ARTIFICIAL STALL WARNING FOR SAILPLANES

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Introduction

As concept this stall warning device was honored as the best entry for the OSTIV competition in 1987 for development of a stall warning device for sailplanes. This system is based on the measurement of a local dynamic pressure ($1/2rV^2_{local}$) at a small orifice behind and below the nose of the sailplane, see Figure 1.

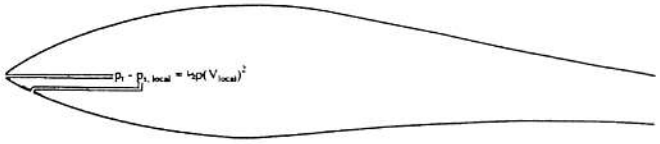

Figure 1. Position of the additional pressure orifice.

The measurement of a local dynamic pressure, however, makes the system dependent of angle of attack and the flight speed. When the system is calibrated for a low wingloading (according to JAR22.207 the warning margin must lie between $1.05V_{s1}$ and $1.1V_{sl}$), the system does not warn in case of high wingloading (e.g. by water ballast, one/two seater).

Operation principle

To counteract the wingloading dependence, the local dynamic pressure at the orifice is divided by the free stream dynamic pressure $1/2rV^2$ from the pitot tube and the static ports of the glider. This results in a coefficient:

$$f_s = \frac{\frac{1}{2}\rho V^2_{local}}{\frac{1}{2}\rho V^2_\infty}$$

This is equivalent for the pressure coefficient at the pressure orifice. Since the pressure coefficient only depends on the angle of attack, the system operates independent of the wingloading. If f_s drops below a reference value, called the warning threshold level, the aural and visual warnings of the device are activated. Figure 2 shows the schematic system set-up of the electronic device that was made for testing.

Flight tests with the ASW-19BX

Two pressure orifices at 60 and 90 mm from the nose have been tested, but no difference in system behavior is noticed during flight tests. In general, a position between five and ten centimeters from the nose seems to be appropriate, depending on the glider construction.

Figure 3 shows a registration of the flight speed and fs

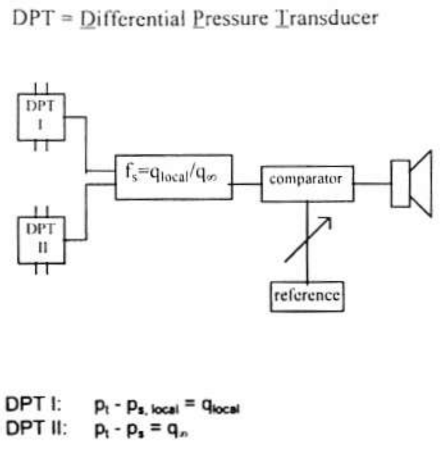

Figure 2. System set-up.

during a wings-level stall test. The horizontal timebase is 2 sec/div. The warning speed is equal to the speed at the point at which fs drops below the warning threshold level. The warning speed is about 73.5 km/h in wings level flight and 78.0 km/h in a turn with 30° angle of bank, as can be seen in Figure 4. The wings-level stall speed was estimated to be 67 km/h and in case of $\varphi = 30^\circ$ 72 km/h.

One flight test with 60 ltr water ballast has been carried out to test the system independence for changes in wingloading. It was found that the warning speed had increased from approximately 73 to 80 km/h (which corresponds with theory).

A flight test with fully extended airbrakes, see Figure 5, has pointed out that the warning speed increases to about 80 km/h due to a loss of lift. This means that similar to the effect of a change in wingloading, the relative margin (%) remains constant.

In a lightly skidding turn, it is noticed that the system operates similarly to a normal turn, but in an excessively skidding turn, the warning sounded at the moment the glider started a wing dip. This can be anticipated by increasing the warning threshold level. This increment could be realized in such a way that the stall warning will also function as a warning not flying to slow during thermaling.

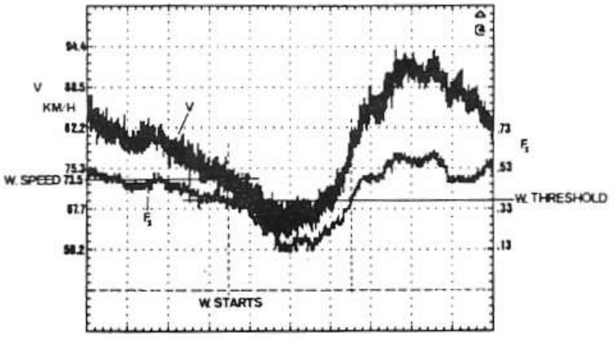

Figure 3. Wings-level stall.

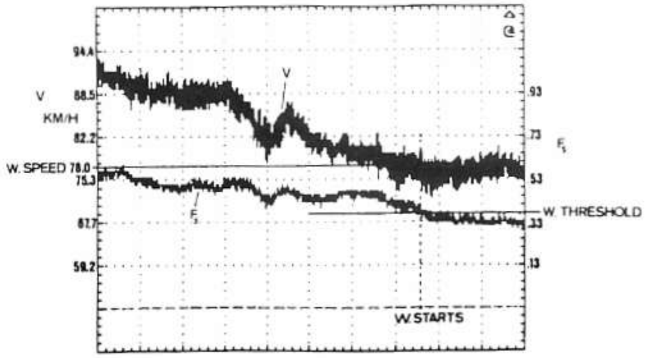

Figure 4. Stall in 30° angle of bank turn.

Conclusions and recommendations

Despite the satisfying flight test results, there are several ancillary problems. Since the system is an electronic system, it is dependent on a supply battery that is too unreliable to have a critical item like stall warning dependent upon. This problem can be solved by using a battery or solar panels as backup for the main battery or the stall warning device only.

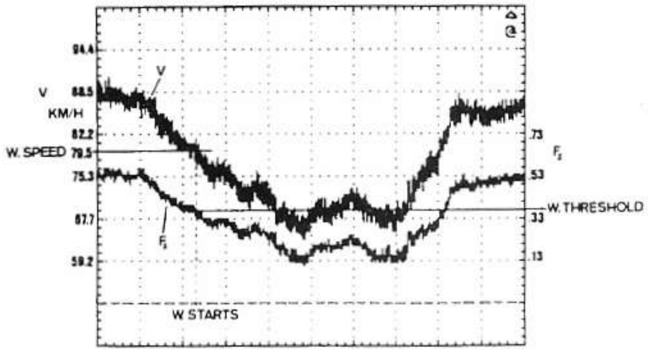

Figure 5. Stall with fully extended airbrakes.

An interesting application is the combination of stall warning with (micro processor) for final glide computing. The advantages of this combination are the saving of a pressure transducer and analog electronics.

In case of gliders with flaps, the problem of a changing critical angle of attack can be anticipated by a microswitch on the flap handle. When a certain flap position is selected, automatically the right warning threshold level will be selected. The principle of a micro switch on the flap handle is already applied in final glide computers for gliders with flaps to select the right speed polar.