Ground Lesson: Advanced Systems

Objectives:

1. to understand advanced aircraft systems for the purposes of aircraft familiarization and complex checkout

Justification:

1. as a commercial pilot there are many opportunities that will require complex aircraft operation
2. a complex aircraft is required for the commercial check ride

Schedule:

Activity	Est. Time
Ground	1.5
Total	1.5

Elements Ground:

- fuel injected engine
- turbocharged engine
- constant speed propeller
- retractable landing gear

Completion Standards:

1. when the student exhibits knowledge relating to advanced aircraft systems

Presentation Ground:

Fuel Injected Engine

1. *:engine in which fuel is delivered via a fuel control unit and fuel manifold valve to more accurately and precisely control the volume and quality of fuel/air mixture into the cylinders*
2. benefits:
   (1) cylinders receive a specific quantity of fuel, thus a better controlled mixture ratio
   (2) extra cooling due to the vaporization process
      i. the cooling also results in higher density mixture for combustion
   (3) faster throttle response
   (4) low probability of internal icing
3. disadvantages:
   (1) difficult starting a hot engine
   (2) vapor lock during ground operations on hot days
   (3) more difficult to start an engine after fuel starvation
4. normal start
   (1) review POH for normal start procedure
5. hot start
   (1) vapor lock *:condition in which a hot engine's fuel boils in the lines after shutdown due to the lack of airflow through the cowling*
   (2) review POH for hot start procedures
6. engine monitoring
   (1) EGT - exhaust gas temperature gauge
      i.can be used to adjust mixture to produce desired performance
      ii. review POH for correct temperature settings for given performance configurations
   (2) CHT - cylinder head temperature gauge
      i. used to monitor the health of the engine, and if installed, correctly open and close cowl flaps
7. induction icing
   (1) impact icing may occur due to blockage of the induction air filter or intake air scoop
   (2) as this occurs, the engine performance will decrease due to restricted airflow.
   (3) to combat this situation, most aircraft and alternate air sources to provide warm, unfiltered intake air to the engine.
      i. this may occur manually (via a knob) or automatically (via design)

Turbocharged Engine

1. *:an engine system designed to compress the intake air (via the exhaust gas) to increase it's density, and thus increase engine performance*
   (1) supercharged engines do the same thing but use an engine driven pump to compress the air instead
2. theory behind engine power
   (1) engine power produced is directly proportional to the amount of air (density) available at the time of ignition
   (2) in a normally aspirated engine,
      i. the maximum possible density of the air coming in can't be higher than the surrounding air density.

ii. thus the maximum power an engine can produce is directly proportional to the density of the surrounding air

iii. as altitude increases, density of air decreases, and thus the amount of power an engine can produce decreases

(3) in a turbocharged engine,

i. the intake air is compressed to pressure even higher than the surrounding air pressure.

ii. thus the engine can produce more power at a given altitude than a normally aspirated engine.

iii. moreover, the pressure of the intake air can remain constant as the altitude increases (up to a point) and allow the engine to produce sea-level power at higher altitudes

(i) critical altitude *:maximum altitude at which a turbocharged engine can produce its rated horsepower*

3. advantages:

(1) engine is able to produce more power due to the compression of air

(2) engine can maintain sea-level power output up to the engines critical altitude

(3) increases the aircrafts service ceiling allowing the pilot to take advantage of high altitude flight performance benefits

4. disadvantages:

(1) more complex engine, thus higher maintenance costs

(2) precautions must be taken to properly cool the engine before shutdown

(3) care must be taken not to overboost the engine

5. components of a turbocharged engine

(1) turbine - driven by the exhaust gases, it drives the compressor of the intake air

(2) compressor - driven by the turbine, it compresses the air going into the cylinders

(3) waste gate - controls the amount of exhaust directed through the turbine

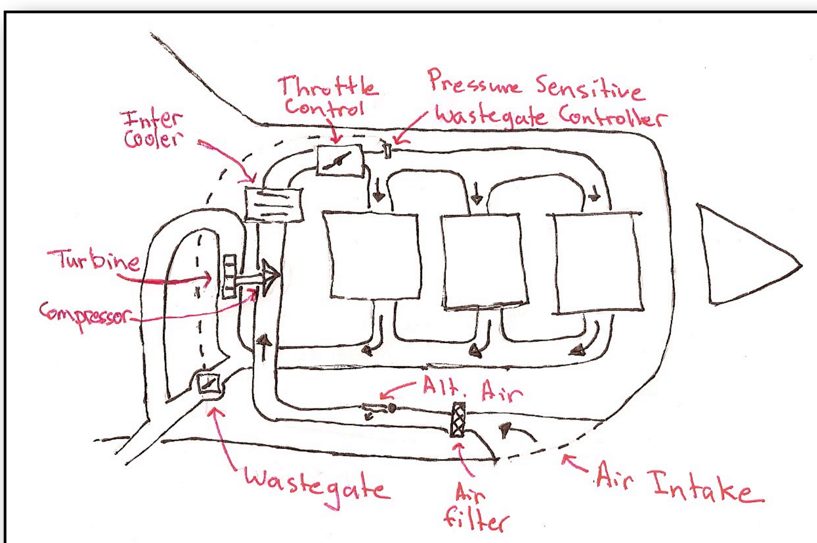
i. most new aircraft have automatic waste gates driven by engine oil pressure (which is driven by a pressure sensing actuator) to properly control the amount of exhaust gas driving the turbine

ii. some older TC engines and after market TC engines have manually actuated waste gates

(i) these engines should be monitored closely to avoid an overboost situation in which the compression of the air is higher than engine limitations

(ii) when the waste gate is fully closed, the compressor will no longer be able to speed up if necessary, thus the engine will now act as a normal aspirated engine

(iii) when the waste gate



is fully open, the turbine is note being driven, thus the aircraft will be powered similar to a normally aspirated engine

(4) intercooler (optional) - used to cool the compressed air before delivering it to the fuel distributor

6. operational considerations

(1) when applying power (especially to a cold engine), advance the throttle slowly, as the oil may be cool, and thus may not be able to adjust the waste gate quickly

(2) turbocharged engines run very hot due to the available power. when starting a descent, it is important to plan the descent to allow for adequate cooling.

i. You should never “chop” the engine to make a descent unless it is an emergency

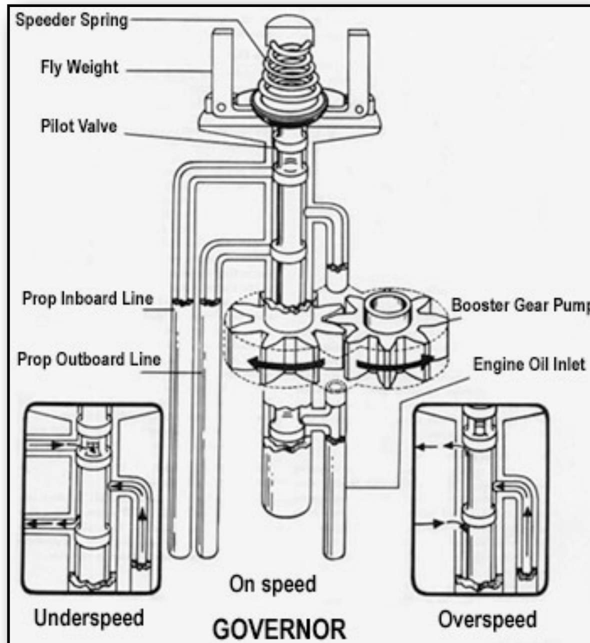
ii. a good rule of thumb is 2” every 2 minutes until you are in a lower MP setting (21”)

(3) before shutting down the engine, ensure the aircraft has had proper time to cool (see POH or 5 minutes, which ever is more)

i. since the turbocharger runs at extremely high speeds (in excess of 80,000 RPMs), oil must be used to lubricate the bearings

ii. at those speeds, the oil can get extremely hot

iii. if the aircraft doesn’t have time to cool down before shutdown, the oil may boil inside the turbocharger, leaving carbon deposits on the bearings and shaft and dramatically reducing the turbochargers useful life.



Constants Speed Propeller

1. *:the most common type of adjustable pitch propeller systems in which you can adjust the pitch of the propeller from the cockpit to attain maximum amount of thrust for the given brake horsepower.*

2. propeller review

(1) thrust is the forward acting “lift” the propeller creates

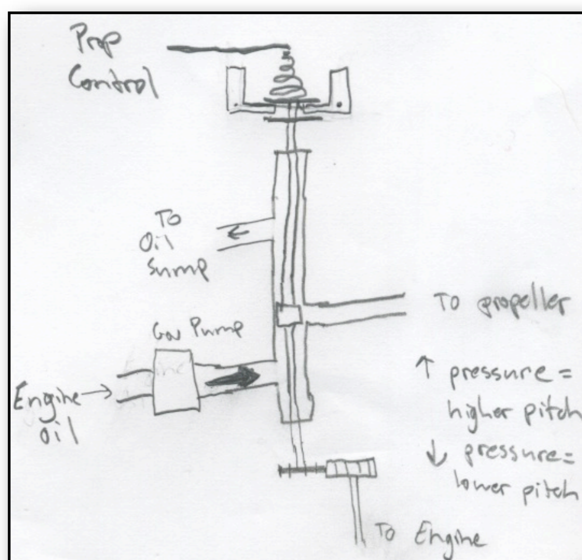
(2) the higher the angle of attack, the more thrust produced (to a certain extent)

(3) as the aircraft moves through the air, the forward airspeed reduces the angle of attack thus reducing the thrust created

(4) increased airspeed reduces AoA, thus reducing load on the engine, and visa versa

3. CSP theory

(1) a fixed pitch propeller cannot change pitch depending on the situation, and thus must be designed as a compromise of all the desired situations the aircraft will be in



i. mainly climb and cruise

(2) a constant speed propeller allows a pilot to adjust the engine RPM and manifold pressure to allow the optimum combination for the type of operation being conducted

i. *in a climb*, pilot wants maximum power, thus a low pitch to allow high RPMS

ii. *in cruise*, pilot wants maximum speed and fuel efficiency, thus a higher pitch to allow greater AoA and thus greater thrust

(i) also, as a result the engine has a higher load, and so RPM is lower, thus reducing fuel consumption

4. system

(1) a constant speed propellor system is made of up two or more propeller blades, the propeller governor, and the propeller control

(2) governor

i. *:device which senses engine speed, and delivers high pressure oil to a piston located inside the propeller hub, which in turn causes pitch-change of the propeller blades*

ii. governor system is made up of a governor pump, speeder spring, flyweight, oil piston, and inboard/outboard pressure lines

iii. speeder spring sets the “on speed” pitch of the propeller (i.e. the rpm setting)

iv. the flyweights adjust the oil pressure distribution piston to correct the pitch for “under speed” and “over speed” situations

(3) propeller control

i. controls the “tension” of the speeder spring, and thus the “on speed” pitch

(4) oil pressure holds high pitch/lower rpm while aerodynamic forces tend to force the aircraft to low pitch/high rpm

i. if oil pressure was lost, the propeller would act as a fixed pitch propeller with a low pitch/high rpm configuration

5. operational considerations

(1) to reduce unnecessary stress on the aircraft, reduce manifold before reducing rpm (increasing pitch), and increase rpm (decreasing pitch) before increasing manifold

(2) the propeller has limits to it’s pitch range. when the propeller hits it’s limit, either low or high it acts as as fixed pitch propeller in the direction in which it has hit it’s limit

i. if low pitch limit has it, any increase of speed will increase rpm

ii. if high pitch limit has been it, any decrease in speed will decrease rpm

iii. this is known as being out of the governors range

retractable landing gear

1. *:landing gear designed to streamline the airplane by allowing the landing gear to be stowed inside the structure during cruise flight*

2. advantages

(1) better aerodynamics, thus in general better airspeeds

(2) allows aerodynamic braking to slow down aircraft

3. disadvantages

(1) more complex, thus higher maintenance costs

(2) more complex, thus, more to go wrong

(3) gear is typically not as strong as a fixed gear equivalent would be

4. system

(1) there are basically two types of systems: electrically actuated, and hydraulically actuated

i. electrically actuated systems use reversible electrical motor(s) to drive "jacks" to extend and retract wheels

ii. hydraulically actuated uses pressurized fluid (via engine or electrically driven pump) to actuate linkages that extend and retract wheels

(2) due to the complexity of retractable gear, there are a number of safety systems to ensure the gear will operate as expected

i. gear position indicators

(i) lights which help indicate what position the gear is currently in.

(ii) typically there will be green light(s) to indicate gear down, and red light(s) yo indicate gear up - refer to POH for specific aircraft information

ii. gear warning horn

(i) in most aircraft, to remind pilots to lower the gear, certain configurations will cause a warning horn to sound. examples include:

a. throttle below a certain power setting with gear retracted

b. certain amount of flaps with gear retracted

iii. safety switch (or squat switch)

(i) prevents inadvertent retraction of landing gear when the aircraft is on the ground

(ii) the switch will be activated (not allow retraction) due to the weight of the aircraft on the landing gear. when the aircraft takes off, weight is release, and the switch will deactivate

iv. emergency extension

(i) in case of a system malfunction, all aircraft have some sort of manual extension

a. hand crank system, hand pump hydraulic system, freefall system, gas pressurized system

(ii) refer to POH for specific procedures

5.operational considerations

(1) Since retractable gear are operational appendages of the aircraft, there are speed limitations associated with extension, retraction, and extended configurations

i. Vlo -> maximum landing gear operating speed

(i) there may be different speeds for extension vs retraction due to the varying loads each will put on the system

ii. Vle - maximum landing gear extended speed

(i) this speed may be faster than the Vlo speed

(2) landing gear lever is located in different places in different aircraft. typically they are shaped like a wheel to allow for tactile recognition

i. a good rule of thumb is ***never*** touch a landing gear while on the ground

ii. for checklist procedures, point at landing gear instead of touching it