HOW TO REALIZE HIGH PERFORMANCE BY POWERED FLIGHT AS WELL AS BY SOARING SHOWN BY THE D-39b OF THE AKAFLIEG DARMSTADT

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Introduction

If you want to buy a motorsegler, you will find that, up to now, a lot of powered sailplanes have been designed and a lot of powered aircraft, which are able to glide, have been made too. But is it possible to build a plane, which can be used for soaring as well as for powered flight?
As an answer, I will present the D-39b of Akaflieg Darmstadt (Fig. 1).

Problems of motorsegler design

Realizing high performance needs very high aerodynamic qualities. This means that a motorsegler has to look very much like a sailplane, than like a powered aircraft. So, its main characteristics are a large wingspan in order to increase the aspect ratio and a relatively low weight. The wing loading has to be small enough to permit efficient thermalling under European meteorological conditions.
So, as you see, to lower the weight is one of the major problems in motorsegler design.
Of course, to realise high aerodynamic qualities, a slender fuselage is also necessary. To achieve this, in a two seater motorsegler, the seats must be placed one behind the other.
Some other important points are a retractable landing gear and a canopy following the fuselage contours.
Another problem of motorsegler design is where to put the motor. In order to permit high power-on performance, the best way would be to put it at the front.
This does not hurt the aerodynamic qualities very much (Fig. 2). The increase of the drag factor is only 0.003 C_D comparing the standard class sailplance D-38 and the motorsegler D-39, which have exactly the same wings.
Remind, that the D-39 has no possibility to dose and seal the cooling air's intake. Of course, it is helpful to lower the drag by avoiding this stream of air passing the engine while soaring. Problems of too forward a position of the centre of gravity can be easily avoided by sweeping the wings a little bit forward.
Another point of interest is what to do with the propeller while soaring. Figure 3 shows that simply feathering the propeller will increase the drag by less than 0.001 C_D. Since every mechanism for putting the propeller into the fuselage will in-

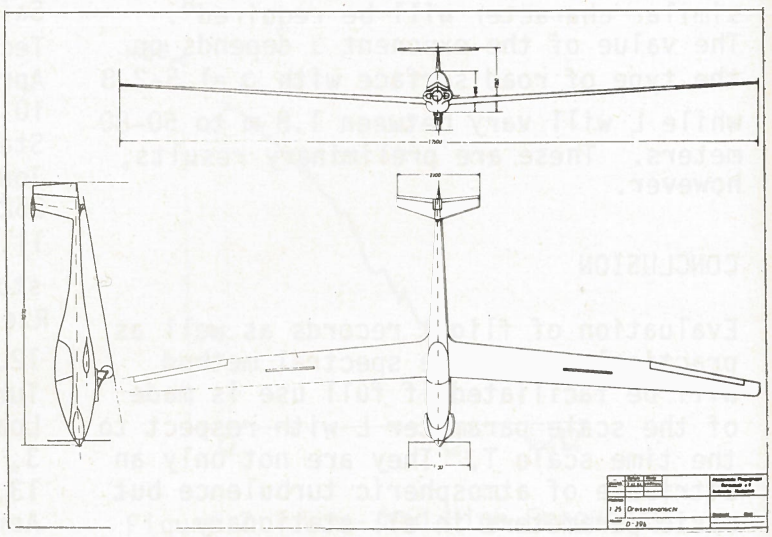

Fig. 1: . . . views of the motorsegler "D-39b", constructed by Akaflieg DARMSTADT.

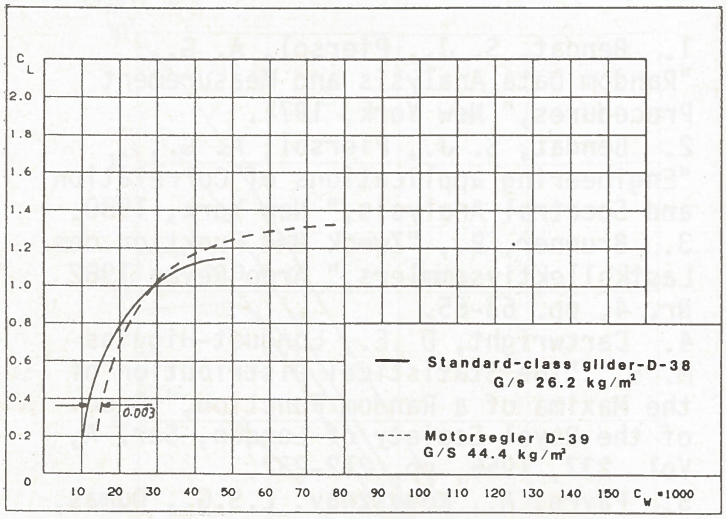

Fig. 2: Polar curves cr/cw of standard class glider "D-38" and motorsegler "D-39"

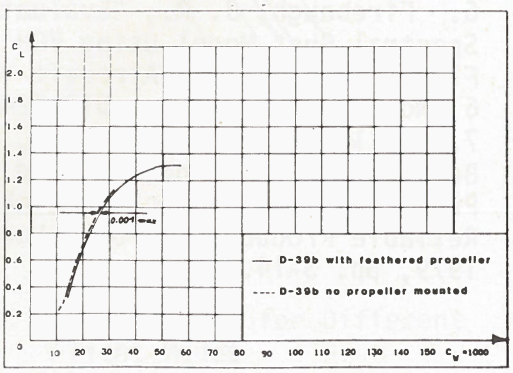

Fig. 3: Polar curves cr/cw of motorsegler "D-39b" without propeller and with feathered propeller.

crease weight, I think it should not be done.

D-39b: Solving these problems

As the D-38 was finished, the students of Akaflieg Darmstadt planned to design a motorsegler, using the D-38's wings and at first a 43 HP-Wankel engine located in the front of the fuselage. The propeller should be folded into the fuselage contour while soaring. Later it was realised that this engine was not powerful enough. So we decided to use a 68 HP-Limbach engine, which is a modified VW-engine. As a result of this, there was no possibility to use the folding-propeller, even though this propeller had been sufficiantly tested. In consequence the D-39 became much heavier and the centre of gravity moved to a very forward position.

In June 1978 the D-39 was flying for the first time. We soon realised that the D-39 was very much like a very good racing aeroplane than a sailplane. So after three years flying the D-39 we decided to alter its wingspan and to make some other changes in order to make it a real motorsegler.

For solving the wingloading problems and the problem about the centre of gravity, we just cut off the inner part of the wing spar. Now, we were able to enlarge the wing area as well as the wing span quite a lot; also we swept the wing 3 degrees forward to move the entre of gravity to a proper position, and we were able to fix a new propeller, allowing to switch different angles of pitch for climbing and cross-country flight and to feather it for soaring. This needed some changes of the cowling contours. Furthermore, a new exhaust was put in, in order to reduce the noise. Meanwhile, the wing shape near the fuselage had been improved and had been tested in a windtunnel. Table 1 shows the changes of characteristical data from "D-39" to "D-39b".

In the new configuration the motorsegler, now called D-39b, first flew on July 1982.

Table 1: Characteristical data of motorseglers "D-39" and "D-39b".

D-39		D-39b
15.	Wing span [m]	17,5
11.	Wing area [m^2]	13,4
20,5	Aspect ratio	22,9
370.	Empty weight [kg]	438
100.	Mass able to carry [kg]	125
470.	Gross weight[kg]	563
41,8	Wing load [kg/m^2]	39,4
FX 61-184.	Inner wing section.	FX 61-184
FX 60-126.	Outer wing section.	FX 60-126
34.	L/D max.	37
105.	at speed [km/h]	100
0,8	Min. sink rate [m/s]	0,7
92.	at speed [km/h]	87
87.	Min. speed V_{SO} [km/h]	78
280.	Max. speed V_{NE} [km/h]	270
185.	Max. horizontal speed V_H [km/h]	200
8.	Fuel needed at V_H [l/h]	12
5.	Climb speed [m/s]	4,2

Only three weeks later, we managed to fly a 300 km triangle without using the engine except for starting, proving the D-39b's soaring qualities. Up to now, the D-39b has been flown by many pilots, the flights including measurements of performance (Fig. 4) and handling qualities by IDAFLIEG and DFVLR. Despite the fact that all control surfaces were designed for a 15m wing span, the D-39b's handling qualities are excellent.

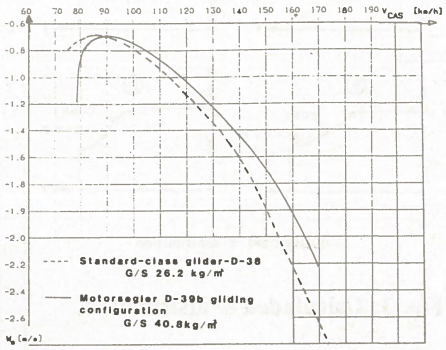

Fig. 4: Polar curves V_{CAS}/Ws of standard class glider "D-38" and motorsegler "D-39b" in gliding configuration.

But let us have a look at the point of safety. One of the great problems of motorseglers with a retractable engine, is getting it started while flying. It takes a lot of time, getting it up and making it run, while the glide ratio decreases to 1:17 and less. As a matter of fact, a lot of crashes have been reported caused by this. If you have a look at the D-39b, you see that it is much easier in its case. There are no large masses to be moved upwards. Only the propeller must be switched, which is easily done, and the motor can be started. All this takes very little time and makes you sure, the engine will run in a few seconds.

Looking into the future, it might be possible, to build a two-seater "D-39b", using carbonfibres instead of glassfibres, designing from the beginning as a 18m ship and using the Limbach engine. This might reduce the weight enough to cater for the second seat.

It is not planned yet, but I think, there are good chances to build a real motorsegler, able to soar as well as flying by an engine, having both, very high performances and excellent handling qualities.