Here’s a pressure-puzzle for you: Inside the combustion chamber during a WOT power stroke the burning gases can momentarily exceed 1500 psi. With a three-inch bore and so a seven-square-inch top surface, the piston transmits over five tons of force down the connecting rod. The bearing surface between the connecting rod and the crankshaft journal, however, is barely three square inches on many engines, and only about half really supports any load. This makes for a unit pressure between connecting rod and crankshaft throw as high as 5000 psi. Meanwhile the oil pump only puts out perhaps 50 psi. Why don’t we have metal-to-metal contact at every power stroke if there’s a hundredfold difference in the pressures? And if that bearing load is hard to understand, what about at the wrist pin bushings, lubricated on many engines by nothing more than splash?

Here’s a clue from another automotive phenomenon: aquaplaning. An incautious driver enters a stretch of pavement with water standing on the surface, and the car skates out of control on the puddle. The tires ride up a ramp of water just thick enough to break the rubber-to-pavement connection. The unit pressure between car and road is nearly identical to the pressure in the tires, say 30 psi. If we have a quarter inch of water standing on a road, that pressure is about 0.01 psi. The pressure differences here are about the same order of magnitude apart as in the engine bearings, and the mechanism is similar: a wedge of outflowing fluid separates two solid objects. Between the tire and the road, we want the water to squirt out quickly to maximize contact friction, that is, wheel traction. We avoid aquaplaning by driving slowly through standing water and by using tire tread patterns with escape channels for the water. Between the bearing and the journal, we want the oil to stay in, minimizing contact and friction (we don’t want the bearings to have any ‘traction’). We maximize ‘oleoplaning’ by keeping the
crankshaft speed up, by using as smooth and close a clearance as possible and by actively pumping oil into the unloaded side of the bearing gap. That’s why the oil pump has to turn faster and pump more at higher engine speeds.

**Volume and Pressure**

So what’s really important in the lubricating system is oil volume. The pressure merely insures enough oil gets to the back end of the circuit to fully lubricate whatever’s there (usually the cam bearing farthest from the oil pump). In fact, some newer engines use oil pumps that do not put out full pressure at warm idle. Oil from the gallery sticks to the crankshaft journals, which pump it through the bearings; and the journal speed determines the volume needed. Since there is little requirement for volume at idle (and much less downward force on the pistons), manufacturers can reduce the load and slightly improve emissions quality under those circumstances, inasmuch as it always takes some energy to turn the oil pump and it always takes some fuel to produce some energy. Some even go so far as to cease lubrication pressure in the transmission to zero at idle in Park; nothing is turning, after all, and there will be pressure before there’s vehicle movement. But you can’t do that in an engine; things have to keep moving.

**The Cylindrical Wedge Pump**

You see, the crankshaft journal is the real high-pressure oil pump. Because of the force of the compression and power strokes, the journal does not remain exactly in the center of the bearing cylinder, but shifts downward with the force of the combustion’s fire. As the journal turns, it pulls oil at its surface along, while the bearing shell holds oil at its surface. This film of sheared oil forms a ramp, just like the water under the aquaplaning tire; but the oil ramp is curved into a cylinder, following the small gap between the journal and the shell. As the journal turns and the space narrows, more than enough pressure builds to offset the compression and power stroke forces, squeezing oil out each side. The opposing force is the viscosity of the oil, which only has to hold fluid in place for the fraction of a millisecond it takes the journal to turn through its heavily loaded section of arc. Were it not for the movement of the crankshaft and the oil it pumps into the critical area of the bearing, the combustion pressure would overwhelm the oil pump pressure in an eyeblink.

What does this mean in practical terms in the shop? Let’s consider the two most common ‘quick-fixes’ for low oil pressure: using a heavier-weight oil and replacing the oil pump with a high-volume unit. Heavier oil won’t raise the pressure, of course—that’s determined by the pressure-relief valve and the volume of the pump. But it will increase the viscosity of the oil and thus its resistance to being squeezed sideways out the bearings. Whether this is a net benefit or not, however, is open to question since a heavier oil takes longer to build pressure throughout the system and never reaches full pressure at the far end. That higher viscosity resists pumping through the gallery just the same way it resists pumping through the bearing. It is possible the increased wear during startup cranking will offset whatever gain is had from the reduced bearing wear, and there will be lower delivered volume at that back cam journal. Heavier oil will also mean more fuel consumption, obviously, since that increased viscosity remains as a load as long as the oil is in the engine. It’s true thicker oil is the least expensive measure, but also the one least likely to have long-term benefits. You should be aware that some engines seem to develop valve deposits rapidly with a heavier oil than recommended.

While it is true that if anything gets oil, the oil pump does, it’s also true that if anything gets grit, the oil pump does. At low engine speeds, even small amounts of wear can reduce lubrication volume measurably. At cruise speeds and loads, even marginal oil pumps can usually deliver enough. What can we say about high volume oil pumps? Will they pump greater volume? Of course. They have wider teeth or lobes in the pump and move more oil with every turn. Obviously this will have the most effect at the lowest engine speeds, because at higher speeds, once the pressure reaches the point when the pressure relief valve opens, the greater volume is just dumped back in the oil pan (or recirculated into the pickup tube). A good bit of the perceived improvement from a higher-volume oil pump may come simply from the new pump’s having much closer tolerances than the original, as well as from the fact that the same gap tolerances on a larger pump represent a smaller percentage of pressure loss.

If there’s just enough bearing wear to let the idiot light flicker at warm idle, a higher-volume oil pump can deliver enough to douse the light. Race engine builders customarily install high-volume pumps even in ‘tight,’ new engines, but their purposes are somewhat different from yours in working on a customer’s car. The experience of most shops is that a higher-volume pump will turn off a blinking idiot light for six months to a year, after which the only fix is bearing inserts or an overhaul, depending on how much wear there is. My own preference is to install a new set of standard size bearing shells if the journals mike within specification, except for those few engines on which you don’t have to remove the oil pan to get to the oil pump. Inserts alone are, of course, also a temporary repair. But then, so is everything.
More’s Better?
Well, if increasing the volume could do some good sometimes, how about increasing the pressure? It’s not hard to do - just open the pressure relief valve and shim things up to make it harder to open. You don’t even have to buy parts other than oil and gaskets. That will increase the pressure, but it won’t do any good and can do considerable harm. Manufacturers specify the pressure to guarantee the volume at the far end. If you have that pressure and increased volume, consider what additional pressure will do: it will increase the pressure inside the oil filter and at the filter gasket, raising the odds of a leak; it will squeeze more oil than needed through the bearings at normal running speed; it can transport more oil into areas such as the timing chain tensioner or the cylinder head than can drain back by gravity fast enough. You could thus get lower oil pressure from aeration! It can even lock the valves open with over-pressurized lifters, causing a no-start you won’t figure out until the filter balloons and pops off the block.

The fundamental job the oil does in an engine, of course, is to keep things from touching. In principle, and usually in fact, there is no electrical connection between a crankshaft and the engine block when the engine is running and the crankshaft is floating on a ganged cushion of oil inside the bearings. Nor between the pistons and connecting rods or the valves and the lifters. This minute distance offset (much less, actually, than the bearing clearance) is not the oil’s only function. By convection it also carries off heat produced either through friction or combustion in different locations; it physically flushes out small particles broken loose in the bearing gap; and it serves as a damper to prevent microvibrations within the bearing. These are not vibrations of the entire, say, crankshaft or camshaft but of the single connecting rod throw, making for a very high frequency overtone of the basic frequency. Finally, modern oils all contain special detergents and other additives to remove accumulated dirt and varnishes, to preserve seals and gaskets and so forth.

We always suppose the internal parts of engines are pretty much the way they are in our hands on the workbench, even when they’re under load in an operating engine. And of course on the macroscopic scale, they are. But that heavy and inflexible crankshaft, twisted against a load by several tons pressure, bends and flexes—hopefully always within the tolerances of the bearings.

Pressurized Protection?
It’s always liberating to shed false beliefs, so let’s look at what oil pressure does in the engine. The one thing it doesn’t do is to support the loads imposed by the pistons during the compression and power strokes.
While the crankshaft journal and the connecting rod and main bearing holes are (or should be) perfectly circular, when running they are not perfectly concentric. Not only do the compression and power strokes push the crankshaft down, the partial vacuum of the intake stroke pulls it up. And, of course, the crankshaft undergoes similar forces at the other cylinders, though not in phase with the first. This movement within the bearing circle means there is a different clearance at different points on the circle, and the lubricating ports for the bearings are oriented to fill the space where it is widest. As the journal turns, it pulls the oil with it, squeezing some out the sides of the bearing shell, but carrying enough to keep it from touching at even the closest point of conjunction. In the absence of this protective layer of oil, obviously, we would have metal-to-metal contact and rapid wear. This damage can result from either insufficient oil volume, oil that is too thin to remain in the bearing for the rotation, or from grit carried with the oil but not filtered out in the oil filter (which can occur either from a poor-quality oil filter or from a good one that is plugged with dirt and opens its bypass valve).

What actually pumps the oil through the bearing, then, is the crankshaft journal, the very thing the oil lubricates! What keeps the oil in place under the high pressure of the power stroke is the film strength and...
viscosity of the fluid for the short period of time the pressure applies. Of course, this depends entirely on the rotation of the crankshaft in the bearing; in the absence of that movement, the pressure penetrates the oil film almost instantly. This is exactly why there is so much engine wear during startup cranking—especially during startup crank after an oil change, with all the residue drained out and made all the worse if the pump needs to fill the oil filter first.

This pumping action of the bearings explains one other puzzling fact. In a machine shop, you may have seen oil pumped through a crankshaft on an engine with the oil pan removed. The lubricant drips at about the same rate from each bearing, varying only with the pressure applied. Why should we use an oil pump that turns at a fixed speed to the crankshaft? It looks offhand as if the amount of oil that will go through the system will be fairly constant, varying only somewhat as the oil gets warmer and thinner. But the pumping action of the journals themselves indicates why the increase in volume is necessary with an increase in engine speed: they pump more as they turn faster. What’s needed is not more pressure from the oil pump, but more volume. And that’s just what higher pump speed delivers.

Why not increase the pressure anyway? If some’s good, isn’t more better? Nope. The purpose of the pressure is to insure sufficient volume is delivered throughout the entire lubricating system. A long oil ‘pipeline’ with volume losses all along its length would lose pressure at the extreme ends simply because of the oil ‘leaked’ through each bearing along the way. If the pressure is high enough and the oil channels are wide enough, the oil will fill each of the bearing gaps completely, insuring against metal-to-metal contact.

—By Joe Woods