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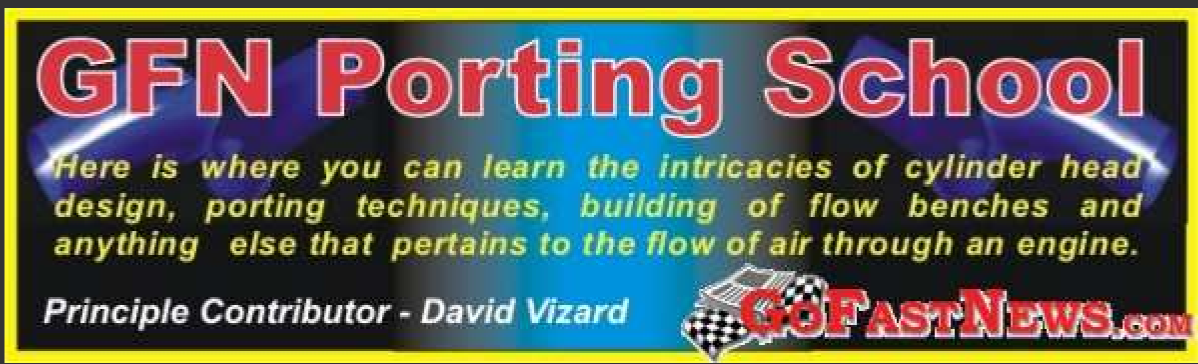
06-02-2008, 06:55 PM #1 (permalink)

DavidVizard-GFN OFF
Pit Crew

Join Date: Apr 2007
Posts: 840

Porting School #2 - Super Cheap Flow Bench



#2 Building a Flow Bench – Really Cheap

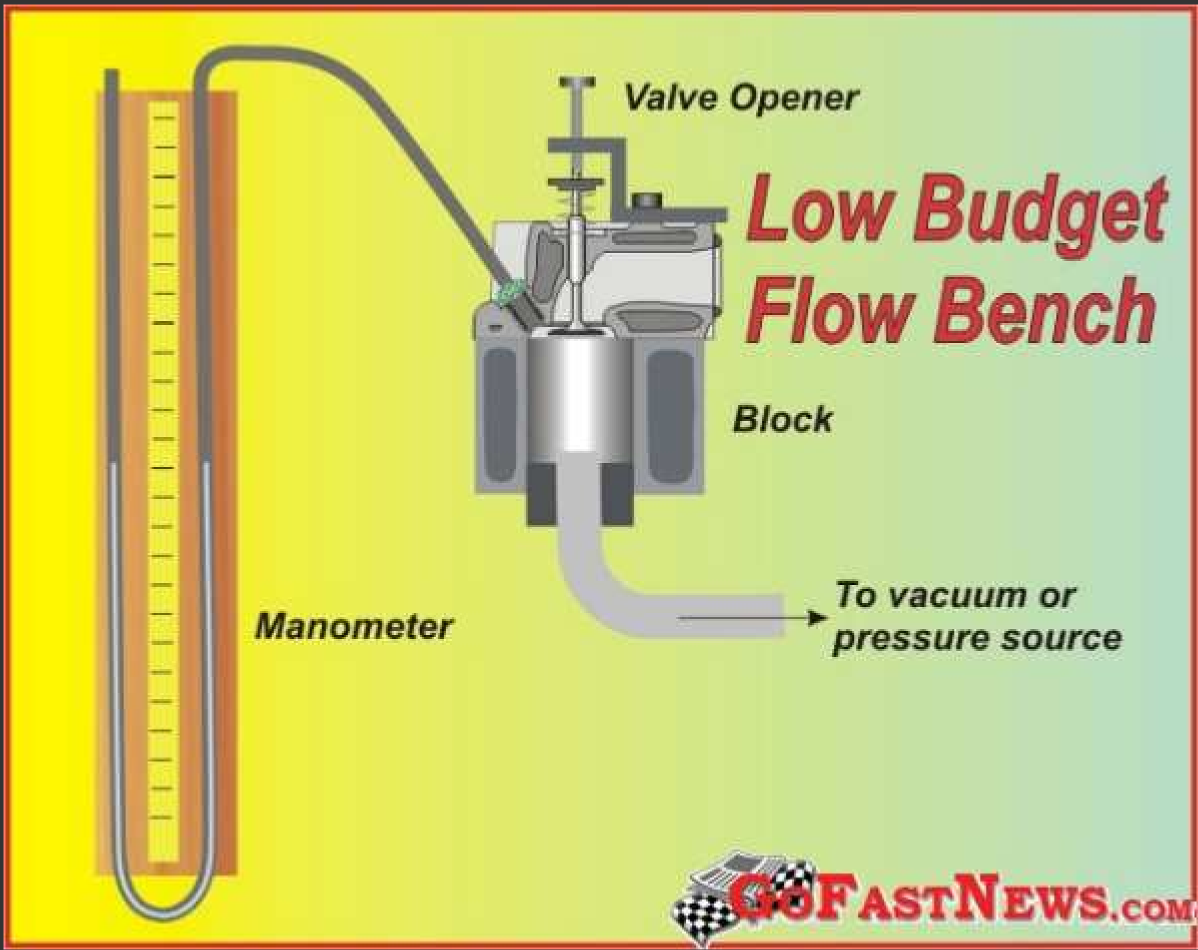
By

David Vizard

May 2008 is something of a milestone for me as far as the modification of engines for more performance goes. It is 50 years this May 2008 that I flowed my first cylinder head. The technique I used was crude to say the least but it worked and looking back on it many years later I realized I should have continued flowing heads using this original method instead of being swayed by 'convention'. As thus feature develops you will see why **I will, once again, fly into the face of convention.**

Here is how events unfolded. The first 'flow bench' was in fact my mother's vacuum cleaner. What I did was to mount the head to be tested (an 'A' Series head as per Austin/Morris engine) on the block with a means of opening the valves. I then located the suction side of the vacuum cleaner to the bore and sealed the hose so there were no leakages at this point. Next a spark plug with the middle removed and a piece of ¼ diameter copper tube glued in was installed into the spark plug hole and connected up to a manometer made for clear plastic tubing stapled on to a 8 foot long piece of 2 x 4 wood. This was marked out in inches from – 48 inches at the bottom all the way through zero to plus 48 inches at the top. The plastic tubing was looped so that the bottom of the 'U' was formed about a foot below the bottom of the 2 x 4. Water with food dye was used to fill the 'U' section of the u-tube until it reached the zero mark.

The schematic below shows what was involved.



As you can see there is not much too this bench. It can be constructed in a few hours for a minimal expenditure. If you already have a shop vac then the rest of it costs probably less than thirty bucks.

Here is how it works. The more open the valve is the lower the pressure drop as measured by the manometer. At low valve lift, say 0.050 valve lift the manometer can read (depending on the vacuum cleaners capability) anywhere between 60 and about 100 inches of H2O (and if it does you will need to adjust the length/height of your manometer acordingly - my original one only pulled about 50 inches). If the flow at a given lift is improved the manometer reading at that lift will drop. Let's say that the stock head at 0.050 valve lift produced a reading of 80 inches. We then do some seat blending on the valve and head casting and on the next test the manometer reading is 70 inches. This means the flow has gone up so the pressure drop pulled by the vacuum cleaner is lower. To a first approximation the flow has increase by the square root of 80 divided by 70. That works out at 1.069 or 6.9% improvement.

From what has been said you can see that this bench primarily tells you whether or not the port has got better or worse. Also we can see that it does not test the head at a standard pressure drop as per almost every pro built bench does. This is what is considered convention so that the cfm of flow can be established. At this point you may be thinking that not having the ability to do that is a small price to be paid to establish positive or negative trends in heads airflow. After having built my 'bench' I spent a couple of years wondering how I can get real cfm numbers off the bench like the guys at Westlake (the big name in airflow at the time). Then one day I was talking to an engineer who was somewhat older than I and he happened, during our conversation, to drop the key words for me. These words were – 'Standard Pressure Drop'. Well there we go I now realized that if I could adjust the test pressure/ vacuum so that it was a constant then I could calculate the cfm. It was not quite as easy as that but that in essence was it. So over the next few years I built increasingly more sophisticated benches until I finally, during the early 70's built a bench that conformed to British Standards as far as precision gas flow measurement was concerned. It was a 15 foot long monster. I even did some work on it for the McLaren F1 guys.

A Rethink on Matters.

By the time the mid 80's came around I began to have second thoughts on the use of a standard pressure drop to test heads. The issue here is what sort of pressure differences do we see between the port and cylinder on a live running race engine. In his book on Power Secret's Smokey goes to some lengths to make sure we understand that the pressure differential needs to be above a certain value to get dyno results that sort of coincide with what you might expect from any flow increase seen. The number that Smokey came up with was 28 inches of water. That is about an industry standard as of 2008. But here is the problem – a race engine does not see a fixed 'Standard Pressure Drop'. Here we need to take a look at what actually happens.

The induction system on a true race engine is, for the most part, exhaust driven. That is the scavenging pulse from the tuned exhaust pulls a far bigger depression in the cylinder than the piston going down the bore. On something like a cup car engine this can amount to as much as 120 or more at TDC in the overlap period. The draw on the intake port at TDC can be such that even though the piston is virtually 'parked' the intake charge in the port can be traveling at as much as 100 mph! When the valve is near wide open and the piston is traveling at peak piston speed (this is between 72 to 74 degrees after TDC) the draw on the valve is between 15 and 20 inches of water.

All the forgoing leads us to one conclusion. If we want to more nearly simulate what happens in a running engine our intake flow tests need to be done at a high pressure drop at low valve lift and a lower one at high lift. This is exactly the situation that happens with a flow test rig as shown here in the diagram. An uncontrolled vacuum source (such as a shop vac) will pull a large vacuum when the intake valve is closed and a progressively lesser vacuum as the intake is opened. So running a 'floating' pressure drop as we are doing here is actually a more realistic simulation of what is going on in real life.

At this point we have a flow situation that more closely mimics the pressure differentials seen in the cylinder/intake port of a running engine. So what are the advantages? If the pressure drop used is too low the flow pattern that is developed will not be the same as it would be at a higher pressure drop. If we use a low enough pressure drop the flow will be virtually laminar. Let us say we used only 2 inches of pressure drop to test a head. At such a low pressure drop the flow in the port will be slow and air will stay attached even around the worst short side turn. When a result from a test like this is corrected to say the commonly used 28 inches, it will produce numbers that is much higher than if the head was really tested at 28 inches. By running the tests at real world test pressure drops we create the same pattern of flow reducing separations as would occur in actual use. From this it follows the port modifications that produce positive results are doing so by addressing those flow patterns and improving the port shape to deal with or cancel out such. The bottom line is this 'cheapo' flow test setup will actually be a better tool for developing an intake port than would be a $10,000 commercial flow bench. The only down side at this point is knowing just how many CFM the head is flowing when each reading is corrected to the common 28 inch pressure drop. Without this number you won't be able to make a comparison with other flow test results to be able to gauge your work compared to others. This can be fixed relatively easily but for now lets consider the exhaust.

Flowing the Exhaust.

Without making some rather more fancy test equipment we are not going to be able to flow the exhaust at real live test pressures. Normally when an exhaust valve opens the cylinder pressure is somewhere between 90 and 120 psi. If you are intent on having a pump that will develop this kind of test pressure even for just the low lift tests than be aware that you will need about a 200 hp motor to drive the pump. Very few flow bench setups are capable of this (Although unconfirmed I have heard that Fords flow bench can approach real world pressure drops and that it cost a mere seven figure number to build). For the most part we flow the exhaust at 28 inches and live with the fact that it is not the best way to do things. However, we find once again that our low buck bench with it's uncontrolled floating pressure drop actually does a better job than a commercial bench at a fixed pressure drop.

Quantifying Results.

My friend Roger 'Dr. Air' Helgesen built a bench that worked along the same lines as this some 25 years ago and still uses it to this day to flow heads an intake manifolds. As is usual Roger adopted a singularly simple way to convert the pressure drop seen on the manometer to CFM at 28 inches with nothing more than a sheet of graph paper and a few calibration orifices. The why and where-for of doing this will be the next subject we will tackle in the GFN Porting School.

David Vizard

Other parts in this series are at:

#1 Porting School #1 - Why engines need airflow

#2 Porting School #2 - Super Cheap Flow Bench

#3 Porting School #3 Budget Bench Calibration

#4 Porting School #4 - Budget Bench Electronics

#5 Porting School #5 Identifying Primary Restrictions

#6 Porting School #6 - Secrets to reduce valve shrouding

#7 Porting School #7 - Power & Port Volumes

#8 Porting School #8 Optimal Port area's

#9 Porting School #9 - 5 Rules to Goof-Proof Porting!

#10 Porting School #10 - Pushrod Pinch Point Power Issues

In addition to the Porting School articles there are directly related cylinder head development subjects at the following sites:

Wet Flow :-

Six Wet Flow Mistakes

Combustion Dynamics:-

#1:- Turbulence and Combustion Dynamics

#2:- In cylinder Turbulance and Combustion Dynamics

#3:- Turbulance and Combustion Dynamics - Part 3

#4:- Coming soon

#5:- Turbulance and Combustion Dynamics - Crevice Volumes - Stealth Power Thief

Want to learn how to develop and port heads for high performance professionally?
If so click on the link below.

Last edited by DavidVizard-GFN; 09-18-2008 at .

QUOTE

06-03-2008, 06:47 PM #2 (permalink)

MadBill OFF
Garage Sweeper

Join Date: Sep 2007
Posts: 76

The 'appetizers' are a joy on the palate David; can't wait for the subsequent courses! (Hopefully even more than the traditional twelve..)

QUOTE

06-04-2008, 02:41 AM #3 (permalink)

bnio OFF
Garage Sweeper

Join Date: Apr 2008
Posts: 5

Its nice to see that people are willing to talk about head design, testing and flowbenches these days. I have a question for you though, are you going to cover port velocities, localized (like around the short turn of a chevy head), average velocity and at what speeds does the velocities cause a problem and also how detremental are localized high velocities (in excess of 375 fps) are to overall port performance? I have yet to read anyone who is willing to shed some light on port velocities and how important they really are to the performance of the head. I mean you are using a flowbench to check cfm then why aren't you using the bench and a pitot tube to probe the ports for velocities so you can have the whole picture of whats going on. It wasn't till I had a couple of pitot tubes that I really began to learn what was happening. Anyway I hope I didn't step on any toes here. I always enjoy reading your posts keep up the good work.

QUOTE

06-04-2008, 03:27 PM #4 (permalink)

DavidVizard-GFN OFF
Pit Crew

Join Date: Apr 2007
Posts: 840

Quote:

> Originally Posted by **MadBill**
> *The 'appetizers' are a joy on the palate David; can't wait for the subsequent courses! (Hopefully even more than the traditional twelve..)*

Bill,
It will be a whole lot more than twelve for sure - could be more than one hundred!
DV

QUOTE

06-04-2008, 03:49 PM #5 (permalink)

Stan Weiss OFF
Tire Changer

Join Date: Sep 2007
Location: Philadelphia, PA
Posts: 189

David,
Did the Electrolux look anything llike this?

Stan

Stan Weiss / World Wide Enterprises
Offering Performance Software Since 1987 http://users.erols.com/srweiss/index.html

QUOTE

06-04-2008, 07:30 PM #6 (permalink)

bnio OFF
Garage Sweeper
Join Date: Apr 2008
Posts: 5

This looks to be a very interesting topic. I was wondering if you will be covering port velocities localized and average through the intake port. I am having localized trouble areas mainly where it is to high, 465-485 fps from .500" lift on up and over 400 fps at .400" lift, around the short turn. This is something I would like learn more about because I have no idea how to begin to tackle this problem yet or if it can even be resolved within the constraints of my ports. Anyway I hope you cover port velocities with some depth. I always enjoy your posts keep up the good work.

QUOTE

06-04-2008, 08:38 PM #7 (permalink)

comp OFF
Garage Sweeper
Join Date: Apr 2008
Posts: 43

ok ,,going for lotto tickets

QUOTE

06-04-2008, 10:57 PM #8 (permalink)

old blue 75 OFF
Garage Sweeper
Join Date: Mar 2008
Posts: 83

David here is a forum aimed at diy flow benches(more commercial type).

iB::Flowbench General

Keep the info coming.

QUOTE

06-05-2008, 03:58 PM #9 (permalink)

old blue 75 OFF
Garage Sweeper
Join Date: Mar 2008
Posts: 83

David here is a link to a forum on diy flow benches, members might like.

iB::Flowbench General

One of the members on there works for Ford on there high dollar bench.

QUOTE

06-06-2008, 04:05 AM #10 (permalink)

FlowSpecialist
Tire Changer

Join Date: May 2008
Posts: 129

Excellent stuff David. I couldn't agree more that a simple home made flowbench can not only do the job of an expensive professional one but in many cases a better job and not only that but the user learns more about flow in getting to understand how to build a bench than just going out and buying one.

Those basic flow lessons about CFM per sq inch at 100% efficiency, what sort of efficiencies poppet valves can reach and how the two relate can often resolve the truth or otherwise of flow claims you see from porting shops that sometime beggar belief.

For those that are interested it was David who spotted the mistake I'd made in my own first flowbench design some 20 years ago where I'd copied someone else's mistake without thinking about it properly and had a pressure tapping in the wrong place. That enabled me to go on and refine the design and eventually achieve an accuracy against calibrated orifice plates of under 0.3% over the full scale of flow and for that as well as many other things over the years I'm greatly indebted to him.

Dave

QUOTE

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