Transcript of Question 4

Presented by
Engine Builder magazine

www.enginebuildermag.com

Engine Builder Engine Bearing Summit Participants

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Raymond King
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Michael James
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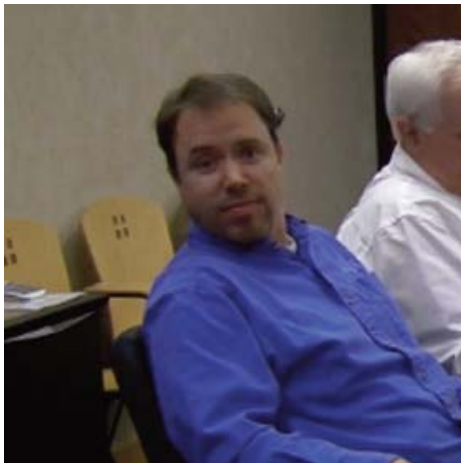

Brendan Baker, Senior Editor
Engine Builder magazine

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Engine Builder magazine

To answer questions and allow an open discussion about engine bearings without falling into a "pizza wars" debate we convened the inaugural *Engine Builder* Engine Bearing Summit on March 31 at the Babcox Media corporate headquarters. We invited participants from the leading bearing manufacturers to participate in a roundtable discussion on pre-determined topics.

To say the day exceeded expectations would be an understatement. Participants were prepared, cooperative and frank about engine bearing technology and applications.

The following industry experts participated in the Summit. From Federal-Mogul Corporation: **Bob Sturk**, Chief Applications Engineer, Bearings: North America; and **Raymond King**, Director of Global Engine Parts. From King Engine Bearings: **Dr. Dmitri Kopeliovich**, R&D Manager at King's manufacturing facility in Israel; and **Michael James**, with King's export and high performance programs. From MAHLE Clevite Inc.: **John Havel**, former Director of Aftermarket Engineering (Retired); and **Bill McKnight**, Team Leader – Training.

Brendan Baker, senior editor and **Larry Carley**, technical editor of Engine Builder joined editor **Doug Kaufman** in moderating the discussion.

Question 4: What effect have low viscosity, low-ZDDP motor oils, and the changes in emissions had on bearing construction and selection?

MCKNIGHT (MAHLE Clevite): Well, it's my turn now. The ZDDP thing has nothing to do with bearings, you know. That has to do with lifters and stuff where there is a shearing action going on. So we can just take that out of the equation totally for bearings. Once you have done that, we can talk about the next part of that question and that was today's low viscosity oils. And frankly, low viscosity oils work real well with low bearing clearances and have. And, as a matter of fact, most of your NASCAR engines now run zero viscosity or zero to five weight, you know, so it works well.

And speaking of bearing clearances, and I suspect that this is probably true for all of us, the rule of thumb normally is seven-tenths to a thousandths bearing clearance for every inch of shaft diameter. So if you have a two-inch shaft, somewhere between a thousandths and a half and two-thousandths bearing clearance, vertical bearing clearance, is a good starting point. And we get asked this question a lot. And we get asked it a lot by performance customers, you know, what should I have in my performance engine? And generally what we'll tell them is to add an extra half thousandths to that minimum and start there. And then it becomes strictly a matter of kind of fine tailoring and working from that direction down. And what it boils down to is a number of things. One: in general, lower clearances are better. The tighter the bearing clearance, the more area you are spreading the load on between the crankshaft and the bearing. So tighter is better.

And what ultimately becomes a factor is, how good is the geometry of that rod bore? And we have been talking, Raymond, about that already. As the rod bore moves and constricts and expands, that becomes an issue on whether or not you can run a certain amount of minimum clearance.

The other thing is the geometry of the rod bores, and we have also mentioned that. The OE's stuff is pretty good. Some of our customers' isn't quite as good so if you've got two or three ten-thousandths of taper across the bearing bore, then you've got an issue

with what your minimum clearance is going to be and whether you are going to get edge loading on one side of the bearing or not. So that becomes a factor.

The next thing would be temperature. If it's tight and you warm your oil up and you are running a very, limited range of temperatures, you can get by with a real tight clearance. But if you go out in 10 or 15 below zero, or if you are in racing and you don't heat the oil pan up, you can have a problem. I was down in Charlotte at the drag races recently, and it was colder than blazes Friday. And we are running top fuel motors and other drag stuff. And everybody was busy with heat packs, getting the engine warm and keeping the oil warm. So those are all issues when it comes to what minimum clearance you can run.

We work quite a bit with NASCAR, and I don't know if you are familiar or not, but right now they are running a 1.850″ shaft in NASCAR. And that's the minimum shaft size for the rod bearing, 1.850″ and 1.999″ for the mains. So you can't go any smaller than that. Now you can go as narrow as you want. They haven't restricted how narrow you can go. But those are the diameters.

Most of the teams are running rod bearing clearances of about a thousandth on that 1.850″ shaft, so that would be below our basic starting point. But again, outstanding geometry. The best oil money can buy, very limited conditions. We don't have any cold starts. We're not going out there and firing a motor or anything. So they can get away with that sort of clearance. We wouldn't recommend that for most of our customers.

Oil quality is a big issue too. And I get involved because I answer a couple thousand online tech questions a year that come in for us. And, you know, it's amazing that customers of all of ours will spend a lot of money on an engine and a lot of time thinking about the bearings they are going to use and the crankshaft they buy, and then they buy cheap oil. They decide, "Well, I'm going to scrimp on the quality of the oil I put in the engine," which is a really bad place to scrimp. Engines that are high performing, high-output, demand and deserve high-quality lubricants. And I think that's important to stress to our customers in general is you've got to have good quality lubricants.

KING (Federal-Mogul Corp.): If I could kind of add to that a little bit, Bill, I think you bring up a really good point. One, the ability to throw any type of additive into an engine has gone away because of the environmental concerns and a lot of the things we all have within our social conscience to pay attention to. So you are going to see different things in the future – it almost takes away some of the crutches or different things that we're used to helping with those compromised situations we talk about. And then the concept of going to low viscosity oil, that's going to become more and more important. In fact, I think it's pretty interesting to see, I know when you look at a performance world, you start seeing some things that are happening with the newer engines now. I just think that it's very interesting that they are looking more and more like the engines that were being prepared for performance than the engines that are being prepared for the normal consumer right now.

MCKNIGHT: That's a wonderful point. In fact, I drove over here on zero-weight oil in my van. That was NASCAR oil.

KING: Exactly. And it's all a reflection, I think, that where we are going is as a society is we are continuing to find ways to be able to get ourselves around with less impact to the environment, less dependence on fossil fuels and all of those things we hear about. So as we kind of talk about what the impact is, I mean, that is the future where we are all going to be in to supply. And so, I think every year we are going to see, in a broader application of the vehicles and engines that we service closer and closer tolerances and all of these things because that clearance on the engine bearing ties into the viscosity of the oil and the diameter of the shafts and all of these things.

So I guess the main thing that I'm seeing, it all goes hand in hand. So it puts another onus on us as suppliers of quality parts and industry to make sure that we are able to adapt the theoretical design and make it have a practical application so that it provides that kind of – it meets our customers' expectations. That customer may be the OEM engine builder or it might be the local custom engine shop just building one engine a month. Everybody's looking to attain the right result. And the right result is some combination of vehicle performance, dependability and longevity and then kind of responding whether – can it pass the local emissions law and the smog test or does it meet the satisfaction or the vision of the car owner who also has a newfound interest in, say, am I driving the right car? Is it right for me to get a remanufactured engine? Is it going to be worse for the environment or better?

You know, I think our end result is we want everything we touch to be better if we can. So that adds to some of this excitement, I think, that's going on. This is a really good time to kind of have this discussion because this is a change in environment and it's opportunities for people to take the right approach and the right effort. I enjoy this a lot better than talking about, you know, the issues of the marketplace that get a little more in turmoil from, you know, just throw something in and fix it. You can't really do that in some of the areas we are talking about today. I don't know, Bob may have a little different view of some of the direction we are going.

STURK (Federal-Mogul Corp.): One of the comments I made earlier concerned the sort of bearing distress we think is going to be more common in the future rather than debris issues that we have seen in the past. My concern is always with seizure. And this is one of the reasons low viscosity, high shearing oils, this all results in very, very low operating oil film thicknesses and it puts a tremendous amount of priority on the material to last and to live under those very low oil film conditions. So material development, coatings, all those things that can help us with low oil film thickness operation are what will be important in the future.

HAVEL (MAHLE Clevite): The engines typically operate at higher temperatures too.

STURK: Exactly, exactly. One of the things about zero weight though is mostly they are cold synthetics, which are good oils, so that helps us there. But in terms of cold synthetic strategy, I think, for the aftermarket, Bill, you used the same yardstick I do, about seven-tenths per inch. I don't think that changes much. We see it a little bit tighter or a desire to be tighter on the original equipment side for noise concerns. And that again gives us issues with geometries. Everything has got to be right. We do our part, as Raymond said, to make sure that our bearings are geometrically proper, that we don't have any lumps

and bumps. And I like to use the analogy that because of these low oil film thicknesses we have to fight for every micron deviation –every micron, that's 40 millionths of an inch. Our oil film thicknesses are less than that. You are lucky today to get a half a micron oil film thickness. Deviations have to be eliminated to make sure that your assemblies are as geometrically perfect as you can make them.

KOPELIOVICH (King Engine Bearings): The low viscosity oils produce less friction and therefore they decrease the fuel consumption and decrease the combustion gas emissions. But one of the consequences of low oil viscosity is a decrease of minimum oil film thickness. The shaft surfaces get closer to the bearing surface. This increases the failure threat level of such factors as surface roughness, shaft-grinding irregularities, oil borne foreign particle, geometrical distortions, misalignments, et cetera. Direct intermittent metal-to-metal contact between the surfaces occurs more frequently and the wear rate is increased due to the direct metal-to-metal contact. In this case seizure resistance of the bearing material becomes more important.

I do not totally agree that ZDDP has nothing to do with bearings. ZDDP is an extreme pressure additive in motor oil to decrease seizure. I agree that it is more important for the crankshaft and lube than in bearings. But mainly the bearing has a direct metal-to-metal contact. ZDDP also important.

So I would say that the effect of low-ZDDP motor oils is somewhat similar to the effect of low viscosity oils. Low ZDDP is the environmental issue to provide longer life of catalytic converters. Therefore, they are trying to reduce its content in oils. Now, so the seizure resistance is more important. The lead based overlay of the conventional tri-metal bearings has very good seizure resistance. And if the misalignments – shaft grinding defects, etc. – are very small, a tri-metal bearing could work perfectly with low viscosity and low-ZDDP lubricant. However, if the dimensions of the geometrical defect is close to the overlay thickness, which is about five to eight ten-thousandths of inch, the overlay is worn fast in some bearing areas and the intermediate layer is exposed.

The intermediate layer has some level of emergency seizure resistance, but this level is very low. Aluminum/silicon bearings are much more tolerant, as we saw in the graph, to the geometrical defects due to the large thickness of the bearing alloy, which is one one-hundredths of inch. And if there are some problems with distortions and misalignments, aluminum/silicon bearings will work better than tri-metal bearings.

Another problem with low viscosity oils is a shade of distribution of oil pressure over the bearing surface. Oil viscosity doesn't exert influence on the average pressure, but it does affect the values of the pressure peak. The pressure distribution in low viscosity oil is less uniform. The peak pressure is higher, therefore the load applied to the bearing material in this particular area is higher. This may cause fatigue if the fatigue strength of the material is insufficient. The effect of low viscosity oil on the pressure distribution may be compensated by a decrease of the bearing clearance.

KAUFMAN (*Engine Builder* magazine): Have the requirements with the low viscosity oil required bearing manufacturers to increase your accuracy? You know, over the years everyone else has become a little better at making parts, but how have bearings changed?

STURK: Yes, it has. It has. And not just for us, for everybody. Like I say, every micron deviation – that means the bearings, the crank, the housing, everything.

HAVEL: Well, better parts have allowed better clearances. Better clearances require better parts. Which came first, the chicken or the egg? The industry is striving for better, more accurate parts, better quality parts, better quality engines, longer life.

STURK: And all of this with low oil in the face of higher speeds and increased cylinder pressures.

HAVEL: We're all basically trying to do the same thing, I think. We're just trying to make a better overall end product, i.e. the engine.

CARLEY (*Engine Builder* magazine): What's being designed at the OEM these days in terms of durability? Is it 150,000, 200,000 miles? What is the issue?

STURK: Every OE has their durability schedules that replicate a certain amount of mileage. Now it's probably in the 150,000 range. But these tests that they run, GM GED, which is engine durability, or Ford FIE, very, very, very severe tests, extremely severe tests.

HAVEL: Something the engine will never see.

STURK: Never see, never see.

And one of the things we didn't talk about but should a little bit is fuel. E85, for instance. The E85 tends to run richer so you get more blow by with E85. And the more alcohol we put in the fuel, we are going to expect to see more dilution of the oil with that fuel. What does that do? It lowers viscosity again and it makes things tougher. So we have seen with E85 a propensity to get more dilution and again lower operating film thicknesses and potential issues with seizure again. So high alcohol fuels are another issue we are going to have to face.

Next question: From your perspective on the installer side, what are the biggest installer-focused issues and concerns regarding bearing installations? In other words, what are installers doing wrong? Are there some generalities you can make? And what should they be made aware of? *(see Bearings Q5 transcript)*