



Tech Basics - Turbos

Factory turbo cars first hit our streets in large numbers more than 15 years ago. So, how does a turbo work and how do you make a turbo car go hard?

By Julian Edgar

You can pick up a turbo car on any budget from \$1500 to \$300,000, so there's literally something for everyone. At the budget end of town highlights include the Commodore Turbo, Pulsar ET, Sigma Turbo and Cordia Turbo. Plus of course a turbo (or two) can be fitted to any engine, so if you're a confirmed V8 person then that's no problem.

Forced Induction



Take a 3-litre engine for example. The '3 litres' refers to how much volume is displaced by all the pistons after they've done one stroke. So, if that 3-litre engine has six cylinders, each piston displaces 500cc of air - or, to put it another way, each can **breathe in** 500cc of air. When the piston moves downwards, atmospheric pressure (101kpa or 14.7psi) pushes air in past the open intake valve. Generally speaking, even if the intake flows are perfect, the engine can't breathe much more than those 3 litres of air.

Okay, but what if we jam in more air than flows with just atmospheric pressure behind it? What if we **boost** the air pressure? Let's say that we double atmospheric pressure - we add 14.7 psi of boost. In the same time that the intake valve is open and with the same piston movement, our 3-litre engine can now actually breathe in 6 litres of air! And, since it's air intake that limits engine power more than anything else, a '6 litre' with the right addition of fuel can produce a heap of grunt!

Boosting the air intake can be done in two ways - by a supercharger or turbocharger. A supercharger is a pump which is driven directly from the engine's crankshaft. While a supercharger has benefits over turbos in some ways, from a budget point of view, it remains the more expensive of the two forced induction options.

Turbos

Instead of being driven directly from the engine's crank, a turbo uses the energy left in the exhaust gases after they've come out of the engine. In a non-turbo car, the heat and pressure in the exhaust is usually wasted - sent out of the back of the car with nothing much done with it.



On a turbo car, those exhaust gases are channelled by means of a special exhaust manifold to the turbine side of the turbo. Here there's a wheel with specially-shaped blades attached to it. The exhaust gases are nozzled down so that they increase a lot in speed, and are aimed at the wheel. This causes the turbine to spin very quickly - at up to 100,000rpm. The turbine is mounted on a shaft, and fixed at the other end of the same shaft is a compressor. This is another wheel with special blades, but the job of this one is to blow air into the engine - to develop boost.

How it Happens



At idle, there isn't much exhaust gas coming from the engine. The gases are still all directed at the turbine side of the turbo, but often they simply flow through the wheel, not even causing it to turn. Likewise, the compressor end of the turbo isn't turning yet - if the turbine is stationary the compressor must be too, because they're both solidly attached to the one shaft! Even in cars where the turbo is spinning at idle, there's no boost being developed yet.

Okay, you put your foot into it. The engine revs and load rise, and so the amount of exhaust gases coming out of the engine goes up quickly. This starts the turbo spinning fast. Once the turbo is spinning fast enough, it will start developing boost - blowing a heap more air into the engine than the engine can actually breathe. That's why the pressure in the intake manifold goes up. But the engine will still breathe in more than usual, and so the exhaust flow will also rise. This spins the turbo even faster - so pushing more and more air into the engine, which in turn produces more exhaust flow....

The result is that a turbo car often has a characteristic feel - the faster you go, the harder the car goes!

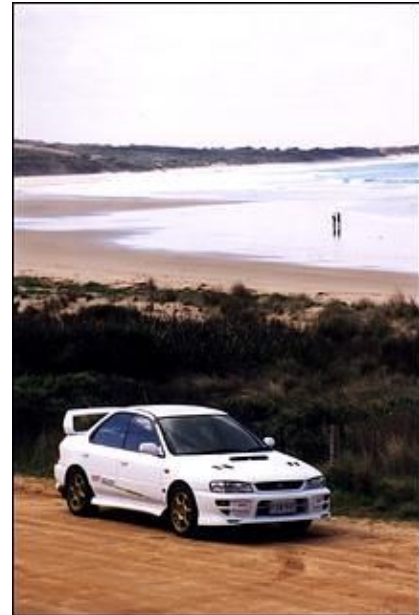
Advantages and Disadvantages of a Turbo Car



Like most car performance approaches, there are pros and cons. For a turbo car the advantages include the fact that the power is cheap, a turbo car driven sedately gives very good economy, it's easy to increase the engine's power output, and a turbo car has excellent mid-range and top-end grunt.

On the negative side, the major one is that a turbo engine will have poorer low-down torque than other performance approaches. Generally, a 200hp turbo car won't lay rubber like a 200hp atmo V8, for example. However, the quarter mile time of both cars will be similar - the turbo car making up for its slower off-the-line performance a little further down the strip! Another negative is that if you treat the engine badly - hot shut-downs, poor oil - the turbo will wear out faster than the rest of the engine.

Wastegate Control



Because a turbo can vary so much in its speed, the airflow coming out also varies a great deal. So that the turbo will generate boost as early as possible, turbos are sized so that they'll spin up quickly. However, once they start spinning really fast, they'll also over-boost the engine! To prevent this happening, a flap valve called a wastegate bypasses the flow of exhaust gas from the engine around the turbine, limiting its speed and so also the boost being developed by the compressor.

Controlling the movement of the wastegate valve is a diaphragm and rod. On one side of the diaphragm is a spring, with boost pressure from the compressor's outlet applied to the other side. Let's say that the turbo's not spinning fast enough to develop any boost. The diaphragm stays stationary, and the rod connected the diaphragm to the wastegate valve keeps the wastegate shut. As a result, all of the exhaust gas goes through the turbine.

When you've got your foot down hard, the turbo will quickly spin up to speed. The boost pressure might be 7 psi, and so there's also this much pressure pushing on the diaphragm. That's enough to flex it against the spring, and so the rod going to the wastage moves, opening the wastegate valve and letting some of the exhaust gases bypass the turbine. The turbo then doesn't exceed this boost pressure.

Making Them Go Harder

So you reckon you've got it all figured out - all you need to do is to modify the wastegate controller so that you get more boost! The engine breathes in more and goes harder, right?

While this is true, it's also important that the air being blown into the engine stays cool. A turbo heats this air as it compresses it, and if you lift the boost pressure on a non-intercooled car, this can cause detonation. Detonation can literally destroy an engine in a few seconds... So, in non-intercooled cars (like those mentioned at the beginning of this article) the first step is to fit an intercooler. This is basically just a special radiator that the air passes through after it leaves the turbo and before it gets to the engine.



After the intercooler, the next best step is a big exhaust. Just like any other car, a turbo car loves a big exhaust - the bigger the better. The third step is to lift boost. The cheapest and easiest way of doing this is to put a T-piece in the hose that goes to the wastegate diaphragm and bleed off air via a small orifice. The more you bleed off, the higher will be the boost pressure developed.

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