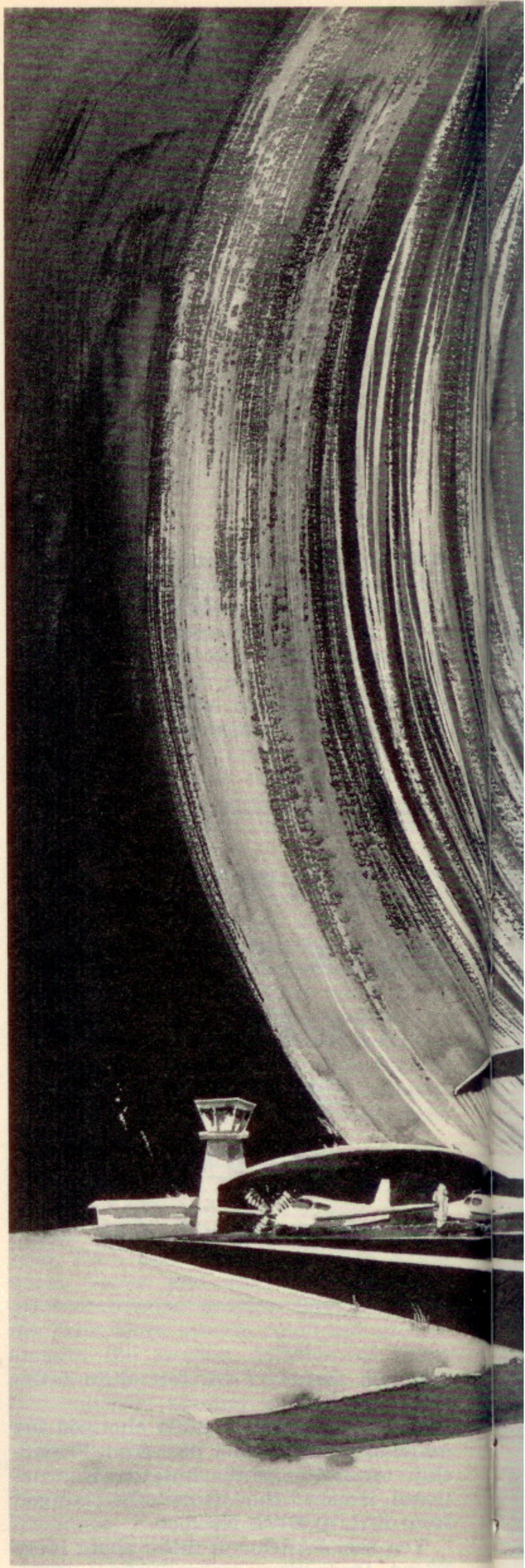
Deadly Duo: Overheating and Thermo-Shock

The way you fly—and the way you make power adjustments—have a direct bearing on your engine life

by DENNIS NOBLE as told to JOYCE MARSH



■■ The number one enemy of your aircraft engine is overheating followed closely by thermo-shock. The effects of these conditions are predictable ring breakage leading to cylinder loss and potential forced landings. Overheating by itself accelerates engine part wear.

Overheating, as measured by a cylinder head temperature (CHT) gauge, can occur as little as 35°F above recommended operating temperatures. For example, in the Continental O-200 engine, the recommended CHT is about 490°F with a maximum of 525°F; in the Lycoming IO-540, recommended CHT is about 435°F with redline at 500°F.

Thermo-shock occurs with rapid throttle closure often accompanied by a nose-low attitude change. It could be monitored with an exhaust gas temperature (EGT) gauge because the shock occurs as a result of the instantaneous reduction of temperature and pressure inside the combustion chambers.

Pilots can minimize overheating and prevent thermo-shock. First, take a look at the cooling system. Most aircraft engines are pressure air-cooled. The two most visible cooling elements are the spinner which directs airflow into the engine compartment, and the propeller which forces ram air into the compartment during *cruise*. The ram-air effect is much less efficient at normal ground operating rpms. Overheating on the ground represents the major opportunity for reaching redlining cylinder head temps.

Less visible, a series of pressure baffles under the cowl prevents the ram air from easily exiting at the rear of the engine compartment. They redirect the air down and around cylinder fins to absorb cylinder heat and exit usually at the bottom of the aircraft.

Engine oil works both to prevent heat build-up and to cool. The oil lubricates and prevents friction-heat build-up. During overheating, the oil loses its lubricating property and friction heat is added to the overheating problem.

Oil is sprayed or splashed on the cylinder walls, following the pistons during the upstroke. It absorbs heat from the combustion chamber and is removed by the oil ring as it wipes the cylinder walls during the piston downstroke. The oil is returned to the oil sump where it is air-cooled.

Fuel as an engine coolant, through the concept of valve overlap, is less well understood. In the typical four-stroke engine the exhaust valve allows spent gases and heat to escape. The intake valve opens slightly before the exhaust valve closes and allows an initial surge of fuel-air mixture to enter the hot cylinder both to help scavenge out the exhaust gases and to help cool the combustion chamber. A small amount of the fuel-air mixture escapes through the exhaust and cools the exhaust valves and valve guides. The remaining mixture helps cool the piston head and the combustion chamber.

The remaining heat transfers from the piston through the rings to the cylinder walls. The heat not absorbed by the oil passes through the walls to the fins and is dispersed by the pressure air cooling system.

When cylinder fins become heat overloaded, the normal escape route for the heat is blocked. The rings, caught between hot walls and hot piston, overheat and lose their temper (strength).

With cooling design subverted, the engine becomes vulnerable to damage from thermo-shock through ring breakage. Unless caught immediately, broken rings score cylinder walls and can progress to cylinder failure.

Training fleets are notorious for broken rings. Training maneuvers leading to ring breakage include the emergency landing exercise when the instructor closes the throttle with the speed of a striking snake. The pressure inside the chamber reduces so rapidly

that the rings literally flutter.

High-performance takeoffs on hot days, a stall series—moving without delay from departure to an an approach stall—and prolonged operation at minimum control speed contribute to overheating and thermo-shock.

The above are normal flight training maneuvers. Without curtailing these necessary training operations, the chance for damage can be lessened by giving the engine a few seconds of transition between exercises and a chance to wind down and cool down.

Even experienced pilots stress their engines. Consider the following normal flight maneuvers:

• Ground handling. Overheating occurs during long, slow taxiing and long waits for either takeoffs or IFR clearances. One hapless pilot made a forced landing recently because two cylinders failed in flight. He never connected the forced landing with the time he spent one hour "swinging the compass."

• Vertical S. A valuable exercise for IFR students calling for a standard rate climb (500 fpm) for one minute followed by a standard rate descent for one minute. Power settings must go from full power to slow cruise every minute.

• Long climbs followed by immediate glides. This situation occurs on climbout from a valley, over a mountain range, followed by a descent into another valley for landing.

• Power reduction for entry into the pattern. Some pilots jerk the throttle back so fast the resulting pop from afterfiring can be heard from the ground.

The picture drawn here has been deliberately grim and the examples purposely drawn from normal flying to make the point. Overheating and thermo-shock are ever-present dangers which can happen to anyone.

Overheating and thermo-shock can be prevented, however, by recognition of the problems, by using proper throttle control, and by installation of a CHT gauge on aircraft not so equipped.

The key to proper throttle control is smooth and gradual throttle movement—don't be a "throttle jockey." Allow your engine a transition time to cool down and wind down after a long climbout. Use two steps. After the climb, reduce throttle to normal cruise in level flight. After a few seconds, reduce the throttle again and lower the nose for a glide.

On hot days and during extended climbs, make the climb angle shallow to keep the airspeed up for increased cooling. Avoid high-performance takeoffs. While higher airspeeds will promote engine cooling through greater airflow over the engine, fuel, through use of richer mixtures, is another means of controlling CHT. For the latter, follow the engine manufacturer's recommended procedures which can vary widely between normally aspirated, supercharged, and turbocharged engines.

A cylinder head temperature gauge lists at about $60 and may require as little as two hours to install. It consists of a thermocouple installed on the hottest cylinder. The temperatures recorded correspond closely to cylinder head temperatures.

Remember, too, the range between recommended operating temperature and redline may be only 35°F. There is about a five-minute lag in the readings. This means that by the time you see redline in the cockpit, overheating has already been going on about that long.

The cost, when balanced against cylinder replacement is relatively cheap. Our entire training fleet at Sacramento City College (where summer temperatures soar into the 100s) sport CHT gauges.

All the references for heat management apply equally to fixed and constant-speed props. Aircraft with cowl flaps for cooling definitely have an advantage.

To prevent problems of overheating and thermo-shock, use shallower climbouts and higher airspeeds on hot days and search for cooler air during temperature inversions. Exploit the cooling function of fuel. Keep ground operations to a minimum and remember, handle the throttle as you would touch a baby's cheek—smoothly and gently. □