Task XI.C: Power Off Stalls

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Lesson Overview

Objective

The student should develop knowledge of power-off stalls regarding aerodynamics, factors associated with stall speeds, as well as proper recovery techniques. The student will understand situations in which power off stalls are most common and most dangerous and will have the ability to perform a power-off stall as required in the ACS/PTS.

Reference

- Airplane Flying Handbook (FAA-H-8083-3B, page(s) 4-8)
- Stall and Spin Awareness Training (AC 61-67C)
- POH/AFM

Key Elements

1. Critical Angle of Attack
2. A Stall Can Occur at any Airspeed, Attitude, Power Setting
3. Recovery (Reduce the Angle of Attack)

Elements

1. Aerodynamics
2. Various Factors and their Effect on Stall Speed
3. Possible Situations for a Power-Off Stall
4. Entering the Maneuver
5. Recognizing the Stall

6. The Recovery

Equipment

1. White board and markers
2. References
3. iPad

Instructor Actions

1. Discuss lesson objectives
2. Present Lecture
3. Ask and Answer Questions
4. Assign homework

Student Actions

1. Participate in discussion
2. Take notes
3. Ask and respond to questions

Schedule

1. Discuss Objectives
2. Review material
3. Development
4. Conclusion

Completion Standards

The student will become familiar with the conditions that produce power-off stalls and will develop the habit of taking prompt preventative or corrective action when in a situation resulting in a stall.

Instructor Notes

Introduction

Attention

Stalls can be intimidating and frightening but understanding how they work and practicing them will make you more comfortable with them and a much safer pilot. A stall can occur at any airspeed, in any attitude, or any power setting, depending on the factors affecting the particular airplane.

Overview

- Review Objectives and Elements/Key ideas

What

A stall occurs when the critical angle of attack is exceeded. When this happens, the smooth airflow over the wing is disrupted resulting in a loss of lift and increased drag. Power on stalls (also known as departure stalls) are practiced to simulate stalls in the takeoff and climb-out conditions and configuration.

Why

Stalls in general are practiced to become familiar with an aircraft's particular stall characteristics and to avoid putting the aircraft into a potentially dangerous situation. Power-on stalls are essential to safety in the aircraft. It is important to understand how they happen, how to avoid them, and how to recover from them.

Lesson Details

A stall occurs when the smooth airflow over the wing is disrupted and lift decreases rapidly. This is caused by the wing exceeding its critical angle of attack. The stall is strictly related to AOA, which means it can occur at any pitch angle, with any power setting.

More specifically, when the AOA is increased to approximately 15° to 20° (usually 18°), the air can't follow the upper curvature of the wing. This is known as the critical angle of attack. As the critical AOA is approached the air begins separating from the rear of the upper wing surface. As the AOA is incensed the air is forced to flow straight back and a swirling/burbling of the air begins to flow over the upper surface. When the critical AOA is reached that turbulent flow spreads over the entire wing surface. This results in a sudden increase in pressure on the upper surface and a loss of lift. Due to the loss of lift the form drag is such that the remaining lift can't hold the aircraft aloft.

Most wings are designed to stall in a predictable and controlled manner. They stall from the root outward to the tip. This is achieved by various mechanisms, one of which is building the wing with washout (a slight twisting of the wing along the chord so the AOA is slightly different from root to tip). This leaves the ailerons somewhat effective up to the point where the wing is fully stalled.

Various Factors and their Effect on Stall Speed

There are a number of factors that play into the stall behavior. Stalls can occur at any airspeed, attitude, or power setting depending upon all the factors acting on the aircraft.

Configuration

The extending of the gear or flaps can impact stall. Both increase drag, and flaps increase lift. This increase in lift can reduce the speed at which the aircraft will reach the critical AOA.

Weight

As the weight of the airplane is increased more lift is required, which generally results in a higher angle of attack in cruise flight. Therefore the aircraft is already closer to the critical AOA, and thus will stall at a higher indicated airspeed.

Center of Gravity

- In the case where the aircraft is loaded with a forward CG, it will feel "heavier" and consequently will be slightly slower than the same aircraft in the same configuration loaded with a more aft CG. This configuration requires a higher AOA, thus a higher stall speed. However, due to the longer arm between the CG and the horizontal control surfaces the aircraft is somewhat more controllable.

- In the case where the aircraft is loaded with an aft CG, it will feel "lighter" and consequently will be slightly faster than the same aircraft in the same configuration loaded with a more forward CG. This configuration requires a lower AOA, thus a lower stall speed. However, recovery from a stall becomes slightly (or significantly, if extreme aft loading is the case) more difficult due to the reduced length of the arm from the CG to the horizontal control surfaces.

Load Factor

The load factor is the ratio of the total load acting on the airplane to the gross weight of the airplane. The airplane’s stall speed increases in proportion to the square root of the load factor. Therefore, a plane that stall at 45 knots can be stalled at 90 knots when subjected to Gs. This condition is known as an accelerated stall.

Bank Angle

When an aircraft is banked, if altitude is to be maintained, the load factor is increased. As the bank angle exceeds 45° the load factor rises quickly. At 60° a load factor of 2Gs is imposed on the airplane’s structure. As the bank angle rises only an additional 10° to 79° the load factor quickly rises to 3Gs. As discussed above, this raises the stall speed in proportion to the square root of the load factor.

Snow, Ice, and Frost

Any frozen moisture on the wings can raise the stall speed significantly. This is due to the basic shape of the wing being changed and the additional surface roughness that disrupts the smooth flow of air over the wing. All snow/frost/ice must be removed from the flying surfaces before flight.

Turbulence

The presence of turbulence can cause the aircraft to stall at a higher airspeed. A vertical gust or wind sheer can cause a rapid change in the relative wind, which can result in a greatly increased AOA. This increase can exceed the critical AOA thus resulting in an immediate stall.

Possible Situations for a Power-Off Stall

These types of stalls are most often encountered during normal and emergency approach to landings. In these scenarios a cross-controlled turn from base to final can provoke a stall (and a spin). Attempting to recover from a high sing rate without using a combination of pitch and power (ie. just pitching) can result in a stall. Generally mis-managing airspeed during flight in the pattern, or trying to "stretch a glide" can leave the aircraft too slow and at too high an AOA, thus provoking a stall.

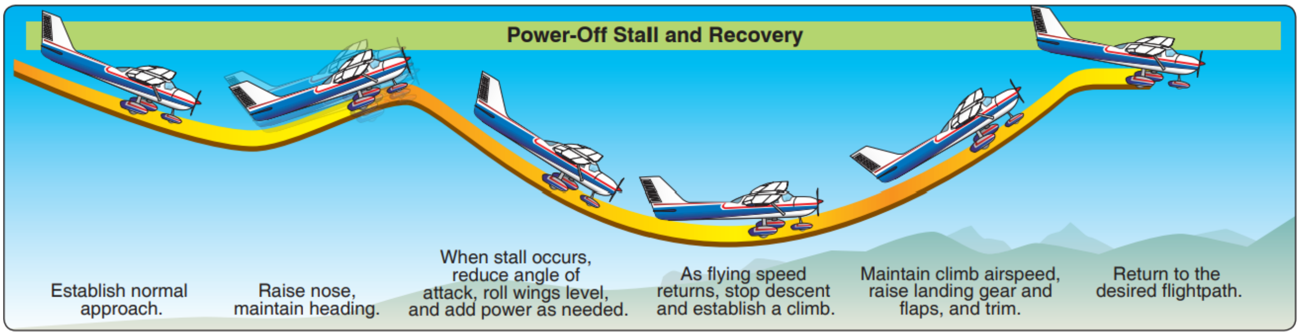

Figure 4-7. *Power-off stall and recovery.*

Before Starting

1. Perform the pre-maneuver checklist
    a. Fuel Pump - ON
    b. Mixture - RICH
    c. Gauges - GREEN
2. Ensure that the area is clear of traffic
3. Select a starting altitude
4. Select the desired configuration for the aircraft for the maneuver
    a. The "dirtier" (more flaps) the airplane, the slower it can fly. The "cleaner" (less flaps) the airplane the higher the stall speed.

Executing the Straight Ahead Power-Off Stall

1. Slow to a normal approach speed while maintaining altitude
2. Extend the flaps, and find a reference point off the nose to help maintain directional control and pitch attitude
3. Then, smoothly pitch nose down to maintain the normal approach attitude and approach airspeed
4. Once stabilized, power should be reduced to idle and the nose should be smoothly raised and held at an attitude that will induce a stall.
    a. This simulates a flair to landing, and directional control should be maintained throughout.

Executing the Turning Power-Off Stall

1. In a descending turn the same procedures apply as a straight ahead stall, except the desired bank angle is maintained.
2. When the power is set and the descent is established, then establish the desired bank angle.
    a. Aileron pressure must be constantly adjusted to keep the bank constant due to over-banking tendencies. Whatever control pressures are needed should be applied to maintain the bank and maintain coordination. This may even result in crossed controls.

Recognizing the Stall

There are a number of indicators that the stall is imminent. These include the following indicators.

Sight

The attitude of the aircraft is one indicator, as stalls (from level unaccelerated flight, at least) are accompanied by nose-high attitudes.

Sound

Some aircraft are equipped with a stall warning horn/buzzer which will sound as a stall is neared. There can be a reduced engine sound due to reduced RPM brought on by an extra load on the propeller. Reduced airflow over the airframe can also reduce the sound experienced.

Kinesthesia

This is a sensing of a change in the direction of speed of motion, and can be the #1 clue to the more experienced pilot that a stall is near.

Feel

Control pressures become increasingly less effective, and feel "mushy". The lag between control inputs and the response from the aircraft become greater. There can also be aerodynamic buffeting, uncontrolled pitching, or vibrations just before the stall. This is due to disturbed airflow over the aircraft as the stall gets closer.

Stall Recovery

1. First, reduce the pitch attitude
   a. Since a stall is brought about by an excessive AOA, the first step in recovery is to reduce the AOA of the aircraft. Only reduce the pitch just enough to allow the wing to regain lift. Do not pitch forward excessively.
2. Second, apply maximum allowable power
   a. Power is not essential to stall recovery, as the stall is caused exclusively by an excessive AOA, but additional power can help increase airspeed which can speed the recovery process. Right rudder will be needed to maintain coordination and heading with the application of power.
3. Always maintain directional control and climb at Vy Directional control is maintained with the coordinated use of aileron and rudder.

Ailerons and Recovery

Most aircraft are designed such that the stall progresses from the root of the wing to the tip. Therefore aileron authority is maintained at higher AOA and the aircraft remains controllable as the stall is approached. When the aircraft is fully stalled, use of ailerons can aggravate the stall condition.

During recovery the return of lift starts at the tips and progresses inward, thus making the ailerons effective before the stall is completely recovered. However, the increase in drag and aggravated stall on one wing will yaw the aircraft in the direction of the wing and could result in a spin. So resist the use of ailerons during stall recovery.

Rudder and Recovery

Coordination in the stall (i.e. keeping the ball centered) is the key to avoiding a spin entry. Even if excessive aileron was applied, a spin won’t occur if yaw is maintained by rudder pressure. This makes the use of rudder in a stall critical.

The primary use of rudder is to counteract any tendency of the airplane to yaw or slip. It is often the case that one wing will drop during a power-on stall, and use of rudder to "pick up the wing" and maintain directional control is mandated.

Common Errors

- Failure to establish the specified landing gear and flap configuration prior to entry
- Improper pitch, heading, yaw, and bank control during straight ahead and turning stalls
- Improper pitch and bank control during turning stalls
- Rough or uncoordinated control procedure
- Failure to recognize the first indications of a stall
- Failure to achieve a stall
- Improper torque correction
- Poor stall recognition and delayed recovery
- Excessive altitude loss or excessive airspeed during recovery
- Secondary stall during recovery

Conclusion

Exceeding the critical angle of attack causes a stall. A stall can occur at any airspeed, in any attitude, or any any power setting, depending on the total number of factors affecting the particular airplane.

ACS Requirements

CFI PTS Standard

To determine that the applicant

1. Exhibits instructional knowledge of the elements of power-off stalls, in descending flight (straight or turning), with selected landing gear and flap configurations by describing:
   a. Aerodynamics of power-off stalls.
   b. Relationship of various factors, such as landing gear and flap configuration, weight,

center of gravity, load factor, and bank angle to stall speed.

c. Flight situations where unintentional power-off stalls may occur.
d. Entry technique and minimum entry altitude.
e. Performance of power-off stalls in descending flight (straight or turning).
f. Coordination of flight controls.
g. Recognition of the first indications of power-off stalls.
h. Recovery technique and minimum recovery altitude.

2. Exhibits instructional knowledge of common errors related to power-off stalls, in descending flight (straight or turning), with selected landing gear and flap configurations by describing:
    a. Failure to establish the specified landing gear and flap configuration prior to entry.
    b. Improper pitch, heading, yaw, and bank control during straight-ahead stalls.
    c. Improper pitch, yaw, and bank control during turning stalls.
    d. Rough and/or uncoordinated use of flight controls.
    e. Failure to recognize the first indications of a stall.
    f. Failure to achieve a stall.
    g. Improper torque correction.
    h. Poor stall recognition and delayed recovery.
    i. Excessive altitude loss or excessive airspeed during recovery.
    j. Secondary stall during recovery.
3. Demonstrates and simultaneously explains power-off stalls, in descending flight (straight or turning), with selected landing gear and flap configurations, from an instructional standpoint.
4. Analyzes and corrects simulated common errors related to power-off stalls, in descending flight (straight or turning), with selected landing gear and flap configurations.

Private Pilot ACS Skills Standards

1. Clear the area.
2. Select an entry altitude that will allow the Task to be completed no lower than 1,500 feet AGL (ASEL) or 3,000 feet AGL (AMEL).
3. Configure the airplane in the approach or landing configuration, as specified by the evaluator, and maintain coordinated flight throughout the maneuver.
4. Establish a stabilized descent.
5. Transition smoothly from the approach or landing attitude to a pitch attitude that will induce a stall.

6. Maintain a specified heading, ±10 if in straight flight; maintain a specified angle of bank not to exceed 20°, ±10°, if in turning flight, while inducing the stall.
7. Acknowledge cues of the impending stall and then recover promptly after a full stall has occurred.
8. Execute a stall recovery in accordance with procedures set forth in the POH/AFM.
9. Retract the flaps to the recommended setting; retract the landing gear, if retractable, after a positive rate of climb is established.
10. Accelerate to VX or VY speed before the final flap retraction; return to the altitude, heading, and airspeed specified by the evaluator.

Commercial Pilot ACS Skills Standards

The same as the Private Pilot, except

1. Maintain a specified heading, ±10 if in straight flight; maintain a specified angle of bank not to exceed 20°, ±5°, if in turning flight, while inducing the stall.
2. Configure the airplane as required after a positive rate of climb has been established.