2006 Mach Z w/ Boondocker regulated N2O system

Canadian Stan Kondrotas uses internet names “PuttyTatMan” (he likes Arctic Cats) and “Spike”. This 06 MachZ one of his trail/ lakeracer sleds, and other than a Straightline can muffler (not too loud) and Fireball ceramic coated pipe (gloss silver w/ black flames) Stan says the sled is stock.

Stan had local SkiDoo dealer Jim Cooper come to the dyno to help out with Jim’s SkiDoo computer (Jim charges his shop rate of $60/hr to come to the dyno). He has the ability to change factory EFI maps (like we did on the stock Mach Z tested on this website), tweak ignition timing, monitor the engines during testing (throttle position, engine coolant temp, detonation etc) and to turn the engine on and off from the control room via a long cable connecting his laptop to the sled’s ECU.

One issue was that Stan had tweaked on the TPS on the throttle bodies to help his off the line performance, and Jim’s computer showed that at WOT the TPS indicated less than 90 degrees. This might be why this sled delivered leaner than normal fuel flow at 30 deg airbox temp, surely part of the reason for the 180+ HP we made on two back to back dyno runs with 125 degree coolant temp. It’s also possible that the ECU delivers more timing at less than WOT which also might contribute to Stan’s good baseline HP. For proper comparison between Normally Aspirated and N2O added, I have included observed HP column (EngPwr) next to Standard Corrected (STPPwr) column.

Stan's MachZ na baseline EngSpd RPM	STPTrq Clb-ft	EngPwr Hp	STPPwr CHp	FulA+B lb/hr	BSFC lb/hph	Air1+2 scfm	A/FA-B Ratio	AirTmp degF
6100	94.1	105.1	109.2	80.2	0.763	216	12.31	33
6200	93.8	106.5	110.7	80.1	0.752	217	12.39	33
6300	95.6	110.4	114.7	80.9	0.733	218	12.36	33
6400	100.7	118.1	122.7	83.4	0.706	226	12.42	33
6500	104.2	124.1	128.9	85.8	0.691	230	12.31	33
6600	109.1	131.8	137.1	89.3	0.677	236	12.11	34
6700	109.9	135.2	140.2	90.2	0.667	240	12.19	31
6800	113.7	142.1	147.2	95.2	0.671	247	11.86	31
6900	116.4	147.4	152.9	96.8	0.657	250	11.84	32
7000	117.3	150.6	156.3	97.6	0.648	253	11.89	32
7100	120.2	156.4	162.5	99.8	0.638	261	11.99	33
7200	120.6	159.2	165.3	100.6	0.632	263	11.95	33
7300	124.1	166.1	172.5	104.6	0.631	270	11.81	33
7400	124.8	169.5	175.9	108.1	0.637	276	11.72	32
7500	124.2	170.9	177.4	108.4	0.634	278	11.74	32
7600	125.1	174.7	181.1	109.2	0.625	283	11.85	31
7700	124.3	175.6	182.3	109.5	0.623	283	11.82	32
7800	122.9	175.7	182.6	109.2	0.622	282	11.82	33
7900	116.8	168.9	175.6	109.6	0.649	279	11.65	33

Stan was here to tune his new Boondocker N2O kit to make it hopefully safe for the 91 octane gas he uses in his sled. I normally suggest for tuning for pump gas that people run at least 50/50 mix on something like this (in part to compensate for tuning goofs) but Stan wasn't able to obtain any race gas for this session, so all tests were done on Stan's "upnord" [hopefully] 91 octane gasoline.

This new Boondocker N2O system uses a high pressure regulator to control and make the delivery of N2O more consistant to the two five hole nozzles. According to Boondocker, this regulator (somewhat like a paintball gun regulator) will keep the N2O delivery more constant regardless of cylinder head pressure which varies widely depending upon N2O cylinder temperature. In this case I believe Stan set the regulator at 200 psi. Stan and Jim Cooper tweaked the two fuel settings (one centered at 180 psi N2O pressure, the other centered at 340 psi) and the second run matched the first run's fuel flow. We were on the uphill of the learning curve on this new system. These two runs are averaged here, and our fuel flow at peak HP was too low in my conservative estimation for nearly 220 CHP (210 actual observed HP) on 91 octane gas. The N2O dyno runs are done with a faster acceleration rate, WOT for about seven seconds compared to 12 second runs on the NA baseline, with Jim Cooper reporting 125 degree plus coolant temp (dash mounted temp gauge below ¼). But I'm sure that Stan will want to do 1000 ft blasts for top radar speeds with his upnord gas powered sled. Also note that with N2O making up part of the intake charge, air drawn in through the airbox is reduced, rendering our mechanical A/F numbers incorrect. Here we concentrate on fuel flow lb/hr and BSFC. The close-to-.60 lb/hphr BSFC made my armpits wet.

First two N2O runs, averaged

Initial N2O runs lean fuel setting

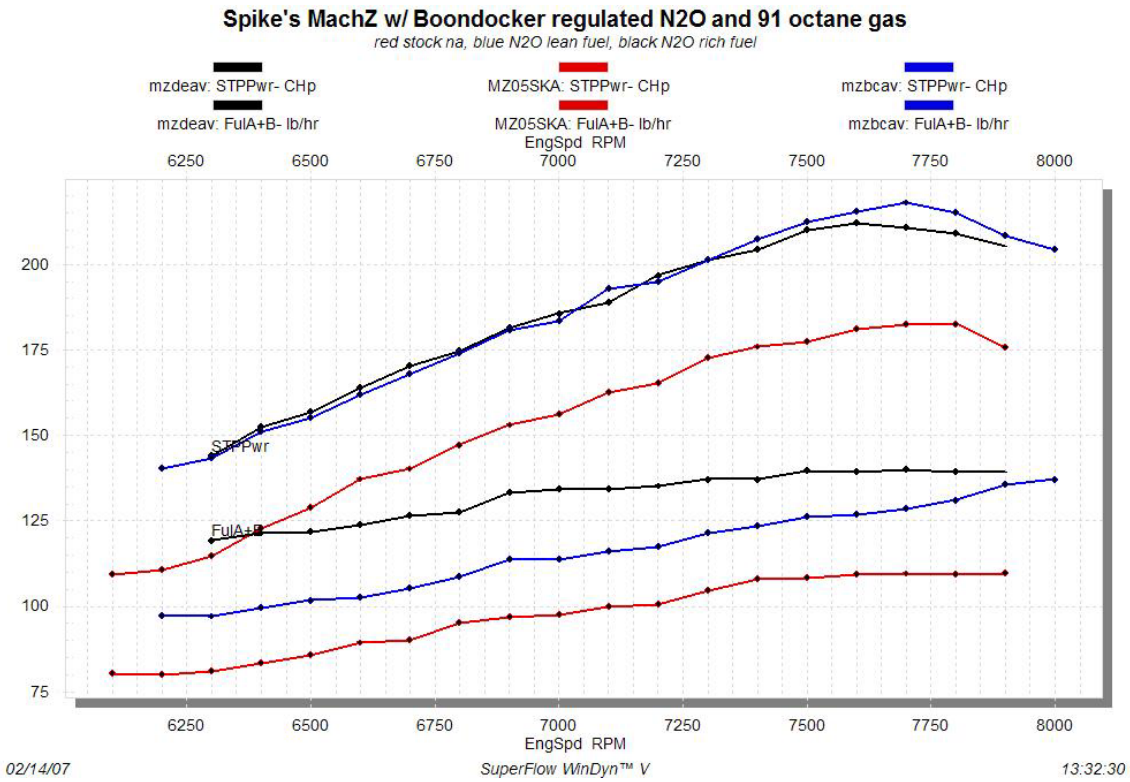
EngSpd RPM	STPTrq Clb-ft	EngPwr Hp	STPPwr CHp	FulA+B lb/hr	BSFC lb/hph	Air1+2 scfm	A/FA-B Ratio	AirTmp degF
6200	118.8	134.8	140.2	97.1	0.721	204	9.61	35
6300	119.4	137.7	143.2	97.1	0.704	204	9.64	35
6400	123.9	145.1	151.1	99.4	0.685	208	9.61	35
6500	125.4	149.3	155.2	101.7	0.681	211	9.52	35
6600	128.8	155.8	161.9	102.6	0.658	216	9.63	34
6700	131.6	161.6	167.9	105.2	0.651	219	9.54	34
6800	134.3	167.4	173.9	108.5	0.648	224	9.46	34
6900	137.6	174.1	180.8	113.6	0.653	230	9.26	34
7000	137.6	176.6	183.5	113.6	0.643	232	9.35	34
7100	142.6	185.6	192.8	116.1	0.625	241	9.52	34
7200	142.1	187.5	194.8	117.4	0.626	244	9.51	34
7300	144.7	193.6	201.1	121.4	0.627	249	9.38	34
7400	147.3	199.5	207.5	123.5	0.619	255	9.46	35
7500	148.8	204.5	212.4	126.1	0.617	259	9.42	34
7600	148.9	207.4	215.4	126.9	0.612	262	9.44	34
7700	148.7	209.8	218.1	128.6	0.613	263	9.37	34
7800	144.8	207.2	215.1	131.1	0.632	263	9.19	33

7900	138.6	200.8	208.5	135.7	0.676	260	8.78	33
8000	134.1	196.5	204.3	137.1	0.698	257	8.61	34

Next Stan and Jim figured that they had to tweak the fuel flow at both the 180 and 340 psi fuel settings, and added 20 numbers to both. This would add more fuel at low RPM than at HP peak—it's probable that the added midrange fuel kept the stock single pipe cooler during acceleration (hence the higher airbox airflow) and resulted in about six less HP (still 204 observed HP) with just a bit higher peak HP fuel flow. The fuel flow at torque peak (where deto is most likely), was 12 lb/hr higher with this safer fuel setting. Note that the safer fuel setting flatlined for about the last 500 rpm of the dyno runs. On the last dyno runs, I included fuel rail pressure to show that the stock MachZ pump is keeping up with two wide open injectors. Once again, to help smooth the data, we averaged two final "safer" Boondocker fuel setting dyno tests. Note that the combination of added fuel flow, cooler pipe, and lower HP resulted in BSFC closer to .70 lb/hphr which for Stan's poor fuel situation makes me a bit more comfortable.

Two "safer for pump gas?" N2O runs, averaged

second N2O tests, wide open fuel flow EngSpd RPM	STPTrq Clb-ft	EngPwr Hp	STPPwr CHp	FulA+B lb/hr	BSFC lb/hph	Air1+2 Scfm	A/FA-B Ratio	FuelP psig
6300	120.1	139.3	144.1	119.2	0.856	214	8.23	57.7
6400	125.1	147.1	152.4	121.3	0.825	215	8.11	57.6
6500	126.7	151.4	156.8	121.9	0.805	217	8.15	57.5
6600	130.3	158.1	163.8	123.8	0.783	221	8.16	57.5
6700	133.5	164.2	170.3	126.5	0.771	225	8.16	57.4
6800	134.9	168.4	174.7	127.5	0.757	229	8.21	57.4
6900	138.1	174.7	181.3	133.2	0.762	234	8.05	57.3
7000	139.2	178.9	185.6	134.2	0.751	239	8.16	57.3
7100	139.8	182.1	189.1	134.3	0.738	242	8.25	57.2
7200	143.5	189.6	196.7	135.1	0.713	249	8.44	57.2
7300	144.9	194.1	201.3	137.1	0.707	254	8.47	57.1
7400	145.1	197.1	204.4	137.1	0.696	257	8.59	57.1
7500	147.1	202.5	210.1	139.7	0.691	262	8.61	57.1
7600	146.5	204.3	212.1	139.4	0.682	265	8.71	57.1
7700	143.7	203.1	210.7	140.1	0.689	265	8.65	57.1
7800	140.7	201.2	208.9	139.4	0.693	263	8.63	57.1
7900	136.4	197.6	205.2	139.3	0.705	260	8.56	57.1



If Stan decides to spend the money for some fresh race gas, he can surely increase N2O pressure and/ or add some N2O nozzles (remember his injectors are tapped out at 140 lb/hr) to bring his observed HP safely up to about 233—(140 lb/hr divided by .60 lb/hphr)—which would [I believe falsely] correct up to about 240 CHP. But 233 is huge HP for a stock engine with only an aluminum cylinder next to the can muffler. But since we didn't have good gas, we couldn't turn up the N2O.

Since we've recognized that 140 lb/hr of fuel flow is the limiting factor for creating HP on this engine, Boondocker is soon coming out with a four-injector N2O system that will add lb/hr and HP capability to the system. This is really necessary for lakeracers who are running 200 HP NA with porting and Crankshop twin pipes and thus are limited to only about 33 HP worth of N2O by the two injectors.

There are two 518er madmen lakeracers (Eastern NY area code) waiting for four-injector Boondocker N2O kits for their MachZs. Since they both will probably have their sleds tuned here before blasting down the lake, we may discover how much fuel those extra two injectors will add (maybe next week?). If we get another 40 lb/hr these Mach Zs will be fun to watch on the dyno and on the lake especially if we can make 300 observed (not corrected) HP for six seconds.

Adding 100 HP with N2O can be done, but it's good to creep up on it (adding fuel, then N2O, then more fuel, etc until the goal is reached). During dyno runs the newest SuperFlow software allows us to watch a real-time graph of the observed HP as it happens. As long as HP climbs and exceeds the prior run we continue the test. But if HP

tails off or flatlines from incorrect tuning or deto we can usually abort a test without damage. But when tuning for BIG HP with N2O detonation can hit suddenly and the HP curve doesn't just flatline or tail off, it drops like a rock straight down and we have maybe 1/10th second to yank throttle back and let off the button (the N2O button in the control room is always operated by sled owner!) before plugs are speckled. The dyno operator and button pusher must stare intently at the graph as it happens and be prepared to chicken out at the first hiccup! Not too many years ago we used to open cheap fizzy wine, pretending it was Champagne, when we made 200 HP. Today it takes 300 for that celebration to occur. Maybe next week.