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DYNOTECH

THE SNOWMOBILE PERFORMANCE PUBLICATION

BATTLE V OF OLD FORGE

THE TECHNICAL DETAILS

The prospect of dyno testing eight stock snowmobiles in two days makes me cringe. I almost never dyno test more than two of anything in one day. Hooking up snowmobiles, giving them a couple of "pulls", and unhooking them is the most tedious and unproductive form of dyno work. The fact that these eight sleds would be brought to me by my pals George Taylor (owner of Shootout Headquarters Van Aukens Inne), Tom & Doug Smith and their pal John (of Smith Marine Ski Doo), Jon Martin and his assistant Spot (of Big Moose Arctic Cat/ Yamaha) and Don and Jamie Losen (Don's Polaris), plus the knowledge that the high horsepower dealer each day would pay for dinner at Alex's Restaurant afterwards, made it more than tolerable once again. As these guys have helped out in the dyno room for five years in a row now, they're also qualified and able assistants.

The Dyno Certification is sometimes the first chance we get to see what kind of engine performance the manufacturers have to offer for the consumer each year. This year, the SkiDoo Formula III was all-new. Dyno testing this one would be the highlight of our gruelling two-day dyno session. This was the first FIII sled to be released by Bombardier; it had been rushed to Smith Marine SkiDoo just in time for the Shootout.

As was the situation last year with the then-new XCR600, there was not a stack of crated units from which we could select one. With no way of determining what is "typical" of this engine's output we would, however, have to accept what we had no matter how much horsepower it made. As with the '94 XCR, we were satisfied that the FIII we received for certification produced the numbers we should expect.

On this new SkiDoo Formula III engine, we really expected one hundred twenty-something. How could it be less? Take any "old-fashioned" 600cc piston port triple, install good individual tuned pipes on it, and you easily get 115-120 CBHP. Considering all of the FIII's modern technology and Rotax' ability to build powerful engines, if this was not substantially more than that, we would have been surprised.

Sporting a hefty 30% power advantage over everything else in its class, the new 600 Rotax heralds a new era of middleweight sled performance. From now on, 600 class sleds will likely require 120+ CBHP to be competitive.

We almost had a ZRT 600 for our shootout. Big Moose Yamaha/Arctic Cat had received their first ZRT 600 prior to our event, but Cat brass reportedly would not allow the new machine to be entered in the Event. It seems that some minor early production glitches in ZRT 600 header pipe to flange fit caused performance to suffer, and the bosses from Thief River Falls decided it would be better to wait until the production problems were corrected before they lined up publicly with the new SkiDoo Formula III.

The 1995 V-Max 600, XCR 600, and 580 ZR fuellie were the same as past versions. No suprises here. The electronic fuel injected Cat was not measured for fuel flow, due to the complexity of setting up our fuel system on this model. The electric fuel pump is in the bottom of the fuel tank; fishing it out and then measuring the fuel going through it (minus the return line flow) is tedious and too time consuming considering the circumstances. Had this engine, however, made too much horsepower, we would have gone back and measured the fuel flow. Of course, the 580 ZR's horsepower was typical, so no further analysis was necessary.

As usual, our dyno "teching" of each sled consisted of a short part throttle warm-up to preheat the engine and clear as much air as possible from our dyno fuel feed system, followed by two or more full throttle 10 second acceleration dyno tests. Jetting was left box stock in every case. We used locally purchased 93 octane unleaded gasoline.

After each engine is dyno tested, we document it's cranking compression and squish clearance. After the field shootout, these are measured one more time to ensure that nothing has been altered.

The fuel flow shown in our eight certification runs was slightly lower than actual, due to a flow measurement glitch that was proportionately the same for each sled. The actual flow was correct, but the measurement was off.

Comparing the V-Max 600 certification dyno run with the same test in our accompanying GYT Kit article (where the fuel flow data was correct), you can see the percentage difference.

1995 SKI DOO FORMULA III WT. 588 LBS.

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .745
Vapor Pressure: .25 Barometer: 29.73

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	76.7	102.2	48.4	174.8	17.4	.48	47
7250	77.8	107.4	56.8	180.0	15.2	.53	47
7500	78.6	112.2	63.2	181.7	13.8	.57	47
7750	79.1	116.7	69.0	183.2	12.8	.60	47
8000	79.9	121.7	72.9	184.8	12.2	.61	47
8250	81.1	127.4	71.8	192.5	12.9	.57	47
8500	72.2	116.9	73.3	200.3	13.1	.64	47

1995 V-MAX 600 WT. 558 LBS.

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .745
Vapor Pressure: .30 Barometer: 29.99

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6250	60.1	71.5	38.2	130.3	15.7	.53	49
6500	62.1	76.9	42.4	133.0	14.4	.55	49
6750	64.3	82.6	48.8	139.2	13.1	.59	48
7000	66.1	88.1	52.6	143.7	12.5	.60	49
7250	65.9	91.0	55.3	146.9	12.2	.61	50
7500	65.8	94.0	58.4	150.9	11.9	.62	48
7750	63.6	93.8	60.0	152.7	11.7	.64	49
8000	55.5	84.5	60.8	151.2	11.4	.72	49

1995 XCR 600 WT. 530 LBS.

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .745
Vapor Pressure: .25 Barometer: 29.75

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	54.7	72.9	48.4	145.0	13.8	.67	55
7250	56.5	78.0	61.4	147.2	11.0	.80	55
7500	58.1	83.0	65.8	150.3	10.5	.80	55
7750	59.7	88.1	59.0	151.9	11.8	.68	55
8000	59.7	90.9	59.2	152.6	11.8	.66	55
8250	59.1	92.8	60.0	153.5	11.7	.65	55
8500	57.5	93.1	59.2	154.3	12.0	.64	55
8750	54.8	91.3	59.5	154.1	11.9	.66	55
9000	52.4	89.8	60.7	153.1	11.6	.68	55
9250	49.6	87.4	60.7	152.8	11.6	.70	55

1995 ZR 580 EFI WT. 554 LBS.

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .745
Vapor Pressure: .30 Barometer: 30.00

RPM	CBT	CBHP	CAT
6500	53.5	66.2	49
6750	54.9	70.6	49
7000	59.0	78.6	49
7250	60.5	83.5	49
7500	61.2	87.4	48
7750	61.0	90.0	47
8000	62.4	95.0	50
8250	62.2	97.7	48
8500	59.1	95.6	49

800 CC CERTIFICATION

Dyno certification of the 800 class sleds went off without a problem as well. We had previously tested the 1995 V-Max 800 and ZRT 800, but this was our first chance to see the new Storm and Mach Z, which were both slightly lower in power compared with the 1994 versions. As we expected, the big Yamaha and Cat models were virtually the same as the early 1995 units we tested in Vol 6 no's 1 and 2.

1995 V-MAX 800 WT. 620 LBS.

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .745
Vapor Pressure: .30 Barometer: 29.99

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6750	77.9	100.1	51.2	173.2	15.6	.51	47
7000	81.0	108.0	59.1	184.8	14.4	.54	47
7250	86.9	120.0	63.4	199.0	14.2	.53	47
7500	91.5	130.7	69.7	205.2	13.6	.53	47
7750	94.0	138.7	74.1	213.4	13.2	.53	47
8000	95.1	144.9	77.8	221.4	13.0	.53	47
8250	95.1	149.4	81.2	227.2	12.8	.54	47
8500	91.6	148.2	83.7	230.6	12.6	.56	47
8750	84.9	141.4	85.0	233.0	12.6	.60	48

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1995 POLARIS STORM WT. 616 LBS.

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .745
Vapor Pressure: .25
Barometer: 29.77

RPM	CBT	CBHP	FUEL	BSFC	CAT
6500	71.3	88.2	47.3	.54	56
6750	68.8	88.4	56.7	.65	57
7000	78.7	104.9	68.0	.66	57
7250	81.5	112.5	72.4	.65	57
7500	84.7	121.0	76.0	.64	57
7750	89.2	131.6	81.2	.62	57
8000	87.1	132.7	84.0	.64	55
8250	80.4	126.3	87.8	.70	55
8500	66.8	108.1	91.6	.86	57

1995 ARCTIC CAT 800 ZRT WT. 614 LBS.

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .745
Vapor Pressure: .30
Barometer: 30.01

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	81.5	108.6	86.8	.80	50
7250	87.2	120.4	90.9	.75	49
7500	90.1	128.7	93.5	.72	50
7750	97.9	144.5	96.1	.66	51
8000	99.2	151.1	96.4	.64	51
8250	94.2	148.0	99.0	.67	51
8500	83.6	135.3	100.3	.74	50
8750	52.0	86.6	104.4	1.20	50

1995 SKI DOO MACH Z WT. 608 LBS.

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .745
Vapor Pressure: .25 Barometer: 29.74

RPM	CBT	CBHP	FUEL	BSFC	CAT
6750	91.3	117.3	66.9	.58	60
7000	92.7	123.6	75.6	.62	59
7250	94.0	129.8	81.1	.64	61
7500	93.3	133.2	84.7	.65	60
7750	94.4	139.3	90.6	.66	59
8000	96.5	147.0	92.2	.64	59
8250	95.2	149.5	94.1	.64	60
8500	75.8	122.7	94.5	.78	59
8750	57.8	96.3	95.0	1.01	61

FIELD SHOOTOUT

Covered in its entirety in American Snowmobiler Magazine (612-738-1953) our field shootout showed that, by and large, the machines are coming set up increasingly well from the factories. Judging from the results of the "dealer prep" session, it's becoming much more difficult to significantly improve upon the out-of-the-box performance.

One facet of our field shootout that we would like to improve is the ability of the dealers to assess the clutching changes that are necessary on the test sleds. We usually figure that most stockers overrev during acceleration, but how much and for how long?

Being able to determine how closely the clutches are keeping the engines to their horsepower peaks is a tough task for Shootout pilot Zach Taylor; controlling the accelerating sleds over the length of the less than glass-smooth 1/4 mile course makes accurate engine speed monitoring almost impossible.

What we need to find is some type of engine speed recording device that can be moved easily from sled to sled. Maybe an on-board computer or one of those VDO tachs that record and replay a run could be used. I would be open to suggestions for doing this next year.

As we can see from the dyno session, even interpolating in some extra fuel flow, the sleds are coming jetted pretty close for typical winter conditions, so jetting changes must usually be subtle to be safe.

Subtle is not a word that can be used to describe Tom or Doug Smith. Even though their Formula III had the 600 class covered by nearly 10 MPH, they wanted theirs to be the first middleweight to hit the 100 MPH mark in the quarter mile, and possibly outdo the 800 Storm in the process. Zach had reported that the clutching was close to spot-on, so the only thing left was to lean down the already closely jetted Rotax.

Their decision to remove the baffling from the Formula III's airbox resulted in the detonation of one cylinder instead of achievement of the desired century mark.

They performed the same airbox modification to the Mach Z. Zach had reported the Mach Z had been overreving horribly to 8500+ RPM (note the power loss at that speed, even on the second hot pipe run) so they installed a two degree steeper helix and adjusted the "clicker" two numbers lower to reduce the operating speed. These modifications added several MPH to the Mach Z, allowing it to narrowly nip the ZRT800 for top speed of the day. The lower fuel flow also resulted in the Mach Z detonating when Zach was returning from the second dealer prep pass. That was especially suprising, considering that many of Smith's customers have run such a combo all winter long with no problem.

The Big Moose Yamaha/Arctic Cat guys saw both of their big sleds slow down as the result of changes they made which should have helped. Their V-Max 4 had the ignition pickups slotted and moved ahead two degrees, and the ultra-safe (vent hoses-down) jetting dropped one size to 132.5. They also evened up the float levels while they were at it. Zach thought that it, too, had been overreving slightly so they installed an unnumbered multi-angle Helix that they received from Yamaha dragracer Pat Hauck.

The ZRT 800 was jetted down from 420 to 390s, and had the needles dropped one clip position. It also had an unnumbered D&D Cycles multi-angle helix istalled to pull its revs down during shifting.

The Big Moose guys also installed the GYT Kit on the V-Max 600, which included a new Y-pipe and tuned pipe, stiffer drive clutch spring and lighter weights. They also installed one size larger main jets.

The 580 ZR EFI seemed to be overreving just a bit. To be sure, it received another mystery multi-angle helix to pull the revs down, and a yellow-green drive clutch spring to help the hole-shot.

The Don's Polaris tuners had their sweet combo used on the identical XCR 600 from last year. Like last year, it worked to perfection. The setup included removing the shelf from the airbox, leaving the jets alone. A black spring was installed in the front clutch along with a 48/34 multi-angle rear helix and white rear spring. As we've seen from the dyno test results on these engines, overreving is not so critical on this engine. The stock tuned pipe allows excellent horsepower beyond the peak.

The 800 Storm's triple pipes are not nearly as forgiving for overrev, which Zach Taylor reported it had plenty of. A 52/34 multi-angle helix, a black front spring, and white secondary spring were used to pull the shift speed down to reality.

PUMP GAS EPILOGUE...

Examining the shootout speed results after the dealer prep where sleds were leaned down, I wonder about the Old Forge 94 octane gas. Could it have been tainted with alcohol or MTBE?

Considering the reduction in speeds in the ZRT and VMax 800's after they had been correctly clutched and jetted, is it possible that they were experiencing some detonation or leanout horsepower loss? Remember our experience with the new Mach 1, detonating at .64 lb/hphr.

Then, there was the V-Max 600, with ultra-safe 155 main jets as run at the consumer shootout, returning to the dyno the next week for the evaluation of the Gyt Kit. The Old Forge gasoline in the fuel pump and float bowls mysteriously made several more horsepower than the pump gas we used for the dyno session. That is a fact.

Since repairing the SkiDoo Formula III, Tom Smith has been safely running that same.combination this winter, albeit on pump gas mixed with a bit of race gas for safety.

It is only conjecture on my part, but the results of our "dealer prep" portion of the Shootout may have been affected by the quality of the gas we used.

The moral of this portion of the story is, if you run pump gas you are rolling the dice. If you've jetted down or bumped your timing to a range that used to be a safe high performance level, *be cautious.*

YAMAHA'S GYT KIT FOR THE V-MAX 600

At the time of our December Shootout, the Gyt Kit for the V-Max 600 was being released as a dealer installed option, or tuneup. The Gyt Kit consists of a new Y pipe with a larger diameter outlet, a new tuned pipe, and clutching components that allow higher RPM operation.

Jerry Bassett and I felt that since it was a factory supplied, dealer installed option that had no effect on the warranty, it should be allowed as a dealer tuneup for the Battle of Old Forge V.

Yamaha service tech guru Tom Parr was given the unenviable task of being the first to very publicly set up a V-Max 600 with the Gyt Kit. Up until this time, the Gyt Kit had only been field tested in Alaska or someplace, and Tom knew little about it.

When we found out that the Gyt kit was supposed to run 250 RPM higher than stock, and required a stiffer spring and lighter weights to achieve that operating speed, I was leery. The snowmobile drive clutch is like a built-in dyno; add midrange and top end horsepower to an engine, and it will automatically rev to a higher RPM, sometimes even overrev, with the original weight/spring combo. If you have to lighten up the clutch setup to gain a couple of hundred revs, you probably haven't gained much.

As the field test after the dealer prep session indicated, the higher revving Gyt Kit did little to improve the quarter mile performance of the V-Max 600.

To his credit, Tom Parr worked his butt off the following day during our Consumer Shootout at the Ole Barn Restaurant. George Taylor was shooting consumer sleds for a couple of bucks a pop with his Stalker radar gun at 1/8 mile only, using the last (better) measured half of the Shootout drag strip. We were there with Jerry Basset, goofing around with turbo sleds, and it seems as though every fourth sled making a pass was Tom on the Gyt-Kitted V-Max 600, trying in vain to find the elusive horsepower. He clutched up and down, to no avail.

Yamaha was understandably concerned about the lack of performance increase during our field test; they had built several hundred kits, all of which were presold, and many of which would probably be returned after American Snowmobiler published the test results, if these problems weren't resolved.

Yamaha engineer Greg Marier arranged to have Big Moose Yamaha's Jon Martin bring the shootout sled and the Gyt Kit to the C&H Dyno for evaluation. Greg accompanied the machine and, as the field test and all of Tom Parr's work had indicated, the horsepower of the Gyt Kit pipe was virtually identical to stock (but at a higher RPM), when the stock jets were retained. We then jetted down to 155.0 mains to establish our stock baseline at 50 degrees CAT.

1995 V-MAX 600
STOCK PIPE 155.0MJ
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .744
Vapor Pressure: .18 Barometer: 30.33

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	55.2	63.1	41.7	121.6	13.4	.65	52
6250	58.9	70.1	45.1	126.5	12.9	.63	52
6500	60.3	74.6	48.7	131.7	12.4	.64	52
6750	65.1	83.7	53.1	140.6	12.2	.62	51
7000	65.2	86.9	56.6	144.8	11.7	.64	51
7250	65.4	90.3	58.1	147.7	11.7	.63	51
7500	65.6	93.7	60.3	151.1	11.5	.63	51
7750	63.6	93.8	61.2	153.4	11.5	.64	51
8000	56.9	86.7	62.3	153.3	11.3	.71	51
8250	45.5	71.5	61.5	148.1	11.1	.84	50

We then dropped the main jets one size, per Yamaha specs for the Gyt kit.

1995 V-MAX 600
STOCK PIPE 153.8MJ
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .744
Vapor Pressure: .18 Barometer: 30.36

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	56.6	64.7	36.6	123.1	15.4	.55	45
6250	60.2	71.6	43.0	130.5	13.9	.59	45
6500	62.7	77.6	46.4	136.3	13.5	.58	45
6750	64.8	83.3	50.8	142.7	12.9	.59	45
7000	65.7	87.6	54.4	145.9	12.3	.61	46
7250	66.2	91.4	56.9	149.6	12.1	.61	46
7500	66.1	94.4	58.3	152.3	12.0	.60	46
7750	64.6	95.3	59.8	154.7	11.9	.61	46
8000	57.5	87.6	61.6	154.6	11.5	.68	45
8250	48.0	75.4	60.3	150.5	11.5	.78	45

GYT Kit continued

1995 V-MAX 600
GYT KIT PIPE AND Y 153.8 MJ

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .744
Vapor Pressure: .18
Barometer: 30.35

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	47.9	54.7	32.4	118.5	16.8	.58	46
6250	51.3	61.0	39.8	123.7	14.3	.64	46
6500	53.4	66.1	44.3	129.5	13.4	.65	46
6750	58.8	75.6	48.3	138.2	13.1	.62	46
7000	60.8	81.0	50.9	142.8	12.9	.61	47
7250	64.2	88.6	54.2	150.6	12.8	.60	45
7500	65.6	93.7	58.1	154.7	12.2	.61	47
7750	65.0	95.9	59.5	157.8	12.2	.61	47
8000	63.9	97.3	60.2	160.5	12.2	.60	47
8250	60.7	95.3	59.7	162.5	12.5	.61	47
8500	57.4	92.9	61.0	165.8	12.5	.64	47

Now, the BSFC was quite similar, and power was just a bit higher. But, Greg's contention was that because of its low backpressure (as indicated by the higher airflow), the VMax 600 could handle *two sizes leaner jetting*. This is an example of questions we have had raised, and raised ourselves in the six years of instrumented dyno testing.

Engineer types say that, when comparing engine component performance, A/F ratios must be kept constant. After we discovered the significance of pounds of fuel flow per horsepower hour (BSFC), that became something we paid more attention to. Sometimes, differing A/F ratios resulted in equal BSFC numbers. Confused? So are we, and again, more often than I care to admit.

Now we have a less restrictive Gyt Kit pipe that Greg Marier contends can tolerate leaner jetting than the more restrictive stock pipe, because of its lower backpressure and resulting lower piston and combustion chamber temperatures (surmised, not measured). Whew.

So, we dropped another jet size, and the following dyno test data resulted.

1995 V-MAX 600
GYT KIT PIPE & Y 152.5MJ

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .744
Vapor Pressure: .18 Barometer: 30.34

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	48.4	55.3	33.7	119.7	16.3	.59	44
6250	50.1	59.6	37.3	122.1	15.0	.61	43
6500	54.7	67.7	44.2	130.6	13.6	.63	43
6750	58.2	74.8	48.2	137.2	13.1	.63	44
7000	62.3	83.0	50.7	145.2	13.2	.59	43
7250	63.8	88.1	53.9	149.7	12.8	.59	44
7500	66.2	94.5	57.2	156.6	12.6	.59	45
7750	65.7	96.9	59.1	158.5	12.3	.59	45
8000	64.3	97.9	60.3	161.7	12.3	.60	44
8250	60.8	95.5	61.1	163.9	12.3	.62	44
8500	58.0	93.9	61.0	167.9	12.6	.63	45

This has opened a new can of worms for us, one that we've recently recognized, but need to address to a greater extent when comparing components. How much leaner will a higher flowing pipe or pipes operate before detonation occurs? Is it up to DynoTech to determine that? Not practical, until some detonation sensor is perfected. Yamaha uses a neat spark plug tip temperature indicator provided by NGK to tell when deto is occuring; when cooling boundaries are washed away by the shock of detonation, spark plug tips are subjected to skyrocketing temperatures seconds before meltdown occurs. Those gauges are, unfortunately, available only to NGK customers who buy a zillion plugs a year. Since we buy our plugs when they're on sale at KMart (no preference, they all make the same horspower), C&H Dyno Service doesn't qualify for a tip temp gauge.

The next best bet is to consider what jetting each engine component manufacturer recommends. Have you ever heard an aftermarket pipe manufacturer recommend leaner than stock jetting? Sometimes, it probably is justified.This Gyt Kit pipe is one example. Leaner is better, when it makes more reliable horsepower.

What is Yamaha recommending for jetting the Gyt Kit? I believe that they have conservatively decided on one size leaner. You see the data. However, those Gyt Kit owners with whom I've shared these test results had good field performance with two sizes leaner jetting. Sleds are easy to clutch, with broad, forgiving power bands. They are also, according to people with the smaller jets, noticably quicker than stock in the field.

How should we address future pipe shootouts? I welcome comments regarding this issue.

Vaporization

and modified carbs

I've come to the conclusion that, while the industry standard Mikuni VM and TM carbs are easy to tune, they do a less than perfect job of vaporizing gasoline, especially at low air velocity and low air and fuel temperatures. Cruising and trail riding, the carbs see high velocity beneath the slides. Engines run safely and powerfully on lean A/F ratios.

When the throttles are whacked open, however, air velocity is temporarily low, and I think that gasoline drizzles into the engine and gets beaten into at least a partial vapor by the hot, spinning crankshaft/ rod/ piston assembly.

Stale pump or race gasoline delivered by standard Mikuni carbs doesn't have a prayer of being totally vaporized by the time it reaches the combustion chambers. Standard Mikuni carbs are dependant upon the "light ends" of the gasoline to initiate the vaporization process. When light ends are diminished by "staleness", high engine component temperatures are necessary to assure even partial vaporization.

In the old days, we used to mysteriously detonate and seize engines on the dyno when our "light ends" disappeared (with some race gasoline, the light ends were gone within a few days after opening the sealed containers). Safe A/F ratios, BSFC, and EGT's belied the fact that stale fuel was blowing through our engines in unburnable, lava lamp-like globs that only cooled our EGT probes.

"Cold seizures" are absolutely caused by cold gasoline failing to vaporize. Cold engines being fed nice 12-1 A/F ratios actually see maybe 20/1 A/F ratios if you count only the burnable (vaporized) fuel. It's the lean real A/F ratios that cause the detonation and/ or overheated pistons.

Now we understand, and store our race gas under nitrogen pressure with our "Fuel Safe" nitrogen barrel bung/dispensors (available from Carl McQuillen for about $200 at 716-768-2322). Fresh gas prevents cold seizures, and makes lots more cold engine power.

If our Mikuni carbs really did their jobs, it wouldn't be quite so critical.

Along comes George **BOSWELL**. "Bos" Boswell is an interesting and ambitious guy. He does something to Mikuni carbs to make them vaporize fuel better than they do stock. People who have their carbs modified by Boswell report better acceleration and throttle response. I tend to believe them, even though I typically see zero power increase on the dyno with Boswell (or any other) carbs.

Hundreds of subscribers have called to see if we've tested Boswell carbs. We have done back to back tests on maybe six different applications comparing stock Mikuni carbs to Boswell modified carbs. Five times, there was no difference in horsepower. One time there was a few percent increase. That one time was likely the result of someone else's less than fresh fuel and old fashioned shiney-smooth intake and transfer port finish.

The problem with the dyno is its perfect operating conditions, ideal for even the lousiest fuel delivery systems. We load the engines just on the pipe at W.O.T., for a few seconds until the engines are running cleanly and smoothly. Air velocity is relatively high, internal engine components are nice and warm, and our always fresh fuel is relatively well vaporized. Only then is the test button pushed, and the engine is allowed by the

Vaporization

computer to accelerate very gradually to its power peak and just beyond. In these ideal conditions, it is impossible to assess the effects of improved low velocity or part throttle vaporization on engine performance. It is impractical, if not impossible, for us to test what happens during the important transition from idle to full throttle, where good vaporization is so critical.

So, when I tell people that Boswell carbs don't make any more HP than stock carbs, I qualify that statement.

The first time I saw **LECTRON** carbs being used was in the late '70's at the local drag strip where I used to hang out and drag race my turbocharged KZ1000. FBG owner Paul Gast built Lectron carbureted H1 and H2 Kaw two-stroke drag bikes for local guys as well as dragracers all over the U.S.. The thing that always amazed me about the Lectron carbureted drag bikes was the fact that they could "stage" on the starting line at a ring-ding-ding sounding fast idle, and the riders could simultaneously dump the clutch and open the throttle at the green light without ever sputtering or bogging. I didn't understand it then. I almost understand it now. Those carbs do a great job of vaporizing fuel in the transition condition as well as full throttle.

Pro Stock King Dave Schultz ran a FBG H2 750 in Pro Stock in the early eighties, setting records at the time, and to this day is still hooked on the Lectron carbs.

I've dyno tested several H2 Kaws fitted with the early 40mm Lectrons. Because of their comparitive lack of tunability (all fuel flow was determined by the D-shaped needle only), I felt that they were always too lean at low airflow, WOT, then too rich at high airflow, WOT, and couldn't be tuned to perfection. They needed larger needle jets, but there was no such adjustment. Because of that, I blew the Lectrons off as being untuneable.

Paul Gast is a good pal of mine, and he is the distributor of Lectron carbs (FBG Megatron Carbs) to everyone who sells them. The new 44mm Megatrons have a correct fuel curve, are now being used by every competitive Pro Stock motorcycle dragracer, and the bizarre phenomenon that occurs with their use is that no one ever adjusts fuel flow! Whether they race at Atco, NJ at sea level 50 degrees or the Mile High Nationals at Denver at 70 degrees, the fuel flow settings are the same. I don't quite get it.

Paul tells me that Freddie Klies of Eastern Cycle Performance is using on-board computers to provide some empirical data supporting the performance increases with the 44 Megatrons. Freddie's testing indicates a one second reduction in the time from clutch engagement to reaching the power peak (three secs. to two secs.) when switching from 48 roundslides to the 44 FBG Megatron carbs.

Rob Schooping of HTG Racing, who's also a long-time pal of Paul Gast just started selling them as well, and is raving about the reduction in E.T.'s on their drag sleds. Interestingly, the first set of 44 Megatrons Rob installed on a 200+ HP Storm dragracer picked up a tenth and a half over the 48mm roundslides they replaced. This was during a 20 below zero F ice drag race in Wisconsin. Next, the same sled was run at the Canadian world series at 25 degrees F and no jetting changes were reportedly necessary to win its class there.

Is it possible that well vaporized gasoline is much more forgiving for tuning than poorly vaporized gasoline?

We will be doing a side-by-side analysis of standard Mikuni, Boswell and FBG Megatron carbs in the near future. I suspect that using some typically well-aged stale race gas in an engine would be one way of determining the vaporization capabilities of standard Mikunis compared to the Boswell and Lectron carbs. Again, stay tuned.

PIPE SHOOTOUT# 31

ARCTIC CAT 580 ZR

Here's every set of pipes that we could obtain to test on a bone stock 580ZR engine. The 40mm carbs were fitted with 310 main jets, which were marginally safe for the high 60's Carb Air Temp during our test session. Note that with the stock pipe, the fuel flow reading dipped at the peak horsepower point, indicating a lower than actual BSFC. Like many of the Cat twins we test, fuel flow numbers need to be interpolated.

STOCK ARCTIC CAT 580 ZR 88dB
310 MJ

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .752
Vapor Pressure: .30
Barometer: 29.92

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6250	47.9	57.0	36.7	126.6	15.8	.66	67
6500	50.5	62.5	42.2	132.5	14.4	.69	65
6750	54.7	70.3	48.5	137.7	13.0	.70	67
7000	56.6	75.4	55.2	141.1	11.7	.75	67
7250	57.5	79.4	58.2	143.5	11.3	.75	67
7500	60.1	85.8	61.9	145.9	10.8	.74	68
7750	61.6	90.9	62.2	148.1	10.9	.70	68
8000	61.8	94.1	60.6	149.4	11.3	.66	67
8250	60.9	95.7	59.8	149.6	11.5	.64	68
8500	58.1	94.0	62.2	149.9	11.1	.67	67
8750	50.8	84.6	60.0	149.4	11.4	.72	67

Aaen makes a stock single pipe that delivered a bit less than stock peak horsepower. It also had less than stock midrange horsepower. It was "tighter", or more restrictive than the stock pipe. While the engine performance wouldn't be much lower than stock, the Aaen single is noticably lighter, which would be of some benefit. It is also twice as loud as stock (see "The Decibel Explained" in Vol. 6 no. 2)

STOCK ARCTIC CAT 580 ZR
310 MJ--AAEN SINGLE PIPE-94 dB

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .752
Vapor Pressure: .30
Barometer: 29.91

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6250	43.1	51.3	48.0	122.3	11.7	.96	70
6500	42.5	52.6	48.5	121.8	11.5	.94	70
6750	43.2	55.5	49.7	121.7	11.2	.92	71
7000	51.2	68.2	56.1	131.8	10.8	.84	72
7250	53.5	73.9	58.5	136.3	10.7	.81	70
7500	57.0	81.4	64.1	139.3	10.0	.81	70
7750	59.9	88.4	64.3	142.0	10.1	.75	71
8000	60.7	92.5	60.7	144.2	10.9	.67	70
8250	59.9	94.1	61.4	147.1	11.0	.67	69
8500	56.7	91.8	60.3	148.2	11.3	.67	70
8750	53.6	89.3	56.9	148.2	12.0	.65	71

We next went to the twin pipes, and had to jet around a bit to obtain a marginally pump gas safe mid .60's BSFC.

PSI's twins exit the stock bellypan outlet, and made ten more horsepower than stock with only a 250 RPM increase. They required a increase of two jet sizes.

STOCK ARCTIC CAT 580 ZR
325 MJ--PSI PIPES 98dB

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .752
Vapor Pressure: .30 Barometer: 29.91

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6250	50.8	60.5	49.9	129.2	11.9	.84	67
6500	52.4	64.9	56.5	133.2	10.8	.89	67
6750	53.8	69.1	63.2	137.9	10.0	.93	66
7000	54.1	72.1	63.8	139.7	10.1	.90	67
7250	56.5	78.0	63.3	142.9	10.4	.83	67
7500	60.3	86.1	69.5	148.0	9.8	.82	68
7750	63.7	94.1	71.2	152.6	9.8	.77	68
8000	66.3	101.0	71.7	157.5	10.1	.72	68
8250	66.6	104.6	69.1	160.5	10.7	.67	68
8500	65.5	106.0	67.7	162.1	11.0	.65	68
8750	60.4	100.6	69.3	162.6	10.8	.70	68

PIPE SHOOTOUT

CONTINUED FROM PAGE 5

D&D Cycles' twins also exit the stock outlet, and were the quietest at 90 dB. Note that while the power peak is shown at 8250 RPM, the peak slides easily up to 8500 as the pipes are heated on a long run.

STOCK ARCTIC CAT 580 ZR
325 MJ--D&D TWIN PIPES 90dB

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .752
Vapor Pressure: .30
Barometer: 29.88

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6250	50.5	60.1	44.1	123.3	12.8	.75	67
6500	52.7	65.2	47.6	130.1	12.6	.74	67
6750	54.8	70.4	55.3	134.4	11.2	.80	66
7000	56.1	74.8	58.2	137.8	10.9	.79	66
7250	58.5	80.8	59.8	141.6	10.9	.76	66
7500	62.9	89.8	68.6	147.8	9.9	.78	66
7750	66.5	98.1	70.0	155.6	10.2	.73	65
8000	68.2	103.9	69.2	160.2	10.6	.68	66
8250	67.3	105.7	68.0	162.0	10.9	.66	66
8500	64.1	103.7	69.6	161.3	10.6	.69	67

Black Magic's twins are available in two designs, one for trail use and a shorter set for lake and dragracing. Along with the trail set we had, Black Magic's Mike McArdle sent us a "mod" set (with a cut and weld seam in each center section) that revved to 8750 RPM.

STOCK ARCTIC CAT 580 ZR
310 MJ--BLACK MAGIC TWINS 96 dB

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .752
Vapor Pressure: .30
Barometer: 29.91

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6250	45.3	53.9	44.4	123.3	12.8	.84	66
6500	48.5	60.0	48.6	125.6	11.9	.83	66
6750	52.2	67.1	54.8	131.4	11.0	.83	66
7000	54.0	72.0	59.1	135.4	10.5	.84	66
7250	54.9	75.8	58.7	137.9	10.8	.79	66
7500	57.7	82.4	64.5	141.9	10.1	.80	66
7750	59.6	87.9	67.5	144.6	9.8	.78	67
8000	64.4	98.1	68.7	153.2	10.2	.71	66
8250	65.5	102.7	67.7	157.7	10.7	.67	65
8500	65.1	105.4	68.2	159.6	10.7	.66	66
8750	60.7	101.1	68.2	159.8	10.8	.69	67

STOCK ARCTIC CAT 580 ZR
310 MJ--MOD BLACK MAGIC TWINS 96dB

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .752
Vapor Pressure: .30
Barometer: 29.91

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6250	46.1	54.9	43.1	122.4	13.0	.80	66
6500	49.0	60.6	49.1	124.7	11.7	.83	67
6750	50.6	65.0	56.6	128.7	10.4	.89	66
7000	52.1	69.4	59.2	131.5	10.2	.87	66
7250	52.6	72.6	58.1	133.6	10.6	.82	66
7500	54.4	77.7	61.7	136.0	10.1	.81	65
7750	57.8	85.3	67.2	140.6	9.6	.80	66
8000	60.8	92.6	65.6	146.0	10.2	.72	67
8250	64.1	100.7	63.9	154.1	11.1	.65	66
8500	65.5	106.0	67.5	160.0	10.9	.65	65
8750	64.8	108.0	67.6	163.9	11.1	.64	66
9000	59.5	102.0	68.0	163.9	11.1	.68	66

Hooper Racing's twin pipes feature blown center sections with outlet pipes leading from the center sections into individual glasspack silencers. These had good horsepower, but were "peaky" and sensitive to pipe heat on the dyno. The peakiness is made obvious by the fact that both the horsepower and torque peaks occur simultaneously on our printouts. This phenomenon requires more than average clutch tuning skills to keep the engine operating at its peak.

STOCK ARCTIC CAT 580 ZR
325 MJ--HOOPER PIPES

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .752
Vapor Pressure: .30
Barometer: 29.90

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6250	51.8	61.6	38.7	128.0	15.2	.64	66
6500	53.0	65.6	46.2	133.3	13.2	.72	67
6750	54.3	69.8	55.8	135.7	11.2	.81	66
7000	55.9	74.5	56.5	135.3	11.0	.77	66
7250	58.4	80.6	57.8	135.2	10.7	.73	66
7500	58.7	83.8	59.1	135.9	10.6	.72	67
7750	64.4	95.0	66.4	142.5	9.9	.71	65
8000	67.5	102.8	61.3	150.2	11.3	.61	65
8250	68.0	106.8	68.3	159.0	10.7	.65	67
8500	60.0	97.1	69.5	165.8	11.0	.73	66

1995 SKI DOO MACH I 670

Bombardier seems to have pulled out all the stops for the '95 edition of the Mach I, now in its third season as a 670cc twin cylinder. Gas shocks, full instrumentation and the easy-to-operate Brembo Italian hydraulic brake are what separates this potent trailrocket from its little sister, the '95 Formula SS (both now appearing on Ski-Doo's new lightweight F-2000 all aluminum chassis). Oh yeah, there are differences in the motor too--lots of differences: note that the cylinders, crankcase and cylinder head will not interchange with previous style 670 twins or the 670 found in this year's SS.

Ski-Doo has built twin-piped engines in the past, the most recent being the Mach IX, forerunner of today's 670 type engine. The '92 Mach IX was alimited build, twin piped version of the 617 Mach I motor, and was withdrawn from service later that year. Owners of these models were offered a one-time deal to swap cylinders, exhaust and related components changed to '93 Mach I 670 specifications. Of course in doing so, the twin piped version disappeared and the single piped Mach I continued through the '93 and '94 model years and in '95 as the Formula SS, Summit 670 and Grand Touring SE.

The re-appearance of the twin piped 670 will be a welcome development for high-performance trail riders. To accomadate the twin exhaust management capabilities, the engine was fitted with 44mm round slide Mikuni carbs with (224) AA7 needle jets, a new 7EG06 needle taper and 430/410 main jets. Note that the stock jetting is richer on the PTO side, a reversal of most Rotax engines of the past, in which the richer jetting was normally found on the MAG side cylinder. An altered crank with a 7.6 mm shorter flywheel end (sans flywheel) has been stuffed into a new crankcase with a 1.5mm higher deck height. The cylinder head has been milled 1.5mm thinner to correct the higher piston TDC resulting from the deck height change. The new cylinder head has a stamped "1" between the spark plugs to distinguish this new thinner head from other 670 models. There are now multiple basegasket thicknesses available for this motor, and the ones we checked on crated snowmobiles delivered to our dealership indicates that the factory installs the correct gasket as the motor requires. The thicknesses vary from .013" to .030"+. If the '95 Mach I motor requires a gasket change due to service and repair, it would be advisable to measure the old gasket prior to replacement to ensure the same engine specifications as stock.

A new 501 rotary valve and internal port timing changes complete the twin piped engine for '95. With 50 degree temperatures, carbs were fitted with two sizes leaner jetting for our box-stock baseline dyno test. The data would suggest that midrange calibration is conservatively rich, while the main jets are nearly spot on for WOT trail and lake running on pump gas. (The needle clip position for this test and others was the factory calibrated 3rd clip position). The new '95 Mach I produced a very stout 122+ CBHP at 8000 RPM.

1995 STOCK MACH I 670 390-370 MJ
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .740
Vapor Pressure: .30 Barometer: 29.38

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	55.0	57.6	45.2	111.2	11.3	.80	48
5750	53.0	58.0	47.6	120.2	11.6	.84	49
6000	54.0	61.7	47.4	120.8	11.7	.78	49
6250	72.7	86.5	66.7	162.6	11.2	.79	49
6500	73.9	91.5	71.9	171.1	10.9	.80	49
6750	73.5	94.5	76.6	176.2	10.6	.83	48
7000	75.9	101.2	73.8	179.7	9.8	.84	49
7250	78.5	108.4	81.2	184.7	10.4	.76	49
7500	82.2	117.2	81.2	194.7	11.0	.70	47
7750	82.5	121.7	78.9	197.4	11.5	.66	48
8000	80.4	122.5	80.9	198.3	11.3	.67	48
8250	76.3	119.9	82.7	198.4	11.0	.70	48
8500	63.6	102.9	80.5	196.3	11.2	.80	47
8750	47.4	79.0	81.2	188.6	10.7	1.05	48

Advancing the timing to .085 BTDC improved our midrange and peak horsepower by 2 HP at most RPM (safe for *guaranteed* 92 octane *conventional* fuel). The pipes were also a bit hotter on this pass, due to shorter cool-down times between runs.

1995 STOCK MACH I 670 390-370 MJ--TIMING .085
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .740
Vapor Pressure: .30 Barometer: 29.39

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	52.6	55.1	45.5	112.7	11.4	.84	47
5750	55.0	60.2	51.0	124.4	11.2	.86	48
6000	55.4	63.3	50.1	125.5	11.5	.81	48
6250	70.6	84.0	66.7	159.1	11.0	.81	48
6500	72.1	89.2	69.6	166.9	11.0	.79	48
6750	72.1	92.7	71.4	172.4	11.1	.78	46
7000	73.1	97.4	73.7	177.4	10.1	.77	47
7250	77.8	107.4	79.0	184.0	10.7	.75	47
7500	80.7	115.2	82.0	189.6	10.6	.72	48
7750	82.8	122.2	78.4	195.3	11.4	.65	48
8000	81.6	124.3	80.5	198.6	11.3	.66	48
8250	78.1	122.7	83.0	198.8	11.0	.69	48
8500	68.1	110.2	81.9	196.8	11.0	.76	47
8750	52.0	86.6	81.5	189.7	10.7	.96	48

Kevin Freeman owns The Sled Shop, Inc. (207-764-2900) a Ski-Doo dealership in Presque Isle, Maine, about 800 miles from the C&H Dyno. When they're not selling and tuning customer sleds, they can be found at most Eastern Ice Drag Race competitions throughout the winter racing season, racing for TEAM PEPSI.

1995 Ski-Doo MX-Z stock evaluation & drag setup

Our SkiDoo dragracer pals Bob Calpeter and John Johnson brought their new MXZ to the C&H Dyno for breakin and evaluation, and drag setup.

During our session, it was in the mid 40 degree F range, and 260 main jets were required for marginally safe operation on what is today always marginal pump gas (93 octane that was purchased locally). For our dyno acceleration tests, turning the RAVE valves out one turn was ideal.

1995 SKI DOO 440 MXZ
260 MJ RAVE LOOSENED ONE TURN
Data for 29.92 inches Hg, 60 F dry air
Test:200 RPM/Sec Acceleration
Fuel Specific Gravity: .745
Vapor Pressure: .11 Barometer: 30.11

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5000	39.1	37.2	37.5	79.4	9.7	.99	44
5250	40.5	40.5	36.7	82.0	10.3	.89	45
5500	40.8	42.7	35.2	85.8	11.2	.81	43
5750	42.8	46.9	33.6	91.6	12.5	.70	44
6000	44.2	50.5	35.0	95.9	12.6	.68	44
6250	45.2	53.8	37.9	98.7	12.0	.69	45
6500	45.6	56.4	39.4	101.4	11.8	.69	45
6750	46.6	59.9	42.2	105.4	11.5	.69	45
7000	52.6	70.1	45.9	120.2	12.0	.64	44
7250	54.6	75.4	46.7	128.7	12.7	.61	45
7500	55.2	78.8	52.1	134.5	11.9	.65	43
7750	54.9	81.0	54.6	137.1	11.5	.66	44
8000	51.1	77.8	58.6	136.8	10.7	.74	44
8250	43.9	69.0	63.2	133.1	9.7	.90	45

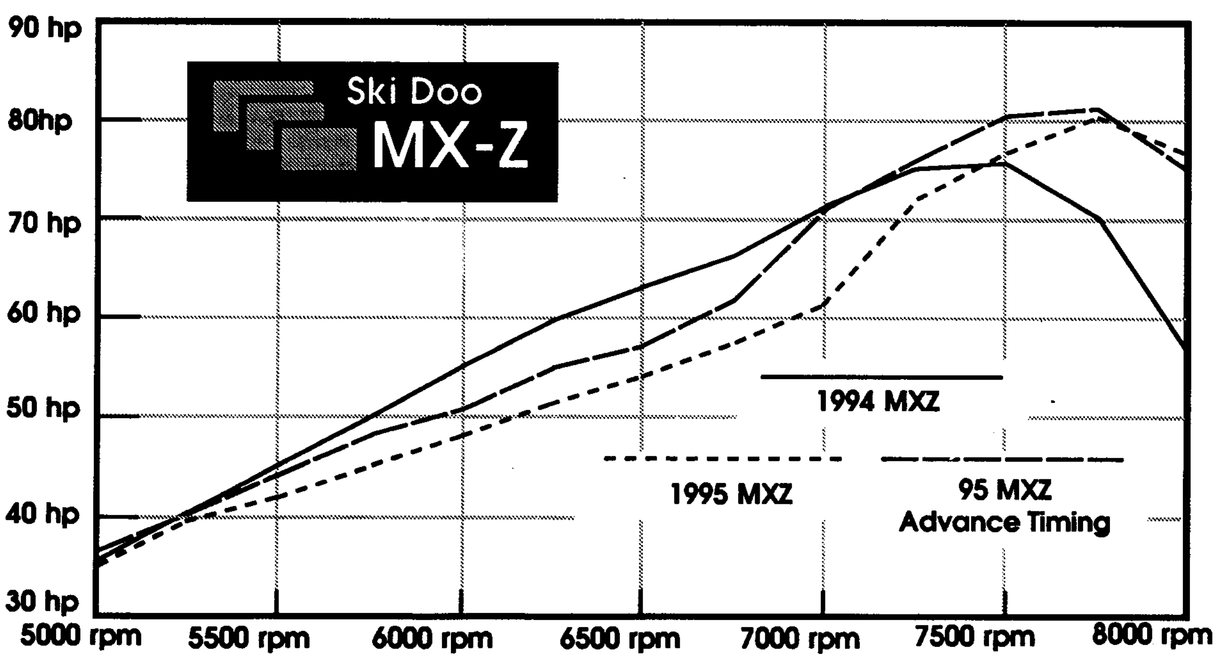
Next, Bob and John advanced the ignition timing from the stock .058" BTDC to .075" BTDC. This modification is fine for dragracers or those who always run 93+ octane gauranteed.

1995 SKI DOO 440 MXZ
260 MJ-- TIMING ADVANCED
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .745
Vapor Pressure: .11 Barometer: 30.12

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5000	38.8	36.9	26.4	76.1	13.2	.70	44
5250	40.4	40.4	28.6	80.4	12.9	.69	42
5500	42.3	44.3	30.3	85.7	13.0	.67	42
5750	43.9	48.1	30.1	91.9	14.0	.61	43
6000	44.5	50.8	31.5	95.8	14.0	.61	42
6250	45.9	54.6	36.6	99.6	12.5	.65	41
6500	46.5	57.5	39.6	101.8	11.8	.67	43
6750	48.2	61.9	41.4	105.6	11.7	.66	43
7000	53.4	71.2	43.7	120.1	12.6	.60	43
7250	55.5	76.6	46.7	130.3	12.8	.60	44
7500	56.4	80.5	51.3	135.3	12.1	.62	41
7750	54.9	81.0	56.3	138.0	11.3	.68	42
8000	49.3	75.1	59.3	135.5	10.5	.77	44
8250	39.2	61.6	65.0	133.1	9.4	1.03	43

Next, we tried some semi-legal name brand oxygen bearing gasoline that made no difference in power.

100LL was tested next, and we lost an unusual three horsepower in this case. Could the pump gas we were using in this engine be oxygenated? Probably.



NEW EXCUSE FOR TARDINESS:
I've recently sold my three welding supply stores to enable me to capitalize and devote more time to Aerodyne Dallas and First Choice Turbo Center. Completing a complex arrangement like this has taken a great deal of my time.

Our Harley Davidson (R) Aerocharger program is growing rapidly, and we're confident that this is going to be the project that brings success to Aerodyne Dallas, the Aerocharger turbo factory, by providing the volume necessary (1000+ units annually) for profitability.

Turbocharged snowmobiles are great fun, but have fairly limited appeal for all but the most power hungry riders due to their high initial and maintenance costs and the need for precise fuel system and clutch tuning.

High altitude snowmobilers represent by far the greatest turbo customer base, but that base won't be large enough to support Aerodyne Dallas until such time that EPA mandated reductions in emissions reduce stock snowmobile performance significantly.

Aerodyne Dallas is hoping to see future four-stroke snowmobile engines which will be slow, heavy, and extremely easy to turbocharge. Four-strokes are great; fuel flow that is a bit low only reduces horsepower and makes the pipes glow red instead of squeeking and breaking pistons.

SPEAKING OF REFORMULATED OR OXYGENATED FUEL
I suspect that this winter has been a tough one for every snowmobile manufacturer. What has been their rate of detonation related warrany claims? Pump gas has been a nightmarish problem for many this season, with oxygenated gas being a major culprit.

It's bad enough that you always have to sweat out being cheated on octane at the pump, but dealing with oxygenated gasoline is a whole new problem. Originally, oxygenated gas was intended to be sold only in urban areas where air quality is suffering. In New York State, the Buffalo, Syracuse, Albany, and NY City areas were targeted for the reformulated gas.

We're 30 miles from Buffalo and, I suspect that the gasoline tankers don't always switch gasoline formulation as they cross the county lines. Refiners are using increasing amounts of MTBE in their gasolines, which leans out engines, to reduce air pollution. Gasoline makes maximum power at about 12.5-1 A/F ratio. MTBE makes maximum power at about 10.8-1!

Countless subscribers I've spoken to can no longer safely run last year's setup. Jet specs that used to be safe now burn engines down at an alarming rate. Ralph Schmidt's turbo V-Max 4 was bulletproof on pump gas at 8 psi boost for two prior years. This season he's detoed the engine twice. The only change is the MTBE laced gas that seems to be everywhere. He needs bigger jets or more octane or less boost.

When we dyno tested Kevin Freeman's 1995 Mach 1, we used locally bought Sunoco 94 unleaded, and detonated a piston in ten seconds at a BSFC of .64 lb/ hphr! After replacing the piston, we added a gallon of 100LL Av gas to the four gallons of whatever the Sunoco station had sold us, and we had no more problems. Even advanced timing and drag jets couldn't get this mixture to knock.

One subscriber who works for a major refinery in California doesn't like to run the MTBE laced gas they make in his Mach Z. He said they tested a 50/50 mix of their 93 octane gas and 100LL Av gas, and found 106 R+M/2 octane. Evidently, the tetraethyl lead in the Av gas really compliments the pump gas.

Based upon this information, it makes good sense for performance snowmobilers to lace each tank of mystery gas with a couple of gallons of Av gas or race gas. It pays to be cautious.

For years, our BSFC readings have been used by thousands as a nearly foolproof tuning guide. Reformulated gasoline is a new twist that we have to address. As higher percentages of MTBE find their way into our fuel tanks, it may take a .75 lb/hphr or even higher BSFC to be "pump gas safe". Maybe the occasionally blubbery stock factory jetting that we've made fun of for years isn't so dumb after all.

V-FORCE REEDS FOR THE ARCTIC CAT 800 ZRT

"Ten extra midrange horsepower by installing the V-Force Reeds!" That's what some of the ads were saying, but we didn't observe such a dramatic change during our Thundercat Performance Improvement article in Vol 6 #1. Some ads were written by well equipped (instrumented dyno cells) and well informed suppliers.

When we do reed evaluations such as this, it is important to observe the effects of the different reed cages and/ or reed petal materials on fuel flow to determine the true horsepower loss or gain. If a reed change allows say, two percent more airflow through an engine, the horsepower is usually increased by two percent. Sometimes, higher flowing reeds will cause the fuel flow to increase at an even higher rate, negating any possible horsepower increase, or even reducing horsepower. Adjusting carb jetting is sometimes necessary when evaluating reeds.

Increased airflow as a result of reed changes does not always increase horsepower. Sometimes, smaller reed cages will deliver more air/fuel mixture, but the engine will make LESS HORSEPOWER. One such example in the past was with a fully modified 750 V-Max 4 engine. In that situation, we tried YZ250 reed cages which had larger-than-stock reed window openings, and saw the airflow go up a bit, and the horsepower go down a bit. Next, we installed Phazer reed cages with smaller-than-stock openings, and the airflow went down a bit, and the horsepower went up! We don't know why for sure; we surmise that higher air velocity helped the cylinder reed inducted engine in this situation.

In the case of the V-Force reeds we have tested, every engine has had both its airflow and horsepower increased after having them installed. We haven't tested them on stock displacement Storms or Mach Z's, but many large displacement versions (900-1000cc) have benefitted, usually to the tune of three to five horsepower throughout the horsepower curve.

I have, however talked to several owners of stock displacement Polaris Storm whose sleds' performance suffered after installing the V-Force reeds. Apparently, the V-Force reeds cause the stock displacement Storm carburetion to go extremely rich. Perhaps the "lazy" pressure changes in the stock displacement Storm engines allow the reeds to not slam shut, causing a "multiple carburetion" effect (some intake air going back and forth across the needle jets on each stroke, picking up more fuel on each trip) very much like that which occurs on wildly ported piston port engines. Total recalibration is reportedly required on these engines, and then we are unsure of the net effect of the V-Force reeds. I would appreciate hearing from any standard displacement Storm owners who have evaluated this combo on an instrumented dyno.

Stock displacement T-Cats and ZRT 800's, however, don't appear to suffer from such enrichment. They appear to be a bolt-on and go affair. Long term durability of the reed material is undocumented.

In the case of this stock ZRT 800, fuel flow numbers danced a bit due to some vibration. Interpolating the numbers, it appears as though there may be a very slight leaning of the A/F mixture. The 2.5% increase in peak airflow resulted in 2.5% more peak horsepower.

Midrange airflow and horsepower was increased by an even greater percentage. Some of this increase may be due to pipe temperature differences between runs (note the reduction in overrev power), but the increase was substantial in every case.

1995 800 ZRT 390 MJ STOCK REEDS
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .752
Vapor Pressure: .30 Barometer: 29.89

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	78.4	104.5	89.7	186.3	9.5	.87	64
7250	82.2	113.5	90.7	191.3	9.7	.81	62
7500	87.6	125.1	87.5	197.9	10.4	.71	64
7750	93.8	138.4	89.8	211.6	10.8	.66	64
8000	97.5	148.5	93.6	233.6	11.0	.64	64
8250	97.1	152.5	102.7	233.3	10.4	.69	65
8500	91.5	148.1	108.7	234.6	9.9	.75	64
8750	75.4	125.6	106.6	227.7	9.8	.86	64

We also tried a Thundercat CDI on the 800 engine for one run, which has advanced timing throughout the curve. This gave us more midrange horsepower, equal peak power, and a weaker overrev. It might be acceptable for stock dragracing, but may be hazardous for trail riding on pump gas. We reinstalled the stock CDI after this run.

1995 800 ZRT
390 MJ--STOCK REEDS--'94 TCAT CDI
Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .752
Vapor Pressure: .30 Barometer: 29.89

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	80.1	106.8	87.5	187.4	9.8	.84	67
7250	84.1	116.1	90.2	192.5	9.8	.79	65
7500	91.2	130.2	89.7	204.1	10.4	.70	66
7750	93.5	138.0	91.8	212.7	10.6	.68	65
8000	99.1	151.0	98.6	225.9	10.5	.67	65
8250	96.8	152.1	106.2	234.6	10.1	.71	66
8500	87.4	141.5	107.3	232.0	9.9	.77	64
8750	62.4	104.0	106.1	216.2	9.4	1.04	66

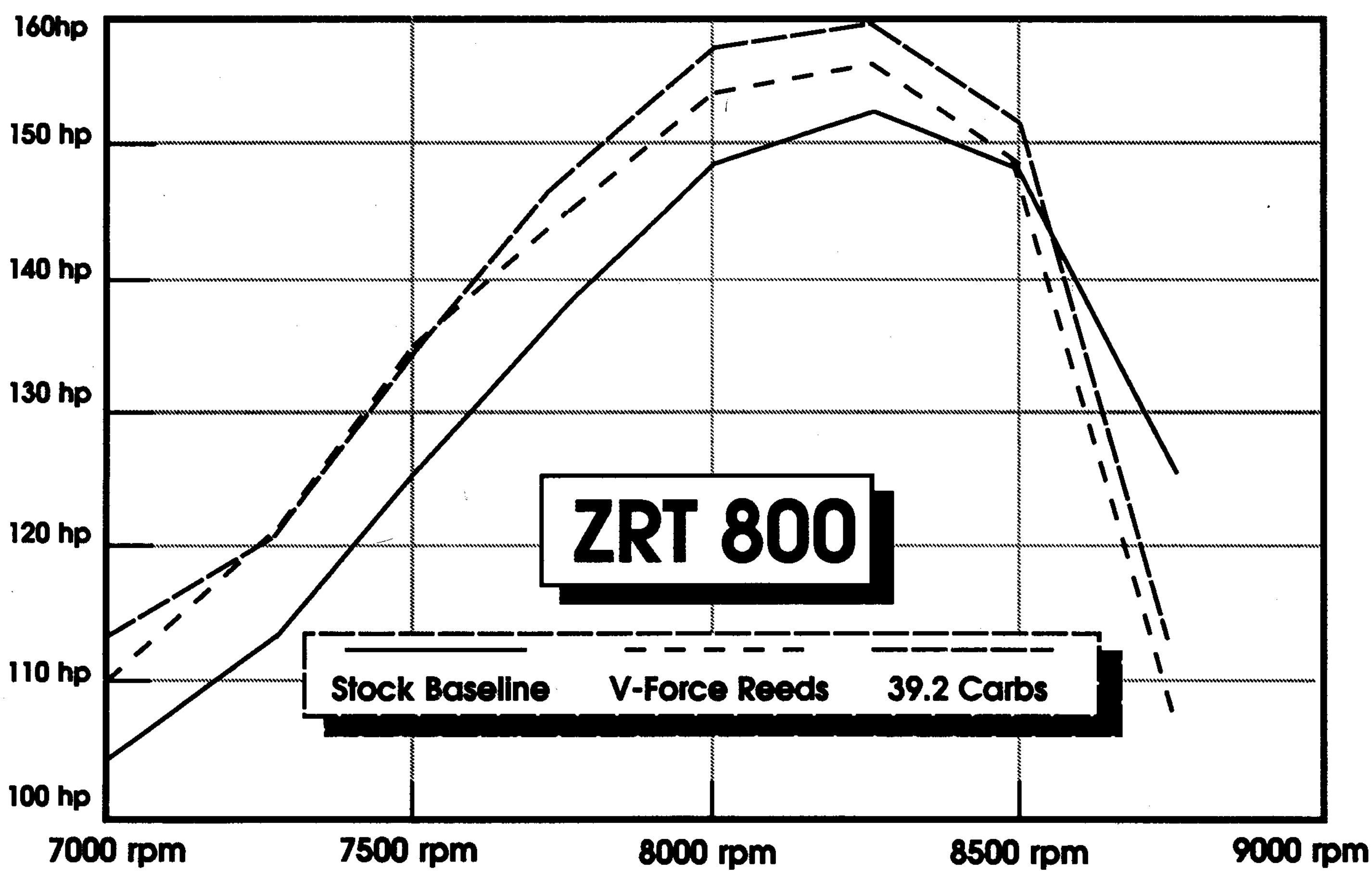
1995 800 ZRT
390MJ--STOCK CDI--V FORCE REEDS
Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .752
Vapor Pressure: .30 Barometer: 29.88

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	82.5	110.0	79.9	187.5	10.8	.74	66
7250	88.0	121.5	98.1	196.8	9.2	.82	66
7500	94.4	134.8	93.9	210.1	10.3	.71	66
7750	98.1	144.8	96.1	218.7	10.5	.68	66
8000	101.1	154.0	98.0	229.8	10.8	.65	66
8250	99.4	156.1	104.3	239.0	10.5	.68	67
8500	91.8	148.6	107.0	238.8	10.2	.73	66
8750	70.4	117.3	107.7	227.9	9.7	.94	66

With the V-Force reeds in the engine, we installed a set of stock carbs which had been bored to 39.2mm. One step larger needle jets, and three steps larger main jets almost corrected the jetting to be the same A/F ratio as the stock 38mm carbs. It was, however, just enough leaner to cause the engine to make two percent more horsepower with only a one percent airflow increase.

1995 800 ZRT
39.2 CARBS--420 MJ--V FORCE REEDS
Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .752
Vapor Pressure: .30
Barometer: 29.86

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	84.9	113.2	89.9	194.1	9.9	.81	66
7250	87.8	121.2	91.9	198.0	9.9	.77	66
7500	94.0	134.2	90.5	210.1	10.7	.69	66
7750	99.1	146.2	91.0	221.4	11.2	.64	67
8000	103.3	157.3	97.7	233.7	11.0	.63	67
8250	101.5	159.4	101.6	242.4	11.0	.65	66
8500	93.7	151.6	104.3	243.5	10.7	.70	66
8750	68.4	114.0	102.9	227.8	10.2	.92	66



more about SUSPENSIONS

THE CELLAR DWELLER

KEVIN CAMERON

Two issues ago I declared that there is a suspension revolution afoot in snowmobiling, and I went on to describe how both longer suspension travel and improved suspension damper technology (so-called "gas shocks") are being introduced. Long travel greatly increases the bump energy that can be absorbed proportional to the square of the travel. By permitting a reduction in suspension spring rate, long travel improves the isolation of the machine from bumps; the skis and track can move up and down over terrain, while transmitting less disturbance to the chassis and rider. This means that you can run faster over rough terrain before the motion of the sled becomes so rough that you begin to lose control.

Improved dampers accomplish two major tasks. First, the new gas-pressurized dampers do not "fade" (lose much of their damping) in the first few minutes of hard use, as most previous dampers did. Second, the new dampers can be tuned to deliver a damping curve that actually corresponds to what you need. Earlier dampers were very hard in high speed compression; they delivered a mule kick when a sharp bump was hit at speed. This hardness forced riders to use their arms and legs as "living suspensions", leading to rapid operator fatigue. The new dampers avoid this by providing a bump damping curve that does not continue to rise with increasing suspension velocity.

I spoke with Jack Struthers of Carl's Cycle Shop (208-853-5550) who was one of the first to apply improved dampers (from Fox Shox) to snowmobiles. He indicated that Gerard Karpik had simulated similar suspension work on Polaris machines.

"Look at Polaris. Those three models with the gas shocks are half their sales. The XLT Special's biggest advantage is that 10" (of travel) up front. The move is definitely towards more travel. Polaris has 10" now, Arctic'll have more soon."

He went on to explain how much softer suspension can be when travel is extended, yet with improved bump handling ability. Where a stock sled of the old school might have 120-140 lb-per-inch spring rate, a sled with ten inches of travel can run less than half of that; 50-60 pounds per inch. For each inch that a bump compressed suspension on the older sled, an upward force of 120-140 pounds would be applied to the front of the machine, punching it upward. With long travel, this disturbing force is nearly cut in half.

"Of course, the danger is, you can get ton tall", Struthers continued, "And that can make your sled tippy." He also cautioned against homemade suspensions that look OK, but which produce toe changes (variation in the angle between the two skis) as they move through their stroke.

HEIGHT

Dampers with the coil spring mounted over them permit easy ride height adjustment by means of the threaded spring-seat collars. This allows the height and attitude of the sled to be adjusted. The taller you make the sled, the more weight will be transferred to the track during acceleration, and the less there will be on the skis for steering. Likewise a taller sled transfers more weight to the outside ski during turning--usually undesirable. There is a compromise here; adding suspension travel has to make the sled taller--and that, as Struthers noted above, can lead to poor turning. Tilting the sled back (higher in front/lower in the rear) increases rear end weight slightly, and vice versa.

DAMPING ADJUSTMENTS

If your adjustable dampers are part of the OEM package, begin with the recommended settings and remember that if you get "lost" in the process of tuning in your suspension, you can always go back to that baseline and begin again.

SET REBOUND FIRST

Otherwise it's best to start with both rebound and compression clickers at minimum damping and then move up from there. Begin with rebound (extension) damping first. It is controlled by the clicker on the shock body. Most suspension damping is accomplished on the rebound stroke because this produces less disturbance to the vehicle (it can't push it upward, as compression damping does).

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Always remember that the main purpose of suspension damping is to dispose of unwanted suspension energy; a bump lifts a ski, compressing a spring, thereby storing energy in it. If that energy is not disposed of, the sled may bounce again and again like a car with worn out shocks does after every bump. Therefore you should click in just enough damping to prevent bouncing, and stop there. Suspension has to move easily in order to do its job of isolating the sled from bumps--and if the damping is set too stiff, it will interfere with that job. There are powerful myths that die hard. A major one is "stiff is always best". This comes from jalopy racing, where chassis were floppy and dampers cost $2.50. The easiest way to make such a car stable was to make the suspension almost rigid. On a smooth track, that can work, but when the going is rough, suspension has to follow the ups and downs or you just go skating off the turns.

> "There are powerful myths that die hard. A major one is "stiff is always best".

One problem that comes with long travel and softer spring rate is chassis roll in turns. With the older stiff suspensions, turning response was quick and sharp because little time was wasted in chassis roll. But with softer spring rates, time is wasted as the chassis rolls toward the outside ski. This can be resisted with anti-roll bars as used in cars; when either ski rises by itself, it twists the bar, which resists the motion, but when both skis hit a bump together, only the suspension springs are compressed.

Damping must always be proportional to spring rate. Therefore expect to change damping when you switch to a harder or softer spring. A heavier rider or load may require stiffer springs; and vice versa. Likewise, a track with banked turns will place more load on suspension, requirinng more spring and damping.

How can you tell when you have too much rebound damping? When the damper is set too hard for the spring, the result is "packing"; each bump you hit compresses the suspension, but there isn't time for the spring to fully rebound between bumps because of the excessive damping. Therefore the suspension "packs down" and the sled gets lower and lower, with the ride getting progressively harder as the suspension travel disappears. Bottoming is the eventual result.

The better the traction, the higher the forces suspension must deal with. The faster the sled moves, the harder it hits the bumps, and the larger the spring/damper force that is required to absorb the hit. More traction also translates to more chassis roll because turns are taken faster. But when the track is rough and choppy, the suspension must move extra freely to find some grip, calling for softer action. Long travel widens the range of surfaces over which the suspension can cope, but as Jack Struthers notes, you can have too much of a good thing.

COMPRESSION DAMPING

For many years, quite adequate dampers were built with almost no compression damping at all. This is because compression damping was tricky to use with technology the way it was before the early 1980's. Compression valves tended to be too small, leading to very high damping forces when bumps were hit at high speed. No damping at all was less disturbing than wildly too much.

Compression damping can be very useful. For example, suppose that you have springs and rebound damping settings that are working well everywhere but in a sudden dip, where you are bottoming your sled and coming to the edge of control. You could stop the bottoming with stiffer springs, but that would make the sled too hard in a lot of other places, where it would skate. Therefore you try a bit of compression damping--just enough to give extra support in the dip, not enough to make the ride harsh.

Sometimes the amount of rebound damping needed for best average performance leaves the machine feeling "floaty" and uncertain. A bit of compression damping can firm up the feel.

OFF-SCALE

What happens when you dial the clickers up and

MORE ABOUT SUSPENSIONS

down through their range and can't find what you need? In this case, remember the clickers are just "trim" adjusters; they control a small flow orifice that is not part of the washer stacks, or "Christmas trees" that actually control medium and high speed damping. The clickers will move the damping curve up or down a small amount, but to change their shape, the damper has to come apart and the washers shuffled by an expert. That is why the damper makers send their service trucks to important competition events.

In order for suspension systems to work well, all the flex should be in the springs and all the friction should be in the dampers. In real life, the chassis is flexible, and there is friction in every suspension joint. Chassis flex is bad because it is a spring without a damper; set the chassis to flexing and there is no damping to stop the resulting chatter. Therefore racers add struts or even whole subframes to prevent chassis twist and flexure. This can settle skittery chassis down. Consider that a typical sheetmetal snowmobile chassis is like a cardboard box with the bottom cut out; it's easily twisted. When a hundred or more horsepower get to pulling in it, it gives, and the result is spring where there should be none.

Another flex related situation occurs when you move to stiffer springs to solve one problem, only to find that with them, your sled develops several new problems. The stiffer the spring, the less it deflects--and the more a flexible chassis is therefore forced to bend or twist. It is the undamped chassis bending and twisting that cause the new problems. Adding chassis stiffness in the right place will usually relieve the situation.

Suspension friction is bad because it is uncontrolled--especially in cases where the damper and spring are operated through leverage that multiplies the forces on suspension bushing and joints. This friction can be remarkably large when all the joints are loaded by spring force, mking your suspension stiffer and less responsive than it could be. All the friction should be where you can control it--in the damper. Ball joints and rubber or plastic bushings are suspect items; over time you will see low-friction bearing types take over jobs done by cheaper, more flexible, and friction-laden OEM parts. An example of such change is the ProShaft, which substitutes an aluminum track suspension shaft, turning in a low-friction Delrin (a type of nylon) bush, for the stock aluminum-on-steel combination.

What about damper temperature? I asked Jack Struthers that question, and he replied it takes only 2-3 minutes of operation to get a Fox shock up to operating temperature of 100-120 degrees (F). Damper overheating has been an issue in some hot-weather sports; not so on the snow.

Struthers also called attention to new products for tuning grip to local conditions; a new ski from Starting Line Products that "you can race with" , and the availability of tracks in a variety of tread patterns and heights between 5/8" and 2".

DON'T TRUST MEMORY ALONE

Now that suspension has become so adjustable, getting a good set-up takes time and may involve many settings; too many to remember. Therefore, write down what you have learned to save time next time--just as you already do with clutch. engine and stud data.

The new suspension technology is just a tool, not a solution. It can therefore be used well, or badly. Your brain is the best speed equipment you have.

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