Turbines to Speed

The time to bolt on a turbocharger has never been better. Read on and you'll soon see why!

By Michael Knowling

The ultimate run-down on turbos - the basics, current tech, used examples, hi-po modifications and everything else you could possibly want to know!

The role of a turbo is to increase the density of air being ingested by the engine, thus enabling more fuel to be burned. This is how more torque per combustion cycle is achieved through the use of forced induction. In the case of a naturally aspirated engine, the greatest volume of air/fuel that can be drawn into the engine is that pushed in by atmospheric pressure, which is 1 Bar (14.5psi). But the wonderful turbocharger pushes in an intake pressure higher than this so the combustion charge density can be increased.

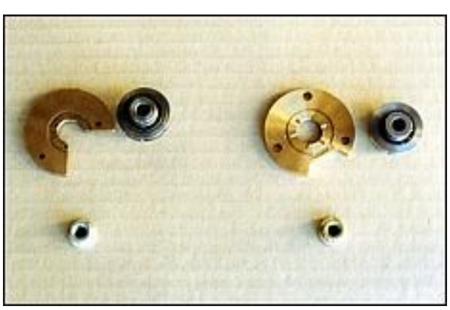
The turbo consists of two primary elements - a turbine and compressor. Exhaust gas energy spins a turbine wheel within a turbine housing. The rotation of this wheel is transferred via a common shaft to another similar-ish looking wheel (the compressor) at the opposite end of the turbocharger. The compressor wheel rotates within its own housing, drawing in air and then forcing it through the outlet of the compressor housing.

To a certain extent, the higher turbo boost pressure is, the larger the volume of air that is inhaled by the engine. But you can't just keep on increasing the boost pressure from the same turbo to some ungodly level. Not without problems, anyway. Overworking a turbo that is too small results in overheating, excessive back-pressure, surging, turbine housing cracks, short bearing life, spat oil seals and possible engine damage! Sure, you can lift boost from a typical 8 to 12-14 psi without too many problems, but if you want to go beyond that you should modify or change the turbo unit.

Turbo Modifications

Common turbo modifications include the fitment of a higher-flowing compressor wheel, and perhaps a back-cut turbine wheel. Back-cut turbine wheels posses less impeller curvature towards the turbine, enabling more exhaust gas to flow at a reduced turbo speed. Both the compressor and turbine housings can usually be swapped for larger ones, once again allowing for higher gas flow.

Remember though, for a road car it is all-important to have a well-matched turbocharger. This means one with equal flow capabilities on both the exhaust and intake side. Contrary to this, we've recently seen a lot of apparently mis-matched "hybrid" turbos being used in the UK for some reason. Can anyone out there explain that one for us? It is also very important to note that any modified or "high-flowed" turbo will not deliver the same strong bottom-end torque as the standard unit. Car manufacturers configure the engine and turbo for good low-rpm boost response and torque while trading off some top-end performance.



Improvements can also be made to increase a turbo's high boost durability. Most turbos use a 180-degree thrust bearing located within the core. This is fine under normal boost pressures, but they can be prone to wear under high boost duress. The solution is a heavy-duty 360-degree bearing, which can be fitted to most of the more common cores to increase the turbo's life span.

Those modified turbo engines more likely to back-fire (for whatever reason) can also have a reverse threaded nut used on the end of the shaft to retain the compressor wheel, eliminating the possibility of the nut working its way off.

Imported Used Turbos

If you're working on a budget, check out buying a second hand Japanese-import turbo. These range from tiny IHI RHB31's to reasonably large Garrett T3's, with every possible size in between.

Aim to get a turbo pulled from a similar displacement engine that produces near (or nearer) the power output you want to obtain. For example, a turbo from a Galant VR4 engine - with up to 172kW in some guises - will certainly liven up the top-end performance of a reworked Starion (Conquest) engine.As a guide, here is a list of some of the most commonly available import turbos and their engines maximum factory rated power:

NISSAN

SR20DET (Garrett T28) - 164kW

TOYOTA

2JZ-GTE (Toyota CT twin turbo) - 208kW

MITSUBISHI

G63B Starion (TD05/6) - 131kW

MAZDA

B6 Turbo (IHI RHB5*) - 104kW

DAIHATSU

CB70 (IHI RHB5*) - 78kW

*The IHI RHB5 turbo is used on both the CB70 and B6, but each turbo has different 'trim' specs. Given the engines' peak power and swept volume differences, there would be little in common between these two turbos.

Current Generation Turbos

Some pretty trick new gear is now available for those keen enough to spend up. These new-wave turbos are clearly showing their advantages in competition circles, so why not apply this technology to your road car?

Ceramic Turbine Wheels

Ceramic wheels have a significantly lower density than steel, meaning there's a lower moment of inertia that results in faster transient response. Most mass-produced turbos use high-temperature austenitic nickel steel alloy for their turbine wheels, but lightweight ceramic wheels have been fitted to many late-1980s onwards turbo Nissans.

During the initial concept stage, Nissan carried out extensive ceramics testing. This revealed up to a massive 45% improvement in transient response, along with a 21% time reduction to reach 40kPa boost over a conventional turbo.

However, the common problems of ceramic wheels are high brittleness and vulnerability to the impact of foreign particles, such as those shed from the walls of an exhaust manifold.

Roller Bearings

A roller bearing turbo is designed to offer the benefits of reduced bearing friction plus added thrust strength. It was Nissan that once again tested the merits of roller bearing turbos, and they found a 45% improvement in transient response with the turbo taking 28% less time to hit 40kPa boost. Apparently, Garrett roller bearing turbos can be identified by six bolts being used to hold the housings to the core, as well as a plumper core section.

Garrett is the primary manufacturer of roller bearing turbos, and they also supply aftermarket companies such as HKS with parts for their own turbo line-up. APEXi is another Japanese go-fast company, which uses IHI-based roller bearings. We've seen these turbo kits installed on modified Subaru WRXs and they have appeared to perform very well indeed.

Split-Pulse Turbine Housings

These turbine housings have separate divided paths leading into the turbine wheel. This keeps exhaust pulses more isolated, thus preventing interference and giving slightly better turbine response. Split-pulse housings are quite commonly available in the aftermarket, and are factory fitted to the so-called 'twin-entry' Toyota 3S-GTE engine, plus various Nissan engines.

Variable Geometry

One example of a VGT is a variable nozzle turbine. Here, multiple vanes are arranged around the periphery of the turbine housing. The vanes are linked by a mechanism that gives adjustment of all vane angles. The gap between each vane can be varied, thus changing inlet area and exhaust flow angle onto the turbine wheel. A control system is needed for its operation, with the main input signal usually derived from engine airflow. There are numerous variations on the names and descriptions of the variable mechanisms, but all aim to deliver an optimal performance throughout the airflow range. At the time of writing we were unable to locate any official distributors of VGTs in Australia.

Wastegates

When discussing turbos it's difficult not to mention the all-important wastegate. The purpose of a wastegate is to bypass a certain proportion of exhaust gas around the turbo, thereby limiting turbo speed and boost pressure. There are two types of wastegates available:

Most turbo cars use an **internal** wastegate that is incorporated into the turbine housing. But because of its cramped location, the cross-sectional area of the bypass can be quite small and restrictive. This can have the effect of forcing more exhaust gas to pass through the turbine - creating out-of-control boost pressure and the potential for engine damage. Another problem is both the bypassed and "turbo'd" gasses merge very sharply into a shared exhaust pipe. This turbulent mixing of gas has the potential to limit peak power and effect the rate of boost rise.

External wastegates are usually quite large valves, mounted separate to the turbo and are generally best on competition cars only. These valves have the potential to be more durable and reliable, but their size and associated plumbing often prevents them from being fitted under the bonnet of a road car. Companies like HKS, Garrett and Turbonetics make external wastegates in a number of sizes; your choice will depend on how much power you're expecting (and your budget). One advantage of the external 'gate is their adjustment mechanism, which can change the point at which the valve starts to creep.

Deciding Which Option to Take

The first step in deciding which turbo is best for you is to establish the conditions it will be operating in. Is it going to be hammered relentlessly on the drag strip or driven everyday on the road? Remember, it's wise to be a little conservative in the turbo sizing of a road car - it's a real nuisance waiting for a turbo to spool up when you need the torque boost immediately.

On top of this, there are a few essential things to look out for and consider when sussing out a particular turbo. Such as:

A/R ratio

This is the area at the tongue of the turbo inlet divided by the radius to the centroid of the area. Don't worry if that doesn't make sense - the higher the number, the slower the turbine will spin to produce a given boost pressure but also the poorer the bottom end performance will be.

Both of these pictured compressor housings are from T04s. However, the Nissan turbo (on the right) has a 0.6 A/R ratio compared to the AiResearch's 0.42 A/R - even although it's barely noticeable. The Nissan turbo, because of it's larger 'tongue area' can therefore pass more air at slower shaft speeds.

Back Pressure

Once a turbo has been fitted, the ratio between back pressure on the engine and boost pressure at the compressor outlet should remain less than 2:1. Obviously boost pressure will play a huge part in this ratio for any given turbo size, but this general rule gives an indication of when the efficiency of the turbo is dropping off.

Core Cooling

Where possible, go for a turbo with a water-cooled core. They dissipate more heat away from the centre bearing and increase both bearing and seal longevity. Most of the older conventional turbos use air and the lubricating oil as their only cooling media and so offer a generally shorter service life.

Physical Dimensions

Make thoroughly sure there is enough room not only for the turbo, but also for exhaust manifolding, oil and water feed and return, the inlet pipe and the exhaust pipe. Will anything need to be moved?

Adapting to Suit

If the turbo bolts straight up, that's good. If not, things can start to get messy. An adaptor plate can be made to fit the existing manifold to a new turbo. Or better, a new manifold can be fabricated - but these can often (but not always) have problems with the thermal loads, leading to cracking. They aren't especially cheap either.

Do You Really Need Compressor Maps To Select a Turbo?

Speak to those people mad on turbos and they'll start talk about the "need" for compressor maps. These graph the airflow delivered by the turbo and its corresponding boost pressure. This is great if a) you know exactly what airflow requirements your engine has (and how do you work that out with accuracy?), and if b) turbo manufacturers/distributors were prepared to release the maps!

Plus it has been suggested to us that the few copies of compressor maps that are floating around are deliberately slightly fudged, as competing manufacturers would be able to duplicate these intricate designs quite easily if accurate graphs are available.... So no, compressor maps aren't absolutely essential - but they can provide you with a basic guide. The only really effective way to reach optimal performance is by experimenting on a chassis dyno.

Using the 'Net as a Resource

Most major turbo manufacturers have their own sites and these often have links to many other interesting sources of info. One of the best sites to visit is Ray Hall's at http://www.turbofast.com.au where you can use the Turbo Match program to obtain the optimum turbo set-up. This site is also linked to the excellent Turbonetics site at http://www.turboneticsinc.com/ and others that can give you further guidance.

HAPPY TURBO HUNTING!!!

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