OPERATION OF RAJAY TURBO ON LAKE LA-4-200

DISCUSSION

The Rajay Turbo installed on the Lake LA-4-200 is controlled by a manually operated waste gate by the pilot through a cable/lever arrangement installed on the cabin ceiling. There is NO over boost protection and no automatic control of any type, so it is essential that the pilot fully understand the mechanics and thermodynamics of engine turbo charging to obtain maximum performance from the system without over stressing the engine.

Unfortunately, as typically installed, there is little or no instrumentation to indicate power output of the engine, except the Manifold Pressure gauge and the Tachometer, and unless there is a clear understanding of the factors affecting engine power, the Manifold Pressure, in particular, is NOT an accurate indicator of power output. Some of the parameters which must be known other than MP and RPM are: Exhaust Back Pressure, "Deck" or Compressor Discharge Pressure, EGT, or better, TIT (Turbine inlet temperature), Compressor Discharge Temperature, Fuel Flow, and Turbine RPM. The following operational technique was developed through experience and can be used as a general guide. It is important that instrumented parameters such as Cylinder Head Temperature, Oil temperature, TIT, Etc., be frequently calibrated, and then watched carefully so as not to exceed specified limits.

NORMALLY ASPIRATED OPERATION

There is a valve in the air filter air box assembly that does not allow air from the turbo compressor to enter the induction system unless the compressor discharge (deck) pressure is approximately ½ psi (1" Hg) higher than ambient static pressure. All induction air, therefore, is taken through the standard air filter and the turbo system is "locked out". In addition, if the waste gate is fully open (as it should be), little or no exhaust should be routed through the turbine, but rather directly overboard. Except for minimal back pressure due to the longer exhaust stacks, there should be little effect on engine operation. An estimate of power loss due to back pressure is about 5%, or 10 BHP at full throttle. Because any induction air supplied by the turbo compressor is un filtered, the engine should always be operated in the Normally Aspirated mode whenever conditions are dusty or there is foreign matter in the air. In addition, except for emergency power use, the Turbo mode should not be used when density altitudes are below sea level.

HIGH ALTITUDE OPERATION

The primary purpose of a turbo charger on an aircraft is for power recovery at high density altitudes. Although it is possible to obtain 100% or greater power output at lower altitudes (See T.O. procedures and emergency power procedures), the manufacturer of the turbo charger (Rajay) states maximum manifold pressure should be limited to 29" Hg. In the turbo mode, this results in something less than 100% power, even at 2700 RPM; however, it is recommended that this value not be exceeded for continuous operation, primarily for temperature and cooling considerations.

Because of increased exhaust back pressure in the turbo mode, combined with high injector servo inlet air temperatures caused by compression of the induction air by the turbo compressor, it is necessary to indicate a higher manifold pressure than would be the case for a normally aspirated engine producing the same power. Although every distinct situation (for example, change in density altitude) results in some variation, if the pilot wishes to select a certain power setting, he should normally add from 3" to 4" Hg. to that desired in a normally aspirated engine at the particular altitude and O.A.T. he is flying. That is, if he desires 75% power, which in a normally aspirated engine might be 24" and 2450 RPM, he should select approximately 27" or 28" MP and 2450 RPM in the turbo mode. Typically the most accurate method to determine actual power output is to lean normally and set power by the fuel flow indicator if so equipped. The IO-360 engine should be consuming about 10.2 GPH at 75% power leaned to peak TIT.

Since it is possible, and probable that, in the turbo mode, manifold pressure will exceed ambient air pressure, the fuel injection nozzles in each intake port must be pressurized as well. At full throttle, the nozzle, or "deck" pressure, will be the same as the manifold pressure. It is advantageous, however, for fuel atomization and throttle response, that the "deck" pressure be somewhat higher than the manifold pressure, typically about 4" Hg. This is accomplished by operating at somewhat less than full throttle in the turbo mode. One advantage is that use of the throttle for small power adjustments is much easier done than with the waste gate control, if "deck" pressure exceeds manifold pressure.

It is important to remember that the turbo system operates in a "feedback loop". That is, a change in throttle, mixture, RPM, waste gate setting or altitude, changes ALL the engine parameters. For example, if the mixture is changed in a particular situation, the thermodynamic energy of the exhaust changes, which changes the energy that drives the turbo compressor, resulting in a manifold pressure change, which requires a throttle change which then requires a mixture change, and so on. This is particularly true at higher altitudes when the waste gate is closed or nearly closed. For this reason, caution must be used when making power adjustments, and these adjustments should be made in small increments.

The following procedures have been shown to give good results:

Climb:

(1). Mixture full rich regardless of altitude

(2). At full throttle, increase waste gate control slowly until a positive increase in MP is noted, but not over 29" Hg.

(3). Reduce throttle about 3" to 4" Hg.

(4). Increase waste gate control again to obtain desired MP (usually 29").

(5). As MP is lost in climb due to altitude, add throttle to maintain desired MP until at full throttle.

(6). Repeat steps three through five.

Cruise: (at 75% power or less)

(1). At full throttle, increase waste gate control to obtain desired cruise MP plus approximately 1" - 1 ½" Hg.

(2). Reduce MP by approximately 2" Hg.

(3). Increase waste gate control again to obtain desired cruise MP plus approximately 1" - 1 ½" Hg.

(4). Lean mixture until Manifold Pressure peaks. If equipped with TIT, this should be about 125 deg F. on rich side of peak. Note cylinder head temperature after three minutes.

(5). Continue leaning until:
a.) Manifold Pressure drops 1" to 1 ½".
b.) Cylinder head temperature drops approximately 35 deg F.
c). TIT is at peak or 25 deg F. cooler than peak (1650 deg F. Max) on lean side.

(6). Readjust throttle for desired cruise power.

LET DOWN AND LANDING

Normal powered let downs can be made simply by reducing throttle to maintain desired Manifold Pressure. Let downs from very high altitudes (above 15,000 feet) may require some decrease in waste gate control with decreasing altitude. Normally, enriching the mixture is not recommended except to maintain smooth engine operation.

For landings at airports with density altitudes above 6,500 feet, the waste gate control should be adjusted prior to landing to give 29" hg. at full throttle at an altitude of 2,000 - 3,000 feet above the elevation of the airport. Any go-around/balked landing, demands careful use of the power controls (See Take Off procedures below).

Once below 6,500 feet, the turbo should be completely disengaged and the throttle and mixture readjusted for normally aspirated operation. However, again, if it is anticipated that the turbo charger will, or may be needed for a subsequent Take Off, it may be advantageous to set the waste gate control to give 29" Hg. at full throttle when 2,000 to 3,000 feet above the landing area.

TAKE OFF

The turbo charger can be used at any time to recover power loss due to density altitudes higher than sea level. The problem facing the pilot is to be able to set the waste gate controller prior to take off without sustained full throttle ground operation. There are several methods to do this: One method is, on a prior flight, to select an altitude of approximately 3,000 feet above the airport elevation and adjust the waste gate control to show 29" Hg. MP at full throttle. Mark the position of the waste gate control lever on the cabin ceiling with a pencil or tape, and use this mark to preset the control prior to take off.

Another method is to set the MP at approximately 65% of available power on the ground, and advance the waste gate control to show about ½" Hg. increase for each 1000 feet density altitude above sea level.

During turbo charged operation, because of high induction air temperatures, and exhaust back pressure, it is necessary to boost MP to 32" - 33" Hg. to get the same power out put as a normally aspirated engine at sea level standard day, notwithstanding Rajay's limitation of 29" Hg. It is felt that the use of 32" MP for take off and initial climb when temperatures are warmer than ISA, should not be detrimental to the engine IF mixture is fully rich and cylinder head temperatures are maintained below 435 deg F.

In addition, FOR EMERGENCY USE ONLY, and with some discretion, as much as 36" MP can be used for periods not exceeding 30 seconds to get the aircraft "on the step", or to clear an obstacle when it would otherwise be impossible. It must be understood that the primary hazard to the engine at high MP is from detonation and high local temperatures (not necessarily indicated on the cylinder temperature gauge). Therefore, emergency over boosting, if necessary, should be done only at maximum RPM, full rich mixture, and cylinder head temperatures as low as possible (preferably below 400 deg F), and with the knowledge that sustained operation will probably result in damage.

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