The Basics of Propellers

A. General Information About Propellers

Propellers are the all-important part of airplanes that provide the necessary thrust for powered flight. Even our jet engines have bypass blades to assist in producing thrust. In the simplest terms, a propeller is an airfoil traveling in a circle with a positive angle of attack relative to the incoming air to produce thrust.

Propeller performance is affected by several factors. Among them are diameter relative to RPM, and blade area relative to power absorption and pitch.

Diameter: The measurement (usually in inches, but also in cm or centimenters) of the prop from tip to tip.

Pitch: Defined as the theoretical advancement of a propeller in one revolution (usually measured in inches). Pitch defines the speed and maneuverability characteristics of flying. Pitch is also known as the “Twist” of the blades. For example, a 10x6 describes a diameter of 10” and a pitch of 6”, or forward advancement of of 6 inches per revolution. In metric measurement this would by 30x15. Further in this discussion is the formula for figuring the propeller speed in “feet per second” (fps) by using diameter and rpm. If you wish to measure pitch, note that industry standard is that pitch is measured at 75% of radius. Design characteristics will add certain pitches to other parts of the blades, but the true measurement of a particular propellers’ pitch is at 75% of the radius.

Now, more about pitch, which is the hardest part to visualize. With a 6” pitch propeller advancing 6” per revolution, the faster you turn the propeller, the more rapidly you will advance. However, model propellers have a practical limit on how fast they can turn (RPM), which is based on the power curve of the engine and the diameter of the prop. Another practical limitation is due to noise considerations. These limitations can be expressed by tip speed, which is explained below.

Slow speed, aerobatics, great takes-offs and landings can all be accomplished with low pitch propellers. Higher pitches lead to less maneuverability, but faster flying. Because modelers do no have the luxury of variable pitch, most select a pitch based on how they like to fly, or compromise speed and maneuverability with a pitch somewhere in the middle - around 65 - 70% of the prop diameter. A limiting factor which will decrease propeller efficiency is engine horsepower and aircraft drag. This means that a high pitch propeller cannot make an airplane faster than it is capable of being. Too low of a pitch can result in lower power and thrust.

Thrust: Refers to the force exerted by the rotating propeller in the direction of travel of the airplane. This is the whole purpose of a prop - to convert the power of the engine, which appears as a rotating force, or torque, in a linear force to ‘propel” the airplane. Thrust is usually measured in pounds (lbs) or ounces (oz), and it is a function of AIR DENSITY, RPM, DIAMETER, ADVANCE RATIO, and REYNOLDS NUMBER. Figuring thrust is complicated, but what is important to remember is that thrust is different for every shape of propeller and changes with fling conditions.

Power Absorption: Refers to the power output curve of the engine. Power is the product of torque times rpm. As rpm increases, an engine products less force (or torque) because the air/fuel mixture is not as efficient at higher rpm’s. This is why a power curve becomes flat or decreases at higher rpm’s, and means that the most efficient propeller is the one that allows the engine to operate at its’ optimum power band.

An interesting point in understanding power absorption is that propeller power varies by the cube of the rpm. Consequently, twice the rpm requires 8 times the power.

TIP SPEED is measured in FEET PER SECOND and below is a formula to find this measurement.

For model airplane purposes, the best tip speeed for efficiency and noise requirements is 600 to 650 feet per second. This is due to compressibility losses, and that subsonce airfoils do not work well in transonic/sonic speeds with required sound levels.

FEET PER SECOND (ft/s) = RPM x diameter in inches x .00426

For example, to find the tip speed of a 10x6 on a .40 size engine running at 13,500 RPM, the equation would be 13,500 x 10 x .00426 = 588.6 ft/s.

To find the correct diameter at 600 ft/s, use this formula: Diameter in inches = 138,000 / RPM

Using a .40 engine running at 13,500 RPM, the equaiton would read: 138,000/13,500 = 10.22.

Rounding down the correct diameter is 10”.

For both of these formulas use RPM for the optimum power band of your engine (not top RPM). Consult your owner’s manual if you do not know this number.