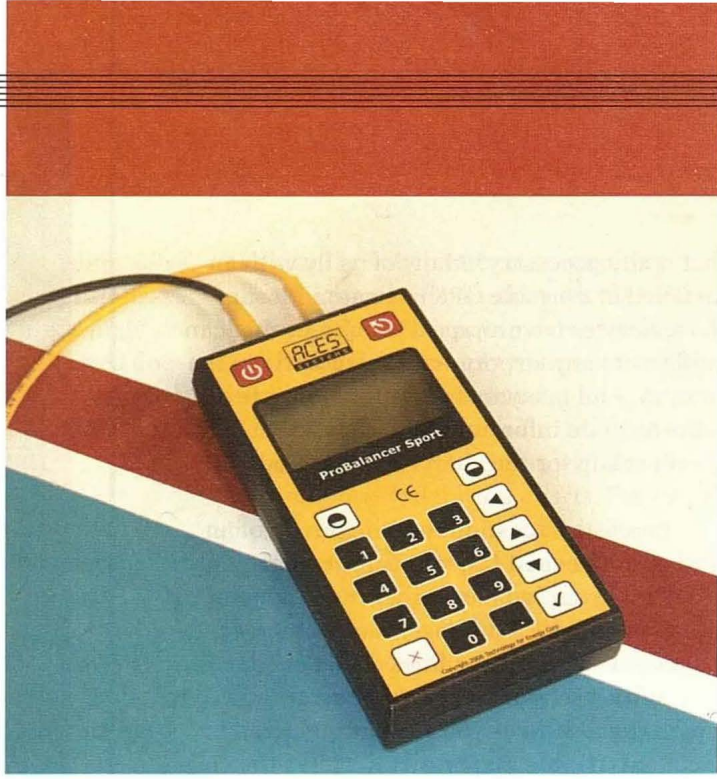
STEVE ELLS
COMMENTARY / THE WORKBENCH



Smooth Your PTRC

"MOST DYNAMIC BALANCE equipment manufacturers specify 0.15-0.2 inches per second as being an acceptable level. McCauley Propeller Systems agrees that 0.15-0.2 ips is an acceptable level, but our experience has shown that 0.07 ips or lower is noticeably smoother."—McCauley Service Letter 1989-4D

"The minute I pushed in the throttle I knew I'd done the right thing," Rockwell "Rock" Swanson said. Rock believed the engine in his Cessna Turbo 210 was smooth until he rode in a friend's airplane. Rock's power train rotating component (PTRC) needed balancing—in prop-balancing lingo the initial reading of imbalance was 0.714 ips. Rock's PTRC was seriously out of balance. Numbers between 0.5 and 1.0 are categorized as rough; above 0.15 is fair; and above 0.25 is slightly rough. Any number above 1.0 is very rough and above 1.25 is regarded as dangerous. After balancing, the imbalance was reduced to 0.026 ips.

Kent Felkins of Felkins Aircraft Service in Tulsa has been doing dynamic propeller balancing for 15 years. He is a believer. Using the 0.2 ips standard as a baseline, Kent has kept records showing that the propellers on 88 percent of the 580 airplanes he tested were *above* this baseline.

EQUIPMENT

The first balancing equipment was created in the mid-1950s by Jim Chadwick and Jim Helmuth. They formed the Chadwick-Helmuth company of El Monte, California, to balance rotor blades of helicopters. The technology was later applied to propellers. The company is now owned by Diagnostic Solutions International. ACES Systems, DynaVibe, and Dynamic Solutions Systems also manufacture and sell balancing and engine vibration spectrum analysis tools.

Charts in "The Smooth Propeller" by Chadwick-Helmuth and ACES Systems' "Guide to Propeller Balancing" are more stringent, showing that a reading of 0.15 ips is the maximum acceptable level after balancing. Readings between 0.15 and 0.25 are termed "slightly rough" and affect passenger comfort.

Dynamic prop balancing is effective at decreasing vibrations that occur at propeller rpm. These vibrations are called first-order vibrations (1x) because they occur once for each crankshaft-propeller rotation (assuming the propeller is not geared). Excessive first-order vibrations ar destructive—rivets loosen, wear in avionics and instruments is accelerated, and pilot fatigue increases—since engine-mount vibration isolators aren't very effective at dampening these frequencies.

THE NUTS AND BOLTS OF BALANCING

The process is simple. Basic PTRC balancing equipment uses one vibration sensor that converts motion to voltage (10 mV per g in one case). During the procedure the sensor is temporarily mounted near the front of the

engine. These electrical signals are fed into a processor box. During an initial engine run at a cruise power rpm—Jim Beech of Dynamic Solutions Systems says that 2000 rpm is high enough since it's above the excitement rpm of the engine mounts—the signal processor detects the magnitude of the mass imbalance. When combined with a prop disc index signal that provides a zero point of reference, the processor then "knows" the location (azimuth) of the imbalance with reference to a single point in the propeller disc. A weight and azimuth solution is derived, and simple weights (almost always in the form of aircraft-quality screws, nuts, and washers) are temporarily attached to either the spinner support assembly or the starter ring gear support assembly.

The engine is then run up again. The processor plots the effect of the initial weight solution and creates a final solution. Experienced operators can often reduce the vibration below the 0.02 ips threshold after only one correction and run, but usually it takes at least two. Rock's took three.

Manufacturers of balance equipment recommend rechecking the balance every 400 to 600 hours. Kent cautions that anytime the prop is removed—to change an alternator belt on a Lycoming engine, for instance—the propeller-engine combination should be rebalanced.

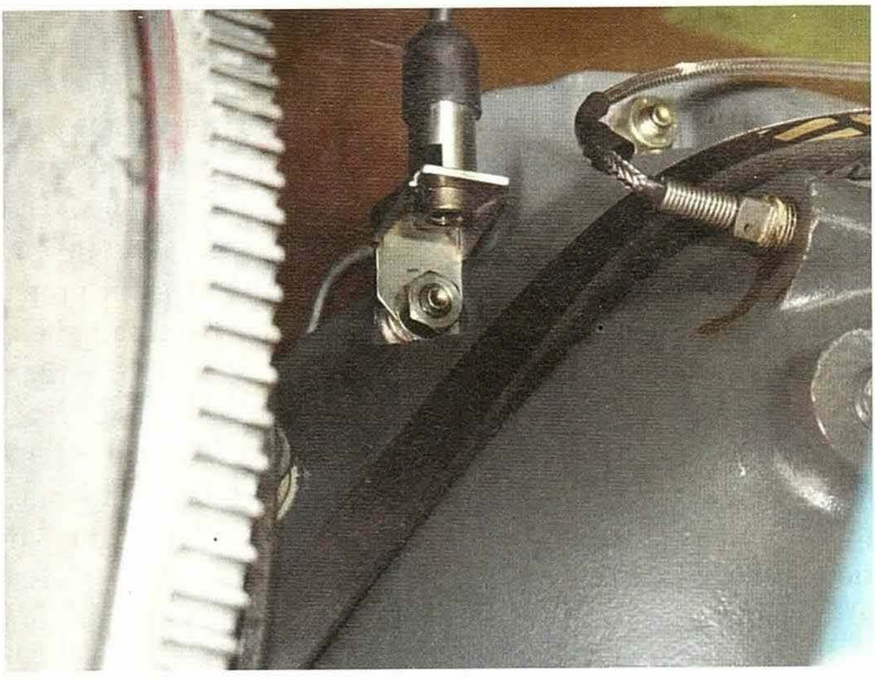
The goal of balancing is to bring the center of the rotating weight (mass) into alignment with the rotational center of the crankshaft. Because there are manufacturing tolerances built into propellers that allow them to be mounted onto the crankshaft flange, removal and reinstallation require rebalance.

I paid a little more than $1,400 for a ProBalancer Sport that is a simple but complete balancing tool from ACES. On-screen menus lead the user through the step-by-step process. I've also heard good reports about the DynaVibe units. The DynaVibe Classic is similarly priced, and like the ProBalancer Sport is an easy-to-use and effective tool for balancing the PTRC.

It's not uncommon for EAA chapters to buy one of these units for the use of all members.

VIBRATION SPECTRUM ANALYSIS

All of the companies listed also produce balancing equipment that uses a second vibration sensor mounted at the rear of the engine to sense and plot a complete vibration spectrum analysis of the engine. In the hands of an experienced operator these analyses are invaluable in pinpointing engine mechanical problems. A typical spectrum analysis display shows vibration energy on the vertical scale and multiples of crankshaft rpm on the horizontal scale. For instance, since the camshaft is geared to



complete two revolutions for every one crankshaft revolution, any vibration from the camshaft will be displayed as 0.5x on the horizontal scale.

There's one other very intriguing PTRC balancing solution, especially for pilots who are looking at engine monitors.

Insight Avionics incorporates real-time displays of both PTRC imbalance and the engine analysis spectrum in its G3, G4, and G4 Twin graphic engine monitor instruments. The 2-1/4-inch G3 retails for just over $2,500.

FAA Advisory Circular AC 20-37E titled, *Aircraft Propeller Maintenance*, includes text citing that dynamic propeller balancing is not considered a major propeller repair or a major airframe alteration when using FAA approved or accepted procedures such as those outlined in "The Smooth Propeller" and the "Guide to Propeller Balancing." The AC does recommend that a maintenance record entry be made listing the date, engine hours, final balance vibration, location of weights, and name and certificate number of maintenance person.

In addition, it suggests that a sticker be applied to the propeller hub or bulkhead stating that the propeller has been dynamically balanced and that the PTRC is a balanced and indexed assembly.

HOW SMOOTH IS YOUR PTRC?

Based on Kent's figures, only a few pilots have ever flown a smooth airplane. That, coupled with the fact that personal definitions of smoothness are subjective, often makes skeptics out of airplane owners. Yet Cirrus, Lancair, Mooney, and other high-end airplane manufacturers now dynamically balance their PTRCs prior to delivery. Try it; there's a pretty good chance you'll be surprised by the result. EAA

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