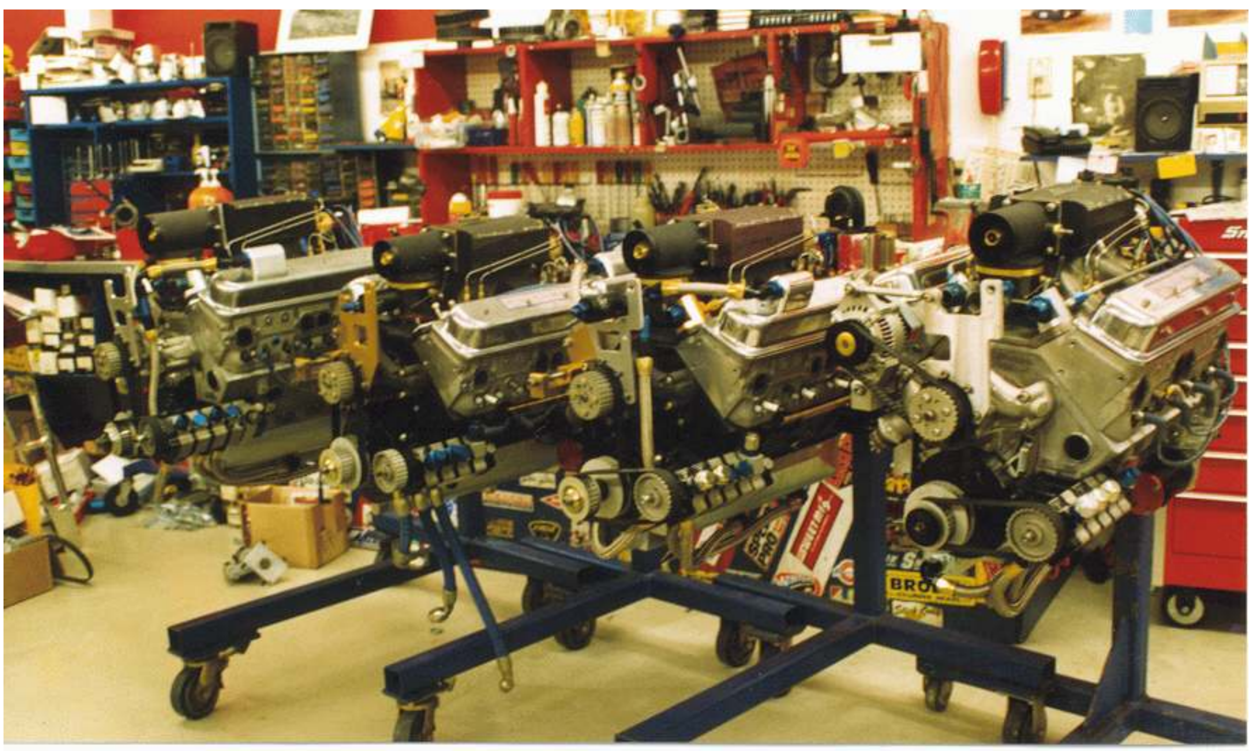
Sunset Engine Development

NERDLETTER 3

It has been over two years since I wrote my last newsletter (or since my last confession) and it's time I resumed my awesome literary responsibility. A lot of things have happened with me and SED since I did this last, both good and bad, (mostly good if you don't count women). Our business expanded when we started building engines for the experimental aircraft market. These are big and small-block Chevrolets for 2/3 and 3/4 scale P-51 Mustang replicas. It has been very challenging in terms of how the engines are built and tested. It has been interesting in the types of customers we have had. A lot has been learned and that has kept our creative juices flowing. I would not say, however, that it was a gainful financial experience



Small-block aircraft engines from 350 to 427 cu. in.

because of the great increase in time that it took to go on this learning curve. In the beginning of this aircraft engine endeavor we wrote some papers about building automotive conversion engines for aircraft and that is where the writing energy was expended.

Anyway, since then we have still been building race boat and race car engines and have gotten a lot of dyno time under our belts. We have made a lot of good discoveries but, as always must be the case, our entropy increased immeasurably. Perhaps our best discovery was made two years ago last winter when we discovered the trick of wearing pantyhose over your shoes to keep from slipping on the ice. I have my own theories as to how this works, and it really works good, but if anyone wants to share their explanation I'd like to hear it.

So, since we've had this afore mentioned large entropy increase I'm going to write about what I don't know about what I know. I like to write about our experiences and observations in the dyno room because it's real science, real life, and quite often real frustrating

I'm reminded of a statement by E.L. Doctorow. "*Writing is like driving at night in the fog. You can only see as far as your headlights, but you can make the whole trip that way*.

PLUG READING

If you place yourself in the large group of engine experts who prides himself on his ability to "read" sparkplugs then I have a tip for you that you might not like.

We've all seen, no doubt, the incriminating tell-tale signs of abnormal combustion on sparkplugs. These range from the "salt & pepper" specks that is believed to be related to too much spark advance to the black shinny balls that is believed to be detonation or even aluminum looking splashes that might also indicate detonation. Years ago I was peering through the ophthalmoscope (the most perfect device ever invented to see deep down into a sparkplug with) at a **new** set of plugs and was surprised to see signs of detonation (black balls) on the porcelain.

This piqued my curiosity, so I began looking at many new sparkplugs. I was able to find a lot that looked as if they had just come out of an engine. One could say they were victims of all the conditions I have previously mentioned including some I haven't, like black specks related to oiling the upper end.

It was then that I started looking at all sparkplugs before installing them. I made notes of the ones that had spots or conditions that might later fool me when I looked at them with the ophthalmoscope.

I have tested this observation on live guinea pigs called engine experts. On more than one occasion I have looked at the plugs before the customer put them in the engine (on the dyno) and saw questionable deposits but said nothing to the owner or tuner. When the plugs would be removed after a acceleration test I would again observe the condition on the plug in question and surreptitiously show it to the guy. He would throw up his hands and exclaim, “holy-cow, she’s a detonatin,” we’d better fatten er up” - or something to that effect.

Ophthalmoscope - the world’s best device for viewing spark plugs.

What I’m not saying, is that reading spark plugs is a waste of time, or that you can’t observe good and bad engine conditions on the plugs. After all, they live right in there where it’s all happening and should be the first to know if something bad is going on.

What I am saying is, beware of being led astray by plug readings that are bogus - that is, a plug condition and not a combustion condition. Maybe these deceptive conditions happen when the side electrode is welded onto the shell because it can look like metal or slag has been splashed onto the porcelain or shell. Some types of plugs seem to be freer of these types of conditions, when they are new, than others.

The ophthalmoscope, by the way, is a device that ophthalmologists use to look at the optic nerve and such inside eyeball, something I have been using to observe spark plugs for the past 23 years..

Reading spark plugs can be very difficult or very easy. For instance, it can be difficult if you’re trying to decide if the jetting is correct and you’re within a jet size or two of being right-on (what is “right-on” by the way)? Or if the little black specks your seeing is from over-advanced timing or from oiling the combustion chamber.

So, that sums up what you might call nondestructive plug reading which probably doesn’t account for much if the engines air/fuel mixture is not far off and the plugs heat range is correct. To really get down to where the “rubber meets the road” the plugs must be put in a lathe and the threaded steel shell portion must be removed by turning it back until the porcelain is exposed to where it expands to the seal area.

We were just getting a feel for looking at plugs with this method when it was pre-empted by using O^2 sensors in every cylinder. We were looking for a dark ring close to the bottom of the porcelain. This will happen before anything can be seen even with the ophthalmoscope. O^2 sensors have saved a lot of work and spark plugs.

BSFC

A recent article in Circle Track Magazine didn't speak as to how an acceleration test effects the BSFC (brake specific fuel consumption). The article only glossed over the FHP (friction horsepower) effects. We don't look at BSFC and usually consider it to be valueless data. I still hear about people who jet their engines on the dyno via this parameter but I think they've got their head in the sand. BSFC, like the overall air/fuel ratio is a mean number from all the cylinders. If you have seven running at .45 and one at .30 the average is going to give you a .43 which is a common number. I would be more concerned about finding out what the leanest hole is doing.

EGT (exhaust gas temperature) isn't a good way to determine this either. Too many hidden variables with EGT. Reading spark plugs is a joke. I have observed that the spark plug readings, as often as not, do not back up the EGT data. O^2 is the best way. We abandoned EGT long ago and now I see a least one very respected Winston Cup engine builder has also.

An engine with a single four barrel carb may have a wider range of mixture discrepancies than say, a fuel injected turbo or supercharged engine. That doesn't mean that the injected turbo motor however, is not going to have some cylinders much closer to the detonation limit than others. Just because the mixtures are even on a particular engine doesn't mean that some cylinders could be detonating or close to detonating while others at the same A/F run happily. This could be due to poor water circulation. A big bug-a-boo is the efficiency with which the heat is removed from the metal surrounding the combustion chamber.

It did our hearts and consciences a lot of good a few years ago when we heard Fritz Kayl (Katech) say he didn't know how to read plugs.

Port Window

The port window, choke point or throat, whichever you prefer to call it, will define the point where the engine will make peak power rpm.

Some SCCA Trans-am engines that we dyno were coming up a little short on everyone's horsepower predictions. Even the modeling says the power should be another four or five percent above where it is. In discussing the engines with Allen Lockheed he turned me onto a port condition that is both interesting and conceptually feasible. I'll attempt to paraphrase Allen's opinion of this using some of his jargon.

"It seems that if the entrance to the port runner is smaller than the valve curtain area at the maximum airflow demand point you will get a choke there also. That is, the velocity is higher in the runner, therefore, the air is at a lower pressure than it is across the valve seat. It's another way of saying that the valve has dropped out of the equation and the port is now running on the port and the piston. It seems that when you have an excessively small runner the engine will peak power at the rpm corresponding to the airflow at the valve curtain area that corresponds to the runner entrance (if that point is the throat - such as at the pushrod restriction)."

This seems to make sense even though I hadn't thought about it quite like that. It certainly shows why the manifold runners need to be tapered. Air only likes to flow from a higher pressure to a lower pressure. You can't defeat Mr. Bernoulli's laws.

Allen pointed out that you should be able to use this less than an optimum situation to your advantage. When you have a system where you don't want to make as much power as the port and the area allow, instead you can choke it off there, and use a really high lift cam, and the high lift cam won't cause the engine rev into oblivion, instead it will take advantage of the extra airflow, or the low resistance to airflow, in the remainder of the cycle after it hits this choke. Therefore you can stuff the cylinder a little better with a more radical cam without raising the power band out of sight. It's a way to handle some BB Chevies and 351 Cleveland's etc. Engines that with some displacements could have ports that are too big. You can set the choke point window in the manifold and regulate the air for the curtain area you want to run at and let the camshaft do its own thing.

To reach and exceed two horsepower per cubic inch the shape of the intake manifold runners and ports have to be shaped correctly and there can be only one throat and it needs to be in the correct location. At least this is one of the many popular theories. This is not easy to achieve.

Manifolds can also be a problem. In drag racing where they let you use fabricated tunnel-ram intakes manifolds this isn't a problem. In some other types of racing you have to use a stock "appearing" manifold. Because of the way manifolds are cast, I guess, they have taper in them. Trouble is, the taper is usually in the wrong direction creating a situation like Allen described. So it becomes necessary to cut the manifold apart, make the runners the right shape and length, and then put it back together so that no one can tell on the outside that its been messed with. Not a simple task but it is done.

In theory, when all these areas are coordinated one with another, and you get the maximum velocity and stuffing through the cycle. It's like finding the engines "G" spot.

Like I have said before, getting all eight pulses to reach the proper place at the same time with a common plenum intake manifold is like trying to organize earth worms. I don't even know if it's possible. Independent runner (IR) manifolds like fuel injection or tunnel rams, should make it much simpler.

I think this is why we don't always see header changes have much effect on the power curves at high RPM with a typical cast single four-barrel intake manifold. Unless every intake runner and intake port is exactly the same (along with cam-timing and probably another dozen or so variables) how can we expect every pulse to arrive back at the combustion chamber at the proper time on every cylinder. Assuming you could get all eight intake tracts to behave exactly the same, so you could perhaps take advantage of this "inertia supercharge" effect, then you have the exhaust side of the system to contend with.

To expect the same effects (pulse returned to port) from each primary tube would mean that each would have to be of the same configuration, concerning diameter, length, restriction, and heat loss. All this sounds like a fairly daunting task, if not a fairy tale. I suppose when everything is right, as in sync with all the other pulses, there should be a big horsepower gain. But I can't say for sure because it has never happened to us. This must be why Ferrari (in F1) went to the trouble to change intake length while the engine is running. Certainly you would have to adjust intake and exhaust dimensions for different types of race tracks.

Cam Change:

A phrase I heard someone say is worth remembering. "Money spent is an independent variable of horsepower." They were referring to a recent dyno test where the baseline cylinder heads were changed to ones with much higher airflow. The new heads showed no power gain.

When we switched to a cam with much more lift but with almost same valve events and overlap, there was a drop in power. About as pure a test as you could have. This must be why God invented alcohol.

Carburetors

The Braswell three circuit, triple lean-out, twelve hole booster carburetor is a real good piece. He's got more changeable air bleeds in that thing than my IQ. It has enabled us to observe our first almost flat BSFC curve. We can actually lean the fuel/air ratio above the torque peak. These guys are artists. But I would still like to see the fuel curve get even leaner as the rpm goes up.

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