STRUCTURAL ANALYSIS OF HATZ AIRPLANES
By Jurg Muller

Before signing off a homebuilt with the Swiss airworthiness agency, the Federal Office for Civil Aviation (FOCA), requires a structural analysis of the most important structural components of the airplane. The results of the analysis together with a thorough study of the plans may lead them to request mandatory modifications of the structure or of components before approving the project. Since I am the first Hatz builder in Switzerland I have to provide all the requested information. Except for a limited loads analysis of the wing performed by P. Uhlig and an engineering friend of his which was published in the Hatz newsletter, there was nothing available. Fortunately, being an aeronautical engineer myself, I was able to perform the needed analysis and didn't have to hire it out to a consultant, thus saving many thousands of dollars.

The work presented herein is still a work in progress, in particular, the fuselage hasn't been analyzed yet. Also, it hasn't been approved by the FOCA yet. Nevertheless, I think the results obtained so far may be of interest to some of you. The analysis is performed for the Hatz configuration which I am building: a Hatz powered by a Lycoming 0-320 with the maximum take-off weight set to 1600 lbs. But the results can be adapted to the more original, lower powered Hatz with reduced take-off weight which many are building (see below). This article gives just a short overview of the most important results. It is limited to results obtained for the wing structure and for symmetrical loadcases. The complete analysis is more than a hundred pages long so far. It is available to those interested upon request for the cost of shipping and copying.

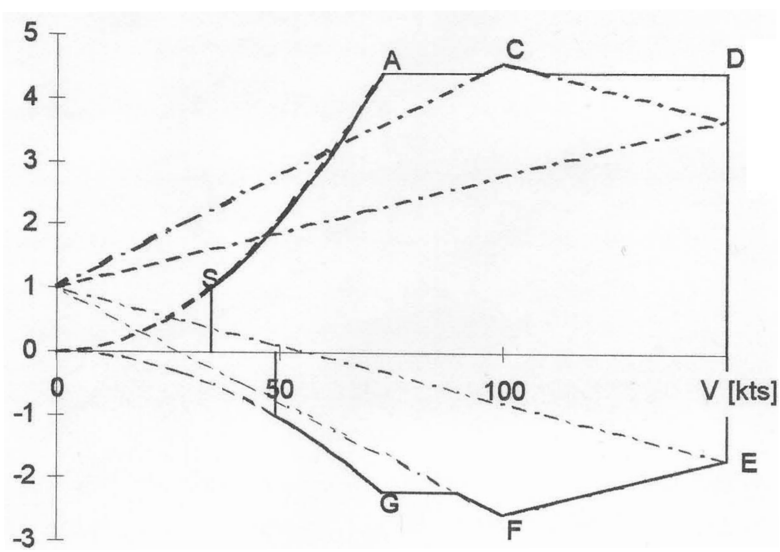

Fig. 1: Flight envelope

A stress analysis must begin with the determination of the flight envelope. The flight envelope defines the velocities and the normal acceleration (the number of g's) the airplane is expected to see in operation. The flight envelope used for the present structural analysis is shown in Figure 1. The flight velocity is plotted on the horizontal axis and the normal acceleration on the vertical axis. The region delineated by the points (SACDEFG) gives all the combinations of flight speeds and acceleration for which the structure must be analyzed. It includes the loads generated by maneuvers as well as gusts. The flight envelope used for the present analysis (Fig. 1) fulfills the requirements set forth in FAR Part 23, the airworthiness regulations valid for light planes. The positive load factor is chosen to be n=4.4 and the negative n=2.2. This corresponds to an airplane which would be certified in the utility category, thus allowing limited aerobatics. The speeds defined in the flight envelope also determine the markings on the airspeed indicator. In the present case, the redline will be at 155mph and the end of the green arc at 115 mph.

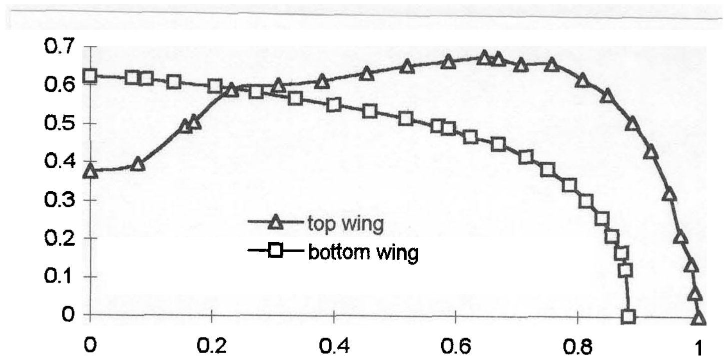

Fig.2: Lift distribution on top and bottom wing

Now the aerodynamic loads can be determined. Although the structural integrity must be assured for the whole flight envelope, it is usually sufficient to limit the analysis to the boundary points. Figure 2 shows the lift distribution on the wings which is calculated using a computer program. This information is now used to calculate the loads acting on the wing structure. Figure 3 shows the bending moment and the normal force acting on the top wing for the loadcase C (see flight envelope).

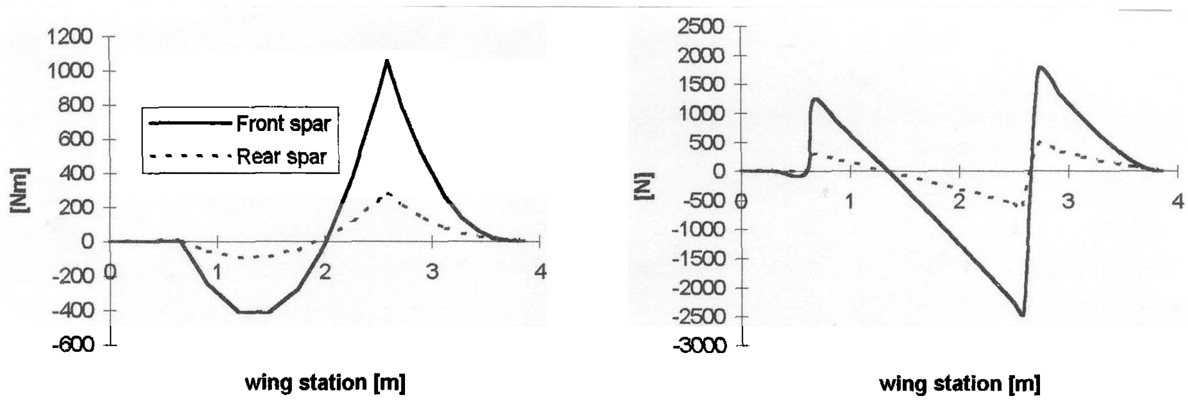

Fig. 3: Bending moment (left) and normal force distribution (right) on top wing spars

The general shape of the curves remains the same for other loadcases. The highest bending moments and the largest normal force occur where the interplane struts are connected to the spars. In addition, the flying wires induce a compression load on the inboard section of the spars. Thus, structurally, the most critical station is located just inboard of the strut attachment. The loads on the bottom wings are generally much lower and are not critical. From the loads thus determined and the known cross section of the spars, the maximum stress at any given spanwise station can be calculated and compared to the allowable stress. In my airplane I used Douglas fir for my spars. The wood which I bought from a European airplane manufacturer is certified to a maximum stress of 58 KSI.

It turns out that the front spar of the top wing is the most critical. Taking into account a safety factor of 1.5 yields a margin of safety against compression failure of 0.06. This means that the structure is 6% stronger than needed. This doesn't seem like much, but this figure was obtained without taking into account the plywood doublers present in this area. On the other hand, the bolt holes were also neglected. Beside the spars, various fittings and bolts, the struts and the wires were also investigated. The table on the next page gives a summary of the results for some of the components analyzed.

Element	Failure mode	safety margin	loadcase
top front spar	compression	0.06	C
top rear spar	compression	0.86	C
bottom front spar	compression	1.1	C
bottom rear spar	compression	3.1	D
lift wire front	tension	1.76	C
lift wire rear (pair)	tension	1.22	C
drag/anti drag wires	tension	2.8	A
compression struts	buckling	1.2	A

No overstressed component was found. Some are overdesigned.

If the maximum take-off weight (MTOW) is decreased, the number of g can be increased in the same proportion. This is only approximately true since in practice the flight envelope will also be slightly different. Nevertheless, we can use this approximation to estimate the normal acceleration for a lower powered, lighter (MTOW 1400 lbs.) Hatz: n=1600/1400* 4.4=5.0 This is close to the figure of n=5.2 which often is stated as the g-limit for the original Hatz CB-1.

In conclusion, one can state that the wing structure of a Hatz built per plans is adequate for its intended use. This is also true for the other parts analyzed so far. Limited aerobatics should be possible if the gross weight is kept low. Personally, I wouldn't feel comfortable in a Hatz with a maximum gross weight above 1600 lbs.

Jurg,

Many thanks for sharing your knowledge and hard work. I would like to point out that Douglas Fir weighs 33 pounds per cubic foot and has 10,900 PSI strength in bending compared to Sitka Spruce at 28 and 9,400 respectively. This means the fir is 18% heavier and 16% stronger than Spruce. Jurgs' analysis is based on the stronger Douglas fir. If you have a light Hatz with Sitka Spruce you are probably fine but if you have the heavy Hatz and spruce spars you may not have the g available at 1600 pds gross weight. Heads up. We have 2.4038 cu. ft. of spar material in the Hatz. The Spruce weight is 67.3064 pds and the Fir weight is 79.3254 pds. You add 12.019 pounds to the plane if you substitute fir for spruce on the spars.