Proceedings of the
International Conference on Mechanical Engineering and Renewable Energy 2013
(ICMERE2013) 1 - 3 May 2014, Chittagong, Bangladesh

ICMERE2013-PI-038

DESIGN AND DEVELOPMENT OF A CONTROLLABLE WING FOR UAV

Md. Tanvir Ibny Gias[1], Mohammad Mashud[2] and Abu Nayem Md. Asraf Siddiquee[3]

[1-3]Dept. of Mechanical Engineering,
Khulna University of Engineering & Technology
Khulna-9203, Bangladesh.

[2]mdmashud@yahoo.com

Abstract- *With the passage of time the concept of fixed wing area has been changed in different aircrafts specially used in military purpose by controllable wing. This work describes such a kind of controllable wing capable of controlling its wing area to get desired lift or drag when needed. The wing is equipped with a controllable shaft and the controllable shaft is that which makes the wing controllable. This controllable shaft is consists of three concentric pipes .The pipes are made sealed to response with the injection and suction of air. Two openings are kept in each pipes, except the last one to make connection with the compression pump and the vacuum pump. Compression pump injects air and the vacuum pump sucks the air out of the sealed pipes .The controllable shaft is attached with three concentric wings of airfoil shape and all these three wings form a controllable wing. This wing can do expand or get compressed in two stages. The expansion and compression in two stages provides the aircraft with achieving a large scale change in lift and drag. Introduction of controllable wing in UAVs can bless the history of aviation with a new dimension .The aerodynamic characteristics of the controllable wing has been analyzed to judge how perfect it was to be applied in UAVs.*

Keywords: Controllable shaft, Variation of wing's area.

1. Introduction

Recent interest in morphing aircraft has motivated the study of controllable wing[1–6]. New time of aviation calls for the wing which can easily be controlled to keep authority over lift and drag. Controlling the wing area by any means can do generate adequate lift and drag as needed. When an airplane embarks to fly it requires to generate high lift; if it can increase it' s wing area, the extended wing will provide the airplane with high lift; as same to the drag although angle of attack plays an vital role here. Introduction of a controllable shaft make a wing control.

The concept of fixed aerodynamic surface introduced fixed wing. When air passes around the wing with a high velocity, there is a pressure difference between the lower and upper faces of the wing. The lower face of the wing feels a positive pressure when air passes around the wing with a high velocity, there is a pressure difference between the tends to raise it higher from the ground level and with the same time the upper face a negative pressure or suction pressure. This pressure difference results in a lift which pulls the airplane up.

In recent years the concept of controllable wing has developed .Specially for UAVs the essentiality of controllable wing got increased day by day. Using actuator, hydraulics in metallic wings and morphing wing developed the concept of controllable wing and expressed it to the world in concrete form.

A Compression pump can inject air with a great variety of range of pressure on the other hand a Vacuum pump sucks the air. In this project the injection and suction of air controls the movement of controllable shaft.

The goal of the project is to vary the wing area in a wide range by introducing two stages expansion and contraction of wing using both compression and vacuum pumps.

2. Construction

A controllable wing is nothing but capable of controlling it's wing span area. With such kind of wings the lift and induced drag can easily be controlled. It can change its wing area with a very short time. The change of wing area causes a little disturbance in airplane's stability; after the change in wing area the airplane gains its new stable condition.

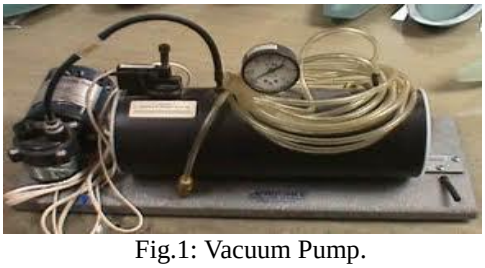

Fig.1: Vacuum Pump.

Fig.2: Compression Pump.

The controllable shaft is made of three concentric pipes one of these pipes is of stainless steel and the two other of plastic. There are two holes in two plastic pipes. With plastic pipes the holes of the pipes are connected to Compression Pump and Vacuum Pump. . Through these holes air is injected and sucked.

A wooden prototype of wing was constructed to get the ultimate prototype made of G.I sheet. Then it was cut down into 3 parts. After getting the three concentric airfoil shape of the ultimate wing these were connected with the controllable shaft.

To join different mating parts Gas welding, Arc welding and a general purpose epoxy compound named "m-seal" were used.


Fig.3: Initial stage of controllable shaft

Fig.4: Initial stage of controllable wing


Fig.5: 1st expansion of controllable shaft

Fig.6: 1st expansion of controllable wing


Fig.7: 2nd expansion of controllable shaft

Fig.8: 2nd expansion of controllable wing

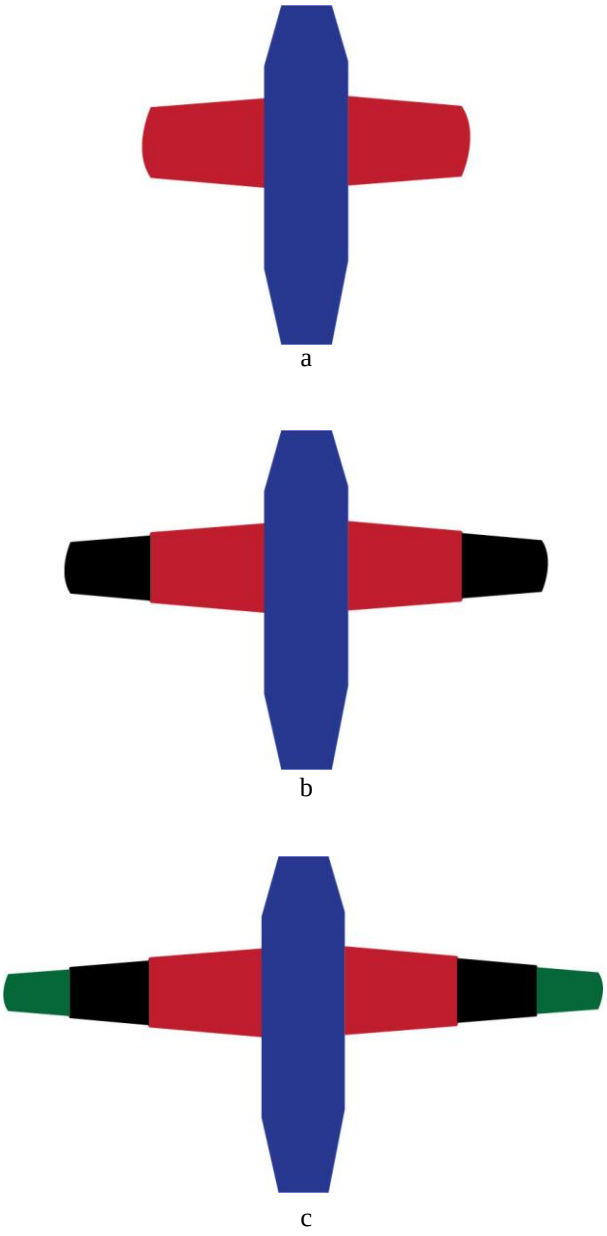

Fig.9: a)Initial stage of wing, b)1st stage of expansion, c)2nd stage of expansion

3. Data and Equation

For the initial stage the area of the wing is 0.085 m^2.
For the first stage the area of the wing is 0.144 m^2.
For the second stage the area of the wing is 0.163 m^2.

$$L=q_\infty * S * c_L \quad (1)$$
$$q_\infty=(1/2)*\rho_\infty * V_\infty^2 \quad (2)$$
$$D= q_\infty * S * c_D \quad (3)$$

4. Results and Discussion

Though it is the construction of a single wing, calculating the wing span the length of the wing was multiplied with 2 to get the real value. Here the two stage expansion of controllable wing indicate the two step increase in wing area; shows that how the lift force and drag responses with the increase of wing area.

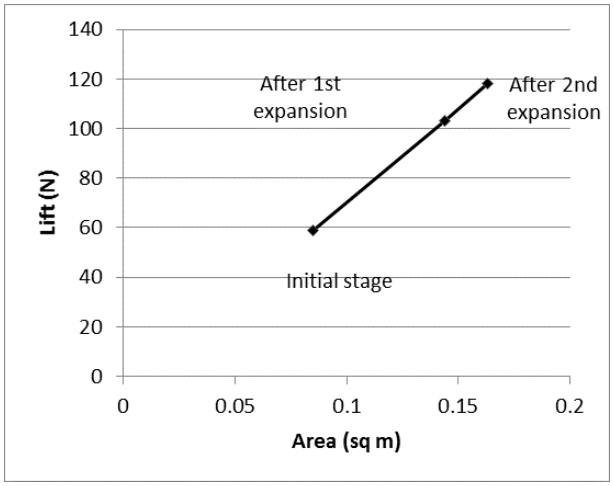

Fig.10: Lift vs. Area

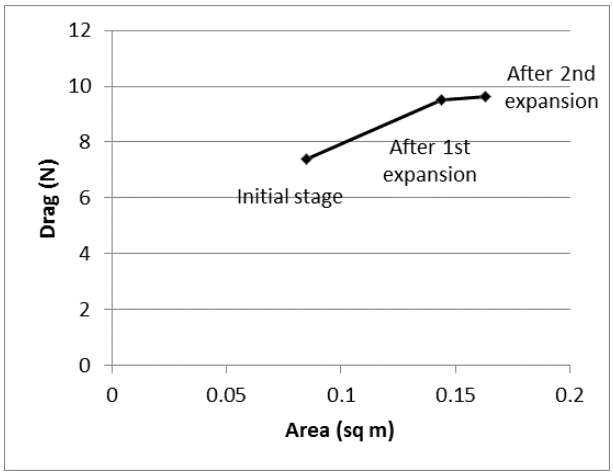

Fig.11: Drag vs. Area

UAVs are involved in sophisticated military works, fighter plane and even in passenger carrying airplane controllable wing can be introduced. When a UAV or fighter plane needs to move between two obstacles like two high-rise buildings and it seems to come about a collision between the wing and obstacle, if it can squeeze it's wings then it can overcome the danger of collision .The feature of two stages expansion and contraction can facilitate a passenger carrying airplane to generate required lift and drag during flight. From the experimental data it is clear that there is an appreciable increase in the lift force with the increase of area. On the other hand the rate of increase of drag with the increase of area is low.

5. Conclusion

A prototype of controllable wing was constructed to find that how much perfect it was to be applied in real airplanes. With the reasonable data it has proof itself as good enough in using and with same time it indices its capable of bringing a change in wing area to achieve desired goal within a very short time.

6. References

[1] David A. Neal, Matthew G. Good, Christopher O. Johnston, Harry H. Robertshaw, William H. Mason§, and Daniel J. Inman, "Design and Wind-Tunnel Analysis of a Fully Adaptive Aircraft Configuration," AIAA paper 2004-1727, 2004.

[2] Bowman, J., Sanders, B., Weisshaar, T., "Evaluating the Impact of Morphing Technologies on Aircraft Performance," AIAA paper 2002-1631, 2002.

[3] Roth, B., Peters, C., Crossley, W., "Aircraft Sizing with Morphing as an Independent Variable, Strategies and Investigation," AIAA paper 2002-5840, 2002.

[4] Martin, E. T., Crossley, W., "Multiobjective Aircraft Design to Investigate Potential Geometric Morphing Features," AIAA paper 2002-5859, 2002.

[5] Marmier, P., Wereley, N., "Morphing Wings of a Small Scale UAV Using Inflatable Actuators for Sweep Control," AIAA paper 2003-7837, 2003.

[6] Blondeau, J., Richeson, J., Pines, D., "Design of a Morphing Aspect Ratio Wing Using an Inflatable Telescoping Spar," AIAA paper 2003-1718, 2003.

[7] http://www.grc.nasa.gov/WWW/k-12/airplane/foil3.html

7. Nomenclature

Symbol	Meaning	Unit
L	Lift force	(N)
D	Drag force	(N)
S	Area	(m^2)
ρ	Density	(kg/m^3)
V	Velocity	(m/s)