Transcript of Question 7

Presented by
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Engine Builder Engine Bearing Summit Participants

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Raymond King
Federal-Mogul Corp.

Michael James
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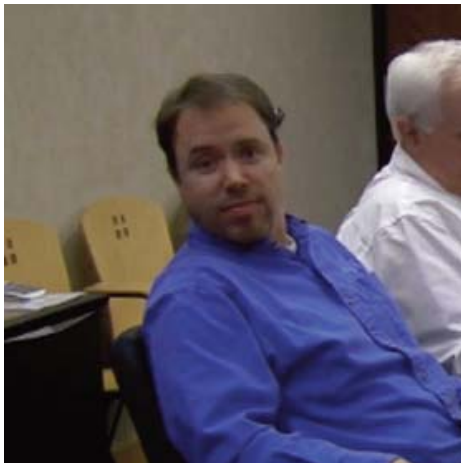

Brendan Baker, Senior Editor
Engine Builder magazine

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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 7: Looking at coatings on engine bearings, it is a new technology that is getting more and more interest. What processes do you recommend for bearings and when? What applications are helped by coatings? And what are the performance limits of coatings?

MCKNIGHT (MAHLE Clevite): I'm glad to go first, because we always get to steal about half your thunder when we start. There is only so much you can say about these subjects, you know. But this coating one is always a hot potato in our business.

There are guys who really seem to like coatings and there are guys who really seem to not like them. And that's whether they work for the company or whether they are out there using the stuff. And it's funny, I've got a lot of NASCAR customers. And I've got one big huge builder who loves coatings, coats every bearing they've got. I've got two other large ones who wouldn't put a coating on a bearing if you were giving it away free. So there is a lot of personal preference and feeling about coatings, and it's a pretty strong feeling.

Personally we don't think it's a black versus white, right versus wrong issue. Frankly, if we had a good oil film thickness in every case and the geometry of the parts was good, temperature conditions are great and everything is working, why would you need a coating? You know, the bearing will survive fine. So what we think of coatings is they're probably put on there primarily for when conditions aren't too good. And yeah, they're a band-aid, they're a crutch, they're an enabler. They do a lot of things. But are they necessary? Well, if everything was working right in its proper parameters, it's probably money that would be wasted.

That being said, we coat bearings and we sell coated bearings. And we sell them to enthusiasts who are building a street car or a street rod or something like that. As a matter of fact, I just shipped 32 trays of coated bearings this morning to Antron Brown's Top Fuel car. And I can guarantee you they are a crutch there.

John showed you some of those bearings that break. There is no oil film there. I mean, there is literally no oil film on a top fuel bearing. And so we have got a lot of metal-to-metal contact. And we have got a coating now that is extremely tough that will withstand that metal-to-metal contact and allow those guys to run a race and come back and not damage any parts. And that's really what it's all about. We've got a $3,000-$3,500 crankshaft and we've got an $8 bearing shell. So the idea is let's make a good pass, let's run 320 miles an hour in less than four seconds and come back and we don't mind throwing away a few seven or $8 bearings. We don't want to trash a crank, we don't want to trash a block. So that's kind of where it's going.

Now, conversely, this is not a "one coating is good for everything" kind of thing. I'm not an engineer, so I am simplistic. I got to thinking if that coating is great for those Top Fuel bearings, it's got to be just the cat's meow for NASCAR. We should switch NASCAR teams over. So we did a little R & D, we did a little experimenting and it was a failure. We found out that that coating we use on the top fuel bearings gets slick as it's run a little bit. It polishes and gets real slick and it's very difficult to keep an oil film there. Well, that's an issue when you are running 500 miles. It's not an issue when you are running four seconds, you know. So it was not the coating to use in a NASCAR engine. We got another coating there.

Yes, coatings are a good tool for us. Our customers, many of them like coatings. So we have coated bearings. In terms of what the material is, and I don't know anybody out here that would tell you otherwise, it's all proprietary. Nobody goes out and says "well, here is the formula for my coating. Help yourself."

In terms of application – and probably 50 percent of coating success has to do with how you apply it – there are a couple of things in general that we could point out. And these are good for *Engine Builder* readers because these are things they ought to be asking their coater.

Number one is "How do you clean the bearing before you coat it?" Because all of us put oil on our bearings to protect them when we ship them. And you can't get a coating to stick if you've got any oil, fingerprints or anything on a bearing. So how does your bearing know they are clean?

The second question is "What temperature do you cure the coating at?" And it's another one of these oxymoron kinds of things. High temperatures make stronger coatings…but high temperatures screw up the materials that we all use to make bearings. So it's very important that our bearings be coated and cured at a low temperature. And generally, if you just want a rule of thumb out there, that's under 350 degrees. So, again, if you are shopping for a bearing coater, don't tell them what you're looking for, just ask them what temperature do you cure at? And if you hear, "Oh, we are about four and a quarter, four and a half…" –

JAMES (King Engine Bearings): Run for the hills.

MCKNIGHT: – stay away from those guys, because they are changing the metallurgy of our bearings when they crank the heat up that high. So that just in a nutshell is probably our feeling on coatings. Yes, I've got customers who love them. And if they love them, we're going to sell them. Okay.

STURK (Federal-Mogul Corp.): I agree with you, Bill. I mean, if everything is right, why do you need it? And one of the things that John and I looked at a number of years ago is exactly the second point you made there is what kind of damage are they doing to that bearing before they put that coating on?

HAVEL (MAHLE Clevite): A lot of these guys abrade the surface or do something they think are preparing it for the coating and don't know what they're doing.

STURK: Right. Now Federal-Mogul's approach to coatings is we do offer them as well because there is a perception out there that they help you in transient conditions and they do. It's slippery stuff you put on there. Usually nobody tells you what it is, but most of it's MOS 2-based. There might be some Teflon. There might be some other things in there. But what Federal-Mogul is looking at – again, for kind of a future development –is developing our own coating not so much for the racing industry but really to extend the usage of some of our conventional materials in a lead-free world. By adding this polymer coating we can mitigate the use of conventional overlays on these bearings.

MCKNIGHT: I'm laughing because we're dinking around in the same area there. Could you put a coating on good enough that you don't need an overlay?

JAMES: Right over the intermediate.

MCKNIGHT: Yes.

STURK: And this material can be put on aluminum or copper with very little change in the process. So this is kind of what we are looking at. And right now we have just, I think we put out a press release last week. We call it Irox, I-r-o-x. And it's under development, will be in production by this time next year in our Blacksburg, VA, facility.

KING : And one of the things that's interesting about this, Bob was explaining this to me, is when you think about the hybrid technology, all of a sudden the start-stop cycles just go out the roof.

STURK: This was our first application with start-stop. And virtually two or three microns wear after 200,000 cycles of start-stop versus any of the other materials. And a lot of the aluminum materials with silicon are pretty good for start-stop, nothing like this. And that was application number one. But also with aluminum bearings: what's the difference between aluminum bearings and tri-metal bearings at high speed? The seizure resistance of the tri-metal. And having that overplated layer on there is terrific. Aluminum bearings run up against the wall at high speed, high load. So this is acting as an overlay to extend their range of these aluminum materials under high speed, high load conditions. So we think there is quite a future in coating.

HAVEL: Eventually you get to the point where the lubrication fails, the bearing surface becomes the lubricant.

STURK: Right, right.

HAVEL: That and a few molecules what might be left.

STURK: We've put different materials into a polymer binder, which are proprietary. I won't tell you that. But solid lubricants and also hard particles for wear resistance. So we think there is quite a future here.

HAVEL: Are you looking at this for the lead-free world as well, I presume? Is that the main reason?

STURK: That's the main reason for it, yes.

BAKER (*Engine Builder* magazine): For production engines?

STURK: Yes.

BAKER: On the OE side or the aftermarket side?

STURK: Both.

MCKNIGHT: We're going to do both.

STURK: A lot of interest on the OE side.

KOPELIOVICH (King Engine Bearings): I would consider coatings not to be a bearing material but more to the lubricating material. In spite of the fact that it would stick to the bearing, it actually is a lubricant, on the side of oil, not on the side of bearing material. The coating has excellent anti-friction properties because it is a polymer composite consisting of a polymer base (commonly PTFE) filled with particles of solid lubricants (molybdenum disulfide, graphite). However, the coatings are a partially superficial layer. They can wear very fast under high load and metal-to-metal contact. And when they wear, the clearance increases. So you can't use coating thicker than some level.
In addition, coatings have no effect on bearing load capacity. But they are excellent for start-up of the engine and initial period of bearing operation. They help to eliminate or reduce metal-to-metal contact within the bearing and the journal surface and also promote conformability of bearing surface to the journal.
Currently because the polymer coatings are applied on mostly Babbitt overlay, which itself has excellent anti-seizure properties the effectiveness of this coating on the Babbitt, I would say is somewhat limited. But I support that coatings applied on the harder material, the aluminum material and even harder metal, high strength material, which we know that the problem of high strength materials is very low seizure resistance. And the coating in this case may be much more effective than when applied on Babbitt.

HAVEL: I agree. I don't know whether anybody caught the glance across the table when Bill looked at me and said "Some people like coatings … and some people don't." I have

never been a proponent of the use of overlays because of what's already been said. If everything is right in the engine, you don't need them. It is a crutch if everything isn't right in the engine.

I remember years ago somebody sent me a rod bearing out of a Caterpillar diesel that went 500,000 miles and still had the coating on it. My response to them was "You didn't need the coating. Everything was fine in the engine. The coating didn't even wear away, which means you had plenty of oil film to run on. So the coating didn't do anything. It's still there." It's a sacrificial coating, like you said.

But I think where it has its place is in what Bob was showing us here. If you are trying to get lead out of the bearing and the conventional overlays that contain lead are to be eventually phased out, that this is probably in the realm of where the future lies. I don't know what the chemistry is. I don't know the magic formula is going to turn out to be. But I believe that there is a future there. And overlays can, as Bill said, be a crutch. When everything isn't right and that oil film does break down, it does help you bridge that hopefully only momentary gap.

STURK: One of the things I want to say, Dimitri, is that we have seen an increase in fatigue strength on our test rigs with this material. And the reason for that, some theorize that, well, we distribute the load a little bit softer, maybe we distribute the load a little bit better, but I don't really think that's it. I think when you see fatigue in an aluminum bearing, it's always usually in a wear start where these materials are rubbing against each other and causing very high surface temperatures. When that happens, the fatigue strength of the aluminum alloy drops right off the table. When you keep it covered with a material and insulate it somewhat and you take advantage of running that lining cooler and avoiding those high rubbing temperatures on the surface, you take full advantage of the strength of the base alloy.

KOPELIOVICH: Because there is no metal-to-metal contact. The contact is through the coating, which is actually the lubricant.

STURK: Right, exactly. So we have seen on our test rigs if you take a base aluminum bearing, run it with and without coating, you will see consistently higher fatigue results with the coating because it's protecting it. I think the same reason that aluminum plated bearings worked so well years ago; the aluminum wasn't that strong, but the plating again protected the surface.

KAUFMAN: Does the coating do anything for embedability?

STURK: We have done quite a bit of contamination tests because that's the number one question that we're always asked. It really doesn't appear to have any detriments to the base metal. In other words, it performs the same in the presence of debris.

MCKNIGHT: It doesn't detract from the performance?

STURK: Correct.

KAUFMAN: It still allows the particles to be embedded rather than in the crankshaft?

STURK: Really what Dimitri said was true, the base metal, embedability characteristics of the base metal are really more important.

CARLEY: Has anybody tried cryogenic-treated bearings? What effect does that has on their durability?

MCKNIGHT: We have. And it was not well received. It was the kind of thing that my race customers said well, yeah, if you do it for nothing, I love it. If I've got to pay for it, I don't see any advantage to it. And that's just about how it shook out.

KAUFMAN: Its value to them is directly proportional to the cost.

MCKNIGHT: We ran about a six-month experiment and just decided nobody was going to pay for it.

CARLEY: But you didn't see any measurable advantages?

MCKNIGHT: No. You know, in a racing environment it's so hard, you know. It's not empirical data. It's all seat of the pants. And as you have all pointed out here, when the bearing's working, well, you haven't got any problems anyhow. So how do you attribute that to whether it's cryogenically treated or whether you've got good oil and everything else is right? So it was just not something anybody could get their arms around and get too excited about. So this is much more exciting.

Next question: What type of bearing do you recommend for the following applications: stock engine, street performance, race engine and diesel? *(see Bearings Q8 transcript)*