Transcript of Question 6

Presented by
Engine Builder magazine

www.enginebuildermag.com

Engine Builder Engine Bearing Summit Participants

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Federal-Mogul Corp.

Dr. Dimitri Kopeliovich
King Engine Bearings

John Havel
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Raymond King
Federal-Mogul Corp.

Michael James
King Engine Bearings

Bill McKnight
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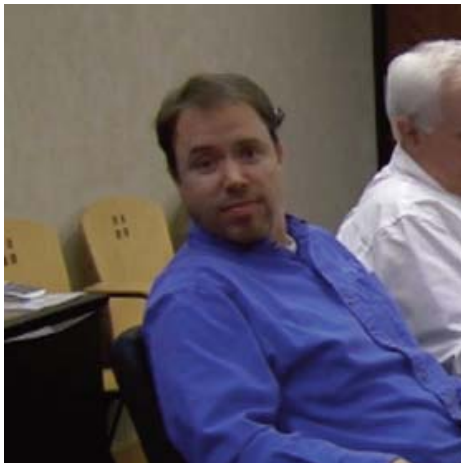
Engine Builder magazine



Brendan Baker, Senior Editor
Engine Builder magazine

Larry Carley, Technical Editor
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 6: Speaking of changes, are there specific problem vehicles that you've had to develop fixes for? There are obviously things in the past that everyone can point to. How about newer situations; are those problem engines still around? Not necessarily just in the U.S. Are there problems in Europe or have they been much better?

KOPELIOVICH (King Engine Bearings): Because the engine power and performance are constantly increasing due to supercharging, fuel that's a high octane number, direct injection, low viscosity oil, modern diesel engines, compact engine designs, etc., all these parameters are there to increase a specific load applied to bearings. So we can't use the same materials that have been used for tens of years. We need new materials with higher load carrying capacity.

And we are trying to develop such materials. As I already mentioned, we have bi-metal aluminum based material with high load capacity up to 14,500 psi. We also developed a high strength tri-metal material with load capacity of about 18,000 psi. The high-strength overlay is composed of two components. One of them has good seizure resistance. It is hard, but it has good seizure resistance; in comparison with copper, it's much, much better. Another is a solid lubricant distributed throughout the base material and additionally improving its seizure resistance and anti-friction properties.

We tested this new material – as I mentioned, it is called GP, in a sprint car engine for an entire week at Ron Shaver's facility. We ran it at constant torque up to 500 ft. lbs. And in order to achieve high specific load applied to the bearing, we reduced the bearing surface considerably in order to increase the specific load applied to the bearing. And the bearing didn't fatigue. In addition to the extremely high load capacity, these bearings have excellent corrosion resistance and high maximum load, high maximum operation temperature. We are now developing the next generation of, or another version of, this material which is lead-free that we are going to market in the European OE market. By the way, the overlay is lead free. So we are developing the intermediate, which is also

lead-free. I think that lead-free material is our future not only in the states, in Europe. We can't prevent this. This is the future so we have to be prepared for this future. We have to develop materials which are lead-free.

And we are also trying to develop a bi-metal aluminum based material for drag racing applications. I was very impressed with the bearings that we have seen in the break. They still yielded under such high load. It's a huge, huge loading of bearings which we have to try to invent something that is capable to withstand both constant metal-to-metal contact and not dry but mixed lubrication and high load.

HAVEL (MAHLE Clevite): I can't speak for any current applications. I have been a little bit out of touch here for the last few years, but I can go back and relate to some earlier applications where we had to do specific development to solve problems. And probably the most notable, which is the top fuel dragster and funny car engines, where they actually had reached a point where they were stymied on how much power they could produce or even the ability to get down the track successfully until we developed the current bearing that I was showing some folks here at the break. And they used to run on a bi-metal Babbitt bearing purely for its ability to provide surface action, low friction and conformability because crankshaft distortions are horrendous in those engines. And what we did was we came up with a tri-metal design to get over that, solve that problem. And it just has been in the market now for almost ten years. And it gave them the ability to continue to progress. And if anybody is a fan of drag racing, you know that ten years ago four-and-a-half seconds was probably a phenomenal elapsed time in drag racing and now they are running like 3.8 seconds.

Well, of course that's apples and oranges too because they are running on a shorter track. You're right, they are running a thousand feet now. But the point is that they are able to run now and bearing failures are few and far between unless there is some other problem. And somebody blew a car, a funny car that blew the body right off of it last weekend. But after going back to the pits and looking at the computer printouts from that run, they found out that the oil pump had failed before the car ever left the starting line. And so they made this run with virtually no oil pressure. And the engine just disintegrated.

STURK: That'll do it.

HAVEL: Yes, that did it. And it didn't have to run for five minutes. I mean, this was less than four seconds. But more commonly our high performance bearings, some of the installers used to complain about the occurrence of overlay fatigue and cavitation erosion, neither of which is really, truly a bearing failure. It's a distress mode that causes concern. And a lot of these engine builders, especially the NASCAR guys, would like the bearings to look better when they take them out of the car than they did when they put them in. And it's been hard to convince them that some of these modes of distress are nothing to get concerned about. So we did take some steps in both the design and in the manufacturing process controls to try to minimize the occurrence or make the bearing more tolerant to the conditions it created, both overlay fatigue and cavitation erosion.

And I mentioned the website where we have created a library of failure modes for people to reference. And I think that that has helped. I used to supervise a group that took

all of those calls from the field when people had questions and problems and so on. Bill, do we still get as many calls as we did or are people becoming aware that that website is our there?

MCKNIGHT (MAHLE Clevite): No. We were talking about electronics here earlier. The nice thing about the web catalog or the web distress guide is we used to have a paper book. And I would sit there and my bearings never looked like the crappy pictures in this paper book, you know. So I go page by page by page and I never could find my bearing. You had one shot and it wasn't very good, you know. Well, the nice thing about the website is they are digital photographs, and most distress modes I've got three or four choices. And every time I find a really nice one, we photograph it. In a couple weeks, boom, it's up on the site.

So the guy out there in the middle of nowhere trying to figure out what's happening to his bearings has got a lot better chance of finding one that looks like his on the electronic guide. A lot of times that's still not enough – they end up calling us, but at least now they call or they email with some information. "My bearing looks just like, you know, number 16 there on your guide." Because it's so hard when you get an email and a guy is trying to describe his bearings to you, you haven't got a clue what's really going on. So it's just been a nice little tool for us.

HAVEL: Well, I know we have drastically reduced the number of people we have answering those phone calls and processing failure analysis reports and warranty claims and stuff. So hopefully a big part of that reduction is fewer phone calls with these basically nuisance questions like, you know, something happened and I don't know what. And can you help me?

STURK (Federal-Mogul Corp.): I'm sure you have done hundreds, if not thousands, of post mortems on bearings. I have.

HAVEL: Oh, yeah.

STURK: And it's always tough to get bearings back and, all right, what happened? You know, it's so helpful to see the other components and to do a real detailed investigation of what happened.

HAVEL: Absolutely. We have frequently asked people to send in additional parts of the engine so we can figure out what was going on overall in the entire total engine system.

STURK: Right. And then, you know, on the OE side you get that advantage where they call you in to take a look, they usually have the entire engine, everything is laid out so it's a little easier. But on the aftermarket side, it's difficult sometimes. You just get a handful of shards. What went wrong?

JAMES (King Engine Bearings): I would just like to throw in an update, if I could, from our perspective. We are getting a lot of phone calls from the high performance marketplace. And apparently there is a great deal of concern out there with regard to

bearings that have overlay distress. In fact, we have come to the conclusion that overlay distress is not a time for high five success.

We can't say that because a bearing is distressed, the engine builder has done a good job, he has developed that power plant as far as he could and you ought to just keep doing what you are doing. Because what happens with today's engines is that they are getting more and more powerful. So whatever might be in a distress mode today, what's going to happen six months from now when someone gets an idea for what he can do to increase the torque a little bit more, make some more power in one way or another?

So what we are hearing is that there are some constraints at the level of innovation where people are a little reluctant to keep developing because they are concerned that, first of all, job one is to finish the race and job two is to finish the race ahead of everybody else. So there is a limit to where you can go. And we have had to address those issues because the conventional overlays that we have all known are starting to get overrun by this continuing evolution that you see in high performance engines.

So, in fact, as Dimitri said, we have developed a lead-free overlay that's working really well. And it's on top of a sintered copper/lead layer. And what we found so far from having looked at many, many high performance engines, mostly circle track engines, frankly, is where we are seeing this, we have seen that the intermediate layers basically don't seem to be the issue. The issue seems to be that top layer. And so we have addressed the top layer. And we think that's where everybody is going to go.

We think everybody has to keep up with the development that the aftermarket itself is doing. It's not just at the OE level but everybody in the aftermarket who is building a performance engine, particularly a racing engine, not necessarily just a street performance engine.

MCKNIGHT: You've got a lot of NASCAR business, circle track?

JAMES: As a matter of fact, that happens to be an area where we have been getting phone calls. And as a matter of fact, we see that as the next step for us just because of that particular situation.

MCKNIGHT: Who do you supply out there now in NASCAR?

JAMES: Right now we are at the beginning stages of actually being involved. Because what's happened is that, for one thing, you guys have done a great job with where you have been historically with them. But I think that the marketplace seems to be saying that what was good then was great, it may not be what's good now. So I think people – I'll take out the word think. People just seem to be looking for new sources that have different things.

MCKNIGHT: I was at Roush Yates on Monday. And they seem to be quite happy with, you know, what we're doing, what we're supplying. They're making, as you know now, probably close to 900 horsepower on a 355 cubic inch NASCAR Cup motor. In the Nationwide Series, of course, now they've got to run a motor two races so they are running 1,200 miles or so before they ever get to the inside. And, you know, Formula 1's

on the economy kick this year. So I think I read, Raymond, you get three motors for the whole season in Formula 1. So the bearings are seeing a lot of use in those engines.

KING (Federal-Mogul Corp.): Now they don't get a fuel stop. They may not even have enough fuel to make them in some. But yes, there is a lot of change. It is interesting to see that a sport that essentially is the epitome of an unlimited budget is starting to look at different ways to manage the sport.

JAMES: Well, even NASCAR has gone to the one engine rule basically.

MCKNIGHT: Oh, yes, they've got them two in a row at Nationwide.

JAMES: Yes. So there you go. There you go. But I think in anything everybody looks for new thinking. Everybody has to look whether it's at the OE level or at the performance level.

MCKNIGHT: I agree there. I suspect Bob and Raymond will, too. We never stop. You know, we continually are working on, you know, what can we do better? What can we do to make this bearing last longer? How can we make it stronger?

JAMES: It's a good philosophy to have. Everybody benefits. Everybody benefits when we raise the bar.

HAVEL: You have to think ahead of the market if you are going to succeed.

STURK: And the big advantage in the race world is we can still use materials that we know work really well, and I'm talking about lead. When we talk about where the challenge is in the future, it's in a lead-free world. These kinds of loads and speeds that we're talking about with NASCAR or top fuel, right now there isn't anything that's going to work out there that doesn't contain lead.

HAVEL: I don't think anybody is close to putting a restriction on the use of lead in that kind of an environment.

STURK: So really the challenge is for us in the future on specific applications are lead-free, high performance lead-free bearings, bearings that perform like tri-metals without any lead. Lead was like the universal band-aid. We could put it in every engine and it worked. But today we find that there are certain combinations of materials out there that work in this class of an engine, or these work over there... There is no universal material anymore in a lead-free world.

JAMES: Bob, I can tell you that our preliminary research so far with race engines on dynamometers at this point is that there absolutely are material combinations that are non-lead that work under current racing rules and under current racing context.

MCKNIGHT: By the way, just a point of interest and not really about the conversation here, when do you expect to have the Gold material out to be purchased and used?

JAMES: Real soon, this year, as in this year.

MCKNIGHT: I tried to buy some. I couldn't find it anywhere.

JAMES: You heard about it already? I didn't even know you heard about it.

MCKNIGHT: It was in *Engine Builder* magazine in a press release and I thought man, I need to see that. And I couldn't buy any anywhere so I just was wondering. So you think before the year is out it will be for sale?

JAMES: Yes, yes, yes. We know before the year is out. Yes, absolutely.

STURK: One other challenge I would like to mention about being in a lead-free world, let's talk about the big stuff, you know, the Class 8s.

MCKNIGHT: It's a whole different look.

STURK: It's a whole different world. In fact, tomorrow I'm going to Cummins to talk about lead-free bearings. And we have a couple of jobs that have taken the lead out of some of those bearings for 15-liter truck engines and it's not easy. And we are in an invention phase right now to come up with a material that works to their satisfaction.

HAVEL: What's their target now for life? It used to be 500,000 miles.

STURK: A million miles.

HAVEL: I remember at the time it was 500, they were taking about 700, 750. But that was 10 or more years ago.

STURK: Right.

HAVEL: A million miles.

STURK: And then there are passenger car diesels – if you want to talk about the toughest applications out there, it's passenger car diesels that you see in Europe. And about half of their market is passenger car diesel now. Those engines are so small and have high specific loads.

JAMES: Direct injection.

STURK: High specific loads. These are the Sputter bearings I think somebody mentioned earlier that Federal-Mogul is in front of the market with Sputter. But they are the highest

load carrying capacity materials out there today. And there are applications that are out at 130 megapascals, whatever that is in psi. I'm sorry, I've been converted.

KOPELIOVICH: Multiplied by 125.

MR JAMES: About 22,000 roughly.

STURK: But production engines that are using Sputter materials. It's the only thing that works.

CARLEY (*Engine Builder* magazine): Is this an aluminum bearing?

STURK: These are Sputter.

KOPELIOVICH: It's tri-metal, but the overlay is made of another material.

STURK: Federal-Mogul's Sputter bearings are 20% tin-aluminum overlay on top of copper substrates. These could either be lead-free substrates or leaded substrates. But if they're in Europe, they're lead free.

KING: That is a real interesting and challenging market. I think part of that question we're talking about though was kind of do we see different vehicle bearing applications that are a challenge or an issue? I think as we get on the OEM side, they're pretty well addressed. So from being a problem in the market, I think it's more likely you would see an OE application that maybe has some kind of erratic oiling issue maybe when it's out in the field or even we do see a lot of cooling things relating to like the under-hood compartment on – and basically what it is, they have so many tests that are run with engines outside the vehicle that you'll come across a problem when it gets put in the vehicle. But it's not necessarily a specific issue with the engine bearing or the crank design or whatever. It's once you put it out into that world or environment that all of a sudden the temperature is a little different than they thought. But generally speaking, I don't know that you see a lot of vehicles today that, when operated as they were intended by the OEM, have a habitual problem.

KAUFMAN (*Engine Builder* magazine): You're not having to solve the problems after they've been out? You're forecasting the problems and solving them before they get out there?

KING: I think that's correct.

KAUFMAN: It's a pre-emptive strike.

HAVEL: Another thing that we need to always try to do is help the customer who is having the problem. And the problem may be manifested in the bearing, but it may not be caused by the bearing. And I think of one particular application where I had to look at some bearings out of big box Chevys that were installed in offshore race boats. And they

were failing prematurely on start-up. Well, come to find out they had water to oil coolers and the water temperatures were very cold and the oil was never getting hot. And so they were using 50 weight oil or 20/50-weight oil. It was never warming up. It never got to the viscosity it was intended to operate at. And bearings were wiping because of lack of lubrication, no fault of the bearing. It was the environment that the bearing and the engine were put into. This is the kind of thing that, you know, this is why we have these technical groups that work with our customers to try to solve these problems, figure out, first of all, why is the customer having a problem and then what can he do to solve it?

STURK: And we are seeing some new failure modes as engine design evolves. We've got a lot of turbocharging boosting going on right now. And a lot of these engines, some are in production, but there are a lot in the development stage. And as you put twin turbos on small gasoline engines, you're really turning the characteristics of that engine into a diesel. You're making a lot of torque at low speed, very low speed. And it's given us a new failure mode in some ways. It's seizure by overloading.

KOPELIOVICH: Twin turbos?

STURK: Yes, twin turbo, uh-huh, and low RPM. Some of these engines, if you look at the torque curves, they go up at 1,400 RPM and they go flat out all the way up. So they're making maximum torque under 2,000 RPM, maximum torque. And we're seeing a lot of problems with those right now. We've got some material developments to try to solve some of these problems, but as we look at more and more boosted applications, this is something that we are fighting with.

Next question: 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? *(see Bearings Q7 transcript)*