Editor's note: This paper received mixed reviews. Nevertheless, the paper is historically significant and, hence, warrants publication.

A Few Words on Airbrakes

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Abstract

Airbrakes are indispensable on modern sailplanes for safety in cloud flying as well as for aid in landing. Effectiveness, safety and ease of operation are required by the pilots. The original Göppingen construction serves well. But, the striving to maintain laminar flow, and after refinements in handling as well as innovative ideas, have produced novel solutions from time to time. Among them the transfer of the brake plates on the wing worked well but more radical solutions often failed in practice.

Nomenclature

c_D	drag coefficient	
c_L	lift coefficient	
k_e	longitudinal stick position	mm
n_y	normal load factor	
w	sink speed	m/s
F_b	control force of the air brake	N
V	airspeed	m/s, km/h
V_{NE}	Never Exceed Speed	m/s, km/h
V_T	Maximum Aerotow Speed	m/s, km/h
ρ	air density	kg/m^3
ΔM_z	tail-heavy moment increase	Nm

Introduction

Airbrakes are indispensable on modern gliders for safety in cloud flying as well as for landing aid. Structural failures indicated the former one[2], while the latter became more and more evident in the early 1930's by the increase in the glide ratio and in the span of the sailplanes. A spectacular proof of this necessity was given at the 1965 World Gliding Championships. On the first two contest days two high-performance sailplanes of the same type were badly broken in field landings because of inefficient trailing edge airbrakes and bad visibility from the cockpit.

Requirements and problems

Airbrakes are intended for increasing the drag of the sailplane. The ideal design should permit the fine regulation of drag without affecting any of the other aerodynamic parameters. Most designers choose the original Göppingen lay-out but there are also divergent solutions[3,4]. Official standards (e.g. OSTIVAS[5]) regulate the maximum permitted speed with extended brakes in say 45° resp. 30° continuous dives and the operating force up to V_T or V_{NE}. Otherwise the minimum standards are left open to the Certification Authority.

Effectiveness, safety and ease of operation are required by the pilots. Typical faults in this respect may be:

- ineffectiveness;
- excessive operating forces;
- poor regulation of the drag force;
- excessive loss of the lift coefficient;
- strong tail-heavy longitudinal moment increase;
- proneness to damage when landing on fields not harvested;
- tail buffeting;
- uncomfortable handling.

The limits on the operating forces seldom give too much trouble. Although the customary $F_b \leq 200$ N limit is occasionally discussed, the author votes for it. We had an intermediate type glider, otherwise not too popular, producing a solid 350 N on approach. In spite of this, no complaint was heard about it. Tail buffeting, too, may be evaded easily.

Typical demands on the innovation are due to problems with the laminar flow, replacement of the brake plates by smaller elements or simply a change in construction philosophy.

Laminar flow

Strictly speaking, it is the original positioning of the brakes at the thickest section (see a-b on Fig. 1) which reveals sometimes problems leading to innovations. It is logical for efficiency and strength but not ideal for laminar flow on the wing. An obvious remedy is to place them a little rearwards (e.g. to c-d on Fig. 1) and increasing the surface of the plates accordingly.

The ultimate in rearwards placing is the trailing edge airbrake, either in the form of 90° extension flaps or as upwards turning parts of the trailing edge (Fig. 2).

Flaps are not ideal as landing aids for the sailplanes because the decrease of the extension for improving the glide angle results at the same time in temporary increase of the sink. The upwards turning version, if having the dimensions of Göppingen plates, is notorious for dangerous inefficiency. Extending the brake to full flap span, as tried on one occasion in Hungary, gave dangerously high control forces closing (temporarily?) the debate.

A brake chute, deployed from the tail, would be ideal for not disturbing laminar flow on the wing. The drawbacks preventing its general use are as follows: First of all, it has only two positions: closed and deployed. We had a type of sailplane, at first two of them, using it for rounding out the ineffective trailing edge airbrakes. The second batch of two has been issued then with conventional airbrakes. After all, handling the deployed chute on the ground after landing is also cumbersome for the crew.

Handling

The first requirement in handling is effectiveness. Complying with the official requirements assures the minimum for safety. If more detailed information is required, then a short flight test for measuring the speed polar with brakes open can be arranged. Special test instruments are not compulsory; the normal air speed indicator and variometer will do in this respect.

The possible undesirable byproducts of wing-mounted airbrakes are the reduction of the lift coefficient and the tail-heavy moment increase ΔM_z. The former, besides causing a number of accidents in hands of inexperienced pilots, increases the landing speed, while the latter can be dangerous in uncontrolled cloud-flying situations. Pilots are more or less accustomed to a moderate amount of both, balancing them nearly instinctively. Caution against an excessive shift in lift and moment is in the hands of the test pilots.

A check on the diminution of the maximum lift coefficient is easy making a slow stall. Even normal cockpit instruments will do for checking the speed difference between brakes closed and open.

For checking the amount of tail-heavy moment due to the brakes the customary longitudinal static stability test[1] is to be repeated with brakes open. The scheme of evaluation is shown on Fig. 3.

Opening the brakes transfers the equilibrium elevator stick positions to curve B. For holding the airspeed corresponding to point P on the curve, the elevator stick position shall be moved to point P_1. If not compensated, the airspeed of the sailplane will drop to the value corresponding to the new equilibrium c_{L2} at point P_2 according to the equation:

$$V_2 = V\sqrt{\frac{c_L}{c_{L2}}} \qquad (1)$$

The transition to the new airspeed is dynamic, including the possibility of swinging beyond the new static equilibrium in case of sudden brake opening and slightly damped short period longitudinal oscillation. If wanted, recording the stick position k_e, the airspeed V, the normal load factor n_y and the angle of attack α can give information on the details.

The decrease of the airspeed V lags considerably behind the angle of attack increase, so emergency situations in clouds can produce near overloads on the wing.

Two original innovations

Shutter-type airbrakes

Most sailplanes are built with Göppingen airbrakes but for various reasons some of the designers prefer novel airbrake solutions[3,4]. But these seldom worked well in practice. It might be useful to remember two of them.

In order to prevent forming bigger separation eddies and for structural reasons sometimes substitutes are sought for the wing brake plates. One of them, mounting shutter-like elements, is shown on Fig. 4. It was used on an intermediate type glider and on a batch of, at that time, high-performance sailplanes, both of them of wooden construction. It proved to be quite ineffective earning the nick-name “flute” for the construction.

I had two remarkable impressions on its merits. Once flying the intermediate type, she was drawn into a developing cumulonimbus in spite of increased speed and brakes open. The lift under the cloud was not more than 3 m/s. A careful field landing with the second type on a harvested cornfield produced a ground roll over cobs seemingly without end because of the ground effect. By the way, further batches reverted to the conventional brake plates.

Bat-type airbrakes

Another interesting but unsuccessful innovation was the bat-wing-like airbrake tried on three different light-metal prototypes. A general view is presented on Fig. 5. Structurally, it seemed quite skillful tackling the problem of drawing in a substantial surface into a limited place. Flying all three gliders I can personally report on them.

Looking at Fig. 5 gives the impression that this construction works like a big 90^o flap on the wing root. On the two single-seaters practical experience seemed to be in line with this.

Efficiency in landing was at limits. Only increasing considerably the approach speed gave an acceptable minimum of sink speed and corrections of the brake extension worked like a 90^o flap on the wing. There was a considerable amount of tail-heavy moment increase, so licensing for flying in clouds was out of the question.

On the third glider, prototype of a two-seater, the airbrakes were a little undersized and mounted a bit lower. Here the absence of the wing interference resulted in further diminution of efficiency. Measured sink rates are shown on Fig. 6 and in Table 1, respectively. The speed polar in clear configuration originates from calculations for the Type Certificate of Airworthiness[6] and the measured sink rate values were taken from the work of Jereb[4]. On Fig. 5 squares show the values measured on the bat-type while circles are for the customary Göppingen configuration.

The diagram as well as the table affirms the practical impression that licensing this construction for ab-initio use was out of the question. It would be more than risky, definitely dangerous, even for the average pilot. So the clever idea had to be shelved forever.

Conclusions

The Göppingen airbrake on the wing is not ideal in every respect but an acceptable and safe compromise even for high-performance sailplanes. The trailing edge brake, in its present form, cannot be recommended because of inefficiency. The brake chute, too, is unwanted except for emergency situations in risky flight tests. Improving on the present situation is a challenging temptation but caution is recommended. Seemingly sound constructions often failed because of inefficiency or other practical deficiencies.

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References

[1]Gedeon, J.: Statische Längsstabilitätsmessungen an Segelflugzeugen *Aero Revue* 1959. No. 11, Nov.; pp. 735-739; *OSTIV Publication V.*

[2]Hirth, W. (ed.): *Handbuch des Segelfliegens,* 6-9nd ed., Franckh'sche Verlagshandlung, Stuttgart, 1939

[3]Jereb, G.: *Vitorlázó repülőgépek* (*Sailplanes*) Műszaki Könyvkiadó, Budapest, 1977 (In Hungarian)

[4]Jereb, G.: *Magyar vitorlázó repülőgépek* (*Hungarian Sailplanes*), Műszaki Könyvkiadó, Budapest, 1988 (In Hungarian)

[5]OSTIV Airworthiness Standards (OSTIVAS), 1997, Chap. 2.8

6 R-26S Góbé Type Certificate of Airworthiness calculations

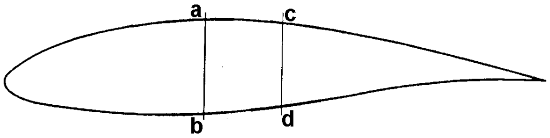

Figure 1 Position of Göppingen-type airbrakes

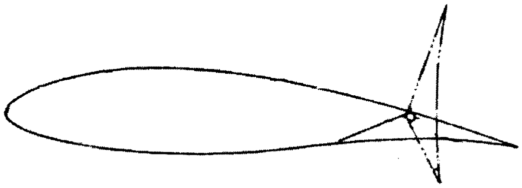

Figure 2 Trailing edge airbrake

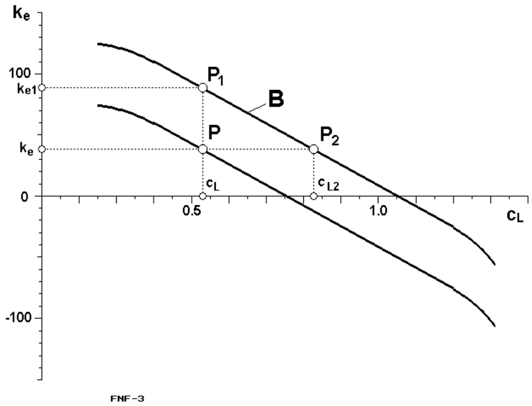

Figure 3 Tail-heavy moment of the airbrakes

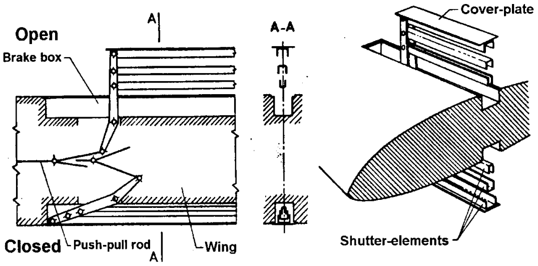

Figure 4 Shutter-type airbrake (Courtesy Jereb[4])

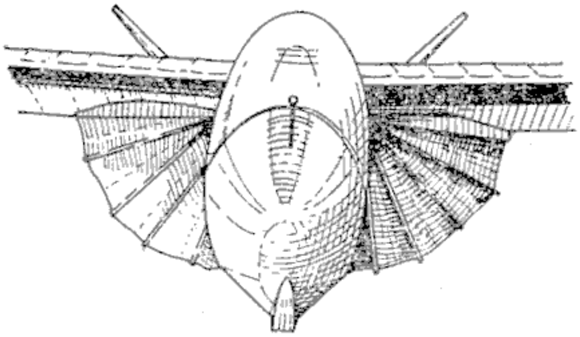

Figure 5 Bat-type airbrakes **(**Courtesy Jereb[4])

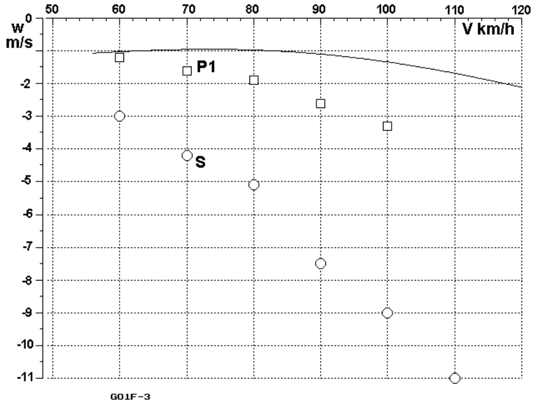

Figure 6 Effectiveness of Göppingen (S) and bat-type (P1) airbrakes

Table 1

Reckoned speed polar[6] and measured sink speeds with bat-type and with Göppingen airbrakes

		V km/h							
		56	60	70	80	90	100	110	120
w m/s	polar[6]	1.31	1.02	0.97	0.96	1.10	1.34		2.11
	R-26P1[4]		1.2	1.6	1.9	2.6	3.3		
	R-26S[4]		3.0	4.2	5.1	7.5	9.0	11.0	