This is achievable through modification of propeller blade. From this study, imbalance blades designs were investigated to determine the dynamic thrust produce from the location of mass propeller.

Fig. 3.6, 3.7, 3.8 presents the location of mass blade design analyses in this study. The performance of propeller blade is influence by the location of the mass from the blade. To determine the influence of blade location, the mass weight is fixed that is 0.3 gram using thumb tack and the shape remains unchanged similar to baseline GWS slow flyer 8' x 4' propeller control blade. The analysis is carried out on three locations, with respect to the length from the center; 7.5cm, 5cm, 2.5cm.

Figure 3.6: GWS slow flyer 8' x 4' propeller location of mass 1

Figure 3.7: GWS slow flyer 8' x 4' propeller location of mass 2

Figure 3.8: GWS slow flyer 8' x 4' propeller location of mass 3

3.2.6 Thrust Stand

The rcbenchmark thrust stand series 1520 to measures thrust, rpm, voltage and current. This thrust test bench will directly measure and log voltage (0-35V), current (40A continuous), power (0-1400W), thrust (±5kg), and motor rotation speed (rpm).

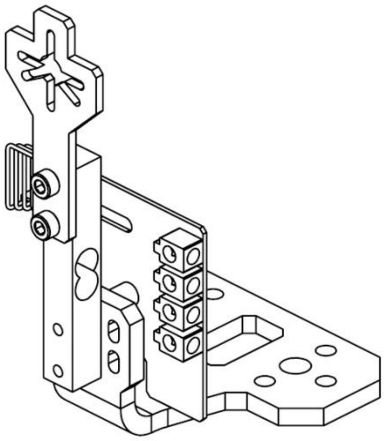

Figure 3.9: Thrust Stand load cell.

3.2.7 Pressure transducer

The pressure transducer specification is Tsi velocicalc 9565 multi function ventilation meter using for air flow testing, range 1.27 to 78.7m/s, accuracy $\pm$ 1.5% at 10.16m/s, resolution 0.01m/s

Figure 3.10: Pressure transducer.

3.3 Experimental Setup

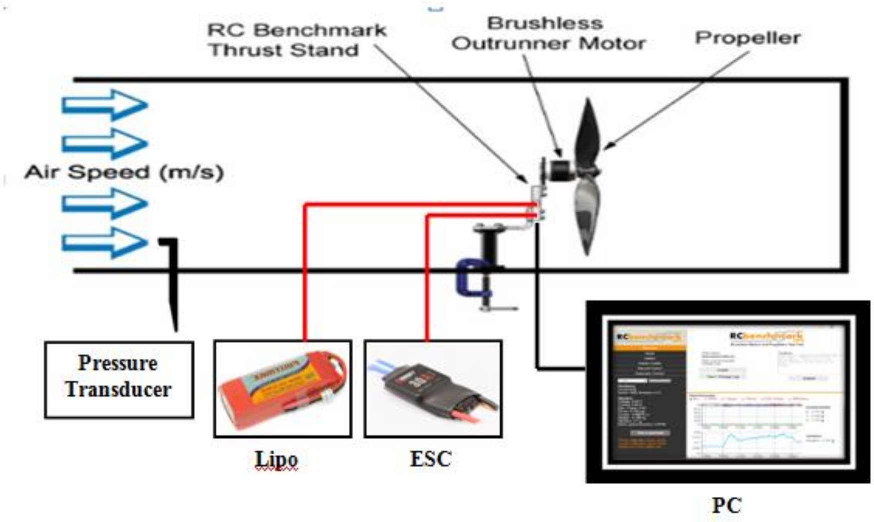

Figure 3.11: Experiment setup inside wind tunnel for propeller testing.

The testing programme was intended to follow the comparison of a imbalance propeller with a baseline propeller control, each modified incrementally and severally to reveal. In all, four propellers were tested including an baseline GWS slow flyer 8' x 4' propeller mode. In the subsections below, test campaign objectives are presented, followed by a description of the test facility.

Figure: 3.11 show the experimental setup for investigating propeller performance in wind tunnel. The many output parameters, generated by the propeller testing: thrust, torque, RPM, efficiency, power and current were measured. Each propeller will generate a different value of thrust. To begin with motor will be joining with load cell and connect the wire from motor to esc and power supply to data acquisition board. The load cell must be joining with stand and will be clamp inside wind tunnel at the centre test section. After that install propeller blade at the hub motor following that connect wire usb to computer. Next we record the data at the computer. The following objectives were formulated for the experimental campaign:

a. To test the different propeller level of imbalance mass (location mass 1, 2 and 3)

b. To test the different air speed wind tunnel (0, 4, 8, 12, 16, 20 m/s) All above experiment will be done inside utm subsonic low speed wind tunnel.

3.4 Flow Chart of Methodology.

The process of the project methodology is represented in flow chart as shown in Figure 3.8. for final year project 1 and Figure 3.9 for final year project 2.

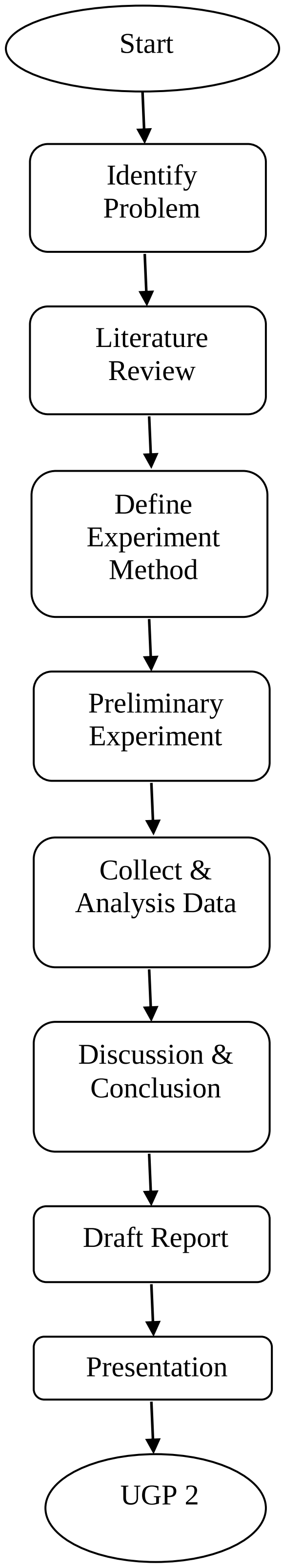

Figure 3.8: Flow chart for the final year project 1

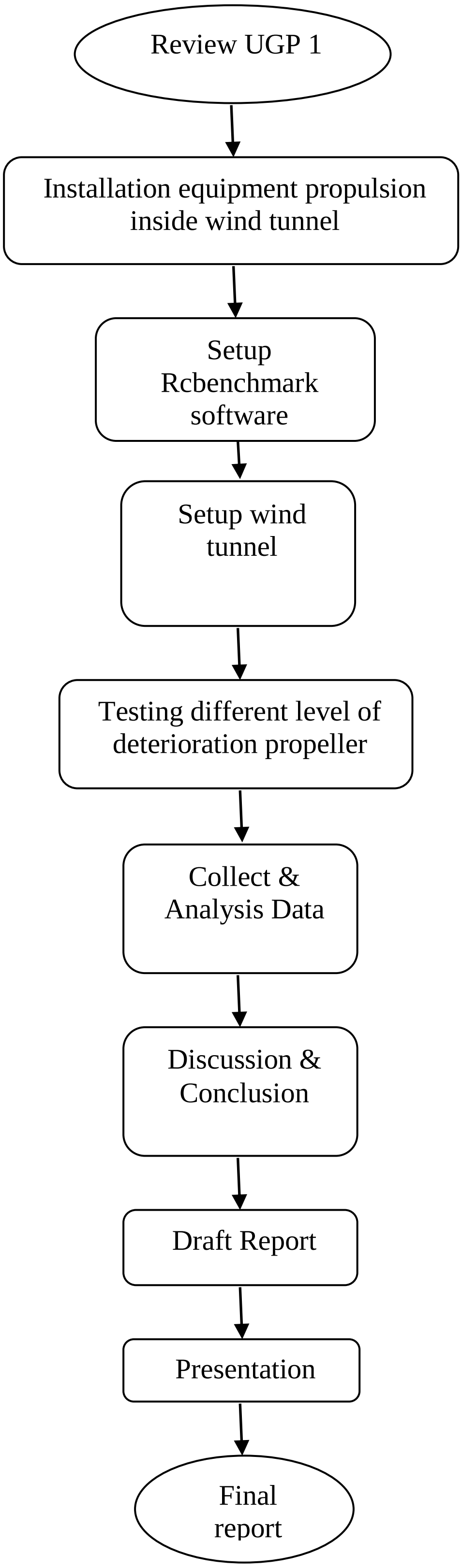

Figure 3.8: Flow chart for the final year project 2

CHAPTER 4

RESULT AND DISSCUSSIONS

4.1 Introduction

In this chapter, the result for the experiment was presented and discussed. The main focus of study is to determine the dynamic thrust and efficiency produce from imbalance propeller using the wind tunnel. All these result were observed and discussed briefly in this chapter and represented in graph.

4.2 Static test result

From the experiment, the data were directly obtained from the software rcbenchmark plotted in the graph below.

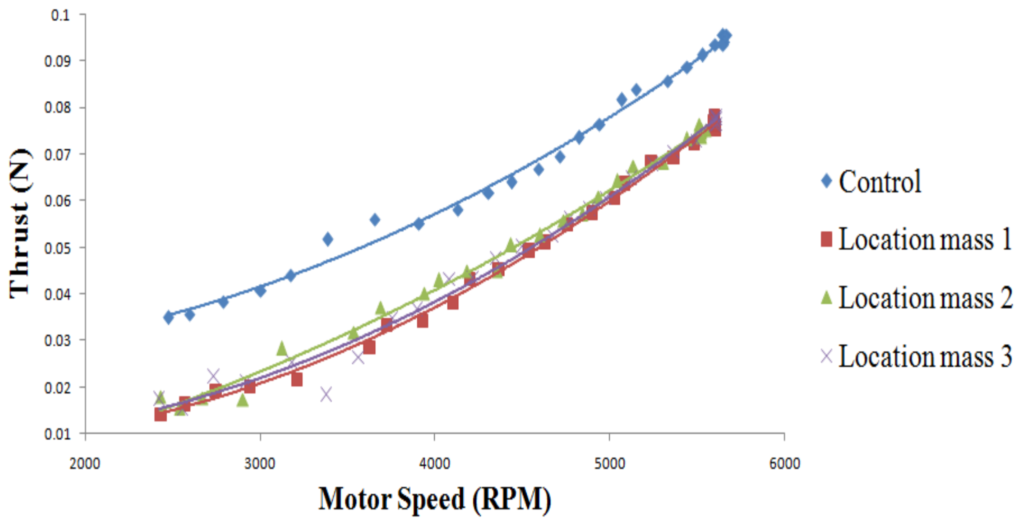

Figure 4.1: Thrust for imbalance blade design for various positions

This experiment confirmed that the propeller baseline control produce more thrust compare with imbalance propeller show in Figure 4.1. The three level location of mass did not show any significant differences between others. It can be concluded that the location of mass 1 is at the bottom of others location imbalance.

4.3 Graph dynamic thrust versus motor speed

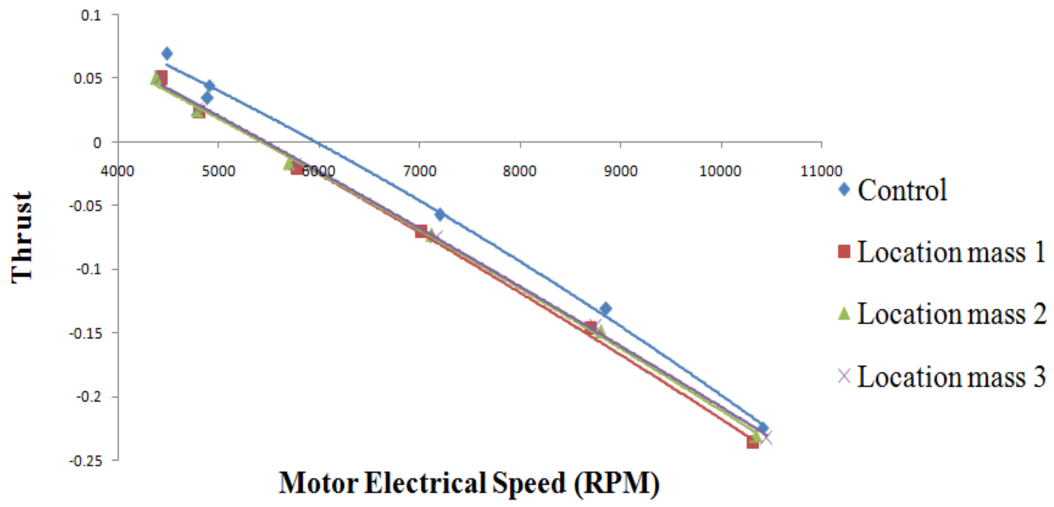

Figure 4.2: Dynamic thrust for imbalance blade design for various positions

During the dynamic tests, the load produced by the wind at air speed generates a thrust also increase the rpm speed. A comparison level deterioration with propeller control show that the effect in thrust produce.

4.4 Current versus air speed

From the experiment, the air speed of wind tunnel increase in stage from 0 to 20m/s. The graph show decreased current consumption when air speed increased.

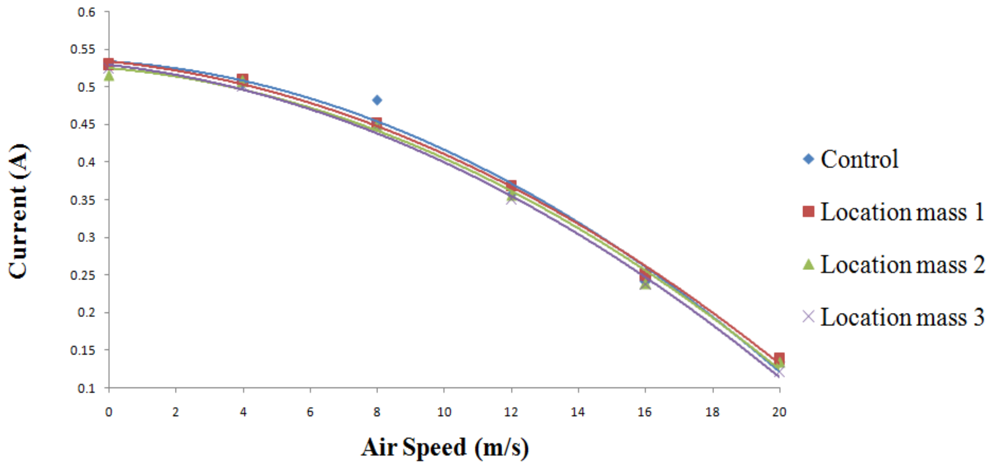

Figure 4.3: Current versus air speed for imbalance blade design for various positions

4.5 Thrust versus air speed

From the experiment, the air speed of wind tunnel increase in stage from 0 to 20 m/s.

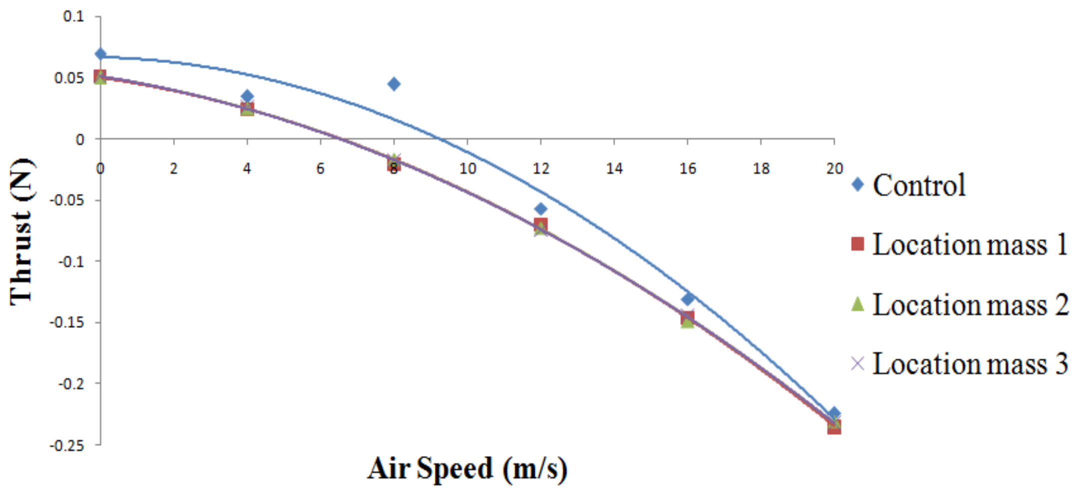

Figure 4.4: Thrust versus air speed

The value of thrust generates by propeller decreases when increasing the air speed of wind tunnel. The decrease of the thrust is due to drag as the wind velocity is increases. Thrust is produce by accelerating the air. When the aircraft begin to move forward, the thrust begin to decrease. It is because the higher the speed the higher the drag.

4.6 Efficiency versus Advance ratio

From the experiment, the air speed of wind tunnel increase in stage from 0 to 20 m/s.

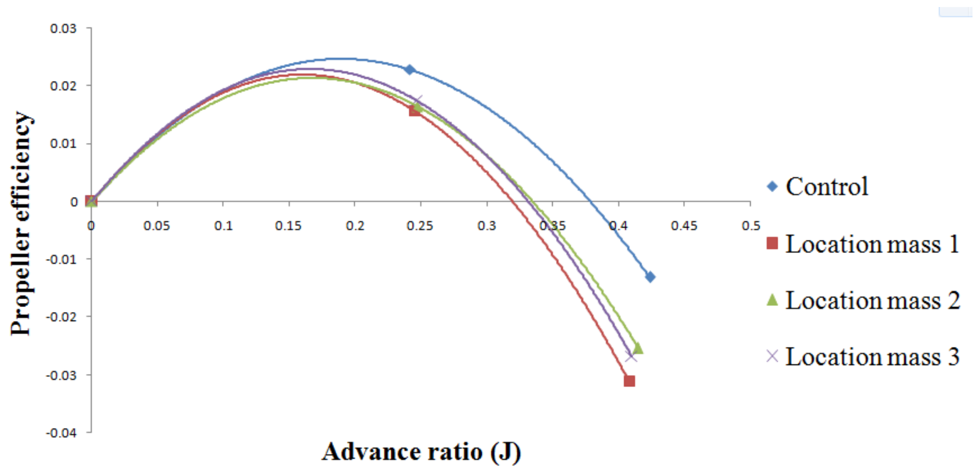

Figure 4.5: Propeller efficiency versus Advance ratio

Based on the result discussed, the first set of analyses examined the impact of imbalance propeller blade lower efficiency. However, increment in power coefficient lead to decrease in the propeller efficiency compared to baseline design, as shown in Fig. 6. This is because propeller efficiency is directly influenced with thrust and power coefficient, in which increase in thrust and decrease in power coefficient is expected. This is due to the effect of the air on the blade.

4.7 Power versus air speed

From the experiment, the air speed of wind tunnel increase in stage from 0 to 20m/s.

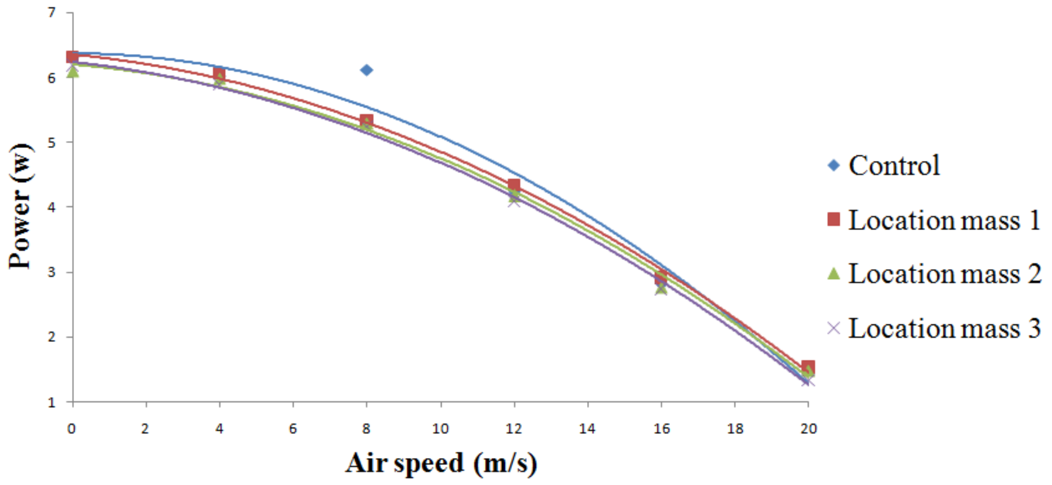

Figure 4.6: Power versus air speed

At the stationary condition, the propeller produces more power in order to accelerate the air. This is because, beside of the additional weight, at low air speed the pressure drags around the blade was high. However, when the air is moving in high velocity, the pressure drag around the blade will also drops. It means the motor no need to work hard.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

These experiment result show the four propellers GWS slow flyer 8' x 4' were tested statically and dynamically in the UTM Subsonic low speed wind tunnel. The testing data were collect from rcbenchmark software also the results showed the effects of propeller efficiency. The results will give effect when using imbalance propeller. The following conclusions can be drawn based on finding of study:

1. The results of this experiment show that the thrust and efficiency decrease when blade propeller have deterioration or imbalance. These results have been compared with baseline propeller control result.

2. During the dynamic tests, the load produced by the wind generates a thrust produced.

3. The distance location of mass and total mass inside blade propeller affecting thrust produce.

5.2 Recommendation

The following recommendation can be considered based on this study:

1. To use larger size propeller and more weight for imbalance propeller to see the significant difference.

2. Use another more number of blade for further experiment.

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APPENDIX A

No	TASK NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		WEEK																
1	Review UGP 1	■																
2	Experiment Setup																	
	i Fabricate Deterioted Propeller with mass		■	■	■													
	ii Setup trust stand in wind tunnel at center				■	■	■											
	iii Wind tunnel testing						■	■	■									
3	Data collection																	
	i Collect the Control propeller testing data								■	■	■							
	ii Evaluate the result based on the mass 1									■	■	■						
	iii Evaluate the result based on the mass 2										■	■	■					
	iv Evaluate the result based on the mass 3											■	■	■				
4	Discustion and Conclusion																	
	i Discussion on experiment result									■	■	■	■	■	■			
	ii Conclusion and recommendation									■	■	■	■	■	■			
5	Completing Draft report 2		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
6	Preparation presentation slide and .										■	■	■	■	■	■	■	
7	Submission of Ugp log book and Thesis																	■

APPENDIX B

Balancing equipment

Propeller

Actual experiment setup