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Crankshafts and Bearings for Street Performance and Racing

The crankshaft and bearings are the foundation of any engine. The type of bearing and crankshaft materials that are used, their strength properties, fatigue resistance and ability to handle high torque loads ultimately determine how durable the engine is and whether it goes the distance or self-destructs.

By Larry Carley



Most engine builders have strong opinions and brand preferences when it comes to choosing a crankshaft and bearing combination for a performance engine application. Their preferences (and prejudices) are usually based on years of experience, both good and bad. Many subscribe to the philosophy that “if it isn’t broke, don’t fix it!” Consequently, if they have had good results with a certain brand of crankshaft and a certain brand or type of bearings, they’ll usually stick with the same setup that works. In fact, they may be reluctant to make any changes unless they are having a problem.

But to be competitive, you have to experiment, take chances and push the envelope. Tried and true will usually do, but there may be a different setup you haven’t tried yet that will work even better.

Old School Engine Building

The “old school” method of building a performance engine has traditionally been to build the engine “loose” with extra bearing clearance to accommodate flex in the crankshaft and main bores. To maintain oil film strength with the wider bearing clearances, a heavy viscosity oil such as a straight 30 or 40 weight oil, or a multi-viscosity racing oil such as 20W-50 is necessary, along with a high volume oil pump. Pushing plenty of oil through the bearings keeps an oil wedge between the crank journal and bearing surface to prevent scuffing, and the extra oil flow also helps cool the bearings. It’s a tried and true combination that has worked for decades, and is still used by many performance engine builders.

But nowadays, some engine builders are using a different approach. Instead of building an engine loose, many NASCAR engine builders have tightened up bearing clearances to as little as .001”. They are also using ultra thin viscosity 0W-20 or 5W-20 synthetic oil to reduce internal engine friction and drag.

The combination of tighter bearing clearances and thinner oil also means they don’t need as much oil pressure or volume to maintain the oil film between the crank journals and bearings. Consequently, they can run less oil pressure and reduce the amount of horsepower needed

to drive the oil pump. It works for NASCAR, but does the same setup work on the drag strip, dirt track or street?

Most of the crankshaft and bearing suppliers we interviewed for this article said the tight bearing, thin oil, reduced oil pressure setup that many NASCAR engines use would probably not be the best combination for other forms of racing.

Street engines can benefit from tighter tolerances and thinner oils for everyday driving. But when power adders such as nitrous oxide, turbocharging or supercharging are used, or the engine's power output gets up in the 450 to 500 plus horsepower range, looser bearing clearances are probably safer to accommodate crankshaft flexing and main bore distortion. The same logic applies to drag motors, truck pull engines and other performance engines that produce serious horsepower. Many of these engines are built with bearing clearances in the .0025" to .003" range.

For the Saturday night dirt track racer, clearance is your friend because of the contaminants that often get into the crankcase. For this type of racing, many engine builders allow .001" of bearing clearance for every inch of crankshaft journal diameter.

Bearing Down

Though bearing materials and designs have changed a great deal in recent years, many performance engine builders continue to use tri-metal bearings. They say they like tri-metal bearings because the bearings can handle high loads and are "more forgiving."

A tri-metal bearing typically has a high strength steel shell with an intermediate layer of copper/lead alloy about 0.3 mm thick, and a thin (.013 mm) overlay of babbitt. The copper/lead alloy intermediate layer in the bearing provides fatigue strength and support, while the top layer of babbitt provides seizure protection and embeddability.

For racing applications that really take a pounding, such as top fuel drag racing, alcohol funny cars and dragsters, and nitro-fueled marine engines, tri-metal bearings with specially engineered top coatings are available to minimize journal scuffing. Some of these engines generate 6,000 to 10,000 PSI of cylinder pressure, which pushes the oil film out between the bearings and crank journals.

The result can be a lot of metal-to-metal contact and wiping on the crank journals. By using bearings with a scuff-resistant top coating in these applications, the bearings can absorb more more punishment without damaging the crank.

One bearing manufacturer says their particular top coating allows bearings that used to last only one or two runs in a top fuel dragster to now last as many as seven or eight runs. The specially coated bearings cost more, but provide greater savings when you consider how much longer they last and how well they protect the crank.

Aluminum bearings, by comparison, are used in most OEM engines these days because of their longevity. Aluminum bearings can go up to 250,000 miles or more in many vehicles, provided the engine is properly maintained with regular oil and filter changes. But some engine builders have the perception that aluminum bearings are "too hard" for serious racing or high horsepower applications.

Several manufacturers of aluminum bearings (including some who make both aluminum and tri-metal bearings) told us various engine builders and race teams are having great success

with aluminum bearings in their engines. Various aluminum alloys have been developed that can handle high horsepower loads without deforming.

One manufacturer of aluminum bearings said the top babbitt layer on a tri-metal bearing is only about 15 on the Vickers scale, making it relatively soft. That's good for embeddability, but not for withstanding high loads. The babbitt layer can deform, causing a loss of oil pressure and bearing noise. And if the thin overlay of babbitt is wiped away, contact with the hard copper/lead intermediate layer may damage the crank. They said their aluminum alloy has a hardness of about 40 on the Vickers scale, which allows it to resist deformation much better than babbitt while still being softer than the crankshaft (which reduces the risk of scuffing if metal-to-metal contact occurs).

The same manufacturer told us that some 1,400 horsepower Monster Truck engines are now fitted with their aluminum bearings.

On the street, aluminum is a good choice for engines that are driven daily and may not be torn down and freshened up for a long time. According to one bearing manufacturer, aluminum bearings can also help polish the journals on cast iron cranks that may have some surface roughness. If the crank has small nodules of iron that protrude slightly above the surface, they will be smoothed down by the relatively hard silicon crystals in the aluminum matrix.

Another thing to consider when choosing bearings is whether or not to use bearings that have an additional scuff-resistant coating. Many bearing suppliers now offer coated bearings as an extra cost option. The coating provides an extra layer of protection against scuffing in the event of a dry start or loss of oil pressure, but it does not reduce friction. Crankshaft friction depends on the shear viscosity of the motor oil because the crank journals spin on a thin film of oil, not the surface of the bearings. The coating materials that are used are a proprietary secret, but typically contain moly, graphite and/or Teflon.

Getting Cranky

Then there's the question of what type of crankshaft to use in a street performance or racing engine. The cast iron crankshafts that come in most stock engines are engineered to handle stock torque outputs. There's a certain amount of extra capacity designed into every crankshaft, but there's also a limit as to how much additional torque a stock crank can reliably handle when the engine has been heavily modified.

We've all read articles in car buff magazines that describe how to build a 600 horsepower budget small block motor, or an 800 horsepower budget big block motor using the stock cast iron crankshaft. Yes, it can be done -- if you start with a good crank, magnaflux it to make sure there are no hairline cracks or flaws, then shotpeen it to harden the surface. But the question is, how long will that stock crank hold up?

The crankshaft in a big block motor has larger journals and a lot more metal than a small block motor. Consequently, it can safely handle higher torque loads when the engine has been modified. But any stock crank has its limits, especially when the modifications go far beyond simple bolt-ons such as a hotter cam, intake manifold, larger carburetor and exhaust headers. When you add aftermarket heads that can make serious horsepower, or use a power booster such as nitrous oxide, a turbocharger or supercharger, the crankshaft better be able to handle the higher torque loads -- or you are going to have one unhappy customer.

Most of the crankshaft suppliers we interviewed for this article said that when the power output of a small block motor exceeds 400 to 450 horsepower, it's time to upgrade to a forged steel crank. For a big block motor, that number is around 500 to 550 horsepower.

Forged crankshafts are usually made of 4340 steel. The ultimate strength of the crank depends on the quality of the steel. Not all cranks that are claimed to be 4340 actually meet ASTM specifications. Strength also depends on the size of the journals (larger is stronger), the radius of the journal fillets (larger is stronger), the location, number and size of the oil holes, the heat treatment and case hardening method used (such as nitriding), and cryogenic treatment (if used).

Because of these differences, you can't judge the quality of an aftermarket crankshaft by appearance alone. What may appear to be identical crankshafts from different suppliers may in fact have significant differences in strength and durability. In short, you usually get what you pay for. If there's a price difference of several hundred dollars or more between "similar" crankshafts, there is usually a reason why.

Even so, there is a lot of demand for budget priced cranks, especially stroker cranks for street performance engines. Many suppliers have a line of budget cranks for street performance applications and entry level racers who can't afford a high end crank. But for serious racing, you shouldn't use anything less than a top quality, purpose-built racing crank from a reputable supplier.

Other differences you need to consider when choosing a crankshaft include weight, the shape and mass of the counterweights, and special design features and/or coatings that may be available. A lighter crankshaft improves throttle response, but the rotating mass of the crank is more important than its total overall weight. Removing weight near the center of the crankshaft has much less effect on its rotating momentum than weight removed from the outer edges of the counterweights. Consequently, two different cranks with the same overall weight may have entirely different inertia. One revs quicker than the other because its mass is concentrated closer to its axis of rotation.

For some types of racing, the inertia of a spinning crankshaft (or lack thereof) can actually have a negative impact on acceleration, deceleration and handling. In drag racing, you want a lot of inertia to help launch the car off the line and maintain engine rpm with each gear shift. By comparison, in circle track racing you usually want minimal inertia because the driver is always on and off the throttle. But on a high speed NASCAR track, if the engine rpm drops too quickly when the driver lets up on the throttle, the sudden deceleration may unload the chassis too much, causing the rear wheels to break loose and skid. Losing control when entering a turn at 200 mph can ruin a driver's day, so for this reason some NASCAR teams run a heavier crank at super speedways.

The weight of the crank also has to be matched to the weight of the pistons and connecting rods. There's not much of an advantage to using a light crank if the engine has relatively heavy pistons and rods. One crank manufacturer said if the pistons and rods weigh 1750 grams or less, you're good to go with a light crank. Otherwise, there's not much to be gained.

The profile of the counterweights on the crankshaft can also affect windage and drag inside the crankcase. In a low rpm torque motor or street motor, the shape of the counterweights doesn't make much difference so the effect on windage and drag is negligible. But in a high revving engine, counterweights that have been profiled to reduce drag can have a measurable effect on power.

Some cranks are available with holes drilled through the rod journals. This helps lighten the rod throws to reduce inertia for faster acceleration. Holes drilled in the main journals reduce the overall weight of the crank, but have minimal effect on inertia. But holes drilled in the crankshaft main journals can help equalize pressure inside the crankcase for better piston ring sealing, reduced blowby and more power.

Billet cranks are another alternative to consider. A billet crank can be CNC machined from a solid chunk of steel to almost any stroke or dimensions. This allows a crank manufacturer to custom fabricate a crankshaft from scratch for an application where no forging is available, or to custom-make a crank to your exact specifications. Billet cranks don't have the grain structure and flow of a forging, but are nearly as strong (some say stronger). The only drawback is that billet cranks are expensive: typically \$1,800 to \$3,000 or more.

Some forged and billet racing cranks have a larger than stock journal fillet radius to improve strength, and require a narrower racing bearing. As for bearing compatibility, tri-metal or aluminum bearings can be used with any type of crank, be it cast iron, forged or billet.

Various types of coatings may also be applied to a crankshaft. The most commonly used coatings are ones that shed oil to reduce drag at high rpm. Such coatings can provide benefits in high revving engines but don't do much in low rpm torque motors.

Crankshafts can also be cryogenically treated to improve strength and fatigue resistance. The cryogenic process involves chilling the crank down to minus 300 degrees below zero for a certain period of time (typically 24 to 36 hours or longer), then allowing it to slowly warm back up to room temperature. The freezing process relieves residual stresses in the metal and alters its microstructure, making the crank more resistant to breaking. A cryo treatment typically costs a couple hundred dollars, but provides added insurance against a crank failure.