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ON THE FLIGHT LAUNCH OF A HIGH-PERFORMANCE GLIDER AIRMODEL

George ARGHIR

Abstract: *The high performance glider airmodel is launched in competitions with height gain, achieved by the kinetic energy imprinted by the competitor at the time of launch. The glider airmodel is subjected to a centrifugal force at launch time to which is added the total lifting force produced by the wing and the horizontal tail. The two forces reach significant values; so that if the flight speed of the model aircraft is 5.5 m / s and a height gain of 50 m is desired, the centrifugal force is 7.9 N and the lift force is 134.5 N and lunching force is of 138.8 N. Considering a loss of 10 %, the effective force required for launching is of 153.7 N (15.7 kgf).*

Key words: *Glider airmodel launch force, height gain.*

1. INTRODUCTION

High performance glider airmodel, according to the FAI Sporting Code, Section 4 – Aeromodelling, Volume F1 Free, Flight Model Aircraft, 2020 Edition [1], must meet the following characteristics:

1. Surface area (St) (wing and horizontal tail): 32 - 34 dm^2;
2. Minimum weight: 410 grams;
3. Maximum length of the launching cable loaded by 5 kgf: 50 m.
4. The competitor must be on the ground and must operate the launching device himself (jumping allowed).

Glider airmodel is not provided with a propulsion device and the lift is provided by aerodynamic forces acting on the surfaces of the wing and the horizontal tail, fixed in flight.

The flight launching of the glider airmodel is done with the help of a cable, facing the wind, the competitor running until the model aircraft reaches the flight height. The glider airmodel can remain at this height or it can gain more height due to the kinetic energy imprinted at the launching time.

The gain height is on the kinetic energy consumption at the launching time. The gain height can be from 0 to 60 m or more. It depends of the competitor physical condition, flying speed of the model aircraft and many other conditions.

It will be discussed in the ideal conditions during launch, only.

2. LAUNCH WITH HEIGHT GAIN

At launch height A, Figure 1, the glider airmodel is launched in flight by the triggering of the tow cable.

There are represented the following in Figure 1: A - the model aircraft at the flight launch time, with the launch speed, sl; B - the place where the glider airmodel arrives after reaching the flight speed, sf; C - the position of the competitor on the ground at the launch time; d – distance / height at which the glider airmodel is launched; h - the height gain of the glider airmodel at the flight altitude (50 m is desired).

The glider airmodel launched with launch speed, sl, gains height, h, consuming the kinetic energy imprinted at launch time, until it reaches flight speed, sf.

Considering the flight of the glider airmodel at launch time in a circular trajectory, with horizontal axis, Figure 1, radius r = d = 52.5 m (50 m length of tow cable, 2.5 m hand raised above the head), subjected to a centrifugal force, Fcf:

$$Fcf = m.sl^2 / r, \quad (1)$$

where m is the mass of the glider airmodel and sl is the launch speed [2].

The centripetal force, Fcp, is

$$Fcp = Fcf \quad (2)$$

and transmitted to the competitor through the towing cable.

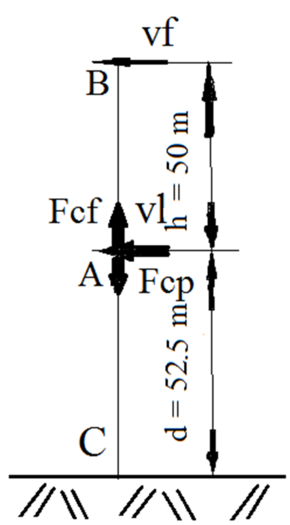

Fig. 1. Glider airmodel at launch time in A; B - where the glider airmodel is to reach, C - the competitor on the ground, sl - launch speed, sf - flight speed, d - launch height, h - height gain, Fcf / Fcp - centrifugal / centripetal force.

The flight speed of glider aircraft is 4 - 7 m/s. There are taken into account 4.5, 5.5, and 6.5 m/s.

The launching speeds, sl, centrifugal forces, Fcf (= Fcp), during launching time and height gain, h, for different flying speed of glider aimodels (4.5, 5.5, and 6.5 m/s) are presented in Table 1.

As the height height gain increases, the launch speed increases, Table 1, for 4.5, 5.5, and 6.5 m / s glider airmodels increase.

The same is for centrifugal and centripetal forces; they slightly increase.

The glider airmodel is in A at the launch time, Figure 1, at d (distance to the earth's surface) = 52.5 m, with velocity sl and kinetic energy at launch, El [3]:

$$El = m.vl^2/2 \quad . \quad (3)$$

where: m is the mass of the glider airmodel (0.410 kg).

The glider airmodel climbing up to B, gains height h and consumes potential energy, Eh [4]

$$Eh = m.g.h, \quad (4)$$

where g is the gravitational acceleration (9.81 m / s^2).

At height h the glider airmodel flies with flight speed, sf, having flight kinetic energy, Ef:

$$Ef = m.sf^2/2. \quad (5)$$

The kinetic energy of the model airmodel at launch time, El, Figure 1, is equal to the sum of the two energies Eh and Ef, the conservation of energies, being an isolated system [5]:

$$El = Eh + Ef, \quad (6)$$

or

$$m.sl^2/2 = m.g.h + m.sf^2/2 \quad (7)$$

where from:

$$sl = (2.g.h + sf^2)^{1/2}. \quad (8)$$

The centrifugal force of the glider airmodel at launch time, Fcf, is given by:

$$Fcf = Fcp = m.sl^2/d = (m/d)(2.g.h + sf^2) \quad (9)$$

in which Fcp is the centripetal force with which the competitor acts on the launch cable time.

Using equations (8) and (9) the launch speed, sl, and the centrifugal forces, Fcf, were calculated to gain a certain height, h, Table 1.

Considering Table 1, flight speeds of 4.5, 5.5, and 6.5 m/s glider airmodel, sf, for different height gains, h, and reporting them to flight speeds of 5.5 m/s glider airmodel result Table 2.

Table 2

Flight speed, sf, of 4.5, 5.5, 6.5 m/s glider flying speed to gain h reported to flight speed, sf, of 6.5 m/s glider flying speed

h, m	0	10	20	50
sf4.5/sf5.5	0.818	0.980	0.985	0.994
sf5.5/sf5.5	1.000	1.000	1.000	1.000
sf6.5/sf5.5	1.182	1.027	1.010	1.006

It is seen, Table 2, the difference between flying speed of 4.5 and 6.5 m/s glider airmodel to 5.5 m/s flying glider airmodel is decreasing drastically as the height increase. The difference is 18.2 % for nil height gain and is of 0.6 % for 50 m height gain.

Analyzing the results in Table 1, it is found that there are no significant differences in launch speeds and corresponding centrifugal forces by passing from a flight speed of 4.5 m / s to a speed of 6.5 m / s. Launch speeds are extremely high; Table 1 and their lifting forces need to be considered. This is due, Table 2, no significant difference between flying speeds for height gain. For this reason, the following calculations are for 5.5 m / s glider airmodel.

3. INFLUENCE OF THE LIFTING FORCE

The lifting force, Fl, given by the wing and the horizontal tail surfaces [6] is

$$Fl = Cz.(1/2).\rho.S.v^2 \qquad (10)$$

where: Cz - lift coefficient; ρ - air density, v - air speed, and S - lift surface (wing and horizontal tail). Relation is reduced to

$$Fl = k.v^2 \qquad (11)$$

where k is a constant containing all constants, including surfaces.

For the flight speed of 5.5 m/s the lifting force, Fl, at the height gain, h, is given in Table 3.

As height gain increase the lift force is increasing drastically, Table 3; it is proportional to flight lunch at two powers, given by Table 1.

The launch force, F, is given by the relation:

$$F = Fcf + Fl - G, \qquad (12)$$

where G is glider airmodel weight (0.41 kgf = 4.02 N) and appears in Table 4.

Launch force, F, increases drastically as height gain increases; it sums the centrifugal force and lift force, both proportional to the launch speed at two powers, Table 4.

Admitting a loss of 10 % to the launch force, F, the real force, Fr, is given in Table 4.

The 10 % loss is a rough approximation for real launch force. It can be higher or much higher. For exact value there are necessary some measurements quite difficult to make.

It should be considered the launch force and real launch force are quite high for high gain.. The difficulty of glider airmodel towing is not the high real launch force, the direction is most disturbing. It is somehow at 10 – 20 ^{o} to the vertical, the competitor has to run with a speed of 4 – 6 m / s.

4. CONCLUSIONS

The high performance glider airmodel is launched in competitions with height gain, which is achieved by the kinetic energy imprinted by the competitor at the launch time. At launch, the model aircraft is subjected to a centrifugal force to which is added the lift force produced by the wing and horizontal tail. The two forces reach significant values; so if the model aircraft flight speeds is of 5.5 m/s and it is wished a height gain of 50 m, launch speed is of 31.8 m/s, centrifugal force of 7.9 N, lifting force is of 134.5 N, and launch force of 138.8 N. Considering a loss of 10 %, the force required to launch is 152.7 N (15.6 kgf).

Table 1

Launch speeds, sl, and centrifugal forces, Fcf at launch, at height gain, h

h	m	0	1	2	3	4	5	7	10	15	20	25	30	40	50	60
sf	m/s	4.5														

sl	m/s	4.5	6.3	7.7	8.9	9.9	10.9	12.6	14.7	17.7	20.3	22.6	24.7	28.4	31.6	34.6
Fcf	N	0.2	0.3	0.5	0.6	0.8	0.9	1.2	1.7	2.5	3.2	4.0	4.8	6.3	7.8	9.4
sf	m/s	5.5														
sl	m/s	5.5	7.1	8.3	9.4	10.4	11.3	12.9	15.0	18.0	20.6	22.8	24.9	28.5	31.8	34.7
Fcf	N	0.2	0.4	0.5	0.6	0.8	1.0	1.3	1.8	2.5	3.3	4.1	4.8	6.4	7.9	9.4
sf	m/s	6.5														
sl	m/s	6.5	7.9	9.0	10.1	11.0	11.8	13.4	15.4	18.3	20.8	23.1	25.1	28.8	32.0	34.9
Fcf	N	0.3	0.5	0.6	0.8	0.9	1.1	1.4	1.9	2.6	3.4	4.2	4.9	6.5	80	9.5

Table 3

Lift force, Fp, at a flight speed, sf, of 5.5 m / s as a function of height gain, h

h	m	0	1	2	3	4	5	7	10	15	20	25	30	40	50	60
Fp	N	4.0	6.7	9.2	11.7	14.4	17.0	22.1	29.9	43.1	56.4	69.1	82.4	108.0	134.5	160.0

Table 4

Launch force, F, at a flight speed of 5.5 m/s and actual force, Fr, as a function of height gain, h

h	m	0	1	2	3	4	5	7	10	15	20	25	30	40	50	60
F	N	0.3	3.1	6.2	8.4	11.2	14.0	19.4	27.7	41.6	55.3	69.2	83.3	110.3	138.8	165.5
Fr	N	0.3	3.4	6.8	9.2	12.3	15.4	21.3	30.5	45.8	60.8	56.1	91.5	121.3	152.7	182.1
Fr	kgf	0.0	0.3	0.7	0.9	1.3	1.6	2.2	3.1	4.7	6.2	7.8	9.3	12.4	15.6	18.6

5. REFERENCES

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ASUPRA LANSĂRII ÎN ZBOR A UNUI AEROMODEL PLANOR DE ÎNALTĂ PERFORMANŢĂ

Rezumat: Aeromodelul planor de înaltă performanţă se lansează în competiţii cu câştig de înălțime, ce se realizează prin energia cinetică imprimată de sportiv în momentul lansării. În timpul lansării aeromodelul este supus unei forţe centrifuge, la care se adaugă forţa portantă totală produsă de aripă și ampenajul orizontal. Cele două forţe ajung la însemnate valori; astfel ca dacă viteza de zbor a aeromodelului este de 5,5 m/s și se dorește un câștig de înălțime de 50 m, viteza de lansare este de 31,8 m/s, forța centrifugă de 7,9 N iar forța portantă totală de 134,5 N și forța de lansare de 138,8 N. Considerând o pierdere de 10 %, forța efectivă necesară lansării este de 152,7 N (15,6 kgf).

George ARGHIR, Dr., Professor Emeritus, Technical University of Cluj Napoca, Department of Materials Science and Technology, George.Arghir@stm.utcluj.ro.