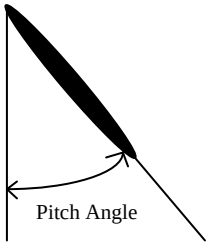
Propeller Control Tutorial
The following brief tutorial is provided to assure we're all speaking the same language and to help the reader understand a little bit more about how this propeller control unit works.

The following are propeller pitch terms as they will be used in this explanation:

- Propeller Pitch Angle – the angle struck between the plane of rotation and a line extending through the centerline of the propeller cord as shown below:



- Coarse Pitch – an increase (counterclockwise change) in pitch angle.

- Fine Pitch – a decrease (clockwise change) in pitch angle.

- Flat Pitch – A propeller pitch angle of zero degrees. This is typically associated with a "ground idle" condition.

- Feather – The propeller pitch state where, with the engine shutdown in flight, the propeller produces minimum drag. For obvious reasons, this position is typically near a propeller pitch of 90 degrees. For this installation, the propeller is in feather when it reaches 82.5 degrees.

- Flight Low Pitch Limit – The minimum propeller pitch angle approved for use in flight. This is almost always a substantially positive pitch value because it is difficult to control engine speed without some load on the propeller. Furthermore, as the propeller approaches flat pitch, the drag and resultant aerodynamic wake effects increase dramatically. These can cause substantial airplane controllability and/or performance problems as was the case in this accident. Consequently operation below this pitch limit is prohibited, except during ground operation. For this installation, the flight low pitch limit is 15 degrees.

- Beta – Pitch range below the flight low pitch limit

- Maximum Reverse Pitch – Just as the name implies, this is the largest negative pitch approved for the airplane.

This propeller control unit is designed to operate in three fundamentally different propeller pitch control modes:

1. A constant speed control mode when the propeller is operating at or above the flight low pitch limit.
2. A direct pitch control mode when the propeller is operating below the flight low pitch limit.
3. A direct pitch control mode when the propeller is commanded to feather, either manually or automatically.

Note: Propeller synchronizing is usually a totally separate automatic fine adjustment that will not be discussed further herein.

When the propeller is operating at or above the flight low pitch limit (+ 15°), the inherent aerodynamic and counterweight forces should be tending to twist the propeller towards greater forward pitch (i.e. “coarse pitch”). The actual blade angle at which the propeller produces zero thrust (torque) depends on the rotational speed of the propeller and the forward speed. The greater the propeller pitch, the greater the engine torque required to run the propeller at any given speed. In the constant speed mode, the pilot selects either 85% or 100% propeller speed. The former being for climb and cruise type conditions while the later is for takeoff, go-around and maximum continuous power type conditions. Then the constant speed servo valve modulates the oil pressure on the “fine pitch” side of the propeller pitch actuator until it just balances out the propellers inherent aerodynamic and counterweight forces at the specified propeller speed and engine power level. If more engine power is applied the propeller initially wants to speed up, but as it does the pitch naturally tends to increase due to counterweight and aerodynamic forces. This increasing pitch causes propeller torque to increase tending to slow the propeller back down. The propeller control simply fine tunes the propeller pitch to assure that the selected speed is maintained. If engine power is reduced, the propeller initially wants to slow down, but as it does the pitch naturally tend to apply less coarse pitch forces. However, in this case the propeller control typically needs to play a bit more of a direct role by applying modulated oil pressure to the “fine pitch” side of the propeller control actuator to assure that the selected speed is maintained. In constant speed mode, propeller pitch angles vary in flight from about +15° to + 45°

When the propeller is operating below the flight low pitch limit, pitch is control proportionally to throttle position using hydraulic pressure directly from the engine high pressure pump. As the throttle is moved back from the flight idle stop towards reverse, high pressure oil is ported to the “fine pitch” side of the propeller control actuator. As the throttle is moved back from reverse towards the flight idle stop, or when “feather” is commanded, high pressure oil is ported to the “coarse pitch” side of the propeller control actuator. A blue low pitch light, located on the central instrument panel, comes on when the blade angle drops below 10°. In direct pitch control “beta” mode, propeller pitch angles on the ground vary from about + 15° to -17° (full reverse).

When the propeller is commanded to feather, either manually or automatically, hydraulic pressure is applied to the “coarse pitch” side of the propeller control actuator either directly from the engine high pressure pump or the dedicated feathering pump (whenever the engine pump is not supplying sufficient pressure). This pressure holds the propeller against the high pitch stop (82°-feather position) in an attempt to minimize the subsequent aerodynamic drag.

Note: There are also overspeed governing modes of the propeller pitch controller. In flight, a propeller overspeed governor comes into operation when propeller speed reaches 104%. The gearbox-driven governor reduces the oil flow to the pitch changing mechanism. If there is no propeller speed reduction, the propeller speed reaches 108% and the overspeed governor intervenes directly in reducing fuel flow. On the ground, with the propeller in direct control mode, overspeed protection is accomplished at 108% by reducing the fuel flow.

This figure provides a graphical overview of the control modes and their domains.