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The Slick Factor: Finding an Edge With Oil

How Quaker State and Hendrick Motorsports are using new oil technologies to find a competitive edge

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Photography by Jeff Huneycutt

Quaker State isn't just a sponsor for Hendrick Motorsports' Nextel Cup Series racing effort. The oil company has actually built a relationship with the racing heavyweight that is so strong that the two actually share critical information to produce better racing lubricants.

If the most you think about your motor oil is the cuss words you mutter when you are cleaning up that puddle your race car is constantly dripping on your shop floor, then you are probably leaving horsepower on the table. The manufacturers are learning that lesson, too, with better lubricant blends designed around the very specific needs of oval-track engines.

Two companies leading the way are Quaker State and Hendrick Motorsports in NASCAR's Nextel Cup Series. Quaker State has been a sponsor on the HMS cars for years, but the partnership, it turns out, involves much more than the Quaker State brass handing over a check.

"We work with teams in different forms of motorsports that like to think outside the box," says Mark Ferner, Quaker State's research and development lead. "A team like Hendrick Motorsports that's really proactive wants to make the motor oil an integral component of the package and not just a product that's added after the fact. We have built a relationship where they will call us and say, 'We want to make this change that may raise the oil temperature so many degrees. Can you help us with an oil that can withstand that temperature for a race?' Or, 'We want to change the metallurgy on this. Will the oil still be able to protect it?' That's when things really get fun."

Hendrick Motorsports' Dr. Andrew Randolph and Quaker State's motorsports lead, Paul Bastien, discuss ideas while testing a complete race engine in this fixture, which measures friction losses inside the engine.

After discussing the needs at HMS, Ferner says Quaker State's team of engineers involved in high-performance applications can work up small batches of blends that they believe should work and ship them to the HMS facilities in Charlotte, North Carolina. They are tested to determine how well they work in the Nextel Cup engine package.

Tests at HMS take several stages. One is a test machine that is essentially a next-generation Spintron that uses a powerful electric motor to spin the crankshaft inside a race block. Everything from the crank to the rocker arms to the water pump can be installed and tested on this fixture to determine the power required to operate. For new formulations of motor oil, it can be used not only to determine if the new blend reduces friction inside the engine, but it can also spin everything inside the engine for a period of time to see how the oil protects individual pieces from wear.

After that, experimental blends are tested in a running engine on a dyno, in a running car in a test session, and maybe even by a car during a race. Over time, Quaker State officials say that the relationship with HMS has really helped the company understand the needs particular to a circle track racing engine and develop oil blends to meet those needs.

Q Racing

Among Quaker State's new line of high-performance synthetic motor oils is a blend designed expressly for oval-track racing. Quaker State's Bastien says many of the properties in this lubricant blend are derived from what the company learned while working with Hendrick Motorsports.

Of course, none of that really helps you and me, since most of us are not working with multi-million-dollar budgets or have the R&D team at a major lubricant's manufacturer on our speed dial. The good news, however, is that when Quaker State decided to produce a line of high-performance synthetic oils known simply as "Q," the decision was made to include a blend made specifically for racing.

It's known as "Q Racing" and, believe it or not, it's really more than a simple marketing gimmick with a new label on the regular stuff. Paul Bastien, who regularly mixes the one-of-a-kind blend for Hendrick Motorsports, says the Q Racing blend is unique and based on what the company learned while working with HMS.

James Roque and Paul Bastien work on a new blend in what Bastien calls one of the smaller mixing vats at his lab.

"Since the Q Racing oil isn't designed to work with passenger cars, we didn't have to worry about meeting any industry guidelines or meeting manufacturers' warranty restrictions," explains Ferner. "In a passenger car, there are certain things you have to do with the oil because of the catalytic converters. Here, we aren't worried about that, so we can do more things to increase the levels of wear protection.

"For example, a racing engine typically has a highly loaded valvetrain to minimize valve float at high rpm. A lot of people may not realize that in the valvetrain of the engine, the pressures between the follower and the camshaft can be extremely high. Even in a passenger car, the pressures at speed are in the range of 200,000 psi. It gets even worse for a race car. That's enough to squeeze the base oil-whether it's a synthetic or conventional oil-out of the way and cause metal-to-metal contact. We have to rely on a special additive chemistry that can form a sacrificial coating on the cam and lifters that can withstand those pressures." Because those pressures are even higher on a race car than a passenger car, Ferner says Quaker State's chemists have taken even greater measures to protect the cam than they have in other oils.

"We've also been very careful with the combination of friction modifiers used," he continues. "We've done some dyno testing on our own and have seen that if we add friction modifier 'A', we get two extra horsepower. If we add friction modifier 'B', we get two extra horsepower as well. But if we try to add both friction modifiers in the same blend, we end up losing three horsepower from where we started. So we've been very careful with the blend to make sure the oil is as slippery as possible to free up as much horsepower as we can."

While talking with Ferner, Bastien, and Dr. Andrew Randolph, Hendrick Motorsports' director of engine development, we picked up a lot of tips and useful information regardless of what brand of oil you use. We thought we'd pass along some of that to you, too.

The Hendrick Philosophy

This photo is a view through the bottom of the block at the top of the cam tunnel. Hendrick Motorsports uses these oil squirters to shoot a steady stream of oil on each of the cam lobes. Randolph says it's the organization's philosophy to provide pressurized oil to any area in the engine where proper oiling is critical. "Splash" oiling is simply too haphazard.

"The one piece of advice I would give no matter what class you run is to use a quality motor oil that's as thin as you can get by with, and run it with the least pressure you can get away with," says Randolph. Of course, as he says this, Randolph smiles because he knows the million-dollar question is, how do you find out how thin you can run the oil and with how little pressure?

Many books can be written on just this topic, but in order to get a more simple, practical answer, Randolph gives me a tour of Hendrick's engine facilities and shows me some of the answers they've found for their lubrication problems. Interestingly, Randolph says the HMS engine department is often experimenting with different viscosities and is willing, in a sense, to build the engine around the motor oil. By that, he means the bearing clearances and oil pressure they want plus how much heat they are willing to say is acceptable.

When it comes to fighting friction inside the engine, Randolph says there are three main areas of concern: the bearings (both main and cam), the interface between the camshaft lobe and the lifter face, and the interface between the pushrod tip and the rocker arm socket. Wherever oiling is critical, HMS tries to make sure it is delivered to that spot under pressure. For example, in addition to providing oil to the cam journal through the oil galleries under pressure, oil squirters also aim a steady stream of oil at each of the cam lobes. To keep the wristpins from galling inside the small end of the rod, each rod is also cut with an oiling gallery through the beam. Pressurized oil feeds the rod bearing from the camshaft, and some of that makes its way through the gallery in the beam of the rod to lubricate the wristpin.

One interesting aspect of how HMS controls oil flow inside its engines is that the engine can actively prioritize what goes where. Oil squirters are installed in the bottom of the block aimed at the underside of the pistons. This spray of oil helps pull heat away from the pistons and aids oiling between the wristpins and the pin bosses in the pistons. This, however, isn't a critical oiling function, so the squirters are built with tiny metering blocks that cut off the flow when the pressure falls below a certain point. For example, when a race car is sitting at idle during a pit stop, the low rpm level means the oil pressure isn't nearly as high as when the car is at racing rpm. This is when the squirters shut off so that when the driver nails the gas to accelerate out of the pits, there is still plenty of oil in the bearings and spraying on the lobes.

Mineral vs. Synthetic

According to Ferner, the difference between mineral-based oil and synthetic oil isn't that one is naturally more slippery than another, as you might think. In terms of lubricity, the base stocks of mineral-based and synthetic oils are quite similar-it's how they react to heat that differentiates them.

"Where the synthetic oil really shines is in extreme temperature situations," he says. "In racing, we're talking about really hot environments, so we'll limit our discussion to that. Having an oil that can withstand higher temps longer opens up some doors for us. If you were to take a conventional mineral-based motor oil and subject it to the most brutal conditions, what you would see is it will slowly start to oxidize as it reacts with the heat and oxygen. It starts to form sludge particles that thicken the oil. So if you track the oil over time of engine operation, you would see the oil start getting thicker and thicker at a progressive rate until it gets to the point that the base oil just cannot take any more. Then the viscosity just skyrockets to a semi-solid condition very quickly."

Even if you typically run low oil and water temps or change your mineral-based oil frequently, there can still be drawbacks. Oil temperatures around the piston rings can spike to 400-450 degrees F, so even if you run an oil temperature sensor in the pan, you probably aren't getting the complete picture. Also, because the viscosity of mineral-based oil makes much greater changes with conventional oil than with synthetic, it can be more difficult to find that "sweet spot" when everything is working together correctly. Finding the right combination of viscosity, oil pressure, and bearing clearances to run is tricky. Add to that the fact that your oil's viscosity changes with temperature, and you've just made yourself a moving target. This is especially true if you are trying to qualify and race the same oil or if the racing program at your track doesn't always give you the opportunity to warm your engine. Synthetic oils are much more stable over a range of temperatures. Although it's not perfect, the viscosity-and ability to protect an engine-of a synthetic oil is going to be much the same at 180 and 220 versus a conventional oil. If you are about to make a qualifying run and wish to completely tape up the nose of the car, the short sharp spike in oil temps that will result won't be as harmful. Likewise, you can also get away with slightly higher temps for a longer period. Although it's probably a little too radical for the rest of us, Randolph admits that HMS has raced with oil temps as high as 350 degrees F.

In addition, the stability a synthetic offers over a mineral-based oil allows the designing chemists the advantage with what additives they are able to work with. "Even if you are changing your oil regularly and not worried about sludge buildup, the advantage of synthetic is that the molecules in the base oil are more consistent," Bastien adds. "We are able to really focus the formulation effort on the additives doing their specific job rather than trying to find additives that work as the base oil changes or oxidizes. The more consistent base that synthetic provides allows us to widen our parameters of what we can accomplish with our additive packages."

Foaming

This photo is a view through the bottom of the block at the top of the cam tunnel. Hendrick Motorsports uses these oil squirters to shoot a steady stream of oil on each of the cam lobes. Randolph says it's the organization's philosophy to provide pressurized oil to any area in the engine where proper oiling is critical. "Splash" oiling is simply too haphazard.

Because it's squirted under pressure, splashed by the valvesprings and crankshaft, and otherwise simply flying around all over the place inside the engine, it's often easier than you think for air bubbles to become trapped in the oil. "Foaming" the oil is the term used when so many air bubbles are trapped in the oil in one area that it can no longer perform as intended. The air bubbles are compressible and reduce the oil's ability to separate moving metal parts with a thin film. It's also difficult to pump effectively.

One of the first signs that the engine oil has foamed up is a loss of oil pressure. Unfortunately, many racers read a lack of pressure as oil starvation when it's actually the opposite. Too much oil in the pan allows the crankshaft to splash the oil, causing air bubbles to mix in. The addition of air bubbles in the oil has the effect of raising the perceived volume of oil, thus raising the fluid level in the oil pan. This allows more oil to make contact with the counterweights of the crankshaft as it spins by and whips it up. You can see where we are going from here. There are other ways for air to become trapped in the oil besides contact with the crankshaft, but the results are never good.

Unfortunately, the high rpm levels inherent in racing makes foaming the oil much more likely. Quality racing oils will include additives that fight the tendency to foam, but you must also take whatever precautions you can to keep foaming down-including not running more oil than your pan and windage tray can effectively contain.

If you suspect your engine oil is foaming, it can sometimes be difficult to confirm. If you are limited to on-track testing, experiment with using less oil in the pan. If your problem actually is oil starvation at the pickup, the low pressure problem should still persist. If, however, too much oil is causing the foaming problem, this may take care of it. If you have the luxury of engine dyno testing, try monitoring the oil level in the pan immediately after a series of pulls. The air bubbles in the oil will slightly raise the level in the pan. If you can track this, you can get an idea if foaming is a problem in your engine. CT