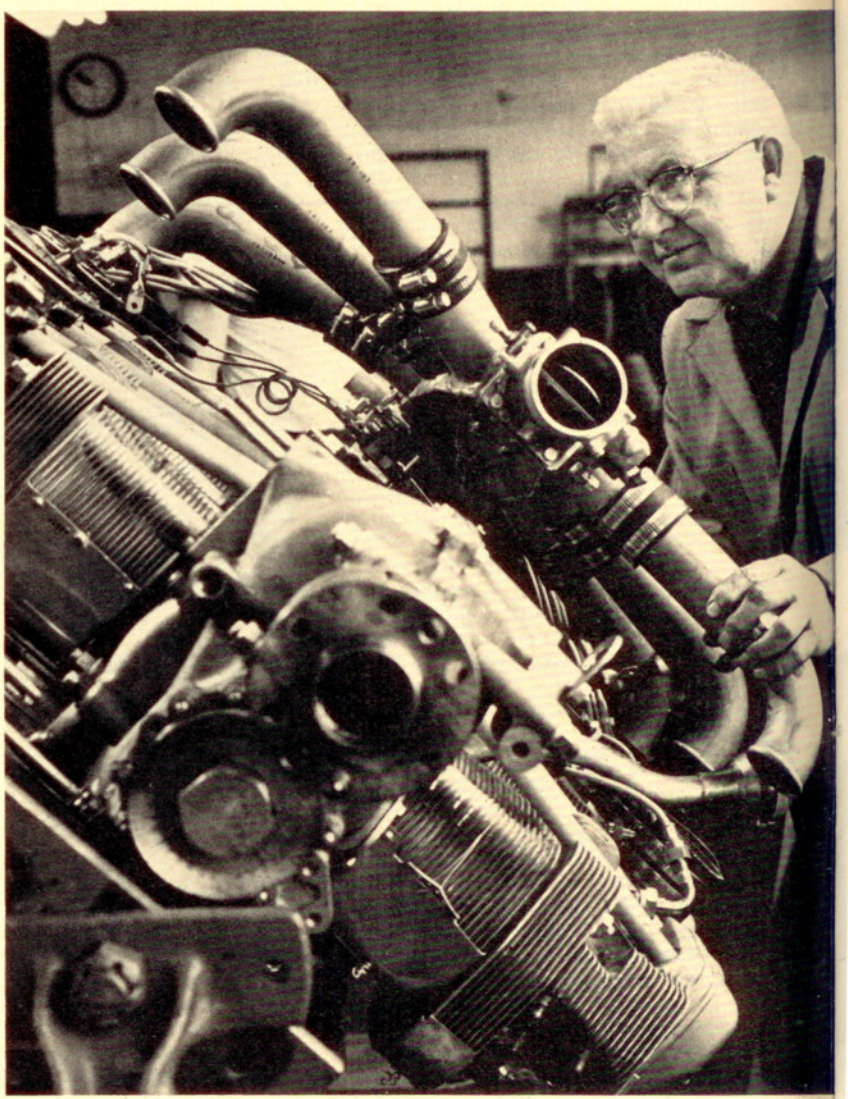
When Should You Overhaul?

There's more to it than looking up a TBO



by KEN GARDNER / AOPA 132319

■■ There are few, if any, airplane owners who haven't faced the dilemma of when to overhaul.

With proper care and operation, the average aircraft engine will last a long time, but even normal wear will eventually necessitate extensive repairs such as a top overhaul (TOH) or a major overhaul (MOH). Such repairs are quite expensive and certainly not anticipated with any degree of enthusiasm. Then there is the element of safety as well. No need to explain the feelings associated with flight behind an engine of doubtful condition, especially at night.

So far as the overhaul decision is concerned, some might say, "That's easy, the engine manufacturers publish the time between major overhaul (TBO) for each of their engine models." Indeed, the engine builders do provide such data, however the published TBO figures are recommended time periods based on a mean average. Such numbers do not consider the worst nor the best situations possible; neither does the TBO consider the likelihood of a possible TOH.

Under ideal circumstances many engines will easily make it

to their respective TBO without having to be topped along the way. In actual practice, the operating and maintenance conditions vary to such a degree that it is virtually impossible for the manufacturer to accurately predict engine life beyond a calculated average. Thus, the TBO number is, at best, a good guide line.

There are reliable means of determining an engine's nearness to an overhaul and the more you know about your engine's background the easier such diagnosis becomes for you. The starting point is engine history which can be summed up in two basic categories—complete and incomplete knowledge of the engine's history. For example, an owner who has purchased his airplane new and was always the sole operator has a complete knowledge of his airplane's engine.

A complete historical knowledge would embrace such situations as the original engine undergoing major repairs, such as TOH, MOH, or even replacement. Consequently, the owner is aware of every hour that engine has flown, the operating procedures practiced and all maintenance performed. He will be equally aware of any abuse or neglect as well. Subsequently, this historical background, both proper and improper, will play an important role in helping the owner decide when the engine is ready for an overhaul.

The other category can be considerably more difficult due to ignorance of the engine's history. For example, an individual acquiring a previously owned airplane may know little if anything about its history. The purchaser may have the opportunity to talk with the original owner and if he is honest, and many are, all well and good. But, I have seen honest owners unknowingly abuse an engine and it's against human nature to admit such things even when it is obvious.

The FAA requires the aircraft owner to maintain log books on both the airframe and engine. Some owners do a very creditable job, but many do not. I have examined log books and frequently learned exactly what the owner intended—nothing. For example, a propeller strike resulting in sudden engine stoppage must be entered in the engine log book. I know of actual cases where the owner, not an A&P mechanic, removed the damaged propeller, installed another and made no entry in the aircraft or engine logs. Illegal, improper, dishonest—yes, but it does happen.

Such unscrupulous incidents are not limited to prop strikes. Wrecked airplanes have been removed from the scene without FAA knowledge, repaired and returned to service with no entry in either of the aircraft's log books. There are owners who consistently enter less time in the airplane's logs than the actual amount flown. Fortunately, such incidents are still the exception rather than the rule. Nevertheless, an individual acquiring an aircraft of doubtful history must consider such possibilities with regard to determining engine overhaul time. The manufacturer's recommended TBO won't be too helpful if you don't know the actual number of hours on the engine.

You may have acquired a previously owned aircraft that has low hours since a TOH or complete MOH. This could be to your advantage, but it could also be otherwise. A TOH at 1,800 hours on an engine with recommended TBO of 2,000 hours may not amount to much if you are faced with an MOH 200 hours later. Or a similar engine, with only 200 hours since an MOH, isn't necessarily going to give you 1,800 more hours before requiring another overhaul. In such situations, you need more factual data about the type of work previously performed.

An engine with only 200 hours since a fresh MOH sounds good, but the term MOH can be misleading. That terminology is *supposed* to indicate that an engine is completely disassembled, inspected and reassembled to factory specified limits—but which limits? There are two separate sets of factory specified limits. One set specifies new engine limits and the other specifies service limits.

A part may be worn beyond new limits and still be within service limits. Consequently, an MOH could be an engine completely restored to its original new limits, or to the opposite extreme, just barely satisfying service limits, or anywhere in between.

Thus you need to know what kind of MOH that particular engine received—new limits, service limits, or somewhere in between?

It would not be difficult if engine overhauls were properly labeled. For example, we already know what a new engine embodies. Next is the remanufactured or rebuilt engine. Such an engine is overhauled to new engine limits throughout. Last is the service overhaul. This engine is reassembled to at least specifies service limits.

The issue is confused by independent engine shops that completely overhaul engines to brand new limits, in some instances turning out better quality than the original manufacturers. Technically, such engines are rebuilt, only the independent shop isn't allowed to use that word. The really good shops must confine themselves to the same choice of words that also label inferior work.

Only the original engine manufacturer is permitted to call an engine overhauled to new limits "remanufactured". Excellent, mediocre and poor, then, are labeled with one "catch all" term, namely MOH, and, as usual, it's up to the consumer to ferret out the difference. Fortunately, this can be done. First, ask to see the overhaul records showing exactly what parts were replaced and how extensive was the work. Don't try to do this yourself unless you are quite familiar with what is involved in an MOH. Hire an A&P mechanic you can trust to do this for you.

If records aren't available, find out who performed the overhaul and check that agency's or individual's reputation. If that isn't possible, you are left to assume that the engine may very well be in doubtful condition. If you are buying an airplane under such conditions, make your doubts known to the seller. If he is sincere and reputable, he or the agency will usually make every effort to provide the information you seek.

Now let's examine the next area of clues that signal need for overhaul. One of the most noticeable indicators of engine wear is increasing oil consumption. With a new engine, observe the oil consumption in order to establish a pattern or trend. One would think that all new engines of a particular make would be the same in terms of oil consumption, and to some degree they are; however, no two engines are exactly alike, therefore, some minor differences will develop.

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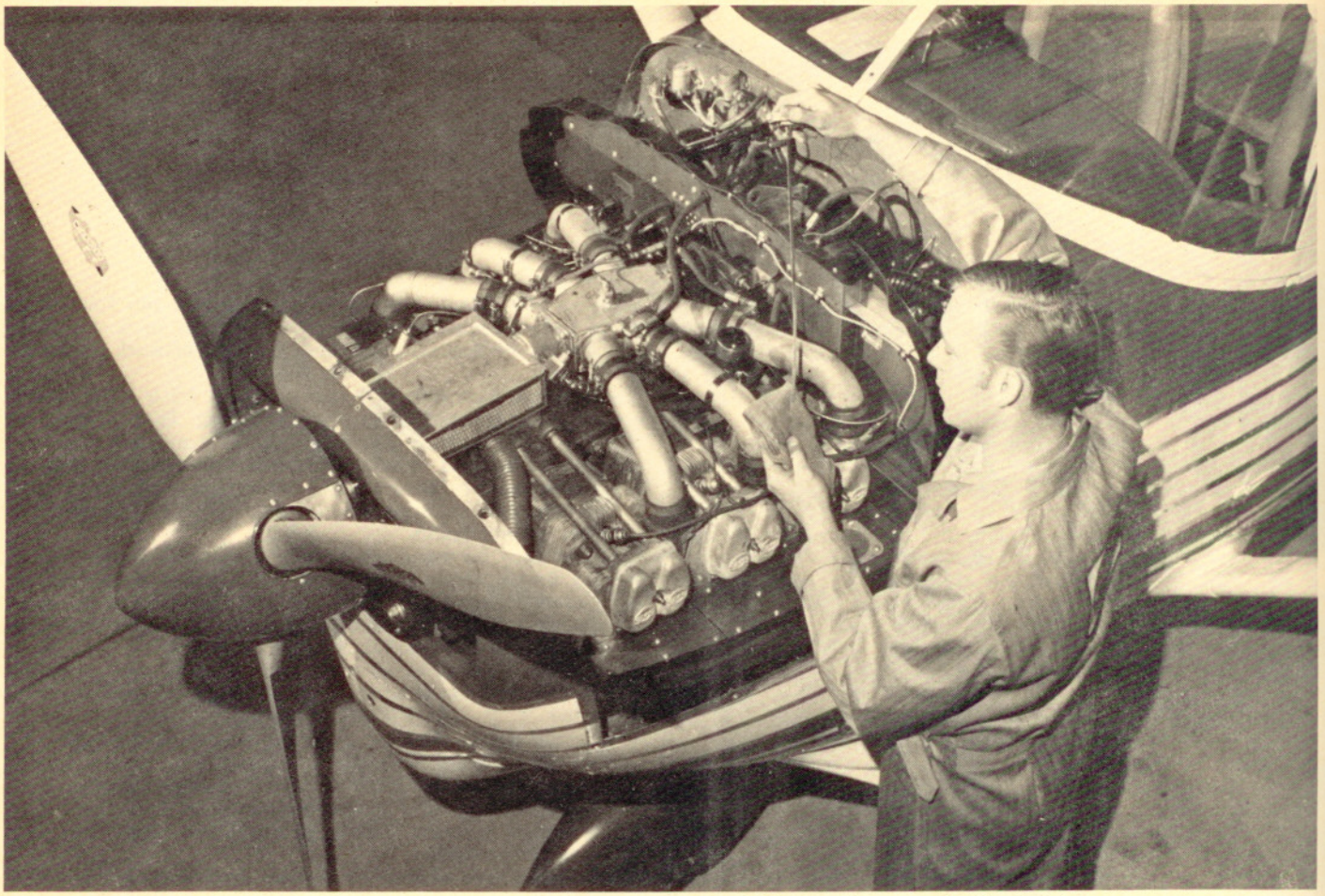

Maintaining an oil consumption history is one of the ways an airplane owner can spot indications that an overhaul is needed.

Oil consumption with a new engine will decrease during the first 25 to 50 hours and should be stabilized at the 100-hour mark. A new Continental IO-520 in a Beechcraft Bonanza might use one quart of oil in three hours at the very beginning. By the end of 25 hours, consumption could be one quart per five hours, or perhaps even one quart in seven hours. If consumption now holds at, say, one quart every seven hours, the situation has stabilized and should remain that way.

The normal average for an IO-520 engine is five to seven hours per quart, some engines consuming slightly more or less. What is most important is the consistency of consumption. Some owners tend to judge the quality of their engine by the amount of oil it consumes. Thus, an engine getting nine hours per quart would be a better engine than a similar model that averaged seven hours per quart. Such a comparison is, at best, a poor indicator of engine quality. Consistency of consumption, within normal limits, is more important than amount.

Once a consistent oil consumption is established on a new engine, the owner should note the amount in his engine log book for future reference. As engine hours accumulate, oil consumption should be compared to the original, stabilized figure. If oil consumption suddenly increases, something is wrong. Under such circumstances, the engine should be checked immediately by your maintenance facility. A sudden increase in oil consumption could be caused by one or more of several factors, such as broken piston rings, restricted crankcase breather, faulty wet vacuum pump or oil separator, external oil leaks, or other problems.

A gradual increase in oil consumption is nearly always an indication of cylinder, piston ring and valve guide wear. A compression check, competently performed, will usually verify a wear situation. Another way to verify that increasing oil consumption is due to cylinder and piston ring wear is spark plug examination. The plugs should always be dry when removed from a healthy engine (opposed type only).

If all of the bottom spark plugs are wet, but the top plugs are dry, excessive wear in the valve guides is usually present. When the top plugs are equally oil-wetted, excessive ring and cylinder wear are likely. Normally, piston ring and cylinder wear is a very gradual occurrence and the resultant increase in oil consumption will be equally gradual.

While a gradual increase in oil consumption usually does signal excessive ring and cylinder wear, it is not necessarily an indication that an MOH is needed. This is where historical background can be helpful. For example, a particular owner has owned and operated his engine since new. This particular engine has a TBO of 1,500 hours; however, at 900 hours, the oil consumption is definitely on the increase. The owner has, to the best of his knowledge, operated the engine properly and provided adequate maintenance. Oil-wetted spark plugs, along with a compression check, verify excessive ring and cylinder wear.

However, minimum oil pressure at idle and cruise are the

same as when new. Oil pressure is another useful clue in determining the engine's mechanical condition. Oil pressure is simply a measure of the resistance encountered by oil flow through the engine's lubricating system. The clearances between moving parts are less on a new engine; consequently, the resistance to flow will be greater and likewise the oil pressure.

Earlier I mentioned that an owner should record stabilized oil consumption figures in the engine log. At the same time, it would be wise to record idle and cruise-speed oil pressures as well. Cruise-speed oil pressure should be the value indicated at normal cruise power with normal engine and oil temperatures. Idle oil pressure should be taken with the engine idling at minimum specified idle speed and after an hour or so of cruising flight to assure normal oil temperature. The log book entries should be the mean average of a dozen or so such observations to assure an accurate assessment of overall conditions.

The engine and airframe manufacturers' operating manuals state minimum idle and cruise oil pressures. However, variations between engines, gauges, etc., can result in noticeable differences. In the interest of detecting any future difference you should make your own observations and subsequent recording at the onset of a new engine's life.

Back to the 900-hour engine in our example. If hot engine oil pressure at idle speed is where it always is, along with the other historical factors mentioned, it is reasonably certain that only a TOH is necessary. Of course your mechanic must be the final judge, but the odds are in your favor. If you wonder why you must have a TOH at 900 hours on a 1,500-hour TBO engine, I cannot answer that question. Usually such a need can be attributed to abuse areas such as excessive use of high power (over 75%), inadequate air filter and oil change maintenance, excessive ground operation, over-heating, excessively lean mixtures and so on—but not always. There are situations where properly operated and maintained engines require a TOH well in advance of the TBO expiration.

Also within the realm of the new owner is the situation of an engine reaching its TBO and showing no signs of deterioration. The question will nearly always be, "What do I do now?" Actually you have two choices—have the engine overhauled, or continue operating until it does show signs of deterioration.

There are no FAA regulations that require you to have an engine overhauled at its TBO. If you choose to continue operating you would do well to have the engine checked every 100 hours for signs of deterioration. As long as the engine continues to run well, oil consumption and pressures remain stable and you can still attain rated power and airspeed, there should be no need to overhaul. Notice, I introduced two new items, rated power and airspeed. These are two more factors that can aid you in overhaul determination.

When an engine becomes worn enough to begin losing its efficiency, it also develops less power for the same instrument readings. If your airplane is equipped with a fixed-pitch propeller, you will do well to observe the maximum rpm it can develop for full-throttle static and takeoff roll conditions when new. These observations should be made after the engine is approximately 100 hours into its life.

A new or rebuilt engine will be a per cent or so shy of its rated power until it is well broken in. When you make such observations always be cognizant of ambient conditions. If ambient temperatures and pressures are different between checks, the rpm can be affected. The checks should always be made at the same airport and under no-wind conditions. A few like observations in the beginning should give you a basis for future reference comparisons. When the engine begins to lose its efficiency from excess wear, it will show in an inability to reach the static and takeoff rpm possible when new.

An even more accurate check can be made with airplanes equipped with constant-speed propellers. When the engine is only 100 hours old make some airspeed observations relative to manifold pressure and rpm. For example, select a manifold pressure and rpm setting that will deliver 60% power. Note the maximum indicated airspeed attainable with these settings.

Make a similar check at 70% power and note the indicated airspeed. Repeat this check several times to obtain a mean average at each power setting. When you are satisfied that your observations are accurate, record the data obtained, along with altitude and ambient conditions, in the aircraft—not engine—log book for future reference. When the engine does wear sufficiently to lose efficiency you should notice a lesser airspeed for the same power setting used to establish your original figures. When making future checks for comparison with the original one, be certain that you select altitudes and ambient conditions as alike as possible to those of the original check.

Now let's sum up the items that will help in determining when your engine is getting near to overhaul:

1. A complete background history of the engine from new, regarding operation and maintenance care, is most helpful.
2. A gradual increase in oil consumption from an original and consistent level signals excessive piston ring and cylinder wear.
3. Consistent oil wetting of the spark plugs, especially the top plugs, indicates valve guide, ring and cylinder wear.
4. Compression checks that consistently indicate below normal readings warn of excessive wear and the need to overhaul.
5. A gradual deterioration of engine oil pressure at cruise and hot idle from the original numbers usually is indicative of excessive wear throughout the engine. Necessity of an MOH is quite likely.
6. Inability of the engine to match its original power, a gradual inability of engines equipped with fixed-pitch propellers to attain static and takeoff rpm equal to original values will usually mean wear to the point of engine efficiency loss. When this is true, a TOH or MOH is at hand.
7. A gradual and consistent inability of constant-speed propeller-equipped airplanes to match original airspeeds with like power settings nearly always signals a needed TOH or MOH.

Items 2, 3, 4, 6 and 7 are indications of top-end wear and may signal the need for only a TOH. It is here that item 1 really counts. It is seldom likely that a 900-hour engine, since new or overhauled to new limits, would need an MOH.

In situations where background history isn't available, or untrustworthy, Item 5 can be helpful by comparing actual readings to owner's manual specifications.

An owner who replaces his run-out engine with a new engine, or an engine overhauled to new limits, or has the original engine overhauled to new limits, has the opportunity for a new and continuous background history. Although a background history is not the complete answer to when to overhaul, it helps considerably.

Some will surely note that I did not include an engine overhauled to service limits in the preceding paragraph. This was intentional, but not prejudicious. An engine overhauled to service limits could have a variety of fits ranging the complete wear spectrum from service limits to brand-new. Such a situation makes it difficult to determine an accurate starting point, since parts already worn have a head start on the new parts having no wear. Neverthless, such an overhaul, when competently performed, should render an airworthy engine of satisfactory behavior.

The aids previously described can be useful in this situation as well. However, it may be a bit more perplexing due to the variables existing at the onset. The final and perhaps most important of all aids in determining when to overhaul is to seek the guidance of a reputable A & P mechanic or overhaul agency. □