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HEMI VS. WEDGE SHOOTOUT

Jon Kaase Settles One of the Most Fiercely Debated Topics of All Time With the Ultimate Dyno Test

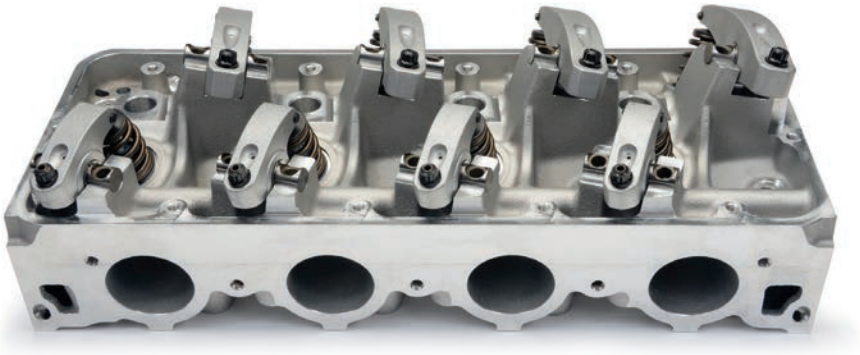
By Stephen Kim / Photos: Vic Moore

Hemi versus wedge. Which makes more horsepower? It's an age-old question that's difficult to answer because real-world uses for both cylinder-head architectures make direct comparisons nearly impossible. Sure, Top Fuel dragsters and Funny Cars easily stomp their Pro Stock counterparts, but comparing a nitromethane-burning, supercharged Hemi to a naturally aspirated, gasoline-burning wedge is an idiotic exercise at best.

Even within the Pro Stock ranks, wedge-headed, 500ci NHRA engines share very little in common with the hemi-headed, 800-plus-cubic-inch IHRA monsters in terms of bore diameter, valve size, piston speed, and peak rpm. Such anecdotal comparisons simply present far too many variables to accurately assess the virtues and shortcomings of both styles of heads. That is, until now. To settle the debate once and for all, Jon Kaase Racing Engines (JKRE) threw all of the silly anecdotes out the window and devised the mother of all hemi versus wedge tests. The results are eye-popping, to say the least.

Compared to an inline cylinder head, the chambers in the canted-valve P51 heads feature a slight clockwise rotation. This improves flow by moving the intake valve farther away from the outboard cylinder wall and the exhaust valve farther away from the inboard cylinder wall. It also creates a straighter flow path between the intake-port entrance and the valve seat.

The Boss 9 hemi heads take this concept to the extreme by rotating the chamber even more, positioning the valves at 11 o'clock and 5 o'clock (opposed to 10 and 4). The hemi heads also boast a shallower and more gradual chamber radius, as well as centrally positioned spark plugs.



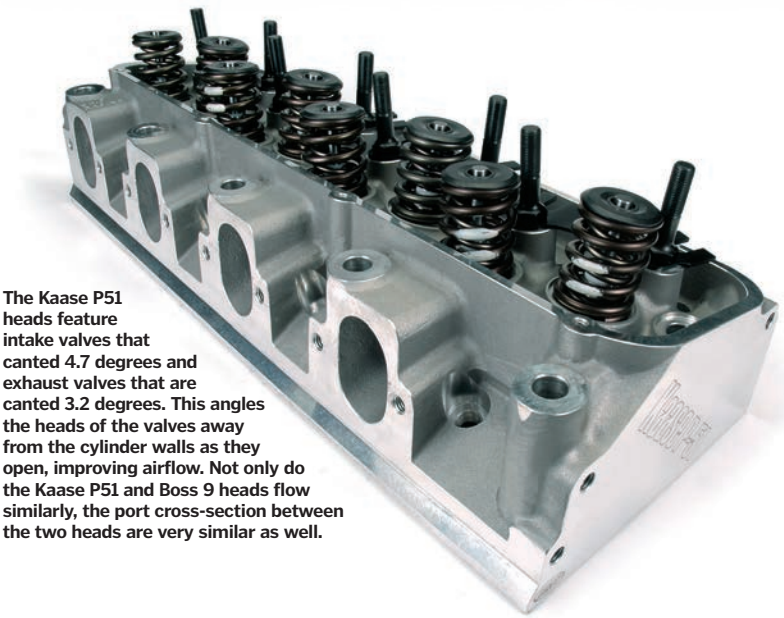
The intake ports on Kaase's Boss 9 heads closely mimic the shape and size of the factory Boss 429 cylinder heads. Although the big, round ports look intimidating, Kaase has found they aren't the most efficient design out there. As such, Kaase designed a flat floor into the Boss 9 intake manifold to increase airspeed through the port.

PRERACE SHOW

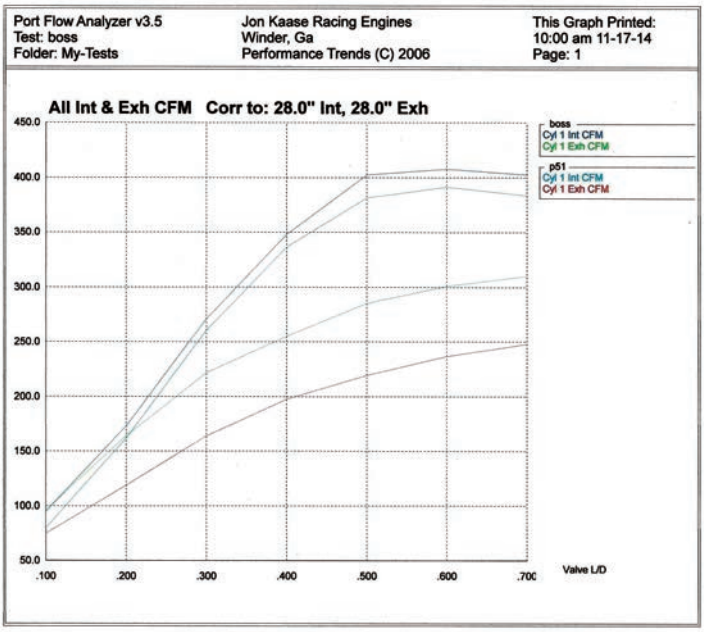
The long list of reasons why engine builder extraordinaire Jon Kaase is the ultimate candidate for settling the hemi versus wedge debate extend far beyond his 13 IHRA Pro Stock championships and five Engine Masters Challenge victories. As an unabashed fan of big-inch Fords, Kaase has gotten down and dirty with just about every OE and aftermarket Ford cylinder head ever built. The diversity of cylinder-head architecture Ford has tinkered with over the years means that Kaase's expertise envelops canted-valve 429/460 wedge heads, Boss 429 hemi heads, inline wedge FE heads, and the full gamut of small-block Ford heads. Not only does he know the pros and cons of each style of cylinder head inside and out, JKRE also manufactures its own line of wedge and hemi heads for 429/460 big-block Fords.

Here's where things get interesting. Both Kaase's P51 wedge heads and Boss 9 hemi heads for big-block Fords flow roughly the same amount of air. For this head-to-head test, the P51s moved 392 cfm through the intake ports while the Boss 9s checked in at 407 cfm. The gap in flow is more pronounced on the exhaust side, with the P51 and Boss 9 heads flowing 248 and 310 cfm, respectively. Obviously, as the manufacturer of both cylinder-head designs, JKRE has no reason to promote one head over the other. While the Boss 9 heads consistently produce more power than the P51 castings on Kaase's crate-engine packages, variations in displacement, camshafts, and induction packages in past combinations have made it difficult to know how much of that additional horsepower was directly attributable to the cylinder heads.

One day, curiosity got the better of him and Kaase decided to test the heads back to back on the same 521ci short-block, the same solid-roller camshaft, the same carburetor, and identically sized header primaries. Although the pistons had to be swapped to account for the specific valve-relief requirements for both heads, each set of slugs weighed within a few grams of each other, retained the same rings



The Kaase P51 heads feature intake valves that canted 4.7 degrees and exhaust valves that are canted 3.2 degrees. This angles the heads of the valves away from the cylinder walls as they open, improving airflow. Not only do the Kaase P51 and Boss 9 heads flow similarly, the port cross-section between the two heads are very similar as well.



When designing the Boss 9 and P51 heads, Kaase focused on maximizing low- and midrange flow. Says Kaase, "Peak airflow numbers are momentary, perhaps a momentary irrelevance that's useful for bragging rights, but little else. No one brags about strong midrange numbers, but they are the ones that make the power. On our street-style heads, I've found that if we can flow substantial air at 0.400- to 0.600-inch lift, the horsepower numbers will be much better than ones that rely on big, high-lift numbers."

For both dyno tests, the 521 big-block Ford used the same QFT QFX-series 1,150-cfm carburetor, Innovators West balancer, Meziere electric water pump, and MSD billet distributor. Variations in exhaust-port design necessitated running different headers, but both sets of pipes had the same 2.25-inch primaries and the same collector diameter and length. The P51 heads performed best with 28 degrees of ignition timing.

and wristpins, and maintained identical 10.0:1 compression ratios. Kaase's pre-race money was on the hemi heads. "The Boss hemi heads should make between 50 to 75 horsepower more than the P51 heads. The valves are slightly bigger in the Boss heads, and they're in a better location within the chamber and within the bore."

TEST MULE

Quite possibly the most thoroughly abused dyno mule still in existence, Kaase's 521ci R&D short-block has endured thousands of dyno pulls over the last 15 years. The combo is as simple as it is rugged. Based on a factory 460 block bored to 4.390 inches, it utilizes a Callies 4.300-inch steel crank, Lunati rods, and Mahle 10.0:1 pistons. A Comp solid roller cam (273/280 degrees duration, 0.791/0.787-inch lift, and a 109-degree lobe-separation angle) actuates the valves, while a Kaase pump and Moroso pan control the oil supply.

Of course, in this particular shootout, the only purpose of the short-block is keeping the test variables as consistent as possible during back-to-back testing. The real stars of the show are the cylinder heads. In one corner are Kaase's venerable P51 castings. Arguably one of the most popular 429/460 big-block Ford cylinder heads on the market, they feature 310cc intake ports, 145cc exhaust ports, 72cc combustion chambers, and 2.250/1.760-inch valves. The factory 14-degree valve angles have been dramatically altered to 8.3 degrees on the intake valves and 4 degrees on the exhaust. When combined with the stock intake-port entry location, this arrangement does sacrifice some high-lift airflow, but the steeper short-turn radius nets dramatic improvement in low- and mid-lift airflow. At just 0.400 inch lift, these babies are already flowing 330 cfm. Peak flow checks in at 392 cfm on the intake side and 248 on the exhaust side at 0.600 inch lift.

In the other corner of the ring are Kaase's remake of the legendary Boss 429 cylinder heads. Since original Boss heads are nearly impossible to find and are only compatible with equally rare Boss 429 blocks, Kaase decided to build his own head castings. The resulting Kaase Boss 9 cylinder heads utilize redesigned oil drains, which makes them fully compatible with standard 429/460 blocks. Likewise, thicker decks allow ditching the goofy factory O-rings in favor of a standard 460 head gasket. Although the Kaase Boss 9 castings look similar to the factory Boss 429 cylinder heads at first glance, they feature extensively revised port architecture, particularly at the approach to the valve seat, the short-turn radius, and the bowl area.

Furthermore, whereas the combustion chambers on the stock Boss 429 heads employ crude quench pads, Kaase's Boss 9 castings boast modern heart-shaped chambers that serve as an extension of the valve job. This vastly improves chamber efficiency and detonation resistance. In fact, the Boss 9 heads look more like a wedge head—whose chambers have been rotated clockwise 80 to 90 degrees—than a true hemi head. By combining the airflow advantage of a hemi head with the combustion-chamber efficiency of a wedge head, Kaase's "rotated-wedge" design represents the best of both worlds.

One of the many advantages of positioning the valves on opposing ends of the combustion chamber in a hemi head is the increase in available space for larger valves. As such, deliberately reducing the size of the exhaust valve to make room for a larger intake valve—a common practice in wedge-headed NHRA Pro Stock and NASCAR Sprint Cup engines—isn't always a necessary evil with a hemi head. At 2.300/1.900 inches, although the valves in the Boss 9 heads are larger than in the P51 heads, they still fit inside the same 4.390-inch-diameter bore. To ensure compatibility with existing intake manifolds and exhaust headers on the market, Kaase kept the ports on the Boss 9 cylinder heads in the stock locations. Even so, the Boss 9s flat out move some serious air, peaking at 407 cfm on the intake side and 310 cfm on the exhaust side at 0.600-inch lift.

Since both sets of cylinder heads utilize factory intake-port locations, the intake manifolds used for this test are street-oriented units that prioritize hood clearance over ultimate performance. The P51 heads were matched with an out-of-the-box Edelbrock Victor single-plane intake manifold, while the Boss 9 heads were fed by a Kaase-designed single-plane casting. Kaase notes that the runner length and plenum volume are very similar on both intakes, further minimizing variation between each top-end package. Both engine configurations shared the same 4500 QFX-series carburetor from Quick Fuel Technology as well.

GREEN FLAG

As the hydrocarbons cleared in the dyno room, the hemi versus wedge test results were downright shocking. The Boss hemi heads didn't merely edge out a victory, they absolutely annihilated the P51 wedge heads. While the 805 hp posted by the wedge heads at 6,400 rpm is very, very respectable for a pump-gas street/strip engine, the hemi heads pounded that figure into submission by putting up 914 hp at 7,000 rpm.

Things get even more interesting when inspecting the torque curves. The hemi heads didn't exactly crush the wedge heads in the peak torque department (736 lb-ft versus 717), but average torque output throughout the rpm band was an absolute massacre. At 4,000 rpm, the hemi heads were already producing 706 lb-ft, and torque output did not dip below 700 until

Before the headers had a chance to cool off, the JKRE crew tore into the 521 to swap out the top-end components. The wedge-to-hemi conversion involves swapping out the cylinder heads, intake manifold, lifters, pistons, pushrods, rocker arms, and valve covers.

Incredibly, Kaase's 521ci test mule has held up to thousands of dyno pulls with nothing more than a Callies crank, Lunati H-beam rods, and two-bolt main caps. The factory oil pump is notorious for cracking, so Kaase designed his own pump.

Mahle worked very closely with JKRE to keep the mass and overall design of the hemi pistons and wedge pistons as similar as possible. Despite the obvious difference in valve reliefs, the two sets of pistons utilize a similar concave dish design and maintain the same 10.0:1 compression ratio.

In the name of parity, the same wristpins and 1.5/1.5/3mm rings were transferred over from the P51 pistons to the Boss 9 pistons. Since the valves on the hemi heads are positioned closer to the edge of the piston, they required lowering the top ring 0.050 inch. A lower top ring increases crevice volume, which can compromise fuel homogenization and power production.

6,400 rpm. In contrast, the wedge heads didn't hit 700 lb-ft until 4,600 rpm, and by 5,600, torque output head already dipped below 700.

While both cylinder heads produce similar peak volumetric efficiency—as reflected by the modest 19-lb-ft difference in peak torque between the two—the hemi heads filled the cylinders much more efficiently throughout the entire rpm range, producing an unbelievably flat torque curve. In fact, at 7,000 rpm the hemi heads are still kicking out 686 lb-ft, whereas torque output with the wedge heads has already dropped to 581 lb-ft. This massive gap in torque at high rpm explains the substantial horsepower advantage posted by the Boss heads. More average torque translates to more average power, and more average power wins races. In this contest, the hemi heads authoritatively take home the win by a staggering 109hp margin.

POST-RACE INSPECTION

Like any great revelation, this hemi versus wedge shootout raises more questions than it answers. How does a mere 3.7-percent advantage in intake airflow (407 cfm versus 392) equate to a stunning 12-percent increase (914 versus 805) in horsepower? The P51 heads convert each of its cfm into 2.05 hp, which is very typical for hot street/strip combinations on pump gas. In contrast, the Boss 9 heads convert each of its cfm into 2.24 hp. Assuming that airflow measured on a flow bench directly correlates with horsepower potential, what factors can account for such disproportional dyno results between the P51 and Boss 9 cylinder heads?

According to Kaase, flow benches are overrated. "We're not big on flow benches at our shop. On most of the engines I've worked on, if I spend a few days making a cylinder head flow better on a flow bench, it rarely makes more power," he explains. "With smaller-cubic-inch, street-style engines, flow-bench numbers can more directly correlate with horsepower. Once you exceed 400 cubic inches, however, you can have heads that pick up 30 to 40 cfm that make no difference in power. That happens a lot in heads with low intake ports that go uphill for a while before turning downward at the short-side radius. The ports are fussy and go turbulent. You can fix the turbulence and increase airflow from 360 to 400 cfm, but there will be no difference in horsepower."

The big question is, how does this relate to the hemi versus wedge debate? "Sometimes the quality of airflow through the port is more important than the quantity. The fewer turns there are in the port, the smoother the flow path will be," Kaase reports. When designing the P51 wedge head, Kaase positioned the intake valves closer to the lifter valley side of the block than the exhaust header side of the block. As the valves open, this "biased" positioning moves the valves closer to the cylinder-bore centerline for decreased shrouding and improved airflow. While the Boss 9 heads follow a similar approach, the hemi architecture allows taking this concept to the extreme. "The valve positioning and combustion-chamber design is just all-around better with the hemi head. When the valves in the hemi head open, they are not close to anything and there's nothing in the way to impede incoming air. The valves are positioned at a sufficient distance from the cylinder walls and chamber walls in both heads, but the hemi heads are just better."

Although it may be difficult for the typical bench racer to come to terms with the concept of airflow quality versus quantity, Kaase has witnessed countless examples of how quality reigns supreme. "Once you get to a certain power level, factors like the shape of the port, the profile of the chambers, and the positioning of the valves become more important than flow-bench numbers. The shape of the port refers to not just the cross-section, but also where the port is big and where it's small," Kaase says. "You can take a set of factory Super Cobra Jet heads and port them to flow 400 cfm, but they still won't make as much power as our P51 heads that flow the same amount of air. Similarly, the airflow isn't much different between the Boss 9 heads and the P51 heads flow, but the hemi heads make a lot more power."

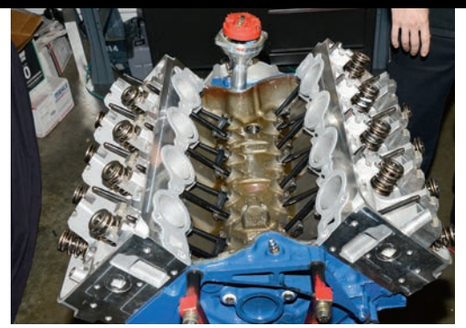
EXHAUST FLOW

Granted that the intake flow figures between the P51 and Boss 9 heads may be close, but the hemi heads trounce their wedge adversaries by 62 cfm (310 versus 248) on the exhaust side. While this would seem to stack the deck in favor of the hemi heads, Kaase's experience suggests otherwise. "I don't know how much of a horsepower difference

Compared to the stock Boss 429 heads, the smaller 87cc chambers found on the Kaase Boss 9 heads allow increasing the compression ratio well beyond 10.0:1 with a flat-top piston. Factory Boss 429 heads typically require heavy, domed pistons. Revisions to the oil drains allow bolting the Boss 9 heads to a standard 429/460 block and head gasket.

the exhaust flow makes, but it probably contributes slightly to it. We've experimented with different-sized exhaust valves on the wedge head, but they never affected the horsepower one way or the other," Kaase reports. "However, if we restricted the exhaust flow in some way on the hemi head, I'm almost certain it would hurt its power."

If Kaase doesn't seem to think that 62-cfm gap in exhaust flow played a large role in the outcome of this test, it's because he's more concerned with dyno and track results than he is with arbitrary rules of thumb. He simply doesn't believe in designing a cylinder head to hit a magic intake/exhaust ratio. The growing sentiment among many of the world's top engine builders is that intake airflow is far more important than exhaust flow, and the logic behind it is simple. While the intake ports must rely on a mere 14.7 psi of atmospheric pressure to push air into the cylinders, the exhaust ports have the luxury of hundreds, or even thousands, of psi of residual cylinder pressure to assist in evacuating the cylinders. "Those intake/exhaust percentages mean nothing to me. A 500ci NHRA Pro Stock engine is only at 50 percent," Kaase says. "Having a fixed



With the new pistons and Boss 9 heads bolted in place, team JKRE swapped out the standard Comp Cams solid-roller lifters for a set of Comp Z-bar units. Although the hemi architecture requires setting the exhaust pushrods at an extreme angle, this positioning alleviates pushrod pinch for far greater flexibility in port design.

ratio in mind doesn't account for the rpm range or camshaft size of an engine. The goal is to get both ports as best as you can, no matter what the ratio is. The higher the peak rpm of an engine, the more important intake flow becomes. That's why Pro Stock engines and NASCAR Sprint Cup engines position the valves away from the chamber walls and cylinder walls to maximize intake flow, even if it crowds the exhaust valve and hurts exhaust flow a bit."

Kaase offers both 4150-style and 4500-style intake manifolds for the Boss 9 heads. They're clearly designed with hood clearance in mind, but are still capable of supporting some serious horsepower straight out of the box.

CROSSFLOW

Perhaps the type of flow our postrace analysis should be focusing on isn't exhaust flow, but rather crossflow. Regardless of engine make, hemi fans have always maintained that the cross-flow motion generated inside the cylinders during valve overlap assists in cylinder filling. In other words, since the intake and exhaust valve are positioned on opposite ends of the combustion chamber, the charge inertia of exhaust gas exiting the cylinders helps draw in additional air/fuel through the intake valves during overlap. Obviously, this isn't nearly as pronounced with the side-by-side valve positioning of a wedge head, and it's not something that would show up on a flow bench, either.

As one of the world's premiere builders of hemi-headed IHRA Pro Stock engines, Kaase probably knows a thing or two about crossflow, but even he doesn't have all the answers. "Maybe crossflow has something to do with the Boss 9's horsepower advantage, but I'm not sure," Kaase says. Of course, there is the distinct possibly that he may be sandbagging on us, but numbers are numbers, and the hemi heads won this shootout by a very large margin. "With the Boss 9 heads hemi, the overall design of the chamber and how the air flows into and out of the chamber is better. At the end of the day, both cylinder head designs are overachievers, but if the same amount of work is done to each head, the hemi heads are always a little bit better."

THE DEBATE CONTINUES

Although the Boss 9 hemi heads stomped their P51 wedge adversaries into a pulp of fine metal shavings in this particular test, it doesn't necessarily mean the hemi architecture is always superior in every application. The truth of the matter is that proponents of hemi heads and wedge heads can each cherry pick specific examples where their platform of choice comes out on top. Ultimately, the pros and cons of each cylinder-head architecture determine which is best for any given application. Most of the time, it's simply a matter of preference.

Generally, hemi heads benefit from superior valve placement, reduced valve shrouding, and the ability to fit larger valves into any given bore diameter. This improves cylinder-filling, crossflow dynamics, volumetric efficiency, and torque output, which can potentially yield more horsepower per cubic inch. On the flipside, hemi heads require longer and heavier pushrods and rocker arms, and can't run as much camshaft duration due to valve-to-valve interference. Ultimately, these factors limit peak engine rpm.

Furthermore, since hemi chambers are less efficient than wedge chambers, they require greater ignition timing advance, thus increasing pumping losses. Traditional hemi chambers (i.e. Chrysler 426 Hemi) also necessitate heavier domed pistons, further limiting rpm. Since hemi heads place the valves

Built by W.W. Engineering, the Kaase-designed rocker-arm system solves several problems inherent to the OE design. By incorporating a rocker mounting saddle into the Boss 9 heads, Kaase was able to get rid of the mounting blocks used in the factory head castings. The exhaust rockers have also been redesigned to move the pushrods away from the block deck, eliminating the need to grind the block and head gaskets.

The Kaase Boss 9 heads may look stock, but their ports employ several tricks that take a keen eye to spot. On the intake side, the cross-section at the short-turn radius is quite a bit larger than stock. On the exhaust side, the size of the port floor has been reduced to boost port velocity.

DYNO RESULTS: KAASE P51 VS. BOSS 9

RPM	P51 TQ	BOSS 9 TQ	P51 HP	BOSS 9 HP
4,000	635	706	484	538
4,100	634	706	495	551
4,200	636	713	509	570
4,300	645	718	528	588
4,400	650	714	545	598
4,500	654	711	560	609
4,600	698	717	611	628
4,700	710	725	635	649
4,800	711	725	649	662
4,900	709	728	662	680
5,000	**717**	729	683	694
5,100	711	729	690	708
5,200	707	**736**	700	729
5,300	709	730	716	736
5,400	699	731	718	752
5,500	702	723	735	758
5,600	695	721	740	769
5,700	699	723	758	785
5,800	686	716	758	791
5,900	683	721	767	810
6,000	679	711	776	813
6,100	675	710	784	824
6,200	660	703	779	829
6,300	660	703	792	843
6,400	660	697	**805**	849
6,500	639	699	791	865
6,600	621	698	781	877
6,700	628	695	801	886
6,800	612	688	792	891
6,900	597	692	785	909
7,000	581	686	774	**914**
AVERAGE	668	736	697	745

→SOURCES

Comp Cams; 901/795-2400; CompCams.com
Edelbrock; 310/781-2222; Edelbrock,com
Jon Kaase Racing Engines; 770/307-0241; JonKaaseRacingEngines.com
Mahle Motorsports; 828/650-0803; MahleMotorsports.com
Quick Fuel Technology; 270/793-0900; QuickFuelTechnology.com

at the outer edges of the piston, the top ring must also be lowered farther down the piston skirt, which reduces power.

Although a wedge cylinder head can sometimes sacrifice ultimate airflow potential to a hemi head, it makes up for its shortcomings with a lighter valvetrain, more efficient combustion chambers, superior ring placement, lighter pistons, and the luxury of greater camshaft duration. These advantages allow a highly optimized wedge-headed engine to burn its air/fuel mixture more efficiently and turn far more rpm. So while the Kaase Boss 9 hemi heads took the win over P51 wedge heads in this shootout, settling the hemi versus wedge debate is usually more about proving out preconceived biases than it is about reaching a definitive answer. Ultimately, determining which cylinder-head architecture is better depends on the edicts of the rulebook, the size of the budget, and perhaps most important of all, personal preference. Kudos to everyone at JKRE for keeping the test variables to a minimum and letting the numbers speak for themselves.

To ensure test-to-test consistency, Kaase performed dyno pulls with both heads in the same 4,000- to 7,000-rpm range. Likewise, he set the Superflow's acceleration rate at 300 rpm per second for both sets of pulls.