How to Make It to Your TBO

There are no guarantees that your engine will last to its recommended overhaul time, but you can tip the scales in your favor

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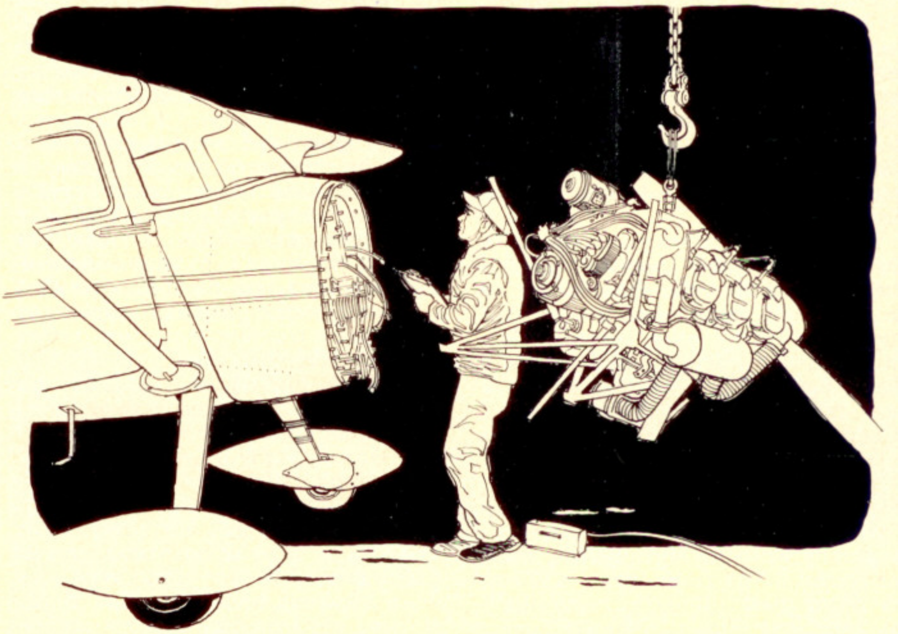

For those unfamiliar with the letters TBO, they are an abbreviation for "Time Between Overhaul"—specifically, the recommended number of engine operating hours between major overhauls.

There are probably few, if any, aircraft owners who do not care about the number of hours they are able to get between major overhauls. The big question is, "Will my engine make it to its TBO before requiring any major repairs?" Yes and no. Yes, because actual records show that many engines do make it to their recommended TBOs with no major repairs required. No, because some engines don't.

The two most logical questions that follow are "What are the odds in my favor?" and "What makes the difference?" Maintenance records reveal that more engines make TBO than don't, so the statistics are in your favor.

What makes the difference includes a number of factors. Some engines do not make their TBOs because of mechanical failures which are not the fault of their owners.

But improper care and poor operating technique are the paramount factors affecting engines that do not make TBO. Most aircraft owners and pilots care about the proper care and feeding of their machines. The basic problems are often insufficient or incorrect information. Let's examine some of the factors that can shorten engine life.

Operating practices will be examined first. Oddly enough, infrequent operation is one of the worst offenders. It is difficult to believe that a machine can actually wear out more quickly from lack of use. A TOH (top overhaul) involves piston ring and valve service. A large number of TOHs are due directly to infrequent engine operation. How can wear occur when nothing is moving? Actually, the damage is not due to wear but from rust and corrosion. The oil that lubricates your engine also protects it from such rust and corrosion by the film it leaves on all internal parts after engine shutdown.

Cylinder wall lubrication is usually accomplished from oil slung into the cylinders from the connecting rod bearings and, in some instances, from squirt jets drilled into the connecting rods.

The oil has to go some distance through the engine before it reaches the connecting rod journals. Consequently, some engine motion will occur before oil reaches the cylinders. In seven days of inactivity sufficient oil has drained from the cylinder walls to permit minor scuffing (metal to metal scraping) to occur with initial start-up, before lubrication resumes. Naturally, this scuffing affects piston-ring and cylinder-wall life.

Fourteen days without running adds the possibility of rust and corrosion to scuffing. Each time the engine doesn't run for extended periods you stand to lose a little more of its possible TBO to rust, corrosion and scuffing. Cylinder wall wear of only .001 inch increases the overall cylinder bore diameter by .002 inch. That may not seem like much, but it is. A new cylinder of a typical aircraft engine will have bore dimensions of 4.433 inches minimum diameter to 4.436 inches maximum diameter.

The maximum allowable service (reusable) limit for that cylinder is 4.438 inches in diameter. Cylinder wear beyond the service limit requires extensive rework or replacement. Assuming minimum cylinder dimensions at the start, you have a total of .005 inches permissible wear. That's only .0025 inches cylinder wall wear, when you consider that it will double itself in terms of cylinder diameter. Therefore, .001 inch of cylinder-wall wear and/or rust damage constitutes a reduction of nearly half the cylinder's normal service-free life.

What can you do to prevent such wear? The simplest solution is to fly your aircraft frequently. The more frequently you fly it, the more you increase the possibilities of reaching the TBO.

Another area of operation that is critical to engine service life is ground running. Nearly all air-cooled engine installations since World War II are of the pressure-cooling type. Proper cooling depends on the ram effect achieved in forward flight. Very little cooling air enters the cowling from propeller-blast, although some cooling air flow through the engine compartment is achieved by low pressure areas on the lower cowling and cowl flaps created by propeller blast. This usually provides sufficient engine cooling during normal ground operations, such as taxi and run-up.

However, prolonged engine warm-ups, full-power run-ups, extensive departure delays and extremely long downwind taxiing can exceed ground cooling capability. Ground operation that results in cylinder head temperatures (CHTs) and oil temperatures at or near their top limits can reduce service life. Various engine components can become overheated, producing the same result.

High ground-running temperatures can easily lead to excessive temperatures in the accessory section as well. This can shorten the service life of rubber and plastic components. It also increases wear in accessories such as magnetos, generators and vacuum pumps. Above 40°F, ground running should be minimized. As soon as the oil pressure stabilizes after engine start, taxi to the runup area. Conduct the prescribed runup, but do not prolong it.

Takeoff should begin as soon as possible. The engine should be ready to accept takeoff power if it accelerates to full throttle and maximum rpm without hesitation.

At temperatures below 40°F it becomes a different ball game. There are only two basic areas of concern when operating in extremely cold temperatures (20°F or less). They are sufficient vaporization of fuel to support starting combustion, and adequate fluidity of the oil. Aviation gasoline is not seasonally blended as automotive fuels are; consequently, the lower the ambient temperature, the more difficult fuel vaporization for initial starting. Excessive engine cranking caused by this condition uses up cylinder wall lubrication before it can be replenished. Raw fuel can dilute or completely wash away existing cylinder wall oil.

Adequate preheating will prevent these ill effects. The pour point of SAE 50 (aviation grade 100 or Mil. spec 1100) is approximately 10°F; for SAE 30 (AG 60 or MS 1065), it is about 0°F. Thus, even SAE 30 is not adequately fluid at 10°F for satisfactory lubrication. With skill a pilot can start an engine at −10°F without preheat; however, he is risking the normal service life of his engine if he does it.

At temperatures below the oil's pour point, it becomes thick and grease-like. In such a state, oil cannot lubricate properly.

If the engine can't be preheated, keep the rpm as near to idle speed as possible after starting. Quite obviously, oil heating is the problem here, not engine cooling—therefore, an extended warm-up period is necessary.

Steep climbouts to cruising altitude in hot weather are another way to overheat engines and accessories. The effects can reduce service life just as with ground overheating. When high temperatures prevail, increase climb airspeed to keep CHT and oil temperature within the normal ranges.

Improper or excessive leaning is another way to shorten your engine's TBO. Improper leaning above 75% power, such as with high density altitude takeoffs (in excess of 5,000 feet density altitude), can summon destructive detonation or preignition. These two evils are not always immediately destructive to the point of engine failure. Incipient detonation can, and frequently has, caused the type of damage that results in a premature TOH.

Climb leaning is another sector of operation where care must be taken with regard to proper procedures. Climb power is nearly always in the high range. Needless to say, high power output coupled with less-than-optimum cooling airflow should not be compounded with excessively lean mixtures.

The added fuel flow of a rich mixture aids in internal engine cooling. Not only does a lean mixture negate this benefit, but it adds to engine temperature. Contrary to common acceptance, lean mixtures by themselves are not the hottest; however, their slower propagation (combustion speed rate) exposes the combustion chamber to the high temperatures of actual combustion for a longer period of time. It is this fact that causes engine temperatures to rise because of lean mixture operation. For high-altitude takeoff and climb, lean only enough to prevent overly rich mixtures. Attention to this detail can help keep your engine out of the shop before its time.

While cruise power mixtures can be considerably leaner than those for climb, this also can be practiced to an extreme. Excessively lean mixtures (at or near engine roughness) at high cruise power (65% to 75%) can cause valve and cylinder damage. Here again, the correct procedures are a must if you wish to avoid a premature overhaul.

Burned valves are not the only service problem to be traced to overly lean mixture operation. Continuous exposure to the prolonged combustion temperatures attendant upon lean mixtures breaks down the oil, especially in the upper cylinder areas. This effect leads to accelerated piston-ring and cylinder wear. Stuck piston rings from carbonized oil are still another result. Miserly gains in fuel savings from leaning could be greatly offset by the cost of a premature overhaul, so don't overdo leaning if you intend to make it to recommended TBO.

Fast, power-off descents from high altitude are a good start for an advanced meeting with the people who overhaul engines. Some pilots fly almost to their intended destination, pull the throttle full back, push the mixture full rich, then literally fall out of the sky to their intended airport. The resultant high rate of temperature change is enough to cause warped, distorted and cracked cylinder heads if practiced frequently. Also, allowing the propeller to drive (windmill) the engine causes counterweight detuning in some engines and continues to be a suspected cause of internal flutter caused by breaking piston rings.

Full-rich mixtures foul spark plugs, combustion chambers and oil. That all adds up to possible premature overhaul. Descent power should be ample enough to maintain minimum green arc CHTs, which is usually enough to drive the propeller rather than have it drive the engine. Mixture leaning for descent should be practiced carefully because that is every bit as important in the life of your engine.

Just operating the engine is not enough. It must be properly maintained as well. The primary source where dirt enters an engine is through the induction system. Once abrasive dust and dirt are taken into the cylinders they find their way into the crankcase and eventually into every part of the engine. Mixed with the oil, dirt becomes an abrasive compound and rapidly accelerates wear.

The induction air filter originally fitted to the engine will effectively keep out approximately 98% of such harmful materials if it is serviced as required and replaced as needed. All too frequently this filter goes unattended and may be serviced only once each 100 hours or so. Most filters will require servicing every 25 hours of operation, or more often if conditions are worse than average.

Many modern aircraft have alternate air doors in their induction systems. These doors may open automaticly should the filters become clogged. Normally, automatic opening of these doors would occur only when impact icing clogs the induction air filter. However, the doors will also open if sufficient dirt blocks the induction air filter, allowing unfiltered air to enter the engine induction system.

Air filters vary in size, shape and type of filter material employed, but all have definite limits to their effective service life. The nonserviceable-type filters may be treated with a dust-attracting agent and cleaning is seldom recommended although, as with other filters, airflow will decrease with accumulation of dirt. The serviceable types, such as oil-wetted flock, will eventually wear away, thus reducing the filter's effectiveness. Whatever the type filter, it is important to keep it in effective operating condition in order to attain full service life of the engine.

Infrequent oil changes also rank high in reducing engine TBO. The theory that oil does not wear out continues to persist, despite the proven fact that it does suffer permanent damage from molecular shear and heat. But, even if oil didn't wear out, it becomes contaminated with dirt and harmful liquids. Contamination makes frequent oil changes essential for normal service life.

Contamination of oil begins the moment the engine starts and continues during engine operation. Most contaminants are not soluble in oil and settle out when the engine is at rest. Present-day dispersant oils will hold most liquid and considerable particulate contamination in suspension until the saturation point is reached. At that point contaminant precipitation will occur just as with nondispersant oils. The recommended oil change intervals are determined by such factors. Most service recommendations are based on average operating conditions. Excessive contamination from unusually dusty or severe cold operation could require more frequent oil change periods.

Contamination deposits can affect operation of hydraulic valve lifters and other parts of the engine that are also susceptible to sludge fouling. Impeded oil passages are certain to result in higher internal temperatures and increased wear rate. A good oil filter is a definite advantage; however, most oil filters remove only the particulate matter of harmful size. Even if an oil filter existed that would remove every single contaminant there would still be the problem of shear and heat damage. Proper oil changes are important to engine life.

There are other areas of operation and maintenance that affect engine life; however, the ones presented are those most commonly encountered. The best possible advice continues to be the recommendations found in the engine manufacturer's operating manual. □