Why consider a turbocharged engine?

If you're contemplating purchasing a piston engine aircraft, you may also be considering whether to purchase a normally aspirated or turbocharged model.

While a turbocharged model may cost more, depending on *the type of missions you intend to fly,* a turbocharger may well be worth the additional investment and could easily be among the most important purchase decisions you make -- both from a performance and a safety perspective.

Standard Day: How Aircraft Engines are Rated for Power

To understand the impact of a turbocharger, it is helpful to understand how altitude impacts aircraft power and performance.

Because the atmosphere changes with altitude – and because these changes impact aircraft performance – aircraft engines are almost always rated for power at universally agreed conditions known as 'standard day'. Standard day conditions are based on common atmospheric measurements such as air pressure and temperature. Rating aircraft engine power in this manner provides a baseline to which all aircraft engines can be compared.

Standard day is defined to include barometric pressure of 29.9 inches of mercury (1013.2 millibars), density of 14.7 lbs/square inch (PSI) and air temperature of 15 degrees Celsius (59 degrees Fahrenheit) at sea level. When an aircraft manufacturer specifies an aircraft engine's horsepower rating, this rating refers to *the engine horsepower that can be achieved at these standard day conditions.*

How Altitude Affects Aircraft Performance

For those new to the world of flying, a common misconception is that manufacturer rated aircraft engine power is maintained throughout aircraft operation. In other words, if an aircraft is rated for 300 horsepower, it is not always understood that *this does not mean* the aircraft engine will continue to perform at 300 horsepower as it climbs.

In reality, because all aircraft engines are dependent on the consistent intake and compression of air for fuel combustion, the amount of power an aircraft engine can produce is directly dependent upon air being pumped into the engine at consistent pressure and density. However, because atmospheric air pressure changes as an aircraft gains altitude, air density is diminished, causing a relative decline in engine horsepower.

A normally aspirated engine in fact typically loses about 3% of horsepower for every 1000 feet of altitude.

How Turbochargers Work

Turbocharging, also known as 'forced induction', involves the use of a gas compressor to force more air into the engine's combustion chamber than would be possible with a naturally aspirated engine, thus allowing the engine to maintain sea-level manifold pressure as altitude increases. In other words, feeding more air to the engine allows the engine to burn more fuel and create more energy to power the aircraft - and thus maintain full, rated power - despite increasing altitudes.

The turbocharger is typically housed in a circular casing that contains a small turbine connected by shaft to an impeller wheel. Aircraft exhaust is sent directly into the turbocharger, where the turbine converts it into rotating energy which in turn spins the impeller wheel and compresses exhaust air. The turbine and impeller found in a turbocharger behave in a very similar manner to the turbine and compressor found in a turboprop (turbine) engine. (Learn about turboprop engines here.) Following compression, compressed air is discharged directly into the engine's intake manifold.

Turbochargers work in one of two ways: A 'ground boosted' turbocharger directly increases overall power output of the engine to achieve its sea-level rated power. A 'turbo-normalized' turbocharger works to assure that sea level horsepower performance is maintained as it reaches higher altitudes.

Turbocharger Cons:

Non-pressurized Aircraft Considerations

The FAA dictates that pilots flying above 12,500 feet for thirty minutes or longer must carry supplemental oxygen -- and many find it necessary at or before 10,000 feet in order to avoid the symptoms of hypoxia. Therefore, a *non-pressurized* turbocharged aircraft calls for oxygen on-board in order to take advantage of the higher altitudes turbocharging affords.

Therefore, when considering the use of a turbocharger, it is important to consider both the type of missions you intend to fly, as well as the type of passengers... For families with small children, oxygen masks can at times be challenging to employ.

TLC for Turbo Charging

Turbocharged aircraft engines tend to be more prone to pilot abuse than normally aspirated aircraft engines…

Ground-boosted turbo engines in particular call for more careful treatment. Because it is possible to push these aircraft beyond stated power, it's important to fly at a lower power setting when flying at lower altitudes so as not to over-boost the engine.

A turbo-normalized engine is a better candidate for engine longevity… especially for the less diligent pilot. (Though with proper training on engine management, any attentive pilot can properly operate a turbocharged aircraft.)

Turbocharger technology has also come a long way since early designs first appeared on the market. Today's more modern turbochargers typically have automatic wastegates that reduce the potential for pilots to over-boost the engine.

Intercooler Caution

An intercooler is often used to reduce the heat turbochargers produce and promote more efficient combustion. Particularly with an aftermarket intercooler, it is often necessary to adjust manifold pressure down from original specifications, to compensate for the cooler compressed air entering the engine. This is important to keep in mind as (without the adjustment) it's easy to miscalculate power and fly at a higher percentage of power than is realized if flying according to the original factory data. Reducing MP to accommodate intercooler impact will help preserve engine longevity.

Learning the Ropes

As with any performance modification, learning how to operate an aircraft with a turbocharged engine takes some additional training. In particular, it is critical to know how to recognize any possible failure of the turbocharger -- and how to adjust aircraft operation if ever faced with this possibility, to ensure the safest possible operation of your aircraft.

Turbocharger Benefits:

So why choose a turbocharged aircraft?

Avoid Bad Weather and Turbulence

By increasing aircraft engine power, turbochargers do much more than prevent the loss of performance at higher altitudes. Most importantly, they effectively raise the aircraft's potential service ceiling.

- This allows aircraft to reach altitudes above inclement weather and troublesome areas, avoiding potential icing and turbulence.
- It also offers pilots the opportunity to climb above mountainous terrain when normally acceptable altitudes become worrisome due to changing atmospheric pressures and temperatures.

Be Safe!

- Flying higher also boosts safety by improving radar coverage for ACR (air traffic control radar) detection and often allows turbocharged aircraft to reach altitudes where lower traffic densities may be available.

Go Green!

- Turbochargers harness exhaust energy that would otherwise be wasted, converting more fuel energy into power.
- Because turbochargers deliver more oxygen to the aircraft engine, fuel combustion is more efficient – and cleaner.
- Fuel flows are typically much lower at higher altitudes, thereby also increasing range – and efficiency.
- The ability to climb also lets aircraft take advantage of stronger winds that may be available at higher altitudes – which further supports greater fuel efficiency.
- While it's true that normally aspirated engines may beat out turbocharged aircraft in terms of overall fuel efficiency at the same, *lower altitude*. At the higher altitudes (which only turbocharged aircraft are able to fly...) airframes become far more efficient due to lower drag -- and turbocharged aircraft can throttle back, and in fact *fly faster on less fuel.*

…Go Fast!

- Given the same altitude, turbocharged aircraft are able to fly faster than aircraft with normally aspirated engines – getting you to your destination sooner and boosting your overall flying satisfaction.

If you're considering investing in a turboprop (turbine engine) aircraft, but have budget concerns, it is helpful to know that a turbocharged piston engine is considerably less expensive than a turboprop – and still delivers excellent performance.

Or if you're considering investing in a piston engine aircraft, you may want to give some serious thought as to what can be gained by the additional investment in a turbocharged model.

At the end of the day, the most important factor in determining whether or not turbocharged aircraft is the right aircraft for you, is an evaluation of the missions you intend to fly. For those flying short missions in optimal weather conditions, a normally aspirated piston engine may be the perfect aircraft for your needs.

But for those considering longer missions where weather conditions are changeable, for those who fly over more challenging terrain, or for those simply seeking more speed with the option to take advantage of high altitude cruising, a turbocharged aircraft may be a great fit! It's important to remember that a turbocharged aircraft can do everything a normally aspirated aircraft can do, but a normally aspirated aircraft can't do what a turbocharged aircraft can do.