Turbocharger vs Supercharger

Keeping the air that enters the engine cool is an important part of the design of both superchargers and turbochargers. Compress-ing air increases its temperature, so it is common to use a small radiator called an intercooler between the pump and the engine to reduce the temperature of the air.

There are three main categories of superchargers for automotive use:

Centrifugal turbochargers – driven from exhaust gases.
Centrifugal superchargers – driven directly by the engine via a belt-drive.
Positive displacement pumps – such as the Roots, Twin Screw (Lysholm), and TVS (Eaton) blowers.

Roots blowers tend to be 40–50% efficient at high boost levels. Centrifugal superchargers are 70–85% efficient. Lysholm-style blowers can be nearly as efficient as their centrifugal counterparts over a narrow range of load/speed/boost, for which the system must be specifically designed.

Positive-displacement superchargers may absorb as much as a third of the total crankshaft power of the engine, and, in many applications, are less efficient than turbochargers. In applications for which engine response and power are more important than any other consideration, such as top-fuel dragsters and vehicles used in tractor pulling competitions, positive-displacement superchargers are very common.

The thermal efficiency, or fraction of the fuel/air energy that is converted to output power, is less with a mechanically driven supercharger than with a turbocharger, because turbochargers are using energy from the exhaust gases that would normally be wasted. For this reason, both the economy and the power of a turbocharged engine are usually better than with superchargers.

Turbochargers suffer (to a greater or lesser extent) from so-called turbo-spool (turbo lag; more correctly, boost lag), in which initial acceleration from low RPM is limited by the lack of sufficient exhaust gas mass flow (pressure). Once engine RPM is sufficient to start the turbine spinning, there is a rapid increase in power, as higher turbo boost causes more exhaust gas production, which spins the turbo yet faster, leading to a belated "surge" of acceleration. This makes the maintenance of smoothly increasing RPM far harder with turbochargers than with engine-driven superchargers, which apply boost in direct proportion to the engine RPM.

The main advantage of an engine with a mechanically driven supercharger is better throttle response, as well as the ability to reach full-boost pressure instantaneously. With the latest turbocharging technology and direct gasoline injection, throttle response on turbocharged cars is nearly as good as with mechanically powered superchargers, but the existing lag time is still considered a major drawback, especially considering that the vast majority of mechanically driven superchargers are now driven off clutched pulleys, much like an air compressor.

Turbocharging has been more popular than superchargers among auto manufacturers owing to better power and efficiency. For instance Mercedes-Benz and Mercedes-AMG previously had supercharged "Kompressor" offerings in the early 2000s such as the C230K, C32 AMG, and S55 AMG, but they have abandoned that technology in favor of turbocharged engines released around 2010 such as the C250 and S65 AMG biturbo. However, Audi did introduce its 3.0 TFSI supercharged V6 in 2009 for its A6, S4, and Q7, while Jaguar has its supercharged V8 engine available as a performance option in the XJ, XF and XKR.

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Turbocharger vs Supercharge cont.

In contrast to turbochargers, superchargers are not powered by exhaust gases but driven by the engine mechanically.[12] Belts, chains, shafts, and gears are common methods of powering a supercharger. A supercharger places a mechanical load on the engine to drive.[13][14] For example, on the single-stage single-speed supercharged Rolls-Royce Merlin engine, the supercharger uses up about 150 horsepower (110 kW). Yet the benefits outweigh the costs: For that 150 hp (110 kW), the engine generates an additional 400 horsepower, a net gain of 250 hp (190 kW). This is where the principal disadvantage of a supercharger becomes apparent: the internal hardware of the engine must withstand the net power output of the engine, plus the 150 horsepower to drive the supercharger.

In comparison, a turbocharger does not place a direct mechanical load on the engine.[12] It is more efficient because it uses potential and kinetic energy of the exhaust gas to drive the compressor. In contrast to supercharging, the principal disadvantages of turbocharging are back-pressure,[12] heat soak of the intake air, and the inefficiencies of the turbine versus direct-drive. A combination of an exhaust-driven turbocharger and an engine-driven supercharger can mitigate the weaknesses of the other.[15] This technique is called twincharging.

In the case of Electro-Motive Diesel's two-stroke engines, the mechanically-assisted turbocharger is not specifically a twincharger as the mechanical assistance is employed only for creation of charge air during starting, and the mechanical assistance is not employed thereafter. Rather, true turbocharging is employed thereafter. This, then, is a modification of a true turbocharger which employs the compressor section of the turbo-compressor only during starting, as a two-stroke engine, such as EMD's, cannot naturally aspirate, and, according to SAE definitions, a two-stroke engine which has a mechanically-assisted compressor during starting is considered to be naturally aspirated.

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