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09-16-2007, 07:30 PM

#1 ([permalink](#))



DavidVizard-GFN OFF
Pit Crew

Join Date: Apr 2007
Posts: 840

#2 Turbulence and Combustion Dynamics

#2 Turbulence and Combustion Dynamics

Good atomization is a big part of the picture – but it is far from all of the picture

By

David Vizard

In the first installment of this series we looked at the possible compromise of supposedly advanced combustion dynamics versus flow and found all was not as it was propertied to be. We also covered more homogenous mixture preparation (mixture quality) and found it was not a guaranteed route to HP. We also looked at the 1970 Chrysler UK Avenger engine and its dire need for a very well prepared mixture of air and fine droplets. The consequences of not having such was a loss of as much as 10% of the engines potential output. To move on from here and stay on track lets look at the last two sentences of part 1:

'I may not have understood but a fraction of what was needed about combustion dynamics at this stage but one thing was for sure. Just knowing a little more than the opposition not only allowed me to make

my car go significantly faster but also to slow all the other Avengers in the class I was to race against on road course the following year.'

To see how this was done and a patent taken out on what might well qualify as the one of the best candidates yet for a 100 mpg carb let me refer you back to the Avengers induction system. From part 1 it was stated:

'To get a good part throttle burn and clean exhaust the intake charge, delivered by the twin inch and a half Stromberg's, was heated. This was achieved by having the intake manifold bolted to the exhaust manifold. Between the two was a 1/16 thick plate with a hole in it. Through this hole the exhaust flame physically played onto the under side of the intake forming a very hot spot. This, at part throttle, probably was sufficiently hot to vaporizing all of the fuel at any sane street or highway driving speeds. OK this might sound like stock boring stuff but now we come to the crux of the matter. My first discovery was that if the hot spot was semi eliminated by replacing the 1/16 thick plate with a hole in it by similar plates with no holes the power dropped from 78 RWHP to 74 even though the charge temperature dropped a whole bunch. With a quenchless chamber I thought that this might be the case and this test suggested to me that this type of chamber needed to have a fair amount of vaporized fuel and the rest delivered in really well atomized form'.

The crux of the matter is I used this piece of unlikely information to my advantage in more ways than one. First the rules for Production Sedans stated that the air element of the engine must remain stock but the fuel element could be changed as required to get the necessary fuel/air mixture characteristics. In other words the fuel side of the induction was free. This meant I could do whatever I wanted to the jets and needles used to calibrate this carb.

It was evident that two specific factors had to be accomplished here. The first was to convince other competitors using an Avenger GT (that was all the front runners) to replace the spacer between the intake and exhaust with one that did not have a hole in it. The second was to atomize the fuel so much better that it compensated for the hot spot in terms of mixture quality.

OK let's start on the first deal here. How to slow down the opposition by convincing all and sundry to go to a no-hole spacer between the intake manifold and the exhaust. The first point here that made the execution of this plot easier is that I had not made it publicly known in any article that the Avenger lost 4 hp when the intake charge was cooled. The normal assumption would be that cooling the intake would increase power.

The race season in the UK starts late April for most clubs so about November - December the previous year I started calling a few influential Tech Inspectors all over the UK. The supposed reason was that I needed some info on this or that and it was their area of expertise. In reality the call was just a ploy to sow the seeds of a rumor that I would subsequently use to my advantage. During the conversation with each tech inspector I would ask if they had heard the rumor that these Avenger engines with there quenchless combustion chambers were prone to detonation when driven flat out for any length of time (as per a 25 mile road race). I told of rumored melted pistons and the like and made it sound pretty bad. After planting the seeds of this rumor I let a few weeks go by then called the chief tech inspector and during a conversation about some other matter asked if he had heard the Avenger's rumored detonation and melted piston situation. Surprise - surprise – he had and from about half a dozen people at that. He mentioned that the situation seemed pretty bad and it would be a possible problem for those running Avengers. Since, on paper at least, it seemed like the most competitive car for the class he expected that there would be quite a few in the field of entries. So far so good – everything is going to plan. At this point I told him I had a simple fix for this detonation/melted piston problem (which of course did not actually exist) "The problem" – I told him, "stems from the excessive heat put into the intake charge by the hot spot. By using a blank spacer instead of the one with the hole in it the problem goes away." His answer went something like this "and the cooler charge might just give you the edge as well". My response – "Well I thought that if I do a drawing of the change you can send it out to all those running Avengers and tell them that this modification is acceptable in view of the susceptibility of these engines to melt pistons under race conditions. If all competitors are using it the playing field should once again be level". This he agreed to and a drawing of the mod was in time sent to all those competing in an Avenger. Now ask yourself – the apparent promise of a little more power from a cooler charge and the avoidance of a melt down – all for under a 'dollar forty nine' – who wouldn't use it? Part one of the plot is now complete.

On to Part Two of the Plot.

With the cooler intake the next deal was to make design changes specifically to the Stromberg's jets to

more finely atomize the fuel. What I came up with warranted a provisional patent (that was the way it was done back then). In a nutshell what I did was to redesign the base of the piston and the bridge that forms the venturi. The following drawing shows roughly what was done.



By moving the jet upward away from the bridge and knife edging the discharge hole the fuel was both atomized and dispersed far better. This resulted in an appreciable increase in output on the Chrysler Avengers quenchless chamber engine.

The key to the increased atomization and reduced wet flow was the sharp and microscopically ragged edge of the jet and the relocation of the discharge point within the carb body. By moving the jets discharge point away from of any nearby surface that the fuel might attach itself too prior to becoming dispersed in the air produced better down stream dispersion. So how was the atomization produced by this set up? The fuel left the jet like a fog. Where as flash photo's had revealed small droplets in the stock Stromberg's discharge from the jet the revised design showed none as the droplets were far too small to show as such. On the chassis dyno the results were very encouraging. With the hot spot in place the new carbs dropped about 3 - 4 hp. With the hotspot blocked an increase in output, by virtue of an increase in torque, amounting to some 14 hp was seen! So what we are seeing here is that mixture preparation in conjunction with temperature, is contributing to a better combustion process to the tune of some 20% increase in output. In addition to this drivability, throttle response and part throttle fuel economy were all improved.

At this point the value of not only a cool intake charge carrying the correct mixture but also one having (on average) appropriate fuel droplet sizes and dispersion of such for the engine concerned is showing to be a distinct advantage. So how did all this work out on the track? The carb changes along with a whole host of selected and/or blue printed parts netted a totally legal engine that would leave even highly illegal cars for dead in the water. The first time out with this engine we put the champ from two years previous who was supposedly the 'King of Mallory" , with, what we later found to be a highly illegal engine, down by about 200 yards per lap.



Here I am racing with the reigning Champ, Bill Sydneham at a wet Silverstone. First place was decided by the width of a headlamp bezel. I had a number of door handling races with Bill but, because of his clean sportsman like driving, never got a single ding in the bodywork.

At this point we could ask if this quenchless chamber engine was something of an enigma. Were we fixing some inherent shortcomings that showed very positive results on this engine but would less likely show as much on more conventional engines? Well that could be but if this engine was, so to speak, acting as a magnifying glass on combustion dynamics it is still a good tool with which to work. However later down the road it was found that this seemingly odd-ball engine was not so far from a mainstream case as might at first be believed.

British Touring Car Championship Year.

After our dazzling show of speed during the last few races of the previous year Chrysler's race boss, Des O'Dell, gave my three man team a car and all the factory parts we may need to build a BTCC car. For the US readers this championship is for a manufactures title and is contested on an international level. It's a bit like having Cup Car racing with every major world manufacture competing.



Built by myself and my crew (Colin Ashdown-Pogmore and Hugh Murray) this Group 1 Avenger, with it's all iron pushrod engine, proved to have the speed to be more than a match even for the twin cam sporty cars from Italy, Germany and Japan.

We were up against twin cam engines of Alfa Romeo, Lancia, Renault, Toyota etc as well as the big bucks of Ford motor company, GM and the like. How did we do – we came out of the gate fast and by about the forth race our two buck, all iron, pushrod powered shopping car was a better rocket by far then the competition's cost no object twin cam sporty specials. Did we win any race's – hell no. Our competition's engines barely made 8000 rpm. Our first engine of the year had a shift point of 8800! By the middle of the season we were turning this pushrod engine to 10,500 and, between two corners at Brands Hatch, to 11,000 rpm. What that meant was during our test sessions (i.e. the race) we broke about one each of everything that could break, sure we would have the fix by the following race but that did not exactly help our cause on the day. Also we were running these races as part timers. From Monday morning to Thursday, 8 am to 6 pm, we all had full time jobs.



Here's Thruxton, a well know UK track some 120 miles west of London. Not only was I fast here but was also given an unofficial title of wheel lifter of the event. On one 110 mph plus turn I balanced the car like this for a couple of hundred yards - every lap!

From 7 pm till 1 or 2 am the following morning and Thursday to Sunday evening we either worked on the car or raced. Our budget for the year was less than what most teams spent per race. By the end of the year our team had managed a second place plus a couple of thirds, a class pole and half a dozen fastest laps. During six races the car had broken in a new engine in practice which put it on the grid on either the last row or last but one row. Sounds bad at this point but we were breaking in. The good part is that before the end of the first lap the number 66 was the class leader! I said the car was fast – and fast is exactly what I meant. So where did all this speed come from? No one thing in general but I can say that cylinder head flow, especially low lift flow, was significant along with cam design, exhaust and, very important, mixture characteristics and combustion dynamics. Let's start with mixture characteristics.

Starting Point - Weber Revamp.

The homologated (that means the ones the car is supposed to have stock) carbs are a pair of side draft Weber DCOE 40's. These came equipped with 30 mm main venturis. The rules allowed us to change main ventures for any design we wanted but the hole had to be no-bigger than 30 mm. Also the auxiliary (booster) venturi was free. This gave me scope to make new auxiliary venturi's based on what I had learned from the Dellorto design mentioned in part 1. The result was a 6 – 7 hp increase throughout the rpm range over anything that could be built using off the shelf Weber parts. At this point I concluded that I had achieved about as good a fuel atomization as the engine needed so attention was turned to the cylinder head.

One of the factors we were stuck with was a 0.390 valve lift. This meant intake valve acceleration and

flow, especially from low lift became important. Now I guarantee you will hear arguments countering the value of low lift flow but before the year is out I will have shown both theoretically and in practice that this is totally wrong. This Avenger engine is the first part of proving low lift flow is important. I won't go into too much detail here because combustion dynamics is the subject but suffice to say that the low lift flow on my head was about 40% more at 0.050 than the Cosworth head while the flow at full lift was identical. Although there is more to it than just low lift flow it's worth noting that my Avenger head made 11 hp more than the Cossy one and that was what the factory used the following two years!

The intake port was critical – here I used a much smaller port than the competition and it was rough finished with an out-of-round 80 grit ball wheel. The rough surface produced cut the tendency of the fuel to coagulate and form rivulets prior to entering the cylinder. Notice I say it cut the tendency – it did not cure it by any means – just made it a lot better.

With the mixture and intake port situations addressed and reasonably fixed it was time to look at the combustion chamber. I felt we just had to be able to do a better job in terms of power than the stock chamber. As it happens the rules specified such things as valve sizes, compression ratio etc but did not specify combustion chamber shape. This being the case we started finding the heaviest pistons (there was a lower weight limit and factory original pistons had to be used) and bringing them down to weight by machining the piston crown. What this did is allow the top ring to be nearer the piston crown thereby cutting the ring land volume. That little space is, as we shall see in part 3 of our combustion dynamics, way more influential than you may suspect. This becomes apparent as I go through the scenario I intend to use to explain such.

In addition to the piston mod the chamber form was also investigated. On the flow bench it was found that better flow could be had by forming a shallow chamber around the intake and exhaust valves. This necessitated machining the top of the block to get back to the 9.9/1 (as I remember) CR called for. This move was done a step at a time from one build to another. Essentially we were building, for race and R&D combined, about 1-½ engines per race. Each time a build or rebuild was done the chamber in the head was increased and the chamber volume residing in the block reduce by machining the block deck. Each time this was done the package more closely approach a conventional chamber with squish. At each new spec some 0.020 more material had to come off the top of the block to bring the CR back up to 9.9/1 and each time more power was seen. When the situation got to where the piston was 0.080 down the bore, which produced the best results to date, I decided that it looked worthwhile to go the whole hog here and put the entire combustion chamber into the head and deck the block for a tight quench rather than possibly do 4 more builds to get there. The results on the dyno were just shy of startling. If all had followed previous form I would have expected about 6 hp more from this combo – instead it was 8 less!

So why am I highlighting these negative results? Simple – I want to emphasis that the subject we are dealing with here is far from simple. I had no idea why power went down then and here we are 30 years later and I am still shy of an answer. In this instance the results were about 180 degrees apposed to all the other tests I have been involved with. This Avenger engine liked to have the piston stop 0.120 (120 thousandths) short of the head face (0.080 down the hole and a 0.040 head gasket) for best results. For just about every other engine I have done tests on like this that piston to quench source gap is about the worst in terms of low detonation resistance and poor combustion. It really begs the question as to whether or not we can give an engine too much quench action. It is this factor, and crevice volumes such as the ring land volume that we will look at in the next installment.



Last edited by DavidVizard-GFN; 08-18-2008 at 08:17 AM.



05-10-2008, 09:58 PM

#2 (permalink)

paulo OFF
Garage Sweeper

Join Date: May 2008
Posts: 3

Hillman?

Hey David.I just joined!First post. This Avenger you prepared and raced,should be the same platform as the Dodge 1800 Polara built and sold by Dodge in Brasil from '74 to '81.I believe the engine was stretched from 1500 to 1800 here to raise power,since our gasoline back then had such a low octane value.When road raced here they could not keep up with VW's Passat eventhough it had a 1600 engine.At first the little Dodge used a verticalSolex 32mm,then a SU 36mm,then a Hitachi and finally in 1981 a vertical 2 barrel Weber that really made a difference,improving fuel economy and power simultaneously,certainly due to a superior fuel aeration.
What camshaft did you use on your 10000 rpm engine?



05-11-2008, 09:06 AM

#3 (permalink)



DavidVizard-GFN OFF
Pit Crew

Join Date: Apr 2007
Posts: 840

This was a cam I designed and had made - the company that ground it is no longer in business.

The specs were 300 degrees at lash about 252-255 at 0.050 - 0.480 lift on a 109 LCA. You may have to experiment with advance - I think we had this at 2 degress.

If you look through the Crane profile catalog you should find something close.

For carbs use Dellorto's - don't even bother with anything else!!!

Our sprint 1600 Avenger made about 175 hp at the wheels.

DV

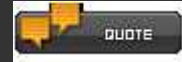


05-11-2008, 07:30 PM

#4 ([permalink](#))**tommurphy73** OFF
Garage SweeperJoin Date: Aug 2007
Location: Ireland
Posts: 58

I was at the Killarney Rally of the lakes two week ends ago and there was an Avenger still rallying in the historic class and it seemed to be going quite well also. I wonder if he was using any of your mods

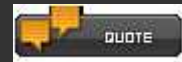
Tom



06-10-2008, 02:01 AM

#5 ([permalink](#))**howieschoon** OFF
Tire ChangerJoin Date: Dec 2007
Posts: 131

Hello David,
First, I am not familiar with Strombergs, but the jet/piston arrangment seems to be similar to an SU. Would the modification of the cutaway in the piston be useful on an SU, in particular if gas milage was the primary concern? This would be on an MGB, so I would assume that power would drop atleast some, as it would on a Mini. Any rough ideas what kind of power could be lost, percentage wise? You mention something like a 7-8% loss on the Longman Mini engine (I realize this is not the same change) , would that be a reasonable (high) approximation on the B engine also? From the little it that I have read on SUs they seem to have pretty good atomization already, is this true? Sorry this was so long and thanks for any information,
Howard



11-27-2008, 05:36 AM

#6 ([permalink](#))**nzenger** OFF
Garage SweeperJoin Date: Nov 2008
Posts: 1

Hi David

I am an Avenger owner for many years and have always enjoyed your tech articles and have a collection of CCC and Hot car with them and now you are adding more tips on these engines.

My current engine is 1700 with a few good bits (and lot of your tips of old) that gave 140hp @ 6900 at the wheels on the last dyno run.

Unfortunity it has developed a creak in #4 and a rebuild is about to happen and I hope to add some mods based on tips from this series of articles including...

Piston .080 down the bore. My current engine is flush and as the pistons I use have a 2mm dish I will machine the top flat giving the 80 thou required, it will also make the top ring 180 thou down from the piston top which fits in with #5 article.

Recess around valves, how deep should this be and how wide from the edge of the valve?

You say that your inlet port was small compared to your compeditor, what size? still round or D shaped?



11-28-2008, 05:12 PM

#7 ([permalink](#))

seattle smitty

OFF

Join Date: Oct 2007
Posts: 226

Tire Changer

My, my, DV, what a shifty charactor you are! I hope you're still not racing, because if you are, how can we trust a word you say?! 😊

You stop short of stating that a warmer charge should help most non-quench engines (other factors being equal), but that is a real interesting extrapolation. On the other hand, your last test in which you introduced a quench effect and LOST power is just plain irritating and inconvenient

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