2004 Arctic Cat F6 tuneup—EFI vs Carburetors?

The only other F6 we've dyno'd prior to this was the EFI sled for the AmSnow certification last December. With hot engine (120 degrees F plus) the shootout sled registered 117hp and 116hp on its first and second runs, respectively, delivering about 94 lb/hr fuel flow at peak revs at 35 degrees F that day. This engine would prove to give us lower fuel flow, and more HP on a day with better air. Also, though we could observe continuous A/F ratio readings while testing, there is some glitch in the computer that gave us gibberish in the A/F column when each test was saved to disc (ie: "4e+290" instead of 11.9/1). So I had to manually figure A/F ratio just as though we had an old instrumented manual control, non-computerized dyno. Since A/F ratio is based up weight, the air consumption math is as follows: Air density lb/cu ft = .077 (30 degree F air, 29.90 baro) x 206 cfm = 15.86 lb/min x 60 (since fuel flow reads in lb/hr) = 952 lb/hr of air / 79.8 lb/hr fuel = 11.9/1. For each test, I did the math to give A/F ratio at HP peak and typed that in. I'm glad to have a totally computerized dyno, and will be even more glad when this software glitch is fixed.

As we've seen in prior tests, the EFI Cats' tuning is affected by water temp. It appears as though as the engine water temp sensor exceeds about 130 F, the timing gets pulled back and HP suffers for the sake of reliability. This is a good thing. Though there doesn't seem to be much airflow difference between 80F and 120+F water outlet temp (*remember these Cats have "reverse cooling" like most modern automotive race engines, and 120 F coming out the bottom of the engine can = a very safe 90 F coming into the engine around the combustion chambers*). For an experiment we chilled the engine down to 50 degrees F water temp. We had done this with Bill LT's F7 race ECU's, and picked up lots of HP, probably due to additional advanced timing. But this cold-engine dyno run on the F6 EFI lost HP, maybe due to retarded timing combined with extra fuel. So, understandably, what works for race ECU's does not work for stock ECUs. It pays to warm the F6 EFI up.

04 F6 EFI, 50 degree coolant temp warm-up mode

EngSpd	STPTrq	STPPwr	BSFC	Fuel A	A/F	Air 2	Fuel P
RPM	Clb-ft	CHp	lb/hph	lb/hr	Ratio	scfm	psig
5900	60.5	68.1	0.88	59.3		126	43.1
6000	61.3	70.1	0.87	60.3		128	43.1
6100	62.1	72.1	0.85	60.4		129	43.1
6200	66.1	77.9	0.84	64.8		133	43.1

6300	66.5	79.8	0.86	67.3		136	43.1
6400	68.2	83.2	0.86	70.7		139	42.9
6500	70.7	87.5	0.85	73.6		143	42.8
6600	72.6	91.2	0.85	76.5		149	42.8
6700	74.1	94.5	0.85	78.9		155	42.7
6800	74.6	96.6	0.84	79.8		161	42.7
6900	76.5	100.6	0.84	83.1		167	42.7
7000	75.9	101.2	0.82	81.7		169	42.7
7100	75.3	101.8	0.82	82.4		171	42.7
7200	75.4	103.4	0.81	83.1		176	42.7
7300	74.3	103.3	0.82	83.6		178	42.7
7400	74.3	104.7	0.81	83.4		178	42.7
7500	75.7	108.2	0.79	84.2	9.9	180	42.6
7600	78.4	113.5	0.84	94.4	9.6	197	42.5

We did additional dyno runs to bring the water temp up—it gradually picked up power as water temp became warm, then began to tail off as temp increased beyond 120F, dropping power into the 118-119 HP range even though airflow CFM remained constant. So, to maintain consistency for the rest of the test session, we replaced the water temperature thermocouple with a resistor that equaled this particular thermocouple's value at about 80 degree F water temp. Note that BSFC is about .70 at HP peak. That 80 degree F water temp seems to be the "sweet spot" for this stock ECU as follows:

04 F6 EFI, 80 degree F coolant temp (all following tests are with this value)

EngSpd	STPTrq	STPPwr	BSFC	Fuel A	A/F	Air 2	Fuel P	AirTmp
RPM	Clb-ft	CHp	lb/hph	lb/hr	Ratio	scfm	psig	degF
5900	61.2	68.7	0.77	52.2		127	43.2	34
6000	60.3	68.8	0.77	52.5		127	43.2	34
6100	61.6	71.5	0.74	52.3		128	43.2	34
6200	64.4	76.1	0.75	56.4		131	43.1	34
6300	65.1	78.1	0.75	58.1		134	43.1	34
6400	66.2	80.7	0.77	61.2		136	42.9	34
6500	68.4	84.7	0.76	63.8		139	42.9	34
6600	71.5	89.9	0.76	67.7		145	42.8	35
6700	75.3	96.1	0.78	74.3		155	42.9	35
6800	76.1	98.4	0.77	74.8		160	42.8	35
6900	76.8	100.9	0.75	75.1		165	42.7	34
7000	76.5	102.1	0.75	75.5		168	42.8	34
7100	77.8	105.2	0.75	78.2		172	42.8	34
7200	77.7	106.6	0.73	76.7		175	42.8	34
7300	77.1	107.2	0.71	75.7		179	42.8	34
7400	77.1	108.5	0.71	75.1		180	42.8	34

7500	76.8	109.7	0.71	75.7		181	42.8	34
7600	83.1	120.1	0.72	85.1	10.5	194	42.5	34
7700	79.7	116.8	0.76	87.3		203	42.6	33
7800	75.1	111.6	0.79	87.3		205	42.5	33

Next, to create a 92 octane lakerace spec for the owner, we lowered top end fuel pressure. As expected, this took a totally different calibration than the F7 EFI's we've tweaked. Do not try this without measuring A/F ratio. For comparison, we added the F6 carb data from the sled on the dyno. The F6 carbs have been leaned out to an A/F ratio similar to the leaned out EFI F6. There seems to be something awry with the carbureted sled, which has been a comparative pooch since day one. Note that though the 40mm carburetors airflow CFM exceeds the 46mm EFI throttle body airflow (remember, slide carbs have no pesky throttle shafts and blades that obstruct airflow), and fuel flow is reasonably close, top end HP is way off the mark. Midrange HP is very similar, and it appears as though top end timing is severely retarded as evidenced by the extended, flat overrev power. In this engine, 430 mains were installed to lean out mixture. The high BSFC on the carbed engine is not from rich mixture, rather it's the lack of HP that creates the illusion of over-safe BSFC. We'll complete a separate article once we find the missing HP.

F6 EFI……………………………………………F6 carbureted……….

04 F6 EFI, reduce top end fuel flow, 11.5/1 A/F ratio at HP peak- 04 F6 carbureted 11.9/1 A/F at peak HP,

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	BSFC lb/hph	Fuel A lb/hr	Air 2 scfm	STPTrq Clb-ft	STPPwr CHp	Fuel A lb/hr	Air 2 scfm
5900	61.1	68.5	0.76	51.2	127	60.6	68.1	59.1	128
6000	60.9	69.6	0.75	51.5	128	61.4	70.1	63.3	131
6100	61.3	71.2	0.73	51.6	129	61.6	71.5	61.2	133
6200	63.5	75.1	0.71	52.4	131	62.5	73.8	59.1	135
6300	66.9	80.3	0.71	55.3	136	68.9	82.7	65.5	147
6400	68.1	82.9	0.69	56.4	138	68.4	83.4	65.2	148
6500	71.6	88.6	0.69	60.1	143	70.1	86.8	72.7	150
6600	73.3	92.1	0.69	62.8	149	74.3	93.3	71.1	157
6700	75.2	95.9	0.69	65.5	155	74.7	95.3	75.3	161
6800	75.5	97.7	0.69	66.9	157	76.9	99.6	72.5	167
6900	77.7	102.1	0.69	69.3	163	77.1	101.3	76.1	171
7000	77.7	103.6	0.69	70.6	169	77.2	102.9	75.5	172
7100	77.2	104.3	0.71	72.1	169	76.4	103.3	76.9	177
7200	78.1	107.1	0.68	72.1	174	75.3	103.2	72.4	178
7300	78.3	108.9	0.66	71.3	178	75.4	104.8	72.1	180
7400	78.5	110.7	0.65	71.5	179	75.3	106.1	88.9	187

7500	82.1	117.1	0.64	74.4	186	74.5	106.4	86.4	192
7600	83.9	121.4	0.66	79.2	197	73.2	105.9	81.2	195
7700	81.5	119.5	0.68	80.9	201	73.4	107.6	80.4	196
7800	75.1	111.6	0.76	84.1	203	74.3	110.3	82.9	198
7900						73.4	110.4	79.8	206
8000						67.3	102.5	102.2	210
8100						53.2	82.1	101.3	211

Next, we added a 2 degree offset key to complement the reduced top end fuel flow. For trail riding, the sled owner will run the advanced timing with stock fuel pressure, around 122 HP and save the leaner fuel flow for lakeracing.

04 F6 EFI, reduced top end fuel flow, added 2 degree timing key

EngSpd	STPTrq	STPPwr	BSFC	Fuel A	A/F	Air 2	AirDen
RPM	Clb-ft	CHp	lb/hph	lb/hr	Ratio	scfm	lb/cft
5000	47.7	45.4	0.86	38.5		97	0.077
5100	47.6	46.2	0.85	38.8		98	0.077
5200	48.4	47.9	0.83	39.1		99	0.077
5300	49.2	49.7	0.81	39.5		100	0.077
5400	52.7	54.1	0.77	41.4		103	0.077
5500	53.3	55.8	0.79	43.3		106	0.077
5600	55.1	58.7	0.79	45.6		109	0.077
5700	56.9	61.7	0.77	47.3		114	0.077
5800	57.3	63.3	0.78	48.5		117	0.077
5900	59.1	66.4	0.75	49.2		120	0.077
6000	61.5	70.2	0.72	50.2		125	0.078
6100	61.7	71.6	0.72	51.1		126	0.078
6200	62.6	73.9	0.72	52.4		128	0.078
6300	64.9	77.8	0.69	53.2		131	0.078
6400	67.2	81.9	0.68	55.2		135	0.078
6500	69.1	85.6	0.69	58.3		138	0.078
6600	72.2	90.7	0.68	60.6		144	0.078
6700	75.2	95.9	0.68	64.2		152	0.078
6800	76.7	99.3	0.66	65.2		159	0.078
6900	77.8	102.2	0.68	68.5		163	0.077
7000	77.6	103.4	0.67	68.9		166	0.078
7100	78.8	106.5	0.68	71.5		170	0.078
7200	79.5	109.1	0.66	71.6		172	0.078
7300	78.9	109.7	0.66	71.7		177	0.078
7400	79.4	111.9	0.65	72.3		179	0.078
7500	80.5	115.1	0.64	73.1		183	0.078
7600	85.3	123.4	0.62	75.8		198	0.078
7700	84.7	124.1	0.64	78.4	11.5	201	0.078

7800	80.3	119.3	0.67	79.6	206	0.078
7900	76.1	114.4	0.69	78.5	205	0.077

Observations:
In the conditions we experience here, it appears as though the exhaust valves open too late. This is evidenced by just how the engine comes alive, airflow and HP jumps suddenly, then falls off just as quickly on warm pipe overrev. This looks tricky to keep clutching on the power band. The valves seem to open even later than the F7 calibration, which is itself a bit early for our driving and dynoing. If we can rectify the problem with the carbed F6 on the dyno now, we may try to wedge the valves open to see how much warm-pipe midrange HP and torque may be M.I.A. because of the late opening. Why not try that trick on the EFI F6? Because if you introduce massive midrange airflow increase early by opening the valves earlier than the Cat ECU programmer intended, there won't be enough fuel flow to match the added air. Severe midrange leanout would result. But the carbs are helpful in situations like this—if we increase airflow, fuel flow goes up automatically. Hopefully we'll have this done Monday, since we have the ProX 800 and Sean Ray's factory mod Rev 800 trail sled waiting for tuning. We've got to get those done next, before they begin calling this DynoCatResearch.