**Turbocharger**

**Working principle**

A turbocharger consists of a turbine and a compressor linked by a shared axle. The turbine inlet receives exhaust gases from the engine exhaust manifold causing the turbine wheel to rotate. This rotation drives the compressor, compressing ambient air and delivering it to the air intake of the engine; this allows more fuel to enter the cylinder because the air is compressed.

The objective of a turbocharger is the same as a normal supercharger; to improve upon the size-to-output efficiency of an engine by solving one of its cardinal limitations. A naturally aspirated automobile engine uses only the downward stroke of a piston to create an area of low pressure in order to draw air into the cylinder. Because the number of air and fuel molecules determine the potential energy available to force the piston down on the combustion stroke, and because of the relatively constant pressure of the atmosphere, there ultimately will be a limit to the amount of air and consequently fuel filling the combustion chamber. This ability to fill the cylinder with air is its volumetric efficiency. Because the turbocharger increases the pressure at the point where air is entering the cylinder, and the amount of air brought into the cylinder is largely a function of time and pressure, more air will be drawn in as the pressure increases. The additional air makes it possible to add more fuel, increasing the output of the engine. Also, the intake pressure can be controlled by a wastegate, which bleeds off excess boost from the turbocharger.

The application of a compressor to increase pressure at the point of cylinder air intake is often referred to as forced induction. Centrifugal superchargers operate in the same fashion as a turbo; however, the energy to spin the compressor is taken from the rotating output energy of the engine's crankshaft as opposed to exhaust gas. For this reason turbochargers are ideally more efficient, since their turbines are actually heat engines, converting some of the thermal energy from the exhaust gas that would otherwise be wasted, into useful work. Contrary to popular belief, this is not totally "free energy," as it always creates some amount of exhaust backpressure which the engine must overcome. Superchargers use output energy from an engine to achieve a net gain, which must be provided from some of the engine's total output; either directly or from a separate smaller engine, perhaps electrically driven from the main engine's generator.

**History**

The turbocharger was invented by Swiss engineer Alfred Buchi, who had been working on steam turbines. His patent for the internal combustion turbocharger was applied for in 1905. Diesel ships and locomotives with turbochargers began appearing in the 1920s.

One of the first applications of a turbocharger to a non-Diesel engine came when General Electric engineer, Sanford Moss attached a turbo to a V12 Liberty aircraft engine. The engine was tested at Pikes Peak in Colorado at 14,000 feet to demonstrate that it could eliminate the power losses usually experienced in internal combustion engines as a result of altitude.

Turbochargers were first used in production aircraft engines in the 1930s before World War II. The primary purpose behind most aircraft-based applications was to increase the altitude at which the airplane can fly, by compensating for the lower atmospheric pressure present at high altitude. Aircraft such as the Lockheed P-38, Boeing B-17 Flying Fortress and Republic P-47 all used exhaust driven "turbo-superchargers" to increase high altitude engine power. It is important to note that the majority of turbosupercharged aircraft engines used both a gear-driven second stage centrifugal type supercharger and a first stage turbocharger.

The first Turbo-Diesel truck was produced by the "Swiss Machine Works Saurer" (Schweizer Maschinenfabrik Saurer) 1938 [1]. The turbocharger hit the automobile world in 1952 when Fred Agabashian qualified for pole position at the Indianapolis 500 and led for 100 miles before tire shards disabled the blower.

The first production turbocharged automobile engines came from General Motors in 1962. The A-body Oldsmobile Cutlass Jetfire and Chevrolet Corvair Monza Spyder were both fitted with turbochargers. The Oldsmobile is often recognized as the first, since it came out a few months earlier than the Corvair. Its Turbo Jetfire was a 215 in³ (3.5 L) V8, while the Corvair engine was either a 145 in³ (2.3 L)(1962-63) or a 164 in³ (2.7 L) (1964-66) flat-6. Both of these engines were abandoned within a few years, and GM's next turbo engine came more than ten years later.

Offenhauser's turbocharged engines returned to Indianapolis in 1966, with victories coming in 1968. The Offy turbo peaked at over 1,000 hp in 1973, while Porsche dominated the Can-Am series with a 1100 hp 917/30. Turbocharged cars dominated the Le Mans between 1976 and 1988, and then from 2000-2007.

BMW led the resurgence of the automobile turbo with the 1973 2002 Turbo, with Porsche following with the 911 Turbo, introduced at the 1974 Paris Motor Show. Buick was the first GM division to bring back the turbo, in the 1978 Buick Regal, followed by the Mercedes-Benz 300D, Saab 99 in 1978. Japanese manufacturers followed suit, with Mitsubishi Lancer in 1978, Toyota Supra in 1980, Nissan 280ZX in 1981 and Mazda RX-7 in 1984.

The worlds first production turbodiesel automobile was also introduced in 1978 by Peugeot with the launch of the Peugeot 604 turbodiesel. Today, nearly all automotive diesels are turbocharged.

Alfa Romeo introduced the first mass-produced Italian turbocharged car, the Alfetta GTV 2000 Turbodelta in 1979. Pontiac also introduced a turbo in 1980 and Volvo Cars followed in 1981. Renault however gave another step and installed a turbocharger to the smallest and lightest car they had, the R5, making it the first Supermini automobile with a turbocharger in year 1980. This gave the car about 160bhp in street form and up to 300+ in race setup, which was extraordinary output for a 1400cc motor. The R5's powerful motor was complemented by an incredible lightweight chassis, and as a consequence it was possible for an R5 to nip at the heels of the quick Italian sports car Ferrari 308.

In Formula One, in the so called "Turbo Era" of 1977 until 1989, engines with a capacity of 1500 cc could achieve anywhere from 1000 to 1500 hp (746 to 1119 kW) (Renault, Honda, BMW, Ferrari). Renault was the first manufacturer to apply turbo technology in the F1 field, in 1977. The project's high cost was compensated for by its performance, and led to other engine manufacturers following suit. The Turbo-charged engines took over the F1 field and ended the Ford Cosworth DFV era in the mid 1980s. However, the FIA decided that turbos were making the sport too dangerous and expensive, and from 1987 onwards, the maximum boost pressure was reduced before the technology was banned completely for 1989.

In Rallying, turbocharged engines of up to 2000cc have long been the preferred motive power for the Group A/NWorld Rally Car (top level) competitors, due to the exceptional power-to-weight ratios (and enormous torque) attainable. This combines with the use of vehicles with relatively small bodyshells for manoeuvreability and handling. As turbo outputs rose to similar levels as the F1 category (see above), the FIA, rather than banning the technology, enforced a restricted turbo inlet diameter (currently 34mm), effectively "starving" the turbo of compressible air and making high boost pressures unfeasible. The success of small, turbocharged, four-wheel-drive vehicles in rally competition, beginning with the Audi Quattro and the Mazda 323GTX, has led to exceptional road cars in the modern era such as the Lancia Delta Integrale, Toyota Celica GT-Four, Subaru Impreza WRX and the Mitsubishi Lancer Evolution.

In the late 1970s, Ford and GM looked to the turbocharger to gain power, without sacrificing fuel consumption, during not only the emissions crunch of the federal government but also a gas shortage. GM released turbo versions of the Pontiac Firebird, Buick Regal, and Chevy Monte Carlo. Ford responded with a turbocharged Mustang in the form of the 2.3L from the Pinto. The engine design was dated, but it worked well. The bullet-proof 2.3L Turbo was used in early carburated trim as well as fuel injected and intercooled versions in the Mustang SVO and the Thunderbird Turbo Coupe until 1988. GM also liked the idea enough to evolve the 3.8L V6 used in early turbo Buicks into late '80s muscle in the form of the Buick Grand National and it's pinnacle (and final) form, the GNX.

Although late to use turbocharging, Chrysler Corporation turned to turbochargers in 1984 and quickly churned out more turbocharged engines than any other manufacturer, using turbocharged, fuel-injected 2.2 and 2.5 litre four-cylinder engines in minivans, sedans, convertibles, and coupes. Their 2.2 litre turbocharged engines ranged from 142 hp to 225 hp, a substantial gain over the normally aspirated ratings of 86 to 93 horsepower; the 2.5 litre engines had about 150 horsepower and had no intercooler. Though the company stopped using turbochargers in 1993, they returned to turbocharged engines in 2002 with their 2.4 litre engines, boosting output by 70 horsepower.