Cold-Weather Starts

Grinding away on the starter is no way to wake up a cold airplane. Warm it and prime it like you know what you're doing

-by Raymond Leis

There is a peculiar high-pitched whining, grinding noise that vibrates your eardrums on those very cold mornings where your breath hangs in the air in little moisture puffs. This screeching sound is only found at airports.

Your eyes don't need much of a search to find the source. A general aviation pilot, struggling to start his airplane engine, is doing it the hard way. If, eventually, the engine fires before the battery goes dead, the power usually comes up to high rpm with a great roar. The pilot is happy, but the engine is practically destroying itself as it is being "warmed up."

Not much of the cold-thickened oil is getting to those vital moving parts. After spending a night in sub-zero temperatures, the oil has become a higher form of tar. The valve train and the cylinders get little if any lubrication until the oil warms up. The main bearings make metal-to-metal contact because they have squeezed against the crankshaft.

Steel, aluminum, copper and nickel are the metals the engine is made of, and they all expand at different rates after engine start. The aluminum pistons will expand rapidly within the steel cylinders, which means a great amount of grinding wear because the oil is still syrupy. This is some of the most damaging wear an engine may ever get, leading to either unnoticed engine damage or an early engine overhaul.

But cold weather doesn't limit its intrusion to the engine. The instruments – engine and flight – don't work well in extremely low temperatures, either. For example, the gyro instruments will be forced to turn at 30,000 rpm or more, and cold weather can mean lubrication problems for them as well.

Batteries can be destroyed by freezing temperatures. A battery that has a full charge can survive, but one that has gotten weak or is getting old can freeze. The only way to fix that is with a replacement.

Think Lubrication

During cold weather, oil is a big factor to consider. Oils thicken as the temperature drops, and stiff oil means the engine is going to resist being turned by the starter. Summer's heavyweight oil certainly won't work for a cold weather start.

The viscosity of oil is described by Society of American Engineers numbers. A test container of oil is drained through a small opening. The time it takes to drain becomes the SAE number for that particular oil. So, SAE 50 weight oil is an oil that takes 50 seconds to drain. A smaller SAE number means the oil is thinner, or less viscous, and more suited to winter operations. Heavier oil works best when it's hot. Incidentally, the viscosity numbers are different between aviation oil and automotive oil. Aviation SAE 100 oil is comparable in viscosity to automotive SAE 50 and aviation SAE 65 is like automotive SAE 30.

Multi-viscosity ashless dispersant oil is the oil of choice for many aviators in the winter because it emulates the viscosity of different weights of oil at different temperatures, getting thinner as it gets colder. A 20W-50 oil has a viscosity range from grade 20 up through grade 50. It also will mix with other grades. A commonly used multi-viscosity oil is 15W-50, which can be used in temperatures as high as 100 degrees F. Surprisingly, it also has a “pour point” of -30 degrees F. These AD oils do an excellent engine-cleaning job, which is another plus. Because these oils are thinner – they flow quickly and smoothly – they allow the engine to be turned over more easily in cold weather.

Multi-vis oils have been an important development in cold-weather operations. Thumbing through some operations manuals for airplanes with radial engines, built in the 1940s, I have noted that they either had internal systems that pumped fuel into the engine crankcase oil after engine shutdown to thin it for the next start, or the operators funneled fuel directly into the oil. The manuals don’t mention fire hazards, but multi-viscosity oils are a much better solution.

Preheating

What it all adds up to is that a little warmth will go a long way toward saving your airplane’s engine, as well as your flight and engine instruments – and your bank balance.

In very cold weather, pre-heating is the only way to operate airplanes. In a severe winter climate, some cost-conscious aviators even drain the oil out of the engine into a container and take it home. When they go to fly, the warm, sometimes even heated, oil from home gets poured back into the engine for a quick start.

If you have the advantages of an electrical outlet in your hangar or at the tiedown, there are a number of systems for preheating, ranging from a simple light bulb to multi-probe engine pre-heater and gas-powered flame throwers.

For the do-it-yourselfer, small electric space heaters, properly ducted and fed through the bottom of cowling or the nacelles, also work well if you hold the heat in the cowling with a blanket. You do need three or four hours lead time with these, depending on the outside air temperature, but the advent of pager-type devices that allow you to turn on the heaters from any phone helps minimize the inconvenience.

If you opt for electric heaters, take all possible safety precautions. In hangars, consider the dangers from fuel spills or tip-overs of the unit. At a minimum, the unit you use should have a circuit breaker and tip switch installed.

There are a wide variety of engine preheater models available – every A&P mechanic has a pack of ads for every kind. At cold weather airports, the FBOs usually have different kinds for rent. To a certain extent, this lets you try before you buy.

The type of engine you’re heating also affects which kinds of preheaters are appropriate. Carbureted engines are generally hard to start in temperatures below 20 degrees F because the fuel does not vaporize well at cold temperatures. Raw fuel then collects in the induction system.

Fuel-injected engines don’t have many starting problems because the fuel is sprayed directly into the cylinders and intake ports to force vaporization, which makes for better start-up combustion.

Because carbureted engines need to be warm, most operators choose some kind of preheater that warms the entire engine. The top of the line, which uses multiple probes and a pad to heat the oil and the cylinder heads at the same time is the best – and the most expensive. Many owners report good results using only pad heaters on the oil pan.

It takes a little time, but this kind of heater will warm the whole engine through conduction, unless temperatures are so extreme that the cold overwhelms the pad's ability to produce heat. The oil pan heats the case, cylinders and the oil. It takes at least a couple of hours to spread the heat around, and covering the cowling with a blanket is a good way to help prevent swirling winds from undoing the heater's work.

The pan heater is a good method of making sure the oil is in a workable, fluid state. Once the engine is started, the oil temperatures and pressures will come up rapidly. The hot oil will be quickly circulated, lubricating the entire engine relatively quickly.

Another popular way of heating engines involves using a propane heater that blows hot air into the engine compartment – and for some people the cabin as well. While this can be effective, impatience is a danger. The engine may seem warm on the outside, but the core – and the oil – may still be cold-soaked.

Pre-heating only the cylinders doesn't go far enough in protecting the engine from damage to parts operating without lubrication. There isn't much value in letting the sump remain cold while you heat the top of the engine. The thick oil is not going to make its way up to the camshafts, cylinders, tappets and pistons until it's warm enough to flow.

A cold-soaked sump may show up as fluctuating oil pressure upon engine start. The pressure fluctuation is a result of the oil pump, struggling to get heavy oil moving, cavitating because the oil doesn't flow into it quickly enough. Once this happens, only a very small amount of the oil gets pumped through the system. Don't waste any time. Shut down the engine.

If the camshaft doesn't get enough lubrication it will begin spalling. Tappets ride on the camshaft lobes. Push rods, which are connected to the rocker arms that open and close the valves on the cylinder head, are inside the tappets. When there is no oil getting to these moving parts, the result can be chipping and pitting on the surfaces where the tappets ride.

Scraping snow and ice from an airplane is only the first step in getting the thing started and in the air.

The effect is that the valves will lose their tolerances, which leads to improper combustion timing, burned valves, premature wear and uneven cylinder head temperatures. Extreme unheated "warm-ups" can cut engine life to half of TBO or less.

Cold Weather Starting

Most of the time, starting an airplane engine is a simple process. If you follow the proper procedure for the airplane involved and the engine is relatively warm, it starts after a few blades and smoothly warms up. It isn't that simple when the power plant is chilled to the bone.

For one thing it's very important to get the engine started on the first try. If you don't, the first few pops of the partial start will bring in moisture that can condense and freeze on the spark plugs. At that point, starting may require removing and cleaning the plugs before you'll get it to fire.

Given the importance of getting a start on the first try in cold weather, there are a couple of things to check.

First, consider the general health of the engine. It should be well maintained. To function at top efficiency, the magneto points should be properly gapped and the spark plugs clean. The other systems – carburetor heat, exhaust, priming and induction – will all have an effect on the engine's ability to start and run, too.

In very cold weather, use an external power source for starting if at all possible. Batteries have two strikes against them in cold weather: Thicker oil can require more cranking power to get the prop turning in the first place, and the battery has reduced output at cold temperatures. Together, those two factors have conspired to rob many a battery of its ability to crank the engine at all.

Freezing temperatures don't affect a fully charged battery much, but a discharged battery will freeze. Once frozen, it's destroyed. If you run down the battery in a futile attempt to start, don't leave it. Get it charged immediately or you will likely be shopping for a new battery when it freezes.

During your starting procedure, pay attention to correct technique and manufacturer recommendations, if any.

Priming

Being able to correctly prime a carbureted engine is something of an art, but it's enough of a science that there are a few things to consider. First is the temperature you are dealing with. Is it cold and dense? Also, you need to know how the priming lines are installed.

Different models of aircraft, even from the same manufacturer, have primer lines installed in different ways. Some aircraft engines have only one primer line that primes only one cylinder. You'll spend considerable time getting one of those to light up on a very cold day.

You need to know how many cylinders are being primed because the total fuel sent out from the primer will be divided up as it gets sent to the cylinders. With colder and denser air, the amount of priming needs to be increased.

Here's where the art comes in. Every airplane has an ideal number of primer strokes to be used for different temperature ranges. It takes some trial and error to get a feel for what makes a particular airplane happy.

Some pilots leave the primer alone and prime the engine by pumping the throttle. This technique seems to be more popular in airplanes that have primers connected to only one cylinder. The theory is that pumping the throttle causes the accelerator pump to deliver fuel to all the cylinders instead of only one, thereby increasing the chances of a spark setting things in motion.

In practice, however, it's a little more complicated. Pump the throttle too fast and fuel will get splashed into the carb heat box. A backfire at that point could cause an engine fire. If you find yourself in such a predicament, continue cranking to suck the fire back into the engine. If it doesn't go out in a few seconds, give up and get out.

Fuel injected engines are another story, because priming is typically done with the electric fuel pump. The drill is usually to turn the fuel pump on and advance the mixture to allow fuel to flow to the cylinders. Just how long to let it go on is something of an art and depends on the airplane and the temperature, but typically cold starts in fuel injected airplanes are not as troublesome as those in carbureted engines.

The fuel part of the mixture equation is controlled by priming and the air part is determined by the throttle setting. When the temperature is very cold, you need to compensate for dense air by adding more fuel for starting, but you may also need to reduce the amount of air as well.

Many pilots respond to a hard-starting engine by advancing the throttle, but that's exactly the opposite of what they should do. If the throttle is normally set at one-half inch open for warm weather, it may need to be set at a quarter-inch for cold weather. It may take some trial and error to figure out the best fuel/air mixture for any given temperature range.

If the engine just doesn't want to start, grinding away with the starter won't do much more than run the battery down or burn up the starter motor. Run the starter for 10 to12 seconds at a time, then let it rest for a few minutes before trying again. Without the cooling period, the starter will seriously overheat and possibly fail prematurely.

Cold weather operation requires the pilot to keep a close watch on engine operating temperatures. The airplane POH will cover normal temperature operating ranges, but winterization kits are a good idea if outside air temperatures are below 40 to 45 degrees F.

Keep an eye on oil temperatures in flight, because they need to be above the minimum recommended temperature. Combustion leads to moisture in the oil, and low operating temperatures will not vaporize the moisture. If the minimum temperatures are not maintained, the oil should be changed more frequently than the usual 50-hour cycle.

Cold starts are just another skill, not too difficult to learn, but one that can make life considerably more pleasant on a cold, clear winter flight.

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