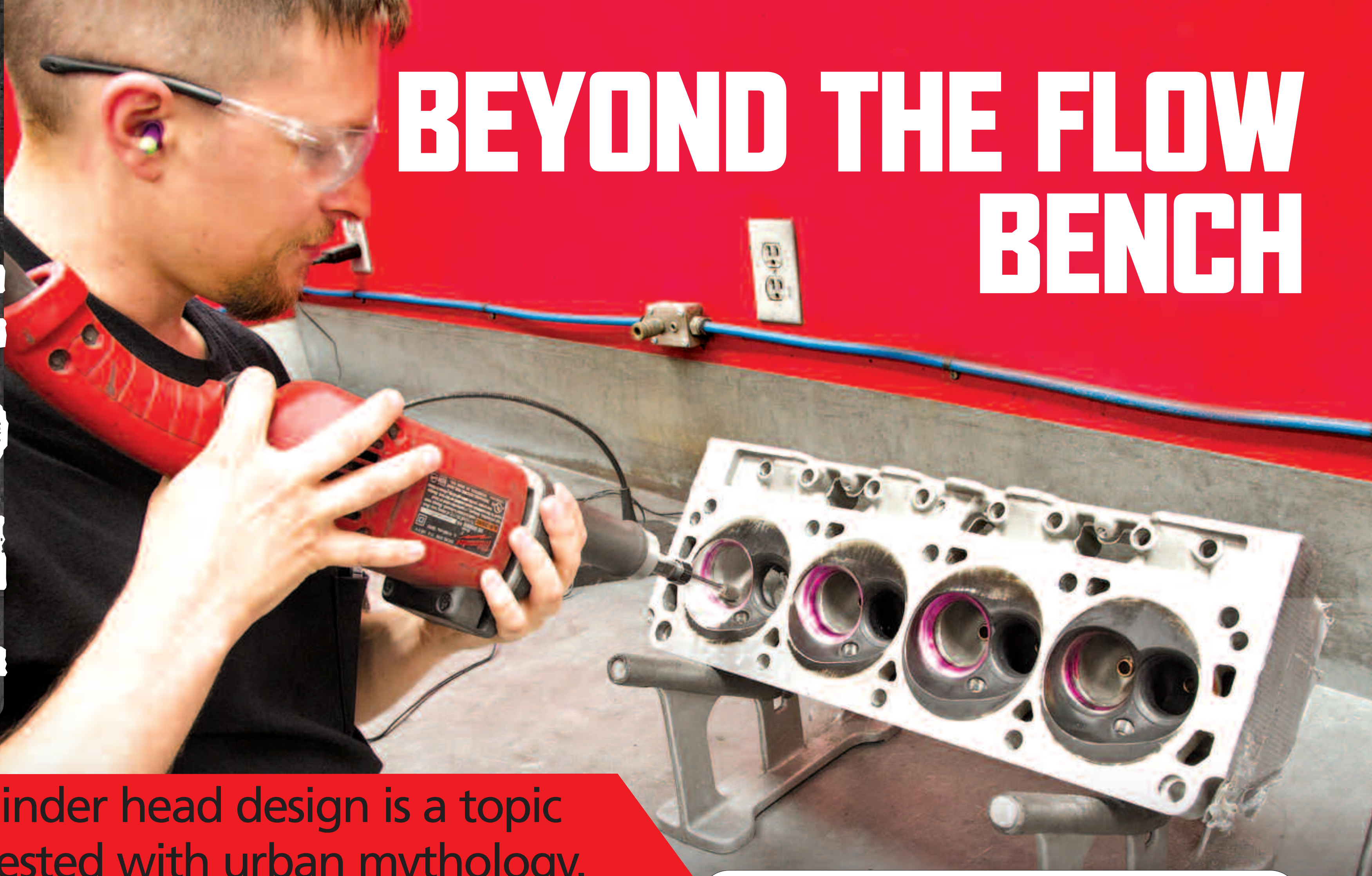
TECH

BEYOND THE FLOW BENCH



Cylinder head design is a topic infested with urban mythology. The real industry experts are here to clear things up.

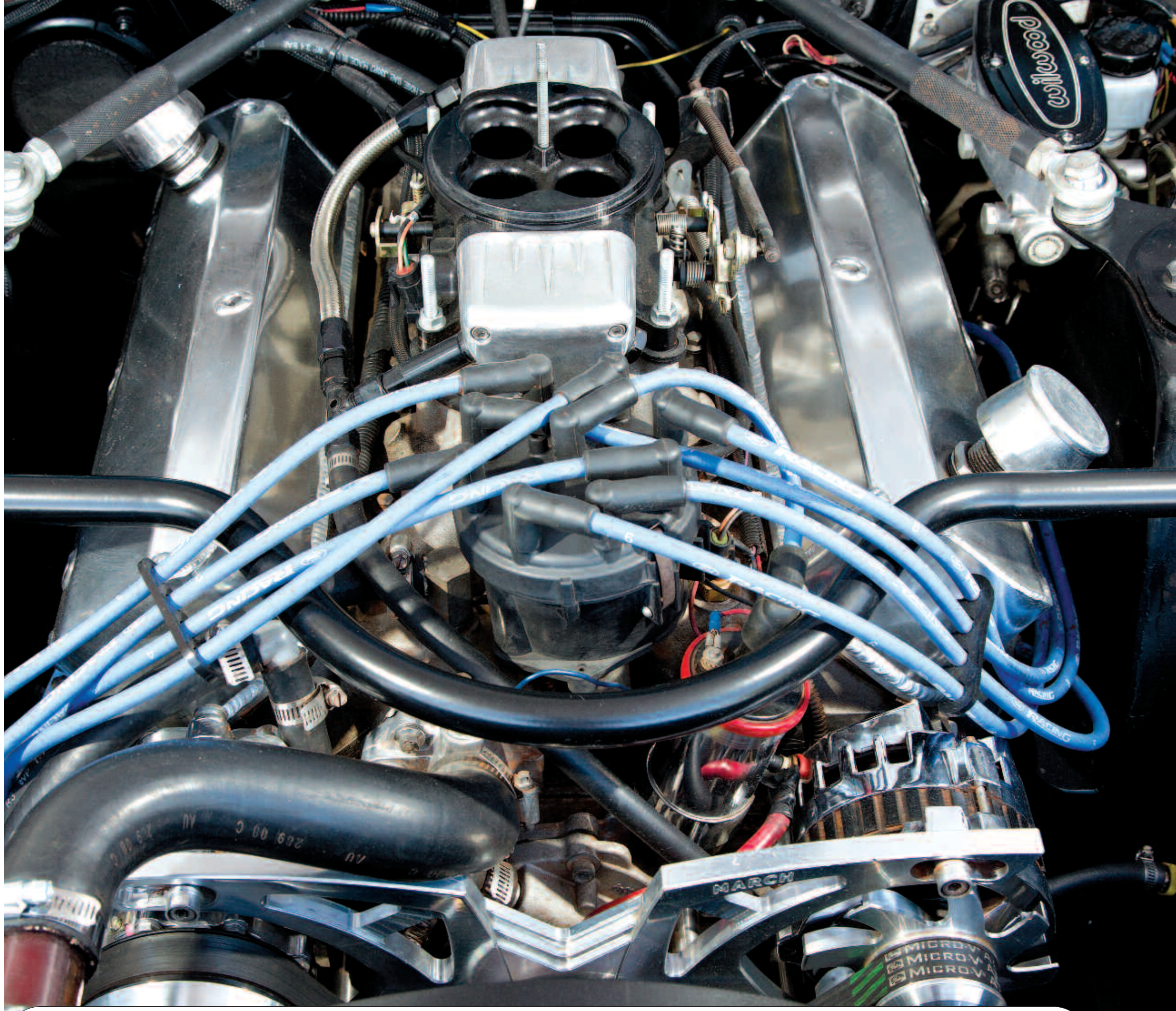
Every last design variable in a cylinder head must be optimized for its intended application. The areas directly above and below the valve seat are among the most critical sections of a cylinder head in terms of overall engine performance.

BY **STEPHEN KIM** PHOTOS **THE AUTHOR AND COURTESY OF THE MANUFACTURERS**

Just like a drag car set up with lots of toe-in and positive caster, air molecules don't like to turn. Working around this basic principle of fluid dynamics has impacted cylinder head design more than any other factor in the last decade. To keep the air flowing instead of turning, ports have gotten taller, and valve angles have gotten flatter. Further clearing the path are repositioned pushrod passages and water jackets. Consequently, today's top small-block cylinder heads handily destroy big-block heads from just a few years ago, and horsepower has skyrocketed accordingly. With so many outstanding cylinder heads to choose from, racers scour over spec sheets trying to distinguish one head from the next. Granted that knowledge is power, is focusing on valve angles and blindly worshipping flow numbers really the ideal approach to gauging the merits of a cylinder head? Not exactly.

The top three VP Racing Fuels Street Outlaws racers in 2015 relied on Edelbrock SC-1 cylinder heads. Edelbrock has also staked a claim in the category's championship since 2005 with the SC-1 heads owning it every year since 2007.

While spec sheets are great for attaching a numerical figure to very specific design metrics—such as port volume or valve diameter— it's downright impossible to precisely predict how each of these factors will dynamically interact with each other to impact overall airflow. Furthermore, the cylinder head that moves the most air on a flow bench doesn't always produce the most power. "Every design parameter—whether it's the port cross-section, valve angle, or runner height—has a form and function. People tend to fixate on numbers, but there are no magic numbers," Curtis Boggs of Race Flow Development explains. "Everyone thinks that flatter valve angles or oval ports make more power, but that's not always true. If you flatten the valve angle but don't raise the port entry, you're just making the port geometry much worse. Manufacturers have experimented with several 9-degree small-block heads that just didn't run well. A 12-15 degree head doesn't look as good on paper, but works great in a typical raised-runner small-block application."



The need to package an engine inside a cramped engine compartment is inherently prohibitive of max-effort cylinder head designs. Determining the most efficient way to draw in air from the side of the cylinder head, turn it 90 degrees, then direct it into the cylinder bores has been the fundamental challenge of head design for decades.

Despite a low port entry, the standard 20-degree small-block Ford architecture is still a very capable design for street/strip applications. AFR's 220cc Renegade castings move an impressive 338 cfm at .800-inch lift.

There's simply no getting around the fact that cylinder head design is some very complicated stuff, and attempting to dissect it into bite-sized pieces of forum-friendly information often leads to disaster. "Didn't you know that everything you read on the internet is true?" Boggs jokes. "One of the biggest issues in our industry is that we now have an entire customer base that's been educated by people who aren't experts. That makes it very challenging for engine builders and cylinder head designers. I take a lot of heat for saying it, but I don't care what the internet or a flow bench says. If a head makes a car go faster and win races, then whatever you did to it was successful."

OK, so if engine builders and cylinder head manufacturers are the real experts, but they're too busy building engines and manufacturing cylinder heads to share their expertise, how do you get them to talk? That's what we're here for. Give the premiere cylinder head gurus in the industry a platform to speak from, and it's amazing what you can learn. As you will see, charting the changes in cylinder head design over the last two decades that have spawned today's crop of badass castings (and billets) paints a very clear picture of what works and what doesn't, while offering a glimpse of where future development is heading.

THE CHALLENGE

Imagine sawing off the top half of a cylinder head, and welding straight pieces of pipe directly to the valve seats. If these arrow-straight pipes were intake ports, they'd have the potential to move a whole lot of air. Unfortunately, there's really no good way to actuate a poppet valve with this theoretical configuration, and the monstrously tall induction package it requires would prove impossible to package beneath the hood. As a workaround, an OHV engine positions the valves on top of the cylinder head, and the port entrances on the side of the head. This is good for packaging, but bad for airflow, as incoming air molecules must now enter the cylinder head at an angle parallel to the deck surface, then negotiate a 90-degree turn to enter the cylinders. In other words, the airflow capacity of modern cylinder head design is fundamentally compromised by packaging restraints.

Transcending this challenge is what modern cylinder head design is all about, and in the last 20-30 years, the OE and aftermarket industry has come up with some very clever solutions. Like many great advancements in technology, over time a series of small evolutionary changes have yielded substantial cumulative rewards. "In the early '80s, everyone used stock castings, even in high-end racing series like NASCAR. Engine builders pushed them to the absolute limit, compromising the cooling capacity and durability of the castings just to get there," Rick Roberts of Edelbrock recalls. "The biggest challenge with a stock port entry height is getting the shape of the short-turn radius just right in order to keep the air flowing at .700-inches or more of valve lift. This simply isn't an issue with a stock motor because you're never going to pick up the valve that much."

With a lack of aftermarket cylinder head castings to choose from, engine builders resorted to some primitive yet effective solutions. "Back then, we used to get the compression ratio up by cutting the deck surface at an angle. By cutting more material off of the spark plug side than the intake manifold side, we were effectively flattening the valve angle and raising the intake port," Roberts recounts. "Racers then got smart, and took a page out of the Pro Stock playbook. Instead of angle-milling the heads after they had already been cast, why not stand the valve up and raise the port in the casting itself? It made so much more sense to integrate these features into the casting itself instead of angle-milling the heads after the fact. Once we did that, the handcuffs were off, and we had port geometry that we could actually work with."

SHORT-TURN, PORT HEIGHT, AND LINE OF SIGHT

Since air doesn't like to turn, the combination of raising the intake port and flattening the valve angle moves the valves away from the cylinder wall while also straightening out the flow path through the intake port. As such, ports heights have continued to increase as valve angles have continued to decrease. "Raising the intake port also decreases the radius at the short-turn, which makes a huge difference in airflow capability. At

Low port entries and flat valve angles don't work well in a high-rpm engines, but according to Trick Flow, this arrangement improves the low- and mid-lift flow in its 11R castings. They have demonstrated their performance potential in street/strip combinations.

Edelbrock, we applied what we learned to our small-block Ford line, and came up with the original Victor cylinder heads by raising the intake ports .380-inch and flattening the valve angle from 20- to 15 degrees," Roberts explains.

"When we started working with Billy Glidden, we noticed that the sprint car guys were taking this concept to the extreme. We raised the ports even more and flattened the valve angle to 11 degrees to create the Glidden-Victor castings. Today, Edelbrock's SC1 cylinder heads are our ultimate small-block Ford offerings. With 7-degree valve angles and intake ports that are raised even more, they're capable of producing 2.5 horsepower per cubic inch."

The improvements in airflow capacity made possible by straightening out port geometry is staggering to say the least. "We can get a 15-degree Edelbrock Victor head to flow 390 cfm at .700-inch lift, so it's a very stout piece," says Greg Changet of Total Engine Airflow. To put those figures into perspective, a stock 5.0L head can barely muster 160 cfm. Topping that kind of flow may seem difficult, but the combination of higher port entries and flatter valve angles pay huge dividends. "With our CNC program, we can get 440 cfm at 1-inch of lift out of the Glidden-Victor II (GV2) castings. They're very popular in max-effort naturally aspirated applications. The intake port entry is even higher on the SC1 heads, which enables us to get 481 cfm at 1-inch lift out of them. The SC1s are very popular in boosted X275 and X325 cars."

CHAMBER EFFICIENCY

Yet another advantage of flattening out the valve angle is an overall improvement in combustion chamber efficiency. Pointing the valves away from the cylinder wall and closer to the center of the bore not only frees up space for larger valves, it also decreases chamber shrouding, burn time, and the potential for detonation. By nature, ignition advance increases pumping losses, as the pistons must fight against an expanding air/fuel mixture that's ignited before TDC on the compression stroke. Since an efficient combustion chamber needs less ignition timing advance, the resulting decrease in pumping losses increases horsepower. "When designing our 11R cylinder head, we basically took a 15-degree Twisted Wedge casting and flattened the valve angle to 11 degrees," says Cory Roth of Trick Flow Specialties. "This gave us a much more efficient combustion chamber that only needs 26-28 degrees of ignition advance. That's as good as any LS head out there."

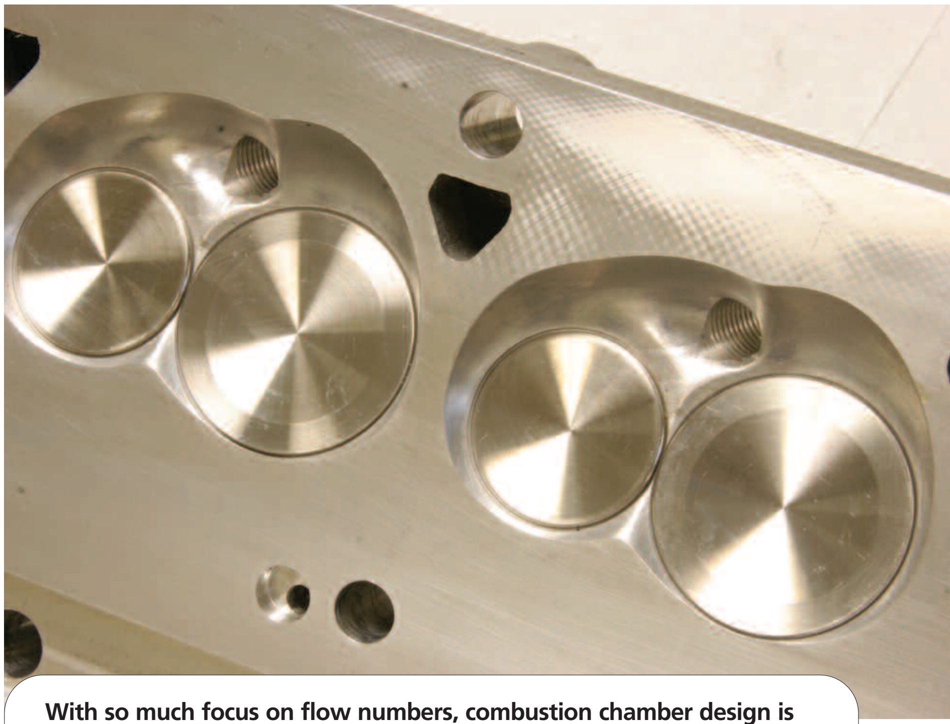
KNOW THE LIMITS

In order to negotiate the short-turn radius, air speed must be reduced. The trick is reducing air speed just enough but not too much. A straighter, taller port reduces the load placed on the short-turn radius, while a lower port height increases air speed at the short-turn. The decrease in frictional losses resulting from a straighter flow path keeps fuel suspended in the air far more effectively, thus producing a more homogenous air/fuel mixture, superior BSFC, a faster burn rate, and more power.

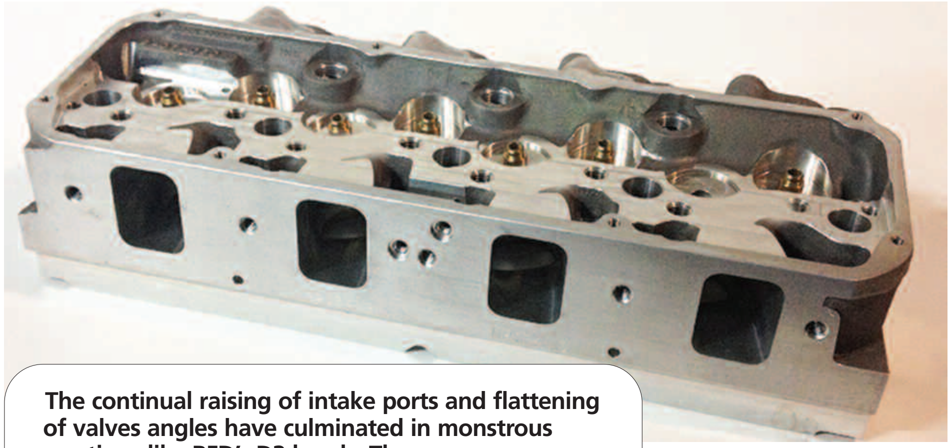
While the 1-2 tandem of raising ports and reducing valve angles can net phenomenal increases in airflow, there is a limit to how extreme these dimensions can get. In any head casting, the intake port can only be raised so much until there is no longer sufficient casting material remaining above the port to support the valvetrain. To prevent the port roof from breaking into the valvespring pockets, many head designers recommend a minimum thickness of .040- to .050 inches in this critical area. To create some valuable real estate, aftermarket manufacturers have continually increased the height of the head casting itself.

That's great for airflow, but from a packaging standpoint taller heads with taller intake ports also require taller intake manifolds—and even with big cowl-induction hoods—there's only so much space available under the hood. The domino effect is that since the port entry and valve seat represent two ends along the same path, once the limit of raising port height has been reached, further flattening the valve angle merely increase the curvature of that path. "If you flatten the valve angle without raising the port, you make the short-turn radius even sharper. Once air speed picks up, it gets unglued from the short-run and airflow tends to fall off very quickly after .600-inch lift," Ron Robart of Fox lake Power Products explains.

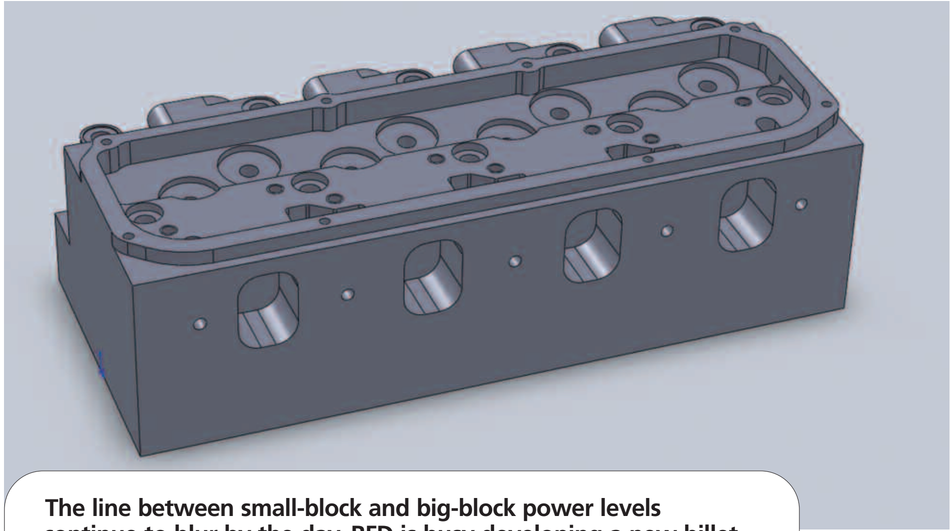
Further complicating matters is how the sharpness of the short-turn radius affects airflow in different parts of the lift curve. Generally, a steeper short-turn speeds up airflow, thus improving low- and mid-lift airflow while sacrificing high-lift flow. Conversely, a more gradual transition at the short-turn slows the airflow down, improving high-lift airflow at the expense of low-lift flow. Given these tradeoffs, it's possible to juggle valve angles and port heights in unconventional configurations that still work well within a very specific and highly targeted rpm range. As always, the goal is to optimize each of these variable to maximize performance for the intended application.



With so much focus on flow numbers, combustion chamber design is often an afterthought for most racers. Essentially an extension of the valve job, the combustion chambers are a vital part of the flow path.



The continual raising of intake ports and flattening of valves angles have culminated in monstrous creations like RFD's D3 heads. They are very common in max-effort naturally aspirated combinations such as in Australian Pro Stock.



The line between small-block and big-block power levels continue to blur by the day. RFD is busy developing a new billet SC1 casting that will flow 500 cfm. Not only is that better than a big-block head, it's better than a very good big-block head.

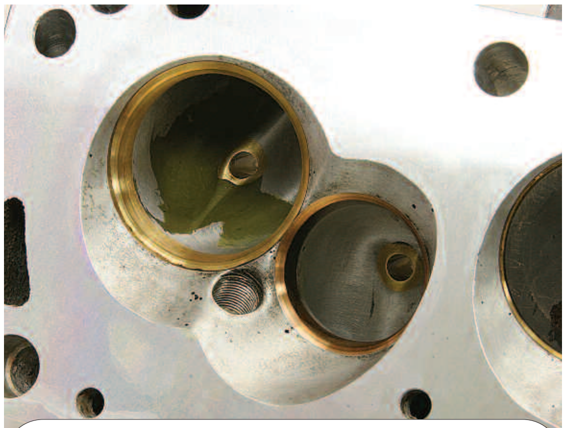
NO BLANKET STATEMENTS

Although a low port entry and flat valve angle are a very bad combination in a high-rpm race engine with lots of valve lift, it's a configuration that can still perform quite well in a hydraulic roller cam street applications. "When specs of our 11R small-block Ford head starting leaking out during the development phase, everyone looked at the 11-degree valve angle and assumed we were designing an all-out race head. Then people saw the stock intake port height and started scratching their heads," recalls Cory Roth of TFS.

As an evolution of Trick Flow's Twisted Wedge heads, the 11R castings are intended for high-end street engines, not all-out racing applications. "By flattening the valve angle, we were able to increase airflow in our target lift range without making the combustion chamber bigger. This design does sacrifice high-lift airflow, but the benefit is that it improves low- and mid-lift airflow," Cory explains. "Hydraulic roller cams have come such a long way that you don't need solid rollers anymore in most street engines. In Spintron testing, we've found that hydraulic rollers are stable up to 8,200 rpm. We recently built a 427ci test engine that had our 205cc 11R heads, 11.59:1 compression, and a 250/254-at-.050 hydraulic roller cam with .595/.595-inch lift. It made 655 horsepower and pulled easily to 7,000 rpm. For the applications it's intended for, the 11R heads work very well."

In contrast, Trick Flow's venerable High Port cylinders heads are a staple of high-rpm racing applications. In addition to boasting a beefy casting design that helps seal in the boost in forced induction applications, the basic architecture of the High Port castings perform better at high lift. "The TFS High Port heads are very popular in solid roller cam applications. With a 20-degree valve angle and stock intake port height, the short-turn radius isn't as sharp with the High-Ports as they are in the 11Rs, which offers improved high-lift airflow."

Just two examples within one manufacturer's line of small-block Ford cylinder heads highlights the dangers of making blanket statements about cylinder head design. Flat valve angles aren't always for race applications, and stock valve angles don't always suck in race engines. It's all about how well the overall cylinder head package performs in its intended application.



Rotating the combustion chambers places both the intake and exhaust valves in positions within the bore that are more conducive to airflow. Some engine builders say that this position enhances swirl to promote superior fuel homogenization.

To give head designers more flexibility, Edelbrock offers its Victor, GV2, and SC1 heads as raw castings. This requires some very labor intensive prep work, but the payoff is tremendous. TEA's SC1 heads flow over 480 cfm.

PORT SHAPE AND PORT VELOCITY

These days, any naturally aspirated race engine worth a lick will exceed 100 percent volumetric efficiency. The only way this is possible it to capitalize on inertial wave tuning potential through the intake ports by maximizing port velocity. This is of paramount importance because velocity and airflow are very closely related. You can't have one without the other. According to many cylinder head gurus, a 10 percent loss in port velocity can reduce airflow by 40 percent. This explains why a 225cc cylinder head that performs great on a 427 cubic inch engine won't run at all when bolted to a 347ci short-block. "If a set of heads has great velocity but mediocre flow volume, you`ll end up with an engine that is responsive and makes good torque, but runs out of airflow in the upper rpm range and horsepower will suffer. If a set of heads has great flow potential, but low air speed, you wind up with a lazy engine with poor throttle response that only makes good power in the upper rpm range," says Tim Torrecarion of Air Flow Research.

In addition to properly sizing a cylinder head for a given application, skillfully manipulating the shape of a port plays a significant role in maximizing port velocity. Port shape doesn't simply refer to the shape of the orifice at the intake flange. Although a typical small-block Ford cylinder head may have a rectangular intake port entrance, the port eventually transitions into a circular valve throat. As the port roof and floor converge, the sides of the port walls must expand at the same rate in order to eliminate potential choke points that can impede both airflow and velocity. Likewise, altering the shape of the port can manipulate velocity in a very specific section of flow path to help change the direction of airflow. For instance, slightly reducing air speed near the short-turn radius can dramatically affect how well air negotiates the turn.

In order to achieve over 100 percent volumetric efficiency, air velocity must be very high as it exits the valve seat. Since the intake valve stays open even after the pistons begin moving upward on the compression stroke, there must be sufficient port velocity—and therefore kinetic energy—to continue pushing air into the cylinders. A typical street/strip cam closes the intake valve roughly 60 degrees after BDC, but the greater the inertial supercharging effect, the later the valve can be closed to continue filling the cylinders even more.

While maximizing port velocity is hardly a novel concept, the benefits of gradually slowing the air speed down after it exits the valve aren't as universally accepted. "The highest air speed in the induction system should be at the carburetor and at the valve venturis. When this is done correctly, there is now tremendous air speed that suddenly dumps into a big, empty cylinder," Curtis Boggs of Race Flow Development explains. "When the air suddenly expands into a giant space, you lose a ton of energy that should be used to draw in more air. This is very important when you're trying to exceed 100 percent volumetric efficiency. To improve the pressure recovery and take advantage of this energy, you must gently slow the air down as it goes into the combustion chamber and cylinder. Generally, deeper chambers help slow the air down more gradually. Ultimately, it's just one of many tuning tools. Pressure recovery on a head that's horrible on one motor can work well in another motor."

GETTING TWISTED

Imagine leaning over the fender and popping the valve covers off of an inline cylinder head. From this angle, the valve stems would point straight up. In contrast, the valve stems point outward in a canted-valve head, which effectively angles the valve heads inward. Since the valves are now angled toward the center of the cylinder bore, they move away from the cylinder walls as they open, reducing valve shrouding and potentially increasing airflow. While this is common knowledge for tech savvy racers, the canted-valve architecture overs several additional advantages that are seldom discussed.

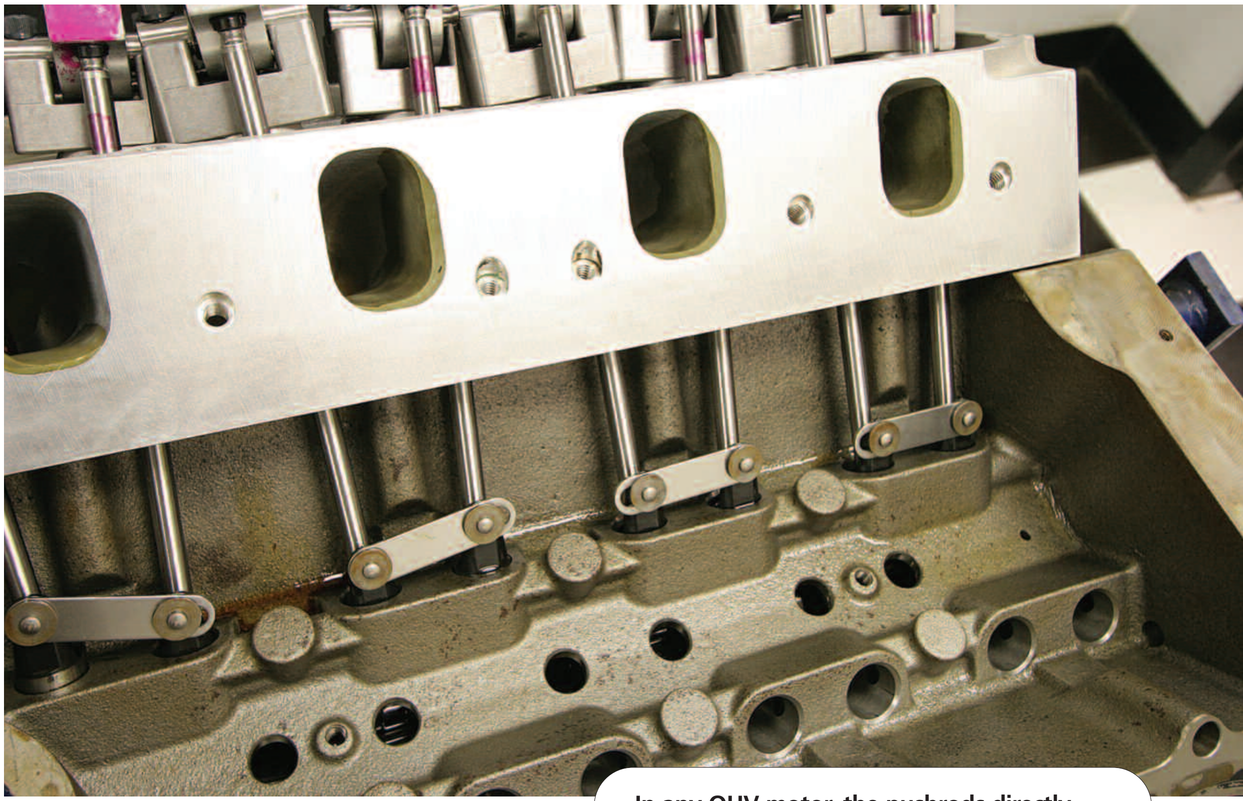
In any OHV engine, port geometry is inherently compromised by the pushrods. If the intake port openings were positioned to provide the straightest, most direct path to the valves, the pushrod would run right through the port itself. To prevent this from happening, the port entrance must be pushed over to the side to direct it around the pushrod, then back toward the valve. By angling both the valves and the pushrods outward, a canted-valve head increases the space available at the pushrod pinch area and allows for a straighter path to the intake valve.

Additionally, when comparing an inline head to a canted-valve head side by side (as viewed from the deck), the difference in valve positioning in relation to the cylinder bore centerline is very dramatic between the two styles of heads. When viewing the combustion chambers of an inline small-block Ford cylinder head (w/intake ports ported upward), the intake and exhaust valves are positioned at roughly 9 o'clock and 3 o'clock. With the typical canted-valve head, the combustion chambers are rotated clockwise, positioning them at roughly 10 o'clock and 4 o'clock. This simple change offers many advantages. First off, it frees up space to fit larger valves. Secondly, moving the intake valve closer to the intake port opening creates a straighter flow path from the port opening to the valve. Furthermore, rotating the chamber moves the intake valve away from the outboard cylinder wall (exhaust header side) and the exhaust valve away from the inboard cylinder wall (intake manifold side) ever so slightly.

The resulting design is a cross between a wedge head and a hemi head. This arrangement offers the airflow advantages of a hemi head combined with the highly efficient combustion chambers of a wedge head. "Ideally, you want the valves squared up in the center of the bore when they open. Twisting the combustion chamber around puts the intake and exhaust valves in a better position to accomplish this," Shawn Hooper of the School of Automotive Machinists explains. "With every new generation of NHRA Pro Stock head, the combustion chamber gets twisted around even more. There are canted-valve cylinder heads out there that don't utilize a twisted chamber, and they don't perform nearly as well. With an inline head, if you wanted to move the intake valve away from the outboard cylinder wall, you'd also crowd the exhaust valve against the inboard cylinder wall and hurt the exhaust flow."

Yet another advantage of a canted-valve cylinder head is the ability to set the intake and exhaust valve angles independently. Since the exhaust port is located on the opposite side of the cylinder as the intake port, forcing the exhaust valve to share the same angle as the intake valve (i.e. inline head) isn't conducive to exhaust flow. Consequently, canted-valve heads typically stand the exhaust valve closer to vertical (lower valve angle) in order to more closely align with the exhaust port geometry. Although not quite as good as a hemi head in that regard, a canted-valve, twisted wedge head doesn't compromise valvetrain geometry or chamber efficiency as much as a hemi head, either. Of course, there are other considerations as well. "The exhaust valve will usually have less of a cant angle than then intake side," Hooper explains. "If there's too much cant, there's only so much duration and lift you can have before the valves clip each other. That's why NASCAR Sprint Cup heads don't have any cant on the exhaust valves."

Although rotating the combustion chamber is most common with canted-valve heads, it can also be done with non-canted heads as well. In fact, Trick Flow has been offering such a design with its Twisted Wedge castings for nearly 20 years. Ultimately, whether or not the airflow advantages of a canted-valve head prove advantageous on track is all dependent upon the application. Almost every sanctioning body on Earth places a weight penalty on canted-valve engines, so the pros and cons of inline heads versus canted-valve heads extends beyond airflow capacity alone.

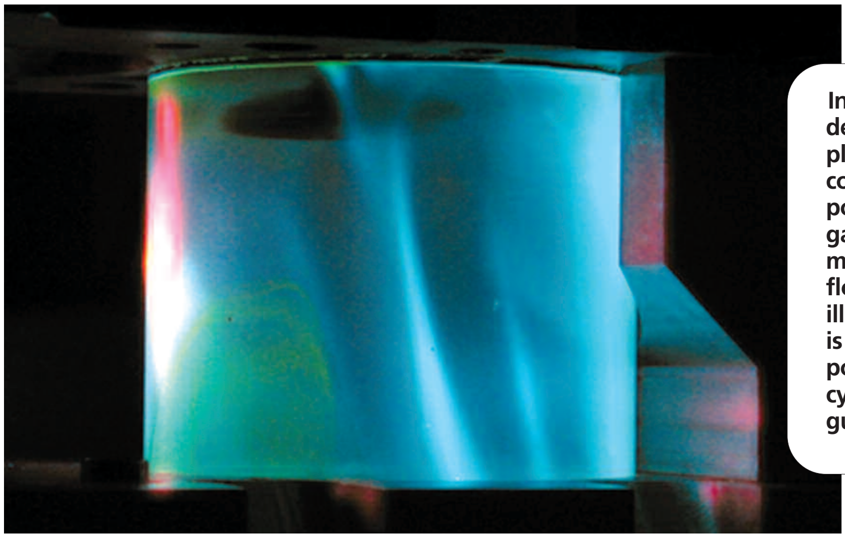


In any OHV motor, the pushrods directly impede the flow path of the intake ports. Canted valve heads tilt the top of the pushrods outward, freeing up space to create a straighter path to the valves.

CASTING IMPROVEMENTS

To give race engine builders more flexibility in designing their own proprietary ports and chambers, all-out race cylinder head like Edelbrock's GV2 and SC1 castings are offered in semi-finished form. However, the same straw-sized ports and virtually non-existent chambers that give porters a blank canvas to work with present a whole new set of manufacturing challenges. "Raw castings like that require lots of metal, which makes it very tough for our foundry. Fortunately, Edelbrock invested in establishing our own foundry many years ago, which gives us complete control over the casting process," says Rick Roberts of Edelbrock.

A casting process that works fine for a street head just won't cut it in a race casting. "When we poured our first



In the past, head designers resorted to placing strings or colored water inside a port to attempt to gauge air/fuel movement. The wet flow bench clearly illustrates exactly what is going on inside the ports, chambers, and cylinders. No more guessing required.

SC1 cylinder head, we made all the tooling and poured metal into the mold the same way we would have done with one of our Performer RPM heads. We used the same material and process, but obviously poured in a lot more metal," Roberts recounts. "All of a sudden, everything started bubbling, and our lead engineer at the foundry stepped back as if something was about to explode. He had poured hundreds of thousands of heads before, but had never seen anything like it. We figured out very quickly that with a head that has so much metal in it, you can't cast it using green sand. You have to use dry sand. Our engineers also revised the alloy, heat treating, and pouring process. Now there are no limitations on the size of the mold we need to use to create a quality casting."

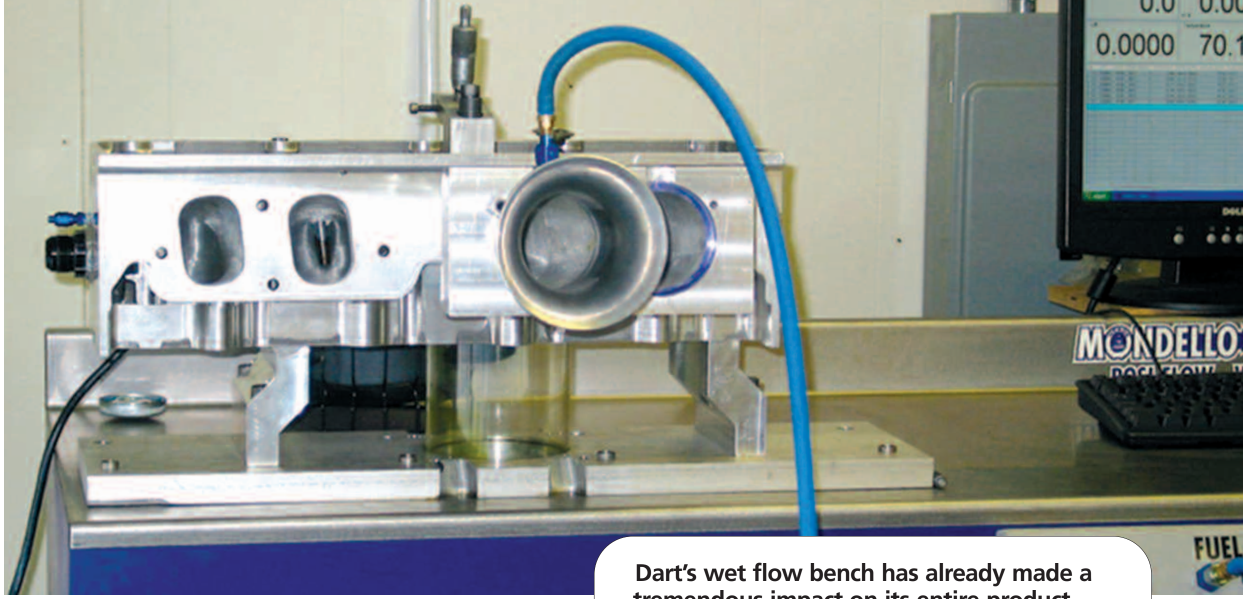
To further improve casting integrity and durability, Edelbrock adopted a Hot Isostatic Pressing (HIP) process originally developed for the aerospace industry. "Anything that's cast aluminum has trapped gas in it. That's just a fact of life," Roberts explains. "This is perfectly normal and acceptable, but the HIP process completely eliminates the gas bubbles. It involves heating the raw castings up to 900 degrees Fahrenheit, then pressurizing it in a chamber at 30,000 psi. This gets rid of all the gas bubbles, and triples the fatigue life of the casting. The result is a very strong casting that nearly matches the consistency of billet. Currently, we perform the HIP process to our Glidden-Victor and SC1 cylinder heads."

As with the design of the cylinder head architecture itself, computer modeling also helps improve the casting process. "If a head doesn't solidify in a uniform fashion, the pockets of molten metal will get trapped and eventually shrink in size. To prevent this from happening, as the head solidifies it has to be fed molten metal," says Roberts." For more precise control over this process, we rely on modeling software that simulates the entire casting procedure. The software lets you identify potential problem areas, and figure out how the metal must flow during the solidifying process. All of these factors combined enable Edelbrock to produce some of the best castings in the world."

FLOW BENCH RACING

In recent years, more and more engine builders have publicly questioned the validity of flow bench numbers. While very few experts proclaim that flow bench numbers are complete nonsense, many contend that flow numbers are not the end-all-be-all measure of a cylinder head's performance potential. "There are so many things going on inside a cylinder head that contribute to horsepower production, but don't show up on a flow bench. As engine builders, what we're actually trying to do is make a car go down the track faster and win races, not make a big number on a flow bench," Curtis Boggs of Race Flow Dynamics opines.

According to Boggs, there is such a thing as being too perfect. "Engines like a little bit of chaos. You can deliver a perfect cone of air into the chamber and use 100 percent of the valve curtain, but if the flow is too perfect you won't make as much power because there just isn't enough turbulence," he says. "Others will argue this point, but the valves in a Pro Stock engine are rotated around the chamber for a reason. The angle the air enters the chamber at creates more mixture motion. That's why canted-valve heads make more average and mid-range power than a hemi head. The position of the valves in a hemi head doesn't create as much mixture motion."



Dart's wet flow bench has already made a tremendous impact on its entire product line. According to the company, its latest heads produce substantially more hp than its older designs despite moving the same amount of air on a dry flow bench.

While the merits of swirl and tumble are hotly debated amongst engine builders, and there are devices that can measure them, a typical flow bench lacks this capability.

Attempting to correlate airflow figures with horsepower potential assumes that a flow bench accurately simulates the airflow dynamics inside an internal combustion. It also assumes that an electric motor providing a steady state of airflow can accurately mimic the pressure differential inside a running engine during the intake stroke, as well as the sudden spikes in cylinder pressure that can exceed several hundreds, and even thousands, of psi on the exhaust stroke. While some means of measuring airflow is better than nothing, and flow benches are very effective in predicting the power potential of a cylinder head in a typical street/strip application, the more extreme the engine combination, the less effective a flow bench is in this regard.

Ironically, perhaps the best way to illustrate the shortcoming of a flow bench is with a different type of flow bench. Dart was one of the early adopters of wet flow bench testing, and it has profoundly influenced the company's cylinder head designs. Although it was first utilized to develop the company's Pro Stock cylinder heads, Dart soon learned that it could greatly benefit its production heads as well. Powered by three 50hp electric motors capable of moving 800 cfm of air at 55 inches of water, Dart's wet flow bench sprays a non-flammable liquid at a 13.0:1 ratio that has the same specific gravity as fuel. A fluorescent dye mixed in with the liquid glows under ultraviolet light, allowing head designers to visualize how fuel moves through the ports and combustion chambers.

The results have been quite revealing to say the least. "A cylinder head that flows 500 cfm dry will flow 30 percent less on the wet flow bench. Since a mixture of air and fuel is heavier than dry air, it doesn't have the same flow characteristics, as it just wants to go straight until it smacks into a wall," Tony McAfee of Dart explains. "The goal is to disperse the fuel as evenly around the seat and valve as possible. Some amount of fuel will always attach to the walls, and the objective is the put it back into the airstream. By using sharp points on the valve job, we can get the fuel to shear back into the airstream. Chamber shape plays a huge role in wet flow characteristics, and how much fuel goes over the spark plug is very important as well. Keeping the air suspended delivers move fuel to the cylinders and makes more power."

On the dyno, the lessons learned on the wet flow bench can yield some staggering results. "We've had instances on Pro Stock engines where we picked up airflow on the dry flow bench, but lost 20 hp on the dyno. We said, 'What the hell, how can that be possible?'" Tony laughs. "That's a perfect example of a dry flow bench lying to you. After we put the head on the wet flow bench, we could clearly see where it needed to be improved. We have completely revised our production heads based on what we learned on the wet flow bench. Our new heads don't flow much better than our old heads on the dry flow bench, but on a 500hp hydraulic roller street engine, they make 20 hp more."■

SOURCE

Air Flow Research
airflowresearch.com
661 | 257 | 8124

Dart Machinery
dartheads.com
248 | 362 | 1188

Edelbrock
edelbrock.com
310 | 781 | 2222

Fox Lake Power Products
foxlakeracing.com
330 | 682 | 8800

Race Flow Development
raceflowdevelopment.com
727 | 222 | 9717

School of Automotive Machinists
samracing.com
713 | 683 | 3817

Total Engine Airflow
totalengineairflow.com
330 | 634 | 2155

Trick Flow Specialties
trickflow.com
330 | 630 | 1555