2009 Arctic Cat Z1 turbo

Here's our first production Arctic Cat Z1 turbo sled, brought here by JD Powersports to verify the dyno numbers from their own SF902 engine dyno.

After engine temperatures (coolant and oil) were up to normal, we have two dyno tests here to report—one with cold outside air blowing directly on the stock intercooler at 80 mph, and one with stagnant low speed airflow like one might experience during hillclimbing at WOT with reduced outside airflow speed.

Cold intercooler temp = higher airflow SCFM = higher HP. The Z1 ECU recognizes the cooler, more dense air intake temp and delivers additional fuel flow to compensate. This results in a world record stock snowmobile 185 CHP. This huge HP number is created with only 90 lb/hr fuel flow while two-stroke 150 HP sleds require 95-100 lb/hr or more to be safe on pump gas.

With less high speed outside airflow cooling the intercooler, like one might experience during low vehicle speed hard on-off-on throttle running or hillclimbing, we can see airflow SCFM drop. But as the dyno test data indicates, the ECU recognizes that the incoming air is hotter, less dense, and lowers fuel flow lb/hr to deliver the correct A/F ratio. But if air temp climbs too high, with low octane fuel there is a detonation sensing system that will lower boost if knock occurs.

Also, while not shown in this data, the stock fuel pump delivers nearly 160 lb/hr fuel flow. This is enough fuel flow to support 300 observed HP.

Note on each dyno test, the boost pressure rises gradually as HP climbs to the 76-7700 RPM power peak, then declines beyond that. It's probable that this boost pressure curve is dictated by the ECU controlled turbo wastegate—delivering peak boost and HP at the RPM deemed safe for the engine, then reducing boost levels beyond that safe RPM. This suggests that clutches be tuned to run at moderate, engine-safe revs.

Why do I think this? In 1977 I bought a new Kawasaki KZ1000 motorcycle that peaked at maybe 70 HP at 8000 then tailed off as revs climbed beyond that (I used to cringe when revs climbed into the red zone above 8000 on the tach during too-often missed shifts). Then I purchased an American Turbo Pac turbo system, installed it on the bike and this incredible new boost pressure caused the HP curve to slide hard to the right—big horsepower (150ish) to 9,000 RPM and beyond until the intake valves floated at 10,000. Now the KZ1000 tach red-zone was in the meat of the powerband! Mechanically controlled boost never tailed off as revs climbed like it does with the computer controlled Cat Z1. That evil, wobbling turbo KZ1000 hooked me on boost forever. Eventually, with bigger displacement and longer swingarm that stock KZ1000 106 mph quarter mile speed became 150 mph quarter mile speed with stock cams and head. Boost is dandy and easy on parts.

I think that the Cat ECU programmers have wisely created a boost curve that maxes where the engine is happy, then declines as revs climb to needlessly higher revs. Maybe I'm wrong, but the dyno data suggests that. Clutch to 76-7700 for max acceleration and the engine is safe and happy. Let it rev higher, then HP drops and acceleration suffers a bit. Perfect. Then, when lousy gas is encountered, the detonation protection system is said to reduce boost accordingly when knock occurs.

Here's the bone stock Cat 09 production Z1, with very cool intercooler blasted by the DynoTech 80 mph cold outside air cooling ducts (visible on the engine dyno room cams).

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	BSFA-B lb/hph	FulA-B lb/hr	BOOST IN HG	A/FA-B Ratio	Air 2 scfm	FuelP Psig
5800	123.8	136.7	0.38	50.8	18.8	16.70	185	48.3
5900	123.7	139.0	0.39	52.3	19.0	16.20	185	48.3
6000	124.8	142.6	0.39	53.7	17.7	15.73	184	48.1
6100	124.4	144.5	0.41	56.8	18.3	14.72	183	48.1
6200	123.3	145.5	0.42	59.6	17.9	13.96	182	48.2
6300	123.3	147.9	0.45	64.6	18.1	12.98	183	48.1
6400	122.7	149.5	0.44	63.7	18.2	13.09	182	48.1
6500	122.3	151.4	0.43	63.0	19.1	13.29	183	48.1
6600	121.7	152.9	0.43	63.5	17.3	13.37	185	48.0
6700	121.5	154.9	0.44	66.3	17.2	12.92	187	48.0
6800	121.8	157.7	0.46	70.2	18.3	12.53	192	48.2
6900	120.9	158.9	0.46	70.8	19.1	12.58	194	48.4
7000	121.6	162.0	0.45	70.7	19.9	12.91	199	48.5
7100	123.6	167.0	0.47	75.3	21.3	12.49	205	49.0
7200	125.8	172.5	0.49	82.3	21.2	11.83	213	49.4
7300	126.8	176.2	0.49	83.0	24.2	12.05	218	49.8
7400	129.6	182.6	0.48	83.8	24.6	12.19	223	50.2
7500	129.8	185.4	0.48	85.6	24.6	12.07	226	50.4
7600	127.9	185.0	0.50	89.2	24.9	11.69	228	50.2
7700	126.3	185.2	0.52	92.3	25.1	11.34	229	50.2
7800	123.7	183.6	0.52	91.7	22.6	11.40	228	50.1
7900	120.7	181.6	0.50	88.2	22.4	11.92	230	49.8
8000	116.1	176.8	0.51	87.7	21.8	11.79	226	49.3
8100	113.1	174.5	0.53	88.8	21.7	11.57	224	49.1
8200	108.1	168.7	0.55	89.1	20.3	11.32	220	48.5

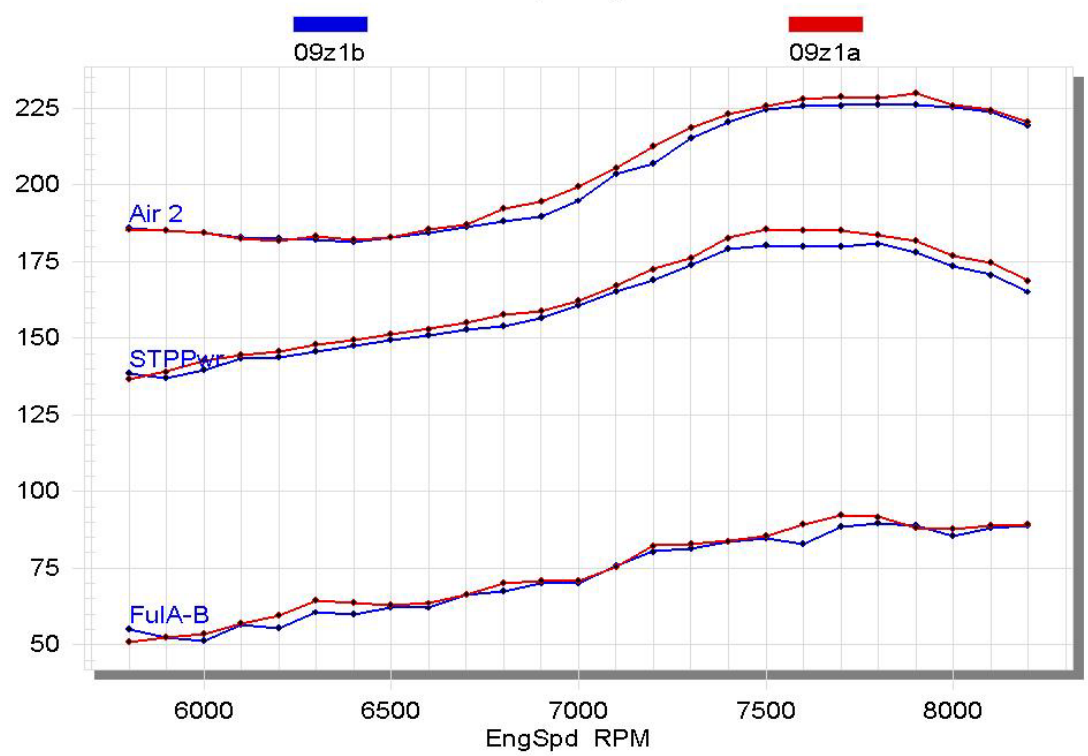
Here's the same Z1 engine, but with intercooler cooling airflow reduced to perhaps 20 mph. Note at WOT the intake airflow SCFM is reduced, and the ECU appropriately reduces fuel flow to maintain A/F ratio and low BSFC. Here, 90 lb/hr fuel flow creates 180 plus HP.

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	BSFA-B lb/hph	FulA-B Lb/hr	BOOST IN HG	A/FA-B Ratio	Air 2 Scfm	FuelP Psig
5800	125.5	138.6	0.41	54.9	18.9	15.50	186	48.4
5900	121.9	136.9	0.40	52.5	18.4	16.14	185	48.3
6000	122.1	139.5	0.38	51.3	18.9	16.45	184	48.4
6100	123.5	143.4	0.41	56.6	19.0	14.80	183	48.2

6200	121.7	143.7	0.40	55.3	19.6	15.12	183	48.5
6300	121.4	145.6	0.43	60.5	19.2	13.77	182	48.6
6400	121.1	147.6	0.42	60.0	18.7	13.84	181	48.3
6500	120.6	149.2	0.43	62.1	19.1	13.47	183	48.2
6600	120.2	151.0	0.42	62.0	17.6	13.62	184	48.0
6700	119.6	152.6	0.45	66.4	17.5	12.83	186	48.1
6800	118.8	153.8	0.45	67.4	18.4	12.78	188	48.1
6900	119.1	156.5	0.46	70.0	18.4	12.40	190	48.2
7000	120.5	160.6	0.45	70.0	19.8	12.73	195	48.4
7100	122.2	165.2	0.47	75.7	21.2	12.31	203	49.0
7200	123.3	169.0	0.49	80.4	20.7	11.78	207	49.3
7300	125.0	173.8	0.48	81.3	21.3	12.11	215	49.8
7400	127.1	179.1	0.48	83.5	23.7	12.08	220	50.1
7500	126.2	180.2	0.49	84.6	24.1	12.15	224	50.4
7600	124.3	179.9	0.48	83.0	24.4	12.44	226	50.3
7700	122.7	179.9	0.51	88.6	23.4	11.67	226	50.2
7800	121.7	180.8	0.52	89.7	24.0	11.53	226	50.0
7900	118.4	178.1	0.52	88.9	24.0	11.65	226	49.8
8000	113.9	173.5	0.51	85.5	23.0	12.06	225	49.4
8100	110.6	170.6	0.54	88.1	21.9	11.64	224	49.2
8200	105.7	165.0	0.56	89.0	20.5	11.28	219	48.5

09 Z1 turbo compare hot vs cool intercooler

09z1b, 09z1a,



12/06/08 *SuperFlow WinDyn™ V* *14:00:52*

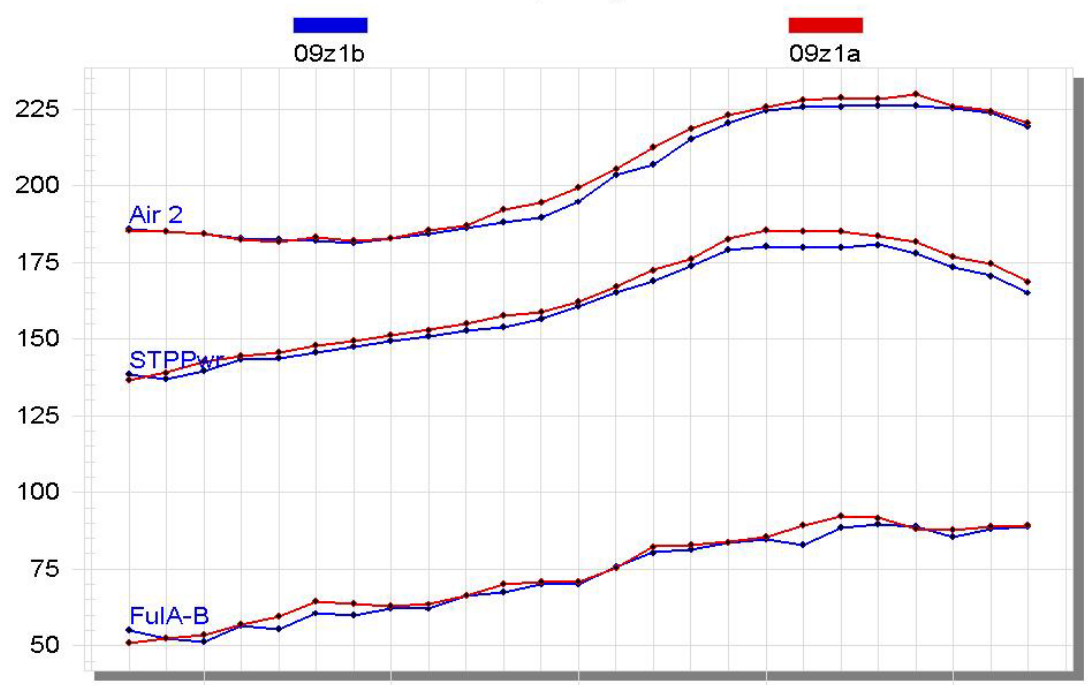
Here's the Z1 engine, but with intercooler cooling airflow reduced to perhaps 30 mph. Note at WOT the intake airflow SCFM is reduced, and the ECU appropriately reduces fuel flow to maintain A/F ratio and low BSFC. Here, 90 lb/hr fuel flow creates 180 plus HP. On modern two-strokes 90 lb/hr is good for 145 HP at this temperature.

EngSpd	STPTrq	STPPwr	BSFA-B	FulA-B	BOOST	A/FA-B	Air 2	FuelP
RPM	Clb-ft	CHp	lb/hph	Lb/hr	IN HG	Ratio	Scfm	Psig
5800	125.5	138.6	0.41	54.9	18.9	15.50	186	48.4
5900	121.9	136.9	0.40	52.5	18.4	16.14	185	48.3
6000	122.1	139.5	0.38	51.3	18.9	16.45	184	48.4
6100	123.5	143.4	0.41	56.6	19.0	14.80	183	48.2
6200	121.7	143.7	0.40	55.3	19.6	15.12	183	48.5

6300	121.4	145.6	0.43	60.5	19.2	13.77	182	48.6
6400	121.1	147.6	0.42	60.0	18.7	13.84	181	48.3
6500	120.6	149.2	0.43	62.1	19.1	13.47	183	48.2
6600	120.2	151.0	0.42	62.0	17.6	13.62	184	48.0
6700	119.6	152.6	0.45	66.4	17.5	12.83	186	48.1
6800	118.8	153.8	0.45	67.4	18.4	12.78	188	48.1
6900	119.1	156.5	0.46	70.0	18.4	12.40	190	48.2
7000	120.5	160.6	0.45	70.0	19.8	12.73	195	48.4
7100	122.2	165.2	0.47	75.7	21.2	12.31	203	49.0
7200	123.3	169.0	0.49	80.4	20.7	11.78	207	49.3
7300	125.0	173.8	0.48	81.3	21.3	12.11	215	49.8
7400	127.1	179.1	0.48	83.5	23.7	12.08	220	50.1
7500	126.2	180.2	0.49	84.6	24.1	12.15	224	50.4
7600	124.3	179.9	0.48	83.0	24.4	12.44	226	50.3
7700	122.7	179.9	0.51	88.6	23.4	11.67	226	50.2
7800	121.7	180.8	0.52	89.7	24.0	11.53	226	50.0
7900	118.4	178.1	0.52	88.9	24.0	11.65	226	49.8
8000	113.9	173.5	0.51	85.5	23.0	12.06	225	49.4
8100	110.6	170.6	0.54	88.1	21.9	11.64	224	49.2
8200	105.7	165.0	0.56	89.0	20.5	11.28	219	48.5

09 Z1 turbo compare hot vs cool intercooler

09z1b, 09z1a,



12/06/08 *SuperFlow WinDyn™ V* *14:00:52*

Here are the two tests: