The Additive Effect Episode 2

Created to provide forward-thinking for orthopedic organizations with leading edge information and to join in the ongoing conversation of additive manufacturing.

This is the Additive Effect.

Hello, everyone, I'm Brian McLaughlin president of Amplify Additive. We're here for our second episode of the Additive Effect, and today we're going to talk about materials, you know the premise of this show is really to always think with the end in mind, you know, and our end product really is an implant, but it's really the patient we always think about. But in order to get there, you know, we have to deal with materials, certainly relative to additive manufacturing.

So with that in mind, our senior application engineering manager, Jonathan Buckley, is here with us today.

Ya, nice to here..

So before we dive into materials and additive and all that stuff, you know, I just wanted to make an introduction to you for everyone who's getting familiar with us in this show. You were really our first employee outside the original founders. That's right. Yeah. What an opportunity for us to get you. First of all, you know, I remember making the phone call to you and asking you I was really looking for an application engineer. Right.

That's why I called you in the first place. And it worked out that, you know, the timing was great.

Yeah. It's a great opportunity as well, you know, to be in the world of additive manufacturing, you know, be able to deliver great orthopedic products to our customers.

Yeah, absolutely. But so before we get into all of that, tell me a little bit about your background. I mean, you know, you're you know, how you got interested in material science. You know where that all started and really how you probably ended up in the world of additive. Let's hear a little bit about your background, John.

So I went to school at Worcester PolyTechnic student in Worcester, Mass. It's a primarily engineering school. My focus at that time was in mechanical engineering. I did my major as that. But however, at that time, I didn't really have a focus in terms of engineering and it tended to be relatively broad. There's a lot of different areas you can really target. So I didn't really have a specific focus when I was doing that, Major. I actually was lucky enough to get an internship at Sikorsky Aircraft down Stratford, Connecticut, during one summer.

And my mentor at the time, since I wanted to really get into focus in mechanical engineering, I had asked him if you could go back and to school and really have a focus in your bachelor's degree, you know, what would it be? And he immediately said material science and engineering, which I thought was interesting. So I asked him, OK, well, why do you say that? And what he told me was that really material science is one of those things that's not as focused on manufacturing as it should be.

There's a lot of aspects regarding mechanical properties of metallurgy, how you end up really planning for your designs that is really taught in the material science background and really the understanding of how fatigue life, crack propagation that really applies to a number of different manufacturing and professions. So when he said that, I thought that was quite interesting. You know, I think that, you know, that may be able to take a few classes of material science really was. So I took a few courses when I got back to school after that next summer, and I loved it.

I thought it was a great understanding. I focused mainly on stainless steel, plastics, a little bit of titanium as well. So then from there I went to get my master's in material science and went back to Sikorsky from there and worked on the materials in the past. The engineer.

Right. So you were with Sikorsky, obviously, your internship. You were there also post graduate and postgraduate for. For how long? For about three years. Great.

And then I moved from there to GE Additive, sorry, GE Aviation and I perform the same profession. I was a materials and processing engineer there. And after those two roles, which were mainly the heat treatments, plaiting thermal spray, a lot of post-processing, Shot peening that type of thing, I really started to look more at the industry, what else I could really be doing. I brought it and put a little bit at 3D printing. I mean, we had a little small 3D printer back at our school where 3D printing was slowly starting to get more traction.

You know, plastics, you know, especially around the early twenty, 2010 period. And then happened to be about Arcam opened a small little office in Woburn, Massachusetts. I just put an application in and I happened to get it. And I started my role as an application engineer at Arcam in late 2016. That's right.

And that's where we have a little bit of overlap, which I find really interesting. So I was you know, as you know, my background is with the DiSanto Technology as they partnered with Arcam after acquiring DiSanto in 2014. And so I was part of the manufacturing business as business unit manager at the time. That's right. So, you know, I parted ways in twenty sixteen, but there was a little bit of a lag in my parting of ways, you know, just some overlap.

And that's where we had a little. But overlap, isn't that I you? Yeah, I think my first time at DTI, I had walked in to do a little bit of customer support and I think I ran into you.

Yeah, yeah, yeah, yeah. It's so, you know, it's nice to kind of go back and look at that and see where we are now. Right. It's pretty interesting. So. Well, that's great. I mean, you know, materials are extremely important in the world of additive manufacturing. Right. Couldn't be more important, really. And when you think about the processes that we're dealing with and the different controls of those processes. Right.

You know, material science is the key. It really is the key to sort of start there. And, you know, that's what really excited me about your background and putting you on the team, you know, because my background is biomedical engineering. Right. So we have that somewhat covered the clinical side of the world, et cetera. You know, you and I both have deep experience on EBM, right. I have the early days of the Q10 platform.

You have the later days. And we both know we have the later days.

Right. Good days. The good days. The better days. Right. I mean, the machines have been behaving very well. Right. And I think in part that is the vision that we have here. Right. So the control, the environment, the consistency with the processes that we have here as a company. But I think it's you know, part of the success is certainly how we've built the team. Right. So, again, biomedical engineering, you have the material science, you know, obviously with our youngest employee, Andre, right, we work with on a daily basis.

Now, that's more the industrial design, obviously some digital marketing built into him, too, but so that we've got a lot of overlap here and now everybody's getting hands on with the machines, which is fantastic. But to have material science in that background is, again, extremely important for us. Yeah.

And that's what it takes. It really takes a lot of knowledge into not only the process but really the output. You know, one thing about the Acram systems is they have a big focus on titanium alloys Ti-64 for grade five to grade twenty three, which is also known as ELI. Those materials have quite a bit of applications in a number of industries. With us, we focus primarily on the medical device industry. But aerospace, automotive, there's plenty of applications that's really additive.

We can focus on titanium. It's really fun and really great stride in that. Right. Right.

So titanium is and I love to reference, you know, some of the videos that people can go look up with regards to, you know, how additive manufacturing is applied in the industry. And one of my favorites, you know, it's not medically related, but the video that we did with GE Additive, right. And they talk about titanium as this holy grail of material. Right. And that just that part of the video stands out for me.

Right. And primarily because of what they're trying to do. And titanium in itself has historically been this expensive, you know, exotic material. It's really how it's classified. Right, in many ways. But I mean, you and I deal with it every day.

Yeah. Oh, yeah. On a daily basis. And in terms of how we turn over machines from powder build products, yeah.

I'm almost thinking we step outside this building, you know, and people are like, oh, what do you do for a living.

They're like, oh well we 3D print titanium orthopedic implants and they just like are right in the blow people's minds. I had that reaction yesterday talking to someone. They're like, you have an amazing job. Can I come visit? Right. It's very cool stuff. Right. I think another piece of that video that I love and we talk about often with regards to what we're able to do with orthopedic implants, and certainly that's obviously not a flat surface in the body.

Right. So we're dealing with designs that, you know, we want to have a level of design freedom for so we can optimize the designs for better outcomes for patients. Right. So ultimately, we're talking in many ways we're talking about fusion for certain implants, you know, eventually going into probably more mobility, you know, but obviously a combination of multiple components in the body will provide that mobility for patients, for total knees, total hips and shoulders, things of that nature.

But design freedom is important, right, for what we do. But it all really starts with the materials. That's right. Right. So talk to me a little bit about, you know, so for us, our materials are powder. It's titanium powder. So talk to me a little bit about, you know, the importance of powder in the process and characteristics of the powder or powder in general, powder.

Not only he's creating the parts in general and for me our parts, but it's also in the process of additive. We're actually creating our material properties at the same time. So typically, if you know traditional manufacturing, you would have a casting or maybe a forging and then you would perform machining for the machining on there in order to get your full part. But the casting house or the forging house would provide you with cert. The cert would tell you the material properties, the grade, the chemical composition and such like that.

With additive manufacturing and because we're using powder and we're manufacturing our parts layer by layer, we're creating all our material properties from the machine. With that, there has to be a strong focus on the powder characteristics. The flowability, the sphericity, the chemical composition, those are highly important in our process. So, for example, let's talk about the sphericity of the powder, the powder that we utilize that powder in general needs to be as spherical as possible, depending on the powder size fraction in order to use it properly.

The reason being is porosity. Let's say your powder is not a spherical as it can be. Let's say you have powder that is more square or has more edges. When you're laying down a powder layer, that's where you have an issue. You have an issue where your powder layer isn't forming as even as possible. And you have maybe these minor gaps between your powder particles. that when you send that melting your layers, you end up being a lot of gaps in between your powder particles that introduce porosity on your finished product.

There are ways to remove that porosity, but how to get the best quality? For your part, you really want to have your powder as sphericity as possible. So, so sphericity it is important. So that leads to probably where you're going to talk about or you mentioned flowability as well in that discussion. But you know, so, so why does it impact, you know, for an Arcam. Right. And I mean, I know the answer here, but I want you to describe it, you know, and especially with how the system configuration is.

It's gravity-fed right at the end of the day. So you want to explain how that works? And again, kind of just revisit the importance of, you know, the sphericity and flowability.

Yeah, sure. So Arcam is a powder bed fusion process. The idea is that we will bring the table down by a specific layer thickness. We will make a layer of powder across that plate. The electron beam on the Arcam systems comes down and melts specific cross-sections of your part. The machine will then bring the table down by another layer, rake another layer of powder and repeat the process. So the key function of that operation really is how you're coding your powder layers.

If your layers are thicker or thinner, if you have humps, if you have a lot of gaps between your powder particles or not, never goes in space, the quality of your powder that you're using. If your powder, for example, isn't as spherical as it can be, you may have issues in the way the machine will be raking powder across the powder. But you may have to choose between gaps and more gaps between your parts of powder particles, which can also translate when you're melting to more pores within your parts, which is detrimental and can be contributing to a weakened fatigue properties or weakened mechanical properties.

So really, choosing your powder manufacturer, choosing your powder quality is very important in the manufacturing process for Arcam systems.

Yeah, absolutely. And I think that's where, you know, early on with Arcam and you know what they did and they acquired AP&C materials that were extremely important to, to make sure that you have a top line powder. Right. And so what that's really translated for the Arcam systems is, you know, a density greater than 99.8%. And so I think what's interesting is a lot of people talk about porosity for additive parts.

But when you actually compare that density to traditional off the shelf bar stock, it's superior. So that's kind of an interesting thing where I think the idea of additive, you have so many problems with so many processing problems, et cetera, but we're actually beyond material that we are so used to using. Exactly. Know as far as overall density. And then you add on top of that the flexibility and the freedom of design that we're able to apply.

Right. Those are extremely important aspects of additive manufacturing.

It's also important to just really talk about where we are for the technology and then and then maybe what we're going to do so that maybe we segment nicely into the future of the industry and how we see it. So, you know, I mean, the systems themselves are improving. We've seen that firsthand with the Q10 plus. Right. Laser systems are continuing to improve as well. And they're mostly improving while they're improving by adding laser systems or lasers on their systems are going from one laser to lasers to four to et cetera.

Right. Because that's how they get faster. It's a little bit different. Where electron beam is managed primarily by electronics are extremely fast. Right. Multibeam technology. Right. We’re an order of magnitude faster than laser, but they're different. Right. You know, laser gives you know, the resolution that's a little bit better as opposed to the EBM. But in fact, EBM is better for fusion, for orthopedics. Right.

There are different technologies. They have different benefits. The way they are heated, a way that they cool down, especially if, you know, that can affect the number of post-processing steps. For example, you know, EBM, you have less residual stresses due to the tempering that is going on after every layer is performed. Laser, you know, at room temperature, going to the melting temperature straight down to room temperature requires an initial heat treatment in order to remove the residual stresses.

So the way they get to the end product between the two is quite different it is. We've talked about this in the past when we had the First to 50 idea, right. And that really has to do with the First of 50 acetabular cups. Right, acetabular cups, this is a component that's used for total hips. Right. This is one of really four components that go into a total hip. Right. So this is traditionally this is a product that gets cast.

So you have to design the casting one. Right. And that's for all your different sizes. And you go typically from maybe a forty-two millimeter cup, up to maybe a seventy or seventy two millimeter cup, depending on how big the range is for the company. So you have to develop your castings for each of those sizes. So that's an expense to begin with. Then you have to cast your part, then you have to machine your part and then, you know, traditional orthopedics and I say traditional, but, you know, historic pathway would be then you would coat it with whether it's HA coated, coated TPS, which is titanium plasma spray or bead coating historically as well, which is I don't know if anybody's ever doing that anymore.

But that's you know, there's a history there. Right. So when you get your product cleared through the FDA, you tend to not want to change the process if you don't have to. Right. You just want to focus on sales. So additive, I mean, removes the casting process. Right. And removes the coating process because you're actually building the coating on your part. Right. And then and then obviously the flexibility of this cup right here, we actually have two different lattice structures designed into it.

Right. And no one is really optimized for making contact with the cortical layer. And then the others are kind of optimized for making, you know, contact with trabecular layer. Right. So far as bone goes, there's a lot of flexibility with which you are able to do there, you know, in the world of orthopedics, which is beautiful. Right. But, you know, material properties are there time the market is drastically reduced, you know, for what we're able to do.

Right. So it's extremely important. But, you know, this is with materials that we know of today, with processes that we're comfortable with or getting more comfortable with, I suppose. Right. I mean, what does the future of the industry look like?

Let me ask you that. Well, in terms of materials for additive, one of the really big benefits you get for adding manufacturing is how you are creating your end product within the machine so you can change your powder. So really, the benefits of using titanium powder are that you can put different elements to get different benefits to then result in mechanical properties or end microstructure. You could also even change that process as a whole. So, for example, my beam scanning strategy, maybe I can optimize it and tailor my microstructure to be more resistant to loads in specific directions to optimize a beam specifically for the design.

So really we've added manufacturing and using different types of powder and optimizing the machines as a whole and those laser scan strategies I can really optimize the end product and improve. Right now. I think we generally have a general process in how the machine will develop and manufacture parts from small parts to larger parts. But being able to tailor it specifically for specific design is really what the industry eventually will go.

So, you know, software plays a huge role in that, too, right. So when you think about, you know, how we design that up front with the idea of those properties in mind, I mean, what you're really talking about is almost non-linear, right, with regard to material properties, that that becomes a pretty big challenge, especially for computers and software. And I'm not sure many of the software tools out there are probably a handful, probably less than five that could probably do what you just described.

Right. Maybe more, but interesting. So, you know, when I think about that, I'd certainly think, you know, the future of the industry is materials, right? Because the processes will continue to be refined and improved. But I think those that will be more incremental right at this point. I think, you know, being considered the fourth industrial revolution, which is additive manufacturing, I mean, you know, it's an extremely efficient process that maybe we'll talk about that here in a minute as well.

But, you know, now you start to get into, again, material designs for specific applications. Right. As opposed to these are the materials of choice. We'll just use it. You know, you've got aluminum bar stock. You have stainless steel titanium. You know, which one are you going to use at the most cost-effective for what you really need to do? Right. Right. Also, you know, it's important to kind of talk about, you know, maybe what machines handle, what materials as well.

Right. So Arcam, because it is under vacuum and its elevated temperatures tend to deal with higher temperature materials.

Right. So they really for possible easier processing titanium is probably more common, one that Arcam uses. But they also have the cobalt chrome. Cobalt chrome has a little bit higher melting temperature. But Arcam systems are pretty well-performing at those. Inconel as well as the material that is nickel-based. Alloy is more commonly processing those machines. That's really based on keeping the heat inside the machines and keeping it easy. So it's easy to process. The machine can keep a specific elevated temperature which allows for the removal of residual stresses That form. Which make alloys a little bit harder to process. It can really result in those alloys being crack-free, so after the machine is completed, the process means less chance for micro cracks forming the parts which could have a detriment to your properties. But going back to your point, in regards to where additive is going, I know one of the barriers that tends to be for additive is the material costs. But overall, there are a lot more improvements in the powder manufacturing.

And there's a day to day I see within the industry quite a bit different manufacturing processes for powder that is reducing the costs, reducing the improving the quality of the powder. So I think overall it's going to be a lower and lower barrier for people to join additive manufacturing and jump in, but also provide better products for the customers. For example, one key function for costs that the aerospace industry considers is that buy to fly ratio. So they look at the amount of material that it takes to actually originally.

To me, that's part they compare that cost to the cost. It is to complete the machine and remove all the weight from the initial material. And comparing those two costs really gives you a sense of the manufacturability, of the process, really, of additive manufacturing. We're building our parts from near-net shape all the way very close to your final part, maybe a few minor machining steps besides that, but really having a very goodbye to five ratio compared to traditional manufacturing really shows the benefits of the materials and the technology compared to traditional manufacturing.

Right, right. I think a great case or great example of that is that whole bracket, you know, bracket challenge from years ago. Right. That was put out. And there was a bracket. I think it was a foot bracket for her for use on and on airplanes. And yeah, I mean, the weight savings on that alone was tremendous. Right. But, you know, for those who are not familiar with it, you can probably just look it up online, just do the bracket challenge out of manufacturing and be able to see various designs on that bracket and into the impact that we can have.

Right. Right.

That's all due to the software, the software really allows that benefits being able to have software that really remove weight from areas that may not be providing any benefit views and results in a lighter part, that's more efficient, that's more cost friendly at the end of the day. Yeah.

So buzz words, right. Let's get into it. So topology optimization, generative design. Right. These are really kind of buzzwords in the world of modern manufacturing. Right. What do they mean to you?

They really mean topology optimization and generative design, really hot topics for this new design concept that people are starting to gain called design for additive manufacturing, DFAM. And really a lot of the designs that, you know, sometimes that we even get are designs that are really made to be machined, traditional, traditional manufacturing. Right. But that may not be the best for added manufacturing, may not even be the best for even the very end customer. We have the capability with additive manufacturing, with using decided what material, whether it be to explore grade five, a grade two three, to have a part that we can manufacture it in unit shape with different additional features.

We talked about lattice structures as well, adjusting the poor sizes and Strut sizes to meet specific customer demands or needs depending on the industry, whether it be medical, whether it be heat sinks, anything like that. But being able to adjust those in really within one step when additive step, can provide quite a bit of benefit. And using the software tools for topology optimization for general design can allow for that.

Yeah, kind of brings me all the way back to, you know, when I think of what we're doing here now, Amplify Additive and the team that we're building. Right. It is not that we're not trying to hire the same people in the same skill set by any means. We're trying to mix it up. Right. You know, again, going back to my background, you know your background, right? So you've got good engineering for what you should get, good material science for additive.

Right. We've both been in technology a long time. You got now, Andre is a nice piece of the team for that, you know, that industrial design aspect. But, you know, we like to think outside the box thinking, right. So that's such an overused term. But it fits nicely. Right. And it's a little bit ironic because we built it within a box. Right. For additive manufacturing. It's a volumetric manufacturing technique.

But it's really you know, it's important to understand all the pieces that really go into what makes a good product that comes out of the machine. Right? I mean, yes. And I think a keyed off your concept of customers may come to us and their product may not be ready for our manufacturing. So that's that's really where we step in, right. We say, OK, what's the end goal? What are you trying to get here?

You know, what are the other products that you've seen that you like are competitive and you want to compete with, for instance? Right. You know, obviously the end goal is the, you know, patient outcome. Clearly, that's always our focus for our clients, hopefully. And certainly for us, you know, supporting that goal, but, you know, how do you get there? What tools are you going to use in the process?

Right. So for us, I mean, any given project we could use, you know, four or five software tools by the time it gets to the machine. Right. So the application knowledge right behind how to do that in a controlled manner. Right. You know, providing the you know, the inputs and outputs for the client. Right. There's a lot there that I think when you think about the industry as a whole, there's a bit of a gap in the knowledge, you know, behind that.

I mean, there, you know, you continue to see software tools coming out. You know, you can continue to see, you know, material companies coming out. You know, you have a bunch of machine manufacturers, whether it's in the EOS or 3DSystems or GE Additive. And GE has got a couple of technologies, right that’s EBM and Laser, you know, TRUMPF and SLM. And, you know, all these companies. Renishaw, you know, just kind of throwing them all out there.

Right. You know, big consideration for our clients is, you know, what's been through the FDA. First of all, that’s a big deal/ time to market, cost, but overall, you know, I mean, it should always come back to clinical outcome. Right. And for us and why we're such believers in EBM, you know, just generally speaking, is the you know, you have historically seen with, you know, what we can get on the other side of the process, you know, this this roughness that is hard to recreate using laser, but it's truly optimal for bone and growth and fusion.

That's right. That's the beauty of EBM technology when we kind of circle it all back around.

Yeah. I mean, Brian, in terms of the manufacturing of first time, as you mentioned, the hip cup, it doesn't take just one company and one technology in order to develop something such as this. You can have a customer such as the GE Additive to provide a machine, a customer such as the software and topology optimization. And you can have a technology that provides a different powder manufacture and different powder type.

However to power to put that all together, you need the right team and the right knowledge in order to really utilize and have a true end product that can be useful to the customer. So, for example, in this hip cup with Ti-64, we have a lattice structure that has a specific pore size and strength size. That's great for initial fixation and bone and growth, but also the one that could have great mechanical properties and can be a last in the acquired fatigue was so really that focus and that knowledge, it doesn't take just purchasing one aspect or one software or one type of powder to really get that.

It really takes the right team and the right not to bring that all together.

And that was really our vision here, right? It started with, you know, a core knowledge, core capability. Right. We've had a tremendous network in the industry for years. Right. And I'd like to say that that network is really, you know, supported us as a company up to this point. But the vision around the technology around having those right materials. But it is really, in my opinion, of the team. Right. And that's you know, I was pleased with that you were our first employee, you know, I'm happy that we were able to find someone with your background that really supports material science of what we do, it is extremely important with regards to additive manufacturing. Right. And listen, I continue to look forward to the growth of this team. Right. You know, we're actually looking for really a project engineer to join the team right now and looking for someone with, you know, additional medical, hopefully orthopedic experience.

That would be ideal knowledge of the additive process. But in the end, you used to teach companies how to use EBM, right? I mean, that was one of your that was one of your roles at Arcam, GE Additive. Right. You were the guy to go out and teach companies how to use EBM technology. Right. So that's when we bring our customers here. We had a client last week. Right. That's your job. You bring them in and you bring your show in the machines.

You do the tour right around that.

I know a little bit about it for my back just a little bit. So, yeah. Now.

Well, John, this has been great. Thank you very much. You know, I think we probably need to get back to work, but, you know, this is exciting. You know, very happy to have you part of the team. You know, I look forward to continuing growth with this team. And, you know, here's to future success.

That's great. Thanks for having me, Brian. Certainly. And for everyone else out there, stay tuned.

We'll be coming out with, you know, probably an announcement of our next episode for The Additive Effect. We'll continue to research and discuss topics of interest for the additive manufacturing community, certainly specific with regard to orthopedics. Thank you very much.