Task XI.A: Maneuvering During Slow Flight

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Lesson Overview

Objective

The student should develop knowledge of the elements related to the rectangular course and the elements involved in maintaining a proper ground track. The student will have the ability to perform the maneuver as required in the ACS/PTS.

Reference

- Aircraft Flight Manual / Pilot’s Operating Handbook
- Airplane Flying Handbook (FAA-H-8083-3B, page(s))

Key Elements

1. Pitch for Airspeed
2. Power for Altitude
3. Coordination

Elements

1. Defining Slow Flight
2. Relationship of Power to Flight Characteristics and Controllability
3. Relationship of Maneuvering Loads to Flight Characteristics and Controllability
4. Relationship of Weight to Flight Characteristics and Controllability
5. Relationship of the CG to Flight Characteristics and Controllability
6. Relationship of the Maneuver to Critical Flight Situations
7. Slow Flight and the Senses
8. Flight at Minimum Controllable Airspeed

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 lesson is complete when the student understands factors affecting flight characteristics and controllability and shows the ability to control the airplane effectively in different configurations of slow flight.

Instructor Notes

Introduction

Attention

When the aircraft is flying at just above the stall speed, there is little margin for error. This maneuver will greatly improve your piloting skills.

Overview

- Review Objectives and Elements/Key ideas

What

Slow flight is flight at a speed which any further increase in angle of attack or load factor will cause an immediate stall.

Why

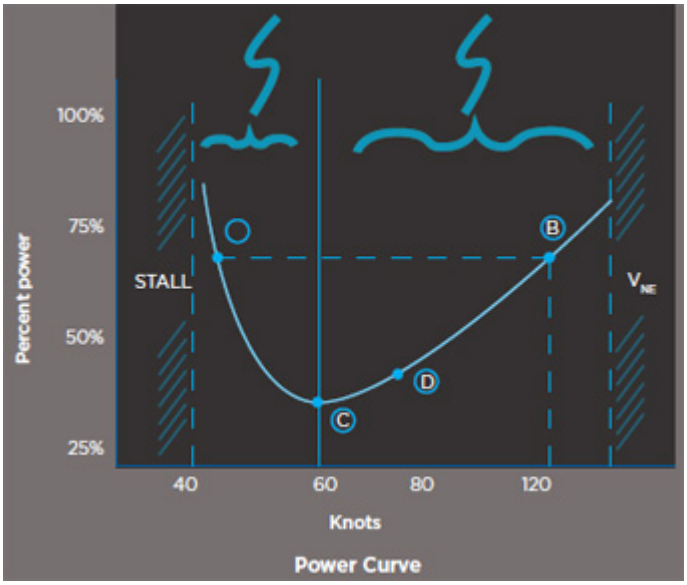
Maneuvering during slow flight demonstrates the flight characteristics and degree of controllability of an aircraft at less than cruise speed. The student must develop the awareness and ability of the characteristics, feel and control responses during flight at slow speed (takeoff, climb, landings and go-arounds) to maintain safe flight, and avoid unintentional stalls.

Lesson Details

Slow flight is when the airplane angle of attack (AOA) is just under the AOA which will cause an aerodynamic buffet or a warning from a stall warning device if equipped with one. It is the point at which any increase in the aircraft's AOA, or load factor, will result in an immediate stall.

Relationship of Power to Flight Characteristics and Controllability

When performing slow flight it is important to know the relationship between parasite drag, induced drag, and the power needed to maintain a given altitude at a selected airspeed. As the airspeed decreases from cruise to L/Dmax total drag and thrust required decreases to maintain a constant altitude. As airspeed decreases below L/Dmax additional power (thrust) is required to maintain a constant altitude. Total drag is now increasing because induced drag increases faster (due to the high angle of attack) than parasite drag decreases. This is known as the "back side of the power curve" or the "region of reverse command".



Notice it takes as much power to fly slow as it does to fly fast!

While straight and level flight is maintained at a constant airspeed, thrust is equal in magnitude to drag, and lift is equal to weight. However in slow flight, as the angle of attack (and pitch angle) increase, the thrust can be divided into two components. One vector which is upward pointing, and another vector which is along the flight path. Since some of the thrust is being directed away from the flight path additional power is needed to maintain both altitude and airspeed. The wing loading in slow flight is actually somewhat less due to this upward directed component of thrust.

Flight controls in slow flight are less effective than in normal cruise due to the reduced airflow over the surfaces. As airspeed decreases control effectiveness decreases disproportionately. The pilot should anticipate this loss of effectiveness and be prepared to utilize larger control movements, though at all times control inputs should be smooth and not jerky.

Relationship of Maneuvering Loads to Flight Characteristics and Controllability

The load factor is the ration of the total load acting on the airplane with respect to the gross weight of the airplane, normally expressed in "Gs". Any increase in the load factor increases the stall speed. Increased load factors are a characteristic of all banked turns, and the load factor increases at a high rate beyond 45° or 50° of bank. At approximately 63° of bank the stall speed is increased by about 1/2.

The normal stall will not produce any added load factors beyond the normal 1G of straight and level flight. As a stall factor occurs, however, this load factor may be reduced to zero. If recovery is initiated by snapping the elevator control forward (not recommended), negative load factors can be produced. During the pull out of the stall significant load factors can be induced, particularly when using an abrupt pull at high diving speeds. Taken to an extreme this can produce what is known as a secondary stall.

Rough air can produce increased load factors as they can suddenly increase the angle of attack. In this situation do not exceed Va so as to allow the aircraft to stall before the maximum load factor is exceeded.

A stabilized spin is little different from a normal stall, except that yaw is involved. From the point of view of load factors they are the same.

Relationship of Weight to Flight Characteristics and Controllability

Lift is directly related to weight, and the heavier a plane is the more lift is required to hold it aloft. As more lift is required the angle of attack must be increased.

To generate the additional lift, a higher angle of attack must be used. This increase in angle of attack causes the aircraft, when at a higher weight, to consequently have a higher stall speed.

Relationship of the CG to Flight Characteristics and Controllability

An airplane which is loaded with a forward CG acts heavier, and is consequently slower than the same airplane with a more aft CG. With a forward CG more nose up trim is required resulting in the tail surfaces creating more down-force and a higher angle of attack. This adds to the total wing loading and the total amount of drag, thus reducing efficiency.

Within limits, this does make the aircraft more stable and controllable. This is due to the somewhat longer arm from the CG to the horizontal control surfaces.

With an aft loading the aircraft acts lighter, and is consequentially faster than the same airplane loaded with a more forward CG. With an aft CG more nose down trim can be used resulting in the tail surfaces having to create less down-force and permitting a lower angle of attack. This reduces the total wing loading and the total amount of drag, this increasing efficiency.

However, as the CG moves aft recovery from a stall becomes increasingly more difficult. This is due to a shortened arm from the CG to the horizontal control surfaces.

Relationship of the Maneuver to Critical Flight Situations

The slow flight maneuver demonstrates the flight characteristics and the aircraft in slow flight. It is critical that the pilot understand these characteristics and control responses, as this understanding is central to avoiding stalls at slower airspeeds. These are speeds that pilots encounter close to the ground during takeoffs, climbs, landings, and go-arounds.

Slow Flight and the Senses

Visually

As the aircraft pitches up the pilot will be looking more at the sky than in straight and level flight. This reduces the number of visual cues forward, and peripheral vision will need to help with visual orientation.

Hearing

When demonstrating slow flight initially the volume of sound will decrease as the throttle is retarded. As the aircraft approaches the stall, however, the stall warning will sound. And as power is increased and the volume of sound will once again increase, maybe to levels beyond the initial cruise power setting.

However, the sound of the wind will be softer due to the reduced speed of the aircraft.

Feel

As the aircraft slows the controls will become progressively less responsive. This will require larger control movements due to the reduced amount of air flowing over the control surfaces.

Additionally, more right rudder will be required as the aircraft starts to yaw to the left. This is due to the left turning tendencies upon the reintroduction of power. Due to the overall reduced control effectiveness, more right rudder than normal will be required.

Flight at Minimum Controllable Airspeed

This is considered to be flight at a speed which any further increase in angle of attack or additional load factor will cause an immediate stall. This demonstrates the flight characteristics and degree of controllability of the airplane at its minimum flying speed.

In flying this maneuver it is critical to remember pitch for airspeed, and power for altitude. During the maneuver both visual and instrument indications are used. The pilot should reference the instruments frequently, and over time the "feel" for the aircraft in this flight regime must be developed to avoid inadvertant stalls.

Performing the Slow Flight Maneuver

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.

Flying Slow Flight

1. Begin slowing the aircraft with a power reduction (aprox 1500 RPM)
2. Maintain altitude as power is lost
    a. The position of the nose relative to the horizon should be noted and raised as necessary to maintain altitude. Maintain adequate back pressure to ensure no loss in altitude as power is reduced. Don't use excessive back pressure which might result in a climb followed by a rapid reduction in airspeed.
3. Continuously trim the aircraft
    a. The aircraft will require nose-up trim to maintain a trimmed condition. Re-trim as needed during the maneuver.
4. If flaps are to be used, lower them incrementally as the airspeed reaches the allowable speed limits.
    a. Incremental deployment will make for easier incremental pitch adjustments. Extending full flaps immediately is more difficult to control than incremental changes. Anticipate the changes in lift and pitch as the flaps are extended or retracted.
5. During the maneuver note the change in the feel and the sounds.
6. During the maneuver note the change in flight control effectiveness.
7. As the aircraft reaches the target airspeed re-introduce power.
    a. Additional power will be needed as the aircraft passes below L/Dmax if the aircraft is to maintain altitude. The additional power will produce yaw which must be countered with right rudder. Avoid losing too much speed or using too little power, which would result in an inability to maintain altitude.
8. Establish the desired pitch attitude needed to maintain speed
    a. Continually cross-check the attitude indicator, altimeter, and airspeed indicator as well as outside references to ensure the aircraft is being controlled accurately. Avoid instrument fixation, and correct deviations early. Failure to do so can result in ever increasing control inputs to catch/correct the deviations.
9. Maintain straight and level flight, making required level turns at a constant altitude.
    a. During turns the pitch attitude and power may need to be increased to maintain speed and altitude. In slow flight even a small bank will result in the aircraft wanting to continue banking, and countering the overbanking tendency will be needed. Adverse yaw due to the downward deflected aileron produces more lift and therefore more drag. Rudder inputs will be needed to maintain coordination. In slow flight only shallow banks are appropriate, as steep banks will result in increased load factors which can trigger a stall.
10. Always maintain coordinated flight

Exiting Slow Flight

1. This is almost like a normal stall recovery.
    a. Full power
    b. Nose Down

c. Clean up the plane (flaps and gear if deployed)

i. Increasing the power and lowering the nose allows the aircraft to build airspeed. However, avoid transitioning into a dive and instead maintain altitude as the aircraft accelerates

2. Remove the first increment of flaps

a. Anticipate the change in lift to maintain altitude, and increase back pressure to avoid the initial tendency for the aircraft to sink.

3. As the airspeed increases and as the aircraft passes through Vx, remove the remaining increment of flaps.

a. Once again anticipate the change in lift, and be proactive. Also as speed increases the amount of right rudder needed will be reduced. Maintain coordination.

Common Errors

- Failure to establish specified gear and flap configuration
- Improper entry technique
- Failure to establish and maintain the specified airspeed
- Excessive variations of altitude and heading when a constant altitude and heading are specified
- Uncoordinated use of flight controls
- Improper correction for torque effect
- Improper trim technique
- Unintentional stalls
- Inappropriate removal of hand from throttles

Conclusion

Understanding the characteristics that affect slow flight and how to perform this maneuver is an extremely important part of a pilot's training. Slow flight develops the student's awareness of the characteristics, feel and control responses during flight at slow speed (takeoff, climb, landings and go-arounds) to maintain safe flight, and avoid unintentional stalls.

ACS Requirements

CFI PTS Standard

To determine that the applicant

1. Exhibits instructional knowledge of the elements of maneuvering during slow flight by describing:

a. Relationship of configuration, weight, center of gravity, maneuvering loads, angle of bank, and power to flight characteristics and controllability.
b. Relationship of the maneuver to critical flight situations, such as a go-around.
c. Performance of the maneuver with selected landing gear and flap configurations in straight-and-level flight and level turns.
d. Specified airspeed for the maneuver.
e. Coordination of flight controls.
f. Trim technique.
g. Reestablishment of cruise flight.

2. Exhibits instructional knowledge of common errors related to maneuvering during slow flight by describing:
   a. Failure to establish specified gear and flap configuration.
   b. Improper entry technique.
   c. Failure to establish and maintain the specified airspeed.
   d. Excessive variations of altitude and heading when a constant altitude and heading are specified.
   e. Uncoordinated use of flight controls.
   f. Improper correction for torque effect.
   g. Improper trim technique.
   h. Unintentional stalls.
   i. Inappropriate removal of hand from throttles.
3. Demonstrates and simultaneously explains maneuvering during slow flight from an instructional standpoint.
4. Analyzes and corrects simulated common errors related to maneuvering during slow flight.

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. Establish and maintain an airspeed at which any further increase in angle of attack, increase in load factor, or reduction in power, would result in a stall warning (e.g., aircraft buffet, stall horn, etc.).
4. Accomplish coordinated straight-and-level flight, turns, climbs, and descents with landing gear and flap configurations specified by the evaluator without a stall warning (e.g., aircraft buffet, stall horn, etc.).

5. Maintain the specified altitude, ±100 feet; specified heading, ±10°; airspeed +10/-0 knots; and specified angle of bank, ±10°.

Commercial Pilot ACS Skills Standards

The same as the Private Pilot, except

1. Maintain the specified altitude, ±50 feet; specified heading, ±10°; airspeed +5/-0 knots; and specified angle of bank, ±5°.