TEXT: STUART GALLACHER

PHOTOS: MARK PAKULA

BOOST JUICE

ANY ENTHUSIAST WILL AGREE, HIGH OCTANE FUEL IS GOOD. BUT WHAT SORT OF BENEFITS DOES IT OFFER THE TYPICAL PERFORMANCE CAR OWNER? WITH THE HELP OF HI-OCTANE RACING, MARTINI RACING PRODUCTS AND THE TUNEHOUSE WORKSHOP, WE SET ABOUT PERFORMING SOME REAL WORLD TESTING OF VARIOUS HIGH-OCTANE FUEL.

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ONE OF THE KEYS to creating high levels of power-per-cube from any given internal combustion petrol engine is to compress each engine cycle's combustion mixture as much as possible, or squeezing the biggest bang into the smallest space. While forced induction and high compression ratio NA setups are paths leading to this one destination, there is one thing that will regulate the extent of their effectiveness completely: the quality of fuel you choose to use. But, what does an increased octane rating of a given fuel do for your engine, and what gains can be had by choosing a fuel with a high octane rating?

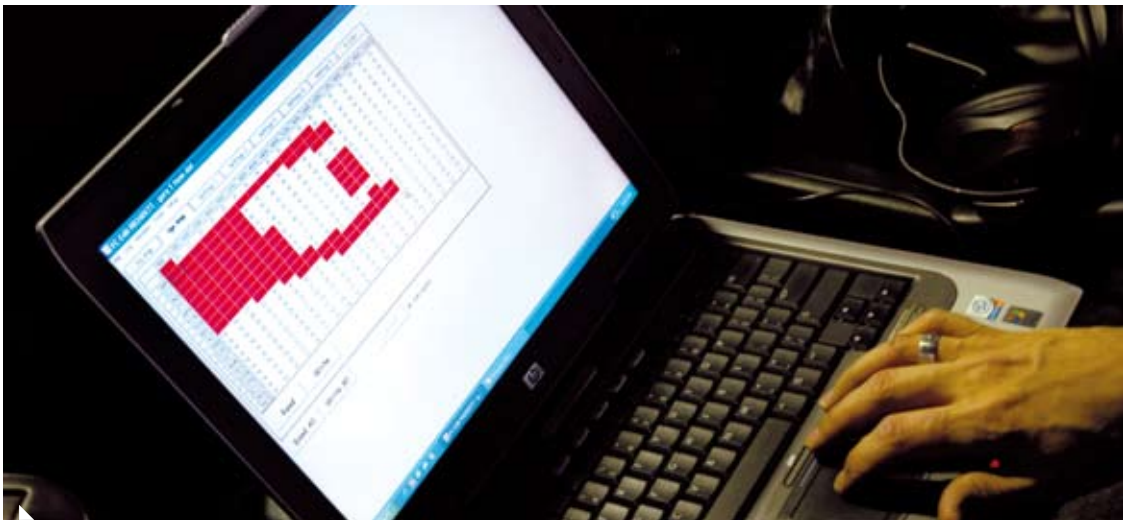
The greatest advantage to using high-octane gasoline is found in its resistance to detonating (as opposed to burning smoothly), when placed under extremes of pressure and heat created by an engine's compression cycle. While it would be understandable to think that easily igniting fuel would be superior for a quicker bang and more power the opposite is actually true. A controllable, smooth-burning situation is required when reliable high performance engine operation is to be maintained.

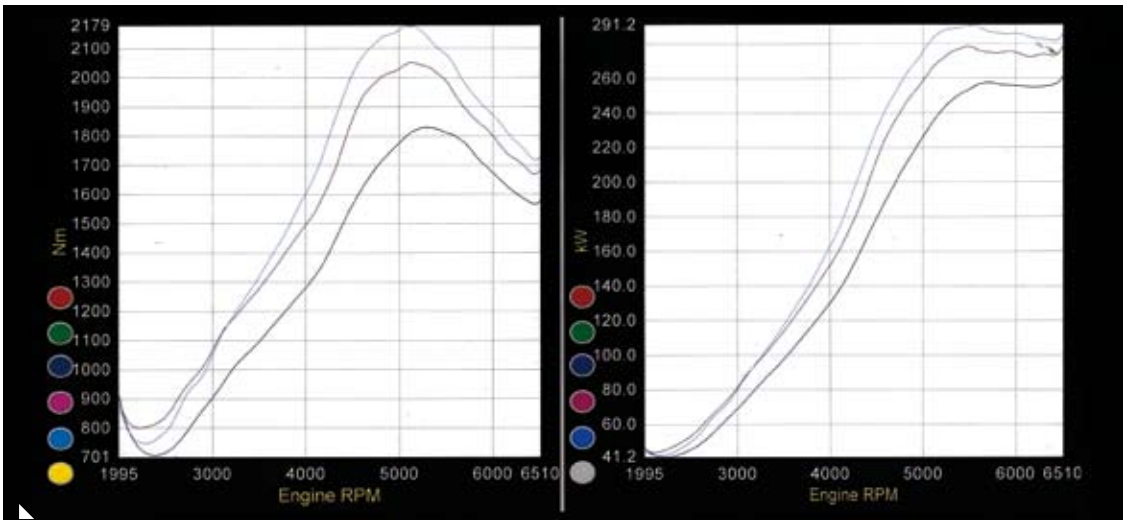
The reason for the higher octane fuel providing increased power levels can be discovered when you consider that the object of building power is to create the highest possible cylinder pressure, at the exact point when it will be the most effective. This point occurs just after the piston has begun its downward power stroke (normally somewhere about 15-20deg After Top Dead Centre, or ATDC). When operating correctly, the mixture should be ignited just before the cylinder finishes the compression stroke, with the flame working around the top of the cylinder and continuing downwards as it consumes the rest of the fuel in the chamber. If the cylinder pressure peaks before this point, due to the fuel exploding (detonation) rather than burning, the force of combustion is going to push down on the piston as it is trying to complete its upward stroke. This scenario is what causes the 'pinging' sound that spells certain engine destruction.

Since increased cylinder compression (upped boost pressure, compression ratio, etc) creates an environment of increased heat, the use of lower-grade fuel in these situations, with its ease of pre-ignition, will see the occurrence of unwanted detonation before the piston has reached that optimum point of 15 - 20 deg ATDC. With the Research Octane Number, or RON, measuring a fuel's given resistance to pre-igniting, it can be realised that the higher-octane fuels will allow for higher cylinder pressures (and the corresponding temperature increases) to be tolerated before detonation will occur. This is the characteristic that allows power gains to be achieved with high-octane fuel.

"HIGHER-OCTANE FUELS ALLOW FOR HIGHER CYLINDER PRESSURES TO BE TOLERATED BEFORE DETONATION WILL OCCUR.

Increased boost pressure, or high compression ratios, (in either NA or turbo applications), are obviously desirable factors that can create more power. The more your fuel is able to resist igniting under these compression and heat extremes, the more power that can be realised per stroke. As one extreme example, in the 1980s Formula One vehicles were producing more than 1300hp from crudely turbocharged 1.5-litre four-cylinder engines. Their super high-octane and high energy fuels (known as "jungle juice") were brewed in laboratories, full of toxins and extremely volatile chemicals that needed to be handled by professional petrochemists. It was their ability to still burn (rather than explode when compressed and heated extremely) which allowed for boost pressures of up to 60psi to be used without the engine grenading under detonation. That being said, the reason for the engineers stopping at 60psi was due to the fuel reaching the limit of its capabilities.





ADVANCING THE TIMING

The process of altering an engine's ignition timing to create more power demonstrates one of the advantages that using a higher octane fuel provides.

At a given boost level and taking into account certain other factors, fuel will burn at a certain rate. Ideally we want that burn to start (spark plugs fire) before the piston reaches the top of its compression stroke and the burn to finish with maximum expansion at the ideal point for power. If you try to do that with low grade, low octane fuel, you would have to start the burn so early that it may have uncontrolled combustion and detonate. The higher the octane rating of the fuel we use, the closer we can get to having our engine complete combustion at the perfect time. This is done through advancing the timing.

Factors that affect the burn rate directly are boost and compression ratio. The more boost we ram into a motor the faster its burn rate is and the more critical it is to have either high octane fuel or retarded timing to prevent engine damage.

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TESTING THE FUELS

With an R33 GT-R test vehicle and the assistance of Tunehouse in Marrickville, we were able to run through the different performance levels achievable with three different RON rated fuels. The test would be run to compare: a quality premium fuel from your regular service station, premium fuel with a bottle of Martini Racing's Octane Booster, and Martini Racing's high octane 110 RON fuel.

To set the scene, the test car was fitted with a few basic modifications in the form of an aftermarket exhaust system and an A'PEXi Power FC ECU. The latter of these two modifications will be important in extracting the best results from each fuel, as it allows a custom set of ignition timing values to be dialled in throughout the rev range. This method of advancing the ignition timing is what we were using as a guide for testing each fuel, with optimised ignition timing creating more power, but also the risk of detonation. This test will distinguish the level to which each fuel can handle advanced ignition timing by resisting detonation, and the level of power achievable with each fuel.

The two most important parameters to watch when tuning an engine for optimised ignition timing are the occurrence of knocking (detonation) and the air:fuel ratio (which will itself contribute to detonation if not correct). Our tuners at Tunehouse would be keeping these factors in mind, and optimising the timing advance for each type of fuel. All of the runs would keep the boost pressure constant at 15psi, so that only the advantages of the timing changes would be measured.

TEST 1: PREMIUM UNLEADED 98 RON FUEL

First on test was your regular service station premium pump fuel. This fuel is what is commonly used in performance cars of this type for everyday driving duties. With an octane rating of 98, it represents one of the highest rated fuels that can be purchased from the pump. Since this is the fuel that is used in the car for everyday driving duties, the existing tune of the car had been tailored to suit this fuel.

To determine the initial state of tune, and current power figure, the GT-R was run through a full pass on the dynopack 4WD dyno, and the results displayed. With the boost pressure set at the control 15psi, a peak power figure of 257.8kW was achieved. The ignition timing at peak power was set at 18deg Before Top Dead Centre (BTDC) and the air:fuel ratio was a healthy 11.7:1. The guys from Tunehouse informed us that to push the ignition timing for this mixture forward any more than 18deg BTDC would create the un-wanted situation of detonation.

TEST 2: MARTINI RACING OCTANE BOOSTER WITH PREMIUM FUEL

Having achieved a base power figure from the regular 98 RON Premium Unleaded, we then added a bottle of Martini's octane booster to the remaining half tank of fuel. This effectively creates an octane rating a number of points higher, with something equivalent of about a 100 RON fuel.

To test the ability of this fuel we began altering the ignition timing of the engine, selecting only the ignition settings for the top part of the rev range - we were testing for the results at peak power above everything else - and began to advance these as much as possible. Using a hearing device that detects all minute sound from within the engine, the process involved advancing the timing incrementally, while performing a few power runs and listening to ensure no signs of detonation.

While this action would have almost immediately caused detonation when using the lesser fuel, the increased resistance to ignition that the octane booster provided, allowed the timing settings to be advanced noticeably from the settings for the premium-only fuel. Eventually a power figure of 277.6kW was achieved, with ignition timing set to 22deg BTDC at peak power, and an air:fuel ratio of 11.7:1.

So, using the octane booster, the ignition was able to be advanced by four degrees, and a power gain of almost 20kW achieved. We were impressed immediately. Considering that the booster can be purchased so cheaply, this represents some pretty good bang-for-your-buck power.

TEST 3: MARTINI RACING FUEL 110 OCTANE RACING FUEL

The third liquid on test during the day was Martini's 110 octane racing fuel, a fuel which has recently been approved by ANDRA for use in competition. While the octane booster combination allowed the timing to be advanced to 22 deg BTDC, the 110-octane fuel offered even greater resistance to detonation.

Eventually, overall power output achieved with the 110 RON fuel was 291.2kW (a 33.4kW gain over standard) with the ignition timing set at 27 deg BTDC and with an air:fuel ratio of 12.3:1. This air:fuel ratio indicated that the mixture had actually become a bit leaner, however as we would find out this is a characteristic of the fuel that has caused this reading.

The Martini Racing fuel has high oxygen content by nature. With a 110 RON, the fuel's resistance to pre-ignition is guaranteed of a higher level than the previous fuels, however a result of the fuel's high oxygen content is that it will provide exhaust O2 readings that indicate a lean mixture and in some cases it may be necessary to add more injector time. The greater amount of oxygen released in the combustion process also contributes to raising the overall cylinder pressure - all in a controlled manner.

It is good to remember that this power gain was achieved by simply advancing the ignition timing a couple of degrees, taking less than five minutes to present a power gain of 33.4kW. Ultimately, there is only so much you can advance the ignition timing in the chase for power. Using a higher octane fuel such as this in conjunction with increases in boost pressure and the like, are where the major performance gains will be found. ■

"OVERALL GAIN ACHIEVED WITH THE 110 RON FUEL WAS 33.4KW OVER STANDARD.

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