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Designing Approach of Blimp for a Hybrid VTOL Aerial Robot

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ABSTRACT
In case of aerodynamic aspects when most of the research is going on how to increase lift, with developing its aerodynamic shape, the most advancement can be drawn with using inflatable blimps where lighter than air gases can be used. The lighter than air gasses will provide a great aerodynamic advances by providing lift using its bouncy forces. For controlling an aerodynamic object there is two forces, one is its own gravitational force in negative direction and controlling forces as required for changing its position .But, most of the cases gravitational forces make the most difficult situation while its time to deal with power consumption. By using inflatable envelope with lighter than air gasses we can easily deal with the gravitational forces of aerodynamic objects. This writing will present a design approach for this kind of inflatable envelope.

Keywords: Aerodynamics, Inflatable, Bouncy, Gravitational

1. Introduction

In recent years, the RC aircraft or drone has a problem with stability and longtime flight duration. A concept of adding blimp with traditional system can be made a better result to overcome the existing problem. The hybrid airplane combines three approved main concepts of human flight. It needs no infrastructure for takeoff and landing and is able to reach a higher cruising speed compared to airships and helicopter. It is built out of lightweight high-tech materials like dry wood, aluminum and high dense foils, while only a low amount of metal is applied to the structure. At present, no clear picture exits of the construction of a VTOL(vertical takeoff & landing) hybrid Unmanned Aerial Vehicle (UAV) for long duration flight in Bangladesh. Therefore, the purpose of this work is to design an inflatable blimp for VTOL aerial robot.

2. Background:

Lighter than air constructions with lenticular hulls that reached the development stage of prototyping were the models XEM-1 to XEM-4 from LTAS/CAMBOT LLC [1], remotely piloted lenticular airships, which were built (from 1974 until 1981) as a demonstrator and for Filming, video observation and telecommunications work and their three full scaled rigid airship variants. W.C. Kelle (1989) observed that blimp made a good impact while boundary layer and atmospheric sampling included measurement of the radioactive transfer through the lower atmospheric boundary layer and ocean-surface flux measurements [2]. J.H.W. Hain (1992) investigated oceanographic sampling in the early 1990s included surface water sampling, phytoplankton hauls, temperature and salinity profiling, deployment of current drifters, and geophysical surveys [3]. W.A. Hoppel (1993) made an Page 3 of 10 airship, which was also used for studies of aerosol distribution and particle formation in the marine boundary layer [4]. Also ALA-600 Thermo plane, an airship filled with both helium and hot gas, which was designed by NAYLER (2001) to operate with heavy loads, without a base or mooring mast was finalized in whereas ALA-40-01 ground tests started [5]. Cs. Singer (2008) made a general comparison between HTOL and VTOL(vertical takeoff & landing) Airplanes, Helicopters, Airships, Trains, Vehicles, Ships and the proposed hybrid airplane over their size, pollution, capacity, speed, range, security and required infrastructure was found out, which based on the quantitative comparison in the transport solution costs of different transportation concepts and their speed [6]. W.F. Putman (2011) investigated design and controls for the vectorotor hybrid VTOL heavy lift vehicle drone for multipurpose application show its commercial aspect [7]. Design of a commercial Hybrid VTOL UAV System by Intel Robot System made the step, review the preliminary design process of such a capable civilian UAV system, namely the TURAC VTOL UAV. Ugur Ozdemir (2014) made the TURAC UAV is aimed to have both vertical take-off and landing and Conventional Takeoff and Landing (CTOL) capability [8]. Yu Ito (2017) analyzed indoor hybrid blimp logistics drone provided with crash-free ability at full power-loss condition is made it easy for proving its advantages [9]. James C. Egan (2018) present discloser pertains to vehicle capable of flight and more particularly, to manned and unmanned vehicles having combined methods of lift, including dynamic lift and displacement buoyancy [10]. However, the construction of a VTOL hybrid UAV for long duration flight has not been made clear until now in Bangladesh. Therefore, in this project, a model of VTOL hybrid unmanned aerial vehicle for long duration flight is constructed.

3. Methodology

In case of inflatable body, it can have a nested capacity or not. Nested wings are subset of re-deploying body in case of emergency design requirements. The main concept of a blimp came from “Airship concept”, but there is different in designing approach.

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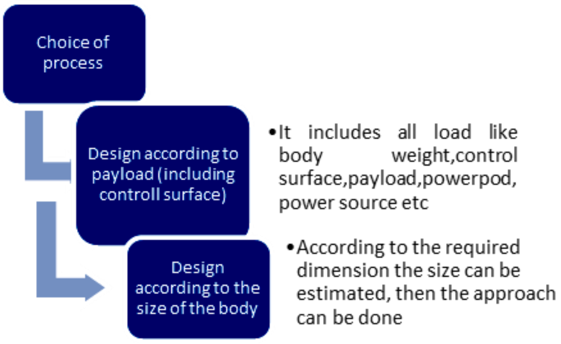


Fig.1 Choice of process for designing approach

The approach with fixed dimension follows a strict property & its capacity of lifting.

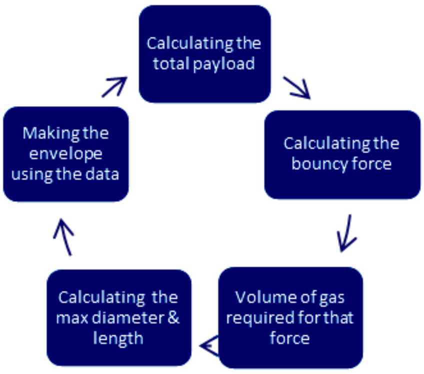


Fig.2 Cycle of working procedure

Nested wing has a unique character with having different material condition in same structure. The following proposed or closed nested wing configuration airfoil is designed by Mueller and Noffke is shown in the beloved figure. The embedded wing concept which is a variant of the nested wing design, except a smaller with the configuration attached wing (is now stowed either as a portion of the main wing with some surface exposed completely internal to the larger loiter wing).
For the sample calculation, the envelope will be assumed as the following shape,

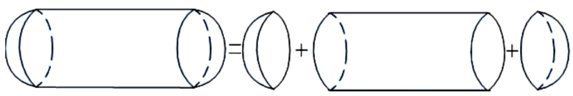


Fig.3 Assumed shape for simple calculation

This allows greater flexibility in designing both wing profiles and platforms with the constraint that the dash wing must be partially or wholly embedded within the loiter wing. But for the shape of the outer surface will greatly affect its drug force thus, it follows a specific calculative shape. There will be a idea while the projectile shape will be observed. The projectile view is given below.

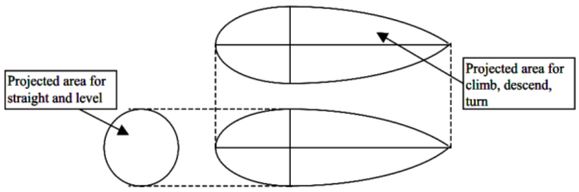


Fig.4 Different projectile view of an envelope

In case of inflatable wing the most important thing is to make a closing system when it is not inflated. Low volume storage requirement is a prime factor in determination of deployable concept. When rigid wing sections are deployed, the stowed volume cannot ever be less than 100% of the deployed wing volume. Packing an aircraft into a specific constrained volume whether a cylindrical-shaped volume for a missile launched UAV or a cone-shaped volume for a Mars airplane will result in unused volume among the rigid sections.

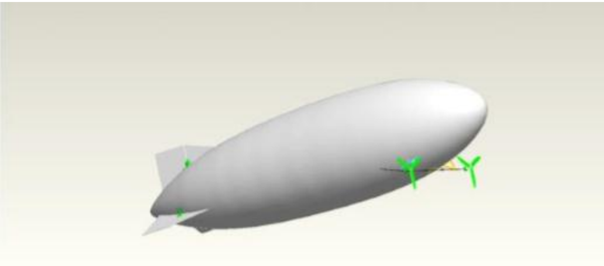


Fig.5 Theoretical model of a blimp

In case of deploying time, it's very important as it can make a very important part for the air craft while it has a crushing condition in emergency landing. Or in case in use of carrying the aerodynamic thing its deployment can make a good effect while its main aim is to quick lunching. Consideration of the overall volume ratio, Vs/V_d , with respect to the span ratio of rigid inner section length to deployed length, b_0/b. In contrast with the large total stowed volume required by hinged rigid wings on carrier decks, the total stowed volume of the FINDER aircraft is seen to include a minimal amount of unused volume associated with the wing packing design. Inflatable wings here assume a 10% stowed-to-deployed volume for the outboard inflatable sections, with inboard rigid section based on the dimension.

3.2 Premises and Design

In case of inflatable aerodynamics, its physics is much more unstable than general one. But, its characteristic makes it easy for a smooth boundary layer. One aero shaped body can make the boundary layer continuous without creating any kind of vortex. But a generous amount of parallel body reduces the time and cost of construction & also it'll give a better left capacity. So,in this case only one blimp will be considered for designing. For the primary design the fore body be generated with the revolution about its X-axis with a simple semi-ellipse, having the equation:

$$1 = \frac{x^2}{2a^2} + \frac{y^2}{D^2} \qquad (1)$$

Where,
D= maximum diameter
a=length of the fore body

For speed & power,

Maximum horse-power,

$$H_p = \frac{\rho v^3 v^{2/3}}{550k} \qquad (2)$$

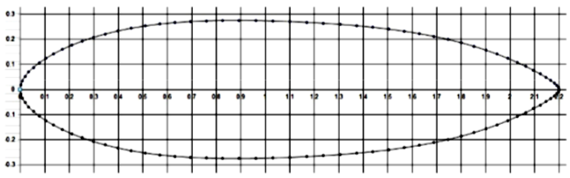
Static & dynamic bending moments,

$$M = C.\rho g.VL \qquad (3)$$

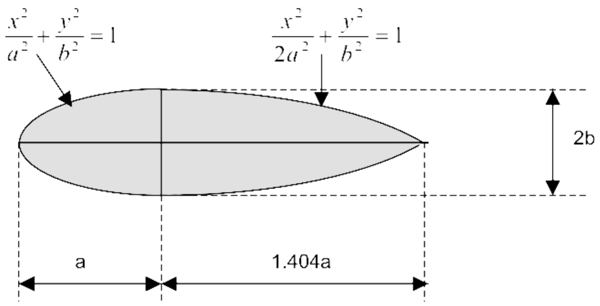
Where,
M=the bending moment
C=co-efficient
Pg=the unit weight of the air
V=air volume
L=length
Maximum stress,

$$S = \frac{2M \sin \emptyset}{Rn} \qquad (4)$$

In case of an ideal design a model Gertler 4154 shape is taken with some specific dimension.



(a)



(b)

Fig.6 (a),(b)Gertler 4154 shape with 2.20 m length & 4:1 slenderness ratio, derived from Series-58 4115 shape tool by Johannes Eissing

For gas pressure & outer cover stress, the pressure and bouncy forces should be calculated.

$$M_B = \rho_{He}\left(\frac{\Pi d^3}{6} - Vm\right) + Mm + f.\Pi d^2 + Mp \qquad (5)$$

$$F_b = \{(\rho_a - \rho_{He})\left(\frac{\Pi d^3}{6} - Vm\right) - (M_m + f.\Pi d^2 + M_p)\}g \qquad (6)$$

ρ_a =density of air
ρ_{He} =density of helium
d=diameter (max)
V_m=Volume of the LTA gass
M_p= momentum
g=gravitational accelaration

In this case as a Lighter than air gas helium is used. So, the density of helium was considered as a LTA gas .The purpose of this mathematics is to figure out the algebra relation between the size and the payload for a safe hybrid blimp. Because of the low cruise speed and stability at zero-power status. The aim of this whole calculation is to figure the limit of payload to keep safe terminal speed at full power loss. If the relation between diameter and payload fills the in equation, the blimp will ascend at such accident and won't cause any crash to the ground .This condition can give the body degree of freedom given below:

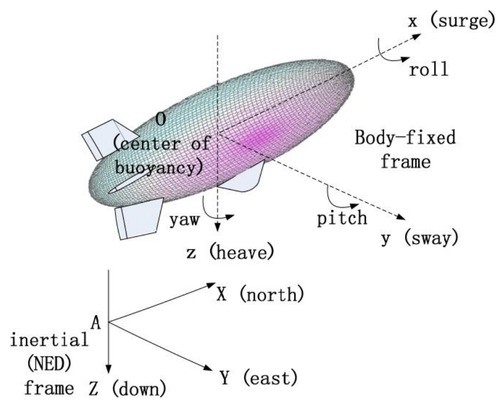


Fig.7 Degree of freedom

In case of tail design, traditional method of controlling platform is used where it will give a better perfection in an easy way.

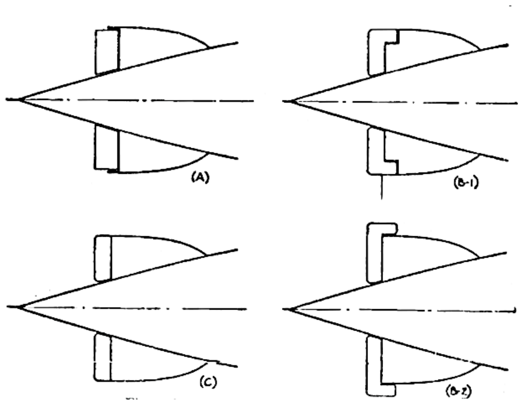


Fig.8 (A), (B) Tail design and positioning of control surface

For the correct view of the tail control system can have a clear arrangement in case of indoor & out door,

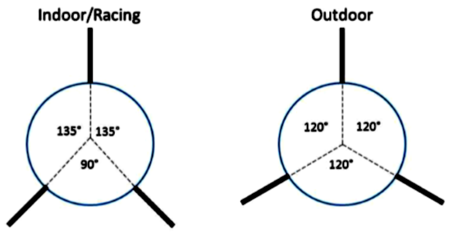


Fig.9 Tail surface mounting position in angular parameters for indoor & outdoor conditions

Traditional design on dirigibles, blimps and airships for transport has had to conceive the existence of airflow from side wind and its relatively high cruising speed. The solution to these wind effects and moments was the Traditional finned cigarette shape of airships and blimps sustained by complicated inner structures. The overall design will have the following view.
In case of more simplification, the moment created by bouncy force & the bouncy force is given below,

$$M_B=0.026\pi r^2 d^3 + 0.037\Pi d^2 + 0.5 + M_p \quad (7)$$

$$F_p= (0.174\pi d^3 - 0.037\pi d^2 - 0.5)g - M_p g \quad (8)$$

(Putting the known value of equation 5&6)

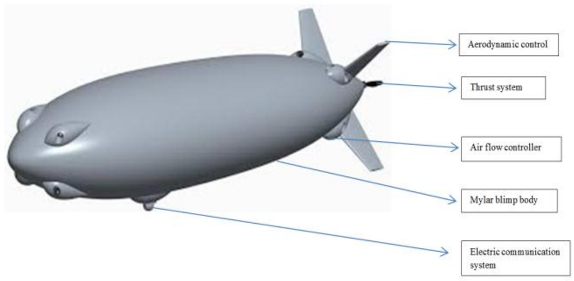


Fig.10 Overall design outcome from the conceptual model & the positioning of the tail part

(a)

(b)

Fig.11 Final fabrication of blimp with different material (a) reinforced & (b) Mylar

4. Result:

The blimp was filled with Hydrogen gas (H_2),and kept for it's buoyancy force test.The following graph is found with the collected data,

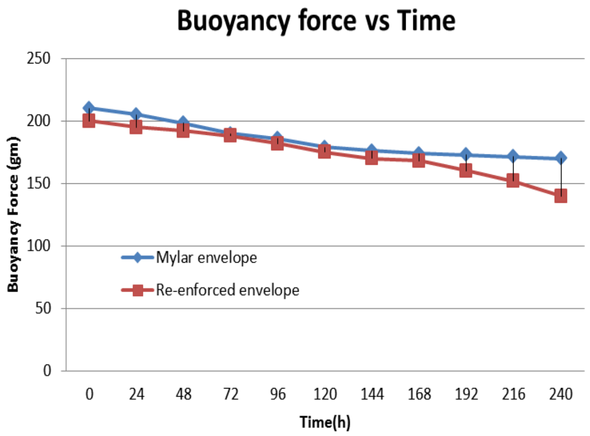


Fig.12 graph shows how the blimp losses it's buoyancy forces.

5. Application:

In case of application, the environment can be divided into three categories .It can be indoor, outdoor & high altitude.
For this section, in what situation will an indoor blimp drone could be applied to will be discussed. Firstly, in order to utilize the virtue as a flying machine to be used in limited space, the building to install such system should be one that contains a wide overhead space or a large well hole area that are free from solid obstacles. Some of the most suitable categories of use of buildings that fit this character should be like as: commercial complex facilities, sports arenas, event halls, concert halls, station concourses, and airport terminals. Needs for indoor logistics should be found from such kinds of buildings. Second, because of the limit of the payload at a handle able craft size, carrying consolidated business cargo is not the most suitable for its mission. Distribution from the hub to the tenants inside a complex facility is often specially designed as a part of logistics practice by service providers. Such business logistics is usually rationalized by integrating the parcels to be delivered to each tenant. Even if to consider the delivery is free from human labor power and therefore assume that a frequent-however-small amount carry is still acceptable from the perspective of service cost, the configuration of the blimp that was aimed to provide safe emergency landing by creating drag will act against the necessary speed and energy efficiency.

6. Conclusion:

This explanation only deals with the approach of design of an envelope for a blimp. In case of hybrid VTOL the design must sustain a categorized shape which will provide a good control over aerodynamics. The steps in designing explain the process of calculating bouncy forces for an exact shape with the help of exact design & it's relation with control platform. And also, the experimental data shows that, Mylar blimp is much sustainable in terms of buoyancy force than the re-enforced one. But, in case of material strengthen-enforced one gives much good result.

7. Limitations & Future Prospect:

The idea argued here only have been discussed theoretically, and thus needs to be tested through actual modeling, prototyping, and proof of concept. Also, the proposed business application never existed before should be considered further how to be connected to the current business seamlessly that will benefit the customer more. Technically, estimation on outdoor application regarding weather conditions such as UV rays, side winds, downburst, and heavy rain is left to be done for further extension of the concept.

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