



Behind the Wheels Podcast Transcription

Episode 9: Aluminum vs. Steel Wheels – An Age-Old Debate

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You're listening to Behind the Wheels with Doug Mason, Dave Walters, and Mike Yagley. This is a show where we talk about heavy truck and medium duty axle ends. Doug, Dave, and Mike bring close to 100 years of experience and expertise in the transportation business.

Join us once a month to learn new things about axle ends. Sponsored by Alcoa® Wheels, the global leader in aluminum wheel innovation.

MIKE YAGLEY

Welcome to another episode of Behind the Wheels. I'm Mike Yagley.

DOUG MASON

I'm Doug Mason.

DAVE WALTERS

And I'm Dave Walters.

MIKE YAGLEY

Today we're going to have an episode on question that we get a lot around here. It's the differences between steel and aluminum. And also, we're going to be touching on different kinds of aluminum wheels. We'll be talking about the differences between forged aluminum wheels and cast aluminum wheels. This is sort of our wheelhouse for pun there, but this is exactly what we spend a lot of time talking about, lot of time explaining to customers. What are the differences? What are the advantages? What are the disadvantages of each of these wheel manufacturing technologies? So, we're going to just dive right into it and let's get started. So, let's start out with steel wheels. Dave, you want to talk a little bit about steel wheels?

DAVE WALTERS

Steel wheels are the dominant wheel in North America trucking. They are by far the most popular and the main reason of that is cost. They're very prevalent in the market. Now on a steel wheel, the way they manufacturer steel. Well, there are actually two pieces, there's a rim and then there's a disc. So, a steel wheel is basically welded together with two pieces and that's how they make a steel wheel. Then they basically now they powder coat the wheel to paint it. And again, it's steel and then they drill holes and it's very simply made for the market. And that's why they are very inexpensive or cost wise to the general public.

MIKE YAGLEY

Now, Doug, you spent some time making cast aluminum wheels. Maybe you can tell a little bit about the cast aluminum wheel manufacturing process.



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DOUG MASON

Certainly. Yeah. Cast wheels, steel wheels, forged wheels, all wheels, fun to make. Cast wheels was the first part of my career and cast will, they're very interesting. They basically like making jello, if you want to think of it that way. Very simplistically, you're going to create a liquid that you're going to pour into a permanent mold or pressurize really. That's the main process nowadays would be a low pressure casting they call it, well where they'll actually put pressure onto the bath of the aluminum middle, then go into the mold against gravity. So, that is then put into a permanent steel mold. It has multiple pieces on it. Once that it has cooled, then obviously you open the mold, you extract the part, and then it will go through other processes that we'll maybe discuss later on advantages and disadvantages, where it is, goes through an x-ray process or it's looking for particular defects.

DOUG MASON

And then it'll go through typically a solution and an aging process. And we'll hear a little more about that. Forgings do a similar process. They call it age hardening. And that's how you get the strength in any particular aluminum alloy that is age harden-able. And then once it's done with the aging process, it'll go into a machining center where they then turn it and mill and drill until you get to the final shape of the wheel. And at that point it will typically be painted many different colors and in some cases, even polished. We can talk about some of the advantages and disadvantages of trying to polish a cast wheel versus a forged wheel as we go through here as well. But that's very simply the process of how a cast wheel is made.

MIKE YAGLEY

So now I'll take the forged wheels. We start out, when we're making forged wheels, we start out with a bar of aluminum. We cut it to size, and then we put it into forge press and there's a blocker. And then there's a finished press. It's like a multiple forge press operation. And so, you start out with a blocker, which makes the wheel into a disc basically. And that starts out, takes that piece of aluminum, makes it into a disk roughly. And then you put it into the finished press, sort of builds up, we call it the skirt, the rim section a little bit, but not completely. And then you put it in the final forging operation, which gives it the shape that looks closer to a wheel, but it still has a lot of additional metal on it. And so, there's an extra metal coverage.

MIKE YAGLEY

You take that forging, this raw forging, heat treat it like Doug was saying, the same thing that they do with castings. That's where it really gets its strength. So, you still have one piece of metal that has all this strength in it. And then you send it to the machining and in the machining, they mill and drill it. They get it to the shape of an aluminum wheel, polish it up, whatever needs to happen from that point forward for the customer. That's one piece of metal. That's one solid piece of metal that you're working with there. So, that's going to come into play. Like Doug said, we'll get into this a little bit more. That's going to come into play with all the different benefits that you get from aluminum wheels.

MIKE YAGLEY

So now that you have an understanding, a basic understanding of the way these three different wheels are made. Steel wheels, I'm just going to go with steel wheels are welded together. Two pieces of metal, two pieces of steel that are welded together. Cast wheel, it's like Doug said, you just pour liquid aluminum into a mold and then that cools and you sort of build up your wheel that way. Or forged aluminum, you start out with a solid piece of metal, heat it up a little bit, but not to melting point. And then you have this solid piece of metal that you're working with through the whole process. Those are the three different ways of making wheels. And those you'll start seeing how that plays out and the different advantages and disadvantages as we move forward. So, let's talk about the advantages of each of these different wheels. Doug, you want to talk a little bit about the advantages of a cast wheel?

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DOUG MASON

I can talk about the advantages of the cast wheel. It kind of falls in the middle between steel and aluminum relative to cost. So, there is a bit of a cost advantage to going to a cast aluminum wheel over a forged aluminum wheel, but it would be more expensive than a steel. And also, some of the advantages that you would have is in the processing of it. It's, I'll say not cheap to set up, but the basic cost to set up a low pressure cast plant would be definitely less capital investment than a steel wheel plant or a forged wheel aluminum plant. From a mechanical property standpoint, it actually has the lowest mechanical properties, but they would be sufficient to do a passenger car light truck, and maybe even some medium duty applications from that perspective.

DOUG MASON

The greatest advantage really to the cast aluminum is the cosmetics that you're able to obtain. As you can imagine, if you're pouring a jello into a mold, you can make it anything you want. And that's what a lot of the passenger car light truck wheels, you'll take a look. They have all these fancy curves and designs and you can do that with a casting, whereas trying to do that with a steel stamped or even a forged aluminum, although you can do it in a forged aluminum, the cost becomes extremely high at that point. So, I'd say that that's the greatest advantage is its flexibility and styling.

MIKE YAGLEY

I'm going to just take a moment here and sort of define what mechanical properties are, because I think that's a big part of this discussion and we'll be touching on that a couple of times as we talk. There's a few different mechanical properties, but the one that I want to talk about mostly here is elongation. Elongation is, we'll say the bend-ability or the brittleness of the material. And so how easily is that material elongated. There's real brittle where you're willing to try and pull it apart. It's snaps right apart like a piece of ice where it doesn't give very much, or it doesn't have a lot of elongation like a rubber band or something. And elongation the higher elongation you have, it's basically the ability to recover from some sort of stress. And that's going to be a big part of this discussion. And so, when you say that mechanical properties are a little lower, what did you mean by that?

DOUG MASON

We would talk about it typically in terms of like yield strength or ultimate strength. If you were to pull something apart, let's just look at it that way, the amount of load that you have to use or force you have to use, ideally, we would say stress as you pull it apart and it'll start to get to a point. If you had a spring, obviously you pull it and it goes back to its original position. And that in itself, there's no permanent deformation that has occurred. But once you pass a certain point, you now have a permanent deformation. That's where the elongation comes in, that you were talking about.

DOUG MASON

And as you continue to pull, you're obviously going to break the part. And so, the amount of the mechanical properties is really how much load can you hold for the cross section of material that you have, something that is extremely strong. Maybe you only need a quarter inch diameter to hold a certain way, but then you go to a material that has more mechanical properties. Then you can imagine, you need to have maybe an inch or two inches of that to hold that same amount of weight. I don't know if that helps explain it better, but that's what I mean by mechanical properties.

MIKE YAGLEY

Very good. The biggest percentage of cast wheels is going to be, the biggest advantage is of course the form of quality. You could make it look however you want. It's going to look great. That's why they hold up pretty good with large loads. And they're relatively cheap. It's a perfect fit for an automotive application, but those mechanical properties start getting to be a problem. Those lower mechanical properties start to be getting a problem on a heavy-duty application. What about steel wheels?

DAVE WALTERS

When I talk about steel wheels, the first thing that comes into your mind is the cost. Being the lowest cost wheel in the market, that's their big advantage. If you talk to a lot of the fleets, they'll tell you the other big advantage of steel wheels is they don't seem to be stolen very much because they're very low cost and it's pretty much the industry standard. So, you don't have to worry about anybody stealing your steel wheels, because that's not what they're going to do. So, when they have a lot of trailers in the drop-in pick, and that steel wheel looks pretty good because you don't have to worry about somebody taking the wheels off. So, it's really cost. And like I said, you don't, I've never heard anybody stealing steel wheels. Now they might steal the wheels, get the tires if they're good, but most trailer applications, the worst tires they can find. So, that doesn't happen. So, it's really a cost factor.

DOUG MASON

Dave, just a quick comment. I think you noted that the largest volume of wheels would be steel wheels. With that, if we break that down between trailer and a tractor, don't we see basically a very high penetration on the trailer per what you were saying. And the fact that there are basically a two or three to one trailers to every tractor out there. But then from a tractor perspective, is this not a higher penetration of forged aluminum wheels than steel wheels? Is that correct?

DAVE WALTERS

Yeah, absolutely. I mean the higher penetration of aluminum wheels on the tractors, and there's a reason because there's normally one driver per truck and that truck is like maintain where, when you're running. Most of these companies are running three, four or five trailers per one truck. And if you're dropping and picking and have trailers everywhere and every lot and every place, that's really where the steel wheel shine is, in the trailer market.

MIKE YAGLEY

All right. So, really the big advantage for steel wheels is cost and the antitheft benefits are really a fallout of that. Anybody want to take the advantages of forged aluminum wheels?

DAVE WALTERS

I can do that. I always tell every training session I do. I say, look, I'm not a professional sales guy, but I'll tell you why you should buy aluminum wheels. And the first thing I always tell them, and it's actually the strongest wheel because it's a forged aluminum wheel in the market, and it's also the lightest wheel. And those are two big advantages for most of the customers that we deal with. They want strength and they want lightweight. Forged aluminum wheels can do both of that.

MIKE YAGLEY

One of the big problems we have, and I did a lot of traveling overseas and I had all sorts of problems where people would look at aluminum wheels and equate them to aluminum cans that you could crush with your hands. And they didn't quite understand what was happening there. That aluminum just because its aluminum is not weak. And we had to pull out some data. We're getting back to those mechanical properties; the benefits of the mechanical properties are forged aluminum wheels make them unbelievably strong. It has the high yield strength that Doug talked about. It has great elongation, so it bounces back to its original shape pretty easily. And so, what you end up with is these wheels, like Dave was saying where they're very light and they're very, very strong. As a matter of fact, we see, and Dave you might want to talk a little bit about these high load applications that are flipping to forged aluminum wheels for exactly that reason.

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DAVE WALTERS

Yeah, I mean, it's funny, I'm sitting here in my office and I'm looking at like a cold truck in Pennsylvania. And when I remember the... I have the picture of the very first one we converted and now I don't know one in Pennsylvania and a lot of the coal hauling States that don't have aluminum wheels on all their trucks. And that's a very heavy application and the severe application they're going off road, they're going on road. They got a lift actual they're picking that up and aluminum wheels just standard now so we do really well and severe applications that are lightweight so they can haul more payload. So that's really like some of the big advantages. Then we get into because they are fully machine the run outs in the balance of an aluminum wheels, tremendous compared to a steel wheel.

DAVE WALTERS

So we get into to those issues that this great aluminum can also dissipate heat at a better rate than what steel can. So, you can dissipate the brake heat and get it away from the tire and that. So, a lot of transit bus industries would do heat studies. The difference between aluminum wheels and steel wheels, and found out that certain tires were getting so hot because of the steel wheels. So, they went to aluminum wheel as a general spec. So, I mean, the dissipation of heat is a thing that most people don't think about. And there's some great advantages of aluminum wheels where the steel wheels, when you get into refurbishing costs, it used to be a lot cheaper. Powder coat paint is not cheap to refurbish a steel wheel. Aluminum wheel you don't really have to ever refurbish it. So, I mean, there's a lot of advantages on forged aluminum wheel.

DOUG MASON

Yeah. You've made up another point, Dave, that we didn't talk about really for forged aluminum. We kind of mentioned in cast, you get this the cosmetic benefit in terms of shape, but forged aluminum wheels are typically made out of 6,000 series alloys, which when polished bring a very bright shine. And so, for the customer who wants that bright bling look on their vehicle and all that, we have different tastes out there obviously, but this is one product that will allow you to give it that high look and that high shine. And I think that in some ways is part of the reason why there's like a better resale value typically with the aluminum wheels. The fact that they are aluminum and maybe they're worth more, that also gives you a good resale value on the truck and the way it looks. But there is the cosmetic portion that is a good advantage for the forged aluminum wheel as well.

DAVE WALTERS

You touched on the resale because I do a lot of dealerships and they'll tell you that the aluminum wheels maintain. There's not a second owner that comes in and I heard it best the one time. He's like, look, the second person buying that truck is so important now, but as aluminum wheels, they're getting some value out of that. The payback is tremendous because it holds the market. And these guys want aluminum wheels when that second. So, resale is a giant value with aluminum wheels.

MIKE YAGLEY

One of the things you brought up that is counter-intuitive to a lot of people is the heat benefit. And so, I want to talk a little bit about that and just my experience with heat and aluminum wheels and steel wheels. We did some testing years ago. And Dave, I think you were part of that, where we put thermal couples all over the wheels, we get a lot of start stop, and I believe it was a trash hauling sort of application. And what we saw was that the steel wheel held onto that after they parked the vehicle. The aluminum wheel was able to dissipate that heat very quickly, that built up over the course of the day. But the steel wheel held onto that heat even after the vehicle stopped. And you saw that heat, the temperatures rise in the lot. And so, the tires and everything was just sitting there cooking out in the lot because the steel wheel was not able to give up that heat very quickly.

MIKE YAGLEY

And one of the great things about aluminum wheels is they do give up that heat very quickly. And so, you end up having a better overall system. It all comes down to heat damage to anything as a matter of time and temperature. So, when you're sitting there, when it's sitting there cooking in the lot after a day of running, that's going to cause problems. Like I said, it's a little, everybody knows that aluminum transfers heat better. And so, a lot of people will say, hey aluminum transfers heat. It's going to seem like it would get hotter than steel. It's going to take that heat away from the breaks and everything else that's happening very easily. Why do you say that heat is a benefit? And it really, the big benefit is when it's sitting after it stops and it's sitting in the lot cooking. And the aluminum doesn't cook, it gives up the heat real quick and the whole system is cooled down relatively fast.

DAVE WALTERS

I mean, I've done over my 32 years here, every heat study that we've ever done with the transit and with the waste haulers and the reason that they're so [inaudible 00:19:44] an average waste truck and residential stopping six to 700 stops, every thought. You're out in Phoenix, Arizona during the summer, you're going to have some extreme heat just to start with and then stop that truck that many times. So, when we did these, they were basically going through tires because the tires got too hot and they cut the bead. So, a lesser degree of wheel basically will save tire life for these refuse haulers, and same with the bus transit because they're stopping like that. So, a normal over the road truck, doesn't near have the brake heat. We can say, Hey, coming down out of the Rocky Mountains, you might heat up, but those guys are every day, just stop and go, stop and go. So very useful industry.

DOUG MASON

And that was to your point, Mike, you were saying basically about the conductivity and how rapid the aluminum can conduct the heat. I think I was looking at those studies, Dave, and it was interesting is that the steel obviously is it begins to heat up and the stops continue to go. It can't reduce the heat as quickly as the aluminum. And so, its peak temperature was always higher than that of the aluminum going through the same run. In addition to what you're talking about, Mike, where, when it stopped it continues to rise or hold the heat as well for a longer period of time. So, you had a peak temperature situation as well as the time. And you would note its time at temperature, which really creates damage in components.

MIKE YAGLEY

So let's talk a little bit about the disadvantages of these different technologies. Who wants to take on cast, the disadvantages of cast?

DOUG MASON

I can do that. That's again, my field from a previous life. And really the disadvantages we said, one of them would be, it is the lower mechanical properties, but it's adequate for the usage that it's intended for typically. But what you run into and why you can't get into the higher loadings with a reasonable weight is because in a casting situation, you have what they call casting defects. You get porosity and there's ways to mitigate that, but you always have some porosity. You always have some inclusions and these things reduce the fatigue life of a component. So, there are incongruities, we'll say within the material that can be reduced. And there's many ways that it's done. I used to work on how to create a inclusion free casting, which is not possible, but you can really improve them. But they still come in at a lower, basically mechanical property and a lower fatigue, strength or fatigue life component.

DOUG MASON

And so that would be the main disadvantage to the casting because you can get everything else. You can get a pretty high polish, it's not as high a polish or a higher luster that you would see in a forged aluminum. The 6,000 series just has more copper. It has a better ability to shine, but you can make them quite shiny. And then you can obviously paint them any color with all contrasting colors. And you see that in the vehicles today, two tones and they get into claddings and partial claddings and all these unique things that they do. And they pass car and light truck, which when you get to the heavy truck, basically we really want the lightest that we can get for the lowest cost, the best benefit and the brightest. So, that would be cast wheel disadvantage basically.

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MIKE YAGLEY

One of the big disadvantages I've seen with cast wheel is impact also in that comes those mechanical properties we talk about so much. Then there are some tests that are industry tests, where you basically just have the wheel sitting on the stand and you drop a load on it. You drop some sort of weight on it. And when you do that with a forged aluminum wheel, it'll bang it up. But the wheel pretty much keeps its shape. It doesn't really have too much trouble with it. I don't think we've ever failed that test. It's a very easy test for us to pass I should say.

MIKE YAGLEY

The cast wheels, when you do that same test, they just explode. We did that test with some wheels and it was one of the earlier ones that we did years and years ago. We dropped this load onto the wheel and pieces of the wheel were flying out into the parking lot of the test lab. They went 30, 40, 50, 60 feet away. Luckily, we didn't hurt anybody. And luckily, we didn't destroy any cars with those wheel parts that were just flying everywhere. It was like a bomb went off and that's one of the big problems with cast wheels is that impact resistance. They just don't have it. And that's something that is very dramatic to see.

DOUG MASON

Yeah. And let's make sure we clarify this. We're talking in the heavy truck industry, and we're talking about extreme weights because in the past car light truck, they do have impact testing as well. And the ability for a cast will have passed those loads. It's capable. It's when you get to these very high loads that we need for the medium duty and really the heavy-duty market that what you're saying it takes place.

MIKE YAGLEY

Right. Yeah. I don't mean to strike fear into people about their auto wheels. There's no concern there, but when you get into those high loads that we're seeing in the heavy truck industry, then impact resistance of a fast wheel really becomes an issue. So, let's talk a little bit about the disadvantages of steel.

DAVE WALTERS

When people talk about steel wheels, they always talk about run outs. And run outs because you're technically welding two pieces together. The run outs are so much greater than what a forged aluminum wheel is. That there's a big difference on run outs. And so, people will always say, well, what does that mean? Well your steer tires are your most expensive that is on the truck. And do you want them actually running as true as possible? Well, with a steel wheel that's run out is definitely an issue. So, we talk about run outs. Then we get into the refurbishing because we live in a very corrosive world because of some of the deicing equipment and solutions that they use. Unfortunately, with steel you're going to have corrosion and then you're going to send it out to refurbish shop. So, you have the cost. And when you go talk to the fleets and you keep saying, here's the cost of this mounting up, I mean, you can run the numbers and say, wow, if I'm going to keep that wheel for a certain period of time, it's just doesn't cost justify having some of that.

DAVE WALTERS

So those are some of the bigger issues, disadvantages of the steel wheel. And the weight, I mean, it's a very heavy. They've done a remarkable job taking weight out of steel wheels, but it's still so much heavier than the aluminum wheel. You can add up some pretty good weight. So those are some of the big disadvantages I see.

MIKE YAGLEY

Really have to tip your hat to the steel wheel guys. The weight they've taken out is remarkable. They've done a great job there. Even with the work that they've done, it doesn't approach aluminum, but they've done a lot. Understanding the technology that goes into that, it really is remarkable. The one point I want to bring up was the run-out. We did some testing years ago, we showed the run out of aluminum wheel versus a steel wheel. If you can imagine, the run-out is basically a measure of how round a wheel is. And so, what this test did was it measured a circle. If it was a perfect circle, it would be a perfect wheel. And any variation from that, any place where the wheel got a little bit out of round, the lines sort of wandered from that perfect round one. And when you looked at aluminum wheel, a coal wheel aluminum wheel, it was perfectly round.

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MIKE YAGLEY

It was tiny variation from the perfect round, but when you put the steel wheel, they measure the steel wheel. And this was a well-made steel wheel. This wasn't a Chinese, there's some really bad Chinese steel wheels, but this is a pretty well-made steel wheel, but it still looked like it was a flower or something. It was all over the place. The line was coming in and out, in and out of that perfection. And that comes down to like Dave was saying, the welding process. It's very, very difficult to maintain that perfect roundness when you have to weld these two pieces together. That's what they were struggling with and that's why it has that run out problem. Who wants to take on the disadvantages of aluminum wheels? Doug, you want to touch on that one?

DOUG MASON

Yeah. And add another comment to that. Maybe we'll get into it for the steel wheel. And I think you mentioned a little bit of this from a maintenance perspective. The painting of a wheel, obviously it can be in chip or to rust, and that creates issues in the mounting surface. So there needs to be attention paid to that area of a steel wheel in more detail. And like you were saying, Dave, it creates the need for the refurbishment over time that has to take place. In an aluminum wheel that is much reduced, but there is still a need to maintain wheels in general, to take a look at how there, whenever they're mounted, dismounted, whether they have the tires removed, you do an inspection, you do a review.

DOUG MASON

And so, I guess a disadvantage would be that it's not perfect and you still have to work on it, that would be a disadvantage. But I think the greatest disadvantage, unfortunately, and we continue to work on this all the time is the cost of a forged aluminum wheel. It is the most expensive. And that has to do with all of the processing variables for doing a forged wheel, the capital that's involved and the cost from the polishing or the finishing perspective. And so that would probably be one of the biggest disadvantages for the forged wheel that we're always working with and trying to offset with the advantages, obviously that we see in a forged aluminum wheel.

MIKE YAGLEY

I think that covers it, everybody. So, talked a little bit about the different manufacturing processes. We talked about the advantages of each one of these technologies and the disadvantages. Hopefully with this information, given your specific situation and what you need for your application. I'll be frank, like we said, sometimes the steel wheels make the most sense if you're in a trailer application, sometimes that's going to make the most sense. Other times aluminum wheels are going to make the most sense and like an automotive in some cast wheels make the most sense. So hopefully we've learned a thing or two when this is, what's best for what situation. If you have any questions, drop us a line. You can catch us on the Alcoa wheels website. I think that's all we've got for today. Thanks for joining us. We'll see you next time.

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