

COMPOUND FORCED INDUCTION SYSTEM: TWINCHARGER

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ABSTRACT: Twincharging does not refer to a twin-turbo arrangement, but rather when two different kinds of compressors are used. It is a combination of an exhaust-driven turbocharger and an engine-driven supercharger, each mitigating the weaknesses of the other (eliminating turbo lag, which would otherwise result when the turbocharger is not up to its operating speed). Twincharging allows getting high boost levels from relatively low cost components. It is a great way to increase the power of a small engine with a high RPM range. Obviously there is a large heat built up issue so a larger intercooler is pre-requisite. Efficiencies of the turbo and supercharger are also multiplied. Its largest benefit over anti-lag systems in race cars is its reliability. The two major types of twincharging are series and parallel. The benefit of twincharging on the same engine is increased torque across the entire power band, and thus optimum performance at all rpm. This paper presents an understanding of the super, turbo and twincharger, their types and application of twincharger and suggests a technique in twincharging.

KEYWORDS: Twincharger, turbolag, turbocharger shaft, inlet air

INTRODUCTION

Twincharger refers to a compound forced induction system used on some piston-type internal combustion engines. It is a combination of an exhaust-driven turbocharger and an engine-driven supercharger, each mitigating the weaknesses of the other. A belt-driven supercharger offers exceptional response and low-rpm performance as it has no lag time between the application of throttle and pressurization of the manifold. Combined with a large turbo which would offer unacceptable lag and poor response in the low-rpm range, the proper combination of the two can offer a zero-lag power band with high torque at lower engine speeds and increased power at the higher end. Twincharging is therefore desirable for small-displacement motors, especially those with a large operating rpm, since they can take advantage of an artificially broad torque band over a large speed range.

I. TURBOCHARGER

A turbocharger is a forced induction device used to allow more power to be produced for an engine of a given size. A turbocharged engine can be more powerful and efficient than a naturally aspirated engine because the turbine forces more intake air, proportionately more fuel, into the combustion chamber than if atmospheric pressure alone is used. Turbochargers were first used in production aircraft engines such as the Napier Lioness in the 1920s, although they were less common than engine-driven centrifugal superchargers.

The turbocharger's compressor draws in ambient air and compresses it before it enters into the intake manifold at increased pressure. This results in a greater mass of air entering the cylinders on each intake stroke. The power needed to spin the centrifugal compressor is derived from the kinetic energy of the engine's exhaust gases.

TURBOLAG:

It is the time required to change power output in response to a throttle change, noticed as a hesitation or slowed throttle response when accelerating from idle as compared to a naturally aspirated engine. This is due to the time needed for the exhaust system and turbocharger to generate the required boost. Inertia, friction, and compressor load are the primary contributors to turbo lag.

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WASTEGATE:

Many turbochargers use a basic wastegate, which allows smaller turbochargers to reduce turbo lag. A wastegate regulates the flow that enters the turbine and therefore the air intake into the manifold and the degree of boosting. It is controlled by a solenoid operated by the engine's electronic control unit or a boost controller.

II. SUPERCHARGER

A supercharger is an air compressor used to increase the pressure, temperature, and density of air supplied to an internal combustion engine. The compressed air that a supercharger provides to an engine supplies a greater mass of oxygen per cycle of the engine to support combustion than available to a naturally aspirated engine, which makes it possible for more fuel to be burned and more work to be done per cycle, which increases the power the engine produces. Power for the supercharger can be provided mechanically by a belt, gear, shaft, or chain connected to the engine's crankshaft.

It is possible to estimate the temperature rise across a supercharger by modeling it as an isentropic process.

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

Where,

T_1 = ambient air temperature

T_2 = temperature after the compressor

P_1 = ambient atmospheric pressure (absolute)

P_2 = pressure after the compressor (absolute)

γ = Ratio of specific heats for air = $\frac{C_p}{C_v}$

C_p = Specific heat at constant pressure

C_v = Specific heat at constant volume

III. TYPES OF TWINCHARGING

SERIES:

The series arrangement, the more common arrangement of twinchargers, is set up such that one compressor's (turbo or supercharger) output feeds the inlet of another. A sequentially-organized Roots is connected to a medium- to large-sized turbocharger. Other series configurations exist where no bypass system is employed and both compressors are in continuous duty. As a result, compounded boost is always produced as the pressure ratios of the two compressors are multiplied, not added.

In other words, if a supercharger which produced 10 psi (0.7 bar) (pressure ratio = 1.7) alone blew into a turbocharger which also produced 10psi alone, the resultant manifold pressure would be 27 psi (1.9 bar) (PR=2.8) rather than 20 psi (1.4 bar) (PR=2.3).

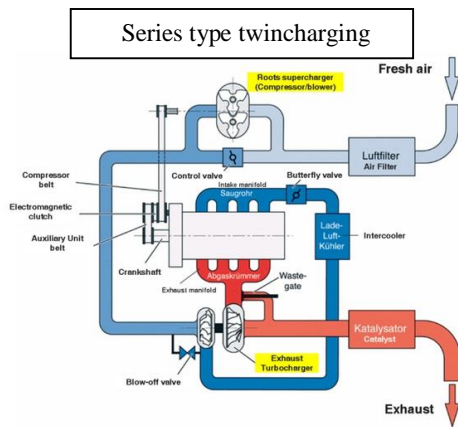


Figure.1 Series twincharger

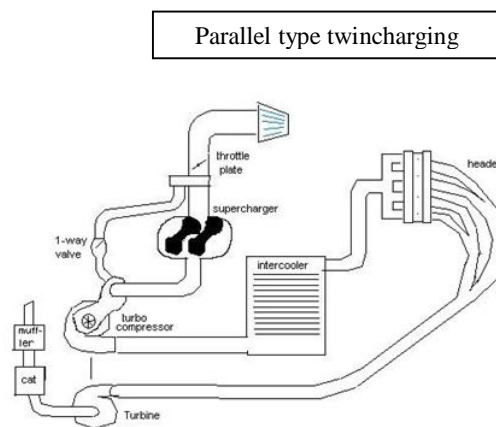


Figure.2 Parallel twincharger

PARALLEL:

Parallel arrangements typically always require the use of a bypass or diverter valve to allow one or both compressors to feed the engine. If no valve were employed and both compressors were merely routed directly to the intake manifold, the supercharger would blow backwards through the turbocharger compressor rather than pressurize the intake manifold, as that would be the path of least resistance. Thus a diverter valve must be employed to vent turbocharger air until it has reached the pressure in the intake manifold. Complex or expensive electronic controls are usually necessary to ensure smooth power delivery.

III.INTERCOOLING

When the pressure of the engine's intake air is increased, its temperature will also increase. In addition, heat soak from the hot exhaust gases spinning the turbine may also heat the intake air. The warmer the intake air the less dense, and the less oxygen available for the combustion event, which reduces volumetric efficiency. Not only does excessive intake-air temperature reduce efficiency, it also leads to engine knock, or detonation, which is destructive to engines.

Twincharger units often make use of large intercoolers (also known as a charge air cooler), to cool down the intake air.

IV. THE TWO IN ONE

A turbocharger can be used a twin charger. An electromagnetic clutch plays an important role here. The shaft between the turbine and the compressor is provided with a gear wheel (driven gear). The driver gear obtains its energy from the engine via a belt or sequential gears. As the engine runs at low rpm, the exhaust gas velocity will not be enough to drive the turbine. At this stage the electromagnetic clutch engages the gears so that the driver gear powers the driven gear. As the driven gear rotates, the turbocharger shaft is rotated. This makes the compressor to compress the intake air with the power derived from the engine. When the engine's rpm reaches a required level to drive the turbocharger, the electromagnetic clutch disengages the gears and the compressor runs on the exhaust gas power. This helps in overcoming the turbo lag and also the use of a separate supercharger is totally avoided. Hence this kind of twincharger may be of low cost and the total weight is reduced nearly to half.

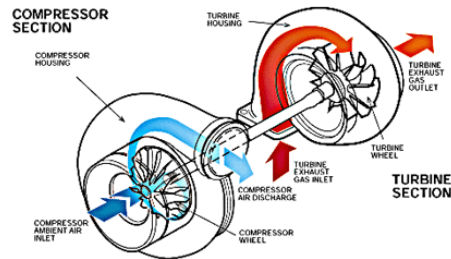


Figure.3 Turbocharger shaft

V. CONCLUSION

Twincharging has a history of about 23 years. It has been evolving since the period of invention. It has been used first in racing where both acceleration and top speed was essential. Later, it has been introduced for commercial use. Now a days Volkswagen TSI engine uses a twincharger. Thus twincharging has played a vast role in forced induction. The use of a single turbocharger as a twincharger may reduce the components required and also the cost.

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