SENSORY OVERLOAD

In past articles we have discussed sparkplug reading. Why? Because it is an indicator of air-fuel ratio, spark plug tip temperature, timing under load, and signs of detonation.

To maximize engine efficiency we need to know what is happening to your tractor during a pull. This article should explains common sensor types so you can decide which ones add value to your pulling efforts. Part two of this discussion will involve my new passion … data logging!

Here are a few popular sensors and how to use them:

Temperature sensor: Relying on a 1940's gauge might be fine for your family wood hauler but competitive pullers need more accuracy and reliability. A modern temp sensor is critical to maintain proper clearances and prevent engine damage.

Often the location of this sensor can be changed to provide more reliable water flow. My Allis WC has the stock gauge at the top of the radiator inlet, where cavitation or low water levels could give false readings or none at all.

Air – Fuel sensor: A quality wide band oxygen sensor is a magical tool that can save you days of tuning and frustration. No other sensor provides critical measurements of the efficiency inside your engine. Buyer beware … using incorrect or plugged up sensors can give dangerously false tuning information.

For this reason, I have become a sensor "snob". The two big players in oxygen sensors are Bosch and NTK. Both have precise, high quality sensors but only NTK is rated for leaded fuel use.

Most affordable meters come with the Bosch 4.9 sensor. While the Bosch is faster reacting under certain conditions, the NTK is known as the industry work horse and can withstand a wider variety of fuels and conditions. I prefer NTK for that reason.

Oxygen sensors are a "consumable" product, meaning it plugs up with soot or wears out even when used properly and is meant to be replaceable with use.

For this reason I remove my sensor after tuning. You can quickly connect your sensor using a weld-on threaded bung or use a portable "sniffer" that sits in your pipe like the one we offer.

Troubleshooting problems are simple. If your meter reads rich but the engine has signs of being lean the sensor is probably plugged from lack of preheating or is worn out. Readings that bounce around or show false lean are usually caused by air flow reversion because your sensor is too close to the exhaust tip or there is an air leak between the engine and sensor.

An oxygen sensor should be pre-heated 3-4 minutes before turning your engine on. If you don't pre-heat, the life and accuracy of the sensor is greatly reduced. We sell and use the AFR-500 meter with

NTK production grade sensor only…. that is my favorite meter and sensor. If you use leaded fuel this is the one to purchase!

One more thing … meters usually read in ratio or Lambda. The difference is the ratio displayed would be calibrated for a particular fuel, usually gasoline. **Lambda will show the same reading regardless of fuel.** Lambda perfect ratio is 1.0 regardless of fuel type and we aim for .75-.85 as a starting point.

Tachometer: I am shocked at how many pullers cripple their pulling success by skipping this basic sensor. Set aside $150-300 for a quality low rpm tach such as VDO or AutoMeter and you'll soon realize how nice it is to have one.

In our business the rpm range is critical to designing timing maps that work in unison with the engine. When to drop timing, how much it drops, and the shape of the timing ramp are things that performance tuners pay close attention to. It makes a HUGE difference especially with a stock or mildly built engine.

Exhaust Temp sensor: We do not use a pyrometer for tuning. We use it as a problem indicator. On a two stroke engine it can save you from seizing the engine from super heated exhaust temps.

When under load, use your air-fuel meter to keep the reading steady at all rpm ranges during the entire pull or dyno run. Once you have tuned for max power or torque the pyrometer reading would be recorded as a benchmark.

If your engine begins to run poor or you made a tuning change the pyrometer can indicate changes in efficiency. Excessively late timing is a good example because fuel is burning in the exhaust instead of in the cylinder.

I was told by a carburetor designer friend of mine that two identical engines can produce different exhaust temps when tuned for best performance. For that reason he suggested on naturally aspirated engines to rely heavily on your AF meter and use the pyrometer as a “warning light” if it drastically changes.

Vacuum sensor: Your car has one but most of us pay little attention unless it fails. **VOES** (vacuum operated electrical switch) and **MAP** (manifold absolute pressure) sensors are commonly used to control timing and fuel injection based on engine load.
While the VOES is a spring loaded grounding switch that requires engine vacuum to function, the MAP sensor converts vacuum to a variable 0-5 volts for use with electronic devices.

I believe a MAP sensors ability to accurately measure engine manifold vacuum can be valuable because it has a direct relationship with engine load.
Unfortunately because some tractors go from idle to full throttle without much in between or for smaller tractors where load is so high that vacuum immediately drops to near zero, this may or may not be a useful tool for engine management.

Could a MAP sensor be used to control timing on your pulling tractor? Maybe. Our C5 optical ignition responds to MAP sensor voltage changes. You can switch between three timing maps, each having less timing than the other. By reading voltage (load) the ignition will advance or retard timing based on the accurate output of the MAP sensor. This is racing technology for your tractor!

Being able to advance or retard timing precisely and consistently is what every performance minded person should strive for. In order to decide if your engine could do this, first you need to measure engine vacuum during a few pulls and determine if the signal varies enough to control timing. Give it a try!

Ground speed & Axle rotation: We commonly talk about speed of course but almost never discuss axle rotation. If you measure ground speed and rear axle rotation you can easily calculate your tire spin which helps determine engine load.

Ground speed can be measured using radar gun, rotating wheel (like a survey crew) or GPS. Using a radar gun is accurate and can be used for indoor pulls but is expensive. Using a wheel is inexpensive but is cumbersome and on rough tracks might not be as accurate. GPS is very accurate and affordable but doesn't work without satellite signal.

Axle rotation is a bit more difficult because you want a high sample count (the most counts per revolution you can get). Using

magnets with position sensor, reflective tape with photo eye, or mechanical counter on a rotating shaft are a few ways to count axle rotations. I'm still working on a method that is simple and portable. If you have ideas please contact me.

Accelerometer: This is my favorite sensor. We are a dealer for AEM electronics and our AQ-1 data logger has a 3-axis accelerometer built in. It measures vehicle movement in all directions with incredible precision.
Why might that be useful? Because if you are measuring other things like rpm, speed, and load, this sensor could indicate where the tractor had an "episode" such as sudden loss of traction, wheelie, or change in direction from working the brakes. It has value when logging data but as a stand alone sensor not so much.

That leads me to the next article. With a basic understanding of how to measure things the next step is recording your data. You have several affordable data logging options so your pulling performance can be studied at a later time.