The evolution of Hentges Racing's Polaris 600 snocross mod engines.

Jim Czekala

Next year, ISOC has mandated that Pro Open Snocross sleds run stock engines and cylinders with only compression and exhaust mods. Since 2012 is the last year for fully modified engines in ISOC Snocross racing, we can now examine the incredible seven year transformation of the 120 HP Polaris 600cc twin into a 170+ HP racer by Hentges Racing. This is a story of extreme tenacity by Hentges Racing Team Manager Tim Bender and his right hand man Team Engineer Sean Ray, and a reasonable budget for finding more HP at DynoTech Research, $1/10^{th}$ of a HP at a time!

Tim Bender has been Team Manager for Polaris factory sponsored Hentges Racing Team since 2007 and before that for Team Industries since 2002. Prior to this avocation, Tim owned Bender Racing in nearby Colden NY, which specialized in making Yamaha snowmobiles more powerful. In 1997 Tim sold his Bender Racing business so he could pursue a career as a NASCAR racer. After several successful years racing the NASCAR Sportsman Series and the Busch Grand National series, crash injuries to his back and neck sidelined him permanently. This brought him back to his roots—racing snowmobiles—this time with a Polaris sled with help from his old friend and now the lead guy at Polaris Race Development in Roseau MN Rick Bates.

Tim began his Snocross career in the early 80s racing Yamahas on courses with what were now considered small jumps that were more like TT Racing on ice than Motocross. After his race car injuries, when Tim returned to Snocross running a single Polaris sled team for his then amateur son Brett, the tracks had evolved much more into Motocross tracks on snow with huge air time jumps. He got to know Sean Ray when Sean was also Snocross racing in the Eastern Regional races often pitting next to him. At that time, Sean worked with me as a technician at Aerocharger Turbo Systems, and operated my motorcycle and sled dynos doing turbo system development. Sean also has operated my dyno with Kevin Cameron for contract testing. I was pleased one day when Tim Bender called me to tell me how impressed he was with Sean's ideas about engine, clutch, and suspension tuning. Sean credits the DynoTech archives and the many Kevin Cameron "The Cellar Dweller" articles (all posted on this site) as being the basis of his two stroke engine knowledge. That pleases me even more.

Some additional redundant background info:

26 years ago when I built this dyno testing facility (then referred to as C&H Dyno Service) Tim Bender was the first adventuresome racer to try to learn with me what could be done with this then-revolutionary (but bewildering) fully instrumented snowmobile engine dynamometer in the quest for more horsepower. We had no idea what A/F ratio, fuel flow and BSFC meant, but we knew HP. More is better! We tested and tuned and burned pistons and learned together. Muriatic acid (used to dissolve and remove aluminum that has been smeared onto cylinder bores) is cheaper by the gallon—don't bother with quarts! It was an educational cluster ----. Most of the time, when we made the pistons (yes, that's plural!) grow bigger than the bore size we learned something. Tim Bender was then a Yamaha factory sponsored ice oval racer, campaigning a "stock"

Formula 56 (HP) fan-cooled Phazer and a modified Vmax 540 twin FIII racer. Back then, being factory sponsored meant that you got a decent discount buying your sleds and that your expenses getting to and from races *might* be covered! When Yamaha sent Tim his first new Exciter 570 engine to make a race engine out of, he grabbed a cylinder and drove 450 miles to Kevin Cameron's house to get some inspiration and ideas for improvement. At his kitchen table Kevin looked at that pathetic Exciter piston port cylinder and declared, to Tim's chagrin, that it must have been designed by Yamaha's golf cart division!

Undaunted and with guidance from KC, Tim hacked Exciter cylinders and welded pipes and dyno tested here, rehacked, rewelded, cut heads, dyno tested some more, etc, etc until that lowly 75 HP engine became 120 HP or thereabouts (the same HP as a stock 600 twin today). Enough HP (when you have max HP jetting and know *exactly* what RPM your best HP occurs at) to win Eagle River three years in a row.

For 1992 Tim and his then crew chief Rick Bates modified the stock Vmax 4 chassis into a full blown Formula III oval race sled and Yamaha Japan sent Tim the first race-ready Vmax 4 750 engine complete with fitted quad race pipes! I believe that as delivered, the four cylinder race engine had about the same HP as the final 2011-12 Polaris 600 race twin shown here. But as expected, that power was greatly improved by Tim on our dyno as the season went on. That would be a good article!

The Exciter and the Vmax 4 have come and gone, and now Tim Bender is busy with Polaris race twins. And as he was as a Yamaha factory racer, he is a man possessed to make every possible HP for Polaris.

When Tim first signed on as Team Manager with Team Industries, they ran Polaris 800 mods. Tim hired Sean Ray to be Team Engineer part time (Sean's full time job is as a Calibration Engineer at Delphi) and they eventually made great HP with the 800 twin (the engine that Levi LaVallee made the almost double back-flip and the record long distance jump with).

Enter the small-bore Polaris 600

As I recall, Tim and Sean were having fits getting proper engine cooling from the then-new IQ600 engine and chassis. They know from dyno and field testing that cool engines make more HP and resist detonation much better. They changed heat exchanger plumbing from parallel to series. Then in an extreme measure to get proper engine cooling, they changed crankshaft/ coolant pump gear ratio to a new ratio provided by Polaris to increase the velocity of the coolant through the engine and heat exchangers! That ratio is now used in all Polaris production stock sleds. For clarification please read Kevin Cameron's tech article posted on this site, TURBULENCE NEEDED.

In 2006 after WSA banned the 800s from competition in favor of the 600s, Tim and Sean had Justin Fuller of Full Power Performance (a former race engine builder at Bender Racing) alter the port timing/ shape on a set of stock cylinders based upon the three of

their's past experience and what they learned on the 800s. That combination worked extremely well and Justin got the nod to do the porting on all of the Hentges Racing's Mod engines. Every year since 2006, Tim and Sean have spent many dyno hours assessing every aspect of what can affect HP—port timing, sizes and shapes; compression ratios and combustion chamber shapes, squish clearance and width; ignition timing curves; reed styles and petal thickness; carb sizes and shapes; every variation in pipe length/ shape, pipe backpressure, etc, etc. Greed is a good thing!

I have on the dyno computer hard drive several thousand (!) Hentges Racing dyno tests, and I have homed in to the final typical dyno results for each year. There was not much improvement in 2009 so that's not included. Note that early on, Sean Ray had been documenting pipe center section temperature as a key tuning component—indicating optimal backpressure and determining the exact RPM of max HP from clutch engagement to the first turn of each race—thanks to Kevin Cameron's TCD input (posted on this website, in the treasure trove of scanned printed back issues) in the late 1980s and 90s. Also note that BMEP, even early on, is extremely high at nearly 200psi. And in 2010 when torque levels peaked at nearly 103 lb/ft BMEP was even higher—incredibly, over 210 psi! In later years, peak torque was reduced in favor of higher HP at higher RPM. And that reduced torque and higher RPM operating speed made the engines less likely to detonate on 116 motor octane race gas that is necessary on these high BMEP engines for max power without detonation (deto is a time-dependant phenomenon).

Beginning with year 2006 and continuing to 2011-12 here are the approximate HP levels achieved each year.

2006 Hentges Racing Polaris mod 600

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	Fuel B lb/hr	BSFC lb/hph	A/F B Ratio	Air 2 scfm	BMEP psi	Exh2 degF
7900	96.6	145.3	92.4	0.656	11.86	239	192.9	550
8000	98.4	149.8	92.2	0.635	12.06	243	196.4	570
8100	99.5	153.5	94.4	0.635	12.00	247	198.7	590
8200	99.4	155.2	92.7	0.617	12.29	249	198.3	600
8300	99.1	156.6	95.3	0.629	11.93	248	197.6	630
8400	98.1	156.8	96.5	0.634	11.86	250	196.0	650
8500	96.2	155.7	95.2	0.630	12.05	251	192.3	670
8600	91.1	149.1	98.4	0.681	11.57	249	182.0	700

2007 Polaris mod 600

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	Exh2 degF	Fuel B lb/hr	A/F B Ratio	Air1+2 scfm	AirTmp degF
7867	98.7	147.8	537	93.0	11.68	237	60
8000	98.8	150.5	563	93.3	11.90	243	59
8100	99.4	153.3	583	93.9	12.10	248	59
8200	99.9	155.9	600	93.8	12.35	253	60
8300	100.3	158.5	620	94.1	12.57	258	60
8400	99.7	159.4	640	94.5	12.62	260	60
8500	97.9	158.4	663	94.9	12.67	263	60

8600	94.1	154.2	687	95.0	12.70	263	60
8733	87.7	145.8	720	94.0	12.94	266	58

2008 Polaris mod 600

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	Fuel B lb/hr	BSFC lb/hph	A/F B Ratio	Exh2 degF	Air1+2 scfm	AirTmp degF
7900	91.3	137.4	77.7	0.608	12.97	670	220	73
8000	90.3	137.5	79.1	0.618	12.73	690	220	73
8100	91.4	141.0	78.8	0.600	12.14	700	226	73
8200	95.5	149.1	80.5	0.580	12.71	710	241	73
8300	97.6	154.3	83.5	0.581	12.51	730	246	73
8400	98.6	157.7	83.1	0.566	12.93	750	253	73
8500	99.1	160.5	84.6	0.566	12.53	760	250	73
8600	98.8	161.8	86.6	0.575	12.44	770	254	73
8700	97.7	161.8	86.9	0.577	12.97	790	265	73
8800	95.0	159.2	88.6	0.598	12.47	810	261	73
8900	92.3	156.4	89.0	0.612	12.62	820	265	73
9000	87.6	150.1	93.7	0.672	12.65	840	259	73

2010 Polaris mod 600

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	BSFC B lb/hph	Fuel B lb/hr	Air 2 scfm	A/F B Ratio	Exh5 degF	BMEP psi
7667	86.4	126.2	0.658	78.6	187	10.91	757	178.1
7800	87.7	130.2	0.631	77.8	192	11.32	763	180.7
7900	89.5	134.6	0.611	77.7	197	11.62	770	184.4
8000	91.6	139.5	0.593	78.2	202	11.85	780	188.7
8100	94.1	145.1	0.573	78.6	209	12.16	790	193.9
8200	97.3	151.9	0.560	80.3	226	12.32	803	200.4
8300	100.5	158.9	0.545	81.8	233	12.49	813	207.2
8400	102.4	163.8	0.547	84.6	239	12.40	827	211.1
8500	102.4	165.8	0.550	86.0	242	12.33	833	211.1
8600	102.1	167.2	0.556	87.7	244	12.23	847	210.5
8700	100.9	167.1	0.562	88.7	245	12.13	857	207.9
8800	99.4	166.6	0.568	89.3	246	12.09	870	204.9
8933	96.9	164.8	0.576	89.7	246	12.05	883	199.7

2011-12 Polaris mod 600

EngSpd RPM	STPPwr CHp	STPTrq Clb-ft	BSFCAB lb/hph	FulAB lbs/hr	AFRAB Ratio	Exh_1 deg F	Air_1c CFM
8300	140.0	88.6	0.649	86.0	11.41	722	222.6
8400	140.7	88.0	0.640	85.2	11.88	728	229.4
8500	145.3	89.8	0.619	85.1	12.27	735	236.7
8600	155.2	94.8	0.589	86.5	12.42	749	243.6
8700	158.8	95.9	0.581	87.4	12.47	758	247.2
8800	161.4	96.3	0.580	88.7	12.50	765	251.2

8900	166.1	98.0	0.575	90.4	12.41	776	254.4
9000	169.2	98.7	0.572	91.6	12.36	786	256.5
9100	171.1	98.8	0.566	91.7	12.41	794	258.0
9200	171.8	98.1	0.573	93.2	12.24	806	258.8
9300	171.8	97.0	0.587	95.4	11.98	816	259.0
9400	169.8	94.9	0.603	96.8	11.78	827	258.5
9500	165.0	91.2	0.630	98.3	11.53	838	256.9

Note that in the last two years, Tim and Sean changed pipe configuration to raise RPM, reducing torque and BMEP, but increasing HP well above 170! And note that this resulted in a flat HP curve that was forgiving on clutching. Remember, torque does nothing without revs—HP is king!

Even though they're limited to stock engines next year, more dyno testing/ tuning will surely be coming, but the day of 170+ HP 600 twin Snocross mods is likely over. That means that Justin Fuller will have more time to devote to building turbo systems and full mod two stroke dragracing engines.

Tim Bender says that several of these turnkey 600 mod engines will be for sale. He can be emailed at tbend19@aim.com

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