ENGINE COMPONENTS, INC.

Dynamic Balancing

Questions & Answers for the Airplane Owner

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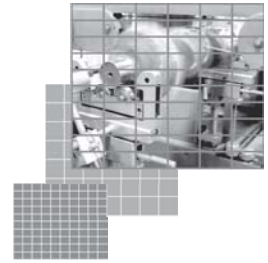

DYNAMIC BALANCING

Table of Contents

QUESTIONS AND ANSWERS ABOUT DYNAMIC BALANCING

I. General Questions

Q: Why don't the engine manufacturers dynamically balance their engines?

A: They do, but not necessarily to the best possible limits or even to accepted industry standards for reciprocating engines. Existing engines were designed to be built on a mass-production basis but at a very low volume. Consequently, the tolerances and part weight groupings cannot be too stringent; or the manufacturers would be forced to reject too many parts. OEM balancing limits have historically been a trade-off between the maximum levels which would result in customer complaints or unusual wear and the minimum levels which will be cost-effective for their production methods and the skill-levels of their workers.

Q: Is Engine Components, Inc.'s (ECi) balancing better than the factory's?

A: Yes. We routinely work to tolerances which are one-fourth, or less, of the tolerances used by the manufacturers.

Q: Can't I just weigh all the parts in my engine and do the same thing?

A: Simply weighing the parts would only statically balance the engine. Static balance is the place to start, but it doesn't finish the process. Connecting rods require special weighing fixtures so that both the rotating and the reciprocating components of rod weights can be matched. Crankshafts, counterweights and associated gears all have manufacturing tolerances and their own residual unbalance. The only way to know how the tolerances will stack up is to put them together and dynamically balance the rotating assembly.

Q: Can't I have my parts balanced at the local "speed shop"?

A: Not legally and not safely. The speed shop has no certification to perform this critical major repair to the engine parts, and they can offer you no data on which to obtain any other type of FAA approval. More importantly, the aircraft engine uses highly-stressed parts and dynamic counterweights which require special techniques and processes in order to achieve balance. For example, drilling and welding are routinely used by the

automotive/industrial world in order to balance crankshafts and other rotating parts. These processes would almost certainly cause catastrophic failure of an aircraft crankshaft.

Q: Does ECi remove metal from engine parts; and, if so, doesn't that weaken them?

A: First of all, manufacturers remove metal from parts in order to balance them in manufacture. ECi may do the same, but the important considerations are where to remove metal and how much. First, ECi works within the manufacturing tolerances of parts in order to match them as closely as possible. Thus, final balance can be achieved with minimum material removal. Secondly, ECi does not remove material from any part or location that is not also used by the manufacturer for the same purpose. Third, all parts are finished with some type of surface treatment (polishing, shot-peening, nitriding, etc.) during manufacture. ECi does not remove material from any part without also restoring the surface treatment after balancing. ECi-balanced engine parts will have a life expectancy which is at least equal to that of OEM parts.

Q: Will dynamic balancing increase horsepower, fuel efficiency and the TBO of my engine?

A: ECi has never made any such "miracle" claims about engine balancing. Engine vibrations have many causes; and the engine power section, fuel system and ignition system must all be in good condition to prevent various types of engine roughness. Dynamic balancing will produce a smoother engine by minimizing the vibrations caused by excessive residual unbalance in the rotating and reciprocating engine parts. The aircraft owner will find the balanced engine more pleasant to live with. Avionics and instruments love balanced engines, as do passengers. The engine installation may see the most tangible benefits in the form of reduced cracking of baffles or induction and exhaust systems, and fewer alternator mount problems.

Q: What parts do you need to balance my engine?

A: We need the crankshaft, connecting rods with bolts and nuts, Lycoming starter gear supports (also called "ring gears" or "flywheels"), pistons, piston pins, counterweights and all counterweight attaching hardware. It is also quite helpful to have TCM crankshaft alternator face gears and bolts as well as rear crankshaft gears for TCM C-series and 200, 240, 300 and 360- series engines. Piston rings, piston pin plugs and rod bearings are quite uniform and do not require a weight check in horizontally-opposed engines. We will be glad to recondition and/or supply any of the parts required to make a complete balanced assembly.

Q: How much does dynamic balancing cost?

A: Contact your ECi Customer Service representatives at 1-800-ECi-2FLY (800-324-2359).

Q: Will balancing increase the warranty on my engine?

A: Engine warranty periods are a matter of policy established by individual engine overhaul shops. Dynamic balancing should be a part of any premium engine overhaul and should be considered when choosing the individual or shop that will perform the overhaul.

Q: Does an investment in balancing at overhaul time have an economic pay back, or is the pay back strictly pleasure?

A: Dynamic balancing an engine is much like making a home improvement such as remodeling the kitchen. The improvement may not necessarily lower utility bills, but it would increase the resale value of the property. Likewise, even if the owner had no plans to sell, he would enjoy the benefits of the remodeling. Either way, the investment is worthwhile.

Q: Reduced wear on instruments and engine mounts has been cited as a benefit of dynamic balancing. What other parts experience reduced wear?

A: Basically, anything which attaches to the engine, such as exhaust pipes, intake pipes, air boxes, cooling baffles, oil coolers, fuel injection lines, prop spinner bulkheads, engine control linkages, etc. Even the electrical windings in alternators and starters can be damaged by vibration. Any reduction of vibration will be of benefit. Of course, all of these parts can also be damaged if installation is sub-standard. For maximum life expectancy, quality installation and dynamic balancing must go hand-in-hand.

Q: Engine vibrations occur at different frequencies. Which are more noticeable in the aircraft cabin, high frequency or low frequency vibrations?

A: Generally, low frequency vibrations are more noticeable. All engines have some tendency to vibrate as a result of cylinder firing, and these vibrations occur twice per crankshaft revolution in 4-cylinder engines, three times per crankshaft revolution in 6-cylinder engines. Cylinder firing may produce very harmful harmonic resonances in the crankshaft (see "torsional vibration" below) but at a frequency which may not be felt in the cabin. Vibrations from reciprocating forces may occur twice per crankshaft revolution, (second order) while vibrations resulting from unbalanced crankshafts or propellers occur once per crankshaft revolution (first order).

Various components in the aircraft cabin may be more sensitive to these first and second order vibrations as engine RPM changes. For comparison, an out-of-balance wheel on a car produces first order vibrations which are certainly annoying, but the effects may seem to come and go as vehicle speed changes.

Q: If a top overhaul is being performed, what are the dynamic balance issues that should be addressed by the technician?

A: When an engine is first assembled, it is best if all piston weights are identical. Certainly the weights of opposed pairs of pistons should match. If a single cylinder is top overhauled and piston replacement is required, the old piston must be completely cleaned in order to get an accurate weight. Then a new piston should be selected to match the weight of the one being replaced.

In some instances older all-aluminum pistons are no longer available, having been replaced with newer and much heavier cast insert ("steel belted") pistons. If one all-aluminum piston must be replaced with a cast insert piston, then the opposing cylinder must also be removed so that a matching new piston and new rings can be installed.

Q: What is the difference between static and dynamic balance?

A: Static balance is simply the equalizing of gravitational forces acting on a part so that it will not have a tendency to rotate when placed on low-friction bearings. Dynamic balance is a much more sophisticated process which equalizes the centrifugal and inertia forces generated in a part when it is in motion.

Q: Why don't all aircraft engines have counterweights?

A: Only certain engine and propeller combinations produce torsional vibrations which exceed the endurance limit of the material in the crankshaft or propeller. Crankshaft counterweights reduce torsional vibrations to levels which will not be harmful to the crankshaft or propeller. While not all engines need crankshaft counterweights for endurance, they could all benefit from some system which would further reduce torsional vibrations.

Q: Why doesn't the Franklin engine have counterweights? Franklin aficionados say the engine idles smoother than any other opposed engine.

A: Actually, some of the larger Franklin engines used by the military had crankshaft counterweights. Most of the engines used in civilian aircraft were smaller and did not have them. Instead, some of the later Franklin engines employed a viscous dampener as part of the crankshaft "flywheel/starter gear." In this feature, they followed a widespread trend of automotive and industrial engine design.

Smooth idle is probably more a function of engine breathing (cam timing, induction tuning, mixture distribution) at low RPM than anything else. Crankshaft counterweights are generally not effective at idling RPM and can actually be damaged by prolonged rough idle operation.

Q: How will I know for sure that the crankshaft and associated parts have been balanced?

A: Engine Components provides written certification of all major repairs and alterations, dynamic balancing included.

Q: Do some engine types benefit more from dynamic balancing than others? (Direct vs. geared; counterweighted vs. non-counterweighted; low horsepower vs. high; four-cylinder vs. six; turbocharged vs. nonturbo, etc.).

A: All engines can benefit from dynamic balancing, but the higher the engine RPM and the larger the components, the more critical balancing becomes. The more parts associated with the crankshaft (counterweights, gears, etc.) the more variables exist and the greater the need for dynamic balancing of the crankshaft assembly.

Q: As a charter operator, would a dynamically balanced engine be beneficial for smoother passenger flight, or would they notice the difference?

A: That depends to a great extent on the airplane and the perceptiveness of the passengers. Even if they are seasoned airline travelers, charter passengers may be having their very first experience to piston-powered aircraft; and they tend to be suspicious of small planes anyway. Unlike the higher-frequency vibrations produced by cylinder firing, vibrations as a result of engine or propeller unbalance tend to be in the 15-45 Hz range and may be felt throughout the airframe.

Anything on a small plane which rattles or buzzes does not instill passenger confidence. Every effort should be made to make the charter aircraft feel solid, smooth and quiet. Dynamic balancing of the engine and propeller is a very small investment in a charter operator's most important concerns: safety and customer satisfaction.

Q: Do the OEM's overhaul manuals specify critical component balancing requirements as part of the overhaul process?

A: Generally, no. The assumption is that the overhaul shop does not even have dynamic balancing equipment, let alone approved data or the skill to accomplish the job properly. Overhaul manuals tend to say what not to do in order to avoid getting into serious trouble. For example, don't mix all-aluminum pistons with cast insert pistons, don't install connecting rods having a weight difference of more than 1/2 ounce, don't assemble counterweights with a weight difference of more than 2 grams, etc. Beyond that, the OEM manuals are of little help.

Q: In mathematical terms, how do you define dynamic unbalance? Is there a right way and a wrong way?

A: As with any other physical parameter, unbalance requires a unit of measure; and there are several possibilities. Many makers of balancing equipment use units of measure which are a moment (weight x arm = moment). These units may be gram-centimeters, gram-inches or ounce-inches. Other balancing systems measure the effect of the unbalance moments in terms of the resultant acceleration forces produced. In that case, the units may be inches-per-second (IPS). Dynamic unbalance cannot be expressed simply in terms of weight or mass.

Q: Can the words IMBALANCE and UNBALANCE be used interchangeably?

A: Yes, they can be, although they tend to express slightly different concepts. Imbalance tends to imply an absolute which is the opposite of balance. Unbalance tends to imply the amount of being out-of-balance, an amount which can be reduced or corrected so that it is within acceptable limits.

Q: If I have the critical components of my engine balanced, will there be any special entries made in the engine logbook?

A: As with any other major repair to engine component parts (crankshaft grinding, crankcase welding, cylinder plating, etc.) engine maintenance records must include documentation of engine dynamic balancing in accordance with FAR 43.9 and FAR 43, Appendix B. ECi provides the necessary documentation and maintenance releases to comply with these regulations.

II. Component-Specific Questions

1. CRANKSHAFT ASSEMBLY

Q: Can my crankshaft be balanced if it doesn't have to be ground undersize?

A: Yes, but in some instances the crankshaft may need to be renitrided even if it does not require regrinding. If your crank uses counterweights or has a Lycoming starter gear, we can most likely create a balanced assembly without grinding or renitriding the crank.

Q: Do I need to send in my counterweights along with the crankshaft?

A: Absolutely. Due to manufacturing tolerances of the parts, there is no way to properly balance a crankshaft and counterweight assembly unless the counterweights are actually installed on the rotating crank assembly. ECi can also overhaul and certify the counterweights themselves as well as provide replacement of all parts required for complete assembly, all at very attractive prices.

Q: How much longer will it take to process my crankshaft if I choose the dynamic balance option?

A: Assuming all the required parts are sent in with the crankshaft, normal processing time will not be affected.

Q: Might you add material as well as take off material in order to balance my crankshaft?

A: ECi will balance your engine parts using the same methods employed by the manufacturers, but to a higher degree of precision. Material removal may be required on the crankshaft; but if so, this is accomplished only in areas of the crankshaft designed for this purpose. Material must never be added to any component of the engine for dynamic balancing, especially the crankshaft.

Q: If a bent propeller flange is straightened in accordance with Lycoming Service Bulletin 201, does this have an adverse effect on crankshaft balance?

A: Lycoming Service Bulletin 201 allows bent flanges to be straightened by "bending or facing" within prescribed limits. The best way is to first

straighten the crankshaft flange as much as possible and then face it true. Dynamic balance of the crankshaft could be affected somewhat, depending on the amount and location of material removed by facing. Dynamic balance should always be checked after flange repairs are made.

Q: Tapered 4-cylinder Continental crankshafts are sometimes straightened by chrome plating of the taper. Does this repair affect the balance to a perceptible degree?

A: It could, depending on how true the taper was before grinding and plating. As with flange repairs, dynamic balance should also be checked after repairs are made to tapered crankshafts. The same holds true for crankshafts which require regrinding to .020" undersize. The crankshaft should be balanced after the stress relief and grinding are completed but before the crankshaft is nitrided.

Q: TCM Service Bulletin M90-11 discusses torsional vibration and the relationship to propeller RPM and manifold pressure in the GTSIO-520 engine. Does balancing the crank affect either of these, or is the concern based solely upon the way the engine is operated?

A: The GTSIO-520 engine is extremely sensitive to torsional vibrations. Operation outside of design parameters can easily result in serious engine damage and/or catastrophic failure. Properly calibrated tachometers and MAP gages as well as properly operating fuel systems, ignition systems and balanced propellers are all essential to the life expectancy of the GTSIO-520 engine. Dynamic balancing of the crankshaft and reciprocating parts of the GTSIO-520 can be quite beneficial, but the concerns of M90-11 are first and foremost operational.

Q: If an engine has a prop strike and has to be disassembled and inspected, should the crankshaft be rebalanced before reassembly?

A: If the crankshaft requires straightening of the flange, it should be rebalanced. The crankshaft should also be rebalanced if it has counterweights. Complete counterweight hardware replacement is always advisable during a prop strike inspection, and one or more of the counterweights may require replacement. In that case, rebalancing would certainly be necessary.

Q: Does it do any good to just balance the crankshaft and not the whole assembly?

A: It never hurts to balance anything, but unless a whole assembly is balanced, the effect of balancing one component may be lost entirely. No one would think of balancing the brake drums and rotors and wheel rims of a car but then skip the balancing of the wheel and tire assemblies. The same holds true for crankshafts.

Q: Does an overhauled engine from the factory have a dynamically balanced crankshaft?

A: Yes, it does. However, the question again is to what degree of precision? If the exact position and orientation of crankshaft counterweight installation on the crankshaft is ever lost, it can only be re-established by dynamic balancing equipment.

Q: What is included in the definition of a crankshaft assembly?

A: For balancing purposes, "crankshaft assembly" means the crankshaft with counterweights, bushings, pins, plates and rings; sludge tubes and plugs; propeller flange bushings; TCM alternator face gears (front alternator engines); and Lycoming starter gear supports. While not part of the crankshaft assembly per se, connecting rods affect the balance of the crankshaft assembly. Therefore, complete engine balance must always include balancing of connecting rods and pistons also.

Q: Can a crankshaft assembly be balanced with the connecting rods installed?

A: No. Connecting rods must be balanced for total weight and big end weight so that they have a neutral effect on the balance of the crankshaft assembly.

Q: What is the function of a counterweight on a crankshaft?

A: That depends on the crankshaft. In automotive and industrial engine crankshafts, the integral counterweights offset the reciprocating forces of the pistons and connecting rods. In horizontally-opposed aircraft engines, crankshaft counterweights serve an entirely different purpose. These dynamic counterweights actually serve as pendulums which absorb unwanted and harmful torsional vibrations in the crankshaft. As such, they are absolutely critical to the life expectancy of crankshafts and propellers.

Q: Lycoming makes some 4-cylinder engines with counterweights and some without. Why? Are counterweighted engines "better" engines?

A: During certification testing of an engine type design, a vibration survey must be performed in order to verify that the engine will not be subject to torsional vibrations which could cause failure of the crankshaft, propeller, or other engine parts. Where required, some engines are equipped with crankshaft counterweights in order to reduce torsional vibrations to safe levels. While none of the Lycoming 4-cylinder engines of 160 HP or less have counterweights, most of the more recent 180-200 HP designs do have crankshaft counterweights. There is at least some evidence to suggest that crankshaft flange failures currently attributed to corrosion pits in 160-180 HP non-counterweighted engines might not have occurred, had these engine designs included crankshaft counterweights.

Are counterweighted engines better? Obviously, it costs a few more dollars to manufacture and to overhaul an engine which has crankshaft counterweights. The "better" engine is the one which repeatedly goes to TBO, doesn't have a pile of bulletins and AD's against it and doesn't cost a fortune to overhaul. You be the judge!

Q: What is torsional vibration?

A: Vibration is the periodic motion of a body in alternately opposite directions from a position of equilibrium. Reeds and strings of musical instruments produce sounds through such back-and-forth movement. When the vibration occurs as a twisting motion in opposite directions, it is called torsional vibration.

All piston engines are subject to torsional vibrations because each cylinder alternately decelerates the crankshaft during the compression stroke while it accelerates the crankshaft on the power stroke. These alternating forces cause the crankshaft to twist in opposite directions much like the springs in torsion bar suspension systems. Torsional vibrations may be inconsequential, or they may accumulate to levels which would cause cyclic fatigue of the crankshaft. Torsional vibrations also may adversely affect other engine parts which are driven by the crankshaft, such as the oil pump or magneto drive gears.

Q: Service literature refers to "orders" of torsional vibrations and crankshaft counterweights (first order, sixth order, etc.). What is a vibration "order?" What are the differences between orders with regard to cause and effect?

A: "Order" refers to the number of times a vibration occurs per revolution of the engine crankshaft. Thus, while the frequency of a vibration may change with engine RPM, the order of the vibration will not. A "sixth order" counterweight is tuned so as to dampen a torsional vibration which occurs at a rate of six cycles per revolution of the crankshaft.

First order vibrations are obviously directly related to the rotation of the engine crankshaft and propeller in direct drive engines, or only to the propeller in the case of geared engines. Second order linear vibrations may be related to unbalanced reciprocating parts in a particular cylinder bay. Second order torsional vibrations would occur in a 4-cylinder engine (two power strokes per revolution) while third order torsional vibrations would occur in a 6-cylinder engine (three power strokes per revolution). Some 6-cylinder engines such as the Lycoming VO-540-B1B3 and the TCM GTSIO-520 have six crankshaft counterweights, all of which are tuned solely for third order vibrations.

In many engines, other vibration orders occur as a result of a resonance which occurs between the engine and the propeller. In terms of part geometry it is often more practical to design a crankshaft counterweight system to operate on a harmonic of the basic order caused by cylinder firing. Thus, it is common to find sixth order counterweights (twice third order) in 6-cylinder engines and eighth order counterweights (four times second order) in 4-cylinder engines. A number of other combinations exist, but all basically have their origins in cylinder firing.

First and second order linear vibrations may be most noticeable in the aircraft cockpit or cabin, but they can be minimized by dynamic balancing of the engine and propeller. Torsional vibrations are handled by the counterweight system of the crankshaft, if so equipped, and also depend on proper operation of the valve train, fuel system and ignition system so that there is even cylinder firing. Reduction of any type of vibration is desirable since the wearing effect on related parts of the installation is additive.

Q: Won't dynamic balancing upset the torsional vibration dampening of the crankshaft counterweights?

A: No. Torsional vibration dampening properties of the counterweights are determined by the geometry of the counterweights, bushings and pins. Crankshaft and counterweight assemblies which are dynamically balanced by ECi preserve all torsional vibration dampening orders required by the type design of the engine.

2. CONNECTING RODS

Q: The connecting rod links the reciprocating motion of the piston assembly to the rotational motion of the crankshaft. What do I need to know about the weight and balance implications of this unique component?

A: Just as the rod links rotating and reciprocating components, the weight, or mass, of the connecting rod has both rotating and reciprocating components. The big end of the rod always rotates with the crankshaft at a continuous angular velocity. Therefore, the big end of the connecting rod has a relationship to the rotational balance of the crankshaft assembly. In order to neutralize the potential effect of the big end of a connecting rod on crankshaft balance, the rod must be offset by an opposing rod having an identical big end weight.

The total weight of the rod periodically accelerates and decelerates as the crankshaft rotates. Again, the total weight of a connecting rod must be offset by an opposing rod having the same total weight so that every acceleration and deceleration is offset by an equal and opposing force.

Q: Do all rods in an engine have to be within the same weight category?

A: Matching only the total weights of the connecting rods is not sufficient for dynamic balance, particularly with TCM connecting rods. Mass distribution varies widely from forging to forging. While it may be nice to have all rods in the engine weigh the same, it may not be possible to do so, given the weight differences of forgings. The most important concern in the horizontally opposed engine is to have connecting rods which match in opposed pairs.

Q: How do you weigh the big end of a rod? Aren't the big end and the small end all one piece?

A: In order to isolate the big end from the small end of the rod, the rod must be placed in a special weighing fixture. This fixture supports the rod horizontally with special anti-friction bearings which find the exact center line of both the big and the small ends. The small end is supported off the scale while the big end is supported by the scale, thus giving a reading which is purely big end weight.

Q: How about the manufacturing weight difference of rod bolts?

A: Connecting rod bolts in aircraft engines are very uniform and precisely machined parts. So long as all the bolts in the engine are of the same part number, weight differences are typically less than 1 gram and are insignificant. The same holds true for rod nuts.

Q: Can you safely grind off metal from a rod in order to achieve a balanced set?

A: Yes, of course. That's how rods are brought into some degree of closeness when manufactured. As with crankshafts, the most important considerations are the location of material removal as well as the amount. That's where some engineering expertise is required. Material removal can be minimized by first creating the closest match of opposed pairs. After material removal, restoration of the finishing process used in manufacture is always essential.

Q: Some FAA repair stations have approved processes to grind metal from the cap face, thereby allowing the big end to be rehoned to restore roundness. Are there any balance problems caused by this repair?

A: There are no balance problems, but there are concerns. Once again, it depends on how much material was removed. In some instances, it may be too little to measure. In other cases, it may be several grams. The best advice is to check big end weight and total weight of the rod after repairs are made to the big end ID.

Q: What is the correct way to define connecting rod unbalance?

A: Connecting rod unbalance may be best understood in terms of its effect on the rotational balance of the crankshaft as well as in terms of inertia required for acceleration and deceleration. The best way to gage these effects is to neutralize them by matching big end weights and total weights as discussed above. The best unit of measure for weighing connecting rods is the gram.

Q: Does a connecting rod have a weight marking?

A: TCM rods are marked only by part number which is no indication of rod weight. Lycoming rods are typically marked with a letter suffix to the part number which ranks the rods according to one of five weight categories, as defined in Lycoming Service Bulletin 439.** Some shops use cleaning and blasting processes which may have removed the part number an/or weight category marking. If so, rods should be weighed and marked in accordance with SB 439.

****<u>NOTE:</u>** Revision "A" to Service Bulletin 439 reduced the number of weight categories for most rods from five to three, effectively doubling the

allowable weight tolerance within a category. Lycoming has always allowed connecting rods in the middle weight category for a part number, designated either by the letters "C" or "S", to individually replace any other rod of the same part number, regardless of weight.

3. PISTONS

Q: Do pistons have to be weight matched?

A: Yes, they do since they affect the inertia forces acting on the crankshaft just as connecting rods do. Again, pistons do not have to be identical in an engine. It is most important that they match in opposed pairs. For the past decade, most parts suppliers have been furnishing pistons in balanced (i.e., matched) sets of four or six. When available, these should always be an engine builder's first choice. Weight markings on pistons or boxes should never be taken for granted, though. The wise engine builder weighs all pistons prior to assembly, just to be sure.

<u>NOTE:</u> It is unwise and nearly impossible to balance mismatched pistons. Due to the low density of aluminum, large amounts of material removal result in only modest changes in piston weight. Always match pistons by finding another new piston of the same weight. Never mix new pistons and old pistons in a newly-overhauled engine. Install only NEW pistons.

Q: Will carbon buildup on the top of the piston cause my engine to become unbalanced?

A: In an ideal sense, possibly. In practical terms, no. Carbon buildup will be fairly uniform from piston to piston, but in any case it will not amount to more than a couple of grams over the TBO of the engine. As a percentage of the total inertia forces of acceleration and deceleration of the piston and rod assembly, the small variations due to carbon buildup would not be measurable or noticeable.

4. PISTON PINS

Q: Do piston pins have to be weight matched?

A: Like rod bolts, these uniformly machined parts typically have weights which are nearly identical (2 grams, or less) within a part number.

Nevertheless, their weights should be checked. In Lycoming engines, do not intermix heavy-wall piston pins with thin-wall piston pins. If separate piston pin plugs are used in lieu of pin/plug assemblies, these must all be of the same part number as required by Lycoming Service Instruction 1267.

5. BEARINGS

Q: Do bearings fit into the dynamic balancing equation?

A: No. Again, these are uniform parts, and no practical benefit will be gained from weighing them. The same is true for piston rings.

6. PROPELLER

Q: Should I have my prop dynamic balanced after I balance my engine?

A: Absolutely! The benefits of balancing the engine may be lost unless the same care and attention are also given to the propeller.

Q: What is a Chadwick analyzer?

A: This term refers to propeller vibration analysis and dynamic balancing equipment manufactured by the Chadwick Helmuth Company, Inc., 4601 N. Arden Drive, El Monte, California 91371 (626-575-6161). This equipment allows dynamic balancing of the propeller to be performed on the aircraft within certain limitations and according to FAA-approved balancing procedures. Similar equipment is also available from Dynamic Solutions Systems, Incorporated, 1285 Stone Drive, Suite 102, San Marcos, California 92069-4079 (760-744-0187). Call your favorite FBO or propeller overhaul shop for further information.

Q: Can't I just have the whole engine and propeller dynamically balanced on the airplane?

A: That's the way to complete the job, but it's not the place to start. The propeller should never be used to compensate for unbalance in the engine.

The amount of correction that can be applied to the propeller or spinner bulkhead is very limited, and unbalance should always be corrected at the source. First, the engine should be dynamically balanced. Next, the propeller should be properly balanced by a reputable propeller repair station. Finally, the engine and propeller assembly should be dynamically balanced. Any prop which has been dynamically balanced to an engine must be re-balanced if installed on another engine, or if the engine or the

propeller are overhauled. No two engines or installations are alike.

Q: Speaking of propeller balance, what should I be looking for?

A: First, propeller blades must be closely matched so that they will be aerodynamically balanced in operation. Second, the center of mass in the propeller blades must also be matched. The prop shop must have a "single blade balancing fixture" to perform this operation. Next, the propeller hub and blade assembly must be statically balanced. Finally, the prop and spinner assembly should be dynamically balanced on a dynamically balanced engine.

Be conservative when seeking the repair and overhaul of propellers with bent blades. Vibration can often result from propellers which have blades which have been improperly or excessively straightened. Strain hardening as a result of straightening may cause a repaired blade to flex differently from the other blade(s). The result may be unusual vibrations which cannot be balanced out.