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Power Requirement for Flying Bike

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Abstract:
The major work on this paper is to find out the required power needed to let the bike fly in air in order to overcome the drag. Since drag is mandatory for any object moving with high velocity against air due to its friction at different altitudes for different pressure. And to overcome such air friction the body is streamlined to get the maximum attainable speed. The streamline body in this case is the Airfoil for which the calculations is made taking angle of contact at 0^o and at 10^o maximum because beyond 10^o the coefficient of lift decreases rather increasing the coefficient of drag. And the drag part is the always surface area during consideration of any body.

***Key words**: NACA Airfoil, Streamlined*

1. Introduction

According to the concept of Aeronautics the wings plays the major role as it is employed to lift the total weight but it has to overcome the drag also. As when the lift is possible then it has to overcome the weight, similarly for thrust the plane or flight has to overcome the drag than only it can maintain the lift in air and to provide the maximum thrust or to provide the level flight the plane either has to be propelled or to get the thrust from the combusted gas with the turbine. But in this case we are dealing with the push propeller in order to overcome the drag. Also a fan wing can be employed in a airfoil. Fan Wing or fan wing is a new concept for a type of STOL aircraft. It is distinct from existing types of aircraft like airplanes and helicopters in using a fixed wing with a forced airflow produced by cylindrical fan(s) mounted at the leading edge of the wing. Its makers claim it is the first horizontal- rotored integral lift and propulsion wing in history to sustain flight

2. Dynamic Modelling Concept

(A)The wings considered here is the rectangular with the surface area of (Front Wing) = 0.232 m² and for (Rear wing) = 0.3127 m². And Drag (D) = $C_D(0.5 * \rho * V^2)$A is to be act on the external surfaces of the wing.

Where,
C_D is the drag coefficient.
ρ is the density(kg/m³)
V is the velocity (m/s)
A is the external/cross sectional area (m²)
(B)The different force which overcomes the drag is called Thrust. i.e., Thrust (T) = Force (F) = m*a and Power (P)= D * V
Where,
M is the mass in (kg)
a is the acceleration due to gravity.
D is the drag force and
V is the speed of air or speed of flight in (m/s)
(C)Also the drag force depends on the
Shape of the immersed bodies
Position of the body immersed in the fluid and

Fluid characteristics

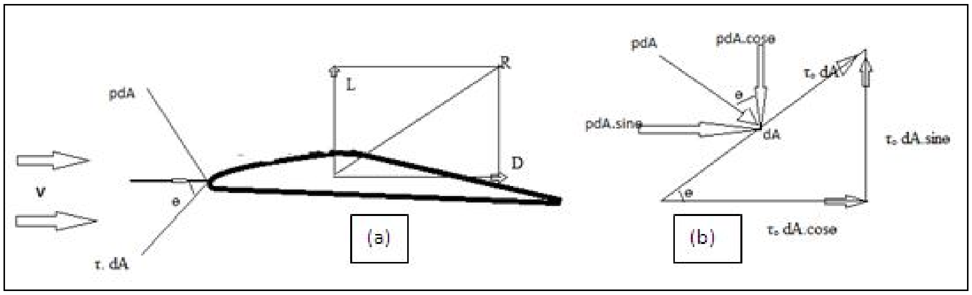


Figure 1: (Different forces acting on Airfoil)

(D)The forces acting at any point on the small element of surface area (dA) on the body are:
Pressure force equal to p.dA in the direction perpendicular to the surface
Shear force equal to τ_o dA in the direction tangential to the surface.
Therefore the resultant force (R) $=\sqrt{L^2 + D^2}$

(E) Aspect Ratio
Condition: (1) The surface area for the front wing (rectangular) =800mm * 290mm = 0.232 m2
And mean chord = 290 mm
Aspect Ratio= mean chord/length= 290/800 = 0.36
Condition: (2) The surface area for the rear wing (rectangular) =590mm * 530mm = 0.3127 m2
And mean chord = 530 mm
Aspect Ratio= mean chord/length= 530/590 = 0.89

(F) Development of lift on an Airfoil
An airfoil is a streamlined body which may be either, symmetrical and unsymmetrical. It is generally characterised by the chord length(C), the angle of attack (α) and span (L) of Airfoil.

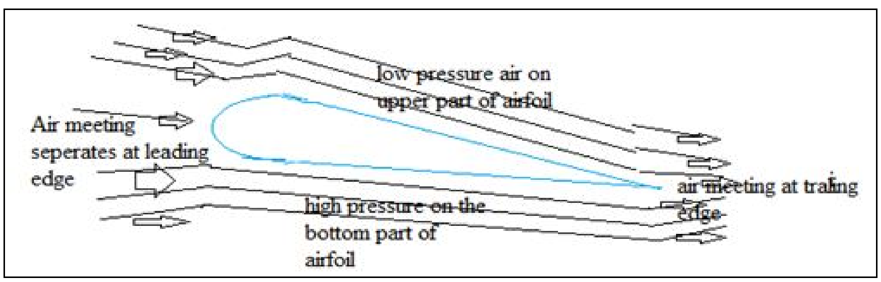


Figure 2: (Flow pattern for combine translation and circulation)

The figure 3, basically it is observed that by proper adjusting circulation (from theoretical analysis) the streamline at the trailing edge of the airfoil is tangential.
And the circulation is given by $\Gamma = \pi.C.V.\sin\alpha$ and------equation 1
Lift force given by using Kutta-Joukowski equaton is $L = \pi.C.L.\rho.V^2.\sin\alpha$--------equation 2
Where, α = angle of attack
C = chord length
V = velocity of airfoil
On substuting equation 1 & 2, we get the coefficient of lift i.e,
$C_l = 2\pi \sin\alpha$ (Since, $L= C_L (0.5*\rho* V^2) S$, $D= C_D (0.5*\rho*V^2) A$, where S is the wing area and A is the surface area during flow.

(G) Therefore, the coefficient of lift is directly proportional to the angle of attack (α), which results and affects the coefficient of drag to increase beyond 10°, since the flow separates. While the ratio of lift and drag coefficient is called as lifting efficiency.
(H) Fan Wing:
FanWing is a STOL aircraft that pulls the maximal airflow through both the propulsion and lifting surfaces. A cylindrical radial turbine (resembling a cylinder mower) is embedded in the wing with its axis parallel to the wing and leaving about 2/3 of the diameter exposed above the top side of the wing's length just after the leading edge. This increases the velocity of the airflow across the wing's

upper surface beyond that of the forward motion of the aircraft. Consequently the wing has lift at slow speeds where a normal wing would stall

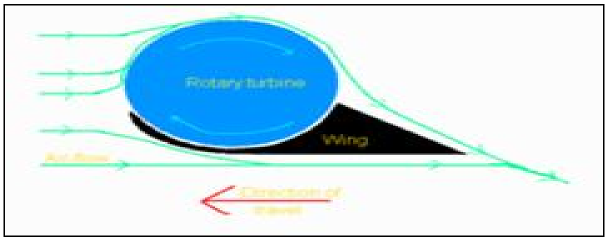


Figure 3: Fan Wing/Airfoil with Rotor

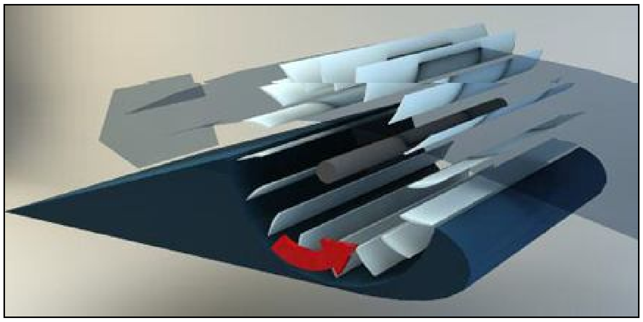


Figure 4: Fluid Dynamics Lift Generator

3. Considerations

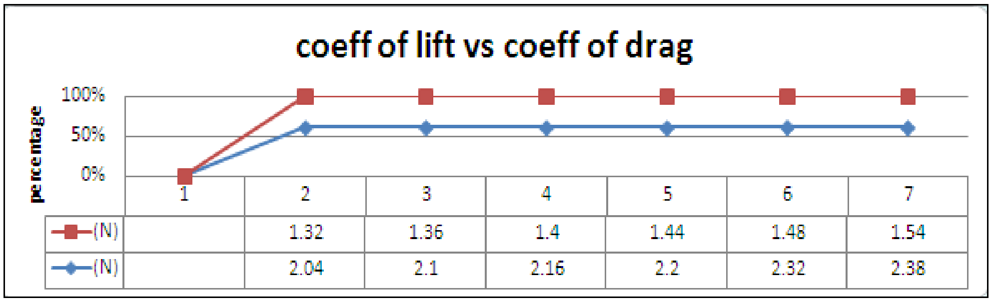
Case 1 for front wings (for maximum speed V = 140 km/hr = 38.88 m/s = a = 0.648 m/s²

- Max weight on front wing = 180 kg = W=L
- Area (A) = 0.232 m2
- Drag (D) = F = ma
- Max angle of attack (α) = 10°
- Chord length(C) = 290 mm = 0.29 m
- C_l (Coefficient of lift from both front wings in the research paper Title: Flying bike concept
- IJRME, Vol 1, PP. 001-011, March, 2014)

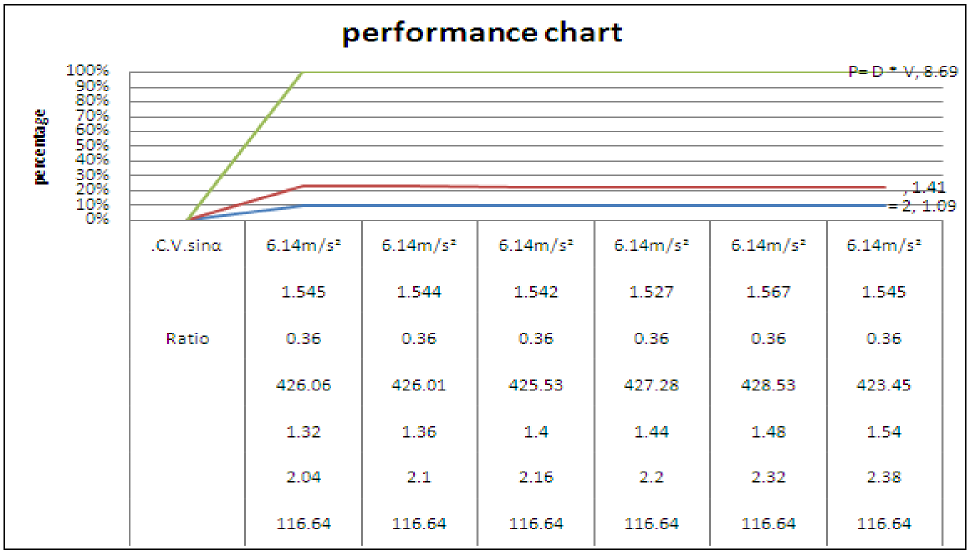
Note: for both wing the factors or parameter are multiplied by 2.

F=ma	C_l (N)	C_D (N)	R = $\sqrt{L^2 + D^2}$	Aspect Ratio	$\eta_l = C_l / C_D$	Γ = π.C.V.sinα	$C_l = 2\pi$ sinα	η_l	P= D * V
116.64	2.04	1.32	426.06	0.36	1.545	6.14m/s²	1.09	1.65	8.99
116.64	2.1	1.36	426.01	0.36	1.544	6.14m/s²	1.09	1.60	9.00
116.64	2.16	1.4	425.53	0.36	1.542	6.14m/s²	1.09	1.55	8.99
116.64	2.2	1.44	427.28	0.36	1.527	6.14m/s²	1.09	1.51	8.98
116.64	2.32	1.48	428.53	0.36	1.567	6.14m/s²	1.09	1.47	8.96
116.64	2.38	1.54	423.45	0.36	1.545	6.14m/s²	1.09	1.41	8.69

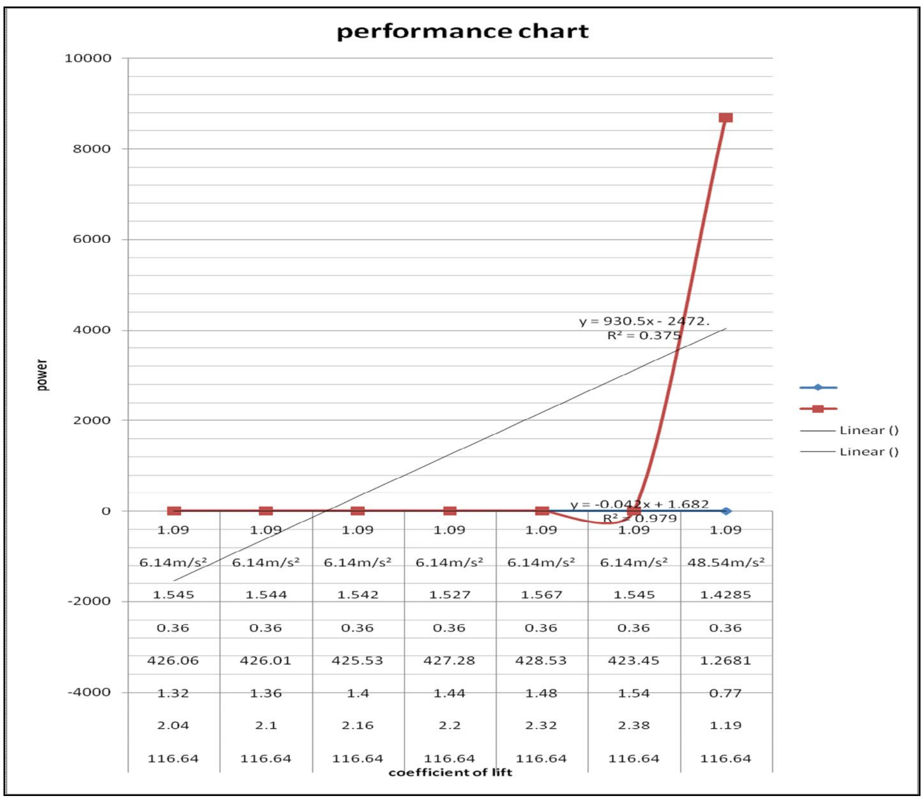
Table 1



Graph 1: coefficient of lift vs. coefficient of drag without angle of attack



Graph 2: Power requirement for the flight based on lift and drag for case 1



Graph 3: overall performance of airfoil for case 1

Case 2: For rear wings (for maximum speed V = 140 km/hr = 38.88 m/s = a = 0.648 m/s²

- max weight on front wing = 280 kg = W=L
- Area (A) = 0.3127m2
- Drag (D) = F = ma
- Max angle of attack (α) = 10^{o}
- Chord length(C) = 530mm = 0.53 m
- C_l (Coefficient of lift from both rear wings in the research paper Title: Flying bike concept
- IJRME, Vol 1, PP. 001-011, March, 2014)

Note: for both wing the factors or parameter are multiplied by 2.

F=ma (kg/m²)	C_l (N)	C_D (N)	R = $\sqrt{L^2 + D^2}$	Aspect Ratio	$\eta_l = C_l / C_D$	Γ = π.C.V.sinα	$C_l = 2\pi$ sinα	η_l	P= D * V (kw)
181.44	2.36	1.52	615	0.89	1.55	11.23m/s²	1.09	1.43	13.96
181.44	2.42	1.58	663.3	0.89	1.53	11.23m/s²	1.09	1.37	14.97
181.44	2.5	1.62	663.7	0.89	1.54	11.23m/s²	1.09	1.34	14.34
181.44	2.58	1.66	663.57	0.89	1.55	11.23m/s²	1.09	1.31	13.95
181.44	2.66	1.72	664.87	0.89	1.54	11.23m/s²	1.09	1.26	14.03
181.44	2.74	1.78	665.42	0.89	1.53	11.23m/s²	1.09	1.22	14.09

Table 2

Case 3: Propeller Design parameters:
No. of blades (B): 2/3
Axial velocity (V) for the flow (flight speed): 140 km/hr (38.88 m/s) maximum
Diameter (D) of the propeller: 580mm=0.58m

C_L and C_D along the radius
ρ =1.22 kg/m^3 (Air)
ρ =1000 kg/m^3 (Water)
The desired Thrust (T) or available shaft power (P):

Thrust (T) = ρ*A* V²

Where, $A = \frac{\pi * D^2}{4}$ is the circumferential area of rotating propeller (or the amount of air drawn by the propeller pushing in forward direction)

Therefore, $A = \frac{3.14*(0.58)^2}{4}$

A= 0.2640 m²

And Power (P) = 0.5*ρ*A*V^3 and Shaft diameter= 19mm

Speed(V)/ (axial velocity)	Thrust (T)	Power(P)	Torque (F.d)=ma.d Let m=180kg	Torque (F.d)=ma.d Let m=280kg
60km/hr=16.6m/s	88.75N	0.73kw	0.63Nm	0.92Nm
90km/hr=25m/s	201.3N	2.51kw	0.9Nm	1.4Nm
120km/hr=33.33m/s	357.79N	5.96kw	1.19Nm	1.86Nm
140km/hr=38.88m/s	487.00 N	9.46kw	1.39Nm	2.17Nm

Table 3

4. Conclusion

From the table it is observed that we had the drag force (F) which have to overcome the thrust develop by the Push propeller. Hence the maximum power required at top speed V = 140 km/hr by front wing to overcome the drag is 8.69kw and from the rear wing it is 14.09 kw from case 1 and case 2 which gives the average power requirement of 11.39 kw. As it is discussed in the consideration case 3 (design of propeller) gives the maximum power at top speed is 9.46 kw and it requires to be modified in order to meet the required complete power to overcome the drag resistance by reducing the weights from case 1 and case 2 or by decreasing the wing span or by increasing the engine power. Also to short out the power difference, an airfoil may be replaced by fan wing or the area of airfoil can be slightly decreased as per the requirements. Thus it makes the bike fly in air.

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