Task II.E: Airplane Flight Controls

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Lesson Overview

Objective

The student should develop knowledge of the elements related to primary flight controls, trim control, and wing flaps.

Reference

- PHAK Chapter 6

Key Elements

- Primary flight controls—airflow and pressure distribution
- Trim relieves control pressures
- Flaps increase lift and induced drag

Elements

- Primary flight controls
- Trim controls
- Wing flaps

Equipment

- White board
- Markers
- References

Schedule

1. Discuss objectives

2. Review material
3. Development
4. Conclusion

Instructor Actions

1. Discuss lesson objectives
2. Present lecture
3. Questions
4. Homework

Student Actions

- Participate in discussion Take notes

Completion Standards

The student can explain the primary flight controls, their function, and how they do what they do. The student will also understand how trim works and can more effectively use it, and understands the different types of flaps and their differing characteristics.

Instructor Notes

Attention

Learning how the flight controls work and why the inputs you make result in the corresponding changes. This is what is actually going on when you move the control surfaces, adjust trim, or use the flaps.

Overview

Review Objectives and Elements/Key ideas

What

The airplane's attitude (rotation around the 3 axes) is controlled by deflection of the primary flight controls. These are hinged, moveable surfaces attached to the trailing edge of the wings and vertical and horizontal stabilizers When deflected these surfaces change the camber and angle of attack of the wing or stabilizer and thus change its lift and drag characteristics. Trim control are used to relieve the control pressures and flaps create a compromise between a high cruise speed and low landing speed.

Why

Understanding how the airplane functions and the effects each control input will have on the airplane results in an understanding of how to control the airplane. Understanding how the airplane works results in a much more proficient pilot.

Lesson Overview

The flight controls are used to manipulate the flight path of the aircraft. They are used to control the plane in three axis, as well as change airfoil characteristics during certain phases of flight.

During the description of the various flight controls a few terms will be used, such as chord line and camber. The chord line is an imaginary line drawn straight through an airfoil from the leading edge to the trailing edge. The camber is the characteristic curve of an airfoil's upper and lower surfaces. The upper camber is normally more pronounced, whereas the lower camber can be comparatively flat. This causes higher velocity airflow over the top, and the more curved the upper surface the more lift is generated.

Primary Flight Controls

These are the key controls used to safely control the aircraft in flight.

Ailerons

The ailerons control roll about the longitudinal axis. They are commonly operated by pushrods or control cables. Each aileron is interconnected with the other and they operate together, moving simultaneously in opposite directions. Moving the controls right causes the right aileron to deflect upward and the left downward. An upward deflection decreases the camber resulting in decreased lift, and the downward deflection does the opposite. The airplane turns because the banking creates a horizontal lift component.

Adverse yaw occurs due to the fact that the downward deflected aileron creates more lift, which creates more induced drag. This added drag causes the nose to swing in the direction of the higher drag wing. Rudder is used to counteract this yawing tendency.

There are various types of ailerons, described below. In general all these variations are intended to help reduce the effects of the added induced drag of wing with the down-going aileron. However, adverse yaw is not completely eliminated and some coordinating rudder is always required.

Differential Ailerons

> These ailerons deflect upward more than they deflect downward when actuated. This helps reduce the adverse yaw created by the wing with the down-deflected aileron.

Frise-Type Ailerons

> When pressure is applied the aileron being raised pivots on an offset hinge which projects the leading edge of the aileron into the airflow, helping reduce adverse yaw. A slot ends up forming over the low aileron making it more effective at high angles of attack.

Elevator

The elevator controls pitch around the lateral axis. These are also commonly operated by either pushrods or control cables. Pulling the elevator control backward deflects the trailing edge up, which decreases the camber of the elevator and creates a downward aerodynamic force. The overall effect causes the tail to move down and the nose to move up (pivoting around the CG). Strength of effect is determined by the distance between the CG and horizontal tail surface. Moving the controls forward does exactly the opposite.

There are various types of elevators, each with it's own unique attributes.

Conventional

The standard configuration is a horizontal stabilizer with a hinged elevator on the rear edge of the stabilizer. This puts the stabilizer and the elevator in the down wash of the propeller.

T-Tail

The elevator is on the top of the vertical stabilizer and thus is generally out of the down wash from the propeller. This gives the elevator more consistent behavior in all flight regimes, but means that it must be moved through a larger range of degrees to be equally effective at low speeds. This configuration is popular on large planes where moving the elevator out of the exhaust stream is desired, and on seaplanes where getting the horizontal surfaces further from the water is beneficial.

Stabilator

This is a configuration where the horizontal stabilizer and elevator are combined into a single surface. When the elevator control is moved backward the entire horizontal surfaces pivots, with the back edge rising, creating a downward force. However, due to the aerodynamics of this configuration an "anti-servo" tab must be incorporated into the design to avoid the tendency for the pilot to over-control in pitch.

Rudder

The rudder controls yaw around the vertical axis. The rudder is commonly operated by control cables. When the rudder is deflected a horizontal force is exerted in the opposite direction. Pushing the left pedal moves the rudder left, and pushing the right pedal moves it right. This movement alters the airflow around the vertical stabilizer creating a sideward lift moving the tail in one direction (leftward, when the left pedal is pushed) and the nose in the opposite direction, pivoting around the CG.

The rudder becomes more effective with speed, and larger deflections may be needed at low speeds and smaller deflections at higher speeds. In a propeller driven plane the slipstream flowing over the rudder can increase effectiveness. The primary purpose of the rudder is to counter adverse yaw and provide directional control.

Trim controls

The trim controls are used to relieve the need to maintain constant pressure on a given control to achieve the flight performance desired. They normally consist of cockpit controls that manipulate small hinged devices on the primary control surfaces (though this is not the only mechanism used). Trimming the plane with these controls minimizes the workload to achieve the aircraft performance desired.

The most common arrangement is a single trim tab attached to the trailing edge of the elevator. This is often operated by a manual control wheel, trim crank, or electric motor. The trim movement is in the opposite direction of the control surface. For example, with the trim tab up, deflected into the airstream, the airflow over the tail forces the elevator down causing the tail of the aircraft to move up creating a pitch down moment. Moving the trim tab in the opposite directions, of course, creates the opposite reaction.

When using the elevator trim first establish the desired power, pitch attitude, and configuration.

Once done, move the trim to relieve the control pressures. Any time any of the power, pitch, or configuration is changed it is likely that the trim will require adjustment.

Balance tabs are similar to trim tabs, but are normally coupled to the control surface actuators rather than being independently operated by the pilot. When the control surface moves the balance tabs automatically move to help relieve control pressures. It is possible for balance tabs to be controlled by the pilot, in which case they operate both as balance tabs and trim tabs.

Anti-servo tabs are similar to balance tabs in that they are interconnected with the control surface, but move in the same direction as the control surface rather than opposite. They also serve to relieve control pressures, and are most commonly found on stabilators.

Ground adjustable tabs operate like any other trim tab, but can only be adjusted to one position. They are often simple metal tabs and are intended to be set for a nominal cruise setting. At other times the pilot must maintain control pressures to achieve the desired aircraft performance.

Adjustable stabilizers allow the pilot to trim the aircraft by the gross movement of the horizontal stabilizer. Instead of using controllable tabs, a jackscrew arrangement drives the stabilizer changing it's angle of incidence, and thus it's natural trimmed configuration.

Secondary Flight Controls

Along with the primary flight controls the secondary controls provide augmentation of control for specialized circumstances. These secondary controls (in light planes, at least) or often flaps, spoilers, and trim controls.

Flaps

Flaps are the most common high-lift devices found in aircraft. They are commonly attached to the trailing edge of the wing and are used to increase induced drag and lift for any given AOA. This control surfaces allows a wing design which permits a compromise between high cruse and low landing speeds since they can extend and retract. Flaps can help permit a slower landing speed and shorter landing distances, as well as permit a steeper angle of descent which can help clear obstacles. They can also be used to shorten takeoff distances.

Flap Types

Plain Flaps

: These are the simplest of all flaps, and are a simple hinged control surface on the back of the wing. They increase camber resulting in increased lift at a given AOA, with a significant increase in drag as well.

Split Flaps

: This is similar to the plain flap in that it hinges downward from the rear of the wing, but is different in that it extends from the bottom, rather than hinging off of the back of the wing.

Slotted Flaps

: This design is the most popular found on aircraft today. They increase lift more than both plain and split flaps, and when lowered form a duct between the flap well in the wing and the flaps's leading edge. This creates a stream of high-energy air ducted to the upper surface of the flap making it more effective.

Fowler Flaps

This is a type of slotted flap which slides backward on a track and then retracts downward. The first portion of the travel increases drag very little but lift quite a bit. As extension continues the flap drops downward increasing drag with little additional increase in lift.

> **Piper Warrior PA28A Flaps**
>
> - Johnson Bar / Manually controlled Flap - Slotted Flaps
>   - 10°
>   - 25° - Soft field Takeoff / Short field takeoff & Landing
>   - 40° - All Landings except in strong windsheer (use 25° for strong sheer).

Spoilers

Disrupt the airflow over the wing, killing left and controlling rearward stall. Puts more weight/pressure on the wheels for more effective braking. Increases drag to slow plane down.

Autopilot

- Pilot relieve modes.
- Reduces pilot's workload.
- Can maintain direction and altitude, accounts for the wind.
- Conflicting signals or unusual attitudes might disengage the autopilot.

Canard

- Make attaining a higher AOA harder, but increases maneuverability when there and can maintain higher AOA better.
- May provide lift after the main wing has stopped providing lift.

Conclusion

The airplane's attitude (rotation around the 3 axes) is controlled by deflection of the primary flight controls. When deflected, these surfaces change the camber and AOA of the wing or stabilizer and thus change its lift and drag characteristics. Trim controls are used to relieve the control pressures necessary and flaps increase lift and induced drag and create a compromise between a high cruise speed and low landing speed.

1. Brief review of main points.
2. Airplane's attitude controlled by deflection of primary flight controls.

3. Trim controls relieve necessary control pressures.
4. Flaps increase lift and induced drag, creating compromise between:
    a. High cruise speed
    b. Low landing speed.

ACS Requirements

To determine that the applicant exhibits instructional knowledge of the elements related to the airplane flight controls by describing the purpose, location, direction of movement, effect and proper procedure for use of the:

1. Primary Flight Controls.
2. Secondary Flight Controls.
3. Trim Controls.