УДК 621.438

HISTORY OF TURBO ENGINES: PAST AND FUTURE

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A turbocharger, or turbo, is a gas compressor that is used for forced-induction of an internal combustion engine. A form of supercharger, the turbocharger increases the density of air entering the engine to create more power. A turbocharger has the compressor powered by a turbine, driven by the engine's own exhaust gases, rather than direct mechanical drive as with many other superchargers.

A turbocharger is a small radial fan pump driven by the energy of the exhaust gases of an engine. A turbocharger consists of a turbine and a compressor on a shared shaft. The turbine converts exhaust heat and pressure to rotational force, which is in turn used to drive the compressor. The compressor draws in ambient air and pumps it in to the intake manifold at increased pressure, resulting in a greater mass of air entering the cylinders on each intake stroke.

The objective of a turbocharger is the same as a supercharger; to improve the engine's volumetric efficiency 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 through the intake valves. Because the pressure in the atmosphere is no more than 1 atm (approximately 14.7 psi), there ultimately will be a limit to the pressure difference across the intake valves and thus the amount of airflow entering the combustion chamber. Because the turbocharger increases the pressure at the point where air is entering the cylinder, a greater mass of air (oxygen) will be forced in as the inlet manifold pressure increases. The additional air flow makes it possible to maintain the combustion chamber pressure and fuel/air load even at high engine revolution speeds, increasing the power and torque output of the engine. Because the pressure in the cylinder must not go too high to avoid detonation and physical damage, the intake pressure must be controlled by venting excess gas. The control function is performed by a wastegate, which routes some of the exhaust flow away from the turbine. This regulates air pressure in the intake manifold.

The first exhaust-driven supercharger was developed by Dr. Alfred J. Buchi of Switzerland between 1909 and 1912, long before Garrett products entered the turbocharger picture. Dr. Buchi was Chief Engineer of Sulzer Brothers Research Department and in 1915 proposed the first prototype of a turbocharged diesel engine, but his ideas gained little or no acceptance at that time. General Electric began developing turbochargers during the late 1910's. In 1920, a LePere bi-plane that was equipped with a Liberty engine and a General Electric turbocharger set a new altitude record of 33,113 feet (10092m). Turbochargers were used sparingly on aircraft in World War I, but their development occurred on a widening scale in the 1930's and 1940's - first in Europe and then in the United States. In the United States, General Electric developed turbochargers for military aircraft, and in World War II, thousands were used on fighter aircraft and bombers, such as the B-17. The Garrett Corporation, formed in 1936 by J. C. "Cliff" Garrett, supplied the charge air cooler (aftercooler) for the B-17, located between the General Electric turbocharger and the Pratt and Whitney engine. On September 27, 1954, Cliff Garrett made the decision to separate the turbocharger group from the Gas Turbine department due to commercial diesel turbocharger opportunities. That was the beginning of the new AiResearch Industrial Division - for turbocharger design and manufacturing. AiResearch Industrial Division would later be named Garrett Automotive. The Chevrolet Corvair Monza and the Oldsmobile Jetfire were the first turbo-powered passenger cars, and

made their debut on the US market in 1962/63. Despite maximum technical outlay, however, their poor reliability caused them to disappear quickly from the market. After the first oil crisis in 1973, turbocharging became more acceptable in commercial diesel applications. Until then, the high investment costs of turbocharging were offset only by fuel cost savings, which were minimal. Increasingly stringent emission regulations in the late 80's resulted in an increase in the number of turbocharged truck engines, so that today, virtually every truck engine is turbocharged. In the 70's, with the turbocharger's entry into motor sports, especially into Formula I racing, the turbocharged passenger car engine became very popular. The word "turbo" became quite fashionable. At that time, almost every automobile manufacturer offered at least one top model equipped with a turbocharged petrol engine. However, this phenomenon disappeared after a few years because although the turbocharged petrol engine was more powerful, it was not economical. Furthermore, the "turbo-lag", the delayed response of the turbochargers, was at that time still relatively large and not accepted by most customers. The real breakthrough in passenger car turbocharging was achieved in 1978 with the introduction of the first turbocharged diesel engine passenger car in the Mercedes-Benz 300 SD, followed by the VW Golf Turbodiesel in 1981. By means of the turbocharger, the diesel engine passenger car's efficiency could be increased, with almost petrol engine "driveability", and the emissions significantly reduced.

Today, the turbocharging of petrol engines is no longer primarily seen from the performance perspective, but is rather viewed as a means of reducing fuel consumption and, consequently, environmental pollution on account of lower carbon dioxide (CO_2) emissions. Currently, the primary reason for turbocharging is the use of the exhaust gas energy to reduce fuel consumption and emissions.

The aircraft engineer Frank Halford experimented with turbocharging in his modified Aston Martin racing car the *Halford Special*, but it is unclear whether or not his efforts were successful. The first successful application of turbocharging in automotive racing appears to have been in 1952 when Fred Agabashian in the diesel-powered Cummins Special qualified for pole position at the Indianapolis 500 and led for 175 miles (282 km) before ingested tire shards disabled the compressor section of the Elliott turbocharger. Offenhauser's turbocharged engines returned to Indianapolis in 1966, with victories coming in 1968 using a Garrett AiResearch turbocharger. The Offenhauser turbo peaked at over 1,000 hp (750 kW) in 1973, while Porsche dominated the Can-Am series with a 1,100 hp (820 kW) 917/30. Turbocharged cars dominated the 24 Hours of Le Mans between 1976 and 1988, and then from 2000-2007. 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 turbocharged engines took over the F1 field and ended the Ford Cosworth DFV era in the mid 1980s. However, the FIA decided that turbochargers were making the sport too dangerous and expensive. In 1987 F1 decided to limit the maximum boost pressure before the technology was banned completely for 1989. In drag racing, an 1,800 hp (1,340 kW), twin-turbocharged Pontiac GTA developed by Gale Banks of Southern California, set a land speed record for the "World's Fastest Passenger Car" of 277 mph (446 km/h). This event was chronicled at the time in a 1987 cover story published by Autoweek magazine. Gale banks engineering also built and raced several diesel-powered drag racing machines, including the "World's Fastest Diesel Truck," a street-legal 735 hp (548 kW) Dodge Dakota pick-up that towed its own trailer to the Bonneville Salt Flats and then set an official F.I.A. two-way speed record of 217 mph (349 km/h) with a one-way top speed of 222 mph (357 km/h). This latter vehicle also showed the fuel economy of a turbocharged diesel engine by averaging 21.2-mpg on the Hot Rod Power Tour.