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NEW W WING SHAPE FOR AIRMODELS

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Abstract: *The new W wing shape (half wing, with "a"half wingspan and "h" wingtip height) approximates the front seen parabola ideal wing by streight lines: line 1 touches parabola at the axis origin and is 25 % of "a", line 2 is tangent of parabola at the wingtip and cuts the hotizontal line at 50 % of "a", and line 3 is tangent to parabola, cuts horizontal line at 25 % of "a" and cuts line 2 at 75 % of "a" and 50 % of "h". Real W wing approximated very close the ideal parabolic wing. The new W wing gives more lateral and directional stability.*

Key words: *New W wing shape, Parabola lines approximation, Glider airmodel.*

1.INTRODUCTION

An airmodel glider wing may have some different shapes: elliptical or squared, straight or cranked [1]. An explanation for the wing lift is proposed by Chattot in [2]. The perfect shape wing is elliptical (F.W. Lanchester) [3] and gives a minimum induced drag.

The wing may have winglets [4]. This idea was launched long before the flights started [3].

Discussion about the shape of the perfect wing for minimum induced drag is continued in [5-7]. We do not deal with this discussion.

The wing is attached at the top of the fuselage.

For lateral stability it was necessary to introduce dihedral – the slight upward tilt of the wings [3]. The dihedral could be replaced with parabola by optimization [8]. We shall use parabola in present calculation for establishing the new W wing shape for airmodels.

Glider wings are constructed using wood, carbon fiber, or a combination of materials to provide maximum strength. Their structure is of ribs running chordwise from leading edge to trailing edge, and longeron. The edges are made of straight sticks for easy construction, check, and repair. Resulting a need of approximation of parabola with straight lines. The present paper deals with parabola approximation by straight lines, resulting a new W wing shape.

2. STREIGHT LINES APPROXIMATION OF PARABOLA

The parabola wing shape seen from the front is approximated by straight lines as in Figure 1.

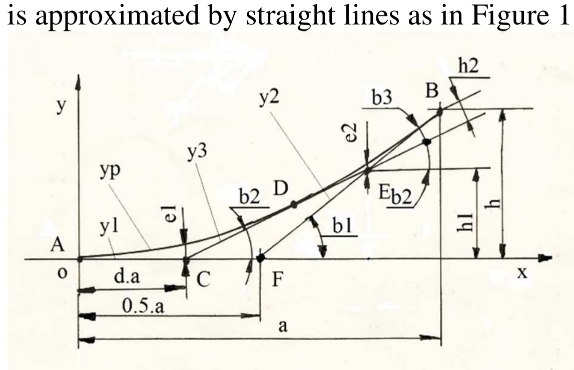

Fig. 1. The parabola, yp, approximated by straight lines y1, y2, and y3.

Parabola, yp, is approximated by three straight lines, y1, y2, and y3. It passes through the points:

A(xA, yA) and B(xB, yB);

where

xA = 0, yA = 0

and

xB = a - half wingspan,

yB = h - wingtip height.

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It had the equation

$$yp = (h/(a^2))x^2. \quad (1)$$

The line 1, y1, passes A(0, 0) tangents yp, and has the equation

$$y1 = 0, \quad (2)$$

The line 2, y2, has the equation

$$y2 = m_2x + n_2. \quad (3)$$

It tangents parabola, yp, in B(a, h)

$$m_2 = (dyp/dx)_B = 2h/a. \quad (4)$$

Angle b1 is

$$b1 = \text{arc tg } m_2 = \text{arc tg } (2h/a). \quad (5)$$

Line 2, y2, passes through B(a, h) so

$$y2 = h = (2h/a)a + n_2. \quad (6)$$

from where

$$n_2 = -h, \quad (7)$$

resulting the equation of y2

$$y2 = (2h/a)x – h \quad (8)$$

Line y2 cuts ox axes so

$$y2 = 0 = (2h/a)x – h \quad (9)$$

from where

$$x = 0.5.a. \quad (10)$$

Line 3, y3, has the equation

$$y3 = m_3x + n_3 \quad (11)$$

and passes through C(xC, yC)) where

$$xC = d.a, yC = 0 \quad (12)$$

where d represents a fraction of “a”. Equation becomes

$$0 = m_3(d.a) + n_3 \quad (13)$$

from where

$$n_3 = - m_3(d.a). \quad (14)$$

The y3 equation becomes

$$y3 = m_3x – m_3(d.a). \quad (15)$$

Parabola, yp, and line 3, y3, are cut in

$$yp = (h/a^2)x^2 = y3 = m_3x – m_3 (d.a). \quad (16)$$

In other shape looks

$$(h/a^2)x^2 – m_3x + m_3(d.a) = 0 \quad (17)$$

like

$$ax^2 + bx + c = 0,$$

where a, b, and c are other constants than those defined before.

Considering

$$\Delta = b^2 = 4ac$$

and if

$$\Delta > 1, x_{1,2} = (-b\pm\Delta^{1/2})$$

$$\Delta = 0, x_1 = x_2 = -b/(2a)$$

$$\Delta < 1, \text{roots are not real.}$$

In this case they cut themselves in a single point, l3 tangents yp, so

$$\Delta = (-m_3)^2 – 4 (h/(a^2)m_3(d.a) = 0$$

or

$$m_3(m_3 – 4(h/(a^2)(d.a)) = 0 \quad (18)$$

resulting

$$m_{3,1} = 0 \quad (19)$$

corresponding with m_1 of y1, and

$$m_{3,2} = m_3 = 4(h/a)d. \quad (20)$$

Equation of y3 becomes

$$y3 = 4(h/a)d.x - 4hd^2 \quad (21)$$

Line 2, y2, cuts y3 in E(xE, yE)

$$y2 = 2(h/a)x - h = y3 = 4(h/a)d.x - 4h.d^2 \quad (23)$$

resulting

$$xE = a(0.5 + d) \text{ and } yE = h1 = 2hd. \quad (24)$$

The horizontal distances (x) are connected to “a” and vertical distances (y) to “h” only.

Deviations e1 and respectively e2 from the parabola, yp, of C and respectively E points, Figure 1, are

$$e1 = (yp)_{xC} = h.d^2 \quad (25)$$

$$e2 = (yp)_{xE} - (y2)_{xE} = h(0.25 - d + d^2). \quad (26)$$

Introducing condition of equality between e1 and e2

$$e1 = e2 \quad (27)$$

results

$$d = 0.25. \quad (28)$$

So

$$e1 = e2 = 0.0625h. \quad (29)$$

Values AC, CE, EB, and ACEB

$$AC = xC - xA = d.a = 0.25a \quad (30)$$

$$CE = 0.5(a^2 + h^2)^{1/2} \quad (31)$$

$$EB = 0.25(a^2 + 4h^2)^{1/2} \quad (32)$$

$$ACEB = 0.25(a + 2(a^2 + b^2)^{1/2} + (a^2 + 4b^2)^{1/2}) \quad (33)$$

The distances (not x or y) are connected to a, h, and d.

Let us consider a = 100 mm and h = 20 mm, resulting a wing as in Figure 2, with values:

d = 25 mm

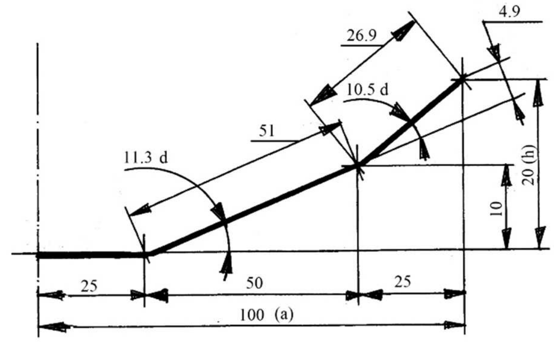

Fig. 2. Approximation of parabola with straight lines as present calculation having a = 100 mm and b = 20 mm.

h1 = 10 mm, h2 = 4.90 mm.

b1 = 21.80°. b2 = 11.31°, b3 = 10.49°

e1 = e2 = 1.25 mm;

ACEB/a = 1.0292.

In the case of Figure 2 “approximation of parabola with straight lines as present calculations, having a = 100 mm and h = 20 mm” is seen: horizontal part is 25 %, first tilt is at 50 %, and second tilt is at 25 % of “a”. The first tilt is at 0 % and the second tilt is at 50 % of “h”. The deviation from the parabola in tilting places is equal in both places to 6.25 % of “h”, which is very low. The approximation by straight lines is very close to the parabola.

3. REAL WING CONSTRUCTION

A **new W wing shape** using these considerations was designed and built, Figure 3.

It is seen the wing shape is almost parabola. The wingspan (2a) is 2192 mm and flying speed is 5.5 m/s. Its wieght is 654 g.

The real wing of Figure 3 is not exactly as that theoretical of Figure 2, considering the proper scale. The real one has horizontl part 2.2 % greater, first tilt to second tilt equal to, and from the second tilt to wing tip shorter than the theoretical one, for bulding considerations. These deviations of real wing to the theoretical one are not significant and have almost no influence on the flight and results.

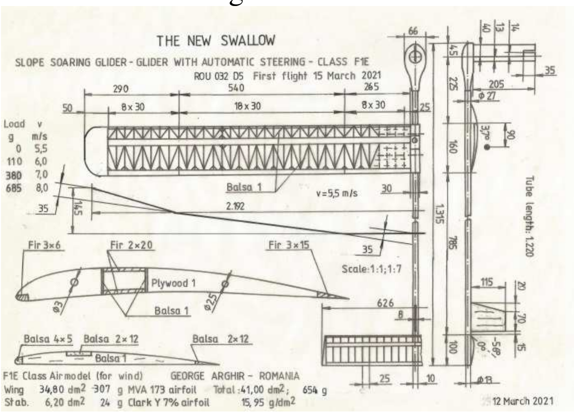

Fig. 3. The **new swallow airmodel** having a **new W wing shape**.

4. CONCLUSION

The new W wing shape (half wing, with “a” half wingspan and “h” wingtip height) approximates the front seen parabola ideal wing by streight lines: line 1 touches parabola at the axis origin and is 25 % of wingspan, line 2 is tangent of parabola at the wingtip and cuts the hotizontal line at 50 % of wing span, and line 3 is tangent to parabola, cuts horizontal line at 25 % of wingspan and cuts line 2 at 75 % wingspan and 50 % of wingtip height.

A W wing was constructed. The real values are close to the theoretical ones. It si not exactly for constructing considerations. It is a favorable solutions. The new W wing gives more lateral and directional stability.

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NOUĂ FORMĂ DE ARIPĂ W PENTRU AEROMODELE

Rezumat: Noua formă de aripă W (jumătate de aripă, cu anvergura „a” și înălțimea vârfului aripii „h”) se apropie de aripa ideală parabolică văzută din față prin linii dreptei: dreaptă 1 atinge parabola la originea axei și este 25 % din “a”, dreaptă 2 este tangentă parabolei la vârful aripii și taie linia orizontală la 50 % din “a”, iar dreaptă 3 este tangentă la parabolă, taie orizontală la 25% din “a” și dreapta 2 la 75 % din “a” și 50 % la “h”. Aripa reală W aproximează foarte aproape aripa ideală parabolică. Noua forma de aripă dă mai mare stabilitate laterală şi de direcție.

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