Peak Performance Motorcycles: Dyno Services

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Why dyno-tuning?

Most of our customers come to us for dyno-tuning because they are experiencing a problem with the way their bike is running. Perhaps it pings under acceleration, runs really hot, has a lean stutter or won't idle properly. Maybe power appears to sign-off inexplicably in the mid-range or well below red line. Many complain they are running the exact same configuration of pipes, cams & engine management system as their buddy, but their buddy's bike is noticeably faster.

This latter point is critical, because contrary to what might be presumed*, no two configurations are exactly the same*. Irrespective of the identical list of components, the aggregate or stacked result of manufacturing deviation in each component nets something different; and this *unique* product has its own needs when it comes to fuel & spark management.

Your engine is an air pump. The amount of air it pumps, under varying load conditions, determines its potential power output. There is a theoretical volume of air passing each combustion cycle based primarily on a cylinders displacement; and then there is the *actual* amount of air that passes. The relationship between the two is expressed as a ratio known as volumetric efficiency or VE for short.

Your engine management system (ECM) knows all about VE. It must, in order to meter the correct amount of fuel. Thus, every ECM is programmed at the factory with a VE table for each cylinder. Think of an Excel spreadsheet with fixed columns and rows. The columns represent vacuum (or throttle position for illustration purposes) and the rows represent engine speed or RPM. The VE table maintains a separate ratio everywhere a column and row intersect.

The ECM is continuously monitoring throttle position[1] and engine speed; and it is continuously looking to its VE tables to determine how much fuel to meter at the given throttle position and RPM.

Motorcycle manufacturers could never afford to develop unique VE tables for every single bike that rolled off their production lines. Hence, all ECMs for a given model are pre-programmed with the same parameters. The parameters or efficiencies utilized are the nominal results from testing a few samples.

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[1] While throttle position is stated for illustration purposes, many VE tables in newer ECMs actually specify vacuum as indicated by the MAP sensor. However, there is typically a close correlation and throttle position is also taken into account.

Motorcyclists don't typically purchase more than one sample of a given model so the differences in power delivery are not usually detected. In any event, it's typically not long after our new bike purchase that we replace the exhaust system, unwittingly compounding the issue, and convoluting any hope for real comparison.

In a typical scenario, you install an aftermarket exhaust that increases the volume of air being pumped every combustion cycle. Meanwhile, the ECM is still utilizing VE numbers based on that factory test mule with stock exhaust and air cleaner. It thinks it's pumping less air than it actually is. Your engine is running lean somewhere –maybe everywhere. It might ping under hard acceleration or surge at cruising speed. The engine is running noticeably hotter.

Perhaps you then install a Power Commander and download a map from the Dynojet web site. The helpful map index might list your bike and even the exact exhaust system you installed. It has to work, right? Not necessarily, let me explain why.

The Dynojet Power Commander is a piggyback product that simply intercepts signals sent from the ECM to the fuel injectors and modifies these signals based on its own map. It doesn't care about VE tables or much else the ECM is "thinking" about.[2]

The Power Commander map is relatively easy to read using its proprietary software interface. Not unlike the VE tables, it utilizes columns and rows representing throttle position and RPM. Everywhere a column and row intersect represents a given load condition and is an opportunity to offset (increase or decrease) the amount of fuel delivered that is indicated by the ECM signal. A negative offset directs the PC module to lean-out the stock signal and a positive offset directs the module to enrichen it. This offset may or may not be what your engine needs in order to deliver optimum power under the given load condition.

The map is a collection of offsets, ostensibly for a given configuration; i.e. model, year, exhaust, air cleaner, etc. However, the fundamental fact that *no two configurations are exactly the same*, even with the same list of components, has not changed.

Simply put, the downloaded map is not going to deliver optimum power under the various load conditions. In fact, our experience shows that these maps typically *de-tune* the bikes we test on our dyno; and when the map offsets are zeroed out (effectively eliminating the Power Commander), the dyno actually registers better numbers. We see this borne out better than 80% of the time!

Of course, we don't stop there. Keeping the dyno results from both the baseline run and "zero" run for later comparative analysis, we proceed to the steady state tuning phase.

[2] The Dynojet Ignition Module is available for some models as an accessory to the Power Commander. The Ignition Module references its own "spark map" and provides for ignition advance/retard modification based on throttle position and engine speed.

What is Steady State Tuning?

Steady state tuning is where we subject the engine to load conditions similarly referenced by the ECM. That is, everything from 100% throttle at 1500 rpm, 1750, 2000, 2250… all the way to redline. Then 80% throttle, 60%, 40%, 20%, 10%, each at similar engine speeds. On a sportbike that redlines at 13,000 rpm, this represents over 280 data points. These data points are all opportunities to optimize power output by increasing or decreasing fuel and/or spark advance.

The data points are manually set based on the (repeatable) results from iterative measurements of power output under the given load condition. The setting that nets the best power is the right setting for that data point. This methodology is known as Best Power Tuning™.

In this manner, a custom map is developed for your bike that represents the best settings everywhere to realize optimum power output. The map is unique to your bike and won't likely do your buddy's bike much good, even if it has an identical list of aftermarket components.

How much does it cost?

As you might imagine, measuring and tuning power output under so many load conditions takes a considerable amount of time. Depending on the application, it can range anywhere from 5-15 hours to get it right.

We charge by the hour. Our shop rate is $90 per hour. Most sessions run $450 plus the cost of any gasoline we provide –we typically run through five gallons of gas.

How long does it take?

While the actual tuning may only take five hours, there are cool-down periods interspersed in the sessions that necessarily prolong the process. Warmer weather may increase cool-down time and/or cool-down periods. Ideally, we'll wrap it up in two full days.

Will it hurt my bike?

The loads subjected to the engine are all self-induced. In other words, the motorcycle engine drives the dyno drum, not the other way around. We use a Factory Pro EC997 Low Inertia Eddy Current Brake Dyno with a 4-Gas Analyzer. There is no concrete-filled inertia laden drum that continues spinning the drivetrain after the throttle is chopped.[3]

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[3] The Dynojet dynamometer design utilizes an extremely heavy drum filled with concrete. Some Dynojet dynos have been upgraded to utilize an eddy current brake to slow down the drum, somewhat mitigating distress on the drivetrain.

There is a moment of braking provided by the electromagnet connected to the lightweight dyno drum. This eddy current braking is utilized to lock the engine speed to the target rpm indicated by the Factory Pro dyno-tuning software so that a measurement can be made.

We take care to maintain engine and tire temperatures within a normal operating range so as not to cause overheating or tire damage. For "H" rated tires typically found on cruisers, we take the additional precaution of tuning in 4th gear only. You wouldn't think an Electraglide could hit speeds over 130 mph. Without wind resistance, in sixth gear, they easily exceed it and "H" rated tires are not designed for speeds in excess of 130 mph.

Doesn't the newer Dynojet model dyno use an Eddy Brake?

There seems to be much public confusion surrounding Dynojet's use of this feature on their newer models. While they can read air/fuel ratios when braking, Dynojet dynamometers are incapable of measuring horsepower while applying the eddy current brake. The reason is simple. They arrive at power numbers based on acceleration; i.e. time and distance. Without acceleration, there is no power measurement. This makes it virtually impossible to do steady state tuning on a Dynojet dynamometer.

Can a Dynojet model dyno accurately measure horsepower?

One would think this wasn't even an issue. After all, the Dynojet software measures acceleration while taking into account the weight of the drum; and the known engine rpm. Newton's second law of motion states that $F=ma$ (force = mass times acceleration). Once you have linear force, you multiply that number by the radius of the driven drum to arrive at torque (rotational force). Torque is then multiplied by the engine's rpm and divided by 5252 to arrive at a horsepower result for a given rpm. Not too complicated.

However, the amount of fuel being metered during acceleration is typically much greater than the fuel metered during a stable, steady state at any given rpm. The ECM utilizes an acceleration map that adds this fuel, much like an accelerator pump on a carburetor. Hence, unless the horsepower is being measured at a steady state, an accurate metric cannot be derived. Instead, the result will be a measurement of the engine under acceleration only, during which the map is modified by the added fuel from the acceleration map. Whereas, there may very well be a significant fuel deficiency at a given rpm that is (temporarily) masked by the acceleration map.

The accuracy issue can be compounded by discrepancies in actual drum weight (mass) vs. what the software uses to calculate force; and there are other issues that go beyond the scope of this paper. The creator of the Dynojet dynamometers is on record stating that the final calculation is "fudged". This was due to the equipment's inability to arrive at the same horsepower numbers as a V-Max (as stated by Yamaha's marketing department) in 1984. The industry has been dealing with this "fudged" yardstick ever since.

What about Air/Fuel Ratio (AFR)?

We consider the best AFR to be that which produces the most power. We don't pick an arbitrary or theoretically correct number to target. We do multiple AFR adjustments and dyno tests to determine the best AFR/power setting for each throttle opening and rpm. In other words, we set the AFR where the best power is realized; and we know what those numbers are by measuring the effect immediately on the dyno.

Contrast this to the method utilized during a typical Dynojet tuning session where operators are taught to target a particular AFR throughout the power band. This may be the chemically correct AFR necessary to achieve a more complete combustion of gasoline, but it's rarely where optimum power is developed. It works well for closed-loop systems on vehicles trying to achieve better fuel mileage and lower hydrocarbon emissions, but we're not driving grandma's station wagon now, are we?

Targeting a fixed AFR is the preferred method for motorcycle ECMs that run in a closed-loop mode. This is also true for those piggyback systems that claim to be "self-learning". We don't ride around with mobile mini-dynamometers on our bikes so these systems can't teach themselves which AFR develops the best power under varying load conditions. Instead, they "teach" themselves how to always get a particular signal from the O^2 sensor, which translates to a fixed AFR. Again, this does not equate to optimum power output.

Rather than let the tail wag the dog, we look to the dyno results to determine what the correct AFR should be.

Is this service also available for my Harley?

Whether you're using a Dynojet Power Commander, S&S ProTune, H-D SERT or TTS Mastertune module, all of the aforementioned services apply. We also have experience with the Vance & Hines Fuelpak and the Terry Components TV-3 as well as ECMspy and Technoresearch's Direct Link product for early and late model Buells.

Call us to discuss which management system is best for your application. We are a Dynojet authorized Power Commander Tuning Center, S&S Authorized Dealer and TTS authorized Mastertune dealer. TTS is the company that developed the Screamin' Eagle Race Tuner which was subsequently licensed by Harley-Davidson until 2008. Since then, the TTS Mastertune product has evolved far beyond the original Race Tuner and its knock-off replacement, the Screamin' Eagle Pro EFI Super Tuner.

How does all this apply to carbureted bikes?

We use the same Best Power Tuning™ method to dyno-tune carbureted bikes. We begin by checking float height adjustment. Then we try various main jet sizes at WOT to tune the high-speed circuit. Once best power is realized at WOT, we move on to the needle & slide settings, where applicable, to tune the mid-range circuit for best power. Finally, we dial-in the slow jet for best power in the low-speed circuit.

Unfortunately, the amount of time required is no less than with Fuel Injection. Repeatedly removing and replacing carbs tends to become quite time consuming.

Do you dyno-tune SuperMoto and Motocross bikes?

If it has two wheels, we can dyno-tune it. The patented dyno drum design provides better grip than any other dyno on the market so we don't even need to change out knobby tires when dyno-tuning motocross bikes. Because our dyno is strictly made for two-wheeled vehicles, we do not dyno-tune Quads or ATVs.

Will my mileage improve?

Not likely. Most bikes we see are running too lean… almost everywhere, but certainly in the cruising range. When best power is then realized by adding the necessary fuel, mileage may suffer somewhat.

This is particularly true for the newer Harleys. The Motor Company needs to sell bikes in California, which is problematic because it means passing stringent California Air Resources Board standards for hydrocarbon emissions. The quick-fix solution apparently came in the form of leaning-out the area CARB measures -the cruising range, where AFR is typically set far too lean at the factory.

What is your success rate?

We maintain a 100% success rate with our dyno-tuning services. Whether they have been race bikes, sportbikes, vintage bikes or cruisers, every motorcycle that has come to us has seen improvement in its power output.

We prove our success by using repeatable metrics and by sharing all of the information we derive with the bikes owner.

Who else uses this Best Power Tuning™ method?

Teams with winning resumes and multiple championships such as Vesrah Suzuki and Jordan Motorsports utilize the same Factory Pro EC997 Low Inertia Eddy Current Brake Dyno. The tuning method is the same, the results are incontrovertible.

Many more Dynojet chassis dynamometers are sold to motorcycle shops than Factory Pro units. The ratio is nearly 100:1. Cost is the biggest factor, but the difference is analogous to using a pair of pliers to determine a torque value instead of a torque wrench. Which do you choose?

How do I schedule a dyno-tune?

There is typically a backlog of a week or more. Contact Danny DiNardo at Peak Performance Motorcycles in Simi Valley, CA (805) 306-9705 to discuss your tuning needs and we'll get you scheduled in the next available time slot.

