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DYNOTECH

JOURNAL OF SNOWMOBILE PERFORMANCE AND TWO-STROKE TECHNOLOGY

1994 Yamaha V-Max 500 & 600

V-MAX 500	V-MAX 600
Weight w/3gals.gas:	**Weight w/3 gals. gas:**
524 lbs.	Same as 500
Engine:	**Engine:**
L/C, 7 port, reed valve	L/C, 7 port, reed valve
Carburetion:	**Carburetion:**
(2) Mikuni TM36 flatslide	(2) Mikuni TM38 flatslide
Bore X Stroke:	**Bore X Stroke:**
68 X 68	74.8 X 68
(494 cc)	(598 cc)

We received one of the first production V-Max 500s last spring, which went to Bender Racing for aftermarket product development. The V-Max 600 arrived just months later--after the introduction of the V-Max 500. After some late season field testing, there had been some minor port timing and exhaust system changes before the engine went into production.

The V-Max 500 uses a crankcase, crankshaft and digital ignition borrowed from the Exciter II. The V-Max 600 uses the Exciter SX crankshaft. These crankshafts have proven themselves extremely durable for the low operating speeds that they were designed for. Yamaha engineers have indicated that there are destructive resonant frequencies in the crankshafts above 8200 RPM, so it is wise to operate the engine below that speed.

The V-Max 500 uses racked 36mm flatslide Mikuni carbs, while the larger V-Max 600 uses racked 38mm flatslide Mikuni carbs that are identical to those used on the Exciter SX. Carb float bowls are vented under the hood, like the V-Max 4. A new extremely free breathing airbox draws cold outside air from behind the windshield like the V-Max 4. And, like the V-Max 4, the jetting enriches automatically at high vehicle speed due to the pressure differential between the two areas (see "The Effects of Underhood Pressure..." in Vol. 4 #3).

Those of you who have not had experience tuning this new series of Mikuni carb will be pleased to know that changing the needle height is delightfully simple, as opposed to the grievous fumbling necessary to adjust the needles on the V-Max 4's racked 34mm flatslide carbs.

Ostensibly intending to lubricate the carb slides, Yamaha has elected to inject the variable ratio engine oil into the fuel pump, far upstream of the engine. Consequently, ratio changes resulting from throttle position changes are delayed by perhaps 10 to 60 seconds.

This is more of an annoyance than a real problem; snowmobile engines will run at WOT safely for long periods of time on the 80-1 idle oil mix. They will also idle smoothly and smokily, for long periods of time on the 20-1 WOT oil mix. Every other snowmobile engine manufacturer injects the variable ratio lubricating oil directly into the intake ports. Interestingly, Yamaha outboard marine engines' "Precision Blend (R)" oil systems inject the oil directly into the intake manifold--which Yamaha claims in their advertising is an advantage over Mercury and OMC- both of whom inject the oil upstream of the carbs.

The good news is, Bender Racing and possibly others will sell an inexpensive direct oil injection update kit for these engines.

The pistons, cylinders and one-piece head are all-new. Large eight-petal reed cages with fiber reeds are mounted on the cylinders. The 500

Yamaha V-Max 600 & 500 continued...

engine has .42mm thick fiber reeds while the 600 has .52mm thick fiber reeds. The reed stops are different for each engine as well. Japanese engineers have obviously spent a great deal of time optimizing these reeds and reed cages to the respective engines. Keep this in mind before rushing to order the aftermarket "performance" reeds and cages which are sure to be offered for sale as soon as the fiberboard purveyors get their hands on the dimensions of the cages.

A Phazer-like plastic boost bottle (which is worth over one horsepower on both the 500cc and 600cc engines) connects the two reed cage areas. The large reed area and intake port are made possible by the use of short cylinder base studs. Elimination of the long studs securing the head and cylinders to the crankcase has another benefit--reducing distortion of the cylinder walls--especially on nickasil lined cylinders. As the aluminum cylinders heat up, they grow much more than do the long steel cylinder studs, causing the cylinder walls to go slightly out of round.

The intake skirt on the piston on the 600 has an 8 mm hole like the V-Max 4; the 500 has a solid intake skirt.

Encircling the walls of each cylinder are 4 transfer ports, and a rear "boost" port or "seventh" port aimed at the exhaust port. The inside of the cylinder looks much like an overgrown V-Max 4 cylinder. And the 600 cylinders won't fit the V-Max 4 or Exciter crankcases. The single exhaust port is timed and sized approximately the same as last year's Exciter SX.

The cylinder head, which gives the V-Max 600 about 120 psi of cranking pressure is much more conservative than last year's Exciter SX, which carried about 150 psi of cranking pressure.

Finally, we have the stock single pipe. Based upon early testing by some experienced pipe technicians, there is probably not much room for improvement. This one is going to be tough to beat. The pipes on the 500 & 600cc engines are identical-- except for the 600cc having a less restrictive aftermuffler. Swapping the pipes from one size engine to another resulted in slightly less horsepower.

We installed a 1993 stock Exciter SX pipe on the V-Max 600 and registered 92 CBHP, or roughly the same as the stock (though much higher compression) Exciter SX!

When we get around to bumping the compression of the stock V-Max 600 to the gasoline-fussy 150 psi of cranking pressure of the Exciter SX, we should see 102-103 CBHP.

STOCK 1994 YAMAHA V-MAX 500

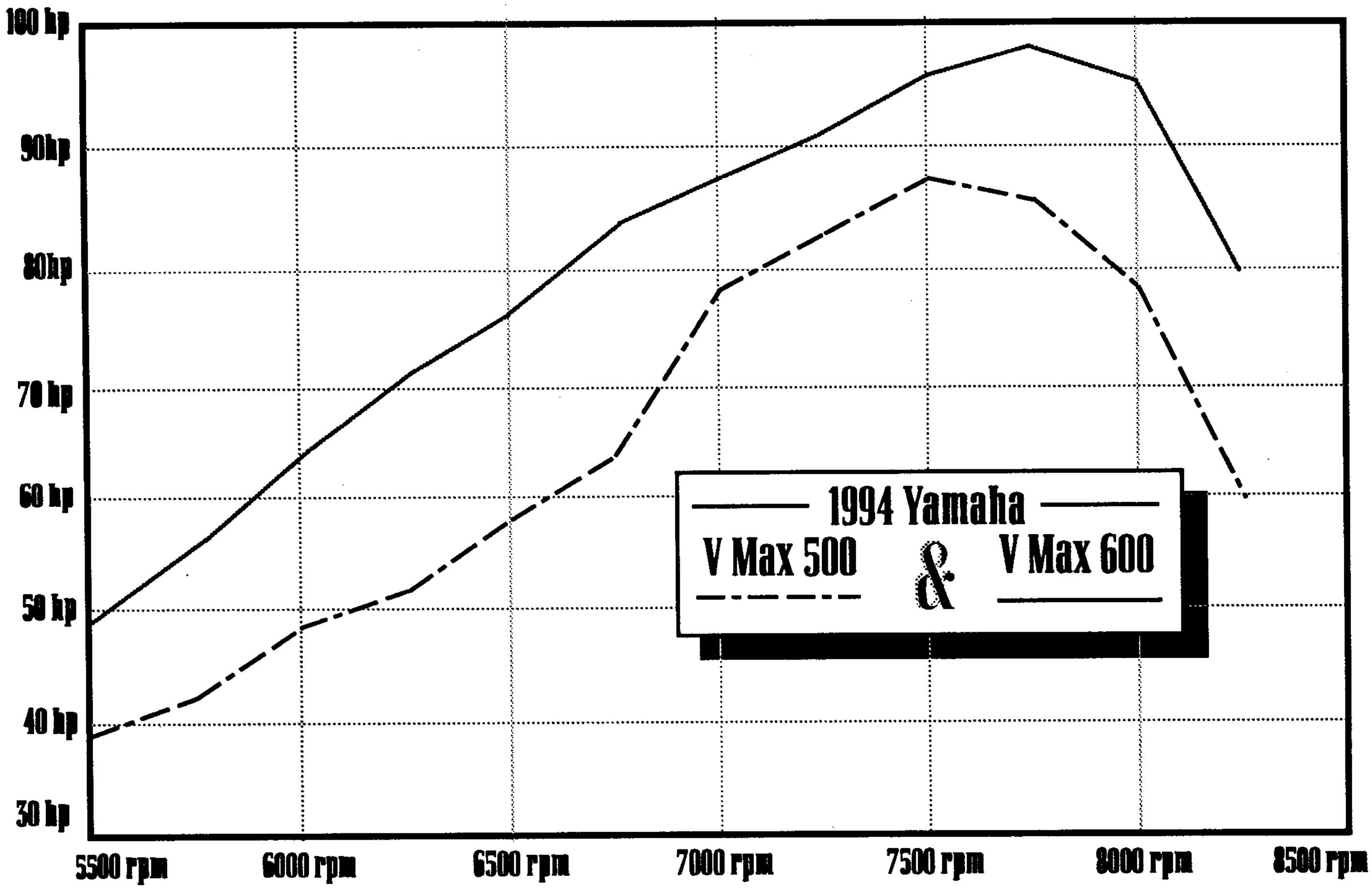
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .718
Vapor Pressure: .70
Barometer: 30.00

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5250	34.6	34.6	29.5	82.3	12.8	.89	80
5500	37.1	38.9	30.4	84.3	12.7	.82	80
5750	38.6	42.3	32.0	87.8	12.6	.79	80
6000	42.5	48.6	35.2	97.5	12.7	.76	79
6250	43.5	51.8	35.9	99.4	12.7	.73	80
6500	47.2	58.4	39.2	109.6	12.8	.70	79
6750	49.7	63.9	40.2	111.7	12.8	.66	79
7000	59.0	78.6	47.0	126.3	12.3	.63	82
7250	60.0	82.8	50.3	129.7	11.8	.64	81
7500	61.3	87.5	64.2	134.4	11.4	.65	80
7750	58.1	85.7	56.3	136.4	11.1	.69	80
8000	51.7	78.8	54.5	134.6	11.3	.72	80
8250	37.9	59.5	52.1	127.2	11.2	.92	80

STOCK 1994 YAMAHA V-MAX 600
140 MJ

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .718
Vapor Pressure: .70
Barometer: 30.00

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	46.9	49.1	39.6	105.0	12.2	.84	74
5750	51.2	56.1	41.4	109.1	12.1	.77	74
6000	56.0	64.0	43.8	115.7	12.1	.71	74
6250	59.8	71.2	47.0	123.2	12.0	.69	74
6500	61.9	76.6	48.2	129.2	12.3	.65	73
6750	65.3	83.9	52.0	135.9	12.0	.64	73
7000	65.4	87.2	53.4	139.7	12.0	.64	73
7250	66.0	91.1	55.1	143.8	12.0	.63	73
7500	67.2	96.0	57.6	148.1	11.8	.62	73
7750	66.7	98.4	58.8	150.5	11.8	.62	72
8000	62.4	95.0	58.6	151.2	11.8	.64	73
8250	50.5	79.3	57.5	146.2	11.7	.76	74



TURBO POLARIS 650 RXL SKI DOO MACH I 670

This is the stock 02 and 03 Polaris 650 engine with the Aerodyne series 53 128N300 turbocharger from First Choice Turbo Center (716-226-2929).

This is the same system that powered Jack Harris' Bonneville streamliner to a record 200.8 MPH (see FEEDBACK in this issue). It utilizes VM38 carbs to replace the RXL throttle bodies, and retains the stock oil injection. The stock EFI fuel pump is used as part of the turbo fuel system. A mechanical fuel pump is added to the RXL turbo for cruising and low or zero boost.

The data is shown with two different boost levels, with the lower being 7 PSI trail boost on high test unleaded pump gas. The 9.5 PSI level would represent a 100LL Av Gas setting. For dragracers (or salt flats racers), raising the boost to 12 or more PSI will give you 185-190 CBHP on 110+ octane gasoline. At 15-18 PSI, we have seen the Polaris 650 make up to 215 CBHP with the larger 143n300 turbo.

1993 POLARIS 650 RXL TURBO
38 mm CARBS 7 lbs. BOOST

Data for 29.92 inches Hg, 60 F dry air
Test: 200 RPM/Sec Acceleration
Fuel Specific Gravity: .710
Vapor Pressure: .17
Barometer: 29.99

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6750	87.7	112.7	74.2	245.2	15.2	.65	51
7000	91.1	121.4	81.1	255.3	14.5	.66	49
7250	94.3	130.2	93.9	263.0	12.9	.72	51
7500	97.6	139.4	96.7	270.8	12.9	.69	51
7750	97.8	144.3	100.8	272.7	12.4	.69	51
8000	97.6	148.7	103.9	275.9	12.2	.69	50
8250	95.6	150.2	100.2	278.8	12.8	.66	50
8500	91.6	148.2	100.8	278.6	12.7	.68	50
8750	87.5	145.8	99.1	280.4	13.0	.67	49

TURBO POLARIS 650 RXL SKI DOO MACH I 670 CONTINUED

1993 POLARIS 650 RXL TURBO
38 mm CARBS
9.5 LBS BOOST
Data for 29.92 inches Hg, 60 F dry air
Test: 200 RPM/Sec Acceleration
Fuel Specific Gravity: .700
Vapor Pressure: .15
Barometer: 29.67

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	104.9	139.8	95.3	289.0	13.9	.69	63
7250	106.9	147.6	98.5	295.3	13.8	.68	63
7500	111.9	159.8	103.6	307.3	13.6	.66	62
7750	110.3	162.8	105.4	312.0	13.6	.66	59
8000	111.0	169.1	108.7	314.0	13.3	.65	61
8250	110.0	172.8	110.2	317.7	13.2	.65	61
8500	105.2	170.3	105.2	318.3	13.9	.63	62
8750	102.2	170.3	108.2	319.4	13.6	.65	62

TURBO MACH I 670

The Rotax rotary valve engines make lots of horsepower with the Aerodyne 143N300 turbocharger. The rotary intake valve appears to control the turbo air flow especially well, allowing the Rotax engines to make more horsepower per c.c. per pound of boost than any of our other engines. In addition, the ultra-low operating speed of the stock engine gives the turbo plenty of time to fill the cylinders on each stroke, building amazing quantities of midrange torque and horsepower. So much, in fact, that we would consider 6 PSI to be the pump gas limit at sea level. Flipping the boost to 8-10 PSI would require 100LL av gas to be sure. Even though the eight second 205 CBHP dyno run shown was made safely on 100LL AV gas, we would consider that a 110+ octane (fresh gas only, please) horsepower level.

The RAVE system operates perfectly with the turbo. The stock plastic RAVE covers are replaced by boost pressurized anodized billet aluminum domes that allow normal functioning at all times.

This is South Dakota turbo baron Rusty Rovere's Mach 1 670 turbo engine. Rusty won the West Yellowstone Expo radar shootout last spring on his Turbo V-Max 4. He liked riding our Mach 1 670 turbo (it ran the same radar speed as his V-Max 4), and figured he ought to have one of those as well. (Everything Rusty owns is either turbo or supercharged) This 670 Turbo engine is in his wife's yellow MX-Z chassis, with FAST's "Fat Boy" pipe designed for this combination.

MACH I 670 TURBO
7 LBS BOOST
Data for 29.92 inches Hg, 60 F dry air
Test: 200 RPM/Sec Acceleration
Fuel Specific Gravity: .710
Vapor Pressure: .80
Barometer: 30.09

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6750	109.3	140.5	100.2	229.6	10.5	.75	80
7000	113.6	151.4	103.1	239.8	10.7	.71	82
7250	115.7	159.7	109.7	249.0	10.4	.72	81
7500	119.8	171.1	108.7	261.2	11.0	.66	81
7750	118.0	174.1	111.1	270.5	11.2	.67	81
8000	92.9	141.5	115.4	269.4	10.7	.85	82

MACH I 670 TURBO
9 LBS BOOST
Data for 29.92 inches Hg, 60 F dry air
Test: 200 RPM/Sec Acceleration
Fuel Specific Gravity: .710
Vapor Pressure: .80
Barometer: 30.09

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6750	113.5	145.9	102.1	240.7	10.8	.73	84
7000	117.0	155.9	102.2	250.6	11.3	.69	83
7250	121.1	167.2	106.6	259.8	11.2	.67	84
7500	124.0	177.1	110.3	271.2	11.3	.65	82
7750	124.9	184.3	111.9	282.9	11.6	.64	81
8000	114.0	173.6	117.5	286.8	11.2	.71	82

MACH I 670 TURBO
11 LBS BOOST
Data for 29.92 inches Hg, 60 F dry air
Test: 200 RPM/Sec Acceleration
Fuel Specific Gravity: .710
Vapor Pressure: .80 Barometer: 30.10

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6750	127.1	163.4	101.4	267.1	12.1	.65	81
7000	128.1	170.7	102.9	273.8	12.2	.63	80
7250	134.5	185.7	110.3	286.0	11.9	.62	81
7500	138.2	197.4	114.1	295.7	11.9	.60	81
7750	139.2	205.4	116.6	306.2	12.1	.59	81
8000	131.7	200.6	119.7	313.4	12.0	.62	81

EXCELLENT ENGINES
BENDER RACING'S IMPROVED STOCK V-MAX 4

Back in Volume I, we ran a photo of the Crankshop's then-new 870cc Mach 1 1/2 hand-welded triple that made an astounding 197 CBHP. In 1989, that was unheard of; the best of the best fully modified production Polaris engines at that time were capable of maybe 130-140 cold shot CBHP. That year, Tim Bender's FIII Exciter made horsepower in the hundered and teens range, after hundreds of hours of hacking and dynoing and cutting and chopping and dynoing.

How things have changed!

We sipped champagne to celebrate the Crankshop's (and our) first 200 CBHP 870 engine in 1989. That was a festive, monumental occasion for us. But, we could never have imagined how things would change over the next five years.

Bombardier came out with 617 and 670cc twins--making custom-built 925 and 1005cc triples, with factory-looking cast crankcases, a reality. The relatively new Aarrow engines (we'll be doing an article on them soon) are becoming popular in open class dragracing these days. These aftermarket $10,000 mountain motors can make as much as 250 CBHP these days--at 2/3 throttle.

But, here come the production-based "improved" stockers! The well-modified Thundercats are reportedly making over 200 CBHP now, though no one has been here with one yet. D&D Cycles Arctic Cat tells me that they will be "popping the cork" next time they're at the C&H Dyno. Jeff Simon at Reichard Performance says he has designed T-Cat pipes that do the trick, giving them 200+. There's a set of RPC pipes on Norman Ball's T-Cat, and it does fly.

The Crankshop has built some wicked big-bore Mach 1Z's for Improved Stock dragracing. I've seen Lanny Benoit's Crankshop Mach 1Z run. It's never been on our dyno, but it must be clicking off 200+ as well.

The Indy 750 Storms improved stockers haven't been in the lime-light yet. The introduction of the new & improved 800 should change that this season.

Here's our own first official 200 CBHP. Bruce Schrader's Bender Racing 866cc V-Max 4 (big bore, with nickasil and cast Art pistons) has dominated the open improved stock and open pro stock competition at the Maine State Championships, the Hay Days (though he wasn't able to run in Pro Stock there due to the lack of a rear tunnel enclosure), the Ohio N.Y. Snow Bash, and the N.Y.S. Championship at Marilla. This is a big-bore copy of Bender's 180 CBHP (hot) 750 FIII V-Max 4 engine. It has the same 38 TMX carbs, gutted airbox, 180 degree firing, and high RPM pipes with silencers added. This data was obtained with cold water in the engine, on a seven second dyno run.

As other engine tuners join the exclusive C&H Dyno Service 200 club with production based engines, we will publish their results.

BENDER RACING V MAX 860 IMPROVED STOCK

Data for 29.92 Inches Hg, 60 F dry air
Test: 200 RPM/Sec Acceleration
Fuel Specific Gravity: .718
Vapor Pressure: .70
Barometer: 30.00

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7250	84.6	116.8	80.0	226.2	13.0	.72	80
7500	93.0	132.8	84.0	237.0	13.0	.66	80
7750	93.8	138.4	84.3	240.6	13.2	.64	80
8000	101.4	154.5	87.7	254.0	13.4	.59	80
8250	106.2	166.8	90.4	262.8	13.4	.57	80
8500	108.5	175.6	92.0	268.8	13.4	.55	82
8750	110.1	183.4	93.6	275.0	13.4	.53	81
9000	113.3	194.2	93.8	282.8	13.8	.51	81
9250	113.6	200.1	94.6	289.2	14.0	.49	81
9500	114.5	207.1	94.9	295.6	14.4	.48	80
9750	111.7	207.4	94.6	298.8	14.6	.48	80
10000	106.1	202.0	91.9	299.8	15.0	.48	81

1992 MACH I 670

PERFORMANCE IMPROVEMENTS

Brian Black, a calibrations engineer at G.M., recently checked out his Mach 1 670 engine at the C&H Dyno. The 670 engine had been "tuned up" by Chuck Walters of Twin Lakes Marine in Lewiston, MI.

The Twin Lakes trail tune-up consisted of:

1. Milling the head approximately .020" to give a squish clearance of .058" and a compression ratio of 12.7-1.

2. Setting the ignition timing at .078" BTDC.

3. General transfer and exhaust port clean-up, with special attention paid to the auxilliary exhaust ports (crankcase porting remained stock).

4. Modifying the airbox by adding the two 1.25" holes, like the old Mach 1X (this made airflow readings impractical). The stock 40mm carbs were used. The rotary valve timing was left stock.

Note when comparing the stock and "tuned up" data, that a portion of the horsepower increase was due to the leaner fuel flow.

We took this opportunity to compare the stock pipe and exhaust cannister to the FAST "Fat Boy" pipe single replacement pipe and the CrankShop twin pipes. This particular Fat Boy pipe is one that has been reconfigured slightly to allow the 670 engine and stock Y pipe and cannister to fit the new "Z" chassis (we borrowed it from Rusty Rovere's Turbo 670 MX-Z also tested in this issue).

The CrankShop twins are tuned for higher RPM horsepower. While the Crankshop twins gave the basically stock tuned 670 a substantial horsepower gain, more radical port and RV timing and larger carbs would probably be an advantage here (we've seen 160+ CBHP high compression high RPM Crankshop 670's). The Fat Boy single's lower RPM midrange horsepower, and high torque, were equally impressive.

Both of these aftermarket pipes probably require just a bit more clutching finesse (due to their narrower than stock horsepower bands).

STOCK 1993 SKI DOO MACH I 670
(From Battle of Old Forge Dyno Shootout)
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .745
Vapor Pressure: .14 Barometer: 29.97

RPM	CBT	CBHP	FUEL	BSFC	CAT
5750	58.3	63.8	44.4	.69	44
6000	58.0	66.3	53.2	.79	42
6250	62.6	74.5	63.2	.84	43
6500	70.1	86.8	68.5	.78	43
6750	72.4	93.1	71.7	.76	43
7000	77.7	103.6	74.6	.71	44
7250	77.8	107.4	78.1	.72	43
7500	78.4	112.0	83.1	.73	43
7750	78.4	115.7	87.7	.75	43
8000	72.8	110.9	90.1	.80	44

"TUNED UP" 1993 MACH I 670
380--390 MJ STOCK PIPE
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .740
Vapor Pressure: .35
Barometer: 29.85

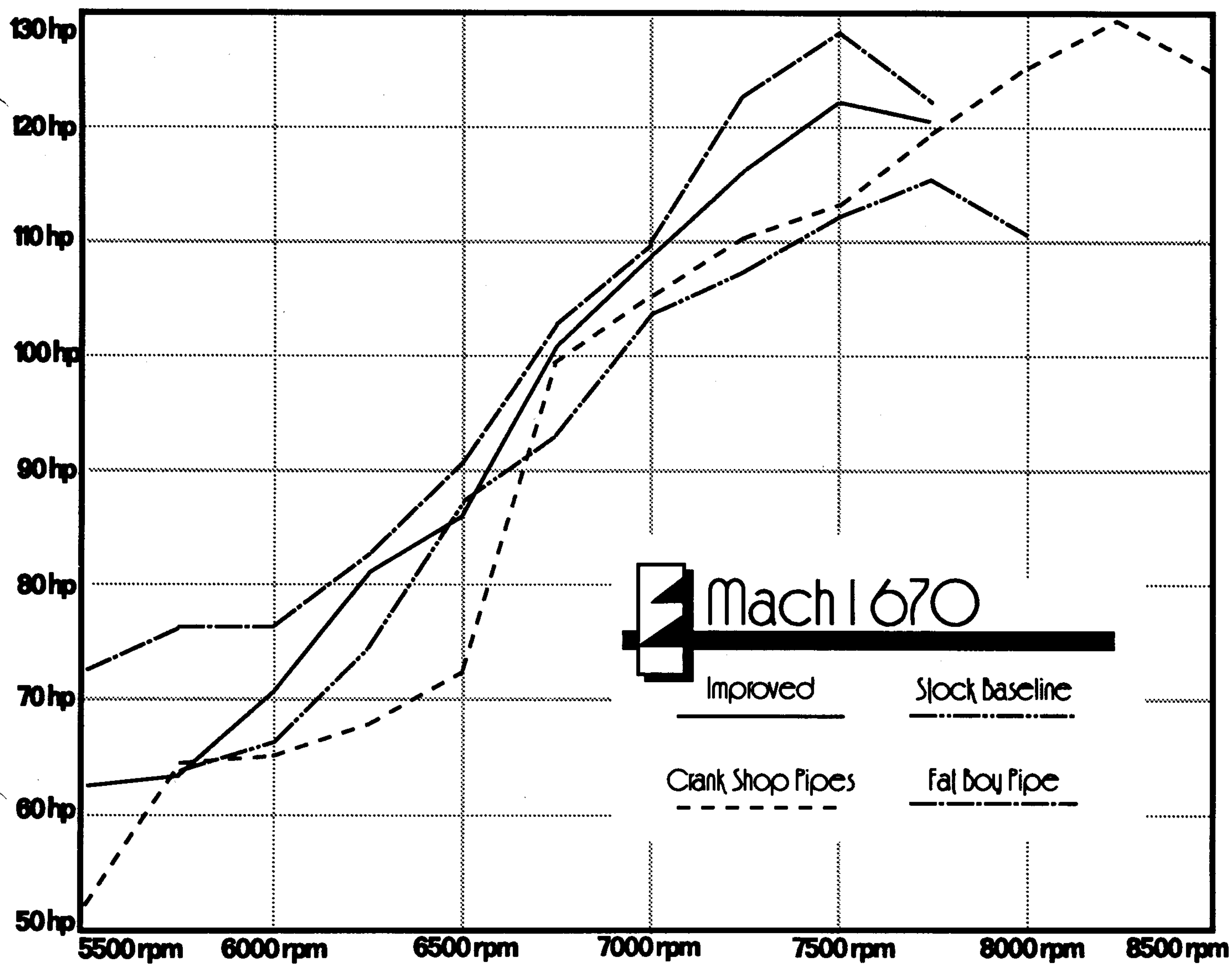
RPM	CBT	CBHP	FUEL	BSFC	CAT
5250	54.9	54.9	37.3	.70	69
5500	59.7	62.5	46.7	.77	68
5750	57.6	63.1	54.9	.89	70
6000	61.8	70.6	60.0	.87	69
6250	68.1	81.0	69.0	.87	69
6500	69.5	86.0	70.6	.84	69
6750	78.5	100.9	75.0	.76	69
7000	81.7	108.9	78.4	.74	69
7250	84.4	116.5	79.0	.70	69
7500	85.9	122.7	81.3	.68	69
7750	81.8	120.7	84.5	.72	70

1993 MACH I 670
380--390 MJ
FAT BOY PIPE
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .740
Vapor Pressure: .35
Barometer: 29.86

RPM	CBT	CBHP	FUEL	BSFC	CAT
5500	69.3	72.6	52.9	.75	71
5750	69.7	76.3	59.1	.80	70
6000	66.8	76.3	65.2	.88	71
6250	69.7	82.9	67.9	.84	70
6500	77.3	90.7	70.0	.79	71
6750	80.1	102.9	73.6	.73	71
7000	82.3	109.7	74.0	.69	71
7250	89.4	123.4	79.6	.66	71
7500	89.8	128.2	82.9	.66	72
7750	83.4	123.1	84.9	.71	71

1993 MACH I 670
380--390 MJ
CRANK SHOP PIPES
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .740
Vapor Pressure: .35
Barometer: 29.82

RPM	CBT	CBHP	FUEL	BSFC	CAT
5500	49.8	52.2	36.3	.72	70
5750	58.6	64.2	53.5	.86	70
6000	56.8	64.9	55.2	.87	70
6250	57.5	68.4	57.0	.86	69
6500	58.6	72.5	60.2	.85	68
6750	77.0	99.0	74.9	.78	70
7000	79.1	105.4	74.1	.72	70
7250	79.8	110.2	75.0	.70	71
7500	79.6	113.7	76.9	.70	71
7750	80.8	119.2	79.8	.69	70
8000	82.6	125.8	84.5	.69	70
8250	82.3	129.3	84.9	.67	70
8500	77.5	125.4	85.9	.70	71



1994 Polaris Indy 800 STORM

by Joe DiSpirito

Recently, I had the pleasure of spending the day on the C & H Dyno, evaluating the 800 Storm. It was given to factory sponsored racer Mike Gross (who was present during the testing) and was one of the first in the 800's in the area.

We were very excited about seeing what Polaris had given us to work with this year. Our gut feeling was that this new musclesled would be up to the task of restoring the Polaris heritage of performance and reliability.

The first impression from our in-shop evaluation was that Polaris had indeed done their homework. The 800 looks like a serious rebound from last years maligned 750, as the following data and opinions will attest.

First impressions of the exterior remain the same--if it's not broke, don't fix it. But a look under the hood reveals the more serious side of the improvements. First the airbox is more "user-friendly" having undergone some extensive changes. It is constructed of 4 pieces; 3 small boxes attached to each carb and hooked together by a common plenum. This will make carb adjustments and jet changes elementary. The normal restrictive internal foam is gone, allowing maximum airflow to be taken through two airhorns directly on top of the plenum. Foam is only used to cover the twin air inlets.

Further probing unveils a twist of fate involving carb vent hoses. This problem has plagued us since 1988 when we first recognized the effects of underhood pressure on carburetor fuel flow. Previous articles in DynoTech have explored this phenomenon, adding merit to the practice of installing vent hoses inside the airbox. Polaris has done a neat job of installing them there on the 800.

The data revealed here is clear evidence of this. Note: As the data reveals in the testing with the hoses unhooked from the airbox, there is an increase in fuel flow which results. The carb is no longer sensing a very negative pressure that exists in the box, and is being exposed to positive atmospheric pressure. Apparently Polaris has set up the jetting to compensate for the pressure differences. The benefit of all this is closer to optimum jetting, without compromise.

Another bonus of this is that when extreme cold temperatures are experienced, you could possibly slide the vent hose off its airbox holder and automatically enrichen your jetting to compensate. WOW!

Carbs remain 38 mm with a radical jet stagger, (350–360–390) likely compensating for differences in either pipes, cooling, or harmonics. Probing further into this we found a mag side cylinder that had .020" more squish clearance and lower compression than the other two cylinders. What first looked like a misplaced stack of headgaskets in this cylinder was traced to another attempt to control some type of tuning or heat compromise. WARNING! Please do not attempt to change this until it is further understood why Polaris has gone to these extreme measures on this cylinder.

A boost bottle has been added to improve the throttle response and is interwoven to relocate the fuel pump and shut-off valve above the engine.

Still further probing shows Polaris has made a serious attempt to improve. The cylinders have been improved--beyond just the increase in bore size. The porting has been changed and features what appears to be a hand ground finish on exhaust and booster port. Note: Tech inspectors will have some problem with this until they realize what Polaris has done.

The other subtle changes in the motor department, such as reed angle and ignition all add up to what we hope will result in a winning season and bar room bragging rights for all.

On a more serious note, the chassis has some overdue improvements. A torque arm was added to the chassis behind the motor. It pushes forward aiding in motor stability and clutch alignment. Bulk head and tunnel reinforcements abound.

Clutching has also been improved. The addition of higher engagement and more aggressive shifting rear helix add up to vastly improved acceleration.

With the additional horsepower and the clutching and chassis improvements, the 800 will, in my opinion, restore the lost faith of Polaris fans.

After helping Mike tune his way to a Pro sanction #1 Points championship in 1992, with the under dog and widely abused 750, we are very excited about the 1993 season!

STOCK 1994 POLARIS INDY STORM 800
340--340--350 MJ
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .40 Barometer: 30.21

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6500	78.4	97.0	66.4	172.6	11.9	.69	66
6750	82.1	105.5	70.7	178.3	11.6	.68	66
7000	87.3	116.4	73.1	186.7	11.7	.64	67
7250	91.0	125.6	77.0	194.7	11.6	.62	66
7500	96.4	137.7	80.7	204.8	11.7	.59	66
7750	97.8	144.3	85.5	212.9	11.4	.60	64
8000	92.6	141.1	86.1	215.3	11.5	.62	64
8250	82.8	130.1	86.8	213.0	11.3	.67	66
8500	53.7	86.9	86.1	201.7	10.8	1.00	65

STOCK 1994 POLARIS INDYSTORM 800
340--340--350 MJ
VENT HOSES DETACHED FROM AIRBOX
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .40 Barometer: 30.21

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6500	84.0	104.0	68.9	172.9	11.5	.67	63
6750	88.1	113.2	80.2	184.8	10.6	.71	63
7000	93.0	124.0	84.1	195.4	10.7	.68	64
7250	96.9	133.8	89.8	205.2	10.5	.68	63
7500	97.5	139.2	89.6	213.3	10.5	.67	63
7750	92.6	136.6	88.9	215.4	10.1	.72	64
8000	81.2	123.7	87.2	214.8	9.7	.83	65
8250	56.7	89.1	82.3	206.8	9.4	1.15	64

Joe DiSpirito is the owner of Cycle Dyne in Clinton, N.Y. (315-853-4444) which specializes in high performance modification of snowmobiles and motorcycles. Joe's last contribution to DynoTech was the Modified Indy 500 Pipe Shootout in Vol. 2 no. 3.

FEEDBACK BACKFEED

Jim Czekala

MORE PUMP GAS WOES

A recent series on Dateline NBC featured an expose on cheating by gasoline wholesalers and retailers. The focus of the series was the various ways that the public is screwed at the pump.

They showed how station owners could easily alter the electronic gasoline flowmeters to read high. A remote switching device was used by one retailer to give a correct gallon reading when they were being checked by employees of the Bureau of Weights and Measures. Then, as soon as they were certified to be correct, the gas pump flowmeters were reprogrammed to read high again.

Worse yet was the true octane of random samples of high test gasoline purchased from 60 different sources that were sent to a testing lab in North Carolina for octane analysis. As I recall, about ten percent of the samples tested for octane were sub-standard. The worst measured 75 octane!

How could any high octane gas test even lower than the standard unleaded gasoline that the stations sell? Dateline NBC described how some cheaters were cutting the gasoline with something called "transmix", a very inexpensive low octane grade of fuel.

How far will a high performance snowmobile engine run at WOT, on 75 octane gasoline, before detonation occurs? Possibly jetting to a blubbery B.S.F.C. of .80 or .90 lb/hphr would cool the combustion temperature enough to allow survival on this fuel.

This extreme sort of octane cheating could be the cause of many performance snowmobilers' mysterious piston seizures. Adulterated "high-test" gasoline must cost snowmobile manufacturers millions of dollars in warranty claims which ultimately are paid by us, the consumer. And, for us high performance afficionados, it's a roll of the dice whenever you fill-er-up at at the local station.

→

One performance pipe manufacturer described to me a group of four snowmobilers with identical sleds who had purchased performance pipes for their machines. All four experienced continual detonation problems that were, of course, first blamed on the pipes. Their local source of "high test" gasoline turned out to be the culprit. Changing fuel suppliers cured their problems.

What can you do to protect your performance snowmobile engines from unscrupulous gasoline dealers and distributors?

There is no simple chemical test for octane. Octane can only be determined by the use of motor octane testing engines which are difficult to get access to. If you happen to ride with a pal with a well-tuned high compression air-cooled engine, he can let you know when octane is off the mark. Low-octane induced detonation that is usually inaudible in water-jacketed two-stroke engines is easily recognized, sounding like marbles rattling inside a tin can, when it occurs in a fan-cooled engine.

Octane boosters can be a helpful Band-Aid, raising the octane perhaps a few points. But, increasing 75 octane gas up to 77 or 78 is hardly a cause for celebration.

Since we've become aware of this growing problem, more and more performance snowmobilers are purchasing 100+ octane gasoline at the local race track or airport.

100+ octane race gas is expensive--between three and five dollars per gallon. But, one must be careful of the source--freshness is critical with some grades of race gas. And, there is always the enticement of huge additional profits that sellers of bulk "racing gas" can make by diluting it with cheaper pump gas. And, what if the pump gas that is used to "cut" the race gas has already been adulterated with transmix? It pays to be cautious. We purchase racing gas from a reputable dealer, who sells factory sealed drums.

Blue 100LL Av Gas is cheap, usually a couple of bucks per gallon. It's over 100 octane, guaranteed, every time. Airport fuel suppliers and vendors are aware that tainted Av Gas can cause alplanes to fall out of the sky; the wrath of the F.A.A. is far worse than that of an occasional snowmobiler coming home on the end of a tow rope.

THE WEST YELLOWSTONE EXPO

What a difference! I was fortunate to attend the West Yellowstone Expo last March, and now I understand what you mountain maniacs really are up to. My turbo partner Greg Bennett and I loaded up 11 turbocharged and three naturally aspirated machines into Larry Mehlanbacher's Peterbuilt and made the trip out to Montana to see what high altitude was all about. The three of us were accompanied by Bob Bennett, Rex Ray, Glenn Sabatine and Rusty Rovere.

We "flatlanders" have it made! Sea level barometric pressure makes for lots of horsepower. Down here, 160 CBHP Thundercats make 170+ real HP because of the "good" air that we typically enjoy. And, the abundance of frozen lakes that we ride on make ice-grabbing traction devices imperative.

When we got out to West Yellowstone at 6000+ ft. altitude, there was no ice. We found that the musclesleds there were typically long-tracks, with high profile lugs and no picks. At those high altitudes, the 160 CBHP Thundercats make 120 real HP. All of the other naturally aspirated machines are equally affected by the thin air.

Our short tracks and now-useless ice picks provided minimal out-of-the-hole acceleration on the semi-packed snow of the fabled West Yellowstone air strip, which is groomed each day. But, the turbochargers "don't know altitude", and the mid-range and top-end acceleration of the short tracked turbos could not be matched by anything without a nitrous bottle.

Even our cigar-smoking truck driver Larry (a businessman who drives trucks for fun) laid claim to our "pogo stick" stock Exciter II turbo, and had fun antagonizing the wheezing naturally aspirated big sleds.

Arctic Cat factory tech wizard Al Shimpa and racer Kirk Hibbert were busy dialing in their new 580ZR turbo for the Jackson Hole hillclimb (which they won), making some minor but revolutionary fuel system modifications that would eventually be incorporated into all of the new production turbo systems for this season. Kirk and Al both enjoyed shreiking past the hapless musclesleds that would willingly roll-on with him during their field testing. They, like us, are now turbo addicts.

There is also an organized quarter-mile radar run for the three days of the Expo, and even the lightweight hand-built triples and bottle-fillers couldn't match the two official 113 MPH runs that were recorded, on loose granular snow, by Rusty Rovere's V-Max 4 turbo and our Mach 1 670 turbo trail sleds. These were the highest speeds recorded during the 1993 Expo Radar Run.

After the radar and air-strip competition, we had a chance to do some real high-altitude bowl and mountain riding. I hopped on our turbo Wildcat 700, and a large group of us on turbo sleds rode to the summit of Two-Top mountain at 11,000 feet. As a closet acrophobia sufferer, this would prove to be a terrifying experience.

The ride up to the top of the mountain was kind of nice; winding, well-groomed trails punctuated by an occasional 1,000 foot deep "bowl", which I'd heard of, but never experienced. Driving down into the bowls, you could look around and see various "high marks" on the near-vertical walls left by other mountain sleds. Those guys must be nuts! What if you squeek a piston down inside one of these bowls? How much does it cost to rent a Sikorsky helicopter to skylift your sled back to civilization? I thought about that as I powered my way, at seven pounds of boost, from the bottom of the first bowl that we encountered, 1/4 mile back up to the relative safety of the groomed trail at the top of the ridge. My heart pounded all the way.

There is a large valley just before the final, near vertical ascent to the top of Two-Top. The narrow, winding path to the top has to be seen to be believed. We stopped there to look things over before the final ascent. In the forty degree F heat of the day, I broke into a cold sweat as the other guys I was with took off, up the final 2,000 nearly vertical feet to the summit. I could hear the shreiking of the other turbos, at full boost, as they blasted up the narrow, winding final path to the top.

I considered for a moment not joining them. But, I dreaded the harassment that I would take for "chickening out" even more than the thought of having to look down from up there!

So, I slowly picked my way to the top, keeping the boost down around five pounds- just enough to keep the track speed high enough to maintain momentum. After a few anxious moments, (during which I thought I might not have enough speed to clear a few moguls half way up), I arrived at the peak with wet armpits--to the cheers (or was it jeers?) of my pals, who were enjoying the panorama.

I hate panorama. Seeing an eagle soaring 1,000 feet below us made me cringe. Worse yet, I could see the tracks left by three insane snowmobilers who had some time previously launched themselves off of a large overhanging snowdrift on the leeward side of the peak. Crawling up to the edge on my hands and knees, I was shocked to see that these sleds had been airborne for perhaps a hundred feet down the sheer wall of the mountain. The tracks reappeared, then disappeared, then reappeared again in the snow, like the tracks left by snowshoe rabbits bounding at full speed, crisscrossing downhill. They disappeared into a crevice that hopefully led to somewhere.

The combination of fear and thin air was making me short of breath. I had to get off of this mountain peak immediately, so I volunteered to go first, down the winding path to the perceived safety of the open valley below. But, when I looked down that vertical, winding mule-path that we had used to make the trip up the mountain, I decided that it would be more polite to let the others go before me.

Last once again, I found that the trip down the hill was even worse than the ascent; with a death grip on the poorly adjusted brake (did those bastards loosen the brake adjuster while I was peering over the edge on my hands and knees?) and dragging my heels in the snow, the unruly Wildcat picked up too much speed as it fishtailed wildly, nearly barrelrolling twice, all the way to the bottom. I still have nightmares of the sound of the 700 twin idling while the track, chaincase and rear clutch whirred away at over 80 MPH!

I really did enjoy the beautiful trail and road riding that we did in West Yellowstone. The mountain scenery was great, when viewed from below. We are planning another trip to the Expo again this spring. Next time I'll stick to the airstrip and the trails.

This mountain riding is something else. Extended periods of time at WOT, sometimes minutes in duration, combined with low vehicle speeds are a common occurance. One Exciter SX owner I met often records 200+ degree F Carb Air Temperature when mountain riding in deep powder. The fact that the engines make so little horsepower at high altitude allows them to survive such abuse.

How about the effect of altitude on the tuned pipes' performance? Duran at Snow-King Performance in Jackson Hole has a SuperFlow dyno set up at 6000 FT altitude. It would be interesting to have him test a group of pipes on an engine there after we tested them here at sea level. We will try to make arrangements to have that done.

THE TURBOCHARGER

How about the turbochargers at high altitude? They, too are affected by the loss of barometric pressure, but to a much lesser extent than normally aspirated engines.

We lose about one pound of barometric pressure for every 2,000 feet of altitude we gain. At sea level, we have 15 PSI of barometric pressure to work with. That's pressure that we don't feel or see on a standard gauge, but exists all around us.

At 10,000 feet, we have only approximately 10 PSI of barometric pressure to work with, a loss of 33%. This represents a huge loss of performance that is magnified greatly when you consider that the parasitic friction of the engines and chassis' are the same at 10,000 feet as they are at sea level.

If a 100 horsepower Indy 650 requires, say, 50 horsepower to maintain a 50 MPH cruising speed in snow, then there's about 50 HP left over for acceleration when you hit the throttle at sea level. Not bad.

At 10,000 feet altitude, our Indy 650 only has about 65 horsepower at the engine. But it still takes approximately the same 50 HP to drive the sled 50 MPH. Now, we only have 15 HP left over to accelerate the machine! Hardly a neck snapper.

A turbocharger set at 8 pounds of boost will give the Indy 650 8 PSI boost + 15 PSI barometric pressure at sea level for a total of 23 PSI *ABSOLUTE*. This gives the engine around 160 HP at sea level. Taking the turbo Indy 650 to 10,000 feet, the Aerodyne turbo will continue to make 8 PSI of boost pressure, due to the design of the pressure controller (the turbo will have to work just a bit harder, spinning perhaps 140,000 RPM instead of the 115,000 RPM required to make the 8 PSI at sea level). With 8 PSI of boost stacked onto the 10 PSI of atmospheric pressure, the engine breathes 18 PSI of absolute pressure, only a 20% loss from our sea level absolute air pressure and horsepower level. We now have around 130 HP at the crankshaft. If our turbo 650 is using up 50 HP to cruise at 50 MPH, now we have 80 HP left over to accelerate the machine. This represents ***5 times more horsepower left for acceleration***. than the naturally aspirated version.

That's why the high altitude guys love the turbos. High in the mountains, even all of the big 750-900cc musclesleds are reduced to a meek 100 horsepower or less! Any lightweight 580 class turbo sled will make much more than that, even at very low boost levels. Jim Noble of Starting Line Products, bought a First Choice turbo for his 1994 XLT. He had so much fun testing it at high altitude, he ordered 80 of them for his company to sell this year.

FIXING SOME MYSTERIOUS CARBURETOR MALADIES

We have encountered some difficult to explain seizures on Mikuni TMX carbureted engines. We have had two TMX carbed turbo Polaris 650's detonate repeatedly for no apparent reason. Both were dyno tuned to a safe .70+ lb/hphr at all throttle positions, with low boost and good gas. Both would run beautifully for a few miles, then suddenly squeek any one of the three pistons. It was driving us crazy.

Harvey and Billy Calden, of Calden Engineering in Jay, Maine (SuperFlow dyno service at 207-897-2100), were having the same problem, and apparently they have figured out the solution. Their TMX carbureted SkiDoo SnoPro 250 engine was driving them into the poorhouse. The mag side cylinder had seized a total of 20 times, usually after only one lap. These seizures lead to the destruction of 20 pistons @ $80 each and 10 cylinders @ $700 a pop, before they found and cured the problem.

They had changed everything--electronics, fuel system, pipes, gasoline, oil, etc., to no avail. At my suggestion, they removed their solid engine tensioner and replaced it with a rubber mounted torque arm. This reduced the frequency of the seizures, but they still were unable to complete a race without being towed off the track.

This lead the Caldens to realize that vibration induced foaming of the float bowls was the culprit. Here is Harvey's report:

TMX CARBURETOR FLOAT BOWL DESIGN

"You will notice that when you hold a TMX float bowl in your hand with the bowl-attaching nut in place on the bowl, there are four small slits for the fuel to run down, make a 90 degree turn through four small holes in the retaining nut, where the fuel sits in this tiny reservoir for entry into the main jet. With some fuel foaming in the float bowl, and with the already small float bowl capacity, there is very little pressure to force the fuel into the slits. This, coupled with the tiny reservoir causes it to run dry--even though there is some fuel in the float bowl. And, the bigger the jet the quicker you will experience fuel starvation."

THEIR SUGGESTIONS:

1. Taper grind additional clearance in the four slits in the bottom of the float bowl to allow fuel easier access to the holes in the retaining nut.

2. Drill four extra, larger holes in the retaining nut, higher up into the float bowl, to allow fuel to flow easier into the small nut reservoir.

3. If you have the equipment, you might weld additional material to the back side of the bowl, and grind it out to enlarge the capacity of the float bowl.

THEIR RESULTS:

"After we modified our TMX carbs, we were able to run lap after lap with even larger jets and could not *make* it burn down!"

OUR RESULTS

We removed the TMX carbs from our own Turbo RXL 650, and installed a set of VM38's, which have wide-open float bowls. The RXL was trail-ridden very hard for 150 miles with the new setup and it was flawless. It is quite probable that those TMX float bowls were causing us all that grief on those 650 Polaris Turbo sleds. Thanks, Harvey and Billy, for the Feedback.

TURBO INDY 650 SETS LAND SPEED RECORD

Jack Harris, who has a First Choice Turbo sales and installation facility in Kaysville, Utah (801-544-3653) made history by running over 200 MPH at the Bonneville salt flats in September.

Using a stock 02 650 Polaris engine with one of our First Choice Turbo systems to power his four-wheeled streamliner, Jack bumped the record to 200.8 MPH.

To accomplish this feat, the AeroDyne Series 53 aerocharger was set at 12 PSI boost pressure (see Turbo Indy 650 in this issue), and ran at WOT for FIVE MILES on 112 octane Cam 2 gasoline! Jack's success was documented on NHRA Today (The Nashville Network) on October 1, 1993.

SORRY CAT AND DYNOMITE FANS

We were trying to include the new ZR series 580 and 700 engines for this issue--but we, (like you) are still waiting for our new sleds. Next Issue?

Also, we wanted to do a side by side comparison of the Land & Sea DynoMite with our SF-901 dyno. The plan began with us dyno tuning D&D Cycle's 150+ CBHP "Improved Stock" 700 EFI Wildcat, using our extremely constant engine cooling water system that is so necessary for repeatability. Then, we disconnected our dyno drive shaft and installed the DynoMite to record the same engine data, on the same day, to see what the DynoMite came up with.

Unfortunately, the water control on D&D's DynoMite malfunctioned because of stripped threads in the valve body. We'll save that test for a later date.

I predict that the DynoMite will give us correct and reasonably repeatable readings, based upon the horsepower numbers that we're hearing from DynoMite users (Bender, D&D, HTG, etc) who rely on their DynoMites on an almost daily basis. Stay tuned.

HOT PIPES: COLD FACTS

Kevin Cameron The Cellar Dweller

Field experience and dyno work alike confirm that exhaust pipe temperature influences performance. On some machines, differences in pipe mounting expose one pipe to cold air blast while shielding others, and it's often necessary to shorten the cold pipe to make it peak with the hot one(s). On the dyno, a hot engine run with cold pipes gives a very different dyno curve than a hot engine run with hot pipes. An even more bothersome pipe temperature problem arises with fuel injection; the injection "map"--the stored information that controls fuel delivery--is made on a dyno, with the pipes hot. Out in the real world, with the pipes cooler than this for any of several reasons (it's cold in Thief River Falls, or the sled hasn't warmed up yet, or you are running at light throttle, etc.), it is common for the injection computer to supply the wrong fuel mixture because it "thinks" the engine is turning faster than the pipe is letting it. Errors of 500 RPM are common in this situation, and this explains the mid-throttle burn-downs some injection sleds have experienced.

The differences this makes are substantial--certainly deserving of our attention in the detailed process of obtaining maximum power. It is not uncommon to find that the hottest pipe in a set has to be more than an inch longer than its cooler mates to peak at the same revs. A pipe length difference of as little as .5 mm can produce big horsepower differences, so you can see there is potential here. In the case of dyno development, a 1992 Yamaha TZ250 was run on the C & H Dyno with cold pipes (cooled after the previous run by the fan) but a still hot engine, power in the overrev region (above the natural power peak) was very poor--just under 50 hp at 13,000 RPM, a full 1,000 revs above peak. When a second run was made immediately, power at 13,000 rose to 70 bhp! The hot pipe acted shorter, so it was closer to what was needed up at those high revs.

All of this is based on the fact that the speed of sound in a gas depends not on its pressure, but on its temperature. To see why this should be so consider that sound must propagate at a speed that has something to do with how fast the average gas molecule is traveling; something happening in one part of the gas cannot propagate to another part faster than the average velocity of the molecules themselves. A sound wave is simply a self-propagating, local rise in pressure that travels via these molecular collisions--and roughly at the speed of the molecules themselves (except for violent "sounds", such as explosions, which travel faster than sound speed). Since temperature is just a measure of the average energy possessed by the gas molecules, temperature and sound speed are related.

When the engine starts and hot exhaust first enters the pipe, there is naturally heat transfer from the gas to the pipe wall, and the pipe begins to warm up. In the process of giving up heat to the pipe, the exhaust gases are cooled, and the speed of sound in that gas will drop somewhat. After a period of running at high throttle, each part of the pipe will have reached temperature equilibrium; heat outflow will equal heat inflow. There will no longer be any change in local pipe temperature until conditions change--if the operator changes the throttle position, or airflow conditions around the pipe change, thereby changing the rate at which heat flows from the pipe surfaces to the surroundings.

Since the hot gases are the heat source, they are going to be hotter than the pipe metal itself. Knowing the pipe's surface temperature doesn't tell us much about the temperature of the gas inside--except to make the general statement that the cooler the pipe is locally, the more the gas within will be cooled, and the slower the speed of sound in it will become as a result.

At any instant during the pipe warmup process, each bit of pipe length has its own local average gas temperature that results from the balance of the heat coming in (from the exhaust gas) and heat going out (heat loss through the inner pipe walls, through the pipe metal, and then to the air outside). Therefore at each station along the pipe's length there will be a sound velocity that corresponds to the average local gas temperature; in the hotter parts of the pipe, the speed of sound will be higher, while in the cooler parts it will be lower. The hotter parts of the pipe will act "shorter", the cooler parts will act "longer". Now comes the problem; as the pipe warms up, it is as though the lengths of all its parts were continuously changing.

"Well", you say, "Let's just wait until the pipes are fully warmed up . Isn't that what we do before racing or dyno testing anyway? What's the big problem?"

The problem is this; sled engines don't run at continuous high throttle in the real world. You are on the throttle hard in the straights, then off it going into the turns, where the pipes have time to cool. It doesn't take long for the pipes to cool quite a bit when sub-zero fresh air hits them. Then you are back on the throttle and the pipes start to temperature up again. As your pipes cycle through this temperature range, they cannot be the right length at all times.

Consider drag racing. To race with a cool intake charge, you come to the line with a cold crankcase--and pipes. You hit the throttle and your pipes begin their climb to temperature equilibrium--but the race is over before they ever reach it. Where on the short piece of track are your pipes really right? Off the line? At the 50 foot mark? One hundred feet?

This type of varying pipe temperature can explain why some pipes that perform outstandingly on the dyno are a flop in particular kinds of racing. These pipes are "right" only when run at the particular temperature distribution created on a particular dyno, operated in a certain way.

Now let's ask yet another bothersome question. What is the best way to test on the dyno? Many older specialists swear by the arduous step-and-hold method. They like it because, although it eats engines it gives good reproducable results--because the pipes are always hot and always close to temperature equilibrium in this kind of testing. For many researchers, reproducable results are the Holy Grail, the proof that the measurement process is working as it should.

But is this good for the circle track or drag racing, where pipe temperatures and exhaust heat input are constantly changing? Obviously not.

Step-and-hold is a good dyno technique only if you are developing an engine for constant duty service, such as long lakeruns, air-racing, or boat racing. It is a somewhat meaningless abstraction if your kind of racing requires that you be on and off the throttle, or that you start with a cold engine. Other operators allow the engine to accelerate at some controlled rate on the dyno--but often neglect the pipe's initial temperature. But what initial temperature is right? You can't know until you measure what it is under racing conditions.

Still others prefer to simulate real world acceleration rates by replacing the familiar dyno power absorption units with a big flywheel. In motorcycle GP racing, one very successful engineer is attempting to couple a variable output blower to his inertial dyno--to simulate the pipe cooling effects to be found out on the racetrack as the machine accelerates through a range of airspeeds. That's fine--if it works and it isn't more trouble than it is worth.

And are you sure that airflow over the pipes is the same velocity and temperature on the dyno as as it is on the track or trail? Of course you're not.

These are some of the reasons why there remain some stubborn individuals who continue to do all of their testing under real-world conditions--without the dyno. Some of them are successful, even though this method can be very expensive in parts and time. It has other problems, too. Like where can you find a frozen lake, 10 miles long, in August?

Another approach was tried three or four seasons ago--to wrap the pipes with insulating tape. This, it was reasoned, would (a) allow the pipes to warm up more quickly and (b) keep them hotter during off-throttle and (c) tend to make all pipes run at the same temperatures. Unfortunately, some tuners experienced increased detonation with wrapped headers; it is believed that the fresh charge that pushes out into the pipe at the end of the transfer period becomes overheated in the hotter pipe, and when the pipe's return wave stuffs this hotter fresh charge back into the cylinder, it detonates just as engines will when their charge is overheated for any other reason. Now if pipes are wrapped at all, the headers are left bare.

Jim Czekala decided to make some measurements of internal gas temperatures and external pipe metal temperatures as the engine ran. He found just what you would expect; initially, the header and other forward, larger-diameter parts of the pipes get warm faster than do the rearward, larger diameter parts. This makes sense; there is more radiating surface in the fat center- body of the pipe than there is in the much smaller header. And we know that the fatter we make a pipe's center-body, the shorter it must be made to bring it in at a given RPM level; the fatter pipe loses more heat and so tends to act "longer".

Jim also found that as the engine continues to run for fifteen or more seconds at steady full throttle, the temperatures along the pipe tend to become equal all along the length, whereas at the beginning of the run, the header section is hundreds of degrees hotter than is the center body. This in turn means that the effective lengths of the various parts of the pipes change by a large fraction of inches--even in a very short span of on-throttle time.

What does this tell us? It tells us that the dyno test method used for pipe development must be tailored to the intended form of racing. Step-and-hold with hot pipes is ideal for continuous, full throttle racing in which the engine does not begin the contest cold. This really only includes propeller sports--air-racing and boat racing. To give detailed info, the dyno test must begin at the engine and pipe temperatures that the racer will actually bring to the line in his event. The engine must then run as it will in the real event.That means having more knowledge than we at present have as to what pipe temperature distributions exist in the various types of racing.

Aw, shucks, why does everything have to be so hard? Can't we just build a winner right out of the catalogs in the good old-fashioned way? Why does racing have to be so much like science? *Let's do it!*

CLUTCHING FOR THE TORQUE PEAK?

Hardly. Forget torque.

Kevin and I have spent a lot of time discussing something interesting.

Of course, using a dyno to determine the RPM where an engine's horsepower peak occurs is very useful for dragracers, trail riders, oval racers, radar runners, etc. And, as we've known for some time now, pipe temperature plays a key role in determining optimum clutching.

I used to think, and probably many tuners *still* think, that a snowmobile engine accelerates best when the clutches are TUNED TO THE ENGINES TORQUE PEAK. That's because we've always found that, in the field, snowmobile engines accelerate from a standstill best when the clutches shift at an engine speed lower than the horsepower peak in our data. The typical performance snowmobile engine has a torque peak around 250 RPM below the horsepower peak, and clutching for that RPM provides optimum performance. Credit Olav Aaen for coining the term "backup torque" to describe this typical situation.

But our horsepower graphs are generated during 10 second dyno tests, and represent only a "snapshot" of a CONSTANTLY SHIFTING HORSPOWER CURVE that moves to the left or right as the pipe(s) cool off or heat up.

Before we understood the effect of pipe temperature on the peak horsepower RPM, we thought that we must be experiencing maximum acceleration because the engines were operating at their TORQUE PEAK.

→

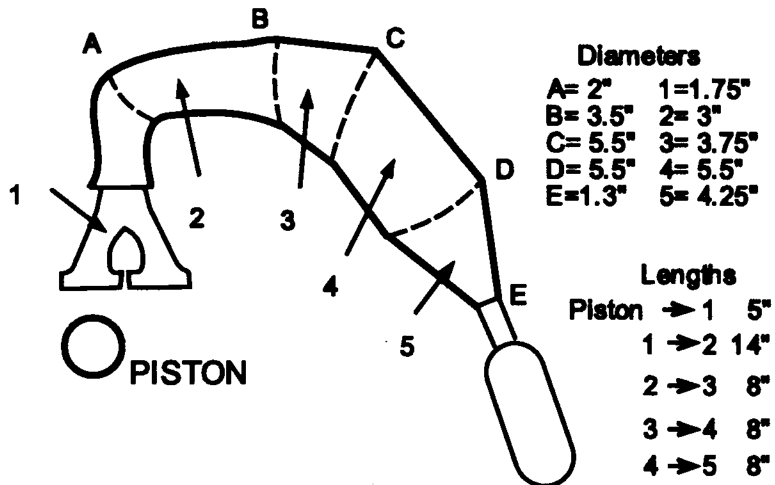
Naively thinking that our horsepower data was the Gospel according to C&H, we figured that torque must have been doing the work, when in fact, TORQUE REALLY DOES NOTHING! After years of imagining that we were clutching to the "torque peak", we find that we are really clutching to a shifting horsepower peak.

The advent of multi-angle driven clutch helixes allows our engines to shift at a gradually increasing rate–in reality chasing the horsepower peak as the tuned pipes gradually increase in temperature. Thanks to Kevin Cameron and the dyno, more of us have a better chance of understanding and achieving optimum snowmobile performance.

To document this phenomenon, I programmed the dyno computer to do rapid, repetitive acceleration tests on a snowmobile engine, brand and size unimportant here. The 5 points where we measured the pipe's internal temperature are shown in the accompanying drawing.

In the year 2004, I expect our variable ratio snowmobile transmissions to be computer controlled, with the tuned pipe center section temperature determining the optimum full throttle engine operating speed.

Now, there's a good job for some of you engineers to get working on! You've got ten years. As Kevin says, "Let's do it!"



Here's the data from the repetitive acceleration test described above. Note how the peak horsepower creeps up the powerband with each repetition. Note also that as the crankcase and pipe build heat airflow and horsepower decrease.

	RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
PASS 1	7300	55.5	77.1	49.5	131.8	12.2	.64	68
	7400	57.9	81.6	51.3	133.8	12.0	.63	68
	7500	57.7	82.4	51.3	135.2	12.1	.62	68
	7600	57.6	83.4	53.0	136.0	11.8	.64	68
	7700	56.4	82.7	53.2	136.5	11.8	.64	68
	7800	54.4	80.8	53.6	135.6	11.6	.66	69
	7900	51.7	77.8	52.3	135.1	11.9	.67	69
PASS 2	7300	53.7	74.6	51.4	131.3	11.7	.69	68
	7400	54.6	76.9	51.9	132.1	11.7	.67	67
	7500	56.7	81.0	52.4	133.3	11.7	.65	67
	7600	56.8	82.2	53.4	133.8	11.5	.65	67
	7700	56.7	83.1	53.2	135.2	11.7	.64	65
	7800	55.4	82.3	53.7	134.7	11.5	.65	67
	7900	53.3	80.2	54.0	135.0	11.5	.67	66
PASS 3	7300	51.4	71.4	50.6	129.5	11.8	.71	68
	7400	51.9	73.1	51.4	129.3	11.6	.70	68
	7500	55.3	79.0	51.7	131.2	11.7	.65	68
	7600	55.2	79.9	52.3	132.2	11.6	.65	68
	7700	55.3	81.1	52.0	133.5	11.8	.64	68
	7800	55.3	82.1	51.8	133.9	11.9	.63	68
	7900	53.5	80.5	53.5	133.9	11.5	.66	68
PASS 4	7300	48.1	66.9	50.7	127.1	11.5	.76	67
	7400	50.0	70.4	51.0	127.3	11.5	.72	67
	7500	53.5	76.4	51.4	129.4	11.6	.67	67
	7600	53.2	77.0	53.3	130.1	11.4	.68	67
	7700	53.3	79.1	53.3	130.5	11.5	.67	67
	7800	53.7	79.8	50.9	131.4	11.9	.64	67
	7900	53.5	80.6	53.5	133.1	11.4	.66	67

Below is a chart of temperatures at the points shown in the above drawing during a steady state test. The engine was held WOT at 7300 RPM and the temperatures recorded every 5 seconds.

SECONDS	THERMOCOUPLE TEMPERATURE 1	2	3	4	5
5	1143	1053	976	844	820
10	1169	1121	1055	927	904
15	1186	1158	1098	983	957
20	1192	1180	1126	1015	994
25	1194	1196	1147	1048	1024

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