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Subject: Friction Fiction – LAVA Magazine 2015

Following is an article from the recent LAVA Magazine, provided with permission from Brad Culp of LAVA Magazine/lavamagazine.com, focusing on drive train friction. This is an excellent article and I have highlighted the article sections that pertains to chains. Listed below are my comments and key points to the article:

1. Mechanical Wattage savings of 6 to 9 watts is available if the chain is properly stripped of the factory coating and lubricated with a wax-based lubrication cocktail.
2. A waxed based lubrication process, like the ICE Friction – ICED Chains, is the least expensive* wattage savings available to all riders and racers.
3. The wattage savings is very significant – 1 watt is worth 30 to 45 seconds over an Ironman bike leg, or a 5 to 6 minute total savings!
4. We have corresponded and conducted testing with Jason Smith of Friction Facts quoted in the article. Jason provided the initial testing conducted by Velo News. We agree with his testing and have developed a chain formulation that matches his friction results and have made changes to further enhance the durability of the lubrication.
5. A chain optimization, like ICED Chains, is a must for race day – FREE RACE DAY WATTS.
6. With the durability of the ICED coating lasting up to 600 miles, why use less efficient lubrication techniques – wasting watts and causing unnecessary drive train wear. Our goal is NO WASTED WATTS!
7. ICED Chains are for all bikes – Road, TT, MTB and CX. Our field test data from the Leadville 100 and ICEMAN Cometh races proves this point.

* If you are at the high end of the Chewbacca scale, shaving your legs might be cheaper watts.

FRICTION FICTION

The truth behind what really makes for a faster drivetrain.

By Jordan Rapp

JAY PRASUHN

Whether it's bearing choice, grease, aftermarket treatments or general user care, a fast, efficient drivetrain is the sum of many small parts.

A roller chain (what all modern bicycle chains are) and sprocket drivetrain is a remarkably efficient mechanism of power transfer. Part of the reason that it has lasted so long is that it is practically–if not entirely–impossible to find any system more efficient for transferring power from one spinning object to another. Typical estimates vary, but a chain drive system is usually estimated to be as much as 98 percent efficient under ideal conditions (remember that word "ideal").

All well-made chains experience increasing frictional losses as the tension on the chain goes up as a function of load, but it's only a fraction of the increased power that the chain transmits. At minimal loads, there is the inevitable friction of the links rubbing on each other, but the losses here are quite small. But the more power you generate, the more efficient chains can get. Driveshafts, belt drives and other similar systems all suffer much greater losses than a good chain-based system does. The bicycle crankset, chainring, chain and cog (as well as the derailleurs that enable shifting) are truly remarkable–but they are not perfect. And, as with anything, there is variance within the system based on different parts, lubricants and levels of TLC. This variance can add up to a

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significant cost or advantage, depending on how particular you are.

What does it mean to be particular in this regard? Does that just mean keeping your chain clean and well lubed? And well lubed with what? And what else besides the chain really matters? Drivetrain losses were brought into mainstream cycling by FSA (Full Speed Ahead), which led the "ceramic revolution" back in 2005. To some

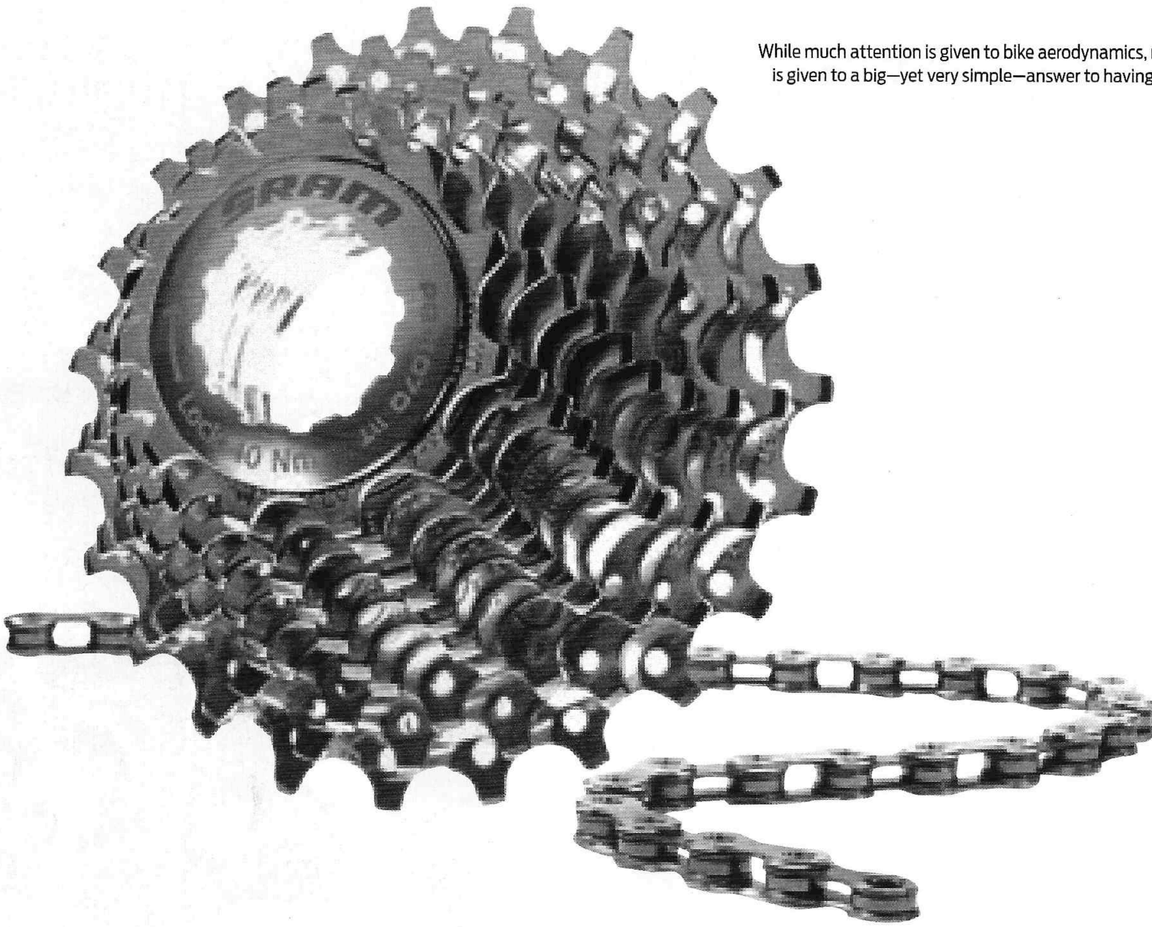
Smith helped create UltraFast Optimization (UFO) treatment on chains (now available from CeramicSpeed) that helps spike the drivetrain efficiency of a stock chain by as much as nine watts.

COURTESY CERAMICSPEED

extent, they piggybacked on the power meter explosion, since speaking in a currency of watts was now possible. FSA started talking about how much more durable a ceramic bearing of practically infinite hardness could be. And suddenly ceramic wheel bearings and bottom brackets were the latest must-have items. People who had never thought about how many watts they were losing from the crankset to the hub were now timing how long their bottom brackets would spin. But one issue that was immediately apparent was that these comparisons lacked perspective. People were told how much faster an FSA ceramic bearing was than a "regular" bearing, but what exactly is a regular bearing? Luckily bearings are somewhat unique in that there is a very nice and practical and, critically, standardized set of guidelines for how they are classified.

Most companies buy their bearings from someone else. Virtually all bearings used (now) in a bicycle are cartridge bearings. Although you used to have a lot of cup and cone bearings, most bearings nowadays are single-unit cartridge bearings. Whether or not this is a good thing is another discussion, but it is what it is. The quality of cartridge bearings is generally described by two metrics. One is the "grade" of the balls. The lower the grade, the more spherical the ball. The grade is a strict numerical scale measuring roundness in millionths of an inch. A grade 1 ball is round to 1/1,000,000 of an inch (that's extremely round, to say the least). A grade 25 ball is round to 25/1,000,000 of an inch. Then there is what is known as the ABEC (Annular Bearing Engineers Committee) rating. Here, a higher number is better. The ABEC rating refers to the precision of races, and there are fixed ratings of 1, 3, 5, 7 and 9. For example, an ABEC 1 bearing will have .0003 mm of radial run-out (roundness variation), while an ABEC 3 has only .0002 mm of variation. In general, the best bearing is the one with the highest ABEC rating and the lowest-grade balls. But not always, particularly on the ABEC side. ABEC 5 bearings are typical for high-end cycling components, but ABEC 7 is not necessarily better. If the tolerances are too tight, then the bearings can have more drag since they may not align perfectly within the frame. With the balls, however, there is no downside to a rounder ball, so a lower-grade bearing is always better.

This is all determined by an independent standard, unlike a wind tunnel test where you can tweak things. There's no way one particular ABEC 7 bearing can have a different precision than another ABEC 7. This is important, because it makes it easy to see when you are not comparing equivalent parts. The issue was that some "high-end" ceramic bearings were often ABEC 3 with something like grade 25 balls, and that bearing was certainly not better in any meaningful way than a steel bearing that was ABEC 5 with grade 10 balls. But this was (and is) relatively easy to expose because it's not a system that can be gamed. Ceramic isn't necessarily better. You can make a more precise bearing using silicon nitride (ceramic) balls, but it's not guaranteed. Just like a carbon bike is not necessarily better than an aluminum one—the material just gives you options.



While much attention is given to bike aerodynamics, not enough attention, Smith says, is given to a big—yet very simple—answer to having a fast drivetrain: keeping it clean.

COURTESY SRAM

But beyond debunking the quality metrics of bearings, how do you find out how well they actually work? The biggest factor affecting performance is the percentage of grease fill. A bearing packed full of a high-quality, high-viscosity grease will last a lot longer than a bearing filled with much less of a cheap grease. But the grease fill slows the bearing down in the classic spin test, and this is why spin tests actually have very little to do with how a bearing performs when you put a load on it–and the forces going through the bottom bracket are much more significant than when you are just spinning the crank in the bottom bracket without a chain on.

This was a particular pet peeve for Jason Smith, founder of Friction Facts, who lent his incredible wealth of knowledge to this article. Smith said, regarding bearings:

"One thing that bugs the heck out of me is seeing somebody on YouTube tout the performance of their new (insert manufacturer here) (insert jockey wheel, wheel bearing or bottom bracket here) by making a video of the product spinning effortlessly and almost endlessly with no load. To make matters worse, the video is usually accompanied by a title like 'Friction free xxx bearings versus stock bearings.' This is very misleading in my opinion. For the most part these demonstrations are really testing the viscosity of the bearing grease (or lack of it). These spin tests do not relate to the performance of the bearing under load, which is where the efficiency counts. But it sure does look cool to see the product spinning away.

"I can take a top-performing low-friction bottom bracket, pack it to 25 percent with medium-viscosity grease, and do the no-load spin test. The cranks might spin a turn or two. I can take a low-quality, higher-friction bottom bracket, a BB with sloppy tolerances, with not-so-good ABEC numbers, and remove the grease, and do the same no-load spin test. That bottom bracket would spin for what seems like forever. The low-quality BB would spin and spin, but ultimately it would be a very poor choice for race day.

"We specifically saw this with a full ceramic pulley, which was provided to Friction Facts for testing. It was a beautiful thing to watch them spin in our fingertips. But when we put the pulleys in the test equipment and applied load, they performed in the bottom-third range of all pulleys tested. The takeaway for these spin tests: unless the bearing is tested under load, the bearing is not really being tested."

Ironically, given how relatively simple drivetrain components can be tested under real loads, objective data was very hard to come by for a long time. In spite of the fact that you can build an entire testing environment for less than the cost of a single day in the wind tunnel, no one had ever actually done it–until Smith did it. He was tired of the hyperbolic claims made by various component and lubricant manufacturers, and so when the opportunity came to leave his full-time job to become a stay-at-home dad, thanks to the support of his wife, Jason decided to build the lab he'd daydreamed about during training rides.

Smith says of the lab: "I thought of the idea for a testing lab back in 2011 while on a bike ride. Product descriptions such as 'the fastest,' 'the most efficient,' and my personal favorite, 'virtually frictionless' are thrown around with no basis. With so many subjective product claims being presented as fact, I thought it would be neat if an unbiased independent lab existed that would test drivetrain products and provide the results to the public, à la Consumer Reports. A cyclist or triathlete would be able to get fact-based frictional loss data regarding drivetrain components, bypassing the often-subjective marketing hype, and use the friction data as a tool for product selection. The initial testing involved analyzing chain friction. It was exciting to see the early test results showing differences in frictional losses between products. Based on those early results, I had the second generation test equipment fabricated professionally, began testing various components, created a website, and then provided the data for sale as it was produced. This was the beginning of Friction Facts."

It was a boon for cyclists. I have never seen someone who had such an immediate effect on the industry. Smith has been thanked and mentioned in virtually every article on drivetrain friction—and with good reason. I couldn't have written this article without the work that he has done at Friction Facts and his willingness to share that information here. What was really remarkable was how much you can deviate from that "ideal" efficiency number for a chain drive system. The simplest thing is keeping your chain clean and lubricated. That's it. But how many of us are as diligent about that as we are about something like pumping up our tires? As Smith said, "Many people probably know this, but I feel it is often overlooked. I wish racers would appreciate the basic importance of racing on a clean chain and using a high-efficiency lubricant. I feel often a racer will focus on the fine details of small watt savings, such as component upgrades, which are definitely crucial as discussed earlier, yet miss the big picture of general watt-savings practices that can provide a big bang for the buck."

Chains themselves are all pretty similar in their construction, and while there is some variance between the big ones—Shimano, Campagnolo and SRAM—it's quite minimal. What is not at all minimal, however, is the effect of different lubricants. Factory lube is inevitably the slowest, but that's partly by design. Factory lube has a lot of roles to play beyond just being fast. But if you want the best, you need to optimize your chain. And doing so can result in some real savings.

As a reference point, 1 watt equates to roughly 30 seconds of time savings over the course of an Ironman bike leg. There's more to it than that, but that's a useful rule of thumb to help you see just how big a difference this can make. Smith created a special recipe—a sub-business called UltraFast Optimization (UFO)—for tweaking a chain that resulted in savings as high as 9 watts (yes, five minutes over an Ironman, just due to your chain). And that's compared to a clean chain... He recently sold this part of his business to CeramicSpeed, which makes bottom brackets and jockey wheels with their outstanding bearings and also provides ceramic bearings OEM to many wheel makers as well. The UltraFast Optimization process is fascinating, and UltraFast chains provide a real benefit, as seen by the large number of pros who use them. My favorite part is that every chain lists the exact savings the UFO process gave you over the chain as it came out of the box.

> "When all of the non-chain aftermarket component savings are added up," Smith says, "the total is approximately 7-8 watts."

I asked both Smith and the team at SRAM why the manufacturers don't produce a chain this way from the start. One reason is certainly durability. A factory lube can often go 1,000 miles or more in good conditions. The UFO treatment breaks down after about 200. Furthermore, the team at SRAM explained that the factory lube is also part of the assembly and manufacturing process and there are, as you might expect, a lot of other concerns besides simply making the lowest-friction chain. But not for Smith. If you want a race-day-only chain, UFO chains are great options. But you can also use a lot of the information Smith provides on Friction Facts to do your own lubrication more intelligently. I have UFO chains for Ironman, but for all other races, I get most of the way there with my own equipment. I bought a cheap ultrasonic cleaner, a slow cooker, some mineral spirits, and some Molten Speed Wax (the fastest lubricant out there, though it's a bit labor intensive), all available on Amazon for about the cost of one UFO chain. And, of course, I very much enjoy having some new toys.

While the chain is the obvious point of focus, optimizing with a good bottom bracket and jockey wheels can also offer up some real savings. Smith explained: "When analyzing individual drivetrain components, the power savings from the chain are greatest. It can save much more than aftermarket pulleys, bottom brackets, oversized pulley systems, wheel bearings and pedals. However, as with any marginal gains, when the power savings of the non-chain components are combined, the total savings can get close to the chain savings. For example, 6-8 watts of savings can be realized from the chain. A high-efficiency pulley set will save 0.9 watts compared to a base-level groupset. A high-efficiency bottom bracket will save about 1.3 watts compared to a base-level groupset. Pedal selection can save typically under a watt. We have not formally tested wheel bearings, but based on the results of the existing Friction Facts bottom bracket and pulley bearing tests, and the given loading and rpm of wheels, we speculate that upwards of 2-2.5 watts can be saved per wheel with a high-efficiency set of bearings. When all of the non-chain aftermarket component savings are added up, the total is approximately 7-8 watts: about the same as the chain savings."

The specifics of what particular components are fastest are available on the Friction Facts website for only $14.95. The majority of the data on lubricants was published by VeloNews and is easily available on the web.

What's truly astonishing about this is just how big of a difference it makes. A savings of 10-20 watts just in the drivetrain? I never would have believed it. But the data is there, and it is compelling. Maybe your best Ironman bike split really is just a faster drivetrain away.