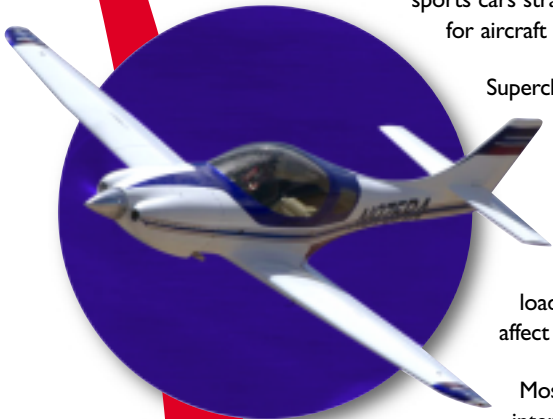


Introduction to Superchargers

In order to understand how a supercharger is going to help your aircraft, you first need to understand what a supercharger is and how it works.

A supercharger is essentially a large pump that compresses air and forces it into the engine's air intake. Turbochargers do the same thing, only they are run by exiting exhaust gasses, while superchargers are powered by the engine's spinning crankshaft, normally via the accessory belt. Originally built for World War II aircraft, superchargers have become very common in today's performance automotive world, and featured as original equipment on some new sports cars straight from the factory! Supercharging is a very efficient way to make horsepower for aircraft applications.



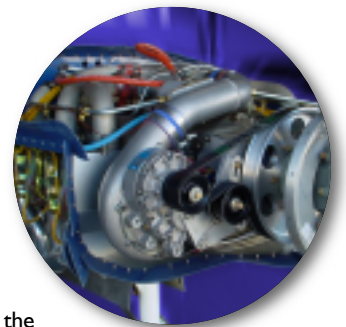
Superchargers have become popular in recent years for several reasons, including cost, efficiency, reliability, and of course, performance. Supercharging an engine often results in huge power increases in the range of 50% to 100%, making them great for racing, cross country flying, or just having fun. Although superchargers carry a fairly high ticket price (\$16-\$17K), nothing provides more horsepower for your dollar... in fact, nothing even comes close. And because of the way superchargers work, they provide power only when the engine is under full throttle or under load... not under normal cruising conditions. This means that the supercharger will not affect the engine's reliability, longevity, or fuel economy under normal flying conditions.

Most of the superchargers sold today are centrifugal-style superchargers, which are internal-compression superchargers, meaning they create the boost (compress the air) inside the supercharger head unit (blower) before discharging it into the engine's air intake. External compression superchargers (roots or screw-type superchargers) have become less popular as centrifugal superchargers have evolved. Centrifugal superchargers (Aero Superchargers, Vortech and Paxton,) are more reliable, especially at higher boost levels, and are capable of creating much more boost than external compression superchargers, while creating a much cooler intake charge (which results in an even denser intake charge).

Supercharger Impeller

Boost is created at the point when the supercharger's internal impeller pushes enough air through the blower to overcome the vacuum force naturally created by the engine's air intake, so air is being forced, rather than pulled, into the air intake. Boost is measured in Manifold Pressure, or MAP. More boost equates to a more dense air charge into the engine's combustion chamber, which allows the engine to burn more air and fuel and create more horsepower. Most superchargers produce somewhere in the range of 16" to 18" MAP, meaning they produce 16" to 18" MAP additional inches of pressure over the atmospheric pressure at that elevation (at sea level atmospheric pressure is 29.9" MAP).

Many people assume that running a supercharger, and hence added intake boost, puts added strain on an engine's engine parts. This is not necessarily true, because engine damage is almost always caused by RPM. Because a supercharger helps the engine produce more power at lower RPM, supercharged engines will make the same horsepower as their naturally aspirated counterparts at substantially lower engine RPM, where today's aircraft engines are designed to run (around 2700 RPM). Another concern some people have towards using a supercharger is that they think it will increase the engine's compression to the point that it will cause detonation inside the combustion chamber. Detonation exists when the combustion pressure is raised so high that the inlet charge ignites itself before the spark plug fires. When this happens, combustion takes place while the piston is still traveling up in the cylinder bore, which puts tremendous loads on the piston, rod, and crank. While it is true that a supercharged engine creates boost and increases the engine's compression. With our kits, detonation is not a concern and you can retain stock compression and stock timing.



Supercharger impellers on centrifugal superchargers are spun via an external pulley that is normally driven from the engine's accessory belt. Because the supercharger pulley needs to spin at very high RPM, an internal step-up causes the impeller to run at substantially higher speeds than the input pulley.

Supercharger Pulley

Because the speed that the impeller spins determines how much boost is produced by the supercharger, changing the input pulley size can have a large effect on the amount of boost put out by the supercharger. Smaller pulleys produce more boost, which is why they have become so popular for supercharger owners who are looking to squeeze every last bit of power from the engine. And because they only cost around \$70, they are an inexpensive way to test and tune your supercharger at different boost levels.

Aero Supercharger uses the engine's oil to lubricate the step-up gears and keep heat and friction to a minimum. While this lubrication is the most common and works well, it does require the engine's oil galley to be used so the supercharger can draw engine oil from the engine.

Some of you may have recognized in part I of this series that in the early days of supercharging, there are three types of superchargers—roots, twin-screw, and centrifugal. You may already be familiar with these buzz-words, but most people don't understand how each technology differs. Before buying a supercharger, you should familiarize yourself with how each type of supercharger works. Each has its own set of advantages and disadvantages that may make it ideal—or not - for your performance needs. Today we take a technical look at the technology behind each type of supercharger.

First lets begin with some basics. There are many components that go into making a complete supercharger system—mounting brackets, boost controller, fuel pump, etc. In this article we look at only one component of a supercharger system - the supercharger itself (sometimes called a "head unit", "compressor", or "blower"). All superchargers, except turbochargers, are driven via a pulley that is connected either to the engine's accessory belt, or to its own belt that goes directly to a crank pulley. This is where the similarities between the different supercharger technologies end.

The Roots Supercharger (aka "blower")

The roots supercharger was originally designed as an air moving device for industrial buildings. The roots supercharger features two counter-rotating lobes that trap air from the intake side of the supercharger (normally at the back of the supercharger), move it around the outside casing of the lobes, and out the bottom of the supercharger through an outlet/discharge port. Like the twin screw supercharger, the roots is a "positive displacement" aka

"fixed displacement" supercharger, meaning that it moves a fixed volume of air per rotation. Notwithstanding minor amounts of air-leak at low rpms, the roots supercharger cannot flow backwards like a centrifugal supercharger, and is thus nearly as efficient in its ability to pump air at low rpms as it is at high rpms. What this means is that roots superchargers are very capable of making large amounts of boost even when engine rpms are very low. This makes for great low-end and midrange power, and also makes them great for trucks and towing vehicles. The roots is also self lubricated, and is the simplest of the supercharger designs, meaning it is reasonably priced and very reliable. This is why roots superchargers have been the choice of GM, Ford, Mercedes, and Toyota for OE applications.

The only real disadvantage to the roots supercharger is that it creates a lot of heat. There are two reasons for this. First, the roots supercharger does not compress air—it only moves from the intake port to the discharge port (i.e. it is the only supercharger design with no internal compression ratio). All of the compression is done in the intake manifold. Laws of thermodynamics kick in in favor of supercharger designs with an internal compression ratio (centrifugal and twin screw) because they do less work on the incoming air charge. We will leave the mathematics of this phenomenon to a later (much more boring) discussion. Another reason roots superchargers create higher amounts of heat is because they tend to carry some of the compressed air in the intake back into the supercharger because it gets trapped by the rotating lobes that are exposed to the hotter air in the intake manifold.

A roots supercharger ("blower").

Want to know why a roots supercharger creates more heat than a centrifugal or twin screw? Calculate the amount of work each does on the incoming air charge and measure the area underneath the curve on the Pressure Volume Graph.

The Twin Screw Supercharger

The twin screw supercharger at first glance appears to look similar to a roots supercharger both inside and out. The two technologies are indeed similar, however there are significant differences. At the heart of the twin-screw supercharger are two rotors, or "screws" that rotate towards each other. The rotors mesh together and draw air from the back of the supercharger. The twisting rotors move the air to the front of the supercharger, while compressing the air before discharging through a port at or near the front of the supercharger.

Because the compression is done inside the supercharger, this design produces less heat than a roots supercharger—in fact, it is almost as thermally efficient as a centrifugal design. Like the roots design, the twin-screw is a fixed



displacement supercharger (meaning that it pumps a fixed volume of air per revolution), and because the tolerances between the rotating screws are very tight, its ability to create boost at low rpms is unparalleled. These characteristics make it ideal for aircraft, where low to mid range power is primary in importance. Another important advantage of the twin screw compressor is its reliability. Unlike a roots supercharger, the rotors in a twin screw supercharger do not actually touch, so there are virtually no wearing parts. For this reason, twin screw compressors are commonly used to pressurize cabins in passenger aircraft. Like roots superchargers, twin screw superchargers are self lubricated and do not tap into the engine's oil supply.

One disadvantage of the twin screw design is that, because it has an internal compression ratio, the twin screw is compressing air even when it is not sending boost to the engine (i.e. under cruising or deceleration). An internal bypass valve releases the pressurized air, but because it takes work to pressurize the air in the first place, the twin screw supercharger draws more power from the engine than while not under boost. Like the roots, the throttle body must be placed before the compressor because it is a fixed displacement supercharger.

The Centrifugal Supercharger

Although the centrifugal supercharger is founded on a technology much newer than either the roots or the twin screw, it was the first supercharger to be successfully applied to automotive applications. Unlike the roots, the centrifugal supercharger is NOT a positive displacement/ fixed

displacement supercharger because it does not move a fixed volume of air per revolution. The centrifugal supercharger essentially operates like a high speed fan propeller/impeller, sucking air into the center of the supercharger and pushing it to the outside of the rapidly spinning (40,000 + rpm) impeller blades. The air naturally travels to the outside of the blades because of its centrifugal force created by its rotating inertia. At the outside of the blades, a "scroll" is waiting to catch the air molecules. Just before entering the scroll, the air molecules are forced to travel through a venturi, which creates the

internal compression. As the air travels around the scroll, the diameter of the scroll increases, which slows the velocity of the air, but further increases its pressure.

The centrifugal supercharger enjoys several advantageous characteristics that make it the most popular supercharger design in the aftermarket world. First, it is simple and reliable because it has very few moving parts—just a few gears and the impeller. Second, the centrifugal supercharger produces very little heat because of its internal compression ratio. It is also small in size and very versatile because it can "free-wheel" and allow the engine to suck air through it or even flow air backwards. For this reason it can be placed anywhere in the intake tract—it can even "blow through" the throttle body, meaning it can be mounted nearly anywhere. It is also the most thermally efficient supercharger, meaning that it produces the lowest discharge temperature.

The only significant disadvantage of the centrifugal supercharger is that it must be spinning at a relatively high speed before it begins to make a significant amount of boost. For this reason, it is not helpful in creating boost (and power) at low engine rpms. Normally the supercharger only begins to create boost at around 3000 rpm, and the boost curve gradually and increasingly rises with engine RPM. Many centrifugal superchargers do not have a self-lubricating oil system, and draw oil from the engine's oil supply. The disadvantage to this is that you must tap the oil pan for the oil return line. However, in doing so, the supercharger becomes virtually maintenance free. Some manufacturers make a "self-contained" centrifugal supercharger that is self-lubricated like roots and twin screw superchargers.

The Turbocharger

You may be wondering where the turbocharger fits in to this equation. Technically, a turbocharger IS a type of supercharger—one that is driven by exhaust gasses rather than from a pulley that draws power from the engine's crank. Because we have covered this topic in depth in our Turbos vs. Superchargers article, we will not re-examine the differences again here. Because the turbocharger relies on a technology substantially different from the three traditional supercharger technologies discussed above, it is beyond the scope of this article.



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