An Innovation of Flap Design for Energy Efficiency Lightweight Flying Vehicle Analysis

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Abstract: - The design of the flying vehicles (FV) is becoming popular and it is very important nowadays. It is drafted in various circumstances and situations such as the military and transportation. The development of flying vehicles is different from ordinary airplanes because of its ability to fly in multiple directions. In this study, a new design for Malaysia was produced based on prototypes from previous models available in Japan. This design improved that it can has better stability of using fans and flaps on flying vehicles. This research paper is concerned with a flying vehicle that can fly a load of up to 480kg with a speed of up to 300km/h. This study is focusing on observed the existing flap design in the recognized literature for current flying vehicles. The plan accomplishes the energy efficiency of the flying vehicles. From the simulation of constraint diagram, the design of the aircraft was optimized; with the initial design of the wing, air foil designing with high performance of motor was done. Propeller and flap was design according to safety standard to fit in for the FV. The design of the new FV flap were compared to the existing model from the teTra aviation corp which was designed in Japan. The result of the new design FV flying vehicle will provide a clearer picture for the new concept that improvement flying time 35 % from the normal design.

Key-Words: - Flying vehicles (FV) design, flaps design, energy efficiency

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1 Introduction

The aviation industry has been of great interest since the beginning of the construction of transport vehicles. To date various types of aviation vehicles have been produced from helicopters to airplanes. In 1906 Wright Brothers built their first airplane that provides much inspiration to today's study. Technological advances and time have given a lot of room for researchers to improve the design capabilities of aviation vehicles. At this time FV has gone through various design processes for various conditions. The designed FV is lighter and produces optimum power and better flight in a variety of conditions. This situation essentially increased the use of FV for education and commercial aviation at a more cost-effective manner. Designing a high performance FV is challenging to meet the needs of all types of aviation especially in a bad weather conditions and at the night. The new design of the FV needs to complies with the standard specification and regulation according for the safety. Moreover, this research is also focusing on the take-off capabilities and the stability during FV operation. Using the lightweight material such as carbon fibre and aluminium, it is will improve the take-off and landing abilities including using smart landing gear system. Manoeuvring abilities of the existing designed FV is to attain +54.4g to -3.8 g force. Henceforth the existing FV development design focusing on great manoeuvring competences, new FV specification is a to improve conception design of flying vehicle with the additional of the flap design system.

2 Design Methodology

Type of the FV flap design were clarified systematically by studying the literature from early flying vehicle configuration including UAV design. Some of the method selected to approaches and supported of designing of the new FV. Its starts from searching the important data from the literature of finding. All the nomenclature is as follows, B: Weight, T: Thrust, C_1 : Co-efficient of lift, β: Density kg/ m^3 , D: Drag, L Lift, C_d Drag co-efficient, Cl Lift co-efficient.

3 Design Process

All the data for the FV is based on the Tetra FV model. According to the specifications of the FV design, it must meet the several standard. Some of the requirements were selected from the literature from exiting design. In this research a FV model from the teTra aviation corp was referred and compared. Among the other establish designs, tetra FV model was referenced and this specification was chosen [1]. The specification = 5m×5m take off area is an important for the FV Cruising distance was around 27 m with Endurance flight increasing to 1.8 hours. Maximum FV Weight = 480 kg Cruising speed = Range 54 m/s - 90m/s generation performed standardizing constraint as a thrust loading (T/B) and wing loading (B/S). Then the constraint limit is set on the graph as the ratio of thrust to (T/B) thrust loading and (B/S) wing loading. Design requirements and specifications - in order to plan the construction of must conditions under which FV. According to the current trend for this design, the was referenced specific were selected from the design of this aircraft. Table 1 shows the design specification of the FV. The objective of this research is to improve the flying time of the FV with the help of the additional flap on the FV. In order to have energy efficiency and better flying range is by improving the lifting abilities [2]. From the Simulation run from the Matlab is as shown in Table 1:

Table 1: Design specifications

FV parameters and specifications	Values minimum	Values with
Flying Range	80km	180km
Cruise velocity	54m/s	90m/s
Take of area	5m X 5m	5m X 5m
Take-off weight	480kg	450kg
Flying time	20 minutes	1.8 hours

3.1 The Take-off Performance

The (Sg) of the design is around 5m X 5m for the take-off area. Formula of runway length is as shown and its corresponding to the B/S value and the T/B value [5].

$$S_g = \frac{(1.21B/S)}{(gp\infty CLmax\, T/B)} \quad (1)$$

Hence for safety requirement, the is set to 10 m, necessary obtain a T/B value. design on air flaps hoist installed in the FV are value of the FV take off (Cl max) becomes 1.6 [5].

3.2 Constraint Diagram Generation

Performed standardizing constraint (T/B) and wing loading (B/S). Next the limit is determined on the graph for the ratio to weight (T/B) to wing loading (B/S). Each limitation is identified for the design space. The next stage is four iterations, a combination of the 3 most qualified.

3.3 Landing Capability

For a track, the B / S value is according to [5].

$$W/S = \frac{9.81 * (Sg - 121.6) * (Cl\ max) * (\frac{\beta}{\beta sl})}{7.293} \quad (2)$$

The landing capacity safety area was 10 m, and it is 2% better and smaller compared constraints specified to (200 m) according to B / S parameter. Due to specifications on air flaps for the FV design, the value of FV take-off and he maximum coefficient during landing ($\boldsymbol{CLmax}$) obtains 1.6. Flying capabilities of the FV is considered to sail up to 6500m altitude from the sea level at the speed around 54 m/s as the FV capability is considered 3000m. Depending on the force (Ps), the cruising of the FV is determined with on air and weather situation [6].

3.4 Carpet Plots – Design Trade-off

From the given specification, when designing an FV are on a scale of 10 and sometimes more than 60 [4]. The designer has the difficult task of getting all the possible combinations in sequence to get the most optional design. In this case, a modification study is done on the additional of flap design for the FV to get various combinations of value T/B and B/S. Some appropriate parameters for the design such as ability of take-off, maximum flying height, are determined. Hence, the combination of these value diversity is exhibited on a trade study chart called Carpet plot. Thus, referring to the constraint diagram, determined T/B = 0.229 and B/S = 309.

3.5 Design of Wing

Refers to the B/S data and parameter, to determine the section of the required limits for the design. From the data (B/S) found as 299 N/m^2. Moreover, obtaining FV optimum weight which is 480 Kg, it can be determine the 500 kg the specified aircraft can take MTOW increments, as following equation (S) is:

$$B/S = 299 \Rightarrow S = 17.985\ m^2 \quad (3)$$

Next the aircraft AR (aspect ratio) value was 8 from the simulation and analysis made for the carpet plots. By placing the AR value of the, the is obtained which is 12 and the aircraft is ensured sail of 7 km cruising around 55 m/s speed. The ratio of taper (Ŕ) FV from 0.2–0.3 [3]. The Taper ratio is 0.3. Now, the main chord (Cr), the last chord (Ct) and the wing are.

Main chord Cr = 2b/(AR(1+Ŕ)) = 2.5 m
Chord and Tip = Ŕ = Ct/Cr => Ct = 0.524 m
Aerodynamic centre mean = 2/3 Ct (1+ Ŕ+ Ŕ 2)/ (1+ Ŕ) = 1.690 m

The position of the middle wing design is selected. Because the current design suited for high level of performance. Next, the fuselage is redesigned and the advantage that it is determined designs traction [7].

The modification is to increase in particular part of the wing design and it is to facilitate a stable and safe state blowing rolling for the flying vehicle (FV). From the study, data and parameter that have been performed on the available aircraft, considered the value of 2^0 for dihedral angle. The cruising aircraft is assumed to consider the take -off mass and the fraction of the cruising mass [8].

The FV lift coefficient (Cl) of the FV was shown as:

$$(Cl)FV = \frac{\text{W cruise}}{(\text{Flap area} * \text{q})} \Rightarrow Cl = 0.699 \quad (4)$$

The design lift coefficient that the wing has to realize at cruise was shown as:

(Cl) flap = Cl FV of the FV at cruise/0.945 = 0.69

Next the design lift coefficient that the wing air foil has to achieve at cruise was shown as:

(Cl) air foil = Cl of the Flap at cruise/0.9 = 0.779

The use of an unspecified hoist is this level, therefore (Cl) force must be generated by an unlimited air rig. Therefore, the NACA air section studied ensured that the highest value of 0.8 ‘CL max’ was sought. Moreover, the value is lift coefficient 0.79, after the whole wing is designed and tested, the value of good ideal lift coefficient decreases due to 3D effect. Therefore, an air determination with a better value than the original value was chosen. NACA 631-308 which obtained 0.854 at 8^0 wing setting angle was selected. The selection factor of this aircraft is because it has a minimum *Cd* mean value of 0.00592, with a maximum value (*Cl/CD*) of 140 and suitable room. The 3D model for the full - wing FV prototype design produced in Solid work is shown in Figure 1.

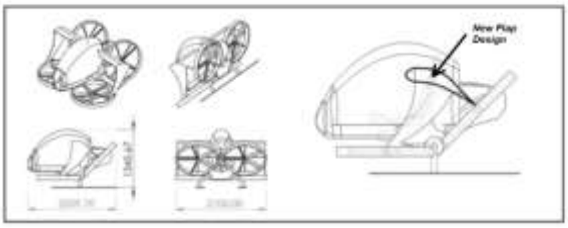

Fig. 1: The new FV prototype with additional flap design

Power plant selection, the most important criteria for selecting 4 types of engine power are related to flying vehicle (FV) performance. The flying vehicle has been designed to sail at an optimal altitude of 2.5 km and at cruising speed of 55 m/s. The setting constraints FV for example engines pistons devices [9; 10]. In addition, there are drawbacks when using turbo-props because there are additional weight of gears. This makes the system heavier. With an adequate thrust -to -weight T/B ratio with the most optimal as received by the engine is optimized as [11; 12; 13] T static = T/B (from Constraint diagram) * FV T static Weight = 2.6 kN. The power used from the engine to launch the flight is considered as: Required = T static * with a transmission requirement of η 90% and a η propeller of 35%, sufficient power from the engine is calculated as: Optimum power Required = Required / (η transmission * η propeller) = 170.34 / (0.9 × 0.8) = 236.58 kW [14].

3.6 Design of Flap

The constraint diagram gives the direction obtained for an FV operating in a variety of conditions. Appropriate propellers should be specified from an existing manufacturer who can provide the desired direction. The geometry specifications of the propellers are obtained from well-known manufacturers such as Hartzell®, Airmaster® and others. The geometric specifications of the propeller such as blade angle design, the resulting thrust is usually not shared by the manufacturer. The study conducted this data obtained and it is appropriate, Clark Y selected in this design [12]. There is also a fuselage design. The main objective of the fuselage design from the current design is to accept additional loads such as weapons or tracking systems along with the amount for which it is important to take into account so as to be suitable for each operation. The FV configurations from the existing FV refer to in the same class, the specifications of the FV designed for future design. Various designs performed, the aircraft cross section is the most suitable design as it is not round in shape according to NASA specification report [13]. Figure 2 and 3 a) shows the tetra aviation corp FV design and compared Figure 3 b) shows the new prototype design of FV.

Fig. 2: The teTra aviation corp FV design [6]

(a) (b)

Fig. 3: a) The teTra aviation corp experiment and [6] b) The new design of the flying vehicle

4 Results

Constraint diagram:

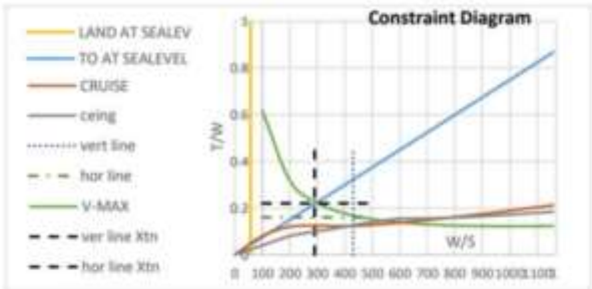

Fig. 4: The design space feasible with the mixed in graphically identifies. (Constraint diagram)

According to the result in the Figure 4 shows g-maneuvered curve, the top speed and the landing system are important in the overall design. T/B and B/S values specified in the section and the design meet the requirement. The black line indicated the design method selected from the existing FV design. The specific mark is determined as a guideline to the lower value of T / B (to reduce energy consumption) and the lower value of B / S (to set the FV wing maneuverability). The design point was specified as B / S = 299 N/m^2 and T / B = 0.23. These B / S and T / B data is important for power plant selection and the configuration and wing measurements. The constraint diagram results are a based to perform the wing design. NACA 631-308 was referred for the FV wing design. Initial wing measurements from the design, wing configuration for the last iteration are shown in Table 1. Hence, Javafoil applet Panel code was analyzed for the airfoil and performed with Reynolds number of 526600 navigations with Calfoil. Figure 5 shows NACA 631-308, Lift curve slope graph. From the study it found that 0.8 lift coefficient was accepted and follows the standard of the design.

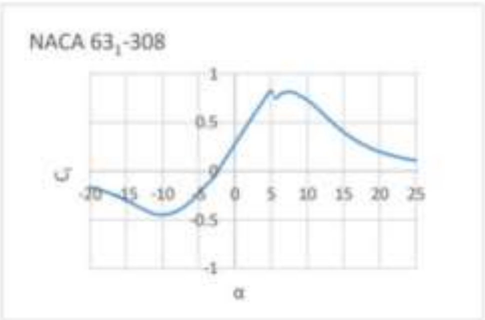

Fig. 5: NACA 631-308, Lift curve slope graph

The wing has been fixed for which this angle should correspond to the ideal lift coefficient of the air. From Figure 5, the ideal lift coefficient of air is 0.79, besides the angle corresponding to the ideal lift coefficient of air flight identified is 1.2^0 .

5 Conclusion

Based on specific design procedures for high - performance FV vehicles it is determined that empirical relationships and data sheets are performed based on specific specifications. In the process of conceptual design is done according to the rules that get a brief atmosphere on the state of the working industry in consolidating and designing FV with specifications set by the customer. Every place FV design is done that gives an accepted concept design concept. The planned FV are qualified to perform at higher altitudes of around 6600m for a time of around 1-2 hours and through rotations of -4.8g and + 6.3g which increase in power efficiency. From the given specification, designing an FV are on a scale of 10 and sometimes more than 60. The designer has the difficult task of getting all the possible combinations in sequence to get the most suitable configurations. In this case, a modification study is done as part of the flap design, to get various combinations of value T/B and B/S can have been done. Some appropriate parameters for the design such as ability of take-off, maximum flying height, are determined. Hence, the combination of these value diversity is exhibited on a trade study chart called Carpet plot. In this research a FV model from the teTra aviation corp was referred and compared. The specification = 5m X 5m take off area capability is important for the FV to take off from a limited space. Cruising distance was around 27 m with Endurance flight = 1-1.8 hours. The simulation shows the FV with additional Flap increased flying time and save more energy up to 35% compared to the existing design.

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