AIRCRAFT PREHEAT - MISCONCEPTIONS

By: Peter G. Tanis

In the book *Stick and Rudder*, Wolfgang Langweische pointedly differentiated airplanes from cars: "It may sound like one and smell like one, and it may have been interior decorated to look like one; the difference is – it goes on wings. Langweische's point also applies to an airplane's engine – it is not like a car's either.

The reason an aircraft's engine needs different treatment from a car lies in the basic construction of the engine. In an auto, the engine block is usually cast iron and the crankshaft is steel; these metals expand at approximately the same rate when heated. In contrast, the horizontally opposed aircraft engine has an aluminum crankcase supporting steel components such as the crankshaft and the camshaft. The cylinder barrels are steel with aluminum cylinder heads tightly attached.

The rate of expansion for aluminum, as it is heated, is twice that of steel. This also applies as it cools – aluminum shrinks in size twice as much as steel.

Because the engine was designed and assembled at room temperature, its clearances between parts can shrink dramatically when the severe cold of winter jets in. At temperatures as high as -11˚ F, one popular engine can completely lose crankshaft bearing clearance. No wonder they turn over hard when they're cold! Even warm oil can't help when there isn't any bearing clearance. Many pilots have ideas on how to operate their engines in cold weather that come from their experience with their automobiles. As a result there are some popular misconceptions.

Misconception: If you can start it…

Myth: ''The main purpose of preheating is to start the engine: therefore, if you can start it, you don't need preheating.''

Fact: An automobile engine survives quite well when cold-started, but an airplane engine can be severely damaged.

Because of poor fuel vaporization, an engine with cold cylinders is hard to start. But if it is started while they are cold, the cylinders are easily damaged. The top end of the cylinder bore is smaller than the base end – this is called ''choke." It's designed to allow a nearly straight cylinder wall once the engine is at operating temperature. The choke has little effect at start-up in moderate ambient temperatures. But the colder the temperature, the more the cylinder is choked. When the cold engine is turned over, the piston is forced into the smaller-than-normal top end of the cylinder.

Another thing happens when the cylinder is cold. It concerns the wrist pin, which in normal operation floats freely, axially within its bore in the piston. But the differences between metals in cold weather may change that. The piston, being aluminum, grips the steel wrist pin. When a piston, which last stopped at the bottom of its travel, cools down, the wrist pin end may be locked against the cylinder wall. When this engine is started, the wristpin end may wear against the cylinder wall. The piston-to-connecting rod juncture also becomes stiff in a cold engine, causing the piston to tip at an angle as the engine is started. The first few times the piston travels in the cylinder, it may do so with its piston rings cocked at an angle and the piston skirt contacting the cylinder wall.

As if this weren't enough damage to the cold cylinder, one more thing occurs once the engine starts; the aluminum piston grows at a faster rate than the cylinder diameter. The result is scuffing of the cylinder wall by the piston until the temperatures equalize. This all might be enough to make the owner of $35,000 aircraft engine grimace to think of the pain his engine already may have undergone. But there are worse effects from cold starting. Starting the engine with cold cylinders may result in excessive wear; starting with a cold crankcase could cause main bearing failure.

Misconception: Warm oil equals warm engine.

Myth: "When preheating, the most important thing is warm oil.'' This idea is similar to some early preheating methods in automobiles, which even in autos were not too successful. The "dipstick heater'' heated automobile oil but didn't help greatly in producing the start.

Fact: Warm oil may not even help if the rest of the engine is cold. Looking again at the automobile engine, the most successful means of preheating is the "in block" type of heater, which heats the coolant. This automobile preheater heats only the cylinders and the block areas – the oil isn't heated at all. It relies on multi-viscosity oil to flow once the engine start occurs. If oil heat were the only significant thing in an aircraft engine, then the new multi-viscosity and synthetic oils would be the only precaution need. But actually, the aircraft engine with a cold crankcase, may have reduced bearing clearance which won't accept any oil at all – hot, cold, or synthetic. The bearings and journals may be in metal-to-metal contact at the first instant of motion.

Consider the damage that might be done by someone who pulls the prop through a few times on a cold engine to "free it up."

Cozy Cylinders

Myth: "If the cylinders are warm, you're preheated." Some methods of preheating heat only the cylinders. These engines start easily and it appears that the plane is "home free."

Fact: While a car lives quite well this way, an airplane may be in trouble because it has reduced bearing clearances due to that cold crankcase.

Many failures have occurred in aircraft engines over the years that have been the result of improper preheating. It's my belief that most of these may have been blamed on other things because the nature of the problem was not understood. Some types of failures that are caused, or aggravated, by improper preheating are as follows:

Cold crankcases may "burn" or excessively wear main bearings even though the engine has warm oil or cylinders. This is usually incorrectly blamed on "stiff oil" or on a congealed oil cooler. In extreme cases, the bearing insert may rotate, blocking oil flow in the entire crankshaft and thereby causing a massive failure of the engine. In less severe cases, the engine may exhibit poor propeller control due to oil pressure losses in the worn main bearings. Twins might demonstrate this by propellers that won't stay "in synch" and won't respond to cures such as overhauling the props and governors. Other clearance related problems may occur within an engine with a cold crankcase, such as improper fit of the camshaft and the valve lifter bodies.

If an engine has a warm "top end" and cold oil, this may create its own problem. When using a straight grade of heavy "summer" oil, the oil system may not be able to draw oil to lubricate the engine once start-up occurs. The newer multi-viscosity and synthetic oils do a much better job in this respect.

Drier Consequences

Myth: "Since the engine is a closed system, moisture is not a problem in preheating."

Fact: The engine is not a closed system. Moisture is produced whenever the engine is run and any preheater vaporized this moisture. Regular flying of the aircraft is necessary to clear out moisture whether it is summer or winter. This is an area not commonly understood. If only the engines lower end (oil sump) is heated, the moisture vapor rises and condenses on the cold parts such as the crankshaft and cam. (One can see the same thing occur on basement water pipes in the summer.) This moisture will produce rust and acids.

But also, under the right conditions, it may freeze in the oil breather tube blocking the breather. If this occurs, the crankshaft nose seal can in many cases be blown out of the engine, followed by the entire supply of oil. The only way to avoid such problems is to assure that the preheater system preheats the entire engine and that the pilot has taken the proper precautions to winterize the engine.

A list of winterizing items should include winter grade oil, an oil cooler cover, and insulated breather tube with an alternate hole, and a check to see that the engine's baffle strips are in place. A winter front should also be used if approved for the airplane. (This is also a good time to check the cabin heater for exhaust leaks!)

Certification

Myth: "Since the airplane is FAA approved, it should operate well under any temperature condition." How could such an expensive device as an airplane engine exhibit such poor characteristics? Didn't FAA approval require it to operate in these conditions?

Fact: The FARs under which the engine was certified didn't require it to meet standards for low-temperature operation. This isn't all bad, but the engine's operator should be aware and take some precautions.

In below-zero weather, the engine develops more horsepower than it was certified to develop – possibly as much as 15 percent more! To counteract this, it's the practice of many cold weather pilots to add carb heat once the throttle is opened full (and to remove it when they reduce power). Also, they don't sit on the run-up pad with the carb heat on for long periods, since it may raise the temperature just enough to cause frost in the induction system. This could cause the engine to die when the throttle is opened.

"One Heater is Like Another"

Myth: "Any preheater that is FAA approved or that has 'No Hazard Approval' will preheat my engine properly." When a preheater is advertised as FAA approved, doesn't that mean that it will do a proper job of heating?

Fact: Since the FAA has no regulatory standards for cold weather operations, to gain approval a preheater may not have to meet any standards – it may not even work. Many preheaters don't have any kind of "approval," nor are they required to because they are not installed on the aircraft.

The crankcase, the part of the engine most critically in need of preheating, is the most difficult part to preheat. This is because of a kind of "wind chill factor," analogous to what people experience in cold, windy weather, which is transmitted through a not-so-obvious mechanism – the propeller.

Typically, the propeller accounts for the largest heat loss on an engine being preheated. It sits outside the cowling in the wind, drawing heat from the crankshaft and case. While this "wind chill" can't cool an engine to lower than the outside air temperature, it will demand more heat output from the preheater to warm the engine to a given temperature. Because of this, an insulated cover for the cowl and propeller is desirable when trying to preheat.

Every preheater has limits as to how much wind chill it can handle. At a given sub-zero temperature, some preheaters don't have enough output to heat properly on a calm day; when wind chill is added, even the best at some point will no loner do the job. When a aircraft owner is shopping for a preheater, he should find that the reputable manufacturer of the unit is able to discuss what temperatures his unit will produce – as measured at the crankcase of the particular engine – and the effect wind chill will have on this performance.

Manufacturers of preheaters make many claims in their advertising – some claim BTUs of heat, others watts of power, and still others that you can "start in only 10 minutes" (or 15, or 20). But considering that the information really needed is whether the preheater will produce safe starting temperatures, it's enlightening to compare preheaters by the same standard.

One can try converting manufacturers' claims to the same measurements. Conversion factors are available in any high school physics book for such things as watts to BTUs (One BTU equals about 0.293 watt-hours). One thing to remember is that there are losses every time energy changes form, or is transferred to some other object.

Obviously, the best standard to use would be temperature within the core of the engine. In the absence of the ability to measure this precisely, spending more time preheating, assuming adequate preheater output, can be like buying extra engine insurance.

Once the threshold of output has been met, there are some other differences among types of preheaters.

Most preheaters sold today are of the "air blower" type. Through one means or another, air is heated and then blown around the engine compartment. Since heat rises and it's often hard to position the blower to be sure that hot air travels by all the cylinders as well as the crankcase, there are often parts of an engine that are extremely cold after what seemed to be a hearty preheating session. Sometimes, the blown air is simply misapplied, and never gets to the critical engine parts. If it's applied without proper engine covers in windy conditions, the blown hot air just blows uselessly away. But the most common mistake is to believe that hot air applied for 15 minutes equals a warm engine, when it could take hours to do the job, with some heaters.

Provided these pitfalls are avoided, there are some hot air preheaters, which can do a reasonable job when properly employed.

Another type of heater being sold today heats the oil pan electrically. However, it does nothing for the "upper" engine, particularly the cylinder heads. There are also dipstick-style heaters, which we can dismiss for reasons mentioned above. And, there is the Tanis preheater, in which electric heating elements are installed at strategic places around the engine – not only an element on the oil sump, but other elements on each cylinder. With a Tanis preheater, the airplane is simply "plugged in" to 110-volt outlet for about 5–6 hours prior to being started. (It can be left plugged in continuously, keeping the engine constantly ready for starting).

It has been my experience that any "air blower" with less than 50,000 BTU is just too anemic to work well. Since the total BTU energy in a typical 16-ounce propane bottle sold with many air blower pre-heaters is approximately 8,700 BTU, there does not appear to be enough heat in the bottle to do the job – even if air transfer of the heat were 100-percent efficient (which is definitely not the case.)

Yet an installed system such as the Tanis TAS100 will do an acceptable job on as little as 250 watts. Why is this? This particular system operates for a longer period of time, makes fewer exchanges of energy, and transfers heat by conduction, which is very efficient.

Whatever type of preheater is employed, its effectiveness can be vastly enhanced by using thermal blankets around the cowl to keep the heat from being blown right out of the engine compartment. Again, there are conditions of wind and temperature, which can make it impossible to preheat the engine to the extent needed for a safe start.

Ultimate Question

At this point, one may consider another question: When the temperature or wind chill drops into the negative teens, should we really be flying? If a pilot had a forced landing, could he survive long enough to reach shelter? When the wind chill reaches -30° F, and lower, a pilot who is normally systematic and safety-conscious can be turned into a madman whose only concern is to get the door closed, the engine started, and the cabin heater turned on. Some cold country pilots don't fly much below -20 ° F, unless it's an emergency. At these temperatures, a pilot may have trouble keeping cylinder temperatures up, and as a result produce more cylinder wear.

To summarize, when the temperature is below 20° F, be sure to thoroughly preheat the engine. If you want to determine the "quality" of your preheat, the cylinders, nose case and the oil should all be warm to the touch. If they aren't, don't start.

Not all cold days are bad. On some cold days, we may climb into warm air and have a beautiful flight. Cold weather fling can be some of the most enjoyable of all flying; the air is smooth and the airplane will perform well. Cold moonlit winter nights can be great flying.

The beautiful thing about winter flying is that once we understand it, we can properly prepare for it. A pilot can dress properly for winter and be comfortable. Try that for hot weather – impossible! – I much prefer winter.