SUPERCHARGER versus TURBOCHARGER

The following is a summary of a technical paper produced for the automotive industry in which the efficiencies of both Supercharging and Turbocharging were assessed. Obtaining the maximum engine power output over a wide operating range while meeting emissions, fuel economy, packaging, cost and driveability standards has been objective of most engine development efforts. With the advent of the fuel crisis and the attendant vehicle down sizing programs, the use of forced induction has been a popular method to increase downsized engine power while increasing fuel economy and in essence meeting the strict emission legislation set down. For this comparison all reference has been made to a standard screw type Supercharger and a standard iron turbine type Turbocharger.

Engine Response

The Turbocharger does not reach its maximum efficiency range until high speed and airflows are achieved later in the vehicle acceleration event. The latest Turbochargers with variable geometry housings and ceramic turbines still take four times as long as a positive displacement Supercharger to produce maximum boost.

The Supercharger is continuously driven at full boost speed for the given engine speed. This offers almost immediate boost response which takes approximately 0.4 sec. to produce 50 KPA boost.

Efficiency

Turbocharger airflow delivery characteristics do not match the requirements of the internal combustion engine because of the volumetric efficiency versus speed difference. Turbochargers only display efficiency over a limited flow range. Turbo systems must be compromised to provide some low speed boost while matching high speed flow requirements. This usually requires wastegating which reduces maximum power.

The Supercharger exhibits airflow delivery characteristics very close to the engine requirement. Thus, boost remains almost constant over the total speed range without wastegating or other compromising control systems.

Noise and Durability

With Turbos driven by exhaust gases turbine noise is nearly eliminated. Durability cycles are affected by the extreme temperatures to which the turbine and housings are subjected, leading to fatigue and inevitable failure.

Supercharger noise, along with durability concerns, has been the expressed reservations associated with automotive use. With improved designs and advanced materials noise levels have been reduced considerably with durability cycles proven well in excess that of Turbochargers.

Lubrication

Turbochargers are subjected to extreme temperatures and in "shut down" situation the oil remaining in the turbine bearing sections will reach coking (burning) temperatures. The carbon build up in the engine's lubricating system will accelerate the internal wear of the engine and add to the rapid deterioration of the oil.

Superchargers can be lubricated by self contained systems which without the extreme heats experienced by Turbochargers will last for periods well in excess of the engine lubricants.

Aftercooling (Intercooling)

Turbochargers are subject to extreme temperatures, and discharge temperatures need lowering through aftercoolers if high performance levels approaching that of Superchargers are to be reached.

Superchargers do not require aftercooling as outlet temperatures rarely exceed 140 degrees C.

Driveability

Unlike a direct coupled Supercharger, performance is only enhanced in proportion to turbine speed. Therefore performance at low speed is limited and a distinct pause is encountered under acceleration known commonly as Turbo lag.

Performance is obtained without sacrificing the practical and constant rate in which this torque is delivered. Towing and Off Road-4-Wheel Driving can benefit greatly from the increased torque at low speeds.

Exhaust Emissions

Turbochargers can be tailored to meet emission levels at normal operating temperatures but suffer on cold starts. Contrary to the heat generated by a Turbo, the exit gases are still low, and results in a longer catalytic light up time on cold starts. This results in unacceptable levels of exhaust emissions at engine start up and legislation is slowly reducing the light up period available which will create problems for Turbochargers.

With legislation increasing pressure on automobile manufacturers to generate clean running engines Superchargers can easily be tailored to suit engine manufacturers emission designs.

Vehicle Modifications

A Turbo becomes an integral part of the exhaust system, therefore requiring major modification to the standard exhaust. This also is the single limiting factor dictating its position in relation to the inlet manifold. Additional pipe-work can be required to reach air cleaners and inlet manifolds when mounted on the opposite side of the engine. If an aftercooler is incorporated the potential piping requirements can become impractical. Turbochargers fitted to some vehicles needs to be insulated with a heat-shield lagging to protect under-bonnet-components from the extreme temperature generated. Brake master cylinders have been known to melt in a Turbocharged vehicle, which creates other problems. Internal modifications are required in some cases such as compression modifications to accommodate the hot delivery air of the Turbocharger. Early opening of the exhaust valve will allow a high blow down pressure giving smaller engines more drive pressure from its exhaust but does sacrifice engine efficiency at cruise due to loss of full gas expansion.

A Supercharger need not change the physical configuration of a motor vehicle. A Supercharger is fitted where convenient by brackets and drive belt. Standard air cleaner and exhaust stay intact. No internal modifications to engines are required as the extra boost delivered is at a moderate temperature and which reduces the chance of detonation. No heat shielding is required for under-bonnet-components as, again, operating temperatures are low. No excessive plumbing required as Superchargers do not require aftercoolers and the unit can be mounted near the intake manifold requiring only a short discharge pipe.

Market Trends

Manufacturers have worked with or around the inherent problems of Turbocharging in the pursuit of performance, economy and emission controls. Now, with other options available, Turbocharging is becoming less important to many vehicle manufacturers.

Supercharging is becoming more widely accepted by original equipment manufacturers and different forms of Supercharging are now appearing on new vehicles.

Summary

In the past, Turbocharging has been an accepted means of increasing engine performance. Even with its inherent problems it was the most cost effective method of forced induction. Now, with improved manufacturing techniques and high volume production, Superchargers can not only offer better performance and packaging characteristics but can also now be price competitive.

References

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