CRANKSHAFTS & ENGINE BEARINGS Guide

When selecting engine bearings, engine builders often focus on achieving the proper clearances and maintaining sufficient oil pressure, but other bearing characteristics should also be considered.

Durability is less of a concern today because the aftermarket and OEMs demand bearings that can last 150,000 miles even under severe stress from a neglectful vehicle owner. In performance applications there are a number of materials that will do the job well. Each material has its advantages in terms of resistance to corrosion, rate of wear, embedability and fatigue strength.

The material makeup of a bearing should feature good sliding properties with very high fatigue strength. Experts say you need hard, strong materials for fatigue strength as well as soft material for sliding properties, embedability and conformability characteristics.

Trimetal copper-lead bearings are available for a wide range of applications, including performance, but bimetal aluminum is used almost exclusively in today's light-duty passenger car engines. Although each manufacturer has its own proprietary mix of material, bimetal aluminum bearings have proven to last virtually forever in light-duty, low to medium load engines.

In a stock production engine, if everything is straight and round, aluminum (bimetal) bearings will last many thousands of miles with little signs of wear, acknowledge most bearing experts.

A more recent trend has seen a move to a lead-free bimetal bearing for environmental reasons. One major manufacturer has been pushing toward its goal of producing lead-free bearing materials for the last several years and says it's been an evolutionary product. Today, the material this bearing manufacturer uses is totally lead-free. The company says it's a very strong bearing, almost equal to its basic trimetal bearing.

Generally, bearing manufacturers say the strategy has been to get away from the lead because of the various environmental issues and to stay competitive with global markets. And some believe it's just a matter of time before these initiatives come to the U.S.

The amount of grinding that can be done on the crankshaft journals is limited by the depth of the case hardening as well as the availability of undersize bearings for the application (Photo by Doug Kaufman).

The real demand for lead-free components has been from Europe, say experts, where the use of lead in new engine designs has been restricted since the beginning of the year. Therefore suppliers and OEMs in the U.S., with hopes and plans to export products to Europe, are designing new engines and transmissions to meet the new directive, which has to do with the recyclability of engines and engine parts after they have been scrapped.

Currently, there isn't any legislation on the horizon in the U.S. to restrict the use of lead, however, experts say Europe is setting the tone and most of Asia is following suit; all of Asia's new engine bearing designs are also lead-free.

While OEs may be moving away from trimetal copper-lead bearings for stock applications they are still available for many engine applications in the aftermarket and remain a viable choice for engine builders, particularly in engines that may have been poorly maintained. A trimetal bearing is stronger than a bimetal aluminum bearing by around 30 percent, according to one expert, and it's more forgiving of crankshafts that aren't perfectly round, smooth and straight. On the other hand, bimetal aluminum bearings work very well in the right environment, if everything is perfectly smooth and true.

Most major engine bearing manufacturers offer a line of performance bearings to meet specific engine load and component requirements. The majority of performance bearings are trimetal, which are modified for higher load applications.

One bearing manufacturer currently offers a performance silicon aluminum bearing for a few high horsepower applications. According to this manufacturer, it's machined a little differently and some dimensions are changed to

"Plastigage" can be placed between the bearing and journal when the bearing is assembled. The main cap or rod cap is then installed and the fasteners are torqued to specifications to crush the plastic between the bearing and journal. The joint is disassembled and the crushed width of the plastic strip is compared to a chart to determine bearing clearance. (Photo by Steve Temple).

increase crush. In addition, the oil holes are opened up a little to improve oiling and eccentricity is a little different. These bearings are also chamfered for radius on the crank so there is some narrowing of the bearings. The bearing is designed to handle most performance applications except in applications where there are extreme loads.

Bearing experts say you may start to have trouble with aluminum in higher horsepower engines such as the marine market because they are typically a severe duty application where the engine is run wide open for long periods of time at high rpm and high loads. One bearing company says it is planning to launch a new performance aluminum bearing that will enable it to handle any type of race engine load. The company says it is in the process of developing a high-end trimetal aluminum bearing.

One of the advantages an aluminum bimetal bearing offers to performance engines is that, even when the bearing starts to fail the crank isn't typically damaged. There are usually warning signs with aluminum bearings because you can see it in the oil. Normally when a trimetal bearing fails the crank is also ruined, bearing experts point out.

Sizing Bearings

A standard Chevy rod bearing and a race bearing should have the same clearance, but experts say you should find more uniformity in the race bearings because manufacturers try to keep the tolerance a little tighter. Rod bearings often called "Xs," allow an extra .001˝ clearance and are intended for select fitting purposes. Experts say it's permissible to combine Xs and standard bearing sizes to mix and match bearings within .001˝ of each other. These can be costly, however, because you have to buy extra sets to come up with the combination you need.

Several bearing manufacturers offer various bearing sizes of .001˝ under or over, and a .009˝ under or .011˝ over, for select fitting in performance applications. Although relatively few engine builders will need them, and some bearings even go up to .050˝ or .060˝ for a few applications. However, for stock replacement applications, it's pretty much the usual .010s, .020s, and .030s, according to experts.

There is a range of select sizes for performance applications, which are available from some manufacturers in mostly around .019s and .021s, but not as many around the .030s. Some manufacturers offer actual .030s but no .029s or .031s. There is also a standard .001˝ and a standard X, which is one below standard. And there are both sides of the .010s, and .009˝ and .011˝ available from some bearing suppliers. The standard X is for the standard crank that needs more clearance.

One supplier says its "crank saver" bearing is becoming more popular as it can help prolong crank life. An example of when to employ this bearing is the first time a crank is serviced, and since many people have a high-dollar racing crank, a .009˝ or .011˝ is used to adjust to a range of journal sizes. This is one way to get more life out of an expensive racing crank, as some engine builders say they aren't comfortable going to .020˝ on a racing engine.

Other Bearing Features

NASCAR is generally split 50/50 with teams that use coated bearings and teams that don't. It's still a big issue for some performance engine builders, and two major bearing manufacturers offer their own line of coated performance bearings, but experts say they're sold generally to enthusiasts and DIYers. Coating companies buy their bearings from major manufacturers and then add their own unique coating. Does it help or hurt? It just depends on what you're used to and comfortable with, says one expert.

Some bearings feature a groove into the lower bearing called a 3/4 groove, which keeps oil pumping up to the rod bearing for a longer period of time. It helps keep the rod bearing lubricated. It's the best of both worlds, say experts: good oil flow to the rod bearing and in the highest loaded area you have more surface to handle it.

Most experts say engine builders are beginning to look at bearings differently because the modern race engine makes more power than in the past. One supplier says he knows of racers who are making upwards of 2,000 hp using his bearings. This can be an issue because a lot of racing and performance applications are supercharged or turbocharged run and some run on nitro. Forced induction really puts a strain on engine components, so bearings and everything else in the engine are becoming more critical to understand because it can be pretty expensive otherwise.

One experienced race engine builder says that regardless of the type of bearing used, he also takes the time to deburr the corner of the thrust bearing in the center of the block to remove any of what he calls "dingleberries" or "stalactites." Which is job security for him and good news for his customers.

Crankshafts

In stock engine applications, a reconditioned stock crankshaft should be more than adequate. Most passenger car and light truck cranks are cast iron and have enough strength to handle the loads produced by a stock or slightly modified engine. If the OEM crank happens to be a forged steel crank (which are used in some high output engines as well supercharged, turbocharged and light diesel engines), so much the better, because forged steel is much stronger and not as brittle as cast iron.

Stock crankshafts are engineered to handle typical loads generated by a stock engine, say 250 to 350 hp in a small block V8, or up to 400 hp in a big block V8 with a redline of 5,000 to 5,500 rpm. But there is a limit on how much additional torque and rpms a stock crank can safely withstand if the engine is modified. Most stock cranks have enough built-in margin of safety to handle your typical aftermarket "bolt-on" modifications such as a street hydraulic cam, a performance intake manifold, larger carburetor, exhaust headers and even aftermarket performance heads.

But when an engine is being built to produce serious power or will be used for racing, a stock crank may not be up to the task. When the loads experienced by a crankshaft start to double or triple over that of a stock crank, all bets are off as far as durability is concerned.

Racing and performance engines are not immune to specialization. Where one style of essential components can be used in one type of engine, the same parts wouldn't even be considered in another.

So what makes a good racing crankshaft? In the case of high-end racing crankshafts the choice is typically between forged steel or billet steel. Because a racing crank must survive extreme torsional loads as well as bending and flexing that would bring lesser material to its knees, strength is paramount. A performance crank has to be tough to survive the rigors of racing.

One race engine builder says if you're building a cutting edge engine you want to use the lightest parts you can. If money is no object, you can use throw-away parts. If you want to save money, you go with larger, heavier parts that may have more longevity.

In recent years, the trend in racing has been to bigger and bigger displacements thanks to the increased availability and affordability of aftermarket blocks. As blocks have grown, increased internal clearances have also allowed for longer stroke crankshafts. Following this trend has been a move to lighter racing cranks, but crank experts say this may have bottomed out because most of the weight that can be safely taken out has already been removed and there's not much room left for further reductions.

Manufacturers say they offer a variety of cranks specifically designed for the various levels and needs of racers.

Crank Materials

If you're building a small block V8 that's capable of making more than 450 horsepower, a big block that's making upwards of 550 horsepower or you're pushing the engine's redline beyond 7,000 rpm, you should upgrade to a performance crank, which usually means a forged or billet 4340 steel crank. Forged cranks made of 4340 alloy typically have a tensile strength of 140,000 to 145,000 psi and are much more resistant to fatigue than 5140 or 1053. A forged 4340 billet crank will typically have a fatigue strength of 160,000 to 165,000 psi. The increased strength is due to the addition of nickel (1.65 to 2.0 percent) and molybdenum (0.2 to 0.3 percent).

The strength of the crank not only depends on the base alloy, but also on how it was made (whether it was drop-forged or machined from solid chunk of billet steel). A welded up stroker crank may be okay for a street engine

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but probably isn't strong enough for racing.

Forgings generally produce a flowed grain structure, which is stronger than a casting. Additionally, the forging process stretches, pulls and deforms the grain structure, and subsequent machining cuts through the grain structure. Forgings require a die to shape the metal. Dies and forging presses are expensive (which adds to the cost of the crankshaft), so the availability of forgings for various applications depends on their popularity and how much people are willing to pay for a forged crank.

Billet crankshafts, by comparison, are CNC machined from a solid chunk of forged steel. The grain structure is not stretched or deformed, and machining leaves fewer residual stresses in the metal. Consequently, some crank manufacturers say billet cranks are the strongest cranks available. Most Top Fuel drag racers run billet cranks, as do many circle track racers. Another advantage with billet cranks is that CNC machining allows a crank to be custom made with virtually any stroke, journal diameter, configuration or countershaft placement that will fit the engine.

Durability

Durability depends on the material the crank is made from, the method used to make the crank (forged or billet), the size of the rod journals, and the radius of the journal fillets. Bigger journals are stronger, but many racers want smaller journals to reduce friction. Consequently, the crank itself must be stronger.

Most racing cranks are heat treated and case hardened to provide additional strength and durability. The journal surfaces may be hard chromed, nitrided or induction hardened. Some crank manufacturers use a "plasma nitriding" process that vacuum-deposits ionized nitrogen on the surface of the crank inside a high temperature oven. Others use a process called Tufftriding that soaks the crank in a hot "ferric nitrocarburizing" salt bath, or heats the crank to 950° F in an oven filled with nitrogen. Nitrogen penetrates the surface of the metal and changes the microstructure of the steel.

Crankshaft Reconditioning

It's not always a simple decision whether or not to recondition a crankshaft. Crankshaft journals must be carefully inspected and measured for wear, out of round, taper and distortion. Based on these important factors, you must make the decision to polish, regrind and replace bearings with undersize or build-up the crank journals by welding and grinding back to standard size.

Some rebuilders say this may take too much time and be too expensive (especially with regard to labor) when there are relatively inexpensive replacement cranks readily available. This doesn't mean you will not have to repair any more crankshafts, however, it may be far easier for you to regrind and polish a crank than to go through all of the necessary steps of welding and grinding the journals and then straightening the crank afterwards.

It's an involved process that is as much art as it is science. Therefore experience and cost may be key contributing factors to why some engine builders prefer to send this type of work to specialists. However, a skilled hand at doing this type of work may land a custom engine rebuilder (CER) lots of work in his area.

Reconditioning large industrial and diesel crankshafts often makes sense because of the high cost of replacement. And many performance cranks are reconditioned; again, because of cost factors it is often times less expensive to repair an otherwise very expensive racing crank. An added benefit to repairing a

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crank is if you want to add more stroke to the crank you can fairly easily at that point. But on many passenger car and light trucks it's usually less expensive to replace the worn or damaged crank than it is to repair the original component.

No matter what you do, however, some cranks will not be worth reconditioning. It is important to thoroughly inspect every crank before reconditioning so you can assess it. It can be a very fine line between reconditioning a crank and purchasing a replacement. If it's too far out of spec it may take too much time and labor to repair versus buying a replacement crank.

Micropolishing

Crankshaft journal micorpolishing has evolved rapidly over the past 30 years and is now understood as a controlled metal removal, surface finishing process. Because engine bearing specifications have become tighter to improve engine efficiency, i.e., mileage, durability and performance, the dimensional tolerance, weight and mating surface of a component's surface also requires further enhancement.

To achieve these required higher quality surface finishes, micropolishing uses a non-compressible abrasive film with a closely graded abrasive crystal in place of the traditional paper or cloth backed abrasives. Using the materials and process consistency described, the micropolishing process has proven itself to be a significant improvement over chemical, electrostatic, slurry and belt polishing processes.

Connecting Rods

The connecting rods are a vital link between the pistons and crankshaft. They connect the reciprocal motion of the pistons to the rotational motion of the crank. The weight of the rods is important because it affects the reciprocating forces inside the engine. Basically, you want a set of rods that are as light as possible, but are also capable of handling all the forces the engine can generate (rpm and horsepower). If you are building an engine for a sprint car, for instance, that is constantly on and off the throttle, an ultra light crankshaft with the lightest possible rods and pistons will deliver the kind of performance that works best in this application.

Rods essentially come in two basic types: I-Beam and H-Beam. Some rod suppliers only make I-Beams, others only make H-Beams, and some offer both types. I-Beam rods are the most common and are used for most stock connecting rods as well as performance rods. I-Beam rods have a large flat area that is perpendicular (90 degrees) to the side beams. The side beams of the rod are parallel to the holes in the ends for the piston pin and crank journal, and provide a good combination of lightweight, tensile and compressive strength. I-Beam rods can handle high rpm tension forces well, but the rod may bend and fail if the compressive forces are too great. So to handle higher horsepower loads, the I-Beam can be made thicker, wider and/or machined in special ways to improve strength.

A growing number of rod suppliers are now offering lower cost performance rods as economical upgrades over stock rods for street engines and other entry level forms or racing. Consequently, these budget-priced rods allow engine builders to offer their customers more options and more affordable alternatives for upgrading an engine. For big buck racers or really demanding applications, though, these kind of rods probably aren't the right choice. Some rod suppliers now have to add a steel "surcharge" to their current prices to help offset their higher cost of materials (which doesn't matter where they buy their steel because the higher prices are world-wide and affect everybody).

The strength and fatigue resistance of most metals can

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also be improved by cryogenic processing after the rods have been heat treated. Heat treating causes changes in the grain structure of steel that increases strength and hardness, but it can also leave residual stresses that may lead to fatigue failure later on. The super cold temperatures also cause additional changes to occur in the metal that help the parts last longer and run cooler. That's why cryogenic freezing is used on everything from engine parts to tool steels, aerospace hardware and even gun barrels.

Most rod suppliers have their own cryogenic vendors who treat their rods for them. But you can also have ordinary untreated rods (even stock rods) frozen to achieve the same results.

Rod length depends on the stroke of the crankshaft and the deck height of the block. If you are switching to a crankshaft with a longer stroke, you are obviously going to need rods that have a shorter overall length. Even so, replacing the pistons with ones that have a higher wrist pin location can allow you to use longer rods.

Racing legend Smokey Yunick used to say that the longer the rods are, the better. The result is usually a broader, flatter torque curve than the same engine with shorter rods. An engine's horsepower and torque curves depend on a lot of variables other than rod length alone. But if everything else is equal, many engine builders say longer rods produce a broader torque curve. Rod suppliers say the only trend they see in rod lengths today is that there is no trend. Engine builders are buying just as many standard length rods as they are longer rods.

This brings us to rod ratio, which is the length of a connecting rod (center-to-center) divided by the stroke of the crankshaft. The range in engines today may be from 1.5 to 2.1, but most performance engine builders are going with ratios in the 1.57 to 1.67 range. Some say that going with a rod ratio over 1.7 makes engine torque too "peaky." Lower rod ratio numbers are typically associated with lower rpm torque motors (a 383 Chevy street motor with a stroker crank and a rod ratio of 1.52, for example), while higher rod ratio numbers tend to be high revving high horsepower motors (a 302 high revving Chevy with a rod ratio of 1.9).

Crank Balancing

Balancing is a must for any high revving performance engine, and with stroker engines it is a must to offset the increased reciprocating mass of longer rods. Stroker cranks often require the addition of heavy metal plugs to the counterweights. On a very light crankshaft, having to add several pounds of heavy metal to a counterweight may also offset much of the weight advantage of the lighter crank. So for many stroker applications, a lighter crank may be more difficult and expensive to balance.

One expert says that engine builders can lose a lot of time and money guessing what to charge for a balancing job. You need to be able to quote the customer a price for balancing beforehand. You do not want to charge too much and lose the sale, but you shouldn't cut your price too low and risk losing money if you encounter a problem.

Some companies have started publishing a "target bobweight" for their cranks. This allows you to estimate how much work you have to do to balance the crank. One manufacturer says its cranks are guaranteed to be within 2 percent of this target bobweight. However, engine builders should not confuse this with actual balancing. The crank still needs to be balanced. The target bobweight just gives you an idea of what you will need to charge before actually doing the job.

There are many things to consider when selecting engine bearings and a crankshaft; whether it's for a high performance application or a daily driver, the right choices will make a big difference in the durability and performance of your engine and ultimately in your customer's satisfaction. **MEPG**

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