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DOCUMENT TITLE

AIRCRAFT GENERAL KNOWLEDGE

CHAPTER 9 – PROPELLERS

Version 1.0

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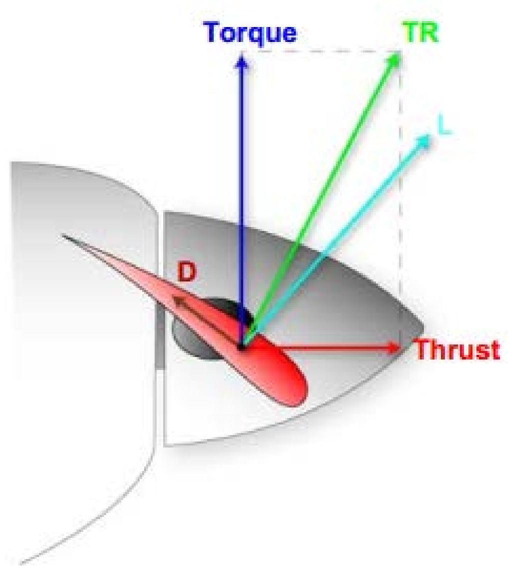
PROPELLERS

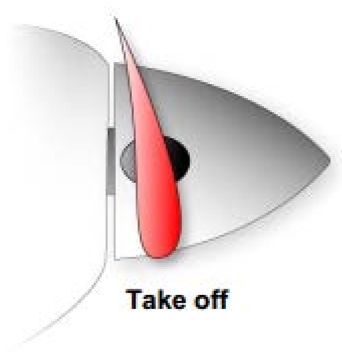
9.1 Introduction

The propeller converts engine power into an aerodynamic force.

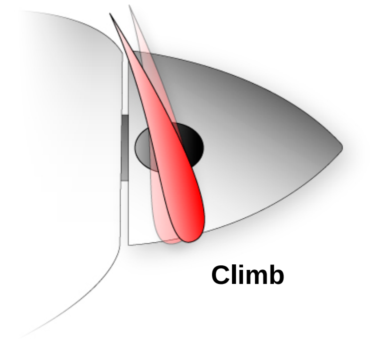


The forward acting component of this force is known as thrust; the component acting in the opposite direction of rotation is known as torque. In unaccelerated level flight, the propeller torque balances the engine torque whilst thrust balances aircraft aerodynamic drag. The thrust conversion efficiency depends on the propeller configuration and aircraft speed. The simple fixed pitch configuration is inefficient at most speeds. The variable pitch, constant speed propeller is reasonably efficient at most speeds.

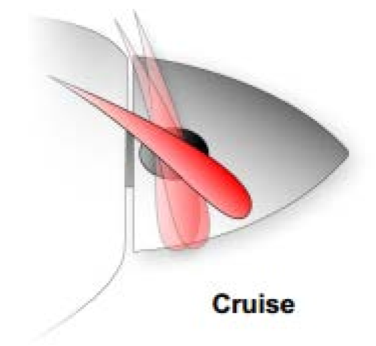
Fixed pitch propellers are designed for efficiency at one particular airspeed and rpm combination. Engine and propeller combinations can be designed for optimum takeoff, climb, cruise or high speed operations. Any change in these conditions results in lower efficiency of both propeller and engine outputs.



A constant speed propeller however, keeps the blade angle adjusted for maximum efficiency for most conditions encountered in flight. During takeoff, when maximum power and thrust are required, the constant speed propeller is at a low blade angle or pitch. At low blade angle the angle of attack is small and efficient with respect to the relative airflow, which results in a smaller mass of air per revolution. Although the air mass is small, the number of revolutions is high thus producing a high slipstream velocity; whilst the aircraft speed is low the resultant outcome is maximum thrust being developed.



For climb after takeoff, the power output is reduced by decreasing manifold pressure and increasing blade angle to lower rpm. Because of the increased airspeed after takeoff, the adjustment of power settings maintains the most efficient angle of attack to relative airflow. Although the rpm is now reduced the airflow mass is high because of the increased blade angle. The reduced manifold pressure decreases engine torque output with a reduction in fuel flow and engine load; the resultant combination of power and load factors keep the engine and propeller at their highest efficiencies.



At cruising altitudes the power requirements are considerably lower than for takeoff or climb, engine power is again reduced by lowering manifold pressure and increasing blade angle to reduce rpm. This new combination of lowered torque and rpm still results in an efficient thrust output as the change to a higher airspeed maintains the best angle of attack to relative airflow.

The load on the engine is the propeller torque. When the aircraft is stationary, with the engine throttle wide open, the propeller torque and the static thrust generated (i.e. the efficiency of the engine/propeller combination) depend on the propeller pitch. If the pitch is zero or slightly negative, the static thrust will be zero and the propeller torque will be very low so that the engine will over speed and lose power. If the pitch is fine (low angle of attack), the propeller will generate near maximum static thrust and sufficient torque to maintain high engine rpm, thus delivering ample power to the propeller shaft. This is the ideal situation to get the aircraft rolling for takeoff and climb out.

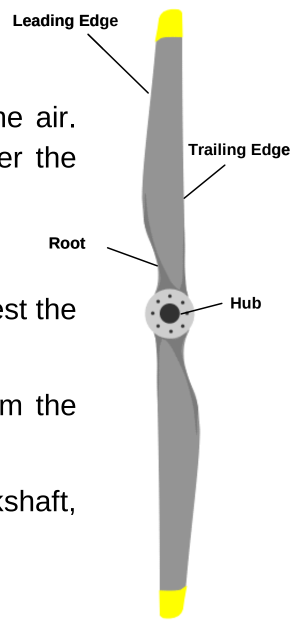
If the pitch is coarse (high angle of attack) then static thrust is low but propeller torque is very high which will slow the engine; this is not desirable for attempting a takeoff.

9.2 Familiarisation and Terminology

The propeller is designed to move the aircraft through the air. A propeller will consist of two or more blades, fixed to a hub, which serves to attach the blades to the engine crankshaft.

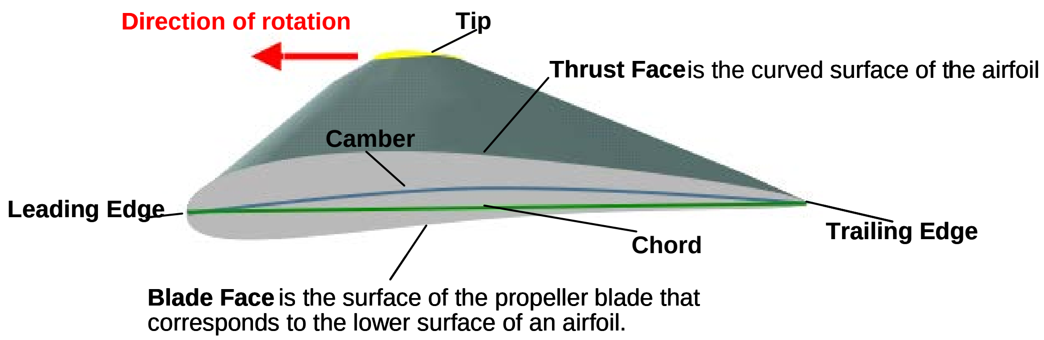
The blades are in the shape of an aerofoil much like the wing of an aircraft and, like the wing, the blades produce a force (Lift) when they rotate. This force (called Thrust) provides the propulsive element to move the aircraft through the air. The majority of aircraft have propellers which are fitted at the front of the engine and PULL the aircraft through the air (Tractor Propellers). Others have propellers fitted to the rear of the engine which PUSH the aircraft through the air (Pusher Propellers).

Either way, the basic designs of propellers are the same, and will have the following:



- **Leading Edge**: the cutting edge that slices into the air. As the leading edge cuts the air, the air flows over the blade face and the cambered upper surface
- **Trailing edge**: rear blade surface
- **Root (Blade Shank):** the section of the blade nearest the hub.
- **Blade Tip:** the outer end of the blade farthest from the hub.
- **Hub:** the mount point for the propeller at the crankshaft, an attachment point for moveable blades.

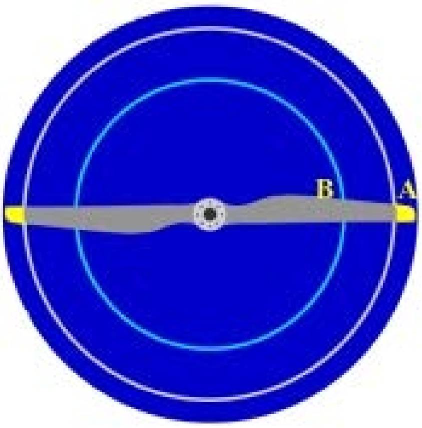
Propeller blade cross-section:



9.3 The Motion of the Propeller

9.3.1 Rotational Velocity

Because the propeller moves in a circular path it is affected by the same laws of physics as any other object travelling in a circular path.



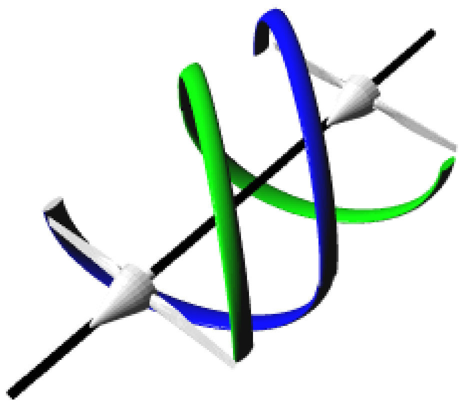
The circular path followed by the propeller is referred to as the **plane of rotation**.

A point on the propeller blade closer to the hub will move slower than a point at the outer edge. **A will have a greater rotational velocity than B**. This needs to be taken into account with blade size, particularly the length of the blade. If the tip speed approaches the speed of sound the propeller efficiency is drastically reduced.

It is therefore apparent that at a constant RPM, the rotational velocity of a blade element will increase as the radius (r) increases towards the propeller tips.

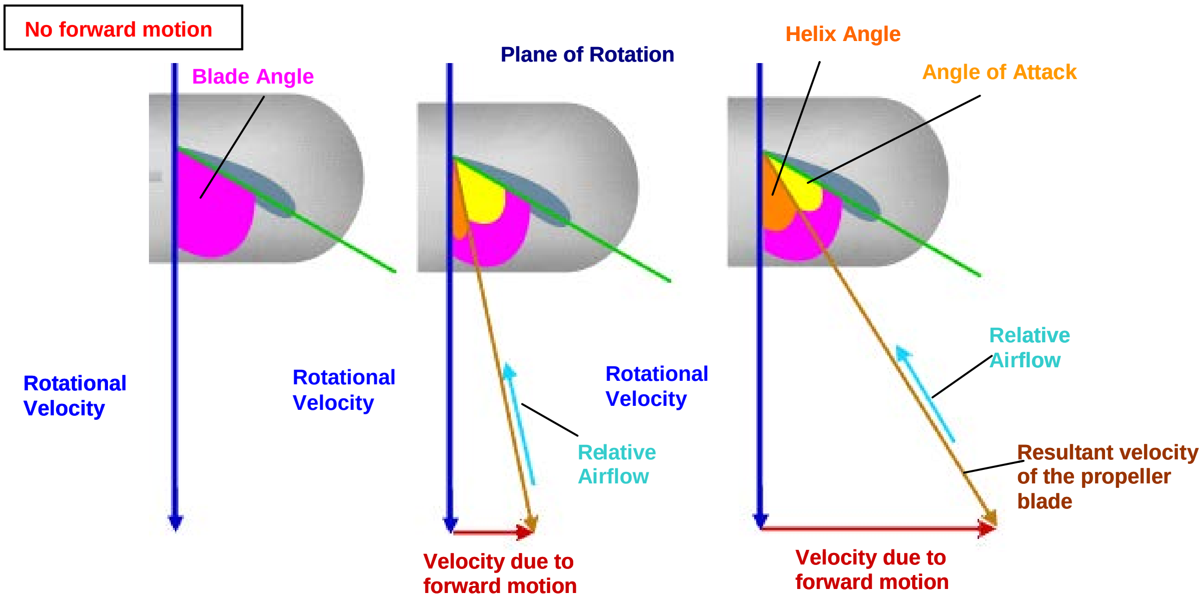
9.3.2 Forward and Resultant Velocity

Apart from the movement around the plane of rotation, a propeller moves forward with the aircraft in the air, which when combined with the **rotational velocity** results in an overall **resultant velocity**.



This **rotational velocity** combined with the **forward velocity** means that each section of the blade follows a helical path (corkscrew) through the air.

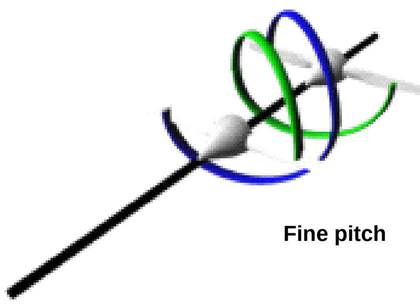
As the resultant velocity changes, the relative airflow (RAF) on the blade section also changes, and with it the angle of attack on the blade section. As with general aerodynamics the angle of attack is that angle between the relative air flow and the chord line of the aerofoil. In the diagram below the angle of attack is represented in yellow.



Helix Angle + Angle of Attack = Blade Angle

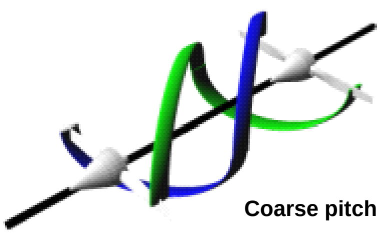
The orange angle indicated on the diagram is termed the helix angle or the pitch angle, or the angle of advance. Pitch can be described as the distance that a propeller will advance through the air for each rotation or the amount of "bite" that the blade has on the air.

A fine pitch propeller has a small blade angle. It will move forward a small distance with each revolution and take a 'small' bite of the air. It requires relatively low power to rotate, allowing high propeller RPM, but achieves limited airspeed.

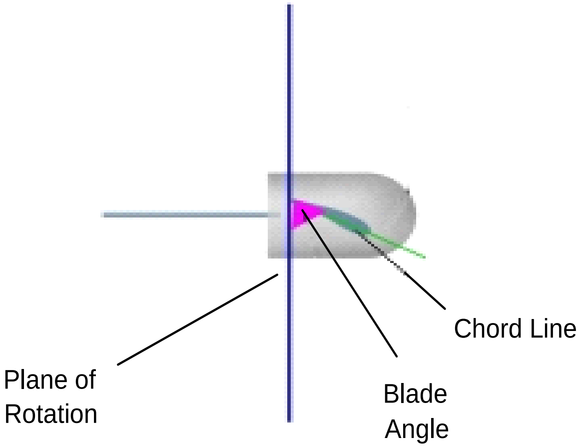


Fine pitch

A coarse pitch propeller has a large blade angle and will advance a further distance through the air with each rotation. During each revolution it will take a large 'bite' of the air. It requires greater power to rotate, limiting the propeller RPM that can be developed, but achieving high airspeeds.



Coarse pitch

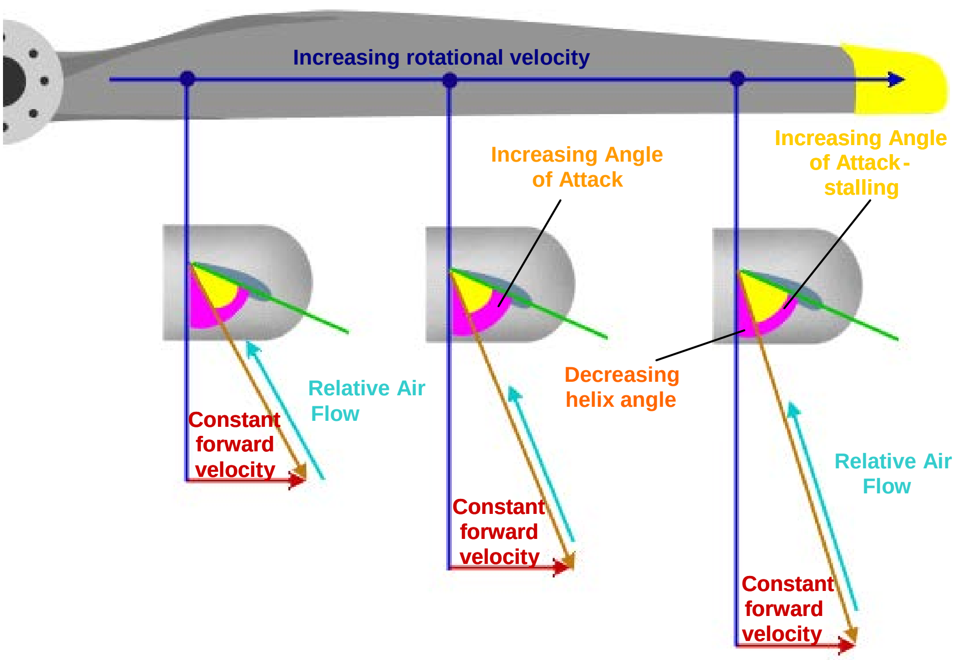


The Angle measured between the plane of rotation and the chord of the blade is known as the blade angle

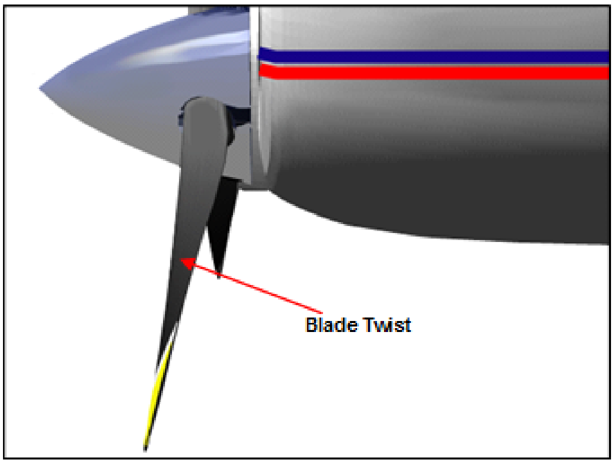
9.3.3 Blade Twist

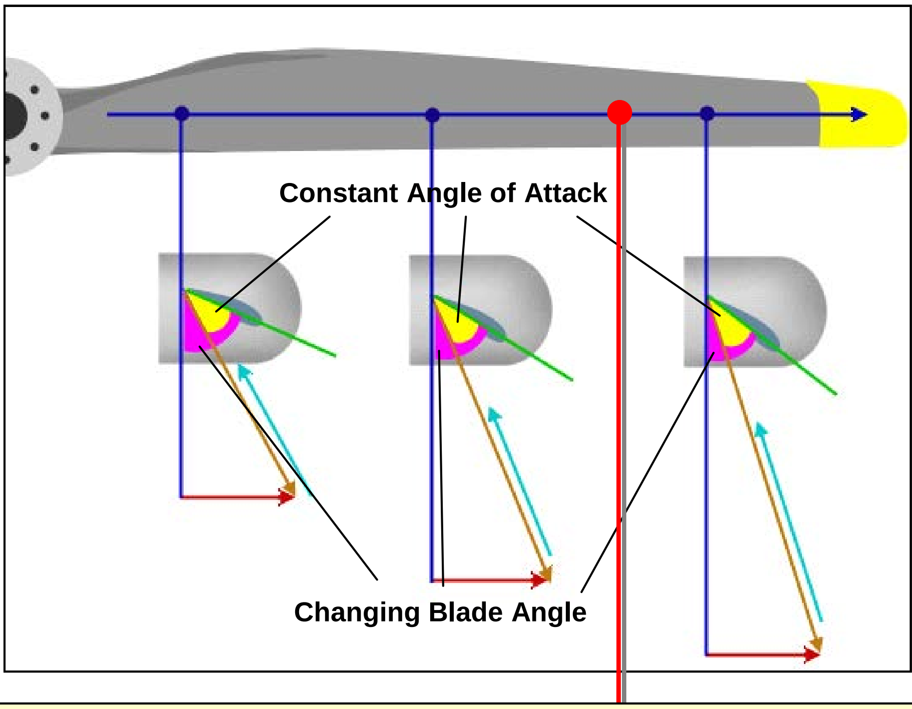
Let us assume that the blade angle of a propeller was the same for its entire length, and that the forward velocity of an aircraft was constant. The only variable therefore would be the rotational speed of various sections of the blade. From the diagram below we can see that as the rotational velocity increases (towards the tip), the angle of attack increases, while the helix angle decreases. This means that the angle of attack along the entire length of the blade will be different at each point.

As with an aerofoil a propeller blade has an angle of attack at which it is most efficient for a specific speed, or RPM and forward velocity. With a changing angle of attack the most efficient angle will only be present at one point on each blade. Furthermore the increasing angle of attack toward the tip can result in the blade stalling!



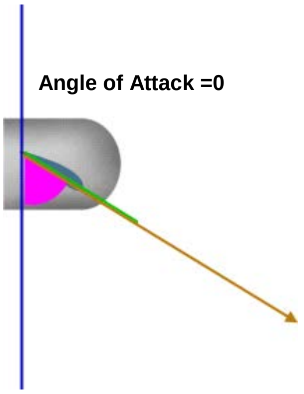
Designers of propeller blades therefore do not design a blade with a single blade angle but rather twist the blade to ensure a constant angle of attack, and therefore maximum efficiency. This is known as blade twist and can clearly be seen in propeller blades. When looking at a blade from the tip toward the root it is apparent that the angle of the blade changes along the length of the blade. This aids in maintaining the desired angle of attack and maximum efficiency for the blades and the propeller as a whole.



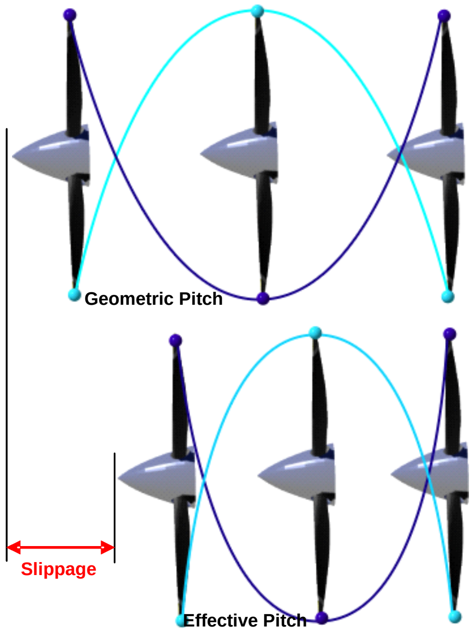


The twist of the blade is achieved by placing blade sections of different angles alongside each other. Because of the twist the blade angle will vary throughout the blade length so normally the standard blade angle is measured at the 75% blade station from the hub centre.

9.3.4 Propeller Pitch (Advance per revolution)



We have already said that pitch can be described as the distance that a propeller will advance through the air for each rotation, or the amount of "bite" that the blade has on the air.

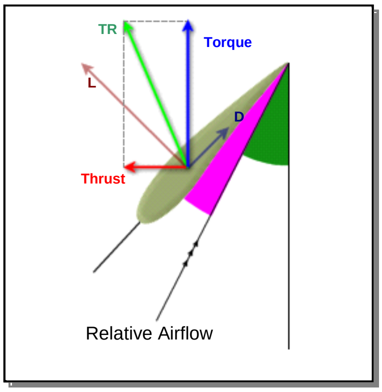


This forward distance for each propeller revolution can be calculated and is termed the **geometric pitch (p)**. The geometric pitch is calculated for a specific blade section moving along a line parallel to the chord (angle of attack is 0º). Geometric pitch is thus not concerned with the thrust of the blade section, but is concerned only with the geometric dimensions.

Propellers are usually designed so that all blade stations have much the same geometric pitch.

While the geometric pitch is the theoretical distance the propeller would advance in one revolution, the **effective pitch** is the actual distance that the propeller advances in one revolution. Because of the fluidity of air the geometric is never attained and effective pitch is always less. The difference between geometric and effective pitch is termed **slippage**.

9.3.5 Forces on a Blade Element



Due to the positive angle (α) at which each blade element is set and the direction of the resultant relative air flow (RAF), the blade section produces lift and drag in the same way as an aerofoil.

However, with a propeller the forces parallel and perpendicular to the RAF are not the most important.

The forces of interest are those that act along the axis of rotation (thrust) and at right angles to the axis of rotation (torque).

> The Propeller Torque force is the resistance to motion in the Plane of Rotation, and just as Drag must be overcome to provide Lift on an Aerofoil, so Propeller Torque has to be overcome to provide Thrust

9.3.6 Blade Angle

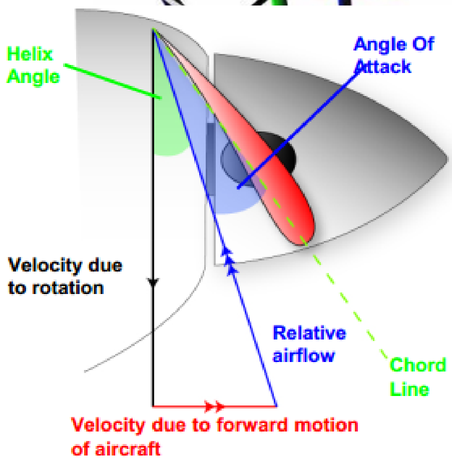
Blade Angle: usually measured in degrees, is the angle between the chord of the blade and the plane of rotation. Pitch is not the same as blade angle, however pitch is largely determined by blade angle and the terms are often used to describe the same position. An increase or decrease in one is usually associated with an increase or decrease in the other.

9.3.7 Helix Angle

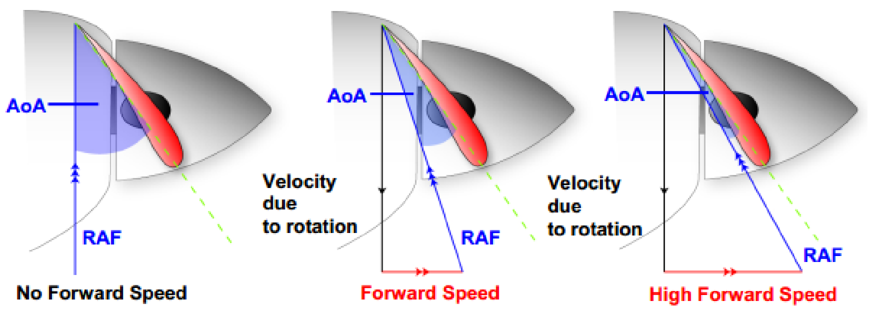
Helix Angle: each propeller blade section follows a corkscrew path through the air, called a helix, as a result of the combined rotational and forward velocities.

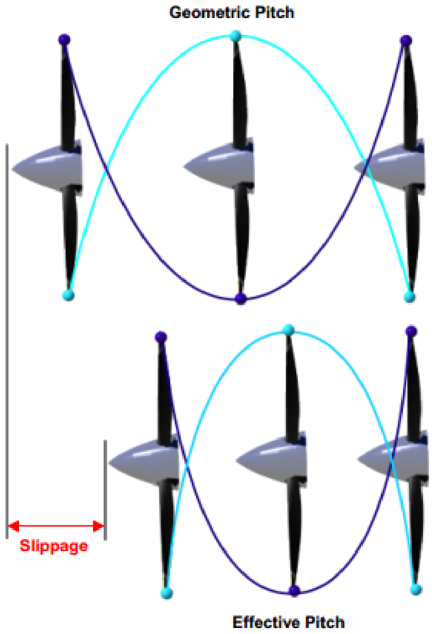
9.3.8 Angle of Attack

The Angle of attack is the angle between the aerofoil chord line and the relative airflow. Note that the angle of attack (aoa) plus the helix angle make up the blade angle. This angle changes with varying flight conditions.



With no forward velocity, the angle of attack of the propeller blade is the same as the blade angle. As the forward velocity of the aircraft increases, the angle of attack of the propeller blade decreases. An increase in rpm will cause the angle of attack to increase; the most effective angle of attack 2 – 4 degrees.





9.3.9 Geometric Pitch

Geometric pitch – is the distance a propeller should advance in one revolution; effective pitch is the actual travel distance. All propellers suffer from slippage as they advance through the air; this is one of the factors in the calculation of thrust horsepower.

9.4 Take Off Effects

Most light aircraft engines are manufactured in the USA and they generally rotate in a Clockwise direction (as viewed from the cockpit), as a result, during take-off the aircraft will tend to *yaw to the left* as power and airspeed are increasing. This is due to a combination of the following factors:

- Propeller torque reaction
- Slipstream effect
- Asymmetric blade effect
- Gyroscopic effect (tail dragger only).

9.4.1 Torque Reaction

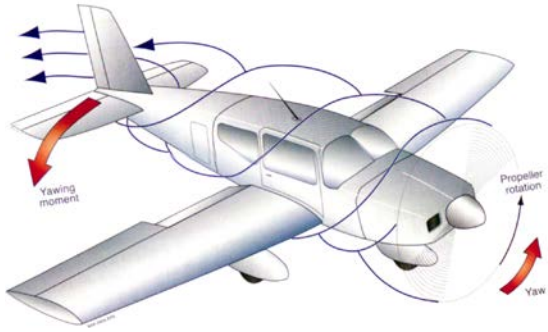
In accordance with Newton's 3rd law, torque is the reaction to the power from the engine being applied to the propeller.

This is more apparent at high engine RPM and low airspeed, (little rudder effect).

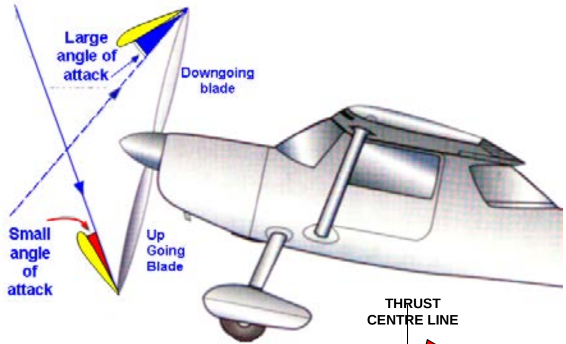
9.4.2 Slipstream Effect

The swirling slipstream from the propeller strikes the Vertical Stabiliser on the left hand side yawing the aircraft to the left.

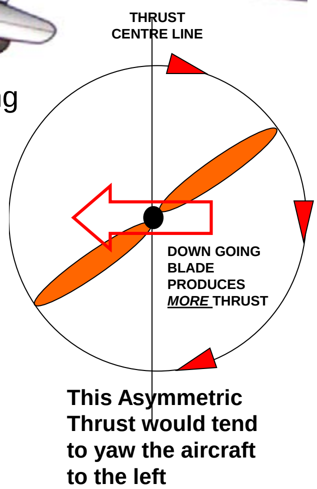
It is more apparent at as the power is increased at low airspeed.



9.4.3 Asymmetric Blade Effect



When the Fuselage of the aircraft is at a large angle of attack relative to the air it is flying through, eg a Tail wheel aircraft starting its Take Off run or in flight at low airspeed or when initiating a climb. As the aircraft moves forward the down going blade of the rotating propeller covers a larger path than the up going blade for each rotation. Therefore the linear velocity of the down going blade is higher than the up going blade, and its angle of attack greater.



9.4.4 Gyroscopic Effect

A spinning propeller exhibits the same properties as a spinning gyro namely ***precession***. As the tail is lifted on a tail dragger a force is applied to the propeller (gyro). This force will move the aircraft at 90° to the applied force which results in a yaw to the left.

9.5 Fixed Pitch Propellers

The pitch of these propellers is set by the manufacturer, and cannot be changed. With this type of propeller best efficiency is achieved only at a given combination of airspeed and engine rpm.

There are essentially two types of fixed pitch propellers:

- Climb power propeller
- Cruise power propeller

Whether the aircraft has a climb or cruise type installed depends on its intended use; distinguishing differences between the two are:

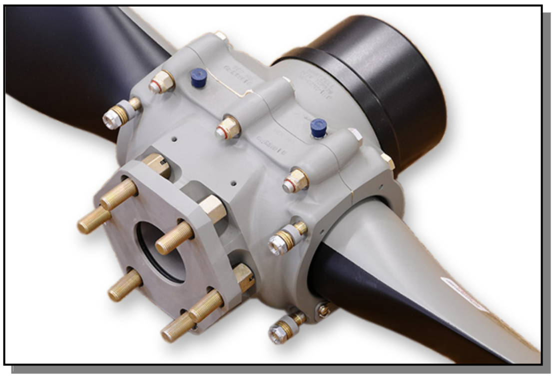
- A cruise propeller has a higher pitch, therefore more Torque. More torque results in lower rpm and less horsepower capability, which decreases performance during take off and climb, but increases efficiency during cruise flight.
- A climb propeller has a lower pitch with less Torque. Less torque results in higher rpm and more horsepower capability, which increases performance during take off and climb, but decreases performance during cruise flight.

The propeller being mounted on the crank shaft will turn at the same rpm as the engine. As propeller diameters increase with larger engines, there is a corresponding increase in the tip speed, if this speed approaches sonic velocities the propeller efficiency is severely impaired. To overcome these problems a reduction gear is often fitted between the engine and propeller thus reducing propeller rpm, but allowing the engine to reach its maximum power output potential.

9.5.1 Power changes

The throttle is the only means of power control on an engine fitted with a fixed pitch propeller. The throttle changes the manifold pressure and this produces a change in power with a proportional change in rpm. As manifold pressure and rpm are both representative of power, on an engine fitted with a fixed pitch propeller, an rpm gauge is the only power instrument provided.

9.6 Constant Speed Propellers



On aircraft that are equipped with constant speed propellers, engine power output is *controlled by the throttle and indicated by a manifold pressure gauge.* The propeller blade angle, on the other hand*, is controlled by a propeller control lever and the resulting change in engine rpm, caused by a change in blade angle, is indicated on the tachometer*. By providing the operator with a means of controlling both engine power output and propeller angle, the most efficient combination of blade angle and engine power output can be maintained for a variety of flight conditions.

The pilot is able to select the desired rpm of a constant-speed propeller, using the pitch control (also known as the propeller control or rpm control) the propeller blades will then automatically change their pitch angle (or blade angle) to absorb the power available and maintain the selected rpm. For instance, if you have selected a cruise rpm of 2,400 with the pitch control and then move the throttle to increase manifold pressure from 23 to 25 in.Hg, the propeller blade pitch will increase to absorb the extra power by taking a bigger bite of the air and providing increased thrust. Conversely, if power is reduced, the propeller blade pitch will reduce to maintain rpm. The constant-speed unit in the propeller operates automatically; usually the blade movement to a new pitch angle is hydraulically operated by a governor sensitive to rpm.

The RPM/MAP combination for a specific setting, to be used for the most efficient fuel consumption, should be the lowest rpm with a high MAP. This combination has a lower friction penalty due to the lower rpm, compared with using a high rpm and lower MAP

Note:

Manifold pressures higher than those recommended by the manufacturer can lead to high cylinder pressures and possibly detonation – to be avoided at all costs – and this can occur if high manifold pressures are set to an rpm lower than recommended.

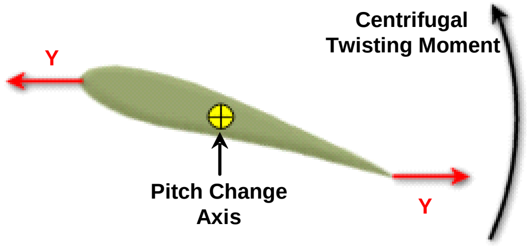
High rpm can increase oil consumption and limit the volumetric efficiency due to the friction of the air flow developed in the intake manifold.

9.7 Twisting Moments

During flight considerable forces and stresses are placed on the engine, propeller and pitch changing mechanisms. The most important of these forces are:

9.7.1 Centrifugal Twisting Moment

The Centrifugal force (CTM) acts on the mass of the blade and can be divided into two components:



The x-component produces a tensile stress at the blade root, while the y-component produces a torque moment about the pitch-change axis.

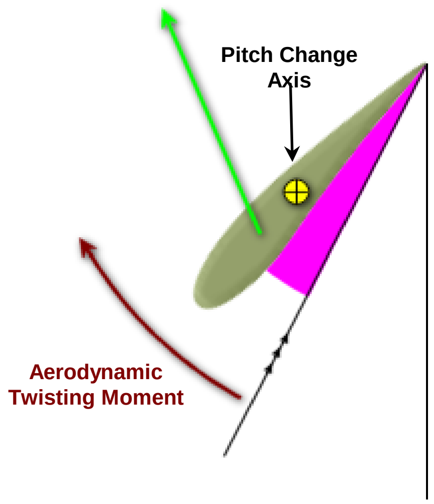
Torque produced by the CTM **y-component** causes a centrifugal twisting moment about the pitch-change axis that tends to "fine", or decrease, the pitch.

Thus, the effort required by the pitch-change mechanism is larger to increase the blade angle than it is to reduce the blade angle.

9.7.2 Aerodynamic Twisting Moment

Aerodynamic twisting moment (ATM) tries to twist a blade to a higher angle. This force is produced because the axis of rotation of the blade is at the midpoint of the chord line, whilst the centre of lift of the blade is forward of the axis.

This Aerodynamic Twisting Moment will tend to *Increase* the pitch angle of the blade and in so doing, partially offsets the Centrifugal Twisting Moment.



The force tries to increase the blade angle. Aerodynamic twisting moment is used in some designs to help feather the propeller.

9.8 Constant Speed Propeller

With constant speed control the pitch is automatically altered by a constant speed unit (CSU) or governor; this unit is engine driven and fitted to the accessory drive housing. After setting the desired engine/propeller speed with the propeller control, the governor acts to keep the propeller RPM at the same value.

If the governor detects the propeller speed increasing, it increases the pitch to restore the selected RPM. If the governor detects the propeller speed decreasing, it decreases the pitch to restore the RPM back within limits.

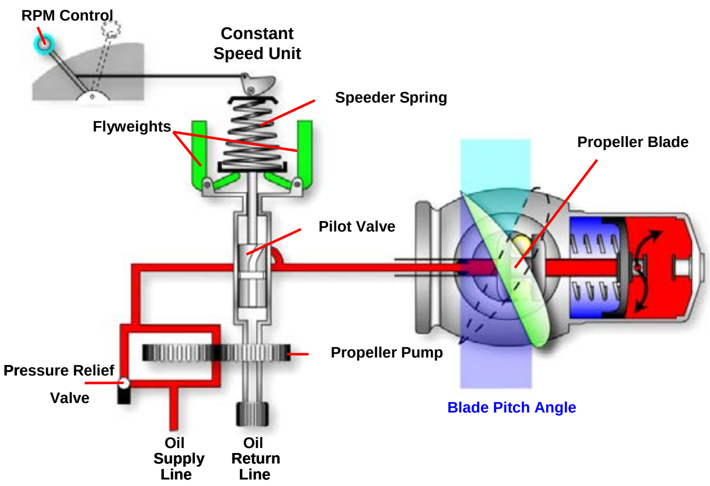
9.8.1 The Constant Speed Unit (CSU) or Governor

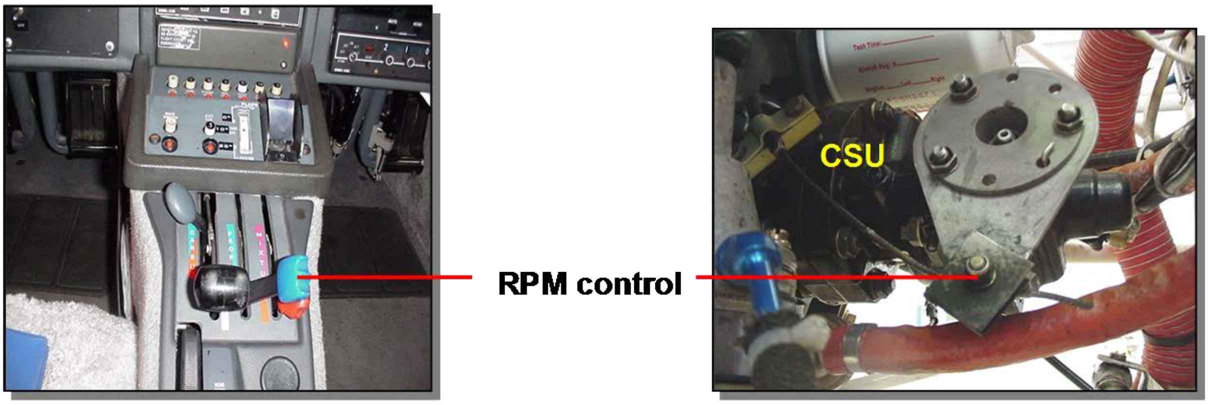
The Governor supplies and controls the flow of engine oil to and from the pitch control mechanism. It serves to maintain a selected propeller RPM setting by applying or removing the pressure within the control mechanism, and in so doing controls the pitch of the propeller.

The engine driven governor receives oil from the engine lubricating system and boosts its pressure to that required to operate the pitch-changing mechanism. It consists essentially of:

- A gear pump to increase the engine oil pressure to a higher value required for propeller pitch change operation.
- A pilot valve actuated by flyweights and opposed by a speeder spring, which controls the flow of oil through the governor.

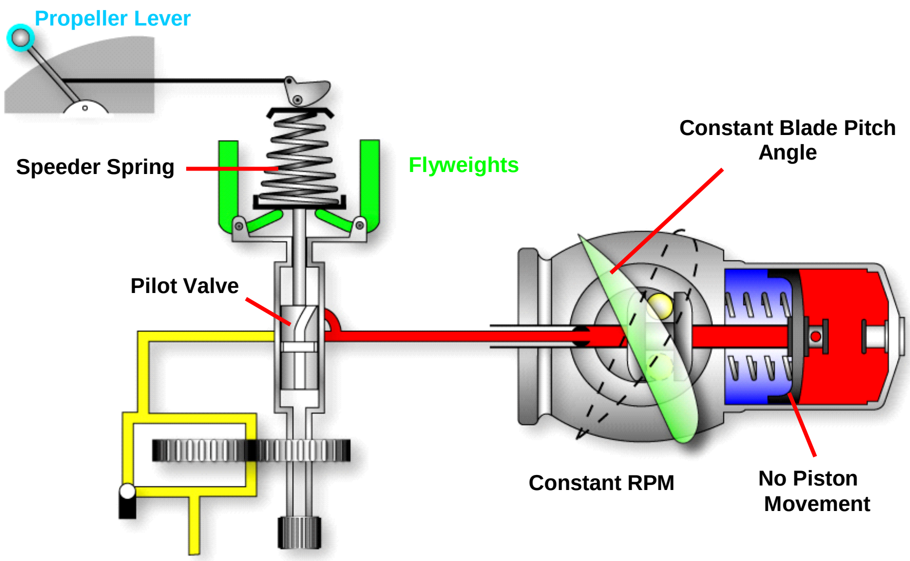
The speeder spring provides a means by which the initial load on the pilot valve is applied; the tension can be varied from the cockpit using the RPM control lever.





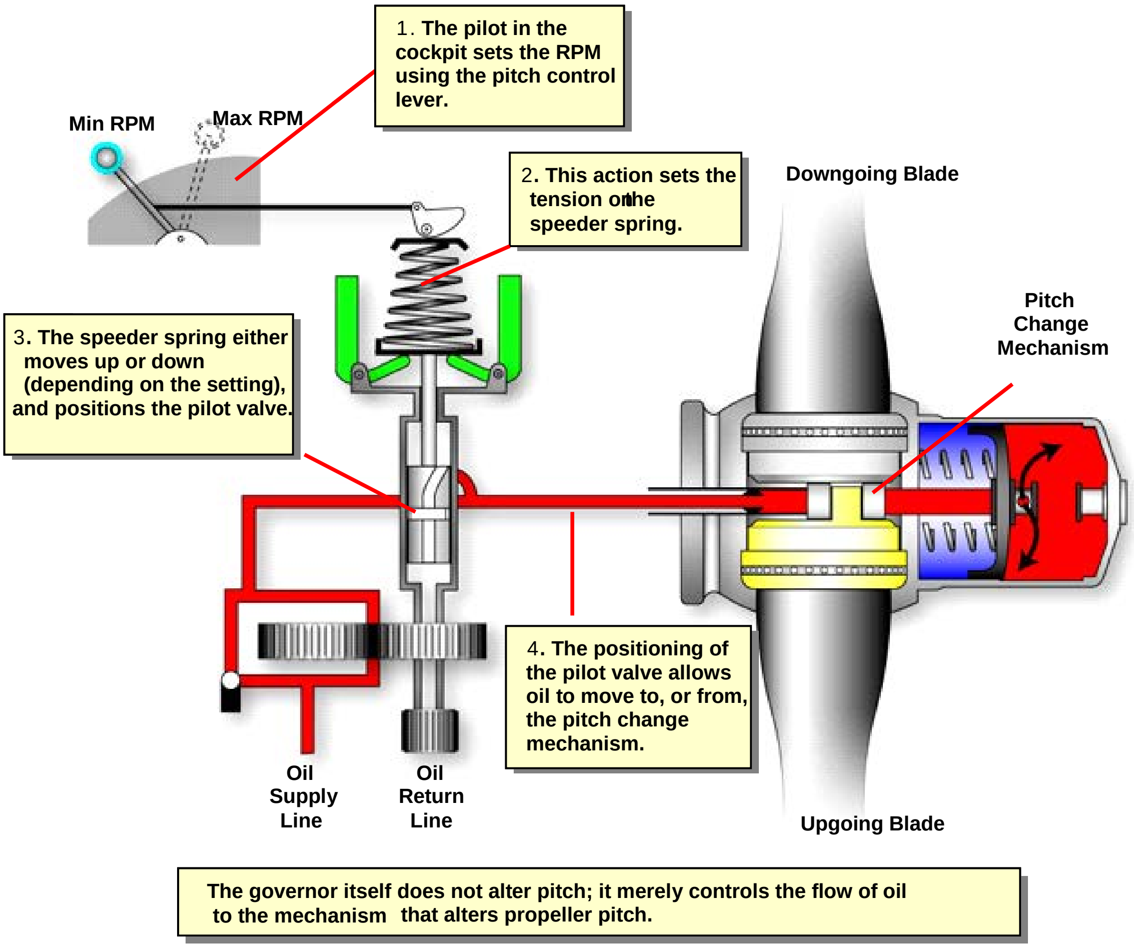
9.8.2 Maintaining the RPM

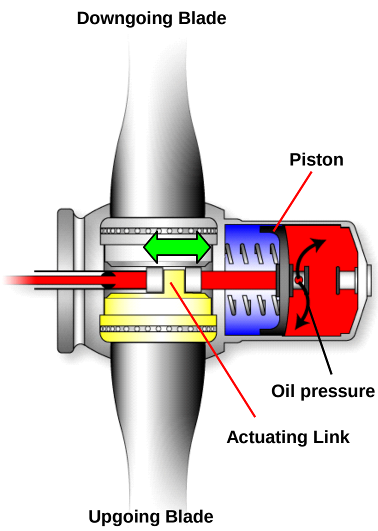
Movement of the propeller lever sets the speeder spring pressure. The flyweights position the pilot valve to direct oil to or from the propeller. This in turn positions the propeller blades at a pitch angle that absorbs the engine power at the RPM selected. When the moment of RPM balance occurs, the force of the flyweights equals the speeder spring load. This positions the pilot valve in the constant RPM position, with no oil flowing to or from the propeller. This balance represents the constant RPM.



9.8.3 RPM Control

As the blade angle of a propeller is decreased, the torque required to turn the propeller is reduced and for any given power setting the RPM of the engine will tend to increase. Conversely, if the blade angle increases the torque required increases and the engine and the propeller will tend to slow down. By changing the blade angle RPM will change.





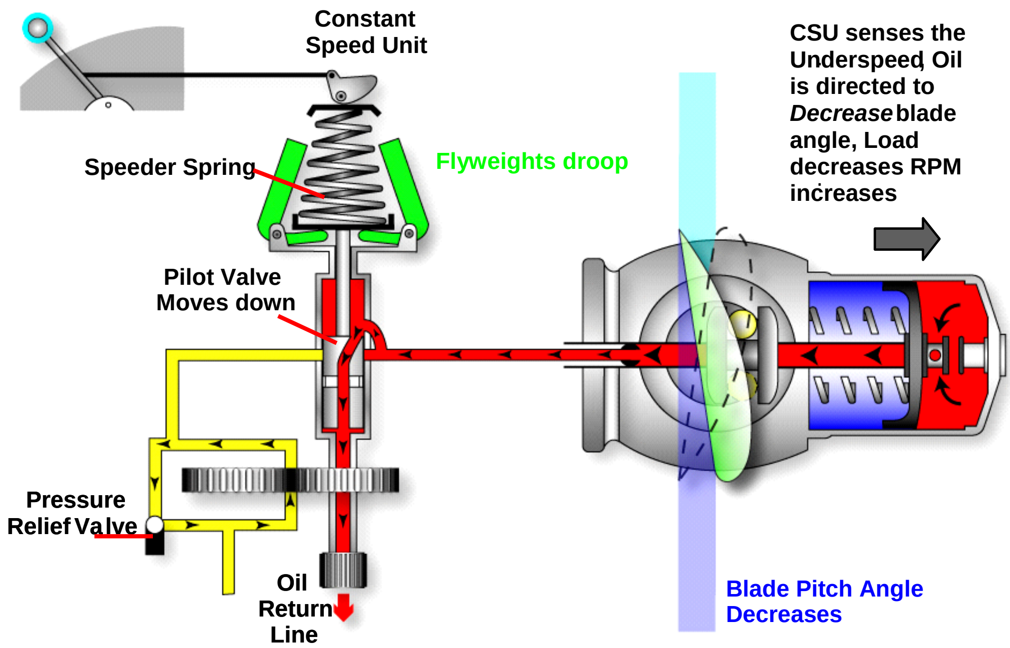
The system permits the pilot to select or set a desired RPM. When maximum power at low air speed is required for take-off, the pilot pushes the propeller lever full forward. With full throttle this gives low pitch and maximum RPM. Whilst satisfactory for getting off the ground, is not desirable for cruising at high air speeds. For cruising, the pilot sets the manifold pressure with the throttle then adjusts back on the propeller control. This increases the pitch and the engine speed settles to the desired RPM for cruise conditions. The RPM automatically stays set until the propeller lever is moved again.

In the propeller hub, oil pressure acting on a piston produces a force that is opposed by the natural centrifugal twisting moment (CTM) of the blades. To increase the pitch or blade angle we direct high pressure oil to the propeller.

This moves the piston back. Motion of the piston is transmitted to the blades through the actuating links moving the blades toward high pitch.

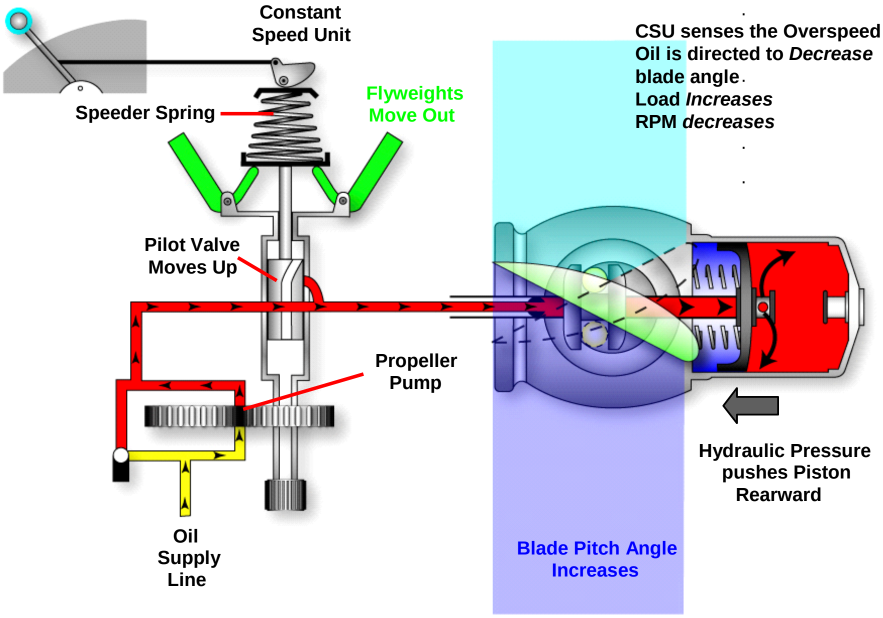
When the opposing forces are equal, oil flow to the propeller stops and the piston will stop. The piston will remain in this position, holding the pitch of the blades constant until the governor or CSU, directs oil flow to or from the propeller.

When a constant RPM is set, if the airplane begins to climb or engine power is reduced a temporary **under speed** results. Airspeed is reduced and, since the pitch of the propeller blades is too high, the engine starts to slow down. However, the instant this happens the flyweights will droop, causing the pilot valve to move down. Then oil flows from the propeller and CTM interacts, reducing the pitch of the blades. This automatically increases the speed of the engine to maintain the former RPM setting.



Single acting non- feathering propeller

If the aircraft is put into a descent or engine power is increased, this causes a temporary **over speed**. The airspeed increases as the pitch of the propeller blades is too low to absorb engine power, and the engine RPM begins to increase. The instant this happens, the flyweights move out and raise the pilot valve which causes oil to flow to the propeller, increasing the pitch of the blades. Engine speed then slows down to maintain the original RPM setting.

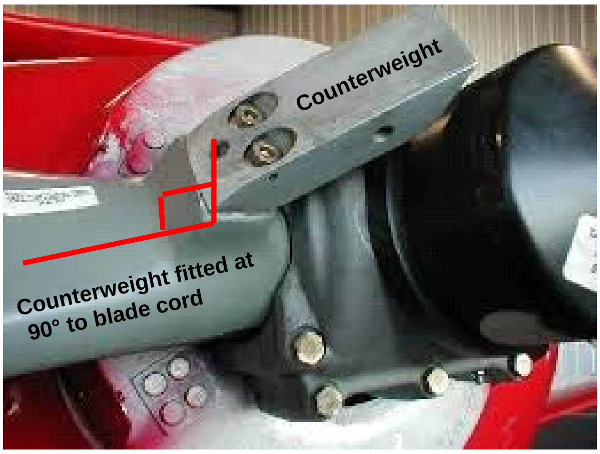


Single acting non - feathering propeller

We have so far only discussed propellers for single engine aircraft. In these aircraft oil pressure is used to move the propeller blades towards coarse pitch. As a result, if CSU oil pressure is lost CTM forces acting on the propeller blades will drive the blades to the fully fine position (high thrust). The pilot can now control thrust using the throttle as if he was operating an engine with a fixed pitch propeller, which is the safest configuration for continued operation.

In multi-engine aircraft this is not a desirable feature because a propeller windmilling in fine pitch produces more drag than one windmilling in coarse pitch. This could cause excessive asymmetric yaw.

Multi engine aircraft typically use **single acting counterweight feathering propellers.** These propellers normally use oil pressure to move the blades towards fine pitch, so in the event of CSU oil pressure failure, multi-engine aircraft propellers are designed to fail to coarse pitch. In order to overcome CTM forces (which try to move the blades towards fine pitch), multi-engine propellers are fitted with COUNTERWEIGHTS. The counterweights are fitted at 90° to the blade cord and centrifugal forces acting on them overcome CTM forces and move the blades towards coarse pitch.



Single acting counterweighted feathering props have a feather position which is used to position the blades at 90° to the airflow. This is the position of minimum drag and is used when an engine is shutdown in flight. The feather position also ensures that the propeller will remain stationary and not windmill. These types of propellers normally have pitch locks to prevent the propeller going to coarse pitch on shut down. This also means that the prop must be turning above a certain RPM (normally about 1200 RPM) to enable it to be feathered.

9.8.4 Pitch Stops

Mechanical stops are installed in the propeller to limit blade travel in both the high and low pitch directions. These stops are known as the fine and coarse pitch stops.

Whenever manifold pressure is decreasing, engine power will reduce and the blades will adopt a finer and finer blade angle until they reach the fine pitch stop. Any further reduction in MP will cause a drop in RPM, from this point the propeller behaves like a fixed pitch propeller.

During a fast cruise descent, if the throttle is not moved, the RPM will increase as propeller torque reduces, and the propeller moves progressively coarser. If it reaches the coarse pitch stop and this condition is maintained, the engine will over speed from the coarse pitch stop.

If RPM is higher or lower than the indicated power lever position, then the system is operating outside its normal operating range and cannot keep the RPM constant.

There are some further considerations when discussing fine and coarse pitch stops. When checking for a magneto drop the propeller is set to fine pitch and behaves as a fixed pitch propeller, this enables an RPM drop to be observed. If left in the governing range, the CSU would adjust blade angle and maintain constant RPM when a magneto was turned off.

9.9 On-speed, Under-speed and Over-speed

The terms on-speed, under-speed and over-speed with regard to the governor, mean the following:

- **ON-SPEED:** If the pilot has set a RPM which is to be maintained, and the RPM is in fact being maintained, the propeller RPM is said to be ON-SPEED.
- **OVER-SPEED:** If the pilot has set an RPM which is not being maintained and the propeller has a higher RPM, then the propeller is said to be OVER-SPEEDING.
- **UNDER-SPEED:** If the pilot has set an RPM which is not being maintained, and the propeller has a lower RPM, then the propeller is said to be UNDER-SPEEDING.

9.10 Power Output

A constant speed propeller allows the engine to develop maximum rated power and RPM during the ground roll and to develop full power throughout its normal RPM range.

With a constant speed propeller the pilot controls inlet manifold air pressure [MAP] with the throttle lever and the engine RPM with the RPM control lever.

The pilot has several combinations of RPM/MAP to achieve a particular power setting. Typical examples would be the recommended combinations for 65% power at sea level:

- 2100 RPM + 26 inches Hg MAP
- 2200 + 25 inches
- 2300 + 24 inches
- 2400 + 23 inches.

The pilot can use low RPM and high MAP or high RPM and low MAP to achieve exactly the same power output. The low RPM/high MAP combination gives more efficient cylinder charging and better combustion with less friction.

9.10.1 Setting Power

To achieve smooth power transitions and avoid over stressing an engine, the following sequence for power changes with constant speed propellers is recommended:

a. Power increase: ensure mixture is full rich, RPM lever to increase followed by throttle to increase

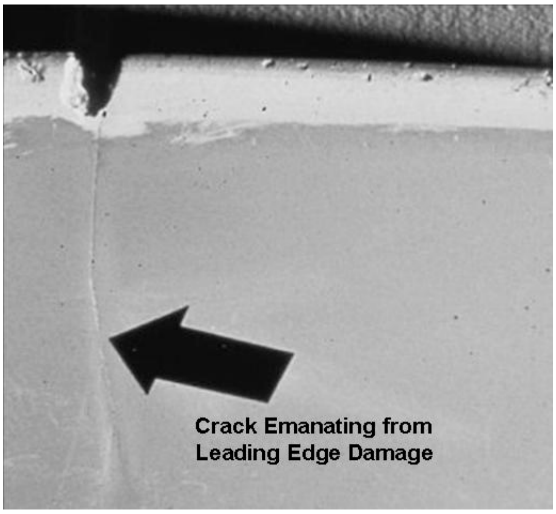
b. Power decrease: throttle decrease, followed by RPM decrease.

The saying –"**REVS UP/THROTTLE BACK"** is a useful reminder of these actions.

The above procedures are designed to avoid excessive manifold pressure during power changes.

9.10.2 Propeller Inspection

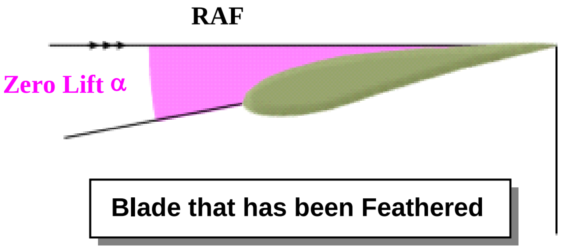
A propeller pre-flight inspection should pay close attention to the propeller blade surfaces. Because of the proximity to the ground, the blades are prone to impact damage from stones or debris on runway surfaces. Stress fractures in the blades can often originate from this sort of damage and, if left undetected, result in blade fatigue and ultimate failure. Given the normal stresses on a operational propeller, blade failure will be catastrophic.



9.11 Other Pitch Modes

9.11.1 Feather

A variable pitch propeller may have a feathering facility which turns the blades to the minimum drag position (i.e. the blades are more or less aligned fore and aft) and stops windmilling when the engine is stopped. Such a feature is not usually fitted to a single engine aeroplane.

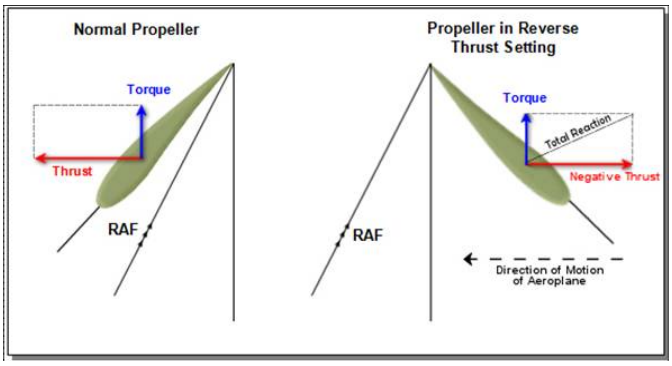


If a damaged engine continues to turn, it may seize, or even catch fire. For these reasons modern propellers have a feathering capability.

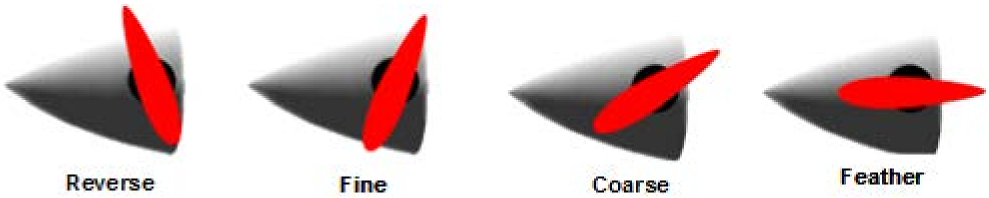
The blades are turned so that the collective effect of all the blade sections produces zero torque and therefore the propeller will stop turning. Drag is reduced to a minimum and further possible damage to the engine is prevented.

9.12 Reverse Thrust

Many aircraft are also equipped with propellers with a thrust reversing capability. Reverse thrust is used to shorten the after landing roll and so achieve better short field performance for transport aircraft operating into unprepared or semi-prepared airstrips.



Reverse thrust is obtained by moving the propeller blades past the fine pitch stop to a negative blade angle. The produces thrust in the opposite direction.



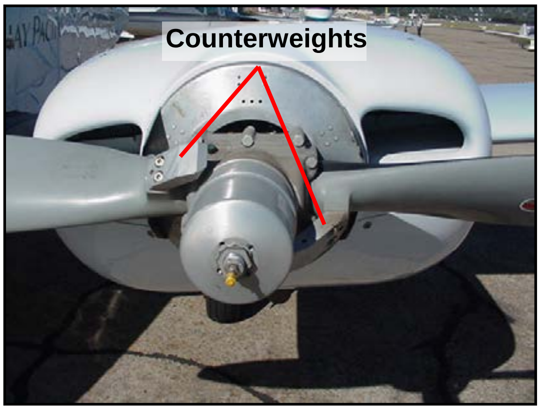
9.13 CSU failure

As a propeller system increases in complexity the possibilities for malfunction increase. A problem associated with constant speed propellers is governor failure or loss of oil pressure to the propeller during flight. Aided by CTM the propeller blades will default to a fine pitch setting. This greatly reduces the load on the power plant and the engine will ultimately over speed, particularly during descent. The RPM of an over speeding engine, sometimes referred to as a 'runaway prop', will quickly exceed red-line RPM. Unless immediate corrective action is taken the engine is likely to be severely damaged. In either event the following is a guide for actions that should be taken:

- Close the throttle
- Reduce the airspeed
- If unable to restore the propeller to constant speed conditions, attempt to feather it if possible.

If the problem is confined to the CSU and not engine oil pressure related it is quite likely that, with careful attention being paid to throttle usage and airspeed, safe flight can be maintained until a suitable landing point is found.

9.14 Counterweight Propellers



Twin engine aircraft commonly have their propellers designed to fail to the coarse pitch position. Counterweights are fitted to the root of each blade. During operation these weights act to increase blade angle. CSU oil pressure is therefore used to decrease blade angle against the counterweight force. Should there be an oil pressure loss, the action of the counterweights will move the blades to a higher angle, and this has the effect of reducing RPM and drag on the airframe.

In addition to the counterweights these propellers will usually have a feathering feature. The counterweights are designed to assist in moving the blades towards feather, thus avoiding handling difficulties as illustrated below.