1. INTRODUCTION

1.1 On Unmanned Aerial Vehicle (UAV)

UAV is an acronym of Unmanned Aerial Vehicle, which is an aircraft with no pilot on board. UAVs can be remote-controlled aircraft or can fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems. UAVs are currently used for several missions, including reconnaissance, mapping and monitoring for the disaster-affected area, non-destructive tests in oil and gas inspection, payload delivery, feasibility surveying, and other widespread requirements. Generally, UAVs are made up of the body (wing, fuselage, aileron, and rudder), electrical components (autopilot system, GPS, etc), and propulsion (propeller and engine). Based on the propulsion, UAV can be classified into two types, there are Plane and Multicopter. The difference can be seen from the number of rotors used. Multi-copter has four or more rotors while the plane has one rotor. A plane has long endurance than Multicopter due to the lift generated from the wing and the thrust from the motor while the multi-copter only generated lift and thrust from the propellers. However, for the long endurance and heavy-lift UAV, the kind of Plane is required.

The plane is needed to carry the payload required to the disaster-affected area or doing the facility mapping nowadays. Moreover, it also is required for mapping the construction area, fertilizer spreader for plantation and agricultural requirements, and feasibility surveying. For those necessities, the total weight is estimated at around 25 kg. These UAVs have been sold in the market. However, the price of either that plane UAV or UAV components such as the propeller is expensive. Local design and fabrication of UAV components are beneficial for the necessities.

1.2 Existing Approach

UAVs are made up of several components. There are wing, fuselage, rudder, and aileron as a control surface, also electrical components, and propeller. Especially for propeller as one of the fundamental elements of propulsion and aircraft design, acting as a rotating wing to produce lift in the same direction as the axis of rotation[1], there are several studies has done for the development of the propeller.

However, in the previous study, Brian David Rutkay[2] has presented the process for the design and manufacture of propellers for a small UAV with MTOW less than 25 kg by using the airfoil data from Reynold Number 75.000-300.000 and classical momentum theory where the thrust is produced due to a difference in the static pressure across an infinitely thin actuator disc. Then an XFOIL program was created to design a propeller that meets the user-requirement. The result has shown that the error is increasing due to the complexity however the development is required. In another study, Anggraeni et al.[3] presented the static-thrust analytical method and engine test for evaluating the propulsion performance for 75 kg MTOW surveillance UAV. The 1/3 of the thrust-to-weight ratio is carried out to decide the compatible engine. Results show that the thrust analytical method and engine test data are similar. Kutty et al.[4] presented the numerical simulation to predict the performance of 3D APC propeller and the result was compared with the available experimental data. The method used is by using tetrahedron meshing and Multiple Reference Frame in FLUENT. The study has shown that the thrust is slightly under the experimental data. Nuno de Sousa[5] has developed the optimization of propeller design for Long Endurance Electrical Unmanned Aerial Vehicle by using blade element theory and blade element momentum theory to perform the propeller analysis. The result has shown that the QPROP software for the numerical calculation and the higher the diameter and the pitch of a propeller, the higher the efficiency and that the efficiency decreases with the increase of the input voltage. For another study, Song Xiang et al.[6] have developed the improved design method for 500 kg MTOW electric UAV according to flight velocity, thrust, and rotational speed of cruise condition. The results has shown that numerical results of thrust coefficient, torque coefficient, power coefficient and efficiency are in close value with the wind-test results.

1.3 Objective

Based on the studies that have been reported in the literature, in this study the propeller for 25 kg MTOW is designed. The objectives of the study as following.

1. Determine the dimension of the propeller blade for 25 kilograms maximum take-off weight plane using the Blade Element Theory procedure.
2. The thrust of the designed propeller is numerically tested using commercial software Ansys Fluent R1 20.0 Student Edition to examine the accuracy of design calculation.

1.4 Problem Scopes

The problem limit discussed in this study is a propeller dimension calculation for 25 kg Maximum Take-Off Weight plane UAV and modeled by using commercial software.

1.5 Report Outlines

The study report consists of four chapters. Chapter I describe the UAV, existing approach, present approach, and report outlines. Then, Chapter II explains the theories, related to the study. Chapter III explains the study design calculation and numerical simulation procedure and each result of the calculation, and the last Chapter IV is the conclusion.