TESTING AIRFOILS AND TURBULATORS IN THE CARGOLIFTER SPACE

Gerd Wöbbeking

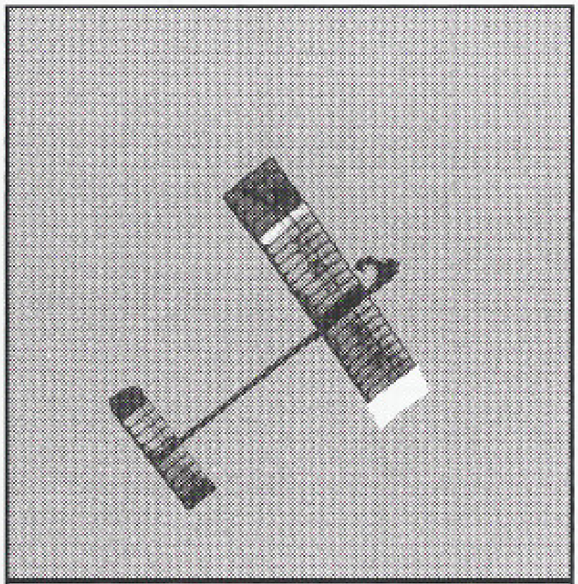
Being the organiser of an indoor event on June 9[th], 2001, I took the opportunity to compare airfoils and turbulators in the biggest indoor space ever. The requirements were three CO_2 models of my standard type "Coco", which I used to winthe British Nats in 1994. All three are almost identical except the airfoils of the wings. The results of these tests may be helpful for P-30 and Coupe d'Hiver, at least because of their similar low Reynolds Numbers.

METHOD

The power of one CO_2 engine is very constant over many runs, especially if the piston does not seal with sensitive O-rings. I still own very reliable Brown B-100 motors with steel/steel piston and liner. It is easy to reproduce exactly the same power every flight when using a standard filling procedure with cooling spray and lubrication of the liner (one small drop of sewing machine oil) every time. Now change the engine from one model to the other and compare the times of the flights, voilà - the result.

AIR

The air in the CargoLifter hangar at 9[th] June 2001 was the best of all six events I organised from 2001 to 2003. F1D models went up and landed after long flights at their launching points. I was able to time up to three indoor models and my CO_2 at once. No fear that my models went through someone else's work of months in a midair. The ceiling (107 meters) never came close because I did not try to speed up the engines to gain as much height as possible.

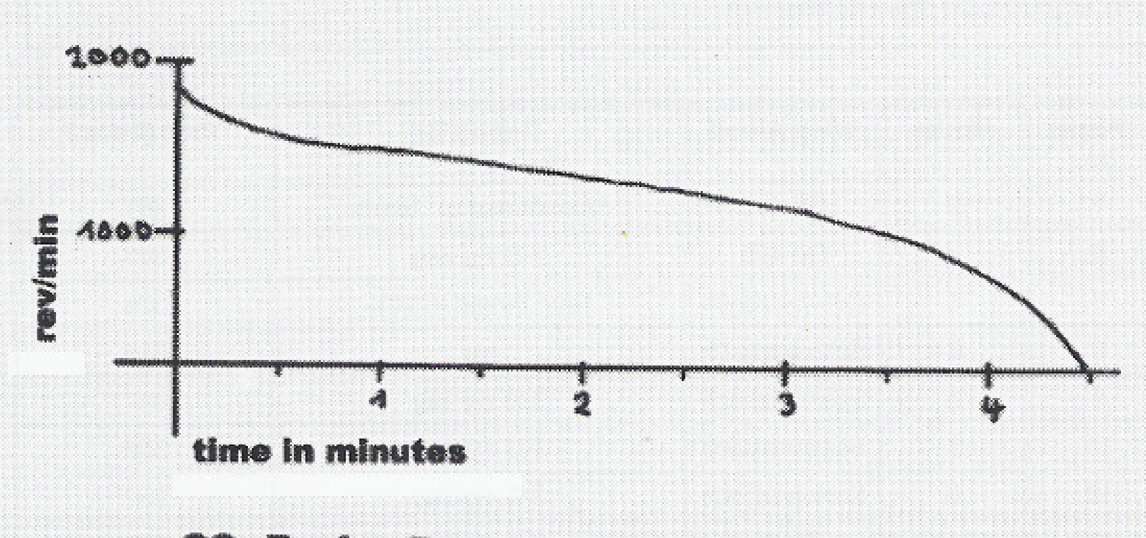


CoCo climbing in the morning sun.

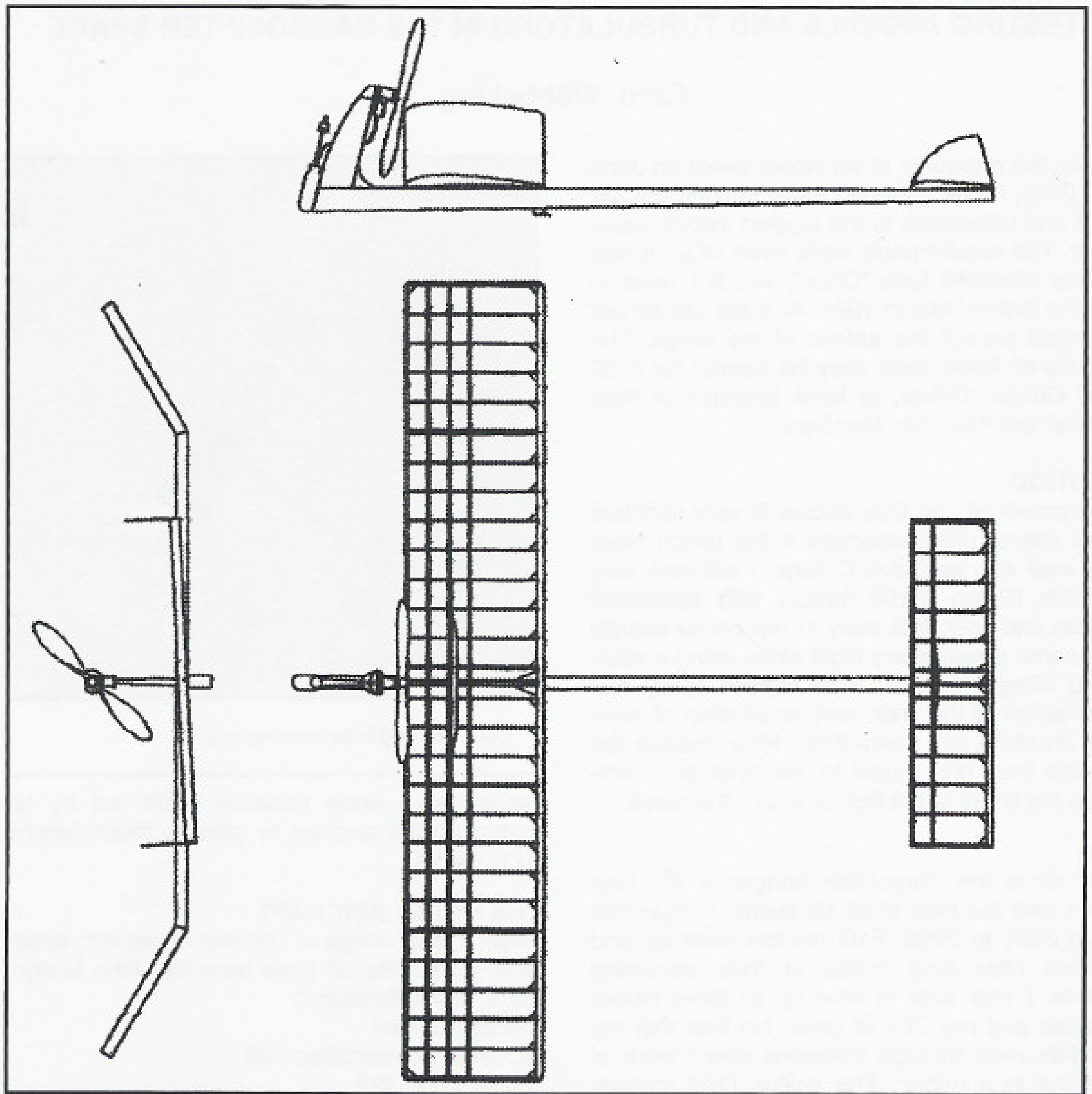
THE MODEL AIRCRAFT

I built "Coco" wings of 120 mm chord with three different airfoils, all three from the John Malkin book "Airfoil Sections".

Model 7: Qinfei
Model 8: Schwartzbach 68
Model 9: Gö 495



CO_2 Engine Power Curve (typical)



The test bed: Wing 650 x 120 mm, tailplane 279 x 68 mm with Wöbbeking 8%, distance between wing and tail 340 mm, weight 50 g, CG 70% of the wing chord.

Flight No.	Model	Wing Airfoil	Turbulator	Time (Secs.)
1	9	Gö 495	1mm thread at 16mm	281
2	9	Gö 495	3-D zig-zag	303
3	8	Schwartzbach	1mm thread at 10%	325
5	8	Schwartzbach	No	314
7	8	Schwartzbach	3-D zig-zag	357
11	8	Schwartzbach	3-D zig-zag	356
12	8	Schwartzbach	3-D zig-zag	357
13	7	Qinfei	3-D zig-zag	333
15	8	Qinfei	3-D zig-zag	334

Airfoil	Turbulator	Time (secs.)	Per Cent	Comments
Gö 495	1mm thread	281		
Gö 495	3-D zig-zag	303	107.83%	Compared to thread
Schwartzbach	No	314		
Schwartzbach	1mm thread	325	103.50%	Compared with no turbulator
Qinfei	3-D zig-zag	334	102.77%	Compared with Schwartzbach with thread
Schwartzbach	3-D zig-zag	357	106.89%	Compared with Qinfei 3-D zig-zag
Schwartzbach	3-D zig-zag	357	109.85%	Compared with thread turbulator
Schwartzbach	3-D zig-zag	357	113.69%	Compared with no turbulator
Schwartzbach	3-D zig-zag	357	117.82%	Compared with Gö 495 3-D zig-zag

No. 8 had been my favourite model. I won many contests with it.

No. 7 served several times as my fly-off model because I had the impression of better performance, particularly after I equipped it with a 3-D turbulator – a small strip of 0,6 mm balsa cut with pinking shears to a zig-zag leading edge after laminating it with double sticky tape to attach it close behind the leading edge of the wing. I tried the 3-D before with No. 10, a small fly-off model with Brown A-23, which flew unsatisfactorily with its 90 mm wing chord. Both models improved visibly with the 3-D.

No. 9 with Gö 495 never reached the performance of 7 and 8 despite being the model in far the best condition. Outdoors I tried thread turbulators in different positions with little progress. This matched with experiences made with No. 5 which won for me the second prize in the Gliwice Black Cup in 1993 but refused to glide at all. Neither strings nor invigorators helped its 90 mm chord wing to improve.

PROCEDURE

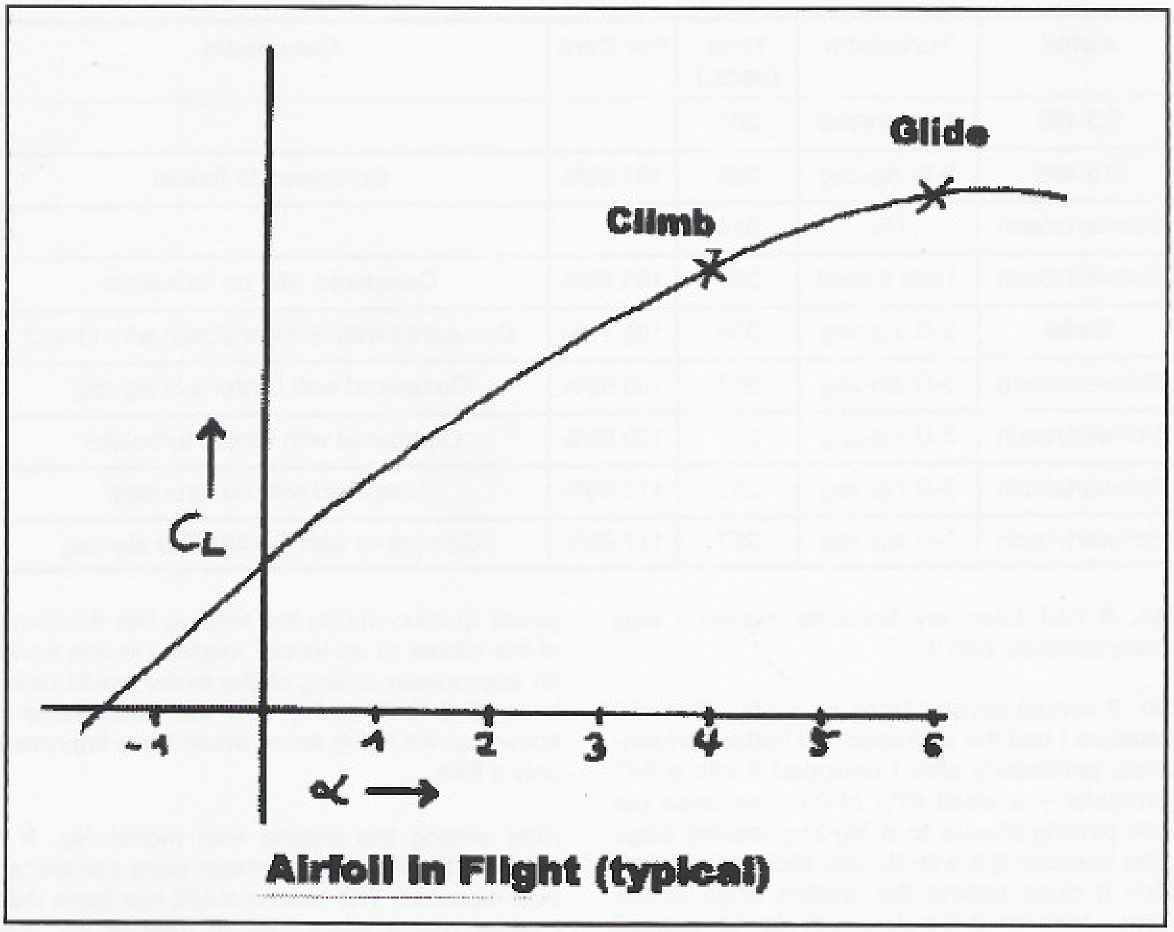
The engine I used was the well run in No. 828 promising the best results. The running time was fixed to about 4:30 minutes expecting to be exceeded with the better flights leaving some time for the glides. This setting was never changed during about 30 flights I carried out nor changed the temperature of the big air mass in the hangar noticeable to accelerate or slowing down the engine.

I accepted a little warp of the scores by this method. Best performance of CO_2 models will be conducted without any glide but with the power quitting during the landing like the turns of the rubber of an indoor model. On one hand an appropriate setting of the motor would have been time consuming. On the other hand I knew that the flying times would have improved only a little.

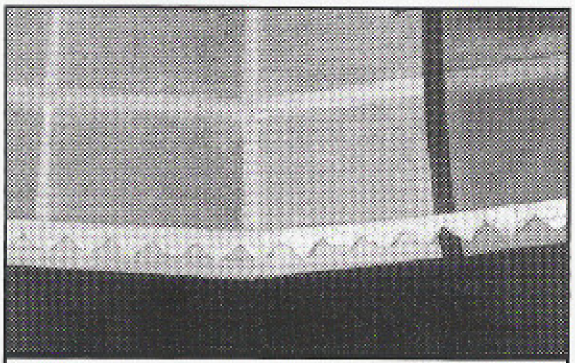
After setting the engine with model No. 9 I trimmed the models. All three were somewhat over-elevated. The reason might has been that I never had a close look at their glides. 2.5 grams CO_2 in the very front of the model and the Very High Thrust layout prevented them from early power stalling. The steeper and slower height gaining approach gave a good impression. But initial speed, realised heights and the flying times improved immediately after correcting the decalage to a smooth glide at the end of each flight.

This trimming was not changed when equipped with better turbulators. Not only John O'Donnell noticed the under-elevating effect of sufficient turbulation of wings. The effect becomes obvious when the wing's back part contributes a bigger share to the whole lift. With the CG at 70% the effect was not that much noticeable. Smooth glides at the end of all flights or the need to watch the indoor competition might have prevented further action. Again this additional trimming would have spread the results to even more impressive improvements with the 3-D turbulators.

Finally it must be mentioned that all flight times had not been counted when the propeller jammed. It happened every forth or fifth flight with the last amount of gas, ruining the glide following.



Gerd's Brown B-100 CO2 CoCo model used in the CargoLifter airfoil tests.



Close-up of the 3-D zig-zag turbulator.

REYNOLDS NUMBERS

The formula I use is the approximation by F. W. Schmitz Re = v x t x 70, with v in meters/sec and t = chord in mm. The speed v of the models could easily be estimated by measuring the diameter of the circle and stopping the time in seconds for one. The resulting 3.5 m/sec match the results of Mike Evatt's glide tests with P-30 models. This more or less 3.5 m/sec are precise enough for the following calculations:

Reynolds number of wings: 3.5 x 120 x 70 = 29,400

To evaluate the turbulators we have to know their Reynolds numbers as well. 6 m/sec air flow had been taken into account because at the upper front of an airfoil the flow has nearly double the speed of the whole moving wing.

Re number of thread turbulator 1 mm diameter: 6 x 1 x 70 = 420
Re number of 3-D turbulator, 0.7 mm thick: 6 x 0.7 x 70 = 294
Minimum Reynolds numbers are 400 for 2-D turbulators and 100 for 3-D. Both turbulators measured sufficient.

Looking back it is a pity not to have conducted the tests in a scientific manner. No flights with the Gö 495 and the Qinfei without turbulators, no position changes of the thread/ 2-D turbulator had been tested. I had in mind the thread not solving nor improving anything after tests with CO_2 model No. 5 mentioned above. My aim was just to find the best airfoil with the best turbulator for further progress.

For this I needed confirmation and proven good results. I got the 357 sec result three times (one 356), and repeated the Qinfei-result (333 sec) with the fuselage and tailplane of model No. 8 (334 sec) suspicious of some miracle performance built in pylon or stabilisers of the Schwartzbach model.

CONCLUSIONS

1. At Re 30,000 neither a sharp nose (Schwartzbach 68) nor a thread of 1 mm diameter seems to be sufficient for turbulation. This is independent of the airfoil. Measured improvements of flying times of 8%, 10% or 14% did not occur by chance.
2. Gö 495 and its typical back camber does not match the expectations despite the success of this profile family in Bob White models or in the F1B of Tony Mathews and Doug Rowsell who threatened Alexander Andruikow in the fly-off of the World Champs 1991.
3. The nice looking Qinfei with its 4,5 % mean camber was not bad in comparison with the 5.9% mean camber of the Schwartzbach 68. And despite having any numbers I had been able to assess its before 3 % superiority with outdoor flights.
4. Good experiences with airfoils of the Køster/Schwartzbach/Korsgaard family in other models and classes had been repeated when using the appropriate turbulator.

FINAL COMMENT

An open question remains. Which angles of attack might the wing of the climbing, cruising and finally gliding CO_2 models have? In all probability the angle will increase with the decreasing power of the engine ending up with 6° during the glide phase, a proven number introduced by Frank Zaic. The lower the angle of attack of the wing the less the necessity for artificial turbulation. My guesses are 4° in the very beginning of the flight making the great importance of artificial turbulation comprehensible.