135 Shannon Ave Geelong West VIC 3218 Ph 03 52224201 Fax 03 52231257
International Phone 61 352 224201 Fax 61 352 231257
E Mail ; sales@tates.com.au Web : www.tates.com.au ABN 80007437523
Importers and Distributors of Quality Radio Control Hobby Products

APC Props

APC PROPELLERS OVERVIEW

APC model airplane propellers have enjoyed strong acceptance and growth since their introduction in 1989. They are especially popular in pattern and racing events. The performance and low noise advantages are largely spawned by the precision methods Landing Products uses to design and manufacture APC propellers.

Landing Products preserves a close rapport with the competition community to benefit from technical interchange so important to improved designs. There is continuous evolution in aircraft design and engine performance. Consequently, propeller design must continuously evolve as well to keep pace with these improving technologies.

Over 300 APC propeller sizes are currently available. The selection is continuously expanding. Current sizes range from 5.5 X 2 up to 26 X 14 in composite materials using long chopped nylon fibers, carbon fibers and hand-laid fibers. This web site maintains a current listing of available selections. Please check the NEW PRODUCTS page for a listing of recently introduced sizes.

Landing Products has recently added expanded manufacturing capability to permit injection molding of even larger single piece propellers. Please note the selection of 3 and 4 blade propellers now in production. The same precision and performance available in the 2 blade line has been extended to 3 and 4 blade designs which offer substantial improvement in ground clearance. Look for expanded selections in the larger 2 blade propellers. Many of these will likely supplant some of the needs currently met with APC component systems which employ aluminum hubs in combination with individual composite blades.

PROPELLER SAFETY CONCERNS

All propellers are inherently dangerous. Model airplane propellers are especially dangerous. Model airplane propellers used in high performance racing are extremely dangerous. Model airplane engines designed and modified to achieve maximum operating capabilities create unpredictable and potentially severe loads, leading to various forms of potential propeller failure. Ignoring reasonable safeguards may likely be catastrophic. This concern is the motivation for the following discussion.

Warnings included with propellers are intended to protect consumers. They also protect manufactures against claims resulting from misuse of the product. Most products with potential for causing injury contain ample warnings about misuse. Some advertisements for products now contain warnings, even before the product is sold! There is a strong proliferation of warnings in most products having potential for creating injury or damage. This inundation of warnings may cause consumers to become inured to product warnings.

The warnings about propeller use must be taken seriously, especially for racing applications. It is very risky to assume that a racing propeller blade will not fail, especially when used with state-of-the-art racing engines. Yet, nevertheless, occasionally model aircraft operators are observed standing in the plane of propeller rotation of high performance racing engines running at full power. This is very frightening. The following information reinforces the assertion that dangers of misuse are very real.

Ideally, a product can be designed with credible knowledge of the environment (loads acting on the product) and capabilities of the product to withstand that environment (not fail). There is nothing ideal about designing a model airplane propeller because some major components of propeller loads are very uncertain. The principle load components acting on a propeller are:

- Centrifugal (from circular motion causing radial load)
- Thrust/drag (from lift and drag acting on blade sections)
- Torsional acceleration (from engine combustion and/or pre-ignition)
- Vibration (from resonant frequencies or forced excitation)

Another potential source of loading is aero elastic tip flutter. This may be caused by self exciting aerodynamic loads at a resonant frequency.

These loads are discussed next in order.

Centrifugal loads are very predictable, given rotational speed and mass density distribution of a blade. Their contribution to total stress is relatively small.

Thrust/drag loads are somewhat uncertain due to complexities of aerodynamic environments. The relative axial speed at the prop (at any radial station) is aircraft speed plus the amount the air in front of the blade is accelerated by the mechanics creating thrust. The latter may be approximated using first order classical theory. Much empirical lift/drag data (from wind tunnel tests) exists to quantify lift/drag loads, once relative velocity and angle of attack distributions are established.

Torsional acceleration loads are generally not known. Analytical estimating technique used by Landing Products to quantify torsional acceleration loads suggests that they can become dominant when pre-ignition or detonation occurs. These analytical observations are supported by test experience with very high performance engines running at elevated temperatures. The latter causes a high torsional load (about the engine shaft) which creates high bending stresses, adding to those from centrifugal force and lift/drag effects. These torsional acceleration loads depend on unique conditions for specific engines. Engines "hopped up" for racing appear to be especially prone to create high torsional loads when lean mixtures lead to high cylinder temperatures and pre-ignition/detonation.

Vibration causes additional loads from cyclic motions. These motions occur when resonant frequencies are excited or when cyclic load variations exist on the blade. The magnitude of these variations depends on how close the driving frequency is to the resonant frequency and the level of damping in the propeller material. Engine combustion frequency is an obvious excitation. Obstructions in front of or behind the blade can cause cyclic variations in thrust load. Once a blade starts to flutter, those motions alter the flow, causing variations in loading. High performance engines have caused propeller tips to break, presumably due to fatigue failure from vibration.

Aero-elastic flutter is speculated to be a dominant mechanism causing rapid fatigue failure near a tip when insufficient or destabilizing tip stiffness exists. The interaction between variable loading and deflection induces a high frequency vibration with unpredictable magnitude.

Efficient propeller design practice utilizes analytical/computational models to predict propeller performance and stresses. However, the uncertainty in impressed and inertial loading from complex phenomena requires testing to assure safe performance. Unfortunately, it is not possible to assure testing that convincingly replicates worst case conditions. The large combinations of engines, fuels, temperature, humidity, propeller selection, aircraft performance and pilot practices creates an endless variety of conditions. If the origins of severe loads were well understood, quantified, and measurable, structured testing might be feasible that focuses on worst case stack up of adverse conditions. However, since the origins of severe loads are really not well understood, it is essential to provide sufficient margins in material properties and design to assure safe performance.

Propellers that are used in fairly routine and widespread applications (sport and pattern) lend themselves reasonably well to test procedures that provide reasonable confidence. In time, a sufficient data base develops that can be used to empirically quantify performance and "anchor" or "tune" assumptions used in analytical models.

However, propellers that are used for increasingly extreme performance applications do not benefit from the large empirical data base sport and pattern propellers enjoy. Assumptions and design practices developed for current generations of engines may not be valid for emerging engines whose technologies continue to push engine performance to greater extremes. Consequently, propellers that are used in applications where performance is already relatively high (and expanding) must be used with great caution.

An adverse cascading effect occurs when propellers are permitted to absorb moisture in high humidity environments. Composite strength, stiffness and fatigue endurance all reduce with increased moisture content. Reduction in stiffness typically causes resonant frequencies to move toward the driving frequency (increasing torsional loads) and, the reduction in strength reduces fatigue endurance. Composite propellers should be kept dry.

In summary, please abide by the safety practices recommended by propeller manufactures. This is especially important for high performance propellers. Assume that propellers can fail at any time, especially during full power adjustments on the ground. Never stand in or expose others to the plane of the propeller arc.

APC PROPELLER MANUFACTURING PROCESS USED BY LANDING PRODUCTS

Process Mold halves used in Landing Products injection molding machines are manufactured using computer controlled vertical milling machines which have automatic tool calibration and tool change features. Each mold half is cut with a series of cutting tools using progressively smaller tool radii and finer mesh spacing. Once started, the operations required to cut a mold half are completely automatic. A minor amount of hand polishing of the mold cavity is performed after the milling operations are complete.

During an injection molding production run, fine adjustments may be made, if required, to mold position within the molding machine to control propeller balance. Molding machine parameters, once set, are stored electronically for subsequent use to assure consistency between batches.

Larger propellers are retrieved from the injection molder with a robotics machine. The only postoperative manufacturing requirement is drilling of the prop shaft hole which uses a guide hole provided by a pin resident within the mold.

Materials

The molding compound used in APC propellers is manufactured using a pultrusion process. This method causes the fiberglass "fibers" to be oriented axially in 1/2" long pellets. This long fiber compound allows a higher fiber (60%) to resin (nylon binder) density than short or chopped fiber compounds. Viscous (skinning) effects during injection molding cause these long fibers to remain dominantly oriented in the propeller span-wise axis. This provides substantially higher strength and stiffness compared to more conventional processes which use short or chopped fibers. While both more costly and difficult to manufacture, the performance advantages of long fiber composites are substantial, as shown on the following table.

Property	Un-reinforced Nylon	Glass Filled Nylon	APC Long Fiber Composite
Tensile Strength	11.0 KSI	18.0 KSI	24.0 KSI
Tensile Elongation	**(Very Large)**	3 to 4 %	6 %
Flexural Strength	7.0 KSI	29.0 KSI	38.0 KSI
Flexural Modulus	0.41 MSI	1.3 MSI	2.3 MSI

The long fiber composite material is both stiffer and stronger than glass filled nylon. The additional stiffness is beneficial to control of vibration resonance response. The natural frequencies of the propeller must be kept high enough to preclude excitation from engine torsional vibration and aero-elastic flutter. The higher strength allows the use of (relatively) thinner cross-sections, beneficial to weight and aerodynamic efficiency.

For a list of prop sizes , prices and stock list - see our Price List

Distributed in Australia By :-

toys..... Tates ...hobbies

Performance Hobbies

135 Shannon Ave Geelong West VIC 3218 Ph 03 52224201 Fax 03 52231257
International Phone 61 352 224201 Fax 61 352 231257
E Mail ; sales@tates.com.au Web : www.tates.com.au ABN 80007437523