Rocker Arm- Form & Function

By Doug Kaufman

For all the changes in the performance engine over the years, one constant remains - no matter what series they're running, no matter what the payout, no matter if it's just a couple of guys trying to outdo each other stoplight to stoplight, racers will often spend money they don't have in search of the most horsepower from hopefully, a durable engine. Engine builders are faced with the challenge of answering that call.

Luckily, advancements in the upper valvetrain components mean there's a much broader list of components to choose from when it comes to designing the perfect engine; not only for racing - performance is apparent everywhere today, even at the standard production engine level.

Rocker arms have come a long way since just opening valves with a pushrod. In modern automotive engines today, rocker arms serve double-duty, opening the valves, pushrods and lifter bore. Take the Chrysler Neon 2.0L SOHC engine, for example. The exhaust rocker arm is designed like a wishbone. The rocker arm has a roller bearing on one end, riding on a single camshaft lobe, while the other end, two encapsulated hydraulic lifters rides on two exhaust valves. It's topped off with a plastic cap to pivot on the valve tip

What a challenge it is to make this part: you have a metal roller bearing pinned to an aluminum body with a metal hydraulic lifter bored inside the aluminum arm. The hydraulic lifter unit's clearance-to-bore is so minute that the inside has to be thermally deburred. Otherwise the lifter may not leak down properly.

Contrast that with another popular engine, the Nissan KA24, which is found in Altimas, 240SX and pickups. That engine has a steel rocker arm with a sintered hardened pad that rides on the camshaft lobe with an encapsulated hydraulic lifter built inside on the other end to open the valve. Rocker arms simply aren’t what they used to be.

With lighter, stronger materials, as well as computer-aided design, modeling and manufacturing, it is easier and faster for rocker arm manufacturers to develop new parts in faster time, in an effort to keep up with the latest demands of their customers.

As it turns out, keeping up with those changes can be a challenge, because racers tend to be a fickle bunch, according to manufacturers we've spoken with. Steel or aluminum? Lightweight components or heavy duty? What was popular 10 years ago - or 10 minutes ago - may be outdated now.

Regardless of application, the demand flip-flops. A few years ago, it seemed like the rage was lightweight components - lightweight lifters, hollowed out valve stems, the works. Now, I hear people wanting to run 900 to 1,000 lbs. of spring pressure with gigantic springs.

The compromise, of course, is between saving weight and retaining strength. Lighter is often the better choice because less weight means less load on the valve springs which in turn translates into more rpms for greater top end power.

How much does weight impact power? According to experts, every gram you can take out of the total weight in the valvetrain adds up to 40 rpm. Theoretically, as little as 10 grams of weight reduction can add up to 400 more rpms to the engine.

Aluminum rocker arms typically offer lighter weight than stock stamped or cast steel rocker arms as well as exceptional durability. With needle bearing fulcrums and roller tips, friction and wear are reduced. The reduction in friction alone can be responsible for as much as 40 additional horsepower when the stock steel rocker arms are replaced by aluminum rocker arms.

Reducing the weight of the rockers will reduce the reciprocating mass of the valvetrain. But experts say reducing the weight on the valve side of the rockers usually benefits the engine's rpm more than changing the pushrod side. The offset of the rocker arm creates a leverage effect that uses the rocker lift ratio to multiply the weight savings on the valve side. For example, take a small block Chevy with a stock rocker arm ratio of 1.5:1. Every gram of weight removed on the valve side is worth 150 percent of any weight savings on the pushrod side.

So eliminating six grams of weight from the valve side of this valvetrain with lighter components such as valve spring retainers or valves has the same net effect as cutting 4 grams of weight from the lifters or pushrods. Reducing valvetrain weight means you can achieve the same rpm with less spring pressure, less friction, and less wear.

Of course, innovation doesn't end at weight reduction.

Aftermarket cylinder head manufacturers have come up with some great products that flow fantastic numbers. What I've found is, while everyday general purpose rocker arms will work with these heads, there are things that an aftermarket supplier can do to make them work even better. By offsetting the pushrod cup or relocating the roller tip forward or backward, maximum rocker arm geometry is achieved.

Changing the rocker arm ratio increases valve lift for more power. But changing the rocker arm pivot point can also reduce friction and the rate at which the valves open and close, adding horsepower with little or no loss in low rpm torque, idle quality or vacuum. By opening and closing the valves at a faster rate, the engine flows more air for the same number of degrees of valve duration. High lift rocker arms also reduce the amount of lifter travel needed to open the valves, which reduces friction and the inertia of the lifters and pushrods that must be overcome by the valve springs to close the valves. On the other hand, increasing the rocker ratio also increases the effort required to open the valves because of the leverage effect. The higher the rocker arm ratio, the greater the force the camshaft, lifters and pushrods have to exert to push the valves open. But when the valves close, the increased leverage of the rocker arms works the other way making it easier for the springs to shut the valves and push the rocker arms, pushrods and lifters back to their rest positions.

On small block Chevy engines, the stock stud-mounted rocker arms are supposed to be self-centering and self-aligning. The ball pivot inside the stamped steel rocker arm allows the tip of the rocker arm to follow the top of the valve as the valve is pushed open. This creates some back and forth scrubbing friction between the tip of the rocker arm and the top of the valve. And the higher the valve lift and the stiffer the springs, the greater the friction. Over time, this can cause side wear in the valve guides, tip wear on the end of the valve stems, and worn rockers.

Aftermarket performance rocker arms, whether they are stamped steel, stainless steel, or diecast, extruded or machined aluminum, usually have a roller tip to reduce friction between the rocker arm and valve. The roller, in theory, rolls back and forth on the top of the valve stem to reduce friction, wear and side forces exerted against the valve. Most stud-mounted aluminum rocker arms also have a needle bearing fulcrum to further reduce friction at the pivot point, and a hardened steel insert in the short end of the arm to accommodate the pushrod. Power gains of 15 to 30 horsepower are often claimed for aftermarket rocker arms even with stock ratios because of reduced friction. Aftermarket performance rocker arms are also stronger than stock stamped steel rocker arms, and provide improved reliability and longevity. But stud-mounted rockers have certain limitations.

One is that they often require pushrod guide plates to help keep everything in proper alignment, especially at high rpms and spring loads. Another limitation is that they can't handle valvetrain misalignment very well. If the rocker arm twists, it may bend the pushrod and/or allow the tip of the rocker arm to walk off the side the valve tip. If that happens, the rocker may push down on the retainer instead of the valve, causing the locks to pop out and the valve to disappear down the guide, destroying the engines.

There's a lot of talk these days about shaft-mounted rocker arms, and while they may seem to be a throwback to the days before the first stud-mounted stamped steel rocker arms appeared on small block Chevy V8s in 1955 they have been engineered for today's engines. One of the features that made the SB Chevy such a performer was its lightweight, high revving valvetrain. But that was a time when maximum engine speeds were in the 6,500 to 7,000 rpm range, not 8,500 to 9,000 rpm or higher, and most engines were running single springs, not double or triple springs.

Shaft mounted rockers offer a number of advantages today. The rigid shaft holds the rockers in perfect alignment, eliminating the need for separate pushrod guide plates while also limiting valve train deflection. At high rpm, pushrods and rocker arm studs can flex quite a bit, and the more they deflect the more it hurts valve lift, duration and valve control. This costs horsepower which can be seen on a dyno. So the more rigid the valvetrain, the less the valve flutter at high rpm.

Shaft mounted rocker arms also provide extra strength and support, eliminating the need for a separate stud girdle. Aluminum stud girdles are often necessary to reinforce the valvetrain when a high lift cam (or rockers) and stiff springs are used. The girdle clamps around the studs and ties them together to reduce stud flex and the risk of breakage. But the girdle also makes it harder to adjust the valves. Shaft mounted rocker arms, with adjusters on the arms, not the studs, are easily accessible.

Mounting the rocker arms on a rigid shaft also eliminates the "jack-hammering" effect that occurs with stud-mounted rockers. Every time the valve opens and closes, the change in valve lash that occurs with a solid lifter cam causes a stud-mounted rocker arm to slide up and down on its stud. This hammering effect can pull a pressed-in stud out of the cylinder head, and may cause fatigue failure in a screw-in stud or the rocker arm.

Another advantage of shaft-mounted rockers is better geometry. By lowering the pivot point of the rockers slightly with respect to the valves and pushrods, the arc that the tip of the arm follows is moved further down the curve. This reduces the back and forth scrubbing on the top of the valve, which reduces friction even more. One supplier of shaft-mounted rockers says this change alone reduces the torque it takes to turn a SB Chevy over by 80 ft. lbs, and is good for 15 to 20 horsepower.

Lubrication can also be an advantage with shaft-mounted rockers. Some have internal oil passages that route pressurized oil directly to the rocker arms and/or valve springs instead of relying on splash lubrication from oil squirting up through the pushrods

Another supplier of aftermarket rocker arms has taken a similar approach by redesigning some of its stud-mounted rocker arms for the LS1 Chevy. The rocker arms require milling the stud pads on the cylinder heads .170? to accommodate the lowered rockers, but the net result is better geometry, less side wear on the valves and faster initial opening, producing more horsepower.

You may not realize that the actual ratio at which a rocker arm opens a valve is not constant, but varies as the valve opens and closes depending on the arc the arm travels and the position of the rocker pivot point with respect to the top of the valve and the pushrod. Those stock LS1 rockers are mounted rather high and initially open the valve at a rate equivalent to about 1.54 to 1 before eventually reaching 1.7:1. The quick lifting aftermarket rocker arms, by comparison, lift the valve off the seat at a ratio that is closer to 1.8 to 1 and then goes to 1.7 to 1 at .200? valve lift. This has the same effect as increasing valve duration about six degrees, and produces 15 to 18 more horsepower.

Serving your customer correctly means selecting the right product for the entire application. Don't assume, say experts, that aluminum rocker arms are the ideal solution for every application because in many cases, steel will be a great option. Just as was stated earlier with regard to shaft-mounted designs, old-school can still be an efficient solution.

Whether your customers' needs are lightweight or heavy-duty is dependent on the total engine package. A lot of guys who run blowers and turbos stick with higher spring pressures, so they're more likely to go with heavier components including rocker arms. On the flip side, guys running naturally aspirated engines tend to stick with lightweight because they like to get as many extra rpms as possible to compete with the turbos!

For demanding high heat applications, lightweight steel rockers for exhaust valves are available for endurance applications where fatigue life is essential. While the rockers are a little heavier than aluminum rockers, their manufacturer explains that the rotational force numbers are about the same. The rockers are available in a range of lift ratios, and can be used with standard pushrods.

Whether you're using stamped steel or extruded aluminum rocker arms, the practice of reusing them when rebuilding an engine should be ended. Just as the smart thing to do is to put in new lifters with a new camshaft, you should put in new rocker arms when you change the pushrods. However, the wear patterns from the push rods and the valve stems are going to change.

Even though new coatings and hardening operations are regularly being introduced, when two metals rub against each other thousands of times a minute, the friction will eventually wear through any case hardening in place. Over time, it will eventually get down into the softer metal, and you could have problems. To reuse an old rocker is just flirting with danger.

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