Volume 4 Number 4 1992

DYNOTECH

THE SNOWMOBILE PERFORMANCE PUBLICATION

1992 ARCTIC CAT EXT SPECIAL

PERFORMANCE IMPROVEMENTS/STOCK AND MODIFIED PIPE SHOOTOUT

Present during test: Dale Roes, Mark Miller, Mike Salisbury, Larry Bartlett

For our EXT Special 550 performance improvement and pipe evaluation, we used a stock 1991 engine with 1200 miles on it as our baseline. Like many of the 650cc & 700cc Arctic Cat engines we have tested, this particular 550 exhibited slightly erratic fuel flow. We interpolated the fuel flow numbers, and were able to keep the Brake Specific Fuel Consumption safely in the high .60's. Throughout this test session, 92 octane gas was used.

1991 EXT SPECIAL STOCK BASELINE 86dB 38MM CARBS 280 MJ

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18
Barometer: 30.26

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5000	35.8	34.1	33.2	93.7	13.0	.95	47
5250	38.4	38.4	34.0	97.7	13.2	.87	47
5500	42.1	44.1	37.6	105.4	12.9	.84	47
5750	45.8	50.1	38.0	112.3	13.6	.74	47
6000	49.8	56.9	43.5	123.5	13.0	.75	47
6250	52.5	62.5	49.5	129.8	12.0	.77	46
6500	54.4	67.3	54.3	130.8	11.1	.79	47
6750	55.3	71.1	57.5	131.9	10.5	.79	47
7000	55.9	74.5	61.1	132.9	10.0	.80	46
7250	56.9	78.5	59.0	135.1	10.5	.73	45
7500	57.4	82.0	57.4	136.5	10.9	.68	45
7750	56.6	83.5	56.7	139.4	11.3	.66	44
8000	54.5	83.0	54.7	140.8	11.8	.64	45
8250	50.2	78.9	67.2	140.6	9.6	.83	45
8500	41.4	67.0	65.0	138.5	9.8	.95	46

We first installed a set of heads that had .020" removed from the sealing surfaces. A .020" head cut is a standard "tune-up" procedure on the 550 Special for D&D Cycle in Lowville, N.Y. (315-376-9191). Co-owner Dale Roes told us that he has had no reliability problems on the many stock 550 engines that he has modified in this manner. This would be the baseline for our stock engine Pipe Shootout.

We obtained the latest EXT Special 550 twin pipes from Decker Racing, Starting Line Products, PSI, and Black Magic. The DG twins that we had ordered did not arrive in time to be included (we have them now and will be testing them on a trail ported engine in late May). We did, however, have a DG single pipe which we included. Aaen has discontinued production of their EXT Special 550 twin pipes; they will be producing a single pipe for sale next season.

Both the PSI and SLP twin pipes use the stock bellypan opening. The others require bellypan modifications for proper fit.

As we have found with other Arctic Cat engines, the stock single exhaust works well on the stock engine. The DG single adds a horsepower and a half, and the four sets of twin pipes added between four horsepower (Black Magic) and seven and a half horsepower (Decker). All of the twin pipes had higher midrange torque and horsepower than stock, with the SLP twin pipes having the highest torque at 62.8 ft/lb.

EXT SPECIAL

CONTINUED

PIPE SHOOTOUT # 25

STOCK EXT SPECIAL

1991 EXT SPECIAL STOCK -.020 HEAD
38MM CARBS--280 MJ--STOCK PIPE

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18
Barometer:30.26

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5000	37.4	35.6	39.3	88.1	10.3	1.08	46
5250	41.6	41.6	35.0	101.5	13.3	.82	46
5500	44.0	46.1	37.3	108.0	13.3	.79	46
5750	47.6	52.1	37.5	115.0	14.1	.70	46
6000	52.3	59.7	44.3	124.9	12.9	.73	46
6250	53.7	63.9	47.5	129.3	12.5	.73	46
6500	56.5	69.9	53.5	133.0	11.4	.75	46
6750	57.5	73.9	57.7	132.8	10.6	.76	46
7000	58.6	78.1	57.9	133.7	10.6	.73	46
7250	59.2	81.7	61.5	135.0	10.1	.74	46
7500	59.4	84.8	61.3	137.6	10.3	.71	47
7750	58.3	86.0	65.7	140.0	9.8	. 75	46
8000	53.9	82.1	66.5	141.2	9.8	.79	46
8250	40.2	63.1	66.0	137.3	9.6	1.02	46
8500	34.6	56.0	72.6	132.2	8.4	1.26	46

1991 EXT SPECIAL STOCK -.020 HEAD
DG SINGLE PIPE--90 dB
38MM CARBS--280 MJ

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18
Barometer: 30.26

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5000	37.7	35.9	33.2	93.1	12.9	.90	45
5250	38.7	38.7	33.6	96.4	13.2	.85	46
5500	42.8	44.8	35.3	104.6	13.6	.77	47
5750	47.6	52.1	37.0	112.3	13.9	.69	46
6000	50.8	58.0	44.8	120.2	12.3	.76	47
6250	53.1	63.2	48.5	125.9	11.9	.75	47
6500	55.5	68.7	56.4	127.8	10.4	.80	47
6750	56.6	72.7	56.1	127.5	10.4	.76	47
7000	57.7	76.9	56.9	128.4	10.4	.72	47
7250	58.4	80.6	57.9	132.4	10.5	.70	47
7500	58.8	84.0	56.9	135.9	11.0	.66	48
7750	58.8	86.8	54.6	137.2	11.5	.62	47
8000	57.4	87.4	56.4	138.6	11.3	.63	48
8250	53.0	83.3	61.0	140.2	10.6	.72	47
8500	43.5	70.4	53.0	138.1	12.0	.74	46

1991 EXT SPECIAL STOCK -.020 HEAD
BLACK MAGIC TWINS--98dB--38MM CARBS--80 MJ

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18 Barometer: 30.26

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5000	34.5	32.8	35.7	90.2	11.6	1.07	47
5250	35.7	35.7	36.9	95.5	11.9	1.01	47
5500	38.9	40.7	33.1	103.6	14.4	.79	46
5750	42.9	47.0	39.9	113.3	13.0	.83	46
6000	46.8	53.5	40.4	122.1	13.9	.74	47
6250	49.4	58.8	47.1	131.0	12.8	.78	45
6500	54.1	67.0	51.3	138.7	12.4	.75	47
6750	58.2	74.8	68.5	142.3	9.5	.90	46
7000	60.6	80.8	59.2	143.3	11.1	.72	46
7250	62.1	85.7	60.8	143.8	10.9	.69	47
7500	61.0	87.1	70.5	143.9	9.4	.79	46
7750	59.8	88.2	58.9	143.8	11.2	.65	46
8000	59.0	89.9	47.0	145.8	14.2	.51	45
8250	58.2	91.4	63.0	150.2	10.9	.67	46
8500	56.2	91.0	58.7	153.8	12.0	.63	46
8750	49.3	82.1	63.3	152.2	11.0	.75	46

1991 EXT SPECIAL STOCK -.020 HEAD
NEW PSI TWIN PIPES--88dB--38MM CARBS--280 MJ

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18 Barometer: 30.24

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	51.3	58.6	37.1	131.2	16.2	.62	48
6250	53.8	64.0	40.5	139.8	15.8	.62	46
6500	58.6	72.5	56.3	145.2	11.8	.76	45
6750	60.3	77.5	63.8	142.9	10.3	.81	45
7000	61.9	82.5	59.9	141.2	10.8	.71	46
7250	61.5	84.9	62.6	139.2	10.2	.72	47
7500	60.9	87.0	59.6	140.8	10.8	.67	47
7750	61.1	90.2	51.8	143.9	12.8	.56	45
8000	61.5	93.7	61.3	150.6	11.3	.64	46
8250	54.3	85.3	69.6	154.2	10.2	.80	45
8500	44.9	72.7	68.7	149.1	10.0	.92	47
8750	38.1	63.5	62.8	141.8	10.4	.97	45

1991 EXT SPECIAL STOCK -.020 HEAD
NEW SLP TWINS--92dB--38MM CARBS--280 MJ

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18 Barometer: 30.22

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	51.5	58.8	39.3	130.9	15.3	.65	46
6250	54.7	65.1	44.8	142.5	14.6	.67	46
6500	57.4	71.0	50.7	144.7	13.1	.70	46
6750	59.4	76.3	55.4	143.3	11.9	.71	47
7000	62.8	83.7	69.9	143.8	9.4	.82	47
7250	62.5	86.3	59.2	143.9	11.2	.67	46
7500	61.1	87.3	59.7	143.5	11.0	.67	46
7750	61.1	90.2	59.5	145.3	11.2	.65	45
8000	61.0	92.9	50.6	150.7	13.7	.53	45
8250	56.3	88.4	69.0	158.2	10.5	.76	41
8500	44.8	72.5	71.9	152.1	9.7	.97	45
8750	37.9	63.1	73.0	144.0	9.1	1.13	46

1991 EXT SPECIAL STOCK -.020 HEAD
DECKER TWINS
38MM CARBS--280 MJ
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18
Barometer: 30.24

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	54.2	61.9	45.1	140.5	14.3	.71	47
6250	56.9	67.7	49.4	145.1	13.5	.72	47
6500	58.0	71.8	58.5	146.0	11.5	.80	46
6750	60.3	77.5	62.8	144.6	10.6	.79	46
7000	61.7	82.2	60.0	143.3	11.0	.71	46
7250	61.2	84.5	62.4	142.0	10.5	.72	46
7500	60.3	86.1	71.6	142.2	9.1	.81	46
7750	61.1	90.2	56.3	144.8	11.8	.61	46
8000	61.7	94.0	55.9	149.4	12.3	.58	46
8250	50.7	79.6	68.6	150.5	10.1	.84	46
8500	44.0	71.2	62.2	147.2	10.9	.86	47
8750	36.7	61.1	54.9	140.0	11.7	.88	46

PIPE SHOOTOUT # 26

MODIFIED EXT SPECIAL

We next installed a set of cylinders that had been "trail" ported by Dale Roes, with the same heads that had .020" removed from them. Dale's "trail porting" specs are similar to the EXT 550 cylinders we tested in Vol3 #6, but with slightly lower exhaust and transfer ports. The intake ports were also a bit more conservative, with the usual rough finish and rounded leading edges. Transfer ports were bead-blasted, and exhaust ports were polished.

Along with a gutted airbox (a modification that does nothing for a stock engine, but added five percent to the ported cylinders' airflow), the engine flowed 14% more air, and made 12% more horsepower. The following data is shown with the stock 38mm carbs having been bored to 39.2mm. ***The larger carbs added no airflow or horsepower to the trail ported engine!*** The larger carbs' reduced velocity, however, caused fuel flow to lean out, and horsepower to rise slightly. Increasing the main jet size corrected the fuel flow, and horsepower was then identical to the stock carbs.

The first test shown is with the stock single pipe installed.

1991 EXT SPECIAL w/ PORTED CYLS. -.020 HEAD
BASELINE--GUT AIRBOX--STOCK SINGLE PIPE
39.2MM CARBS--320 MJ
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18 Barometer: 30.21

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	40.9	42.8	33.9	115.2	15.6	.78	47
5750	41.4	45.3	36.7	119.2	14.9	.79	45
6000	46.5	53.1	41.8	126.0	13.8	.77	47
6250	49.7	59.1	44.3	132.2	13.7	.74	48
6500	52.7	65.2	48.1	139.2	13.3	.73	48
6750	55.7	71.6	48.4	143.7	13.6	.66	48
7000	59.1	78.8	51.6	146.0	13.0	.64	49
7250	61.2	84.5	67.5	151.0	10.3	.79	49
7500	62.2	88.8	62.4	154.5	11.4	.69	48
7750	64.1	94.6	58.8	158.7	12.4	.61	48
8000	63.2	96.3	60.1	161.1	12.3	.61	48
8250	59.7	93.8	64.2	161.8	11.6	.67	47
8500	43.6	70.6	67.4	155.5	10.6	.94	47
8750	35.1	58.5	69.3	145.7	9.7	1.16	48

1991 EXT SPECIAL w/ PORTED CYLS. -.020 HEAD
GUT AIRBOX--*DG PIPE*
39.2MM CARBS--320 MJ
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18 Barometer: 30.22

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	40.9	42.8	30.8	114.2	17.0	.70	48
5750	42.3	46.3	38.0	120.1	14.5	.81	48
6000	46.6	53.2	43.7	126.6	13.3	.80	48
6250	51.0	60.7	48.6	134.3	12.7	.79	49
6500	54.2	67.1	51.5	141.2	12.6	.76	48
6750	57.0	73.3	46.7	144.5	14.2	.63	48
7000	59.0	78.6	47.1	147.2	14.3	.59	49
7250	61.4	84.6	61.8	151.5	11.3	.72	49
7500	62.7	89.5	66.5	155.9	10.8	.73	49
7750	63.9	94.3	54.2	159.5	13.5	.57	49
8000	61.6	93.8	64.7	161.8	11.5	.68	48

1991 EXT SPECIAL w/PORTED CYLS. -.020 HEAD
GUT AIRBOX--*BLACK MAGIC TWIN TRAIL PIPES*
39.2MM CARBS--320 MJ
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18 Barometer: 30.22

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6500	55.1	68.2	51.4	147.2	13.1	.74	49
6750	57.6	74.0	51.1	151.6	13.6	.68	49
7000	60.2	80.2	57.7	154.8	12.3	.71	49
7250	61.9	85.4	66.0	157.1	10.9	.76	49
7500	62.9	89.8	62.3	158.8	11.7	.68	49
7750	63.5	93.7	67.5	160.9	10.9	.71	49
8000	64.1	97.6	61.0	163.5	12.3	.61	49
8250	64.6	101.5	71.3	168.1	10.8	.69	48
8500	64.1	103.7	64.9	171.6	12.1	.62	48
8750	59.9	99.8	71.9	170.7	10.9	.71	48
9000	49.9	85.5	70.8	164.7	10.7	.81	48

EXT SPECIAL

1991 EXT SPECIAL w/ PORTED CYLS. -.020 HEAD
GUT AIRBOX--*PSI TWIN PIPES*
39.2MM CARBS 320 MJ
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18 Barometer: 30.22

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6500	55.8	69.1	54.3	151.9	12.8	.77	47
6750	58.3	74.9	50.0	153.4	14.1	.66	48
7000	60.6	80.8	49.3	153.0	14.2	.60	48
7250	61.4	84.8	55.0	153.6	12.8	.64	47
7500	62.6	89.4	62.3	155.7	11.5	.68	49
7750	65.0	95.9	61.5	162.7	12.1	.63	48
8000	68.1	103.7	67.4	172.6	11.8	.64	47
8250	66.9	105.1	71.7	175.7	11.3	.67	48
8500	60.7	98.2	68.1	175.3	11.8	.68	47
8750	45.1	75.1	69.3	166.0	11.0	.90	47

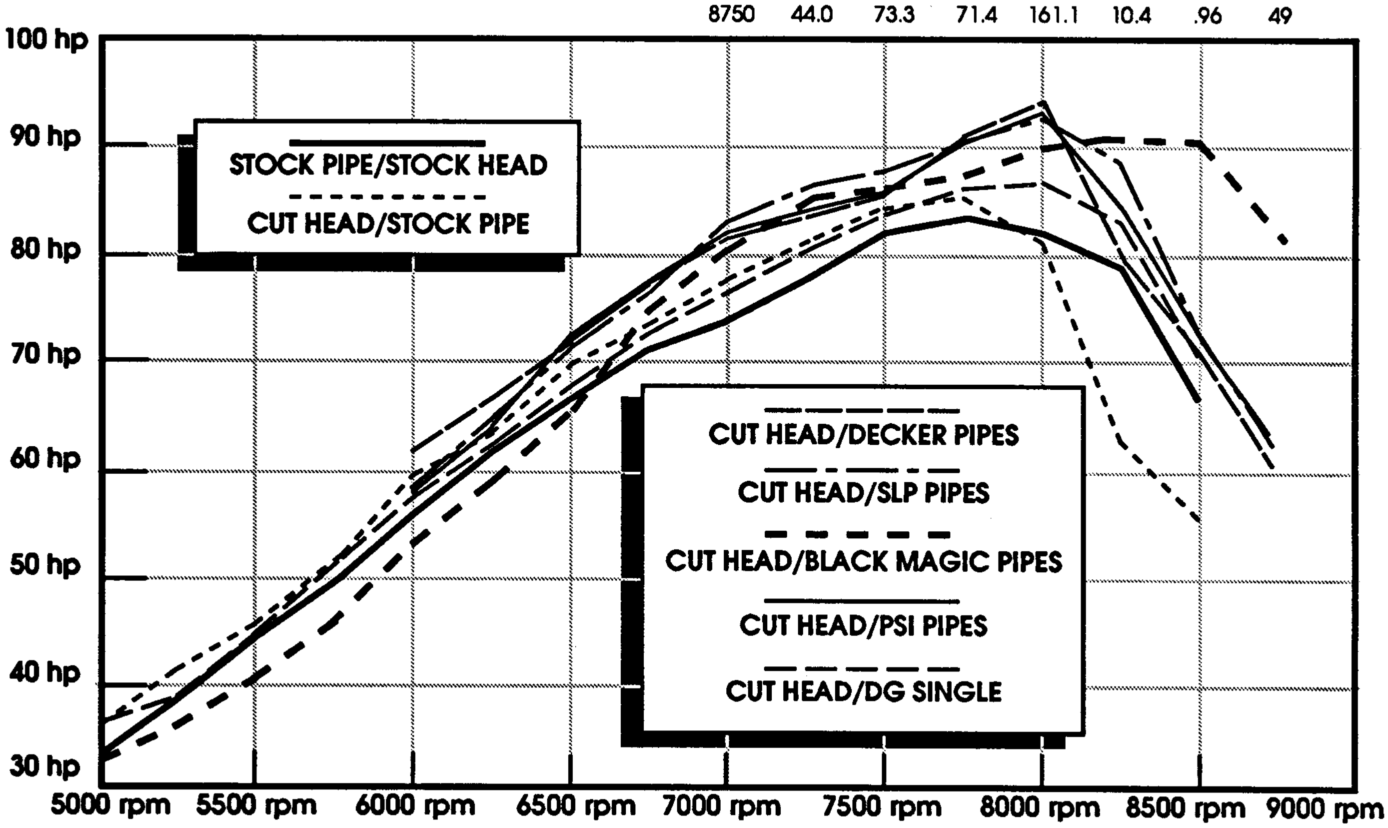
1991 EXT SPECIAL w/ PORTED CYLS. -.020 HEAD
GUT AIRBOX--*SLP TWIN PIPES*
39.2MM CARBS--320 MJ
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18 Barometer: 30.22

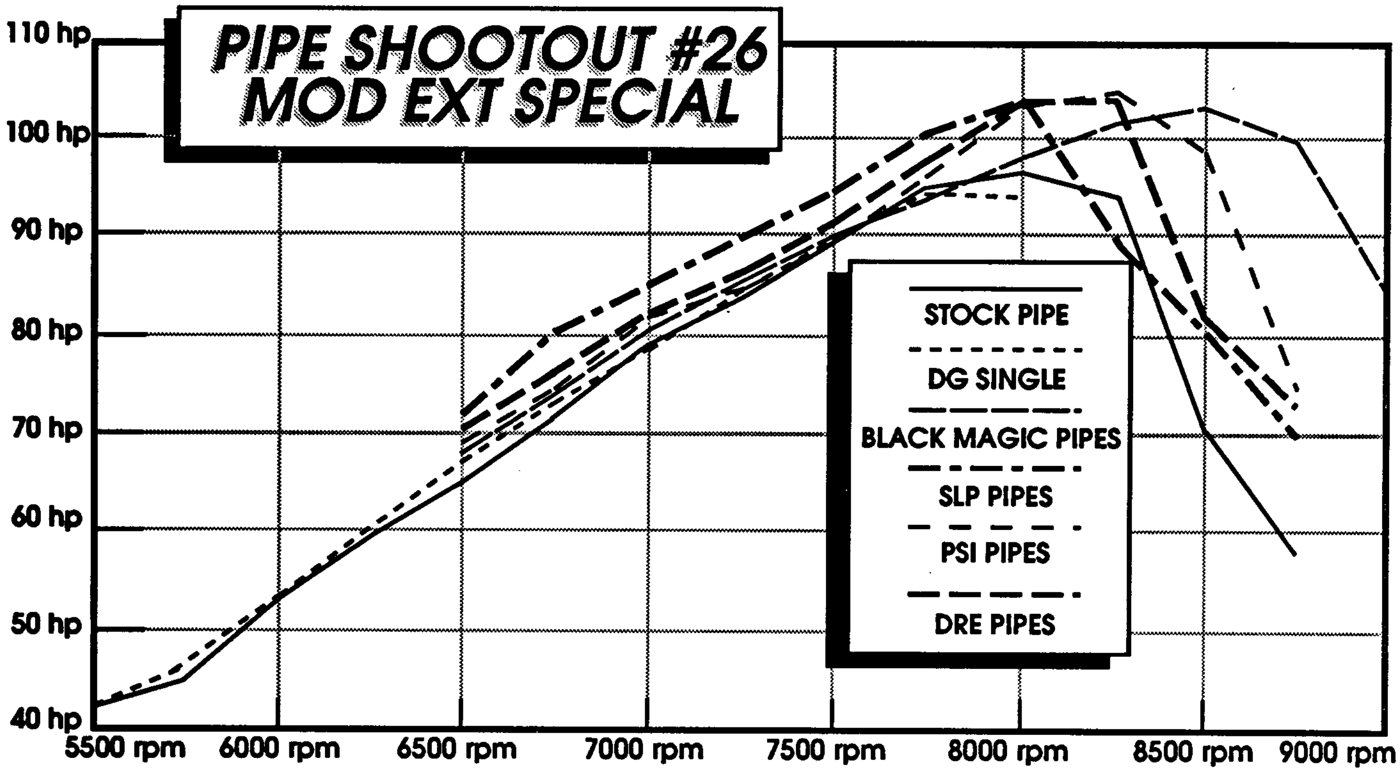
RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6500	58.2	72.0	56.7	156.6	12.7	.77	44
6750	62.4	80.2	46.2	158.7	15.8	.57	48
7000	63.7	84.9	55.7	159.2	13.1	.64	47
7250	64.8	89.5	71.7	159.2	10.2	.79	48
7500	66.2	94.5	60.3	164.3	12.5	.63	47
7750	68.1	100.5	63.4	169.1	12.2	.62	47
8000	68.5	104.3	64.9	175.1	12.4	.61	47
8250	56.2	88.3	63.0	173.6	12.7	.70	50
8500	50.0	80.9	63.1	168.5	12.3	.76	48
8750	41.9	69.8	62.5	161.0	11.8	.88	48

1991 EXT SPECIAL w/ PORTED CYLS. -.020 HEAD
GUT AIRBOX--*DECKER TWIN PIPES*
39.2MM CARBS 320 MJ
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .742
Vapor Pressure: .18 Barometer: 30.21

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6500	57.3	70.9	52.2	152.8	13.4	.73	49
6750	59.6	76.6	49.7	154.4	14.3	.64	48
7000	61.3	81.7	55.2	154.3	12.8	.67	49
7250	62.3	86.0	58.5	156.5	12.3	.67	49
7500	63.7	91.0	76.5	159.8	9.6	.83	49
7750	66.3	97.8	55.7	164.8	13.6	.56	49
8000	68.2	103.9	62.9	171.1	12.5	.60	48
8250	66.4	104.3	69.1	173.2	11.5	.65	48
8500	51.1	82.7	71.4	165.7	10.7	.85	48
8750	44.0	73.3	71.4	161.1	10.4	.96	49

PIPE SHOOTOUT #25
STOCK EXT SPECIAL





1992 Ski Doo FORMULA PLUS X

STOCK EVALUATION

WEIGHT WITH 3 GALLONS GAS:557 LBS.

Sled owner: Kevin Goddard, Onsted, Mi.

The 1992 Ski Doo Formula Plus X 580cc engine is virtually identical to the 1990 Mach 1 580, with the exception of a thinner .3mm basegasket. I would surmise that this Plus X engine has either a different timing curve or slightly lower compression than the '90 Mach 1 we tested in Vol2 #1. Their peak horsepower is nearly identical, but the Plus X has less midrange torque and horsepower, and a bit more beyond the peak.

Because of the multiple airbox openings, it was impractical to obtain airflow readings. 330-350 main jets provided correct fuel flow for the 37 degree F Carb Air Temperature. 94 octane fuel was used.

For 1993, the Plus X will get the 617cc Mach 1 engine. The new Mach 1, in turn, will use the 670cc Mach 1X engine with a single pipe and 40mm carbs.

1992 FORMULA PLUS X

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .744
Vapor Pressure: .14
Barometer: 30.11

RPM	CBT	CBHP	FUEL	BSFC	CAT
6250	58.0	69.0	50.5	.71	38
6500	63.3	78.3	56.9	.71	38
6750	69.2	88.9	65.4	.72	38
7000	69.7	92.9	67.6	.71	38
7250	70.3	97.0	67.2	.67	37
7500	69.8	99.7	62.7	.61	37
7750	67.2	99.2	61.9	.61	37
8000	55.3	84.2	65.4	.75	37

Starting Line Products' RZ 500 Top End Kit for the Polaris Indy 500

Present during test: Jim Czekala, sled owner Mike Schmidt & Dan Cross

The Starting Line Products "RZ500" kit is a complete top end replacement for the Indy 500 twin. Included are an iron sleeved, cast aluminum, reed valve inducted twin cylinder assembly, new matching head, and new cast pistons. Both the cylinder and head are custom castings manufactured by SLP.

One of the advantages of the RZ500 top end is that there is no turnaround time required. It is a shelf item for SLP, and simply bolts in place of the stock top end. Plus, the purchaser has the option of selling his 500 top end, or being able to return his sled to original condition at trade-in time.

How do they work in the field?

Subscriber feedback on the RZ500 has been primarily favorable--with a few exceptions. One RZ500 owner has had difficulty with the power sometimes suddenly going flat at the correct operating RPM. Most others, however, report that they are pleased with the performance.

The RZ500 exhibits a somewhat peaky horsepower curve. It may require a good clutch person to get the engine operating at maximum horsepower--probably at between 8000-8200 RPM, depending upon pipe temperature.

But, if you want your Indy 500 to make 100 horsepower on pump gas, this is the only game in town (although we still haven't tried PSI's Genesis 550 replacement top end yet). A turbocharged Indy 500 will make that kind of power on pump gas, but it requires constant carburetor fiddling while trail riding.

We began our test session with a stock 1990 Indy 500 twin. This engine was freshly rebuilt, with new rings and pistons. Ignition timing was correct, checked with a dial indicator and timing light (it pays to double check the flywheel marks on these engines). The head had been cut .015". Carbs were bored to 39.2mm. Q2 needle jets were retained and the airbox was gutted. 32-1 premixed 92 octane unleaded gas was used for this part of the test.

1990 INDY 500--HEAD CUT .015
39.2 MM CARBS--430 MJ--Q2 NJ
STOCK SINGLE PIPE 86dB
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .746
Vapor Pressure: .15
Barometer: 29.71

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	41.7	47.6	43.6	108.7	11.4	.90	29
6250	44.7	53.2	40.7	117.0	13.2	.75	29
6500	49.2	60.9	42.4	124.1	13.4	.68	29
6750	51.0	65.5	44.3	131.1	13.6	.66	27
7000	52.4	69.8	44.5	134.1	13.8	.62	28
7250	53.6	74.0	45.9	138.1	13.8	.61	29
7500	53.1	75.8	47.6	138.5	13.4	.61	29
7750	51.6	76.1	47.4	138.4	13.4	.61	28
8000	49.0	74.6	47.5	137.6	13.3	.62	29
8250	35.5	55.8	46.7	136.4	13.4	.82	29
8500	25.7	41.6	46.2	133.0	13.2	1.08	29

After completing the baseline testing on the stock engine, we took the opportunity to see how the twin DG pipes and the new quiet SLP Indy 500S pipes would work on the stock engine.

1990 INDY 500 HEAD CUT .015
39.2 MM CARBS--330 MJ--Q2 NJ
1991 DG TWIN PIPES
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .746
Vapor Pressure: .15
Barometer: 29.66

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	40.3	46.0	38.5	121.3	14.5	.82	34
6250	41.7	49.6	39.9	122.1	14.1	.79	34
6500	49.9	61.8	44.7	129.5	13.3	.72	35
6750	50.4	64.8	45.8	131.4	13.2	.70	36
7000	51.2	68.2	46.4	134.1	13.3	.67	34
7250	51.2	70.7	47.6	136.0	13.1	.66	34
7500	50.8	72.5	46.7	136.3	13.4	.64	34
7750	49.8	73.5	48.1	135.6	12.9	.65	34
8000	48.8	74.3	47.6	135.4	13.1	.63	35
8250	47.2	74.1	47.9	137.2	13.2	.64	34

1990 INDY 500 HEAD CUT .015
39.2 MM CARBS--330 MJ--Q2 NJ
SLP 500S TWIN PIPES 88 dB
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .746
Vapor Pressure: .15 Barometer: 29.65

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	47.6	54.4	40.9	129.3	14.5	.74	29
6250	48.5	57.7	44.3	131.3	13.6	.75	29
6500	49.6	61.4	45.6	131.0	13.2	.73	30
6750	52.4	67.3	44.2	133.4	13.9	.65	30
7000	53.0	70.6	46.6	134.7	13.3	.65	30
7250	52.2	72.1	48.2	135.2	12.9	.66	30
7500	51.2	73.1	47.7	134.6	13.0	.64	30
7750	50.0	73.8	47.6	132.9	12.8	.63	30
8000	51.6	78.6	47.6	135.6	13.1	.60	30
8250	50.7	79.6	47.9	141.4	13.6	.59	29
8500	46.9	75.9	50.3	144.8	13.2	.65	29
8750	37.7	62.8	51.1	143.2	12.9	.80	30

We then installed the RZ500 top end and switched to 100+ octane gas to establish the initial jetting. Note that the reed valve engine required much larger main jets to maintain a safe A/F ratio and BSFC. After the jetting was determined to be safe, we went back to the 92 octane gas, to assure Mike that the engine would survive with the jetting we suggested, before he headed out for a trail riding vacation.

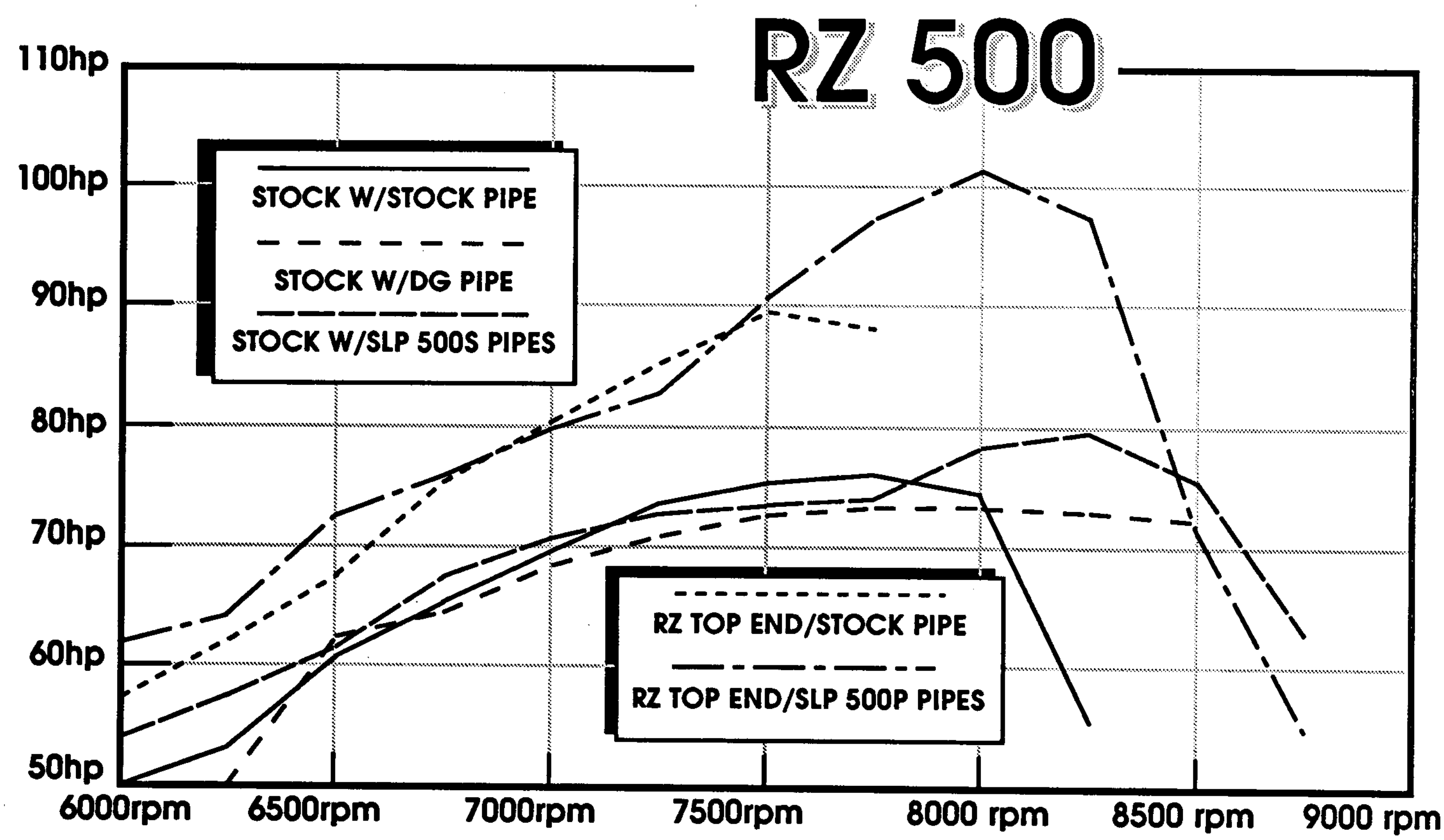
***Since this evaluation was completed, Mike put over 1500 Quebec trail miles on his RZ500. Other than one mild seizure, he was pleased with the reliability and performance.**

1990 INDY 500 W/RZ 500 TOP END
39.2 MM CARBS--400 MJ--Q2 NJ
STOCK PIPE
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .746
Vapor Pressure: .15 Barometer: 29.91

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	50.7	57.9	41.0	120.1	13.5	.69	33
6250	52.3	62.2	42.4	124.3	13.5	.66	33
6500	54.8	67.8	45.9	132.1	13.2	.66	34
6750	58.7	75.4	50.4	141.2	12.9	.65	35
7000	60.2	80.2	55.0	147.8	12.3	.67	34
7250	62.1	85.7	57.4	152.5	12.2	.66	35
7500	62.5	89.3	59.8	155.6	11.9	.65	35
7750	59.7	88.1	61.5	157.0	11.7	.68	35

1990 INDY 500 w/RZ 500 TOP END
39.2 MM CARBS--430 MJ--Q2 NJ
SLP 500P TWIN PIPES
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .746
Vapor Pressure: .15 Barometer: 29.91

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	54.3	62.0	43.9	133.2	13.9	.69	29
6250	54.2	64.5	45.8	134.4	13.5	.69	29
6500	58.3	72.2	51.3	142.6	12.8	.69	28
6750	59.1	76.0	56.4	147.7	12.0	.72	27
7000	59.9	79.8	56.4	148.4	12.1	.69	29
7250	60.2	83.1	57.3	149.5	12.0	.67	30
7500	63.2	90.3	58.7	153.3	12.0	.63	29
7750	65.8	97.1	59.1	159.6	12.4	.59	29
8000	66.4	101.1	62.6	168.8	12.4	.60	30
8250	61.8	97.1	62.2	171.9	12.7	.62	30
8500	44.2	71.5	64.2	162.7	11.6	.87	29
8750	33.0	55.0	61.9	153.2	11.4	1.09	30



PROJECT SLED TURBO YAMAHA V-MAX 4

TURBOCHARGED V-MAX 4

In the last FEEDBACK, I made mention of the fact that Greg Bennett of First Choice Turbo Center (716-226-2929) was installing a rare Generation IV, high volume AeroDyne turbocharger on our V-Max 4 project sled. DP Tool does Greg's machining and porting, and they used their CNC machining center to make billet aluminum and stainless steel airbox adaptors, baffles, and reinforcing brackets to facilitate "force feeding" air to the four cylinder Yamaha 750. The turbo is mounted next to the recoil cover, with a mig welded Y pipe to connect the stock twin pipes to the turbo exhaust inlet. Exhaust is ducted down and out the stock bellypan opening, with a short baffled silencer providing a pleasantly quiet, Lamborghini-like wail.

The turbo air intake is behind the louvers in the right side of the hood. Air is compressed and delivered to the twin airboxes through a neoprene hose snaking above the carbs to a stainless steel Tee which divides the airflow.

A complete Bosch electronic fuel management system (pioneered by Kip Campbell and Forest Lake Motor Sports--see Kip's letter "Turbos--a secret kept too long" in Vol2 #6) is used to ensure ample fuel flow to the engine.

One of the unique features of AeroDyne turbochargers is the oiling system. Turbo lubrication is accomplished by a built-in reservoir that wicks oil to a set of air-cooled ball bearings on the compressor shaft. No external tanks or oil pumps are needed.

Boost pressure is controlled by a set of movable vanes in the exhaust housing. These vanes react to a preset boost sensing external controller mounted on the outside of the turbo.

Our V-Max 4 had Bender Racing's engine "tune-up", including raised cylinders (thicker basegaskets), windowed intake skirts, and higher compression. When Greg installed the turbo kit, we left the engine as it was to see how it would react on the dyno compared to the bone-stock 200+ CBHP V-Max 4 turbo that Michigander Phil Walker had tested in January.

When we first tested our "tuned up" engine on the dyno, Greg installed a seven psi turbo controller. The engine made 200 horsepower at 7 1/2 psi of boost, with over 130 ft/lb of torque, similar to the stock V-Max turbo we had tested previously. But, the engine airflow was 15-20% higher, indicating that the windowed intake skirts were allowing the turbo to blow excessive air/fuel mixture through the engine. For fun, we installed a higher boost level controller and tested the V-Max 4 at 13 PSI. For ten seconds, it made 239 CBHP with 150 ft/lb of torque (248 psi BMEP!) before a ring land broke. The stock cast pistons appear to be the least durable part of the engine.

Next, we installed four stock, unwindowed Yamaha pistons (SwainTech TBC coated for protection), and with the boost back at 7 1/2 PSI, the engine again made 200 CBHP, and the airflow dropped to around 320 SCFM. The slightly extended port timing of the "tuneup" kit apparently didn't affect horsepower much.

Testing the large-turbo V-Max 4 at 200 CBHP at Big Moose Lake was a ball. Part throttle operation with the small pressurized flatslide carbs was excellent--much more forgiving than the large 38mm roundslides on my turbocharged Indy 500. The power band is so wide, even I could clutch it (I was running a 108C Comet with weld-goobered 78 gram weights and a steep Yamaha multi-angle helix). With an engagement of around 4800 RPM (thanks to the monster spring Pete Webb loaned me), the engine was bog-free from a dead stop. Boost came up quickly enough to haze the track for 50 ft., then pull unbelievably hard to 100 MPH in 660 ft. on radar. Twenty DynoTech subscribers have taken turns riding the turbo V-Max 4, and everyone has come back grinning. Even Cat Man Big Bob Goudreau, as jaded as he is, enjoyed it. 130 ft/lb of torque at 8000 RPM is fun.

Backshifting and roll-on performance were another story. During acceleration under boost, you sometimes have to momentarily let off of the throttle to steer the sled (the chassis twisted enough after the track hooked up to cause the V-Max 4 to pull to the right). The boost would drop quickly,

TURBO V-MAX 4 CONTINUED

and it would take forever to come back. Backshifting was almost nonexistant.

Roll-on contests were most enjoyable when done with pals who would wait for the large turbo to "spool up". Bruce Schrader, who was having fun with his 180 CBHP quad piped V-Max 4, would occasionally (not always) extend me the courtesy of such patience. Dragging the brake while applying throttle to build boost helped, but was hardly practical and extremely hard on belts and brake pads.

THE NEW AERODYNE SERIES 53 TURBO

One week later, AeroDyne shipped Greg a rare Series 53 low inertia turbocharger. According to AeroDyne it is sized perfectly for the airflow that the V-Max 4 needs for optimum performance at 7-10 psi boost levels.

Greg fitted the Series 53 turbo to the V-Max 4, and we were back on the dyno where we came up with the following test data. The smaller turbocharger requires just a bit more boost to obtain the same horsepower as the large turbo; it now takes a little over eight psi of boost to attain 200 CBHP. But, it comes on instantly. With the sled on the dyno, the boost gauge would jump as quickly as the throttle was whacked open.

1992 V-MAX TURBO PROJECT SLED SERIES 53 AERODYNE TURBO

Data for 29.92 inches Hg, 60 F dry air
Test: 200 RPM/Sec Acceleration
Fuel Specific Gravity: .737
Vapor Pressure: .23
Barometer: 30.12

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT	MAN-P (IN HG)
7000	115.6	154.1	109.9	284.5	11.9	.71	54	16.02
7250	120.1	165.8	108.3	296.6	12.6	.65	54	16.32
7500	125.2	178.8	116.7	305.6	12.5	.64	55	16.54
7750	127.8	188.6	114.8	316.2	13.2	.61	54	16.52
8000	129.6	197.4	118.1	327.5	13.3	.60	52	16.62
8250	127.8	200.8	118.0	330.5	13.4	.59	53	16.49
8500	123.2	199.4	121.5	330.9	12.8	.61	53	16.82
8750	114.3	190.4	118.5	331.1	12.8	.62	53	17.09

I was fortunate to have late season cold weather near Ottawa, Ontario, Canada to field test the Series 53 turbocharged V-Max 4, at 8 psi boost, before the snow and ice were gone. Arnprior Sportland had a set of '93 V-Max 4 clutches that they calibrated for the turbo. The new weights have a more agressive profile, and two rivet holes. The heaviest weights (double lead) with a light spring (no color) combined with the new polished or chrome plated helix worked great in the new Yamaha clutches.

With the smaller turbo, clutch engagement needs to be around 4500 RPM. Acceleration seems even better than before, with boost coming on immediately, reaching 8 psi in perhaps a second. More importantly, the backshifting and roll-on performance are excellent. Now, the throttle can be rolled off and on at will; boost comes back instantly.

Even while cruising at part throttle, the boost guage registers pressure in the airbox. So, when you open the throttle, the effect of the turbo is immediate. My pals don't have to wait for the turbo to spool up any more. Some might even say it's a bit abrupt--but I like it.

Is a V-Max 4 turbo for everyone? A turbocharger is not for those who spend most of their time trail riding through the woods, bar hopping, or running over slow, moguled trails.

But, this turbo may be an alternative for the V-Max 4 owner who wants to do it all--have a fast, pump gas machine that one can ride off the trail and be competitive on the lakes. And, one doesn't have to be a mechanical engineer to install, maintain, and clutch it.

Attracting a crowd is also inevitable--I enjoy doing that to help promote what we do at DynoTech. The unusual high-pitched shriek of the exhaust does it initially. Then, seeing a 200 horsepower V-Max 4 run on the lake tops it off.

It's not cheap--Greg is currently charging $3500 for the complete Series 53 V-Max 4 turbo system. But, what's it worth to always have enough horsepower?

FEEDBACK BACKFEED

Jim Czekala

THE WAR OF THE HORSES

Huge new, three cylinder case reed engines are coming this year from Arctco, Bombardier, and Polaris. I suspect that as the manufacturers try to "outdo" Yamaha and each other, stock, out of the crate horsepower in the 150+ range will be available soon.

Up until this year, only the best of the Formula III factory racing sleds have generated 150+ CBHP. Even extremely experienced drivers have their hands full safely negotiating haybale lined race courses with 150 CBHP in a chassis set up for racing. This year, anyone 16 or older with enough cash or credit will be able to drive off the showroom floor with FIII horsepower in stock chassis' virtually unchanged since the days when a 92 CBHP engine was "big iron".

To their credit, the factories are constantly working on updating the chassis' to achieve the handling and braking necessary to match the new horsepower. For example, Polaris has lowered the engine in the new Indy Storm chassis some two inches. The Storm also has a more substantial, water cooled braking system to help stop what is sure to be a faster machine. In their V-Max 4 chassis, Yamaha makes more extensive use of aluminum in the bulkhead area. Aluminum has the advantage of being lighter, easier to fabricate, and more corrosion resistant than steel.

Early attempts by Bombardier to use thinner, stronger chromoly steel in their "X" chassis' resulted in some structural failures caused by cracking next to the welds .(The extra carbon in chromoly steel leads to the formation of large, visible crystals of brittle martensite when the welded steel is allowed to cool just a bit too quickly). Bombardier is now reportedly investing heavily in robotics and fabrication equipment to deal with the increased use of aluminum in their chassis'. Not only on the Z, but other chassis' as well.

As of early spring, Arctco was still revising the chassis on their monster 900cc ThunderCat. We're not sure whether they're attempting to save weight, improve handling, increase durability, or all of the above.

We all hope that the track manufacturers are working on developing a more flexible, lighter, stronger drive track. As track technology also catches up with the new engines, snowmobile performance and safety will greatly improve. Holes should be molded in so that we don't have to destroy the belting when cutting or burning holes for traction devices.

DEJA VU

Musclesled buyers of the 1990's are experiencing now just what the muscle*bike* buyers experienced in the 1970's and 1980's. Every year, the motorcycling King of the Hill would be "dethroned" by another manufacturer's engineering marvel. It became a marketing game for the manufacturers. Those with the quickest published quarter mile times sold the most bikes.

In 1977, I purchased a new four cylinder Kawasaki KZ1000 motorcycle. It was quicker than anything in the universe; 78 CBHP and 12.8 second quarter mile speeds made up for the evil handling chassis that would bob and wobble while trying to negotiate turns. I was proud to own the King of Acceleration. I believed, as I drove away in my new KZ1000, that no one would ever be able to top this wild machine. Surely, the "government" would step in and ban such awesome machinery. Boy, was I wrong!

The next year, Suzuki came along and bested the Kawasaki's performance with the GS1000. With a bit more power and little better handling, it was the new King.

Then, it was Yamaha's turn. The then-mighty XS1100 was the first motorcycle into the elevens (quarter mile time by a 92 lb. Cycle Magazine test rider). In the minds of the public, the KZ1000 and GS1000 were now dogs.

The next year, Honda unleashed the CBX--a wide, six cylinder monster which when viewed from the front looked like a calliope with a single front wheel and handlebars! The CBX's low, eleven second quarter mile times literally made my old KZ1000 obsolete.

The good motorcycle publications like "Cycle" and "Motorcyclist" fueled this performance "war" by providing consumers with real dyno test results, track times, and honest riding evaluations.

I couldn't afford to trade bikes each year while all of this was going on, so it was "hopup time". Back then, the west coast was loaded with aftermarket companies specializing in Japanese motorcycle performance. I bought a four-into-one megaphone header from Denco Engineering, which made lots of neighbor-irritating noise and maybe a bit more performance. A big-bore kit was supplied by RC Engineering. Then, Vance & Hines fixed me up with big carbs and camshafts. But I just couldn't keep up. Finally, I wound up with an American Turbo Pack turbocharger kit that allowed my KZ1000 (then up to 1105 cc) to stay ahead of each successive year's "King" by increasing the turbo boost level. But, with its original horsepower doubled, the Kawasaki's attention-getting cornering ills were also doubled! It now even wobbled when going in a straight line (Lots of fun at 140 MPH).

Meanwhile, the tens of thousands of performance addicts like myself enabled the west coast aftermarketeers to prosper.

Over the past fifteen years, the motorcycling "throne" has changed hands many times, but it's beginning to mellow out. While Japanese motorcycle engine performance levels are double what they were two decades ago, chassis handling capabilites have probably quadrupled! All of the new, liquid cooled performance musclebikes from each Japanese manufacturer are capable of 10 second quarter mile times with ride, handling and braking qualities that would make a 1980's Grand Prix champion envious.

Today, you can drive off the showroom floor on an exhilarating street and emmisions legal Kawasaki ZX-11 that will accelerate to 130 MPH in 10 seconds. Riding a stock KZ 1000 is like riding a moped. Sound familiar? The motorcycle consumer asked for the Ultimate Performance, and the factories provided it. But, what about the aftermarket guys who used to sell motorcycle hop-up components? Not much need for them anymore. Besides, stringent EPA regulations prohibit tampering with carburetors and anything else that would affect engine emmisions. Denco, RC Engineering, and American Turbo Pac are all gone. So are Motorcyclist and Cycle Magazines.

Sure, there are still a few street lunatics who want to go 150 MPH in 9 seconds, but the remaining aftermarket companies (some good ones have managed to survive) live off of a few thousand professional and amateur motorcycle drag and roadracers. The street performance market, which comprised the bulk of motorcycle aftermarket performance sales ten years ago, is now a shadow of its former self.

So, will the smowmobile industry follow the trend of the motorcycle industry? We should know by the turn of the century--just eight years from now. Maybe by then, if one desires a 130 MPH snowmobile, he or she will be able to purchase one. No more aftermarket pipes, porting, or tuning creativity will be required to go fast. They may all have EPA approved emmisions, EFI, mapped digital ignitions, and computerized transmissions--guaranteeing maximum performance all of the time.

Is this whole scenario good or bad? I would invite written opinions on this. I personally have mixed feelings. In the year 2000, there may not be much need for modifying or tuning snowmobile engines on our dyno. If the factories succeed in providing perfect performance machinery to the consumer, there also may not be much of a demand for the type of information that is published in DynoTech. It may put me out of a "job" that I enjoy. But then, maybe I'll have free time in the winter to go out and ride my new 130 MPH stocker.

GRASS DRAG SEASON

The grass dragracing season is upon us already. The popularity of grass drags has exploded in the east over the past year, and the new big musclesleds are helping to fuel the enthusiasm.

I'm glad that I don't have to classify all of the new models; there must be a dozen new machines that fall between the cracks of several classes. There is no way that everyone will be pleased with the final stock and modified stock classifications, but to be fair, being a rules maker in any motorsport is a thankless job that not many would relish. But, what is happening with the classification of the big musclesleds?

The major snowmobile racing rules organization, the ISR, has decided not to allow the 900 Thundercat to compete in *any* stock class. It will, however, be allowed to compete in Open Improved Stock class, where it will have to compete against 180+ CBHP modified Storms, Mach 1Z's, and V-Max 4's. Does this sound absurd? It does to me. Sure, the Thundercat can be modified to be competitive in Open Improved Stock, but what about the guy who wants to dragrace his Thundercat stocker? What about the snowmobile performance consumer who wants to see head-to-head competition among the manufacturers?

Assuming that the Thundercat *is* in the 160 CBHP range, it may not be fair to allow it to compete against much lower powered 700 and 750 stockers. But what's wrong with a class of its own--Ultra Stock, or something like that? I'm sure that many of the more competitive, smaller triple and four-cylinder stockers would "jump up" in class to give the Thundercats some competition.

The ISR has also decided that no snowmobile model will be allowed to compete until 500 have actually been produced. This will eliminate all of the new musclesleds from the grass this year. What a heartbreaker for those of us who have been reading all the hype and want an oppurtunity to see how they'll stack up, side by side. Do we really have to wait for the DynoTech/American Snowmobiler "Battle of Old Forge" this year for this to happen?

How about a true, Factory Experimental (FX) class? If a factory builds some prototypes in anticipation of a fall or early winter build, they should have a place to compete. Once again, bonified AA/S and Ultra/S sleds would certainly jump up. The ISR should give the spectators and sled owners what they want to see.

What reason would they have for outlawing the 900cc engine? Did any aftermarket companies see the handwriting on the wall- and exert political pressure?

What if, in 1977, some all-powerful motorcycle racing organization decided that nothing more powerful than the 78 CBHP Kawasaki KZ1000 could compete in drag or roadracing?

Every year, the motorcycle dragracing sanctioning bodies would create new classes or shuffle the existing ones to provide a home for new stock superbikes. They didn't count registrations, or try to dictate the upper level of stock motorcycle performance. They let the motorcycle buying public do that. That's the way it should be.

MORE TURBO NEWS

Long time subscriber Steve Benson of Advanced Turbo Systems (1-800-68-TURBO) in Murray, Utah, is now selling turbocharger kits for the EFI Indy 500 SP. Steve primarily sells aftermarket turbo kits for light diesel trucks but his interest in high altitude snowmobiling led him to begin development on a snowmobile turbocharger. After several years of extensive R&D, it's finally ready for market.

How does it work? Steve told me that he uses Injection Research Services injectors and Electronic Control Unit to deal with the positive pressure and higher fuel flow requirements. According to Steve, he's been able to make 160 CBHP with the stock 500 SP.

One of the first kits he sold was for the stock 500 SP that Kim Rapaleto and Sid Zollinger entered in the Jackson Hole hillclimb. Kim won the Trail Mod class, and Sid won the Open Trail Mod class, both reportedly outclimbing many larger displacement, normally aspirated engines.

Hopefully, we'll be dyno testing one of these kits this summer.

At press time, Greg Bennet of First Choice Turbo Center has made an agreement with AeroDyne to become the sole distributor of AeroDyne turbochargers for aftermarket recreational use. Because of the very large financial commitment involved, and R&D and dyno testing necessary for future applications of the small Series 53 turbos, I've recently become involved on a corporate level with Greg's turbo project. Besides investing capital for inventory and equipment, I will be doing all of the dyno development as new applications arise.

The next project will be turbocharging the Indy XLT 580cc triple. We've just taken delivery of a new XLT, and should have a prototype Series 53 turbo installed on it by early July.

V-MAX 4 VENT HOSES

Those of you who have vented your hoses properly have been rewarded with consistant carburetion. Maynard Troyer's venting system, in which he ran the hoses up the steering column, to the area beneath the handlebar cover, worked well for him. During late season testing at Big Moose Lake, running WOT perhaps a third of a mile at a time, his sled (stock, with Bender Twin pipes) ran quite cleanly with 138.8 main jets at 30 degrees F, at 2000 ft altitude. By the looks of his plugs and pistons, Maynard felt that he even could have jetted down to 137.5's in those conditions.

BENDER PRODUCTION TWIN AND QUAD PIPES

The final production twin pipes actually have worked better than the prototypes we tested in Vol 4 #2, showing a ten CBHP increase over stock at 8000-8250 RPM with better midrange torque and horsepower. The production quad pipes made equal horsepower at lower RPM (9000-9250) and a bit more torque than the prototypes.

ILLEGAL REPRODUCTION OF DYNOTECH

There's nothing wrong with guys sharing information with their pals, but I know of too many examples of blatant photocopying of complete volumes of DynoTech. That is costing you and us money. We have had to periodically raise our price, primarily because we didn't reach our projected number of subscriptions.

Some of you have complained because membership rates have gone up so much since our first year. Others tell us that DynoTech is too cheap- they feel it's easily worth hundreds of dollars a year. We researched the market, and found specialty newsletters targeted for interests as varied as cat lovers and scuba divers priced much higher than DynoTech. We would like to keep the information as accessible as possible to enthusiasts in every income level, with minimal rate increases. However we don't have as many paid subscribers as we need to make a profit, (at $35.00) and we feel that illegal photocopies are hurting us in that regard.

We have investigated a number of methods to thwart photocopying. We tested light blue copyguard ink a few years ago, but the new generation photocopiers outsmarted it. We are now experimenting with a dark purple base color behind black ink that looks totally black when photocopied, but, is more difficult to read.

We are also considering cost cutting measures, but of course that will effect the quality of DynoTech. Accepting advertising is out, so that leaves us with a couple of choices. We can revert to bulk rate mail, or shave a page from each issue to lessen our postal expenses. Both have obvious disadvantages. Along the same lines, we've checked out lighter papers, but they are less opaque, so each page shows through a little. The lighter paper and purple ink are used on our classified page in this issue.

We're sending out questionnaires to a random selection of our subscribers to find out which changes would be most acceptable to our members, and they will be our guideline for future issues. We'd also welcome comments from those who did not receive the questionnaire.

We also ask that you consider the implications of photocopying. Copyrights make photocopying at worst, illegal, and at best unethical. We feel that those who have illegal photocopies don't really realize the harm it causes, and don't think of it as "stealing". We've actually had callers tell us thay have copies of all our issues! But if you think of the time and money involved to produce this, and consider that it's produced with the idea that those desiring the information will pay for it, you can see that it is no different than any other retail item.

This year is the first year we've broken even (I have only pumped money into DynoTech- I've never taken a nickel out of it for myself) and I actually don't mind doing all of this work. Working for free is O.K. if you're having a bit of fun (and you have another source of grocery money). But, we sure would like to be profitable. DynoTech hasen't paid any income taxes in four years, and if we don't start paying taxes next year, the I.R.S. (Internal Revenue Service, not the fuel injection company) is going to think I'm either cheating somehow or have gone out of my mind. And, Debbie deserves a raise.

ASK KEVIN

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Mr. Rick Herrick, of McHenry, Ill., asks about evaluating port areas by the time-area method. He notes that Gordon Jennings, in his venerable book, "Two-Stroke Tuner's Handbook" (available from Motorbooks, Osceola, WI), gives acceptable ranges of time areas for blowdown, exhaust, transfer, and inlet.

Twenty-five years ago I spent a lot of time figuring out time areas with squared paper, planimeters, and whatnot, only to discover that the engines I was working on needed as much as I could give them of nearly everything–especially transfer area. Today if I were interested in time-areas I would buy Dr. Blair's new book from the SAE in Warrendale, Pa. (call 412-776-4970 or fax 412-776-0790), and get the software with it. This software will instantly perform all those laborious calculations for you, and tell you what to increase, etc. If you have to do the computations by hand, you'll do better in the long run to spend that time cutting metal.

In general, large cylinder racing snowmobile engines need 38-40 degrees of blowdown, starting from an exhaust port opening point at something like 75-78 degrees ATDC. The exhaust port needs to be made as wide as mechanically safe–these days we seem to get away with 70% of bore diameter if the port is shaped right. Especially with large bore stuff, run booster exhausts if you can find a place for them. Remember, as a cylinder is made bigger, it gains volume area faster than it gains surface area. This means that the volume of stuff to be flowed (intake, transfer, exhaust) increases faster than the port area through which we must push it.

Especially at high RPM (high means piston speeds in the 4000 feet per minute range) you won't be able to give your engine enough transfer area no matter what you do. Cut down the width of the port dividers, cut in new ports if there is room--do anything to use all available real estate for the transfer area. Don't be afraid to snuggle your main transfers right up against the sides of the exhaust port. The old notion of strangling the transfers to provide more blowdown is a worn out idea now. Be sure you have enough duct area down to the crankcase to support the transfer window area you are giving the engine up in the cylinder. When there is a choice, make the ducts with smooth curves that take the flow outward from the cylinder so it can curve back in gently to the windows--not as pinchy little pipes that creep up the outside of the cylinder liner, then abruptly turn 90 degrees right at the transfer windows.

Engines with piston-ported intake never have enough intake area. A high-RPM engine with a short intake can usually tolerate intake timings over 90 degrees--sometimes as much as 100 degrees or a bit more. Only experiment will find the answer. It's better to cut the floor of the intake port. That's what you want. Make the port as wide as the piston skirt will allow, with a 2 mm overlap for support. Leave a stalactite in the top edge of the port if necessary to keep the piston ring(s) from dropping in at BDC, but otherwise cut the top of the port right up to the level of the piston skirt at TDC. When there is an iron liner, be careful that the liner's rear spigot is still joined to the rest of the liner by enough material to stop it from breaking off.

Reed engines need area in this same way. When adapting bigger reeds on an engine, use reed blocks from an engine that can reach the RPM level that you contemplate. Long, floppy reeds from 500 motocross engines (those 5000 RPM monsters) will get confused when you try to run them at 9500. Ruthlessly cut tunnels to connect the reeds to as many of your transfers as you can. Make passages big; the intake pulse happens in a bang, so it needs area. Don't think of the reed as a one-way valve in a pipe; think of it as a whole intake wall that opens and closes.

Rotary valve port size is determined by the carburetor size, and by the diameter of the disc itself. Sometimes to get the area you need, the port where the disc cuts through it will have to be defined as a pair of radii and a pair of arcs; the outer arc is as far out as you can go and still have some disc overlap; the inner arc is defined by the location of the disc hub; the two radii are defined by your chosen timing and the area you need. Low-performance timing will be something like I.O. 135 ABDC, I.C. 55 ATDC. On the dyno, you will probably find power gains all the way up to timings like 150/100, but the resulting engine may have carburetion/starting/powerband troubles. Discs are cheap, so don't be afraid to chop away. Discs that didn't work are great fun to throw, like Frisbees. Don't necessarily pay attention to me, or Gordon Jennings, or the Almighty--the truth for your application is found by experiment! If all these authorities are so hot, why aren't they winning all the races?

For high power, something like 140/85 might be a good starting point. Be sure that parts of the cylinder liner aren't hanging down in the way of the flow from the intake; if they aren't esential to the health and safety of the piston, cut them out of there! There is sometimes a small power gain to be had from tilting the carb so the flow is aimed more up at the rising piston.

In all cases, intake systems must be made as short as is humanly possible. Mill away carb-mount surfaces on cylinders until carbs are almost touching. Shorten carbs themselves. Run short manifolds if there's a choice. Eliminaate bends if you can, especially in reed systems, whose designers have a demonic determination to aim carb flow at one bank of reeds; this makes those reeds do most of the work, as you will see because they start to crack first. Sometimes you can't tip the carb up enough to center the flow--the idle system starts to siphon--but then you can put a horizontal wing-section divider in the reed box to compel half the flow to turn down to the lower bank of reeds.

HERESY AND REVOLUTION

KEVIN CAMERON THE CELLAR DWELLER

The news is out. Rotax will produce its own three-cylinder snowmobile engines, and these new powerplants will feature case reed induction. After years of rotary-valve induction, is this heresy? Will revolution break out? Or can Rotax owners find happiness with reed intake valves? I believe they will, and for two reasons;

(1) Rotax engineers have more than one good idea

(2) Reeds are now well enough developed to offer better overall performance than disc-valves.

For many years, high performance Rotax engines, singles and twins, were distinguished by having rotary intake valves. Such valves undoubtedly have the least flow restriction of any intake system. Rotax owners felt distinguished as well, because their engines were designed single-mindedly for maximum performance, ignoring the cost-cutting and production-simplifying advantages of piston-port and reed intake.

There are analogies; Ducati motorcycle owners feel the same way about the desmodromic valve system on their machines; instead of the valves being opened by cams and closed by springs, they are both open and closed by a complex system of complementary cams and rockers. Ducati owners identify with this unique system, despite the fact that it no longer offers an advantage over conventional valvesprings. People enjoy membership in an elite group; for Ducati owners, desmodromic valves are the symbol, the secret handshake that makes them special. For Rotax owners, the expensive-to-make, free flowing rotary valve system has some of this same special meaning.

Meanwhile, the broad river of engineering progress flows onward. Reed valves began life as a cheap way to build low-performance outboards and saws. They matured somewhat in kart racing, and then in 1972 appeared on Yamaha off-road motorcycles. In this stage, they were just restrictive little valve assemblies, usually stuck-on where a piston-controlled port had been. They helped bottom end power because of their ability to prevent blow-back by adjusting their open/close timing automatically--but they were a disaster for top-end power because of their restrictive small size. Another power-limiting feature was the stiffness and weight of the only reed material that lasted well; steel.

Yamaha next tried reed valves on its 1972 500cc road-race motorcycle. They were a failure, but reverting to piston-port intake brought success. Later, Suzuki won 500cc championships with disc valves, forcing Yamaha to adopt disc-valve on its road racer in mid-1980. The disc valve was acknowledged in the 1976-1982 era to be the highest-performance intake system for two-stroke engines.

Meanwhile, reed development continued, mainly in motocross. Larger reeds worked better--especially if heavy steel reeds were replaced by lighter fiberglass reeds. Fiberglass reeds broke at the tips after an hour or so of running, but application of thicker coats of cushioning rubber to reed cages moderated the closing impact, prolonging reed life. And, when steel reeds broke, they wrecked engines; fiberglass was more digestible.

Motocross tuners and engineers learned there were better ways to apply reeds. They didn't work best as little rectifiers, stuck in a piston intake port. Tuners cut tunnels from the reed case direct into the secondary transfer ports--and gained power. They cautiously cut holes in the back skirts of pistons--and power grew. Then they cut high arches in piston skirts, or even cut most of the rear skirt away. More power.

Having the reed installed in the cylinder was now a serious limitation, because the cylinder stud locations had been planned for piston port in most of these early engines. Some builders carved right through the stud tunnels in their restless search for flow area, restoring leak-tightness by pushing tubing down the tunnels and gluing it in place. Others tunneled around the studs. The manufacturers quietly evaluated these various innovations and used the ones they liked the best.

All competitive motocross engines were soon reed-equipped. Rotax's disc valve MX engines held on for a time, but were swept away by the new Japanese orthodoxy of reeds.

The next break came when Honda, desperate after fruitlessly spending millions trying to win the International 500 cc motorcycle road races with its oval piston NR four-stroke, played its only two-stroke card--an engine that was essentially the best of motocross technology, packaged for road racing. This reed-valved NS-500 three cylinder was immediately laughed at. Didn't Honda know that disc valves were essential for competitive performance? The novel, compact machine won one race in 1982, then returned the following year to knock out the sophisticated disc-valve opposition and win the championship.

This machine did not have a wide powerband. It did not have a lot of top-end power. But it did have enough of everything to defeat the disc-valve juggernaut. It started easily. It carbureted reasonably well across its operating range. It was light, simple and easy to service. Now all road-racing two-strokes--except for Rotax's Type 258 twin--have reed intake.

High performance disc-valve engines had to have long intake timing to give good power. A minimum race timing might be IO 135 BTDC, IC 65 ATDC, and a radical timing might be 155/90. Engines with such timings are hard to start, and they carburete poorly until they reach their solid power range. The reason for this is that long-duration disc valves have poor carburetion "signal". Because the valve opens soon after BDC, the air column begins moving very slowly, as the piston does near BDC. This gentle intake pulse is not very good at getting the fuel spraying from the carburetor. This is why rotary-valve engines require very rich carburetor slides--such as 1.0-1.5s.

Reeds and piston port open later--after the piston has pulled a substantial vacuum in the crankcase. When these valves open, this vacuum travels to the carburetor, arriving as a distinct "pop" that starts the fuel moving smartly. The result is prompt starting and excellent snap throttle response from even low RPM.

Piston-port remained popular for multi-cylinder snowmobile engines because it packaged so well. As long as there were no highly-tuned large sled powerplants, such engines could hold their own simply based on their chubby displacement. However, now that large area reed engines are being in these big displacements, the piston-port designs are suffering by comparison--and being abandoned. To make competitive power, they need long intake timings that result in poor starting and dismal snap throttle response. Therefore manufacturers are dropping these designs, replacing them with new reed designs that can deliver high performance, excellent starting, and sharp response--all with equally good multi-cylinder packaging.

"New ideas may look ugly because they are unfamiliar, but if you see them in the victory circle often enough, they become beautiful."

In particular, Rotax has made a 250 cc motorcycle road-racing engine for the past several years, both as a tandem and as a V-twin, with rotary valve induction. This design has been almost competitive with Japanese reed valve 250s, but there is no clear cut advantage. Because of this, current development at Rotax focuses on a reed valve design.

Further, private persons have been building a variety of three and four cylinder snowmobile engines, based on existing twins. Using Rotax cylinders, both disc-valved and case-reed multi-cylinder engines have been built, and there appears to be no clear advantage in the far more complicated disc-valved versions. If this is so, why continue to make them? More to the point, if Rotax is to produce three-cylinder engines, why make them overly complex and expensive if there is no performance payback? New ideas may look ugly because they are unfamiliar, but if you see them in the victory circle often enough, they become beautiful.

Please be aware that reed valve induction has problems too. It is inefficient to accelerate air to hundreds of feet per second through the carburetor, then abruptly slow it down again as it dumps out into the much bigger reed case--only to re-accelerate to even higher speeds to slip out under the reed petals. Then the air again

THE CELLAR DWELLER CONTINUED

slows as it enters the crankcase. Slowing air is ideally a process of trading in speed to get pressure, but if it's not done carefully, there are losses that eat into the final pressure that fills the crankcase. Tuners are hard at work on these problems, searching for correct ways to keep velocity up in the reed case, and to efficiently recover pressure as the air jets into the crankcase.

Making the reed big enough to serve the engine's needs may make it hard to get it close to the engine, resulting in a huge crankcase volume. Tuners would like to let air stream directly from the reed, up into the transfer ports, but the best position for the reed usually turns out to require the carburetor to be vertical or in an impossible place.

The reed petals themselves present fascinating challenges. Is the very commonly used G10 board (fiberglass/epoxy) the optimum reed material? Glass has a density of 2.8, but carbon fiber is a much lighter 1.5. Glass can take the pounding, while carbon is brittle, but what about the new carbon/Kevlar weaves? Kevlar could provide toughness, while carbon provides the stiffness-to-weight ratio required to make the valves close quickly. There is plenty to be done.

The remaining problem to be addressed is tradition. If it comes down to a choice between cost-effective performance on the one hand, and tradition on the other, which will loyal Rotax owners choose?

Those who feel that the disc valve is the only that distinguishes Rotax from the rest of the herd should look again. Rotax is a high technology company. At a time when other sled engine makers were still supplying glorified industrial engines for snowmobile applications, Rotax cylinders offered advanced features like triple exhaust ports and flat-topped multiple transfer ports (both subsequently copied by almost every other two-stroke maker). It takes more than a single good idea to stay at the top of the high performance engine business. It's dangerous to chisel your ideas in stone because it's so hard to erase when you have a new idea.

New kinds of two-stroke engines are about to burst upon the automotive and small-engine scene. Direct fuel injection (DI) engines will invade the low RPM field first, making outboard engines and small auto powerplants able to meet emission standards that were previously impossible for two-strokes. Blower-scavenged two-strokes with mechanical valves will offer the possibility of real supercharging. Stratified-charge combustion will accompany DI, and together these technologies will cut two-stroke fuel consumption by 40%

Survival in the engine business is no longer a matter of bringing in accountants with sharp pencils to gouge every last penny out of a static, unchanging product line and manufacturing process. With so many new technologies emerging now, making engines is a business for far-sighted engineers. It will take time and research work to find optimal combinations of all these new technologies. Rather than be disappointed with Rotax for abandoning its "signature technology"--rotary valve-- be glad they are progressive enough to evaluate and produce new solutions.

Is there a future for rotary valve? It's hard to beat the airflow capacity of a smooth, unobstructed rotary-valve intake port, but problems with fixed valve timing and carburetion signal strength compromise this advantage. Fuel injection could mend most of rotary valve's starting and response problems, but that would still leave the fixed timing, which gives either good acceleration or top speed, but not both. More gadgetry would probably fix this, too. The devices that now vary advanced four-stroke engine's cam timing could confer the same advantages on a rotary valve. The result of all this could be a wonderfully strong running--and gadgety--engine. Nature, and good engineers favor simplicity.

DYNOTECH is an independent newsletter published by DYNOTECH Corp., P.O. Box 801 Batavia N.Y. 14021, in affiliation with C&H Dyno Service, 8 Apollo Drive, Batavia, N.Y. 14020. Subscription rate is $35.00 per year (six issues). Phone: 716-344-1313. Send address changes to DYNOTECH, P.O. Box 801, Batavia, N.Y. 14021.