

Boondocker sea level pump gas turbo system for the Polaris CFI2 800

Many years ago when Boondocker (who deserves the Nobel Peace Prize for coming up with the first sled aftermarket EFI tuner that could add or subtract fuel at various throttle positions) was developing two-stroke turbo systems, owner Rocky asked me how many PSI of turbo boost was totally safe at sea level. As I recall, my facetious answer was "zero". At that time, I was still involved with Aerodyne Corp building turbocharger systems for sleds--blowing through carburetors with airflow-challenged model 53 Aerochargers. To make best HP with limited airflow capacity, compression had to remain stock, timing needed to remain stock and mild stock port timing was best. Remember, we made more HP with the mildly ported 1992 VM4 than we could with the more radically ported 1993 with the small model 53s (those tests are in the archived scanned printed issues at the bottom of this website). We relied on absolutely precise pilots, needle settings, and main and power jets to deliver rich, low peak combustion chamber temperature A/F ratio at all throttle positions. We had no inexpensive wideband A/F gauges so there was a lot of hoping-for-the best. If the temperature dropped, needles and jets needed to be adjusted to prevent seizures from detonation or from lean A/F ratio (ie: 16/1) without deto. Detonation was particularly unpleasant--vaporized aluminum or chunks of broken ring lands would decimate those cherry red potato-chip-like foil vanes requiring turbo rebuild along with piston replacement. Wise turbo trail riders always started with full tanks of race gas or 100LL av gas, then watered it down with bar gas as they traveled, becoming increasingly careful as octane diminished.

Fast forward to 2016.

Quick spooling high airflow low friction ball bearing turbos! Now we have fast-spooling low-friction ball bearing turbos from Garrett and others with virtually unlimited airflow capacity which gives turbo engine builders more options in creating optimal horsepower on low octane fuel. No fragile potato chip-like vanes that control boost--instead, internal or external wastegates control boost.

EFI! Proper calibration of piggyback fuel and timing controllers add or subtract fuel flow and subtract timing as needed as inlet pressure rises (yes, add-on turbochargers can require reduced fuel flow in some part throttle conditions for clean running).

Intercoolers! Keep that intake charge temperature as low as possible to help prevent deto on low octane fuel.

Deto protection! These modern two-strokes are fitted with amazingly protective detonation sensors. We see that on the dyno--a click or two results in timing being retarded, then if more clicks are heard, more retard and fuel is added to cool things down eventually going into limp mode. But very seldom do we stick pistons in the bores.

\$150 digital wideband A/F gauges! It's surely a great idea to visually monitor your A/F ratio to be sure that you are safe at all throttle positions. Most turbo tuners seem to like 12/1 or richer at WOT and maybe 13/1 or slightly leaner while cruising at part throttle.

Next, we all must study this great article by the Tech Editor of Cycle World magazine and DynoTech Research Tech Editor/ contributor/ educator Kevin Cameron, explaining detonation. There are some 30 KC two-stroke related articles in the archives at the bottom of this website. Many of us reread those yearly. Note that Kevin's explanation about EGT's dropping during detonation came from my having blindly seized many, many dozens of pistons while searching for max HP (before we began listening to deto with the copper tube) and having finally noted that phenomenon nearly 30 years ago and then sharing that info with KC. Also note that his description of preignition might explain the mysterious burning of reed petals on boosted engines by lighting things off before transfers are closed. Fire in the hold!

<http://www.cycleworld.com/about-combustion-piston-crown-and-cylinder-head-kevin-cameron-top-dead-center/?src=SOC&dom=fb>

After studying and understanding what causes detonation, we can appreciate the value of low compression, retarded ignition timing, and high airflow in preventing deto on pump gas.

Josh Ricotta bought this complete Boondocker turbo system with all the options for his and his brother's Polaris 800 CF12 RMK mountain sleds--fan-cooled intercooler, Boondocker ignition retard module, Tial external wastegate and stainless steel turbine housing with divergent cone outlet. At the recommendation of Boondocker, Josh bought incredibly low compression 10/1 RKT billet heads to complete the low octane boosted package.

It was great that Josh and his brother had already run a tankful of pump gas through each sled trail riding/ blasting with no deto protection code before coming to DTR to check on tuning/ HP.

On this session, a single sweep test would show that this was, indeed, safe and click-free at well over 200 HP! Low compression, low turbine-created backpressure, and extremely high airflow CFM for the HP produced which surely serves to blow those nasty OH negatives out the muffler instead of letting them lurk in the combustion chamber, waiting for the next hot compression stroke to autoignite and wreck stuff. The BSAC is shown here--lb of air per HP per hour which is very high compared to, say, the new TCats/ Sidewinders that run around 5.6 lb/hphr due to their cooling/ OH negative purging exhaust stroke after each power stroke. Along with that extra cooling/ purging airflow comes some unburned fuel, resulting in high BSFC that harkens back to the late 1980s where we needed BSFC that high to keep normally aspirated sled engines running on low octane fuel.

So, per HP this pump gas turbo engine is thirsty compared to the factory boosted four-strokes. But the light weight and reliability surely justifies a few less MPG at WOT 200+ HP. The fuel was tested on our Zeltex 101C octane tester and it was, indeed, pump gas.

Due to the retarded timing, the stock piped turbo has a flat HP curve as shown here with @1000F pipe center section. Due to the retarded timing, long lake runs or mountain climbs might bring that temp to 1400F and higher--causing that HP plateau to slide up to 8500 and beyond. Pay attention to your wideband!

EngSpd RPM	STPPwr CHp	STPTRq Clb-ft	BSFA_B lb/hph	FulA_B lbs/hr	LamAF1 Ratio	LM1Air SCFM	BoostP psig	BSAC lb/hph
6350	145.1	120.0	0.606	84.8	16.59	309	8.8	10.20
6400	143.8	118.0	0.629	87.1	16.83	323	8.9	10.41
6450	143.4	116.8	0.643	89.0	16.97	332	8.9	10.51
6500	143.6	116.0	0.657	90.9	17.06	341	9.0	10.59
6550	144.2	115.7	0.668	92.9	17.11	350	9.1	10.62
6600	145.6	115.9	0.680	95.5	17.08	359	9.2	10.63
6650	148.1	117.0	0.692	98.8	16.95	368	9.4	10.56
6700	173.0	135.6	0.687	114.7	14.43	364	9.7	9.29
6750	173.9	135.3	0.689	115.6	14.23	362	9.6	9.25
6800	174.4	134.7	0.693	116.5	14.08	361	9.5	9.25
6850	174.9	134.1	0.697	117.6	13.95	361	9.5	9.26
6900	175.7	133.7	0.700	118.7	13.80	360	9.5	9.27
6950	177.2	133.9	0.703	120.2	13.62	360	9.5	9.28
7000	180.4	135.3	0.702	122.2	13.37	359	9.7	9.23
7050	184.1	137.1	0.701	124.5	13.19	361	9.8	9.12
7100	187.6	138.8	0.702	127.0	13.02	364	9.9	9.00
7150	189.8	139.4	0.702	128.7	12.88	364	9.9	8.92
7200	191.1	139.4	0.702	129.4	12.74	363	9.8	8.87
7250	191.6	138.8	0.707	130.8	12.56	361	9.7	8.90
7300	192.6	138.6	0.710	131.9	12.45	361	9.6	8.91
7350	194.0	138.7	0.708	132.6	12.38	361	9.6	8.87
7400	195.9	139.0	0.704	133.1	12.31	360	9.6	8.82
7450	201.1	141.7	0.699	135.7	12.09	361	9.6	8.67
7500	202.6	141.8	0.696	136.0	12.05	360	9.6	8.63
7550	203.7	141.7	0.692	136.0	12.03	360	9.5	8.61
7600	204.7	141.5	0.689	136.2	12.01	360	9.5	8.60
7650	205.7	141.2	0.689	136.7	11.98	360	9.5	8.61
7700	206.8	141.1	0.688	137.3	11.95	361	9.6	8.66
7750	209.3	141.8	0.682	137.7	11.93	361	9.8	8.63
7800	212.1	142.8	0.674	138.0	11.93	362	9.8	8.57
7850	213.8	143.1	0.672	138.5	11.94	364	9.9	8.53
7900	214.8	142.8	0.671	139.0	11.95	365	9.9	8.53
7950	214.8	141.9	0.673	139.4	11.96	366	9.9	8.57
8000	214.6	140.9	0.675	139.7	11.95	367	9.9	8.61
8050	214.8	140.1	0.675	139.8	11.94	367	9.9	8.63
8100	215.1	139.4	0.674	139.8	11.93	367	9.9	8.63
8150	214.6	138.3	0.678	140.3	11.91	367	9.9	8.65
8200	213.6	136.8	0.668	137.6	11.88	359	10.0	8.29

Note the fine stainless steel welds/ fabrication of the Boondocker turbo system. The exhaust dumps into the tunnel which dampens sound and lessens backpressure in deep powder compared to bellypan outlets. The black intake pipe brings cold outside air to the compressor inlet. Turbo lubricating oil is provided by a tiny pump feeding from a reservoir below the center section.

