IUT MAV2013, Part I: Aerodynamic design of tailless wing and body configuration

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ABSTRACT

In this paper, a procedure is presented to select the MAV airfoil shape without horizontal tail and to study all parameters of airfoil selection. A number of suitable airfoil sections are examined. Using the proposed procedure, a vast range of airfoils can be evaluated in such a way that the time required for design and flight tests reduces. In this method, the trial and flight tests are key components to conform the most design procedures. Having designed the air vehicle weight, it is necessary that the most fitted plan-form be selected for the defined mission. The designed fixed wing and body configuration for the IUT MAV2013 is presented here.

Keywords: Micro Aerial Vehicle (MAV); Aerofoil flows, CFD, Tailless wing and body.

1. INTRODUCTION

Micro air vehicles (MAV) are very significant due to their application in civil, military and industry researches along with their low weight which is their specific characteristic. They are unmanned and their sizes are less than 1 meter. According to defined mission, the MAV size with its mounted equipments can vary. Their small sizes compared with the other unmanned air vehicles (UAV) causes the MAVs to have an extensive operation field. Although their small sizes reduce the structure costs, the related electronic equipments are very expensive. Also, they are of high sensitivity in design and performance because of their small sizes. On the other hand, airfoil design and optimization is very important in aerodynamics because of its significant role in flight. Therefore, the MAVs bodies are completely made of airfoil to have a better performance [1].

However, they can be categorized into the fixed wings, quad rotors, flapping and vertical flier kinds as shown in Figure 1. The MAVs flight like other unmanned air vehicles by remote control because the human attendance is difficult, dangerous or even impossible. With regard to the mentioned specifications, micro air vehicles have the potential for performing missions like detecting, patrolling. The first research on MAVs was performed in RAND institution (1993). At that work, multiple studies were done on the air vehicles smaller than 5 cm which were able to perform detecting and rescuing missions [2].

Because the MAVs are very small-size and low speed, the Reynolds number are very low that results in unique aerodynamic conditions. [3]. On the other hand, the limited wing surface causes the generated lift force to be low. Plan-forms, the top view of MAVs [4], are in the form of Delta, Zimmerman, Inverse Zimmerman, Rectangular, Elliptical and irregular ones. Some different plan-forms are shown in Figure 2. Aerodynamic optimization of plan-forms causes the aspect ratio of air vehicle to be increased incorrectly and impractically [5]. In classic planes, the shape of the plan-form should be selected in the preliminary steps [6]. Because, the design methods are aimed at improving specific conditions of air vehicle plane, and the proposed design plan can be adapted to the other design cycles, some parts are mentioned beforehand, briefly.

Fig. 1. samples of MAVs

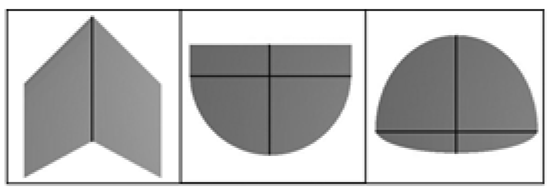

Fig. 2. Samples of Plan-forms

2. XFLR5

XFLR5 is open source software which analyzes 3D problems and as a matter of fact, it is the advanced version of XFoil software. This software has multiple abilities such as airfoil analysis; planning and drawing wing, foil, tail and the other components. Therefore, it is used for the aerodynamic analysis of a modified inverse Zimmerman plan-form shown in Figure 3 and stability control [7]**.**

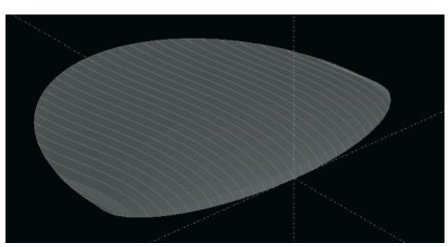

Fig. 3. Sketch of Polars on Plan-form in XFLR5

3. DESIGN METHODOLOGY

The MAV Plan-form is a modified design of inverse Zimmerman plan-form which was designed by Isfahan University of Technology design team. All analysis is performed at leading angle of 4 degrees. Airfoils have been investigated are showed in Table 2.

Table 2 Airfoil tested for the vehicle

Airfoils	Lift Coefficient	Pitching moment
mh81	0.689	-0.009
s5020	0.592	-0.003
s5010	0.58	-0.004
goe744	0.814	-0.017
fx05h126	0.746	-0.039
ah80136	0.628	-0.01
mh104	0.612	-0.011
B29tip	0.683	-0.035
E169	0.443	0.003

Because of the large and non-negligible errors caused by the designing equations the charts introduced later is used [8]. With regard to using airfoils mh81 in previous projects, the same airfoil is used for micro air vehicle. The effect of adapting airfoil on micro air vehicle is to increase the pitching moment by changing airfoil geometry via flapping. Figures 4 and 5 show the effect of flap angle on lift and pitching moment coefficients, respectively.

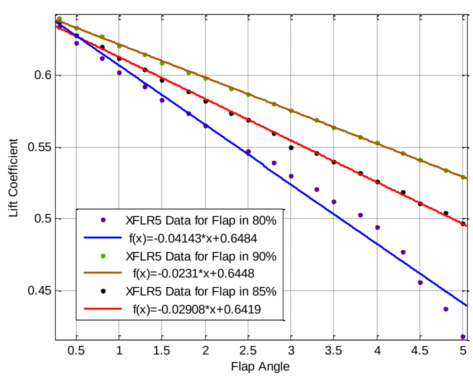

Fig. 4. effect of flap angle on lift coefficient

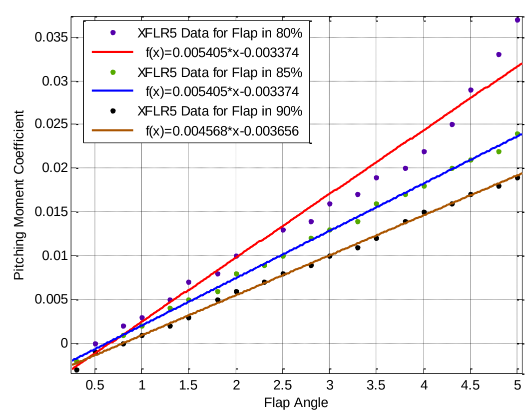

Fig. 5. effect of flap angle on pitching moment coefficient

It is obvious from profiles, increasing flap angle of tail leads to pitching moment increment and lift coefficient reduction. As documented from plots, to meet pitching moment at 85% of Chord line and 50% of airfoil location, flapping is seen and a coefficient of 0.02438 is obtained. This angle is 5 degrees. After considering the volume coefficient of the vertical tail 0.6, defining the tail place, the exact location of the elevators and aria of them, the final stage of designing had been done.

4. CONCLUSION

The methodology proposed in this research, showed that the time spent during the designing and manufacturing the fixed wing MAV decreases enormously. Also in this project a new method has been investigated to stabilize the fixed wing MAV longitudinally by changing in airfoil geometry. The airfoil selected for this project was mh81 that for the designing purpose and also designing aerodynamic needs, some changes in row thickness had been done. The next step was to change the airfoil by changing in reflex of the airfoil for the purpose of improving of pitching moment. The result of the study has worked perfectly in Re=520000 and also proves the efficiency of the methodology proposed.

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