Workshop Forum "X1/9 Tech": Shop talk, repairs, mods, specs, info, how-to advice

Sep 15 2013, 6:54 pm #1

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

Ultimate sohc engine?

"what would be the "ultimate" sohc engine, using a mix and match of stock components?" ....is a question I'm asked very often.

Ultimate can mean different things to different people, so where do we take this discussion? Some may want (or need) to stay with one of the smaller capacity options for licensing or racing rules or for the sake of originality. So which capacity combination of the sohc is the ultimate? Are we purists or are we racers? Maybe the majority of us are somewhere in-between and are simply hot-rodders? I think all here would agree, that the first thing most owners would want from their X1/9 is a bit more power!

It certainly would be nice to match the cars excellent road holding capabilities with a similar level of performance, all the while maintaining a budget that keeps a "sane" ceiling on the overall cost, and retaining the original engine configuration so we can retain the original transmission and drivetrain. As we have a budget, it means we are spending the money only once to do, or have the job done, properly the first time. So for any owner heading down this path we have actually come to our first crossroad, the first choice we need to make in our journey along the "rebuild road" to your personal "ultimate" SOHC. If your prepared to take some effort, a well built "street" SOHC can make an X1/9 quite a quick car.

There is no need for engine conversions, no need for 16 valves, no need for a turbocharger if you only need 90 to 100 hp/l at the crank. Transmissions don't like hard launches with this sort of power level anyway and turbocharging can double that, so a forced induction option would need some thought and money spent in that direction to to maintain the OE reliability factor. I'm certainly glad your choosing to stick with the sohc engine, I think too many people consider powertrain swaps without really knowing the potential of this little gem. To me the SOHC engine is the heart and soul of the X1/9 and replacing it (especially for anything non Lampredi) is almost sacrilegious...

"What is the goal?"

This is what you need to answer and be realistic about it. An achievable target for your budget, your requirements and expectations, and your level of skill. Any performance improvements to the engine would be expected to achieve OE reliability, provide a measurable improvement and be cost effective.

Fortunately here at Xweb it's an eclectic mix and we get to see a wide variety of different builds across the world by members with vastly different goals, and collectively have just about every combination of mix and match covered including turbocharged variants of Lampredi's SOHC 8v. I'm going to try to break down and collate information into what I think are some of the different levels or stages of improvement. Starting from some bolt on, cost effective options that have a measurable improvement, up to what I would consider the most cost effective and reliable way to assemble a "mix and match motor" using components sourced almost exclusively from the Fiat parts bin.

I've been thinking long and hard about format and content and I think (for now) it can be broadly broken down into three main sections, with several subsections in each.

1. What can be done with the "1300" cylinder block (1st series engine)
2. What can be done with the "1500" cylinder block (2nd series engine)
3. What can be done with the "1600" cylinder block (3rd series engine)

A really informative thread is going to need some additional info to do with component selection, include some current OE part numbers to help locate useful parts, and include some of the aftermarket options and their relative cost effectiveness compared to the standard components. It would also need to include some tips on choosing quality components that will perform to expectations. To help decide what those expectations are, it's going to also need a grounding in some of the basic and slightly more advanced aspects of performance tuning this particular engine type, which is where we are going to start.

SteveC

For the sake of keeping all the information in one thread, it's going to mean quite a bit of duplication of things I've already posted here on Xweb, and on other forums ... and I'm also going to have to ask everyone to allow me the indulgence of having this thread to myself. If anyone feels this thread deserves another to discuss any possible content inclusion or problems, then please go ahead and start one. It's simply to allow me to edit this and keep it concise, please comment somewhere else .

I hope that I'm not going to be dry and boring and this will get re read, edited and added to for around the next six months or so ... I'll try and get all the needed pics in here, but in a thumbnail format (click to enlarge in new window) so it can load up quickly. I'm also going to quote other members of this forum directly in this thread, so if you've said or done something and I think it's a good turn of phrase or very clever, I'm going to use it and quote you as a reference ...When I use pictures, most of the pictures will be mine that I have taken, but some will have been lifted from around the web. If you see a picture and it's yours and I haven't quoted you as a reference and you would like me to reference you or not use it, PM and it's not a problem

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Last edited by fiatfactory; Yesterday at 10:27 pm.

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Sep 16 2013, 12:04 am #2

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some basic and slightly more advanced engine tuning theory and practices.

Compression Ratio.
Calculating it and improving on what you have.

To start a short primer on making static compression ratio estimation calculations and some of the measurements that need to be taken to determine it. A basic compression ratio calculation might look like this:

Volume at BDC is (swept volume - pop up volume)+ flycut and ring land clearance volume + gasket volume + chamber volume.

Volume at TDC is (volume in gasket - pop up) + flycut and ringland clearance volume + chamber volume.

Volume of BDC over Volume at TDC is expressed as a ratio to one (xx:1)

You could take a few measurements of your original piston so as to determine what your actual compression ratio was...for the exercise. What we are really interested in is the CR you'll end up with. You can make an educated guess, ask the vendors to supply a few measurements from the parts they are selling or refer to the manufacturers catalouge (usually the most accurate) and use this to decide which piston is best for your needs.

But when the piston arrives and the bore has been prepared, final calculation simply NEEDS to be done by direct measurement, you can't rely on any information you might read on the net or been told... as in the real world there will be production tolerance. A piston needs to be mounted on a rod, a crank fitted and the measurements made, there is simply no other way.

For a Fiat twin cam piston the dome shape is called a conical frustum. Take some basic measurements and use these formula.

http://www.calculatorsoup.com/calcul...calfrustum.php

(this is a handy website for geometrical formula.)

We should also determine the valve flycut depth and if possible the radius or diameter of the circular cut used... and again some math will give us an idea of the flycut volume.

this is an angled truncation of a cylinder, sometimes called a cylindrical wedge...we know the angle (valve angle in relation to the bore axis) so depth and diameter (or radius) is what we need.

Use the formula found here to calculate...

http://mathworld.wolfram.com/CylindricalWedge.html

Next measurement is the compression height of all the pistons in question. Compression height is the distance from the gudgeon pin centre line to the top of the piston (crown) EXCLUDING any dome or dish. To measure accurately, fit a pin into the piston and measure from the bottom of the pin and the piston crown, subtract half the gudgeon pin diameter (11mm) and you've this measurement. If the caliper is used between the top of the gudgeon pin bore and the piston crown (add 11mm) some inaccuracy will come from the caliper tip not quite sitting flat against the inside curve of the pin's bore.

And lastly you need to determine where your pistons sat in relation to the cylinder block deck when the crank is at TDC... this is the "DECK" measurement of the piston, piston down the bore a little is "MINUS DECK", piston crown level with the top of the block is "ZERO DECK", and if the piston was to protrude past the cylinder blocks surface this would be known as (I'm sure you've already guessed it) "PLUS DECK"

The piston's deck measurement is set by the pistons compression height, the con rods centre to centre length and the engine blocks overall height, which can all vary by small amounts (i.e. "production tolerance") The block deck surface can be machined by very small amounts to get the piston crown exactly where we want it. I could write a tome on why it's better to keep the piston at zero deck rather than anywhere else, but a little popup is a good thing sometimes. I use it myself, but never more than 0.5 or maybe 0.6 mm like in my 1599cc builds... and never at the expense of deck height. I only ever give a light skim the block deck surface, to get a fine finish for head gasket retention and guarantee Straight and True. Removing excessive block deck height is a another "compromise" way of getting to an end result as it compromises deck strength, alters the camshaft to crankshaft phase and it alters the timing belt tension.

The pistons deck measurement and the head gasket compressed thickness determine the engines Squish / Quench clearance (SQ)

You need to slip the crank into a block and put a piston down the hole and measure it, do a couple of cylinders so you get good numbers.

You need all this info so you can make an educated decision on the pistons you should buy and so you can come up with a plan for your build.

"What compression ratio have I got?"

The European X19 1300 was 9.2:1 static CR, some unusual models of 1300 sohc (energy saving Uno /delta 1301) came stock with 9.5:1 (? will check references) static CR due to a piston crown change.

For a standard European spec X1/9 1300
(86.0 bore x 55.5 stroke =1290cc)
Cylinder volume = 322.518cc
Head gasket volume = 4.757cc (0.8mm crushed 87 internal diameter)
Volume in head = 34cc (nominal)
Volume of valve relief = 0.55cc (machined valve relief less small dome)
Total at BDC = 361.825cc
Total at TDC = 39.307cc
Compression ratio = 9.20:1

European 1500 X19 was also 9.2:1 static compression, and shares the same basic piston crown shape and CH values as the USA specification engine. Unfortunately with the 1.5mm full circular decompression recess that the US spec engines have, your starting with around 8.5:1 (if your lucky)

Some non USA based 1500 engines use different piston crown variations again, and despite using more restrictive carburettion and valve timing, still put out similar hp and torque values due to a slightly higher factory static compression ratio

European 1580cc displacement engines also use a basic static compression ratio of 9.2:1. It uses pistons that have a dished head to maintain this.

For the engine tuner, as all these pistons have the same basic standard diameter of 86.4 mm and most are interchangeable, it gives good scope for mixing and matching across differing capacities and achieving different static CR . If you have a US spec engine it's likely your static CR will be 8.5:1 - if your lucky. This is the main reason the US spec engines have considerably less output. The next question would logically be....

"How much compression can I achieve?"

The answer to this question determines so many aspects of any SOHC build. Compromises here, and realistically at every single "cross-roads" in the decision making process have a knock on effect. For a performance build there are three basic ways to go about increasing the static CR.

<u>1.) increase the swept volume.</u> this is pretty obvious. Overboring or stroking will increase the overall volume in the bore and combustion chamber at BDC, and with no other changes to the piston crown or combustion chamber the static CR will increase as your compressing this

greater swept volume at BDC into the same volume at TDC

2.) Reduce the volume in the combustion chamber.

a) First up would be getting rid of the full circular recess, a euro spec head doesn't have this, so all else being equal you will get at least 9.2:1 You can machine the recess away, but that creates other issues with cam timing, cam belt tension, and if you should ever need to surface plane the cylinder head again, there simply isn't any material left. Fiat recommend a specific combustion chamber depth as a minimum, by removing 1.5mm (or more) to remove the circular recess, you actually exceed Fiats minimum specifications for head thickness... personally I think the designers know best, and I feel planing the head by this amount weakens the head deck surface.

b) use a head from a smaller engine capacity. The 1100cc version of the sohc has a smaller combustion chamber to keep the static CR at an acceptable level. It however, only has an 80mm bore size and the combustion chamber only has a width of approx 80mm to suit. This unfortunately shrouds the inlet valve and limits the flow potential of the head, the inlet ports are among the smallest available in the range of engines. It will certainly raise the static CR, and this will give the engine good "punch" up to the point where the flow losses outweigh the compression ratio increase, which is up around 5500rpm give or take 500rpm. So this option is very much a "one step forward and two steps back" approach, as again it's a fact of physics that the higher you cycle a four stroke engine (and maintain VE) you will produce more power, and the 1100 cylinder head's compromises will greatly lower the VE above 5500rpm unless it is optimised.

c.) Use a Euro spec cylinder head. IMO this is simply the best option, as it is as the factory intended the engine to be in the first place. Be aware that there are also two distinct combustion chamber shapes for all sohc engines regardless of capacity/ recess or intended market. The post 1975ish style head is definitely the better of the two, it's easy to spot the differences when you see the heads side by side and thumbnails will follow. A 1500 style euro head will give you the added benefit of larger port sizes and also the larger valve seat throat as well as a larger exhaust valve. The tipo style head is effectively a factory performance item, it comes fitted with larger intake valves (in 37.5 and 39.5 mm options). Lots more details and pictures here in the head flow section

3.) Change the piston crown shape or the piston compression height.

a) A very tall wedge style dome is not ideal from several perspectives. It tends to divide the combustion chamber (when the piston is at TDC) into several small pockets and restricts the progression of the flame front after ignition. It's obvious when you look at the ignition advance requirements of engines that run these sort of pistons.

b.) pistons with a taller compression height (CH). Lots of options exist for these engines in both forged and cast.

Matt at Midwest sells increased CH pistons with a flat top, these are one option. Not what I would call a budget item at around $700 for a set of pistons and then you then still need a ring set, but they are a forged custom designed item. http://www.midwest-bayless.com/store...56&i=250929290 In a way these are unique as they are designed to allow use of a decompression recess type cylinder head as the increased CH protrudes well past the top of the block. This pop up is designed to try and fill some of the decompression recess, not the "perfect" engineering solution but IMO far better than skimming the head right back like some people do. These are "fixes" which are designed to get around compromises in components specific to the US market, fortunately we can begin our build from a much better starting point if we want to.

Vick's auto also offer high compression pistons, so this is another option. http://www.vickauto.com/newstore/ind...oducts_id=2997 but how anyone is supposed to decide if they will suit their requirements, I have no idea?? No CH or dome dimensions supplied at all. Not a budget item at $600 for four, plus rings on top of that.

There are original equipment pistons that have higher CH than the stock OE 34.45CH large cast in flycut pistons used in the Euro and US spec 1500 X19 engine. Standard for the euro spec 1300 is 34.7CH and a 0.6mm pimple of a dome. There are other common SOHC variants that use 34.9CH small flycut pistons as standard, and the are even some (difficult to find) OE 1301 engine pistons with 1.6mm raised domes and 35.3CH that give 9.4:1 standard.

"what can I do if I haven't got high compression"

If your engine is compression compromised, you will be "behind the eight ball" in building Mechanical Efficiency (ME) into the bottom end. The only thing you can do with a compression compromised engine is to try and increase the volumetric efficiency (VE) as much as possible. This in effect is the only way you can boost the engines dynamic CR. Performance engine build improvements will build ME and VE, and bump dynamic CR. If your compression compromised, it restricts your choice of camshaft, because you need to attempt to still keep some sort of realistic DYNAMIC compression ratio. In all these theoretical examples, the ME, VE and dynamic CR are considered for a specific amount of engine revs. The VE %age can change considerably at different rates of engine cycling, which is why an engine can drop power at one point of the rev range, and gain somewhere else after any modifications...

Engine example A) Increase the static CR (an improvement in ME) and retain the same cam timing and other engine parameters, your going to see a bump in the Dynamic CR, and a bump in HP.

Engine example B) Retain the static CR, increase the valve open cycle in duration, keep other engine parameters the same, and generally your going to see a drop in the Dynamic CR, and a drop in HP

Engine example C) Retain the static CR, Increase the valve open duration cycle, change other engine parameters which affect the VE (like add twin carbs or free flow exhaust), and with some luck you might have altered the balance back favourably in Dynamic CR (by getting a greater mass of fuel / air in over the same cycle speed) and your likely going to see a bump in HP

But this can "stretch" out into the engine many end up with...

Engine example D) Retain the static CR, increase the valve open duration considerably (big cam) slow the port air speed at low revs considerably (big carbs) the engine described will rev to 8500rpm but it probably won't feel very lively, it won't "pull strongly" and it won't be any fun below 4500rpm.

and this is hardly the best engineering solution to the presented problem... is it... but it does lead to the natural progression of the next idea...

Engine example E) Retain the static CR, retain the standard euro valve open duration (no drop in Dynamic CR) increase the available flow thru the head and the increase the valve lift and improve the exhaust flow (so we are talking BIG improvements in VE) The aim in performance engine building is to increase the Volumetric Efficiency, that's what porting and polishing does, and what fitting twin carbs does as well by allowing the engine to breathe in and out easier. The higher the VE, the lower the required static compression ratio, the lower the required CR, the smaller the required piston dome, the smaller the required piston dome the easier the flame front will propagate in the combustion space and that improves horsepower. It's an interconnected relationship. It's a fact of physics, the higher you cycle (That's REV to you and me) a four stroke engine and maintain VE, you will produce more HP... again it's an interconnected relationship.

"What if this engine is going into a street driven car that's going to be using pump gas? "

If it is then the wedge dome style Hi Compression pistons are not really what you want. They will raise the static CR too high to use with regular fuels, and yes, the dome will interfere with the combustion process which in turn makes the engine very sensitive to ignition timing variations. The other down side is cost and availability. As you would expect with the laws of supply and demand, they have become hard to find and as supplies dwindle prices have risen.

KS once made cast and forged pistons with a rather large raised area, not quite a full wedge as a production off the shelf option. These still pop up from time to time, I'll edit this and add in the additional part number info and a picture. I have a set of these, found on Ebay late 2012, they were expensive! In the day these were one of the few ways to get a 1300 to build sufficient compression. Other vendors sell forged ARIAS pistons that look similar in dome pattern to these, pics / links to follow

"what compression ratio do I need"

Is another favorite question ... and again the answer depends what your expectations are? The best answer will vary depending on what other things you will be doing to improve the engines VE at the same time... and what other components you intend to combine into the engine build.

SteveC

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Last edited by fiatfactory; Today at 8:09 am.

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Sep 16 2013, 1:16 am #3

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slightly more advanced again engine theory and practices.

In my opinion the SOHC is quite a spectacular engine and Aurelio Lampredi's finest mass produced work, eclipsing even it's "big brother" the Fiat twin cam. Despite having it's humble origins as a powerplant for Fiats front drive revolution the 128, during the early '70's it was the engine of choice for many of Italy's finest tuning houses. Many also developed cross flow dohc cylinder heads to fit atop the standard block, but this is well beyond the scope of this discussion which requires a production head to be used.

Why is the SOHC so good? Despite having the "inferior" design non crossflow cylider head, these engines regularly top the magical 100hp/l figure - which is certainly a benchmark for engines of this era - and is certainly something that is difficult to do with it's big brother 8 valve twin cam. I think it boils down to two main things, rod ratio and port angle. The first series of sohc (1116/1290) had an incredibly high rod ratio of 2.162:1 (120mm rod CtoC and a 55.5mm stroke) at the time this was unheard of in a production engine. Aurelio was a very clever man, and intimately understood the relationship between the moving piston and the column of air that follows it, he did afterall design some of Ferrari's finest F1 engines of the 50's and 60's.

Using the 1290cc engine as an example, at 8000rpm we have a mean piston speed of 14.84M/s, but due to the very high rod ratio we have a peak piston speed of 23.86M/s at 78 degrees ATDC - an increase of over 60% over the mean piston speed - and between 64 and 93 degrees ATDC the piston speed is above 23M/s, thats nearly 30 degrees of crank rotation. This imparts a lot of velocity (energy) to the column of air moving through the inlet port, which inturn allows the flow through the port to continue at high velocity throughout the remainder of the inlet valve event. So despite its relatively small inlet valve size of 36mm compared to its large 86mm bore, and very modest inlet port size of just 26mm, it's this high airspeed that allows the little 1290cc engine to produce a healthy 75Hp in stock trim, which is around 58.125hp/litre.

The 1495cc and 1581cc versions behave in a similar fashion.

1495cc (63.9 x 86.4) has a rod ratio of 2.007:1 (128.25 CtoC rod and a 63.9mm stroke) which will give a mean piston speed of 17.087M/sec at 8000rpm, but the peak piston speed is 27.583M/sec at 77 ATDC, it has a piston speed of over 27m/sec from 67 ATDC through to 88 ATDC.

1581cc (67.4 x 86.4) has a rod ratio of 1.906:1 (128.25 CtoC rod and a 67.4mm stroke) which will give a mean piston speed of 18.022 M/sec at 8000rpm, but the peak piston speed is 29.190M/sec at 77 degrees after TDC, it has a piston speed of over 28M/sec from 62 ATDC through to 92 ATDC.

Considering around the same time the 125special was making 100hp from 1608cc (which equates to around 62.5hp/litre despite much larger inlet ports / valves and far higher valve / bore size ratio) the "inferior" SOHC with it's non cross flow design holds it's own. The SOHC was also massively over-engineered in it's bottom end... it uses the very same sized conrod bolts/nuts as it's 1608 counterpart, as well as the same sized main and bigend journals.

So what does all this have to do with your compression compromised 1300 sohc build?

Not much. But I'm hoping it gives some of the uninitiated readers a glimpse into my love of the SOHC and my reasons to build a heavily modified engine based on a 40+ year old design of engine that some would term "ancient and obsolete", I think it is far from that. The sohc engine, in a form that is true to it's original of 1116 cc's is still a current production engine (albeit only with Euro 1 emissions compliance)

Not many mass produced engines can make a boast like that, not even Fiat's twin cam - It only lasted through to the mid 1980's before it underwent major design changes (reverse flow) and then ceased to be produced altogether before that decade ended... a lifespan of just 25 years.

Quote:

> Originally Posted by **AlConsentino**
> *(from FAZA Abarth Fiat Lancia 'bible' by Al Consentino): "Beginning of the Fiat 128-X1 /9 engine actually began back in 1962 when Carlo Abarth unveiled his first all Abarth DOHC engine designed by their chief engine man, Luciano Focchi. The photo here with the Bosch distributor mounted on the chain drive cover and the twin ignition, Marelli distributor mounted on the rear of the exhaust cam is one of the Abarth DOHC engines in the 1300cc category, (1288.3cc). The engine number 230-S has a 76mm bore and 71mm stroke, 3 main bearings, not 5 main bearings like the Simca 1000 engine, which many assumed the origin of this engine block). Abarth also produced this engine in same 71mm stroke with 5 main bearings. Abarth was interested in continuing his G.T. World Championships. In order to do this, he needed bigger chassis than the Fiat 600's to carry the new and more powerful 1300cc DOHC engine. I think he made the arrangement with SIMCA, France through G. Agnelli as the Agnelli family owned the factory that produced the Simca 1000 chassis. What a chassis it was — good enough*

neat many proto-type cars in 93 races the first year and win the World Manufacturers Championship in 1963, 1964 and 1965. After that, Abarth broke it off with SIMCA of France. The main reason was the Fiat 850 had been introduced in late 1964 and would tie in with Abarth's rapport with Fiat. For the 1966 World Mfg. GT Championship, Abarth had an all new engine and every piece was new and different from the camshafts to the sump pumps. The DOHC engine number was 237 with a bore of 86 mm and a stroke of 55.5 mm, totals 1,289 cc's, exactly the same as 1 28-X1/ 9 engines. The Abarth 237 engine also had 5 main bearings as did the Abarth SOHC engine #237-A, the true replica of the 128 engine. Of course, if you ask Fiat engineers where and who designed the engine, they would have another answer for you. With this new DOHC engine #237, Carlo Abarth went on to win with his Fiat-Abarth 1300OT. The last three 1300cc Division I World Mfg. GT Championship in 1966, 1967 and 1968, before F.I.A. dropped the class in 1969.

I'm afraid I think Al's ramblings on this subject are just that...ramblings. To claim that Lampredi's SOHC is derived from an Abarth DOHC engine just because it has the same bore /stroke and same number of crank bearings is perhaps stretching the truth!!

Lampredi's SOHC was according to Fiat literature at the time "all new". It shares some internal dimensions with the 124OHV and early variants of the DOHC engines, which is understandable when you consider mass production techniques that Fiat chose to machine their "new" SOHC engine with the same crank journal sizes as the already (at the time) in production OHV and DOHC units.

The original SOHC, toothed belt drive camshaft, non crossflow 1116cc engine was completely new in its general layout when introduced. When "redesigned" several years later for an increased bore size of 86mm, the block was changed considerably (non siamesed bores, different water jacket layout) but the bore spacing/crank journal sizing/head bolt pattern etc remained constant ... so it's only in the SOHC's second form that it bears any (dimensional) resemblance to the Abarth #237 DOHC 1300 which Al references...

Bore spacing, head bolt layout, rod ratio, bore/stroke ratio, etc etc are just a few of the parameters that an engine designer needs to consider ... To say Lampredi's SOHC was a copy of Focchi's work without a very detailed comparison is a very big claim.

"Do bigger intake valves make a difference"

Fiat intake valves come in three basic sizes. 36mm , 37.5mm and 39.5mm. Unfortunately you can't just put a bigger valve straight into the head onto the existing valve seat smaller.To install larger valves require the installation of a larger outside diameter valve seat insert. A good machine shop can do this, but this sort of work doesn't come cheap because of the skills and machinery required, the new inserts can cost a few lire too as some are made from very fancy steel alloys. Larger intake valves and a larger valve seat throat can make a lot of difference to performance.

If done right it's one of those modifications that doesn't have a downside (apart from the added expense) so I feel it would pay to invest in this modification, and work this into your budget. Not only does it improve breathing in the upper rev ranges, it will give you more torque down low as well. It will improve the VE of the engine by allowing it to breathe easier as some restriction to the air flow into the engine is reduced. I've seen examples of head modifications (and done them myself in the past) that can get a 36mm valve and throated seat up to 120cfm, but I believe that's at the expense of port velocity. I know that a 37.5mm valve can be made to flow around 120 to 125cfm and still maintain good port velocity. I know that a 39.5mm valve and well prepared port can flow up to 160cfm. at very high port velocities. Absolute flow limits absolute HP, sure, but port velocity affects torque throughout the rev range.

"Do I need to have a 3 angle cut on the valve seats?...I'm on a budget."

ABSOLUTELY. This is one of the basics to improving the flow through the cylinder head. A top quality 3 angle valve job will make significant flow improvements at all engine speeds and valve lifts. Try and save money here and you may as well forget doing the job as the results will not meet your expectations. On top of the regular 3 angles, an additional 90 degree straight plunge cut to enlarge the throat of the valve seat will show significant flow gains. It is definitely worthwhile to have this straight plunge cut extend into the alloy head inside the valve bowl to make the straight run into the back of the valve as long as possible.

While cutting the seats consideration also needs to be given to seat height, as this affects the valve spring tension. Relative seat height between the inlet and exhaust valves also needs looking at. Sinking the exhaust valve slightly lower than the inlet will improve flow around overlap and reduce the amount of inlet charge that is drawn out through the open exhaust valve, commonly known as "draw through."

In addition to the seat work, you also need to carefully prepare the valve heads. A 30 degree back cut to both the intake and exhaust valves will improve flow, after the valve is lapped and a clear seating matte grey area is seen, bring the 30 degree back cut right up to within 0.5mm of this sealing line. Careful attention to valve margins and a top cut on the intake valve to reduce flow reversion at overlap are worthwhile steps in a performance head build.

Bottom line is you need to find a competent machinist who is prepared to work to a fine tolerance and pay them well for their efforts, otherwise your simply wasting your time.

SteveC

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Last edited by fiatfactory; Today at 1:52 am.

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Sep 16 2013, 4:09 am #4

fiatfactory
Steve Cecchele

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What can be done with the "1300 block"

This discussion should include the 1116 block and the differences between the 1290 and 1116 blocks. In reality we should refer to these as 1st series engines.

The 1st series block is shorter than the 1500 (2nd series) and 1600 block (3rd series) and this leads to a couple of issues for some bore stroke configurations

The 1300 conrod is quite short at 120mm, and it is cast. The 1500/1600 conrod is 128.5mm and is forged.

The 63.9 stroke crank will fit the 1300 block, no problems, if you overbore to 86.4mm you get a normal 1500, well 1498 cc. It's the same same deal with the 67.4mm stroke crank, it can be made to fit the block with a little bit of grinding here and there to make clearance. You could get up around 1600 c in a "1300 Block" engine, and this was the basis for aftermarket manufacturers like PBS and Alquati who offered these kits before the "1500 / 1600 block" options even existed. They made very fancy fully counter weighted crankshafts to do this application. These kits have been known to change hands for serious $$. The PBS 68 mm stroke crank is known to have a habit of developing cracks, so if purchasing one of these as a used unit crack testing is advised.

One big issue with these "stroker" options is the conrod choice. With this configuration you have connecting rod compromise, a rod ratio compromise and a piston compression height issue in that there is certainly nothing "off the shelf" in the Fiat parts bin that will do the job. Likewise with the cast conrod this will become the Achillies heel of the engine and limit it's rev potential and longevity. What all this amounts to is at least custom pistons and having to remachine alternate rods that meet length and construction crtieria, or have rods custom made... simply lots of extra expense to get where you could be with stock parts in a "1500 block"

For all these reasons I would rate these "stroker mix and match" of parts quite low on a scale for tuning potential...maybe 5/10.

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Last edited by fiatfactory; Yesterday at 4:54 am.

Reply Quote

Sep 16 2013, 4:10 am #5

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

What can be done with the "1500 block"

As with all builds, you need to come up with a plan. In the 1500 block (2nd series engine) your choices boil down to 4 basic options.

1) Stay 1500 and rebuild, retain existing head with a freshen up. Your at the cross roads and get to choose, to some degree, your static compression. You get to set your quench clearance, and you get to position the piston where you want to.

1a) Stay 1500 and rebuild. The option exists to get a Tipo based head and fit it to your engine, 39.5 /31 or 37.5/33 factory combinations, a sort of factory big valve head (without all the compromises that PBS built into theirs) Static compression, SQ clearance and piston position as above

2) Stroke it to 67.4 mm. Retain current head. Static compression, SQ clearance and piston position as above

2a) Stroke to 67.4 mm. Tipo based factory BVH. Static compression, SQ clearance and piston position as above.

IMO the 1603 (87.0 x 67.4) hits the sweet spot when you consider bore / stroke and rod ratios, valve to bore (capacity) sizing, and potential in Hp/l.

1500 / 1600 use the same rod, forged std, 128.5 mm long. To reuse std rod would be fine, and when stroking to 67.4mm they will fit the stock crankcase with very minor work to the crankcase oil gallery. I like to check stuff before I use it (and push it hard) so my rebuild would include crack testing the rods, rebushing them and resizing them after fitting new std rod bolts and nuts. All this adds up to more than you get a set of aftermarket SCAT conrod's for, so it's a bit of a no brainer these days to go the SCAT option if you intend to push the engine hard.

These combinations are what I feel are the best options for a performance "street" engine out of everything presented in this discussion, simply due to the availability of factory crank and piston options, the availability of "off the shelf" aftermarket conrods, and the availability of factory BVH options. I would rate the tuning potential of these options quite high, at least 9 /10.

"should I use 1500 instead of a 1300 as a base"

It's far easier to build compression in a 1500 by using a flat top (and readily available) small flycut cast piston, up to around the 10 - 10.5:1 mark with relative ease (certainly when compared to the 1300) and reasonable costs.

The second advantage would be it opens up a whole range of cylinder heads (that will only suit bores of 86 mm or more) including the 14 bolt

Tipo based options which are effectively a factory BVH (without all the PBS engineering compromises built in to them) These will fit on a 10 bolt block with minor modifications, but the option exists for a 14 bolt 1500.

The third advantage would be con-rods and con-rod choices. 1500 forged rods are way stronger than the cast units of the 1300. Aftermarket options in 128.5 mm CtoC rods are relatively cheap and available, but you can't say the same about the 120 mm CtoC rod for a 1300.

And the fourth advantage would be the availability of a factory crank to stroke the engine easily to 67.4mm and 1600cc.

You miss out on all this if you stay with the 1300 engine.

I've included a subsection for 55.5 crank in a 1500 block, effectively a long rod 1300. More for a theoretical discussion than something I would build, but it would have it's place in the right circumstances. There is also no subsection for "1500 block with longer stroke crank options" as the internal dimensions of the crankcase preclude the use of longer stroke cranks without significant machining, and IMO a loss of OE reliability.

SteveC

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Last edited by fiatfactory; Today at 7:58 am.

Reply Quote

Sep 16 2013, 4:11 am #6

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

What can be done with the "1600 block"

no text yet

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Reply Quote

Sep 16 2013, 4:14 am #7

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

SOHC - pistons 101

"What are these pistons like?"

At the risk of stating the obvious, pistons are not all the same. I can see (in the possibly generic picture that is shown) on some vendors websites the pistons shown have slots in the oil ring groove. Higher quality and stronger pistons have oil holes drillled for the oil return. Same with lots of other differences in construction like steel reinforcing band or not, same manufacturer with different styles of piston to suit engines of the same size, but one coming from the "sports" or "rally" model has the piston made a little differently. Then there are differences in the materials used, obvious when you see a few pistons side by side, as I have over the years. I've got loads of piston pictures to insert here to help explain some of the differences

If you want to do a nice job, quality parts is a given. From bottom of the range to top of the range cast pistons there can be a difference of almost 100% n the wholesale price. Luckily there were so many of these engines made, OEM supply of quality pistons should continue for some time, certainly the more common crown configurations. Shop early, and you'll avoid paying the "I need it now" premium for both parts and postage.

1st Choice. This is a budget build and budget means only doing it once, and doing it properly. This makes the first choice real KS marked Kolben Schmidt pistons. Failing that Mahle branded pistons. Mahle package other peoples pistons in their boxes, so sometimes you'll get Mondial or Borgo pistons packed in a Mahle box. In a rough sort of scale of quality, I'd say KS, German made Mahle, Mondial / Borgo would be a tie for third, each are good up to a particular level of static compression and revs.

There are plenty of parts imported from eastern European countries where they have a lot of these engines, but think the absolute base models with low output... they locally manufacture pattern parts. I think the Germans and Italians make some high quality replacement car parts and these are what I prefer to use. Having established there are differences in pistons, next is different ring sets. You can get a choice of cast ring /chrome ring /moly ring /thinner factory ring. The 1580 standard ring pack is a nice option, thinner rings, (1.5/1.75/3 whereas standard is 1.5/2/4) and even a moly coated options from the factory. Total seal is an aftermarket option but their ring sets come at 86.5, 87.0 and 87.5 sizes, so only 87.0 bore size ties in nicely here with factory oversizes.

I stick with parts I know, I have pushed these particular part numbers and brands in previous builds and have a good idea which brands and construction types tend to fail and where /why. So what does the last 500 words boil down to, basically don't shop for parts for a "performance" build with the cost being the primary consideration.

To sum up with six famous words... "Fast, Cheap and Reliable. Pick Two."

Production Piston crown types.

The Fiat SOHC 8v came with seven different piston crown designs across production. A picture is worth a thousand words, so here are a pictures of all known production crown types.

Type 1.Machined in large valve flycut.

Type 2.Cast in Large valve flycut.

Type 3. machined in small flycut.

Type 4. machined in small flycut with 0.6mm central dome.

Type 5. cast dish and machined flycuts.

Type 6. machined dish and valve flycuts.

type 7. 1.6 dome and machined flycuts.

Type 8. Uno Turbo series 1 - this is only for 80.5 standard bore, but included for further discussion.

Crown shape isn't the only difference, quite a few of these designs are available in several different compression heights. Compression Height (CH) is the term for the measurement from the gudgeon pin centre line, to the crown of the piston (excluding any dome or dish)

Aftermarket Crown shapes.

Compression Height and Dimensions.

MAHLE
From the Mahle catalogues of 1999 and 2005 the basic dimensions of pistons available for the Fiat sohc engine in 86 /86.4mm standard sizes:

P/N 0078000, CH of 34.7mm with flycuts 2.6mm deep,
dome height 0.6mm, crown shape type 4, overall length 77.3mm.
Standard size 86.0mm, oversizes 0.2,0.4,0.6,0.8 and 1.0mm.

P/N 0087000, CH of 34.15mm with flycuts 2.7mm deep,
flat top piston, crown shape type 3, overall length 73.65mm.
Standard size 86.4mm, oversizes 0.2,0.4 and 0.6mm. (replaced by mahle 0087200)

P/N 0087100, CH of 34.45 with flycuts 2.8mm deep,
flat top piston, crown shape type 3, overall length 73.95mm.
Standard size 86.4mm, oversizes 0.2,0.4 and 0.6mm.

P/N 0087200, CH of 34.15mm with flycuts 2.7mm deep,
flat top piston, crown shape type 3, overall length 73.65mm.
Standard size 86.4mm, oversizes 0.2,0.4 and 0.6mm. (replaces by mahle 0087000)

P/N 0087300, CH of 34.9mm, with flycuts 2.76mm deep,
0.5mm dished top piston out to a diameter of 72mm, crown shape 6,
overall length 74.4mm.
Standard size 86.4mm, oversizes 0.2,0.4 and 0.6mm.

P/N 0087400, CH of 34.9mm, with flycuts 2.7mm deep,
flat top piston, crown shape type 3, overall length 74.4mm.
Standard size 86.4mm, oversizes 0.2,0.4 and 0.6mm.

and lastly

P/N 0087500, CH of 33.3mm, with flycuts 2.3mm deep,
dished top piston, crown shape type 5, overall length 72.8mm.
Standard size 86.4mm, oversizes 0.2, 0.4 and 0.6mm.

info from KS catalogue

Mondial catalogue.

34.45 CH smallflycut

34.7CH with 0.6 dome (pimple) small flycut

35.30CH 1.6 dome small flycut

SteveC

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Last edited by fiatfactory; Today at 5:46 am.

Reply Quote

Sep 16 2013, 4:15 am #8

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

SOHC - cylinder head flow.

Power is made in the Ports

If the first part of the plan is "What do I want to achieve?"... then this is closely followed by "How much do I want to spend?"

PBS literature is very very old. Things have moved on since the dark ages of no internet and no eBay. PBS used a Nissan valve for their BVH conversion, the 40mm valve had its collet groove recut to the Fiat style. The valve used was also longer overall, which required trimming for length. PBS often left the overall valve stem length longer than standard (approx 108.5 mm is stock valve length overall) to compensate for the reduced base circle cams they sold. Another way to compensate for reduced stem length or a reduced base circle camshaft would be to machine the cambox to maintain correct valve lash specs.

If your core head is US spec, then it will all have the full circular decompression recess. Planing the head by 1.5mm to remove the full circular recess is just one way to raise the CR, but it comes with several compromises. It reduces the head deck thickness, which ultimately weakens it. By removing so much material you reduce the chance of ever being able to recondition the head should you overheat the engine and need a remedial cylinder head skim as there is simply no material left to skim. It also alters the cam timing and reduces the cam belt tension. It takes a lot of effort to install larger valves, and taking all that effort and putting it into a head that has no reconditioning left in it... well to me that just seems like a poor choice (poor compromise)

In today's world with the internet and eBay many people opt for a euro spec head, which has no machined recess to start with. This is one way to maintain head deck strength and standard cam timing and increase static CR with the smaller combustion chamber volume. In the US a euro spec head would include one from a Yugo engine of 86.4 mm bore size.

In today's world, oversize valves are available from other late model Fiat sohc engines, 37.5 and 39.5mm head size, correct collet groove, correct stem length. Installing larger valves also means installing larger diameter valve seats, at additional cost. Using OEM parts saves having to make some of the "old fashioned" compromises.

In today's world a factory "BVH" is an option. Tipo style head comes in 37.5/33 and 39.5/31 valve configurations "out of the box"

Port Velocity

Most discussions about porting, talk almost exclusively about achieving greater values for airflow. If simply having larger values for airflow were the key to maximum horsepower then we could expect the “bigger is better” theory to hold true, which it doesn’t. The keys to producing the best airflow for an engine lie in port velocity and flow efficiency. If a port is modified to produce good flow with a minimal amount of material removed, then since it is flowing more air through much the same sized port, the velocity (air speed) must have also increased.

Though too much port velocity can limit top end power, low velocity can reduce power throughout the whole power curve. On a carburetted engine, a smaller port volume will improve throttle response as it has less damping effect on the induction pulse. Less damping will enhance the atomisation of fuel from the auxiliary (or second) venturi, which in turn aids both fuel distribution and burning efficiency. Higher port velocities also support atomised fuel better with less chance of fuel falling out of suspension or forming into large droplets.

A small volume - hence high velocity - port will also enhance cylinder ramming at the end of the intake stroke and this will increase volumetric efficiency. This can be coupled with attention to entry direction through the valve which can promote better cylinder swirl and aiding combustion efficiency, which all leads to what we want to achieve - more power being produced.

The exhaust port velocity is also important. A slow exhaust port can cause an engine to have little low-end power before coming "on the cam" abruptly.
As the intake valve opens it's the exhaust flow that provides the energy to initiate flow past the valve, well before the piston begins to move down the bore.
If the exhaust velocity is low, effective scavenging of the combustion chamber is lost during the overlap period.

For both intake and exhaust the key to making an efficient port, is to manoeuvre air around any corners as effectively as possible. Though light, air has sufficient mass to be affected by momentum as it moves through the port, and requires little velocity to exhibit a tendency to go straight ahead rather than around a bend. Air arriving at too sharp a turn in the port will not negotiate the turn at the tight radius, it will simply hug the turn at the wall of the larger radius. This can make the port flow considerably less, and can be seen by the air as a very real constriction.

The key to getting air to negotiate corners efficiently comes down to two main factors.
1.Making the corner as large a radius as possible, and
2. Increasing the port cross sectional area enough to slow the air, hence enhance its ability to negotiate the turn.

The Flow Cone

This next part is a very important part of the porting / understanding flow paths concept - the Flow Cone. I talk quite a bit about how "shrouding" will reduce the total flow through the port considerably, well here is why. Understanding the dynamics of airflow around an obstruction is crucial to achieving good flow through a port. It is vital to remember that the valve head is the greatest restriction to the flow path, as it sits right in the middle of the airstream and all flow must move around the valve head before it enters the combustion chamber. This is one of the reasons I honestly can't see any value in bare port flow numbers... how often is an engine going to be running like this?

Smoke or water flowing thru a clear tube shows how the airflow forms a typical cone shaped path above and below the valve head. An interesting fact is that when flow through the port becomes better and the velocity of the flow increases, these cones become shorter.

Image

Another fact is that if anything happens to break into the area formed by these Flow Cones on either side of the valve head- like tight cylinder wall shrouding or dropping the short side radius - then the total flow through the port is severely reduced. To achieve maximum flow through any port these Flow Cones must not be disturbed in any way. Serious engine builders spend quite a bit of time ensuring that the angles and widths, particularly of the valve face, margin and leading edge (upper for intake, lower for exhaust) are as they want them. This is because these factors have a strong positive influence on this Flow Cone formation.

Some factors that can have a negative influence on the Flow Cone formation, and hence drop the total flow through the port are...

a) Shrouding from the cylinder wall / combustion chamber walls

b) Shrouding by the valve cutout pockets / piston dome

c) Dropping the short side radius of the intake port

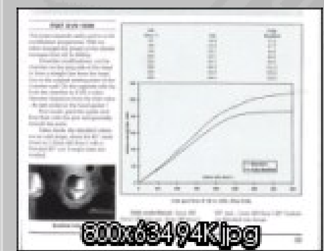
In the Fiat sohc cam engine the greatest factor of these three is the effect of shrouding by the combustion chamber walls. To get good flow on an 86/87mm bore sohc engine, you really need to relieve the combustion chamber and deshroud the inlet valves.

Some people when fitting larger valves or porting cylinder heads have a tendency to drop the port floor (reducing the short side radius) in an effort to bring the flow into the backside of the valve at an oblique angle. This is just totally wrong. If you try and bend the flow right at the edge of the valve, the cone doesn't form around the edge of the valve and total flow drops off considerably. To get a uniform cone formation around the entire circumference of the valve, we want to turn the flow well above the valve head, and let the flow come straight into the back of the valve. There are always restrictions to what is possible, but one thing is absolutely certain, that you should try and get the sides of the intake port dead straight and perpendicular to the valve for as long a distance as possible.

Total flow past the primary obstruction (the valve head) can also be increasedif the Flow Cone becomes more of a Vortex. Think back to Primary School science lessons. Remember getting two bottles of water and inverting them to let the contents empty, and giving one of the bottles a little swirl as you were inverting it.
The bottle that has the extra energy imparted to it forms a "whirlpool" or vortex at the mouth, and empties considerably quicker than the tumbling flow of the "non-swirled" bottle. Precisely this same effect can be applied to an inlet port, and Fiat have already done it for us with the Port Bias that is found in the standard production ports. The offset bias, and the transitions formed by this bias, angles the low flow (the lower portion of the port) towards the far side of the valve, directing the airflow in such a way that a swirl effect is imparted, and total flow increased. If this offset bias is ignored (think of these like the little "winglets" you see all over a contemporary F1 car which angle the airlow around obstructions) then the vortex effect is completely lost, and total flow is reduced.

SOHC head flow data comparisons and conclusions.

Taken from "How to Build, Modify and Power Tune Cylinder heads"
by Peter Burgess / David Gollan - B Eng Hons.- Veloce publishing ISBN 1-903706-76-9



This data relates to a X19 1500 (UK spec) standard 62 rear wheel HP. (rated * 85 crank HP) (9.2:1 CR 24/68 64/28 9.9 mm inlet lift cam, 34DMTR carb, twin out exhaust manifold, no cat conv.) By comparing the same vehicle, on the same dyno, with only the modifications to the cylinder head - and still using standard valve sizes - (ie valve mods, chamber mods, valve seat mods, very light smooth out of ports) results in a noticeable increase of 22 rear wheel HP to 84 rear wheel HP. Max. flow increased from 86.5 cfm to 108.5 cfm at 400thou lift. (measured at 25in. H2O) The flow at 250thou increased from 80.7cfm stock to 92.3 cfm when modified, so the modified head flows more at 250thou lift than the completely stock head had at 400thou of valve lift! These results mirror my own findings and flow testing, which are based over 30 years of Fiat SOHC experience.

If you couple a cylinder head prepared as above, with an increased compression ratio (for example by using 1300 small valve relief pistons in a 1500) a longer duration and higher lifting cam, a free flowing exhaust system (but still using the stock intake and exhaust manifolding) with a 34dmtr carburettor and 2.25 inch muffler and pipes, a well built 1500 overbore can net close to 100RWHP. I have had this in my own 1500 X19 at 99RWHP and have built several customers cars to the same / similar spec, they all gave similar results. 100 rear wheel Hp is certainly achievable from a naturally aspirated 1500cc sohc. It requires more port flow and a higher static CR than standard specificatons, but with a balanced mix and match of the other "good" bits and pieces this sort of result is possible. By working mainly the valve bowls and seats we maintain a high port velocity (as the port size does not get increased significantly) and this results in very good low and mid range response, in fact much better than the standard engine due to the increased port efficiency, and the increased mechanical efficiency provided by the higher CR.

Comparing flow data from different sources

To compare flow measurements when different pressure drops are used for testing is quite straightforward, as flow follows a "square" law of pressure versus flow. To calculate a "correction factor" use the following formula.

Flow at new pressure drop = square root of (NPD/OPD) x flow at original pressure drop

Conversion from 25" H_2O to 10" H_2O would be;

Flow at NPD = Square root of(10/25)x Flow at OPD
= a correction factor of 0.6324

Conversion from 10" H_2O to 25" H_2O would be;

Flow * NPD = Square root of(25/10)x Flow * OPD
= a correction factor of 1.5811

Figures corrected to 10" H_2O for a standard 1500 X19 cylinder head.
50thou = 10.3 cfm
100thou = 21.19 cfm
150thou = 32.95 cfm
200thou = 43.7 cfm
250thou = 51 cfm
300thou = 53.7 cfm
350thou = 54.25 cfm
400thou = 54.70 cfm

What is significant for these numbers is that the %age increase in flow rate above 250thou of valve lift drops off considerably, so the the curve "flattens off" noticeably.

Figures corrected to 10" H2O with modified port/seat/throat/36 mm valve
50thou = 10.95 cfm (6.31% gain over stock)
100thou = 23.84 cfm (12.5% gain over stock)
150thou = 37.44 cfm (13.65% gain over stock)
200thou = 50.6 cfm (15.8% gain over stock)
250thou = 58.37 cfm (14.45% gain over stock)
300thou = 64 cfm (19.18% gain over stock)
350thou = 66.78 cfm (23% gain over stock)
400thou = 68.62 cfm (25.5% gain over stock)

Here flow test data on a standard port flow of the tipo head with 37.2mm valve fitted, seats 3 angle cut but port and OE valve totally standard. Test was done at 10" of H2O, but lift shown on a metric scale. I've done my best to read off the graphed figures accurately at the commonly used lift measurements at 100 thou intervals.

50thou = approx 12cfm (* approx 1.25mm lift)
100thou = approx 23cfm (* approx 2.5mm lift)
150thou = approx 33cfm (* approx 3.8mm lift)
200thou = approx 42cfm (* approx 5mm lift)
250thou = approx 52cfm (* approx 6.35mm lift)
300thou = approx 57cfm (* approx 7.6mm lift)
350thou = approx 63cfm (* approx 8.9mm lift)
400thou = approx 65cfm (*approx 10.15mm lift)

Never having tested a stock tipo sohc 37.2mm intake valve cylinder head I have no raw data of my own to compare, but these numbers look about right. What I do have is data on a X19 1500 cylinder head with modified throats / seats / valves / chamber and fitted with a 37.5mm intake valve, again no significant increase in port size.

50thou = 12.3cfm (up from 10.95cfm - approx 12% over a 36mm valve in a similarly prepared head)
100thou = 25.6cfm (up from 23.84cfm - approx 7.5% over a 36mm valve in a similarly prepared head)
150thou = 43.6cfm (up from 37.44cfm - approx 16% over a 36mm valve in a similarly prepared head)
200thou = 54.6cfm (up from 50.6cfm - approx 8% over a 36mm valve in a similarly prepared head)
250thou = 65.5cfm (up from 58.37cfm - approx 12% over a 36mm valve in a similarly prepared head)
300thou = 69cfm (up from 64cfm - approx 8% over a 36mm valve in a similarly prepared head)
350thou = 72cfm (up from 66.78cfm - approx 7.8% over a 36mm valve in a similarly prepared head)
400thou = 75cfm (up from 68.62cfm - approx 10% over a 36mm valve in a similarly prepared head)

so on average a change from a 36mm valve head to a 37.5mm valve head will net approx 10% in flow across the board on a prepared head

Tipo style head - 14 bolt. aka "The Chinese Head"

I'm quite impressed with the quality. Don't let the "Made in China" tag fool you, there are certainly some good manufacturers over there, with modern machinery and factories, so there are some companies who make quality aftermarket parts. This is an aftermarket Tipo style head 14 bolt, already fitted with LPG compatible valve seat inserts and cast iron guides. 39.5mm inlet valve size, 35.5mm seat throat size. 31.0mm exhaust valve head size, 27.0mm exhaust seat throat size. Inlet port size 28.5/29.0 and exhaust port size 27.5mm.

I've flow tested this head on my bench (which uses a depression of 28" of water for testing) and the results were pretty good for a straight out of the box head. Figures are still at 28" of H_2O, corrected for temp/humidity etc

Inlet
0.050 30.4cfm
0.100 60.6cfm
0.150 77.8cfm
0.200 95.7cfm
0.250 106.6cfm
0.300 118.8cfm
0.350 121.9cfm
0.400 124.0cfm

Exhaust
0.050 25.8cfm
0.100 41.2cfm
0.150 56.0cfm
0.200 70.6cfm
0.250 82.3cfm
0.300 86.1cfm
0.350 87.8cfm
0.400 88.1cfm

Port air speed numbers were good as well. I only took measurements at 200thou and 400thou, my machine plots a port speed profile across 9 points (8 points around the circumference and one right in the centre) using a pitot tube. At 200thou the 9 points range between 249 and 261 feet/sec, at 400thou the range is between 317 and 335 feet/sec, which is very good for an untouched port in both total and %age variation across the port. Now these numbers are with "as supplied" seat cuts, nothing fancy. Some improvement could be had simply by altering the seat cut to a narrower sealing face, at the moment they're almost 3mm wide. Same with the valves used, straight out of the box TRW replacement valves, no backcut or profiling, so these are totally raw figures and my baseline for these heads.

I retested the "Chinese" Tipo test head after I spent a bit of time fettling one of the intake ports to increase the flow capability. I also had larger exhaust valve seats fitted (to suit the 1500 type exhaust valves) and mildly worked one exhaust port as well. The results are very promising. Measured at 28" of H2O and corrected for temp/humidity etc (39.5mm inlet / 33.4 exhaust)

Inlet
0.050lift 32.7cfm (std Tipo 30.4cfm) (stock X19 1500 head 16.3cfm)
0.100lift 61.4cfm (std Tipo 60.6cfm) (stock x19 1500 head 33.5cfm)
0.150lift 83.5cfm (std Tipo 77.8cfm) (stock x19 1500 head 52.1cfm)
0.200lift 102.3cfm (std Tipo 95.7cfm) (stock x19 1500 head 69.1cfm)
0.250lift 118.9cfm (std Tipo 106.6cfm) (stock x19 1500 head 80.7cfm)
0.300lift 128.1cfm (std Tipo 118.8cfm) (stock x19 1500 head 84.9cfm)
0.350lift 136.1cfm (std Tipo 121.9cfm) (stock x19 1500 head 85.8cfm)
0.400lift 143.2cfm (std Tipo 124.0cfm) (stock x19 1500 head 86.5cfm)

Exhaust
0.050 34.0cfm (stock Tipo 31mm valve 25.8cfm)
0.100 53.6cfm (stock Tipo 31mm valve 41.2cfm)
0.150 68.3cfm (stock Tipo 31mm valve 56.0cfm)
0.200 83.6cfm (stock Tipo 31mm valve 70.6cfm)
0.250 95.1cfm (stock Tipo 31mm valve 82.3cfm)
0.300 102.3cfm (stock Tipo 31mm valve 86.1cfm)
0.350 105.2cfm (stock Tipo 31mm valve 87.8cfm)
0.400 107.4cfm (stock Tipo 31mm valve 88.1cfm)

Port air speed has also increased, by an average of around 2%...to the range of 323 to 346 ft/sec

I think there is more flow to be had, as again this was with "as supplied" seat and valve profiles, but as it stands the port shape should flow enough air for around the 140hp (crank) mark on a 1500

This is not a Fiat produced cylinder head, and I've never had a Fiat produced Tipo head to directly compare it to (and flow test with my bench for a direct comparison) Though going from other flow figures found on the web, it does flow a couple of more than the stock tipo head with a 39.5mm intake valve. The port sizes are close to 1500 x19, but slightly larger. Biggest difference is probably at the short side radius, maybe port height.

Stock 1500 x19 heads (best figure for untouched port) that I've had is 88cfm at 400thou lift, these Chinese made Tipo style heads flow 124cfm (same lift and depression) out of the box, a significant difference - and the port air speed is considerably higher too!

I currently (Sept 2013) have modified inlet ports/seats/valves that exceed 160cfm, some with more than 350fps air speed. Should be good for 160+hp on a 1600 engine and dyno sheets will come. New heads should be ready for some CNC treatment early in the new year, and then they will be available to the public. Not really what I would call a "street" head unless your prepared to build the rest of the engine to match. If you need to ask what they will be worth fully dressed, you probably can't afford one.

1500 14 bolt intake 37.5 valve / 34 throat , exhaust 33 valve

New seats fitted, throats 34mm.

Chamber and port untouched.

Port rough out.

Down port rough out.

Rough port shape compared to untouched

37.5 /33 valves back cut prep

Finished chamber and port

This head has had no significant increase in port size. Stock ports measure 28.5mm and this heads ports have barely been enlarged and are 29.0mm. The stock 1500 head has a seat throat of 31.1mm, this head is 34.0mm. Stock valve size is 36mm, this head is 37.5mm. I've corrected these following flow figures from 28" back to 10" of water so they can be compared with other numbers floating around on the web...

100 thou lift (stock 21.2cfm) modified 29.6cfm
150 thou lift (stock 33cfm) modified 43.3cfm
200 thou lift (stock 43.7cfm) modified 56.6cfm
250 thou lift (stock 51cfm) modified 64.6cfm
300 thou lift (stock 53.7cfm) modified 69.0cfm
350 thou lift (stock 54.3cfm) modified 70.8cfm
400 thou lift (stock 54.7cfm) modified 66cfm

Not a bad result, and as is would still be a nice head capable of around 110hp at the crank... if I can push the 350 to 400 thou flow a little higher and get it up to around 75cfm * 10"/ 125cfm * 28" at 400 thou and also drop some of the port turbulence it could be 120hp at the crank. The main focus is on a strong mid rang more than concentrating on outright Hp. More work around the port roof area and a different seat cut yielded good results. The major aim was getting the port to maintain flow after 300 thou, and right now it barely drops away at 350 (120.5) and 400 thou (119.5) and at the same time port speed has remained very high, so I think we've achieved this. The high port velocity is a key with this head, for a street driven car this will make the most difference and will certainly help the engine make more torque.

100thou (start 122f/sec) final 129.3 feet/sec
150thou (start 186f/sec) final 195.2 feet/sec
200thou (start 240f/sec) final 244.9 feet/sec
250thou (start 272f/sec) final 276.8 feet/sec
300thou (start 278f/sec) final 299.9 feet/sec
350thou (start 277f/sec) final 295.5 feet/sec
400thou (start 273f/sec) final 294.0 feet/sec

Here are some flow figures (corrected to 10" of water) for comparison with other figures on the web

100 thou lift (stock 21.2cfm) modified 29.6cfm, final 33.8cfm (gain 54%)
150 thou lift (stock 33cfm) modified 43.3cfm, final 49.9cfm (gain 50%)
200 thou lift (stock 43.7cfm) modified 56.6cfm, final 62.7cfm (gain 42%)

250 thou lift (stock 51cfm) modified 64.6cfm, final 69.7cfm (gain 36%)
300 thou lift (stock 53.7cfm) modified 69.0cfm, final 72.3cfm (gain 34%)
350 thou lift (stock 54.3cfm) modified 70.8cfm, final 72.0cfm (gain 33%)
400 thou lift (stock 54.7cfm) modified 66cfm, final 71.1cfm (gain 31%)

I tested the exhaust flow at four data points (every 100 thou) but the results are very good, so any pumping losses in this engine will be minimal. Flow at 28" of H2O

100 thou 43.9cfm
200 thou 80.5cfm
300 thou 103.6cfm
400 thou 109.8cfm

SteveC

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i cavalli mai abbastanza, ed il peso sempre troppo

Last edited by fiatfactory; Today at 12:40 am.

Sep 16 2013, 5:42 am #9

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

"1300 block" and 55.5 mm stroke crank options.

"Bottom end is std pistons and stock deck height. I'd like it to run on 93 octane, so about a 10:1."

This is the most common "set" of bottom end parameters and would be the most common "perceived upgrade" that people consider. The stock 1300 bottom end, and the owner wanting to get more pep from it by just doing work to the top end. The engine is compression limited. In this scenario it's not likely that the engine owner is going strip the bottom end and machine the block surface to achieve a different piston position.

This is a "compression (height) compromised 1300." No matter which head or head gasket choice you make your Squish /quench clearance is limited (compromised) to the minimum of the head gasket thickness you find PLUS whatever distance you have the piston still down the bore. SQ of 1,0mm for a street engine is ideal, any wider than that and your giving away ME and VE, which is worth real HP. The SQ will be even wider if you use a head with any sort of machined (decompression) recess. If your compression limited you will be "behind the eight ball" in building Mechanical Efficiency (ME) into the bottom end. Performance engine build improvements will build ME and VE, and bump dynamic CR. If your compression limited, it restricts your choice of camshaft, because you need to attempt to still keep some sort of realistic DYNAMIC compression ratio.

The only thing you can do with a compression limited engine is to try and increase the volumetric efficiency as much as possible... this in effect is the only way you can boost the engines dynamic CR.

"Can a 1300 with a polish/ported head, 1500 carb, 1500 intake and 1500 cam be close to 100hp (at the crank)?"

I don't think you will get that...but you could come close.

As your 1300 is going to be standard CR, and standard duration camshaft (even though you have a tiny bit more lift) these will be your limiting factors. There is little point in installing a cam with any longer duration than the standard euro spec unless you raise the static CR, the reason for this becomes clear when you consider the DYNAMIC CR of the end result. If a longer duration cam is used, then the valve is still open while the piston has travelled further up the bore during the compression stroke. At the point the inlet valve closes, there will be less volume in the space above the piston (than there would have been with the shorter duration cam) and the result of this is a lower dynamic compression ratio. This is why a longer duration cam in a standard compression ratio engine will generally deliver lack luster performance, and in many cases will actually drop the HP output.

I have an excel spreadsheet somewhere that calculates the piston height in the bore at increments of crank rotation (for rod ratio comparisons but useful for dynamic CR calcs as well) and I can post links and examples here.

So 100 crank HP from a 1300 with some minor mods and standard CR.... probably not. If you raised the static CR you would come close, but in a 1300 there is a limit (unless you want to spend on hi compression pistons) to the CR that can be achieved with standard parts. Over boring the cylinders will give you a greater swept volume. Skimming the block will get the piston right to the top of the bore. Using a very thin head gasket will reduce the amount this component adds to the chamber volume. Skimming the cylinder head will reduce the chamber volume. A combination of all the above will be the top limit of static CR with standard parts... but all of them are going to add to the cost of your build.

So the bottom line...

1.) If your engine needs a rebuild, then over boring and choosing a piston with a taller CH than stock will help. A light skim of the block to get the piston at zero deck height or slightly proud... the skinniest head gasket you can find while still ensuring the piston to head clearance (squish clearance) is 1.0mm and no greater than 1.25mm. This will get your static CR up a little, maybe as high as 9.5:1, you need to check this by direct measurement and ensure ALL the chamber volumes are the same.

2.) Port the cylinder head as per my recommendations, install 37.5mm tipo inlet valves on a larger valve seat, get the seat throat out to 34mm, deshroud the inlet valve.

3.) Use the inlet manifold (1500) and 34DMTR carb, install a carb spacer of around 50mm tall to blend the flow from the two circular carb throats into the oval manifold mouth. Use a better aircleaner assembly (that has more internal volume than the stock item) and route some cold air to it.

4.) Try and pick up a 1500 sohc twin out exhaust manifold (the internal ports are bigger than the equivalent 1300 item) build or have built a freeflowing exhaust system (at least 51mm pipe size)

5.) Try and find a marelli plex ignition setup from a regata/uno etc (that has no vacuum advance)

6.) Use a lightened flywheel

Do all this and you will get there, do some of it and you'll get part of the way.

"Will using a yugo 1100 head to raise the compression"

Quote:

> Originally Posted by **Matt Brannon - Midwest Bayless**
> *When someone asks about hotting up a 1300cc engine, there is a balance between "everything under the sun" vs. an effective, cost-effective solution.*
>
> *Steve hit on some of the "everything under the sun" issues, and in my opinion, it ends up being a diminishing returns issue. If you are going that far, why not just start with a 1500 to begin with?*
>
> *Assuming that you're sticking with 1300cc and not going the stroker route....*
>
> *For the most simplistic solution, just use a Yugo head, 87mm pistons (quality stock cast are fine) and deck the block so that you get about .010 pop-up out of the block. With that combo you'll get about 10.25-10.5 compression ratio and the motor can run to 7500 RPM all day long.*
>
> *If you are dying to put something really trick inside, spend $200 on a set of TotalSeal rings and take the time to set them up correctly. FWIW, Total Seal rings only come in .5mm increments, so it meshes nicely with 87mm bore.....*
>
> *The upsides on using a Yugo head:*
>
> *1. They do not have a recessed compression reduction area like a North American head has, and can be used unmilled, yielding 10:1 or higher with a bigger bore and minor deck work.*
>
> *2. Even if using a regind cam with a -.040 cambox, and decking the block, timing belt tension can still be set using stock components if an "unmilled" head like the Yugo head is used. Milling a North American head flat plus a -.040 cambox is enough to prevent correct tensioning on a 1300, and there's no simple "go-to" tensioner solution to take up the slack.*

3. Uses standard valves and valve train components so costs are contained.

4. They all have the unshrouded intake valve pockets and laid-back plug face like the 1500cc head which promotes good flame front propagation. Actual 1300cc Fiat heads up to 1978 are really poor in their combustion chamber design.

The downsides:

1. Relatively small intake ports that can stand to be opened up a bit. It's a little fussing but something you can do in your garage with some patience. At a minimum, just port match 1" inward to allow correct alignment with the intake manifold. In the plusses/minus column, it is less problematic to use a head with ports too small than it is to use ports that are too big.

2. 31mm exhaust valves instead of 33mm, but we've proven that the exhaust on these motors is over-scavenged to begin with, so the effect of 31mm exhausts are negligible.

-M

"what other things can I do - cheaply"

If you were going to be prepping a set of 120mm CtoC stock rods the option exists to extend the CtoC length, by just a little. The 1116 and 1290 share the same conrod and it is the same casting. The one difference is the addition of a bronze bush at the small end of the conrod for the 1290's full floating gudgeon pin (the 1116 is a press in fit). You can start with an 1116 rod, have the small end machined out to have a bush fitted and then offset bore the bush to effectively increase the rods CtoC length. I've seen a few NOS 1116 rods floating around on Ebay pretty cheap too, as there's not a big demand. I've done this mod... long ago and not for anything to do with rod ratios... but simply to push the piston a little higher in the bore, and get more static CR. Back when I first started playing with the SOHC some of the OE piston taller CH options just didn't exist, as these came later in the engines production and evolution. This was one way of going from 0.5 minus deck to 0.5 plus deck with what was available.

Prepping rods and having them machined isn't cheap, but I like to check stuff before I use it (and push it hard) so my rebuild would include crack testing the rods, rebushing them and resizing them after fitting new std rod bolts and nuts. If you were to start with a NOS 1116 rod there's no need for resizing the big end, a dye check would suffice to ensure your starting with a rod that has no production flaws, and the bolts would also be new. So this would make economic sense if the NOS 1116 rods were cheap enough ...the 1116 engine is still current production..

SteveC

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Last edited by fiatfactory; Today at 4:35 am.

Reply Quote

Sep 16 2013, 5:44 am #10

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

"1300 block" and 63.9 mm stroke crank options.

If you want to use a 63.9 mm stroke crank in a 1300 block, the piston will effectively travel 1/2 of the extra stoke upwards (aka the "throw" - 8.4mm / 2 = 4.2mm) and past the top of the block so there are two choices, make the rod and /or the piston shorter by this total measurement.

Now the stock 1300 piston has a compression height of around 34.7mm, take 4.2mm from this and you now have a CH of 30.5 mm, unfortunately there are no factory pistons from the Fiat range that have the dimensions we want, so you need special pistons made.

Same with the conrods, there is nothing that is a straight swap out fit, a 115.8mm (120 - 4.2mm) conrod is also a special manufacture. Again as noted earlier the rod ratio is heading in the wrong direction (115.8/63.9 = 1.81) and it's the SOHC's high rod ratio that is part of what makes the engines what they are.

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Last edited by fiatfactory; Sep 16 2013 at 6:29 am.

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Sep 16 2013, 5:45 am #11

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

"1300 Block" and 67.4 mm stroke crank options

The 67.4mm stroke crank can be made to fit the"1300 block" with a little bit of grinding here and there to make clearance, but you have again a rod, rod ratio and a piston compression height issue. This configuration requires a CH of 28.6mm with a 120 C to C rod.

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Last edited by fiatfactory; Sep 16 2013 at 6:32 am.

Reply Quote

Sep 16 2013, 5:47 am #12

Join Date: Aug 2008

fiatfactory
Steve Cecchele

Location: Western Australia

"1500 block" and 55.5mm stroke crank options.

no text yet

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Sep 16 2013, 5:49 am #13

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

"1500 Block" and 63.9mm stroke crank options.

no text yet

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Sep 16 2013, 5:49 am #14

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

"1500 Block" and 67.4mm stroke crank options.

1500 block height (from the crank centerline to the deck face) is 195.7mm (+ - production tolerance approx 0.1mm) If we have a crank throw of 67.4mm (so half is 33.7mm) and a rod length of 128.5mm then the max piston compression height we can have to achieve a "zero" deck height is 33.5mm. (33.7 + 128.5 + 33.5 = 195.7)

The stock 1580 pistons have a compression height of 33.3mm but a dished head that will make the CR just 9.2:1. The stock 1500 big flycut pistons are 34.45 to 34.65 in CH and will poke out the top by around 1mm. X19 1300 pistons are 34.7CH and have a 0.6mm pimple but some uno 1300's use a piston with 34.9CH and smallflycuts. The Mahle / KS pistons known as 0872, have a 34.15CH and smallflycuts that are 2.7mm deep

With these 0872 pistons a "pop up" of 0.65mm will be achieved at TDC with a stroker crank. If used in conjuction with a felpro head gasket (which is approx 1.5mm thick when crushed) this will give a piston to head clearance of 0.85mm, about as tight as you want to get.

Working out some rough CR figures.

87mm x 67.4mm gives 1602cc, so thats 400.5cc per cylinder
Euro cylinder head chamber volume is approx 33.5cc
the head gasket is about 87mm ID and 1.5mm thick when crushed, so it has a volume of approx 7.5cc
"pop up" volume is approx 2.87cc
Flycut and ring land clearance volume is approx 2.2cc

Volume at BDC is (swept volume - pop up volume)+ flycut and ring land clearance volume + gasket volume + chamber volume.

Volume at TDC is (volume in gasket - pop up) + flycut and ringland clearance volume + chamber volume.

V * BDC = (400.5 - 2.87) + 2.2 + 7.5 + 33.5 = 440.83cc
V * TDC = (7.5 - 2.87) + 2.2 + 33.5 = 40.33cc

440.83 / 40.33 = 10.93:1 static compression ratio

That's all in theory as to use these pistons with a larger intake valve and higher valve lift, the valve flycuts need enlarging which is going to drop the CR. Any good machinist with a piston roll-over vice for his milling machine will be able to do the job. It's simply a case of removing the rings (as the piston vice will use the ring grooves to hold and steady the piston) setting the vice up for the 18 degree tilt that the pockets are cut at, setting his cutting tool at the desired radius and making a cut down to the original flycut depth, but only on ONE valve pocket per piston. This means two pistons get the right pocket machined, and two get the left done. Trickiest part for the machinist is getting a nice radius at the bottom of the cut, you don't want a sharp edge here. The original flycuts are approx 19/20 mm in radius, 2.7mm at the deepest point. Recut to a 22mm radius as you need approx 2mm min clearance around the 39.5 valves. Last time I had this done it was $125 for the four pistons. The flycut does deepen the pocket a little, at the deep end of the cut by about another mm in depth, which works well for cams with a high LATDC too.

SteveC

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Last edited by fiatfactory; Today at 6:03 am.

Reply Quote

Sep 16 2013, 5:50 am #15

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

"1600 block" and 55.5mm stroke crank options.

no text yet

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Reply Quote

Sep 16 2013, 5:52 am #16

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

"1600 Block" and 63.9mm stroke crank options.

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no text yet

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Reply Quote

Sep 16 2013, 5:52 am #17

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

"1600 Block" and 67.4mm stroke crank options.

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no text yet

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Reply Quote

Sep 16 2013, 5:53 am #18

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

"1600 Block" and LONGER stroke crank options.

If you have the funds, and the inclination, the 3rd series block lends itself to some large capacity options. There are "factory" cranks available that takes the engine to 1.9l!! There are also quite a few manufacturers that offer speciality stroker cranks, even pistons to suit these long stroke options. AFAIK there are no factory OE pistons to suit these crank selections. Does not fall into what I would call "budget" in any sense of the word except for - blowing it!

One particular long stroke crank completed engine comes to mind. It was well executed, well photographed, and dyno proven with excellent results. It deserves the build to be all drawn together in one place. Ron you spread all those lovely pictures all around Xweb, so I've compiled it and the results in a subsection of it's own. Hope you don't mind.

SteveC

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Last edited by fiatfactory; Yesterday at 9:02 am.

Reply Quote

Yesterday, 8:42 am #19

fiatfactory
Steve Cecchele

Join Date: Aug 2008
Location: Western Australia

Komar 1806

All I really know are some basic specs and what is shown in pictures and a you tube link. 1600 block,Tipo style 14 bolt. Head Tipo style 14 bolt. Valve sizes 39.5mm intake, 33.5mm exhaust. 87.0mm bore. 76mm stroke custom 8 counter weight crankshaft. 1806cc

Built by David Komar for abarth2litre who is a member of this forum.

Nice result.


800x600 39K jpg


800x600 44K jpg


800x600 72K jpg


800x600 50K jpg


800x600 48K jpg


800x600 70K jpg


800x600 67K jpg

This image has been resized. Click this bar to view the full image. The original image is sized 800x600.

http://www.youtube.com/watch?v=FCiQCpg0nyo&feature=related

http://www.youtube.com/watch?v=QYV3qrIhcPY

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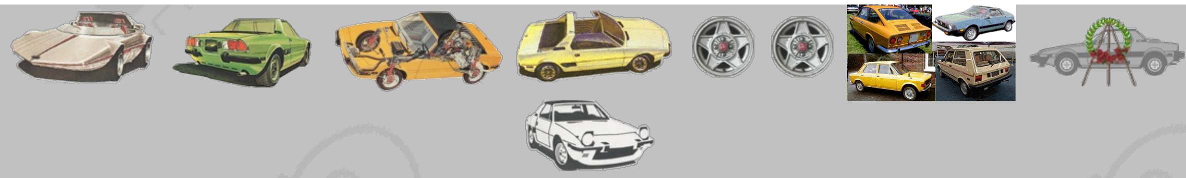

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