

Note 76

Pressure-charging by exhaust turbine



When a piston engine is Pressure-Charged (PC) mechanically, power is taken directly from the crank to drive the inlet supercharger. However, because the inlet pressure in the cylinder is greater than that available with Natural Aspiration (NA) (after allowing for the pressure loss through the valve and the valve opening before TDC) the crank no longer has to supply power to the piston during the induction stroke but is provided with power. As there are mechanical and aerodynamic inefficiencies in the system this recovered power is substantially less than that subtracted originally, but it is some reduction of the power cost necessary to raise the Manifold Density Ratio (MDR) above ambient, which itself multiplies power. The Mechanical Supercharger (MSC), therefore, lowers the Mechanical Efficiency (EM) of the engine compared to an NA unit.

When the power to drive the supercharger is taken by a turbine from the high-temperature exhaust flow, the back pressure in the cylinder rises above the NA level during the exhaust stroke and reduces the crank output but the inlet pressure once again supplies power to the crank and, with typical turbine and compressor efficiencies, this is equal to or greater than the subtraction because of the difference in temperatures. Overall the crank output by TurboCharging (TC) is greater for this reason, compared to NA, before adding the gain from a higher MDR. The value of EM is raised in this case (but this diminishes as IVP is increased).

In effect a gas turbine consisting of a compressor, a combustion chamber (the piston engine) and a turbine has been coupled pneumatically to the piston engine. As the rules allow only one engine per car this is a breach of those rules.

Without elaborating on the above details, Keith Duckworth put forward the argument regarding illegality to the FISA, after TC engines were allowed into competition with his NA 3L DFV, simply on the basis that the TC turbine was another engine and an appropriate equivalent amount should be subtracted from the 1500 cc of the piston engine (851), but they ignored this argument*.

It is interesting that from 1977 Cosworth were making the TC DFX engine to the limited-swept-volume rules (2.65L) of Indy car races without worrying about any theoretical objections but, of course, there was no NA alternative.

Eventually, to stay in GP racing, Cosworth designed, and Ford USA financed, a 120V6 1.5L TC engine (type GB) for 1986, after they had been assured by Balestre of FISA that the regulations would not be changed before the end of 1990. The GB was up to competitive power but was not fully developed before the regulations were changed to ban TC after 1988, ostensibly to reduce cost (TC powers had already been restricted by fuel limits to reduce speeds). Therefore, the Cosworth GB programme was discontinued at the end of 1987.

*The attitude of FISA to the DFV and TurboCharging *may* have been that of a legendary umpire in allowing a blatantly-false LBW appeal against a batsman who had been at the crease very successfully for a long time and who then expostulated “*That wasn’t out!*”. The reply was “*Tha’s batted long enough!*”.
