Advanced Stalling

This *Advanced Stalling* lesson covers the factors that affect the observed airspeed and nose attitude at the stall.

Although the aeroplane always stalls when the aerofoil is presented to the airflow at too high an angle (>≈15 degrees) most aeroplanes are not fitted with an angle-of-attack indicator. Therefore, it is common practice to use the aeroplane's stalling speed (V_S) as a reference.

In level flight the airspeed and nose attitude will vary depending on the aeroplane's configuration (speed, power, flap and gear settings) and therefore airspeed and/or nose attitude are not reliable indicators unless the configuration for the phase of flight is considered. As was seen in the climbing lesson, the aeroplane has a high nose attitude and a low airspeed but is nowhere near the stall.

The purpose of this exercise is to revise the causes of the stall and to compare the aeroplane's nose attitude and airspeed approaching the stall in various configurations, and then to recover from the stall.

Objectives

To experience the effect of power and/or flap on the aeroplane's speed and nose attitude at the stall.

To recognise the symptoms of the stall.

To stall the aeroplane and be able to recover from the stall by taking appropriate action.

Principles of Flight

The aeroplane's manufacturer provides stalling speeds for one or more configurations as a guide to the pilot, for example, from level flight with a slow deceleration, power at idle, and flap up, when this aeroplane reaches the critical angle the airspeed will read ______ knots.

Although the critical angle remains constant, the stall speed will vary for other configurations and with several factors.

$$L = C_L \tfrac{1}{2} \rho V^2 S$$

L = angle of attack x airspeed

Lift primarily varies with angle of attack and airspeed. Since the critical angle cannot be altered, anything that increases the requirement for lift will require an increase in airspeed to produce that lift. Therefore, when the critical angle is reached the airspeed will be higher.

↑ L = angle of attack x ↑ airspeed

Anything that decreases the requirement for lift will decrease the airspeed observed at the stall.

The mnemonic 'WILPS' can be used to remind us of the factors affecting the stall; the first three increase the stall speed the last two reduce it.

Weight

An increase in weight will require an increase in lift, resulting in an increase in the stalling speed.

↑ W → ↑ L → ↑ V_S

Ice or Damage

If ice forms on the wing, or the wing is damaged, the smooth airflow over that part of the wing will be disturbed, allowing the airflow to break away earlier. This increases the requirement for lift and therefore the stall speed. The effect of ice is twofold in that it also increases the aeroplane's weight.

In flight, generally ice will form on the airframe only if the aeroplane is flown in cloud.

The most common danger from ice in New Zealand is its formation on the wings and tailplane of aeroplanes parked overnight, and sometimes it is so thin and clear that it is hard to detect. No attempt should ever be made to take off with ice or frost on the wings or tailplane, because of its effects on the smooth airflow and the resulting increase in stall speed – which cannot be quantified and may be well above the normal rotate speed.

Loading

> Explaining this effect is one reason why advanced stalling is often left until after solo circuits and steep turns; before first solo the explanation is kept as simple as possible.

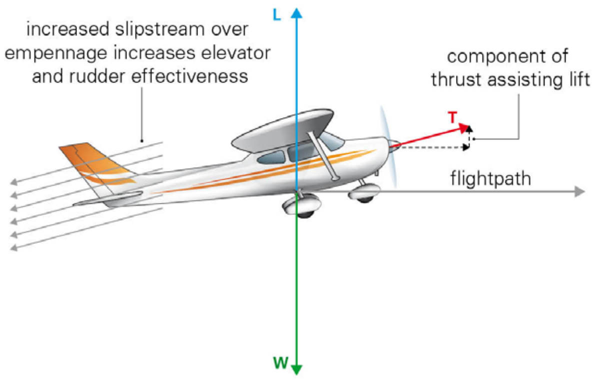
Loading, or load factor, is the name given to the force/acceleration that the aeroplane must support, for example, in pulling out of a dive. When you ride a roller coaster, at the bottom of the dip you feel heavier, as you're pushed into your seat by the force/acceleration of changing direction. You haven't actually gained weight, but it feels that way. For an aeroplane this is often referred to as apparent weight, or G, and this increase in apparent weight increases the requirement for lift, and thus it increases the stall speed.

↑ apparent W → ↑ L → ↑ V_S

Power

If the aeroplane could climb vertically there would be no requirement for lift at all. So when thrust is inclined upwards, it decreases the requirement for lift and reduces the stalling speed. In addition, the slipstream generated by having power on increases the speed of the airflow and modifies the angle of attack (generally decreasing it) over the inboard sections of the wing. The increased airspeed increases the lift and reduces the aeroplane's stall speed, and the modified angle of attack increases the nose-high attitude.

Figure 1



Slats, Slots or Flap

Flap increases lift and therefore the stalling speed is reduced. However, flap also changes the shape of the wing, and this results in a lower nose attitude at the stall.

The effect of flap on the lift/drag ratio should be revised, with particular emphasis on the reason the flap is raised gradually during stall recovery.

Although flap increases lift, it also increases drag – generally, about the first 15 degrees of flap increases lift with little adverse affect on the L/D ratio. It should be appreciated however, that any use of flap will decrease the L/D ratio.

The application of any further flap rapidly increases drag, adversely affecting the L/D ratio.

The point at which drag rapidly increases varies with aeroplane and flap type, but this is usually at the flap setting recommended for a soft-field takeoff.

Slats and slots also increase lift and therefore stall speed is reduced.

Use of Aileron

If at the stall the aeroplane starts a slight roll, using aileron to stop the roll (a natural tendency) will increase the angle of attack on the down-going wing. This decreases the lift even further and increases the drag, continuing the roll not stopping it.

This is the reason for maintaining ailerons neutral in the initial stall recovery and using rudder to keep the aeroplane straight on the reference point.

Airmanship

Reiterate that passengers should not be carried during this exercise.

Situational awareness considers not only the position of the aeroplane three dimensionally within the training area but also the warning symptoms of the approaching stall, and awareness of the flight phase – power reduced but attempting to maintain level flight.

It also includes an awareness of other traffic.

Revise the **HASELL** checklist.

H ***Height (not altitude)***
Sufficient to recover by not less than 2500 feet above ground level.

A ***Airframe***
The entry configuration is revised: power, flap.

S ***Security***
No loose articles, harnesses secure.

E ***Engine***
Temperatures and pressures normal.

L ***Location***
Not over a populated area and clear of known traffic areas, including airfields.

L ***Lookout***
Carry out a minimum of one 180-degree, or two 90-degree, clearing turns, to ensure other traffic will not result in conflict.

Revise the **HELL** checks.

H ***Height (not altitude)***
Regained or sufficient to recover by not less than 2500 feet above ground level .

E ***Engine***
Temperatures and pressures normal, mixture RICH, fuel sufficient and on fullest tank, fuel pump ON.

L ***Location***
Not over a populated area and clear of known traffic areas, including airfields.

L ***Lookout***
One 90-degree clearing turn.

Aeroplane Management

Review the use of carburettor heat.

Revise the need for smooth throttle movements.

Monitor and manage the engine temperatures and pressures between stalls.

Human Factors

The regular turns and steeper than normal nose attitudes could lead to some disorientation. Make sure the student has time between stalls to orientate themselves.

This exercise may produce some discomfort in the student, especially if your aeroplane type has a tendency to wing drop. Reassure the student that this is not a dangerous exercise, when conducted above 3000 feet – as you will be doing. Tell the student that if they feel uncomfortable at any point, they should say so, the aeroplane can then be flown level until they feel comfortable to continue.

Air Exercise

HASELL checks are completed and a prominent outside reference point on which to keep straight is nominated.

Start by carrying out a basic stall entry and recovery as a reference to compare the effect power and flap has on the stall. In particular the student should identify the attitude, speed and recovery references.

Then teach the effects of power on the stall.

Then the effect of flap on the stall.

Finally teach the effect of power and flap combined, on the stall.

Entry

From level flight, carburettor heat is selected HOT and the power smoothly reduced to ______ rpm. As the nose will want to yaw and pitch down, keep straight with rudder and hold the altitude with increasing backpressure.

If selecting flap below ______ knots (within the white arc) select full flap gradually and prevent the tendency for the aeroplane to gain altitude or 'balloon' with the rapid increase in lift, by checking forward or relaxing the backpressure.

Full flap is recommended so that raising the flap can be practised in the recovery sequence.

Through ______ knots, or when the aural stall warning is heard, select carburettor heat to COLD, as full power will shortly be reapplied.

Stall Warning Symptoms

Decreasing Airspeed and High Nose Attitude

The first symptom is decreasing airspeed. The rate at which the airspeed decreases will be affected by the amount of power and flap being used, probably faster in this case with full flap.

Note the effect of power on attitude and airspeed at the stall.

Note the effect of flap on attitude and airspeed at the stall.

Low airspeed and a high nose attitude are not always present in the approach to the stall, as was demonstrated in the no power, full flap case. However, for most phases of flight, low airspeed and high nose attitude are valid indicators; so too is quietness.

Less Effective Controls

The next symptom is less effective control as a result of the lowering airspeed. However, the effectiveness of the rudder and/or elevator will be determined by the amount of power being used. In this case, the elevators will generally retain sufficient effectiveness to bring the aeroplane to the critical angle without a sink developing. Control pressure in pitch will be heavier.

Stall Warning Device

The stall warning device (which is not a true symptom) follows this. Because the stall speed with power and/or flap is reduced, the stall warning will sound later, at a lower airspeed.

Buffet

The last symptom is the buffet. The amount of buffet detected depends on the mainplane/tailplane configuration, as discussed in basic stalling. In both the high-wing/low-tailplane and low-wing/low-tailplane types, the flap deflects the airflow down onto the tailplane, and the buffet will be more noticeable. This will depend on the power setting used, as the slipstream may mask any increased effect. In the low-wing/high-tailplane arrangement there may be little change, but again depending on slipstream effects.

Remind the student to observe the attitude and when the aeroplane stalls note sink and the nose pitching down.

Recovery

The recovery is still in two parts, but coordination and speed of execution are increased.

To unstall

Decrease the backpressure, or check forward, with ailerons neutral and remaining straight on the reference point with rudder. The student should be reminded that check forward with the elevator is a smooth but positive control movement but not a push.

The correct use of aileron must be reinforced to produce the required automatic response.

To minimise altitude loss

Full power is smoothly but positively applied – use rudder to keep straight – and the nose is smoothly raised to the horizon. There is no need to hold the nose down as excessive altitude will be lost, while increasing backpressure too rapidly, or jerking, may cause a secondary stall.

The result is sufficient to arrest the sink and minimise the altitude loss.

Hold the aeroplane in the nose-on-the-horizon attitude and reduce the flap setting (as appropriate to aeroplane type) immediately. Do not raise all the flap at this stage, for example in a PA 38 reduce to one notch of flap, or in a C152 reduce the setting by at least 10 degrees. Any benefit of attitude plus power will be reduced the longer the aeroplane is held in the nose-on-the-horizon attitude with full flap extended.

A pitch change will occur as flap is raised if uncorrected, therefore, the nose attitude must be held constant. In addition, flap should not be raised with the nose below the horizon, as this will result in considerable altitude loss.

Before raising the remaining flap, there are three criteria that must be met;

- safe altitude,
- safe airspeed (above a minimum and accelerating), and
- a positive rate of climb (to counter the sink as a result of reducing lift through flap retraction).

When these conditions have been met, raise the remaining flap and counter the pitch change. The aeroplane will continue to accelerate, and at the nominated climb speed, select the climb attitude.

Straight and level flight should be regained at the starting altitude, and the reference point or heading regained if necessary.

The student should expect an altitude loss of less than 50 feet, and reducing to zero when recovering at onset, with practise and early recognition.

Airborne Sequence

On the Ground

The student should be able to get the aeroplane ready for flight, and carry out the checklists, while still working towards learning the checks.

The Exercise

The student should now be able to take you to the training area and position the aeroplane within the training area at a suitable altitude, completing the necessary checks, and carrying out the basic stall and recovery. Your assistance is given only as required.

To refamiliarise the student with the stall nose attitude or airspeed, the student should start by carrying out at least two basic stalls, with recovery at stall and then at onset with minimum height loss.

> This exercise is leading the student to the realisation that in the approach configuration the attitude at the stall is noticeably lower than might be expected, and that throughout a normal approach the aeroplane's nose is well below the horizon. The emphasis is on the observed attitude at the stall more than the indicated airspeed although the lower airspeed should be noted.

Demonstrate a stall with some power and no flap, and recover. Point out the nose-high attitude and lower airspeed. The more power used, the more noticeable the increased nose-high attitude and the lower the stall speed. At high power settings with no flap, the entry can be considerably prolonged (unless altitude is gained). Therefore, normally somewhere between 1500 and 2000 rpm should be sufficient (refer CFI).

Then demonstrate a stall with no power and full flap, and recover. Point out the nose-low attitude, often similar to the straight and level attitude, the lower airspeed, and with flap how quickly airspeed reduces.

During the demonstrations or follow-through of the stall, with power only and then flap only, you must ensure that a constant altitude is maintained during the entry, as any tendency to gain altitude will affect the nose attitude observed at the stall.

Once the difference in attitude and airspeed at the stall, as a result of the aeroplane's configuration, has been observed introduce the effects of a combination of power and flap on the attitude and airspeed. Use the approach configuration for this.

After the student has experienced the stall symptoms and recovery technique, move on to recovery at onset. Outside the training environment the student needs to be able to recognise the symptoms of the approaching stall and recover before the aeroplane stalls.

Rather than nominate the stall warning as the 'symptom' at which to recover, ask the student to tell you the symptoms they expect to see and in which order, and then say them as they occur. The stall warning will typically activate at 1.2 V_S which is too far above the stall to effectively demonstrate and note the symptoms clearly. The student needs to recognise the feel of the aeroplane when near the stall.

If the stall warning is not operative, the buffet, if recognisable in the aeroplane used, may be used as the symptom at which recovery is initiated. The only disadvantage of this is that, with power on, the buffet may be very difficult to detect.

During the entry and recovery, you should emphasis eyes outside on attitude and keeping straight using the reference point, for it will be shown in the wing-drop stall that, if the aeroplane is permitted to yaw, one wing will stall before the other. In addition, smoothly raising the nose to the horizon and countering the effects of raising flap should be emphasised.

The student should be able to return you to the aerodrome, and make most of the radio calls required.

After Flight

If this lesson is given after solo and circuit consolidation, it is recommended the next lesson be *Wing-Drop Stalling*.

Otherwise, the next lessons will be in the circuit, where the student will be learning how to fly a circuit and land the aeroplane. They will be drawing on all of the skills they have learnt so far. Ask the student to read any notes on the circuit lessons.