DON'T BABY YOUR ENGINE!

by KEN GARDNER

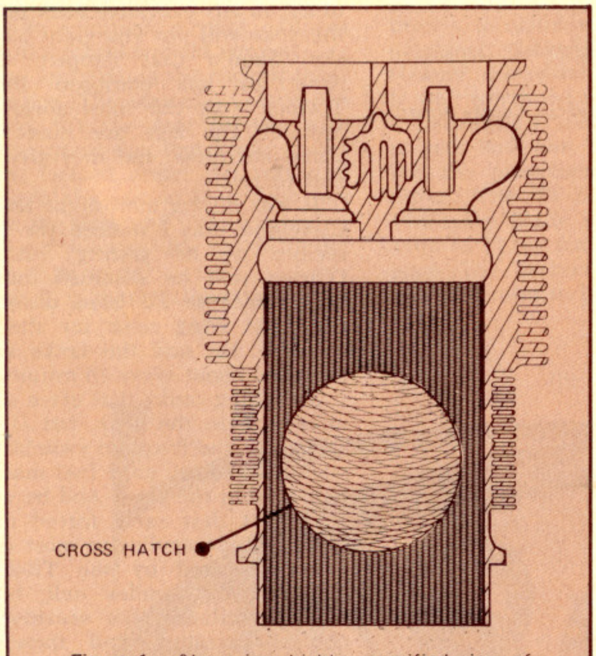


Figure 1. Above is a highly magnified view of the crosshatch pattern honed into the cylinder's surface.

■■ "Engine babiers" mean well; in fact, many have been led to believe that by not using all the available power for takeoff, and by cruising with low power settings, they are conserving their engines.

Usually this type of thinking is the result of experience with the stock automobile engine; however, the aircraft powerplant has very little in common with the stock auto engine in terms of operating procedures. The aircraft engine is the athlete of its species and was designed for high power output. Since this is the case, you are not going to do the engine any disservice by using full power for takeoff and 65- to 75-percent power for cruise.

Even in view of these statements, many pilots are reluctant to fly their engines at high power settings, simply because they are still not convinced that such operation won't hurt the engine. If you are one of those pilots who are "not quite convinced," perhaps it would help if you knew what your engine has to do to prove itself before the FAA grants a type certificate for its production.

Let's say that you're flying an airplane powered by a Teledyne Continental Motors 0-470-R engine. This engine, like any other, began on the drawing board. From the drawing board it became actual hardware, and then it entered the developmental stage. Now a period of considerable testing and refinement follows, until an engine ready for production finally emerges. Before actual production and subsequent sale of this engine can begin, however, it must pass an FAA type test. The first production engine off the assembly will usually be the type-test engine, and here is what a type test involves.

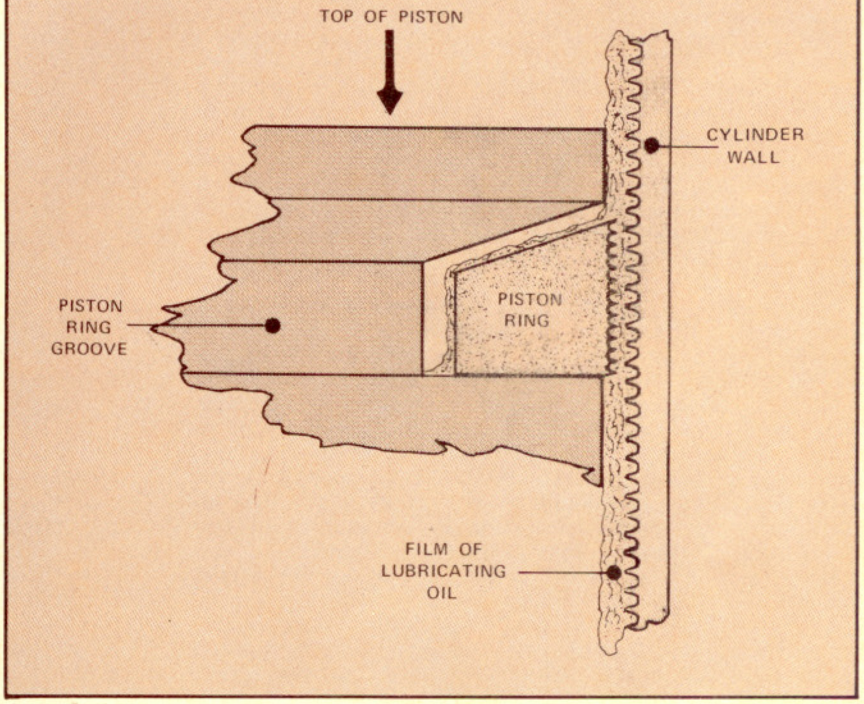
The type-test engine is mounted in a test cell and given a standard production acceptance test. After completion of this series of runs, the engine is ready to begin its type test (also called an "endurance run"). The engine will now be operated at full power (maximum rated manifold pressure and maximum rated rpm) for a period of 50 hours. During this period, the engine's cylinder head temperature (CHT) and oil temperature (OT) will be held at normal range (first two-thirds of the green arc on your airplane gauges).

Upon completion of the first 50 hours, the engine is checked and made ready for the second 50-hour period. During the next 50 hours, the engine will continue at full power—only this 50 hours will be at redline CHT and OT. Imagine that: 50 hours at "full bore" with redline temperatures!

The third and last 50-hour phase will comprise alternating sequences at 65- to 75-percent power and at redline CHT and OT. Often I am asked how we are able to control the temperature with the engine running, especially at full power. Cooling shrouds are placed over the engine in the test cell, and actual cooling air is supplied from an outside blower.

Some pilots do, especially during the break-in period, and the results are often quite discouraging. A Teledyne Continental Motors spokesman tells why

Figure 2. Notice the "sawtooth" surface of the cylinder wall and piston ring face. In this illustration, the piston ring is being held away from the cylinder wall by a film of lubricating oil.



The minimum number of type-test hours required by FAA is 150, and in the sequence just described. Engine manufacturers often exceed this figure by as much as two or three times simply for their own satisfaction that all is well and the engine is trouble free.

After all type-test running is completed, the engine is removed from the test stand and completely disassembled, after which every part is carefully examined. Each moving part is checked with measuring instruments to determine whether any appreciable wear has taken place. Each part must be able to pass the blueprint specifications for new parts.

A type test is quite an achievement in the eyes of most pilots, but it isn't to the engine manufacturer. The type test is simply proof that the engine is able to do the job for which it was designed, and that the materials from which it is constructed are equally capable.

Now let's talk about all the other production engines that will follow the type-test engine.

Each new production engine is given a standard production acceptance test. The last part of this test is the oil consumption run, which is conducted at full throttle. The purpose of this test is initial seating of the piston rings to the cylinder walls. The run is conducted at full power because that is where greatest BMEP (brake mean effective pressure) occurs, and a high BMEP is necessary for good piston-ring break-in. The test house at the factory determines initial piston-ring seating by the amount of oil consumed by the engine during this run.

Only a few hours are involved in the acceptance test, and the new engine is by no means completely "broken in." The finishing-up break-in rests with the pilot who will be flying the engine during the first 100 hours of its life.

The cylinder walls of a new engine are not mirror smooth as one might imagine. A special hone is used to put a diamondlike pattern of "scratches" over the entire area of the cylinder wall. Figure 1 shows a magnified view of these "scratches" (technically defined as crosshatch). This crosshatch treatment plays an important role in proper break-in of piston rings to cylinder walls.

Earlier I mentioned that BMEP was necessary to the break-in process. Here is how it works.

Figure 2 illustrates a cutaway of piston, ring and cylinder wall as these components would appear during normal operation in a new engine of very little time. The illustration is considerably exaggerated for effect; in reality the "sawtooth" appearance would not be that pronounced.

Notice that a film of lubricating oil holds the piston ring away from the cylinder wall. Proper break-in of piston ring to cylinder wall requires that the ring rupture or break through this oil film and make contact with the cylinder wall. During such "metal-to-metal" contact, the little peaks on the ring face and cylinder wall become white-hot and

continued

rub off. This condition will continue to occur until the ring face and cylinder wall have established a smooth, compatible surface between each other. At this point, break-in is said to be relatively complete, and very little metal-to-metal contact will occur hereafter. In fact, as the break-in process progresses, the degree of metal-to-metal contact will regress.

There is one little "sticky wicket" in this process: that film of lubricating oil is there to *prevent* metal-to-metal contact. That's exactly what it will do, and really that's what we want it to do. But during the break-in process we must have some minute metal-to-metal contact, as previously explained; therefore, rupture of the oil film is necessary.

Two factors under the pilot's control can retard this necessary rupture: low power and use of improper lubricating oils during the break-in period. Engine lubricating oils can be divided into two basic categories: compounded (detergent and ashless dispersant) and noncompounded. The compounded oils are superior lubricants, with a greater film strength than noncompounded oils. Consequently, only noncompounded oils should be used during the break-in period.

Some owners insist on using additives or super lubricants along with the regular engine oil during the break-in period. They believe that such practice will aid the engine during its breaking in. With all due respect to such good intentions, this practice is wrong and actually causes harm.

Figure 3 is an exaggerated illustration of oil-film rupture during the normal break-in process. Note that the points, or ridges, of the honed-in scratches have partially worn away. During actual oil-film rupture, only the ridges on the piston rings and cylinder walls contact each other. The little "valleys" between the ridges retain a film of oil and thereby prevent a totally dry condition between piston ring and cylinder wall.

Notice in Figure 3 how BMEP, or combustion pressure, forces the ring against the cylinder wall. This is the key to the break-in process. You can see, then, that low power (low BMEP) won't provide the same results, and the break-in process will require a longer period of time.

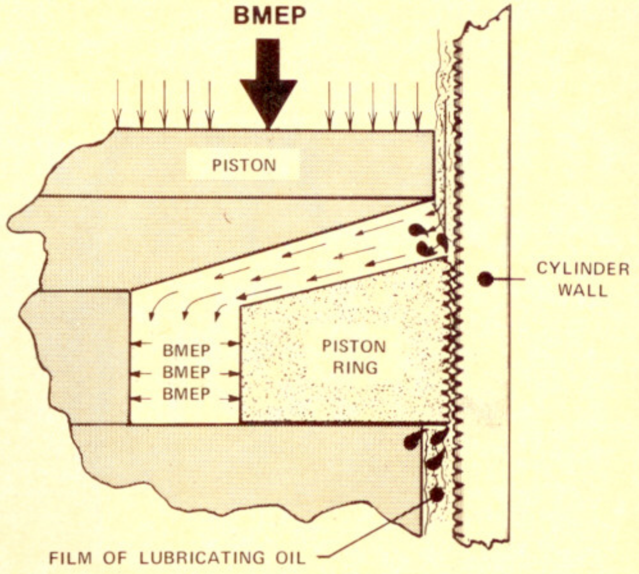
If increased break-in time were the only effect of low-power break-in procedures, it wouldn't matter; however, this isn't the case. Prolonged use of low power during break-in usually results in "glazed" cylinder walls.

During each power stroke, the cylinder walls are subjected to very high temperatures, often 4,000°F or higher. This period is very brief, but nevertheless long enough to cause oxidation of minute quantities of some of the lubricating oil on the cylinder walls. Some of this oxidation will settle into the "valleys" of the honed cylinder wall "scratches." Eventually this oxidation will fill the valleys of the cylinder walls, creating a smooth, flat surface. This is a normal situation; however, the ring break-in process practically ceases when these valleys become filled, or "glazed" over. If this glazed-over condition occurs before break-in is complete, in modernday language, "you've had it." Excessive oil consumption, resulting from incomplete ring seating, will present itself, and the only certain remedy is rehoning the cylinder walls. This is both expensive and unnecessary.

Well, now you know the whole story, so let's examine the few simple steps necessary for proper break-in of any new, remanufactured, majored or top-overhauled engine:

- Pick a good-quality, noncompounded aircraft engine lubricating oil and stay with it throughout the break-in period. Duration of the break-in period is usually defined as the first 50 hours, or until oil consumption stabilizes.
- Drain and replace engine oil as often as recommended by your owner's manual. If operating conditions are unusually dusty or dirty, more frequent draining may be necessary. Remember, no one ever wore out an engine by changing oil too often. Oil changes are more critical during the break-in period than at any other time in the engine's life.

Figure 3. This is an exaggerated illustration of oil film rupture and subsequent ring-to-cylinder-wall contact. Notice how the "points" of the honing scratches have become flat on top. This is how the mating of piston ring to cylinder wall occurs.



- Use full-rated power and rpm for every takeoff, and maintain these settings until you've attained at least 400 feet of altitude above the departure runway. At this point, reduce power to 75 percent and continue the climb to your cruising altitude.
- Maintain 65- to 75-percent power for all cruise operation during the break-in period. Avoid high-altitude operation with nonsupercharged engines during the break-in period; altitudes in excess of 8,000 feet density will not permit sufficient cruise-power development with nonsupercharged engines. Interrupt cruise power every 30 minutes or so with a smooth advance to full available manifold pressure and rpm for 30 seconds, then return to original cruise settings (nonsupercharged engines only)—this procedure helps to hasten a good break-in. (The procedures suggested in this paragraph apply primarily to the break-in period and are not necessary thereafter.)
- Avoid long power-off letdowns, especially during the break-in period. Carry enough power during letdown to keep cylinder head temperatures at least in the bottom of the green.
- Keep ground-running time to absolute minimums, especially during warm weather. During the break-in period, it is better to delay departure than to sit at the end of the runway for 15 minutes or more, with the engine running, in high ambient temperatures.
- Be especially generous with mixture controls and cooling air during break-in. All takeoffs should be made with full-rich mixture except takeoffs from altitudes in excess of 5,000 feet—and then take care to lean only enough to restore power lost from overly rich mixtures. Make your climbs just a little flatter in hot weather, to assure adequate cooling air.

Follow these simple recommendations and your engine will reward you with a healthy service life. Above all, don't baby your engine during its break-in period. ☐