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Development of Wings for Flying Bike

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ABSTRACT

This paper will deal with the developed wing for the Flying Bike in order to provide the maximum lift in a short takeoff and also to maintain the coefficient of lift for smooth landing, for this the development is carried out with the NACA 4 Digit Airfoil series concept on considering Flat Bottom Airfoil as already in use for sail planes and A-18 Airfoil for Small wind turbines, which have significant results on various models of airfoil but the appropriate one is to be chosen among the symmetrical and flat bottomed airfoil for the best flying concept with minimum drag and maximum speed in air. Also we find airfoil everywhere like in wings, tail surfaces (vertical fin and horizontal stabilizer), Propellers and turbofans, helicopters rotors, compressors and turbines, wind turbines, hydrofoils wing like devices which can lift the water boat above water.

Introduction

With reference to the research paper: (Reference: Amit Singh Dhakad, Pramod Singh (March 2014) Flying Bike Concept, IRJME, Vol 1, pp 001-011Flying Bike Concept) www.internationalscholarsjournals.org/download.php?id...pdf... 1 www.internationalscholarsjournals.org/journal/.../**flying-bike-concept** .

The wing considered is the flat Bottom. But in order to provide the maximum lift with no drag we will study analytically and experimentally the factors of NACA wing/airfoil as flight needs a height. The NACA airfoil series are the airfoil developed by the National Advisory Committee for Aeronautics for aircrafts and the shape of the airfoil can be described with the help of series of digits as the parameter in the numerical code can be entered in the equation to generate the Airfoil section using Airfoil tools Generator (Source: http://www.airfoiltools.com/airfoil/naca4digit). This makes all the difference in the world. To understand why, we need a very brief course on what makes an aircraft fly. We may have learned in school that an airplane wing develops lift because air flows faster over the curved top of the wing than it does over the wing's straight bottom. This happens because the air on the top must cover a greater distance in the same time frame than does the air on the bottom. Bernoulli discovered that the faster a given amount of gas moves, the lower becomes its pressure. We call it Bernoulli's Theorem. Since the air on the bottom of a flat-bottom wing is moving more slowly, it must have a greater pressure than the air on the top and tends to push the wing upwards against the lower top pressure. The wing develops lift. It is even somewhat true. But most all full-size and model aircraft have wings that are nearly symmetrical (called semi-symmetrical) or truly symmetrical. The wing shapes are the same top and bottom. How then do these aircraft fly? These wings develop lift because they, like most things in the universe, must follow Newton's Third Law of Motion. A symmetrical airfoil must have a positive angle of attack to the oncoming air to fly. Because of Newton's Third Law, the air deflected downwards pushes the wing upwards with equal force. The greater the attack angle, up to a point of about 17-20 degrees for most models, the more lift the wing produces. A symmetrical airfoil like the Avistar's develops lift using *only* Newton's Third Law. But a flat-bottom wing like the NexSTAR's obtains lift using *both* Newton's Third Law *and* Bernoulli's Theorem. Therefore, for a given wing area, a flat-bottom wing produces more lift at a given airspeed and angle of attack than would a symmetrical wing with the same conditions. This is why all basic trainers utilize a flat-bottom wing. Aerobatic trainers use more symmetrical wings because these airfoils develop the same amount of lift whether inverted or upright. This is good for aerobatic flight, but not usually required in a basic trainer. Semi-symmetrical airfoils have some airfoil shape on the bottom but a lot less than on the top. They use a little Bernoulli and a lot of Newton to develop lift. These airfoils develop more lift than symmetrical ones but a lot less than flat-bottomed airfoils. They also sacrifice some aerobatic performance. The extra lift produced by these wings allows the basic RC trainer to takeoff, fly and land more slowly, Modern RC basic trainers are nearly impossible to accidentally stall because of the excess wing lift. The extra lift can often rescue a student pilot from bad situations such very slow airspeeds in steep bank angles at low altitude. An aerobatic aircraft, even most aerobatic trainers, will stall and snap roll in such situations. When stalled in a steeply banked turn, a basic trainer just kind of levels it wings shakes its fuselage straight and starts flying again. Since it flies slowly with lots of excess lift, the basic trainer allows the student pilot time to think and react. This extra time is really appreciated during landing practice. The slow landing speed also limits nose gear damage during those first hard landings. Thus an experiment is conducted for the performance of the airfoil under a constant velocity of flow or air for particular Reynolds number.

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Reynolds number:

In fluid mechanics, the **Reynolds number** (**Re**) is a dimensionless quantity and used to help predict similar flow patterns in different fluid flow situations. It is defined as the ratio of inertial forces to viscous forces and consequently quantifies the relative importance of these two types of forces for given flow conditions. Reynolds numbers frequently arise when performing scaling of fluid dynamics problems, and as such can be used to determine dynamic similitude between two different cases of fluid flow. They are also used to characterize different flow regimes within a similar fluid, such as laminar or turbulent flow: laminar flow occurs at low Reynolds numbers, where viscous forces are dominant, and is characterized by smooth, constant fluid motion; turbulent flow occurs at high Reynolds numbers and is dominated by inertial forces, which tend to produce chaotic eddies, vortices and other flow instabilities.

$$Re = \frac{\rho V L}{\mu} = \frac{uL}{v}$$

Where,

V is the stream velocity in m/s = 40.45 m/s

L is the length of the body = 140mm for Flat Bottomed Airfoil and 150 mm for symmetrical Airfoil,

ρ is the density of fluid (kg/m^3) = 1.000 kg/m^3 for ground level,

μ is the dynamic viscosity of the fluid (Pa·s = N·s/m² = kg/(m·s)) = 1.983 x 10^{-5} Pa.s

v is the kinematic viscosity $v = \frac{\mu}{\rho}$ (m²/s) = 15.68 at 27^{0}c (room temperature)

Wing Development Concept:

4 digit Series:

The 4-Digit wing section can be defined as:

1. The first digit describes the maximum camber as percentage of chord.
2. Second digit describes the distance of maximum camber from the airfoil leading edge in tens of percents of the chord.
3. Last two digits describe the maximum thickness of the airfoil as percent of the chord.

Dynamic Model:

Here we will discuss about the Airfoil chosen for the development through the NACA 4-digit concept and illustrate with the kind of models.

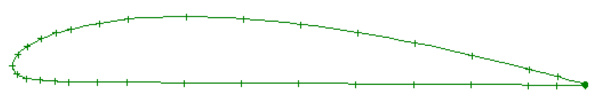

Figure 1. Flat bottom Airfoil

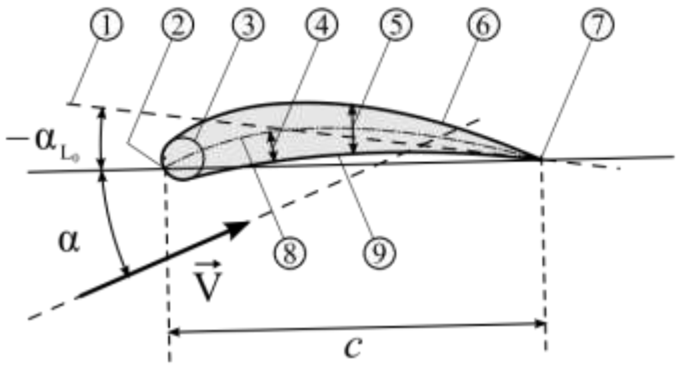

Figure 2. Deep camber Airfoil (eg: A 18)

Where,

1 is the zero lift line
2 is the leading edge
3 is the Nose circle
4 is the camber
5 is the maximum thickness
6 is the upper surface of wing
7 is the trailing edge
8 is the camber mean line
9 is the lower surface of wing
C is the chord length or wing length
α is the angle of contact
V is the velocity of air in opposite direction of motion of flight

Equation for the four digits NACA Airfoil (for symmetrical Airfoil):

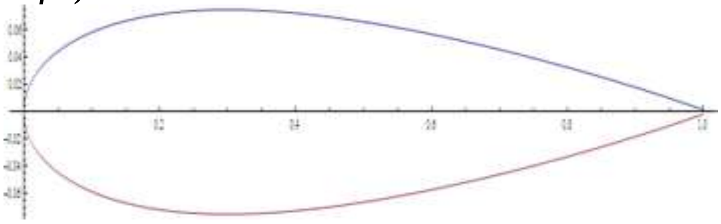

Figure 3

(Plot of a NACA 0015 foil, generated from formula)

Where,

- c is the chord length,
- x is the position along the chord from 0 to c,
- y is the half thickness at a given value of x (centreline to surface), and
- t is the maximum thickness as a fraction of the chord (so 100 t gives the last two digits in the NACA 4-digit denomination).
- Note that in this equation, at (x/c) = 1 (the trailing edge of the airfoil), the thickness is not quite zero. If a zero-thickness trailing edge is required, for example for computational work, one of the coefficients should be modified such that they sum to zero. Modifying the last coefficient (i.e. to -0.1036) will result in the smallest change to the overall shape of the airfoil. The leading edge approximates a cylinder with a radius of:

r = 1.101962.t²

- Now the coordinates (Xu, Yu) of the upper airfoil surface, and (X_l, Y_l) of the lower airfoil surface are:

$$x_u = x_l = x$$
$$y_u = +y_t$$
$$y_l = -y_t$$

Equation for cambered four digits NACA Airfoil:

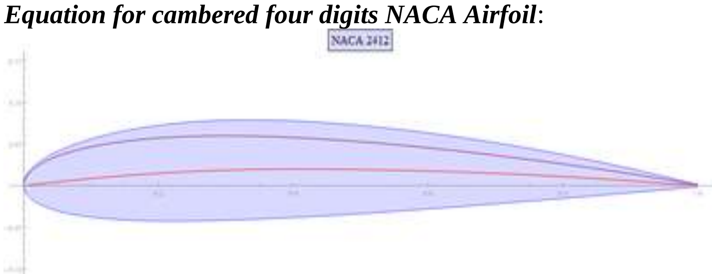

Figure 4

(Plot of a NACA 2412 foil)

(The camber line is shown in red, and the thickness - or the symmetrical airfoil 0012 - is shown in purple)

The simplest asymmetric foils are the NACA 4-digit series foils, which use the same formula as that used to generate the 00xx symmetric foils, but with the line of mean camber bent. The formula used to calculate the mean camber line is

$y_c = \frac{m}{p^2}[2px - x^2]$ where, $0 \le x \le p$

$y_c = \frac{m}{(1-p)^2}\left[(1-2p)+2px-x^2\right]$ where P$\leq x \leq c$

where:

- m is the maximum camber (100 m is the first of the four digits),
- p is the location of maximum camber (10 p is the second digit in the NACA xxxx description).

For this cambered airfoil, because the thickness needs to be applied perpendicular to the camber line, the coordinates (Xu, Yu) and (X_l, Y_l) , of respectively the upper and lower airfoil surface, become

While, ***The NACA five-digit series describes more complex airfoil shapes:***

1. The first digit, when multiplied by 0.15, gives the designed coefficient of lift (C_L).
2. Second and third digits, when divided by 2, give p, the location of maximum camber as a distance from the leading edge (as per cent of chord).
3. Fourth and fifth digits give the maximum thickness of the airfoil (as per cent of the chord).

The camber-line is defined in two sections:

Where, the chord wise location (x) and the ordinate (y) have been normalized by the chord. The constant (m) is chosen so that the maximum camber occurs at x = p

Objective:

To find the best wing for flying with much lift in low speed (Reference: Amit Singh Dhakad, Pramod Singh (March 2014) Flying Bike Concept, IRJME, Vol 1, pp 001-011) through wind tunnel experiment based on the concept of NACA 4 digit Airfoil series on (1) Flat Bottom airfoil which has low camber-low drag-high speed-thin wing section suitable for race planes **and** (2) Symmetric airfoil under experimental result through Wing tunnel test with flow of 40.45 m/s or 145.62 km/hr (speed of air) for/at various angle of attack.

Condition 1:

(Actual dimension of Airfoil according to research paper)

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:

(Actual dimension of Airfoil according to research paper :

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

Generation of various 4-Digit NACA Airfoil (through Airfoil tool generator)

Here with the help of Airfoil tool generator we can construct any profile of required data and can be experimented for results. The five Flat bottom airfoil (NACA-4311, 3310, 3310 with P= 38.6%), 2306, 2206 and Symmetrical airfoil NACA 2412 are generated through this software.(Airfoil tool generator) Source: http://www.airfoiltools.com/airfoil/naca4digit

(a)NACA 4311 AIRFOIL (Type: Clark Y- Airfoil)-Flat Bottomed Airfoil

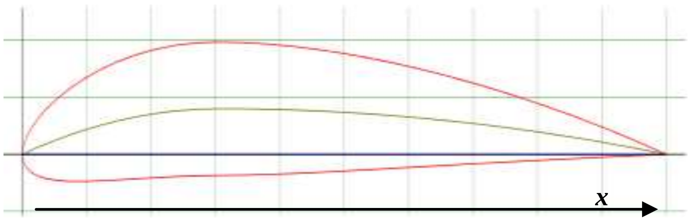

Figure: 5

Dat file

NACA 4311 Airfoil M=4.0% P=30.5% T=11.7%

X	y
1.000000	-0.000000
0.998459	0.000395
0.993844	0.001574
0.986185	0.003515
0.975528	0.006181
0.961940	0.009525
0.945503	0.013487
0.926320	0.017997
0.904508	0.022981
0.880203	0.028355
0.853553	0.034034
0.824724	0.039929
0.793893	0.045951
0.761249	0.052012
0.726995	0.058023
0.691342	0.063898
0.654508	0.069553
0.616723	0.074906
0.578217	0.079879
0.539230	0.084398
0.500000	0.088391
0.460770	0.091795
0.421783	0.094551
0.383277	0.096610
0.345492	0.097932
0.308658	0.098488
0.273005	0.097905
0.238751	0.095723
0.206107	0.092064
0.175276	0.087079
0.146447	0.080946
0.119797	0.073858
0.095492	0.066024
0.073680	0.057654
0.054497	0.048962
0.038060	0.040150
0.024472	0.031407
0.013815	0.022899
0.006156	0.014764
0.001541	0.007108
0.000000	0.000000
0.001541	-0.006302
0.006156	-0.011567
0.013815	-0.015816
0.024472	-0.019085
0.038060	-0.021430
0.054497	-0.022928
0.073680	-0.023671
0.095492	-0.023772
0.119797	-0.023356
0.146447	-0.022565
0.175276	-0.021551
0.206107	-0.020474
0.238751	-0.019498
0.273005	-0.018785
0.308658	-0.018490
0.345492	-0.018204
0.383277	-0.017625
0.421783	-0.016810
0.460770	-0.015814
0.500000	-0.014689

0.539230 -0.013484
0.578217 -0.012243
0.616723 -0.011000
0.654508 -0.009785
0.691342 -0.008619
0.726995 -0.007517
0.761249 -0.006489
0.793893 -0.005538
0.824724 -0.004666
0.853553 -0.003871
0.880203 -0.003153
0.904508 -0.002507
0.926320 -0.001934
0.945503 -0.001432
0.961940 -0.001003
0.975528 -0.000647
0.986185 -0.000366
0.993844 -0.000163
0.998459 -0.000041
1.000000 0.000000

Max Camber (%)	4	First digit. 0 to 9.5%
Max camber position (%)	30.5	Second digit. 0 to 90%
Thickness (%)	11.7	Third & fourth digit. 1 to 40%
Number of points	81	20 to 200
Cosine spacing	☑	Cosine or linear spacing
Close Trailing edge	☑	Open or closed TE

(b)NACA 3310 AIRFOIL (with P=38.6%): Flat Bottomed Airfoil

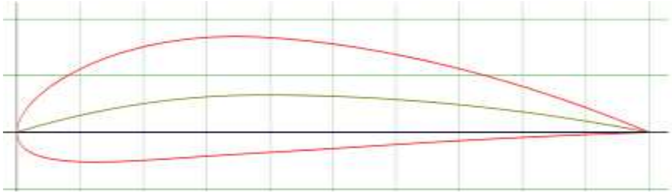

Figure: 6

Dat file

NACA 3310 Airfoil M=3.3% P=38.6% T=10.5%
1.000000 -0.000000
0.998459 0.000361
0.993844 0.001438
0.986185 0.003210
0.975528 0.005642
0.961940 0.008688
0.945503 0.012292
0.926320 0.016388
0.904508 0.020903
0.880203 0.025759
0.853553 0.030873
0.824724 0.036162
0.793893 0.041540
0.761249 0.046924
0.726995 0.052231
0.691342 0.057379
0.654508 0.062289
0.616723 0.066888
0.578217 0.071103
0.539230 0.074866
0.500000 0.078116
0.460770 0.080796
0.421783 0.082858
0.383277 0.084258
0.345492 0.084749
0.308658 0.084165
0.273005 0.082533
0.238751 0.079900
0.206107 0.076330
0.175276 0.071910
0.146447 0.066737
0.119797 0.060927
0.095492 0.054601
0.073680 0.047888
0.054497 0.040919
0.038060 0.033819
0.024472 0.026708
0.013815 0.019692
0.006156 0.012860
0.001541 0.006280
0.000000 0.000000
0.001541 -0.005754
0.006156 -0.010771
0.013815 -0.015052
0.024472 -0.018605
0.038060 -0.021445
0.054497 -0.023598
0.073680 -0.025096
0.095492 -0.025985
0.119797 -0.026317
0.146447 -0.026157
0.175276 -0.025579
0.206107 -0.024665
0.238751 -0.023504
0.273005 -0.022189
0.308658 -0.020815
0.345492 -0.019476
0.383277 -0.018261
0.421783 -0.017082
0.460770 -0.015775
0.500000 -0.014391
0.539230 -0.012977
0.578217 -0.011571
0.616723 -0.010207
0.654508 -0.008911
0.691342 -0.007701
0.726995 -0.006587
0.761249 -0.005576
0.793893 -0.004668
0.824724 -0.003859
0.853553 -0.003144
0.880203 -0.002517
0.904508 -0.001971
0.926320 -0.001499
0.945503 -0.001096
0.961940 -0.000760
0.975528 -0.000486
0.986185 -0.000273
0.993844 -0.000121
0.998459 -0.000030
1.000000 0.000000

Max Camber (%)	3.3	First digit. 0 to 9.5%
Max camber position (%)	38.6	Second digit. 0 to 90%

Thickness (%)	10.5	Third & fourth digit. 1 to 40%
Number of points	81	20 to 200
Cosine spacing	☑	Cosine or linear spacing
Close Trailing edge	☑	Open or closed

(c)NACA Airfoil 3310: (with P=31.8%): Flat Bottomed Airfoil

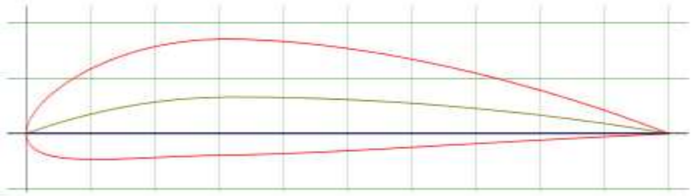

Figure: 7

Dat file

NACA 3310 Airfoil M=3.3% P=31.8% T=10.5%
1.000000 -0.000000
0.998459 0.000345
0.993844 0.001373
0.986185 0.003065
0.975528 0.005389
0.961940 0.008304
0.945503 0.011758
0.926320 0.015689
0.904508 0.020031
0.880203 0.024713
0.853553 0.029659
0.824724 0.034793
0.793893 0.040036
0.761249 0.045311
0.726995 0.050541
0.691342 0.055651
0.654508 0.060566
0.616723 0.065217
0.578217 0.069533
0.539230 0.073449
0.500000 0.076904
0.460770 0.079840
0.421783 0.082206
0.383277 0.083957
0.345492 0.085059
0.308658 0.085461
0.273005 0.084700
0.238751 0.082652
0.206107 0.079412
0.175276 0.075097
0.146447 0.069843
0.119797 0.063802
0.095492 0.057136
0.073680 0.050013
0.054497 0.042600
0.038060 0.035059
0.024472 0.027540
0.013815 0.020177
0.006156 0.013081
0.001541 0.006336
0.000000 0.000000
0.001541 -0.005698
0.006156 -0.010550
0.013815 -0.014567
0.024472 -0.017773
0.038060 -0.020206
0.054497 -0.021917
0.073680 -0.022972
0.095492 -0.023449
0.119797 -0.023442
0.146447 -0.023051
0.175276 -0.022392
0.206107 -0.021584
0.238751 -0.020751
0.273005 -0.020022
0.308658 -0.019518
0.345492 -0.019166
0.383277 -0.018562
0.421783 -0.017734
0.460770 -0.016732
0.500000 -0.015604
0.539230 -0.014394
0.578217 -0.013141
0.616723 -0.011879
0.654508 -0.010635
0.691342 -0.009429
0.726995 -0.008277
0.761249 -0.007190
0.793893 -0.006172
0.824724 -0.005228
0.853553 -0.004358
0.880203 -0.003563
0.904508 -0.002843
0.926320 -0.002199
0.945503 -0.001631
0.961940 -0.001143
0.975528 -0.000738
0.986185 -0.000418
0.993844 -0.000187
0.998459 -0.000047
1.000000 0.000000

Max Camber (%)	3.3	First digit. 0 to 9.5%
Max camber position (%)	31.8	Second digit. 0 to 90%
Thickness (%)	10.5	Third & fourth digit. 1 to 40%
Number of points	81	20 to 200
Cosine spacing	☑	Cosine or linear spacing
Close Trailing edge	☑	Open or closed TE

(d)NACA 2306 Airfoil (with P=33.1%): Flat Bottomed Airfoil

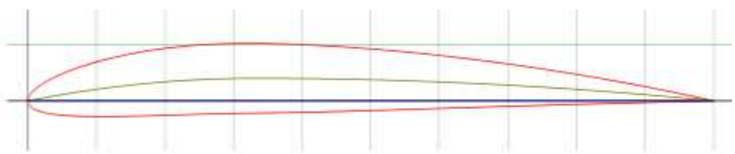

Figure: 8

Dat file

NACA 2306 Airfoil M=2.0% P=33.1% T=6.2%
1.000000 -0.000000
0.998459 0.000208
0.993844 0.000827
0.986185 0.001846
0.975528 0.003245
0.961940 0.005000

0.945503 0.007079
0.926320 0.009444
0.904508 0.012055
0.880203 0.014870
0.853553 0.017841
0.824724 0.020923
0.793893 0.024067
0.761249 0.027228
0.726995 0.030358
0.691342 0.033412
0.654508 0.036344
0.616723 0.039113
0.578217 0.041677
0.539230 0.043997
0.500000 0.046035
0.460770 0.047759
0.421783 0.049138
0.383277 0.050145
0.345492 0.050762
0.308658 0.050903
0.273005 0.050304
0.238751 0.048975
0.206107 0.046970
0.175276 0.044356
0.146447 0.041209
0.119797 0.037615
0.095492 0.033667
0.073680 0.029461
0.054497 0.025091
0.038060 0.020651
0.024472 0.016226
0.013815 0.011892
0.006156 0.007714
0.001541 0.003739
0.000000 0.000000
0.001541 -0.003367
0.006156 -0.006240
0.013815 -0.008623
0.024472 -0.010530
0.038060 -0.011981
0.054497 -0.013004
0.073680 -0.013635
0.095492 -0.013917
0.119797 -0.013900
0.146447 -0.013644
0.175276 -0.013209
0.206107 -0.012665
0.238751 -0.012082
0.273005 -0.011532
0.308658 -0.011085
0.345492 -0.010780
0.383277 -0.010390
0.421783 -0.009874
0.460770 -0.009264
0.500000 -0.008588
0.539230 -0.007872
0.578217 -0.007140
0.616723 -0.006410
0.654508 -0.005698
0.691342 -0.005016
0.726995 -0.004373
0.761249 -0.003772
0.793893 -0.003217
0.824724 -0.002709
0.853553 -0.002245
0.880203 -0.001827
0.904508 -0.001451
0.926320 -0.001118
0.945503 -0.000827
0.961940 -0.000578
0.975528 -0.000373
0.986185 -0.000211
0.993844 -0.000094
0.998459 -0.000024
1.000000 0.000000

Max Camber (%)	2	First digit. 0 to 9.5%
Max camber position (%)	33.1	Second digit. 0 to 90%
Thickness (%)	6.2	Third & fourth digit. 1 to 40%
Number of points	81	20 to 200
Cosine spacing	☑	Cosine or linear spacing
Close Trailing edge	☑	Open or closed TE

(e)NACA 2206 Airfoil: Flat Bottomed Airfoil

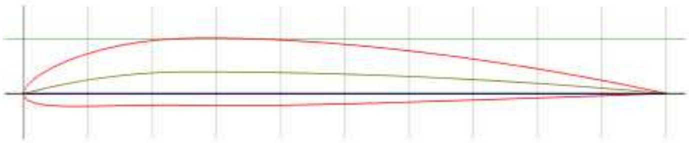

Figure: 9

Dat file

NACA 2206 Airfoil M=2.0% P=25.7% T=6.2%

1.000000 -0.000000
0.998459 0.000199
0.993844 0.000790
0.986185 0.001765
0.975528 0.003105
0.961940 0.004786
0.945503 0.006779
0.926320 0.009051
0.904508 0.011564
0.880203 0.014278
0.853553 0.017150
0.824724 0.020139
0.793893 0.023199
0.761249 0.026288
0.726995 0.029363
0.691342 0.032379
0.654508 0.035297
0.616723 0.038074
0.578217 0.040670
0.539230 0.043049
0.500000 0.045173
0.460770 0.047007
0.421783 0.048522
0.383277 0.049690
0.345492 0.050487
0.308658 0.050897
0.273005 0.050909
0.238751 0.050428
0.206107 0.049034
0.175276 0.046760
0.146447 0.043725
0.119797 0.040057
0.095492 0.035893

0.073680	0.031372
0.054497	0.026630
0.038060	0.021801
0.024472	0.017006
0.013815	0.012350
0.006156	0.007923
0.001541	0.003792
0.000000	0.000000
0.001541	-0.003314
0.006156	-0.006030
0.013815	-0.008165
0.024472	-0.009751
0.038060	-0.010831
0.054497	-0.011465
0.073680	-0.011724
0.095492	-0.011691
0.119797	-0.011458
0.146447	-0.011127
0.175276	-0.010805
0.206107	-0.010602
0.238751	-0.010630
0.273005	-0.010927
0.308658	-0.011091
0.345492	-0.011055
0.383277	-0.010845
0.421783	-0.010490
0.460770	-0.010016
0.500000	-0.009451
0.539230	-0.008820
0.578217	-0.008147
0.616723	-0.007450
0.654508	-0.006746
0.691342	-0.006049
0.726995	-0.005368
0.761249	-0.004712
0.793893	-0.004085
0.824724	-0.003493
0.853553	-0.002936
0.880203	-0.002419
0.904508	-0.001943
0.926320	-0.001511
0.945503	-0.001127
0.961940	-0.000793
0.975528	-0.000513
0.986185	-0.000291
0.993844	-0.000130
0.998459	-0.000033
1.000000	0.000000

Max Camber (%)	2	First digit. 0 to 9.5%
Max camber position (%)	25.7	Second digit. 0 to 90%
Thickness (%)	6.2	Third & fourth digit. 1 to 40%
Number of points	81	20 to 200
Cosine spacing	☑	Cosine or linear spacing
Close Trailing edge	☑	Open or closed TE

(f) NACA 2412 (Symmetrical Airfoil): Symmetrical Airfoil

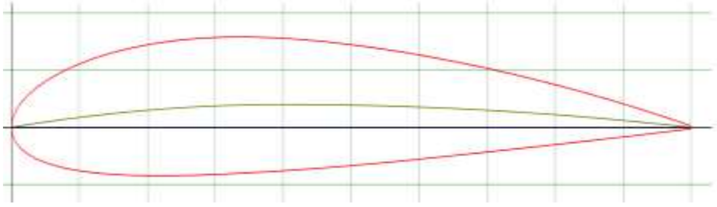

Figure: 10

DAT FILE:

NACA 2412 Airfoil M=2.0% P=40.0% T=12.0%

1.000000	0.001260
0.998459	0.001579
0.993844	0.002529
0.986185	0.004092
0.975528	0.006241
0.961940	0.008935
0.945503	0.012126
0.926320	0.015759
0.904508	0.019774
0.880203	0.024103
0.853553	0.028679
0.824724	0.033430
0.793893	0.038286
0.761249	0.043173
0.726995	0.048022
0.691342	0.052761
0.654508	0.057319
0.616723	0.061627
0.578217	0.065618
0.539230	0.069226
0.500000	0.072385
0.460770	0.075035
0.421783	0.077122
0.383277	0.078574
0.345492	0.079203
0.308658	0.078957
0.273005	0.077832
0.238751	0.075842
0.206107	0.073015
0.175276	0.069397
0.146447	0.065047
0.119797	0.060040
0.095492	0.054458
0.073680	0.048395
0.054497	0.041945
0.038060	0.035205
0.024472	0.028266
0.013815	0.021212
0.006156	0.014114
0.001541	0.007031
0.000000	0.000000
0.001541	-0.006723
0.006156	-0.012893
0.013815	-0.018496
0.024472	-0.023521
0.038060	-0.027955
0.054497	-0.031788
0.073680	-0.035016
0.095492	-0.037640
0.119797	-0.039668
0.146447	-0.041119
0.175276	-0.042022
0.206107	-0.042413

0.238751 -0.042342
0.273005 -0.041864
0.308658 -0.041043
0.345492 -0.039946
0.383277 -0.038644
0.421783 -0.037174
0.460770 -0.035446
0.500000 -0.033496
0.539230 -0.031379
0.578217 -0.029148
0.616723 -0.026846
0.654508 -0.024516
0.691342 -0.022192
0.726995 -0.019903
0.761249 -0.017674
0.793893 -0.015525
0.824724 -0.013474
0.853553 -0.011536
0.880203 -0.009725
0.904508 -0.008055
0.926320 -0.006539
0.945503 -0.005190
0.961940 -0.004021
0.975528 -0.003044
0.986185 -0.002272
0.993844 -0.001712
0.998459 -0.001373
1.000000 -0.001260

Max Camber (%)	2	First digit. 0 to 9.5%
Max camber position (%)	40	Second digit. 0 to 90%
Thickness (%)	12	Third & fourth digit. 1 to 40%
Number of points	81	20 to 200
Cosine spacing	☑	Cosine or linear spacing
Close Trailing edge	☑	Open or closed TE

Experimental Result:
Experimental setup:
Wind tunnel:

AC motor drives a high performance centrifugal fan with constant speed: 1400 rpm. The blower discharges into a setting chamber via a split diffuser. The settling chamber, section, in fitted with pocket type filters, a honeycomb flow straightener, a 4 nylon screens.

The contraction has been designed with a ratio of 12:5:1 and gives an excellent velocity distribution a the entry to the test section.

The cross section of the section is 300mm x 300 mm, its length is 1000mm. The two vertical sides are acrylic. A traversing pitot tube is fitted vertically.

A diffuser, downstream of the test section, reduces the exit velocity, and achieves some pressure recovery, and also prevents flow disturbances returning upstream.

Figure: 10 (Symmetric airfoil in test rig)

Figure: 11 (Flat bottomed Airfoil for test)

Wind Tunnel Reading for the Flat Bottomed Airfoil
(Reference: Amit Singh Dhakad, Pramod Singh (March 2014) Flying Bike Concept, IRJME, Vol 1, pp 001-011) www.internationalscholarsjournals.org/download.php?id...pdf... 1
www.internationalscholarsjournals.org/journal/.../**flying-bike-concept**

NACA 2412(Specimen dimension: 150mm x 300mm)

Table 1:

Sl.no	Angle of attack	Drag Force (kg)	Lift Force (kg)	Hot wire gas flow indicator (m/s)	Reynolds number	Remarks (if any)
1	0^0	0.03	1.05	40.45	427,078	Specimen tested
2	5^0	0.55	2.45	40.45	427,078	Specimen tested
3	10^0	0.17	4.14	40.45	427,078	Specimen tested
4	15^0	1.48	5.28	40.45	427,078	Specimen tested
5	20^0	3.03	0.75	40.45	427,078	Specimen tested

Wind Tunnel Reading for the Flat Bottomed Airfoil:
(Reference:Amit Singh Dhakad, Pramod Singh (March 2014) Flying Bike Concept, IRJME, Vol 1, pp 001-011) www.internationalscholarsjournals.org/download.php?id...pdf... 1
www.internationalscholarsjournals.org/journal/.../flying-bike-concept

NACA 4311(Specimen dimension: 140mm x 300 mm)

Table 2:

Sl.no	Angle of attack	Drag Force(kg)	Lift Force (kg)	Hot wire gas flow indicator (m/s)	Reynolds number	Remarks (if any)
1	0^0	0.10	1.22	40.45	398,606	Specimen tested
2	5^0	0.16	2.26	40.45	398,606	Specimen tested
3	10^0	0.24	3.52	40.45	398,606	Specimen tested
4	15^0	1.16	4.45	40.45	398,606	Specimen tested
5	20^0	1.81	4.43	40.45	398,606	Specimen tested

Conclusion:

On considering the NACA 2412(Symmetrical Airfoil) and NACA 4311(Flat Bottomed Airfoil), from the experimental reading it is observed that the flat bottomed has the best optimum values in both lift and drag comparison to symmetrical airfoil. As we can see from the (Table 1) that the lift force is decreasing gradually beyond 15^0 and also drag force has been increased from 1.48 to 3.03 but in case of (Table 2) the lift is fine up to 15^0 and beyond 15^0 it has decreased to a difference of 0.02 which is much lower than (Table 1), also the drag force in (Table 2) is minimum than (Table 1) beyond 15^0.Where the reyonds number for Symmetrical case is 427,078 in (Table 1) and for flat bottomed airfoil it is 398,606 in (Table 2)which means both the values of (Re) lies in the laminar range satisfying the flow as laminar. But the flat bottom has low (Re) than symmetrical airfoil. Thus it experimentally proves that Flat bottomed airfoil is best to choose for the development of wings.

References:

1. Amit Singh Dhakad, and Pramod Singh. “Flying bike concept.” International Research Journal of Mechanical Engineering, Vol 1, PP. 001-011. March 2014

2. Amit, & Arun Singh. "Power Requirement for Flying Bike." *International Journal of Innovative Research and Development* [Online], 3.5 (2014): n. pag. Web. 17 Jun. 2014

3. Mehrdad Ghods. “Theory of wings and wind tunnel test of a NACA 2415 airfoil” Technical Communications for Engineers, The University of British Columbia, pp-1-13, July 23,2001

4. Christopher A Lyon, Andy P Broren, Philippe Gigu’ere, Ashok Gopalarathnam, Michael S Selig (1997). Summary of low speed airfoil data, soar Tech publications, Virginia.

5. Dava Newman, Pete Young (2004). Introduction to aerospace and Design-Chapter 4, Massachuetts Institute of Technology, pp.1-17.

6. Jonathan Densie, Model Aircraft Design, Defence Science and Technology organisation-Researching Aircraft Flight Mechanics, Melbourne
http://www.concept2creation.com.au/xstd_files/Jon%20Dansie%20Model%20Aircraft%20Design.pdf.

7. Mustafa Cavcar, e-material (2005): The International Standard Atmosphere(ISA), Anadolu University,26470 Eskisehir, Turkey. pp. 1-7

8. Wikipedia on aircrafts (lift, thrust, propellers and theory of flight) http://en.wikipedia.org/wiki/Aircraft

9. Wing Design e-Book (2010). National Aeronautic and Space Administration, Museum in a box series -Aeronautics Research Mission Directorate

10. Fan wing manned aircraft project (http://www.fanwing.com/fanwing%20manned%20aircraft%20project%202013.pdf)

11. B.L Singhal(2011), Fluid Machinery, Tech-Max Publications, ISBN 978-81-8492-805-1,First edition.

12. Airfoil generator(software), www.airfoil.com/airfoil/naca4digit

13. Air properties, M= http://www.engineeringtoolbox.com/dynamic-absolute-kinematic-viscosity-d_412.htmlM=v
http://www.engineeringtoolbox.com/air-absolute-kinematic-viscosity-d_601.html