I am Professor Glenn Daehn of The Ohio State University. My group works on manufacturing process innovation. We often harness energetic discharges from capacitor banks to cause metal to be formed, joined, cut or modified, enabling new products.

Glenn$_{D}ehn^{1}andr/ScienceAMAs^{1}$

[1]Affiliation not available

April 17, 2023

Abstract

Hello, I am Glenn Daehn, a professor of materials science and engineering at The Ohio State University. I find great joy and concern in manufacturing process innovation. On the joy side, my group is working in the unusual area of impulse manufacturing. This is using short-duration, high-amplitude pressure pulses that we use to make things. Usually we shape, cut or weld materials using very high pressures or speeds. Capacitor bank discharge is typically where the energy is stored, and this is then it is turned to mechanical work in one of a number of ways such as by a Lorentz magnetic repulsion from a coil, or by developing a very large pressure pulse by vaporizing a shaped thin metal foil. Examples of what we do are available at my group's website at http://iml.osu.edu. Recently, we have had great interest in using this as a method for the solid-state welding of metals. To allow us to get into a deep and geeky conversation on this, I've prepared a fairly rapid-pace 35 minute lecture on this that you can find here: https://www.youtube.com/watch?v=9H3M8yLKNjY&spfreload=10 We are very interested in developing these impulse manufacturing techniques as go-to methods for manufacturing. Two things lack. First is a good design-science foundation for this work. We (and other researchers – see: http://i2fg.org) are developing that now, and we have invested in some great instrumentation. Second, we need to disseminate these ideas and get some early adopters into this space. I am grateful to reddit for helping sine some light on this technical area. At the risk of diluting the technical conversation, we may also discuss the overall climate for process innovation in America. The US does a breathtakingly good job of top-rate academic research. But in my opinion, we only do a marginal job of process innovation when it comes to new physical systems in areas like metal processing and manufacturing, which are vital to our economy, sustainability and security. I'd be happy to discuss if the US is making the right investments and training people with the right skills to innovate in capital-intensive industries. I think the maker movement and projects like the National Network of Manufacturing Innovation institutes represent great steps in the right direction, but wonder if they are sufficient when we look around our competitive world. Proof: http://imgur.com/w1h8D5f I will be back at 1 pm ET (10 PT, 6 pm UTC) to answer your questions, ask me anything! Hey – gotta take off for now. Will try to check back later. Thanks all for the awesome questions and response and thought provoking questions. Its clear a lot of people would like to try these methods themselves! I'll see what we can do there. I'll try to do one more pass at the board tomorrow (Tue).

the WINNOWER

REDDIT

Science AMA Series: I am Professor Glenn Daehn of The Ohio State University. My group works on manufacturing process innovation. We often harness energetic discharges from capacitor banks to cause meta

GLENN_DEHN R/SCIENCE

ABSTRACT

Hello, I am Glenn Daehn, a professor of materials science and engineering at The Ohio State University. I find great joy and concern in manufacturing process innovation. On the joy side, my group is working in the unusual area of impulse manufacturing. This is using short-duration, high-amplitude pressure pulses that we use to make things. Usually we shape, cut or weld materials using very high pressures or speeds. Capacitor bank discharge is typically where the energy is stored, and this is then it is turned to mechanical work in one of a number of ways such as by a Lorentz magnetic repulsion from a coil, or by developing a very large pressure pulse by vaporizing a shaped thin metal foil. Examples of what we do are available at my group's website at http://iml.osu.edu. Recently, we have had great interest in using this as a method for the solid-state welding of metals. To allow us to get into a deep and geeky conversation on this, I've prepared a fairly rapid-pace 35 minute lecture on this that you can find here: https://www.youtube.com/watch?v=9H3M8yLKNjY&spfreload=10

We are very interested in developing these impulse manufacturing techniques as go-to methods for manufacturing. Two things lack. First is a good design-science foundation for this work. We (and other researchers -- see: http://i2fg.org) are developing that now, and we have invested in some great instrumentation. Second, we need to disseminate these ideas and get some early adopters into this space. I am grateful to reddit for helping sine some light on this technical area.

At the risk of diluting the technical conversation, we may also discuss the overall climate for process innovation in America. The US does a breathtakingly good job of top-rate academic research. But in my opinion, we only do a marginal job of process innovation when it comes to new physical systems in areas like metal processing and manufacturing, which are vital to our economy, sustainability and security. I'd be happy to discuss if the US is making the right investments and training people with the right skills to innovate in capital-intensive industries. I think the maker movement and projects like the National Network of Manufacturing Innovation institutes represent great steps in the right direction, but wonder if they are sufficient when we look around our competitive world.

Proof: http://imgur.com/w1h8D5f

I will be back at 1 pm ET (10 PT, 6 pm UTC) to answer your questions, ask me anything!

Hey -- gotta take off for now. Will try to check back later.

Thanks all for the awesome questions and response and thought provoking questions. Its clear a lot of people would like to try these methods themselves! I'll see what we can do there. I'll try to do one more pass at the board tomorrow (Tue).

READ REVIEWS

WRITE A REVIEW

CORRESPONDENCE:

DATE RECEIVED:
November 10, 2015

Hi Mr. Daehn. Thanks for answering our questions. I'm an industrial designer and often have to make DFM (design for manufacturing) documents that inevitably are sent to China for production. In fact neither I or my colleagues have ever had anything produced in the united states due to the higher costs of manual labor, even though tooling and part-quality is generally considered to be far superior state-side. What do you believe it will take for production for once again take place domestically.

DOI:
10.15200/winn.144707.72007

ARCHIVED:
November 09, 2015

CITATION:
Glenn_Dehn , r/Science , Science AMA Series: I am Professor Glenn Daehn of The Ohio State University. My group works on manufacturing process innovation. We often harness energetic discharges from capacitor banks to cause meta, *The Winnower* 2:e144707.72007 , 2015 , DOI: 10.15200/winn.144707.72007

Smart/flexible production machines that end up off-setting labor costs? A larger workforce trained in manufacturing? Rising prices in transport or foreign labor that makes us reconsider dealing overseas? Or is maybe having a global economy a good thing in your opinion? Thanks for your time and thoughts.

BossExtrude

A lot of work is coming back to the US, and on the plus side, costs are going down here, and there's a recognition that it's more sustainable to make products where they're used, versus shipping them across the world. Quality is very high in the US. But on the negative side we are short on the people who have the broad set of skills required to create brand new, complex, mechatronic systems. Also, if you talk about products like iPhones and plasma television sets, we do not have the full supply chain here to manufacture those items here. It will take many decades or years to bring that back.

But there are lots of reasons to be encouraged. A great discussion of this is given by Harry Moser at his website.

Are there any of your new processes that makers could try at home?

WheresMyRubberGlove

Not so easily. There are some home hobbyists that are deep into this, such as Bert Hickman at: http://teslamania.delete.org/frames/new.html. The key problem is that specialized equipment, safety gear, and power, etc., is needed. This is kind of daunting for most home hobbyists. However, I am working with my friend Alex Bandar at the Columbus Idea Foundry: http://www.columbusideafoundry.com. We have a capacitor bank there and running. My team and I need to go and do some training and complete the project, but we hope to provide for artists and makers to use this equipment, and we hope that they will make things that are more interesting and aesthetically pleasing than my engineering colleagues and I do.

What are your thoughts on additive vs subtractive manufacturing? How long will it take for 3d printing to become a legitimate manufacturing technique? How much longer do you think subtractive machining will be integral to the manufacturing process? Very cool work, and thanks so much for your time!

thefebs

First, it's important to recognize how long it takes to develop these new processes. CNC machining (subtractive manufacturing) got its start in the 1940s, and is still an evolving and exciting area. The roots of additive manufacturing can be traced back to the 1980s, and only recently, with low-cost products such as the maker bot, took on broad appeal. Right now, the big problem with much of 3D printing is that we can do a great job of controlling shape, but we can not control materials properties the same way we metallurgists have been able to control properties.

Great work is going on to develop both shape and properties in 3D printing. And companies such as GE are making large investments that are being led by the creation of components that are otherwise impossible to make with conventional technology.

Both these areas and hybrids that include additive + subtractive + heat treatment + real-time assurance of properties will be a big part of the future of advanced manufacturing.

My former professor Dr. Poirier would be happy to see new areas of interest in his field. I agree with your point on the US doing a marginal job in process innovation. More ciriculum should be pushed to get students thinking of new creative innovations, rather than just learning processes created in the

19th century.

1. I haven't had much time to look into this subject, but are there any surface pre-treatments that can be used to reduce the surface energy of these metals, in order to reduce the energy needed to cause flow?
2. I did some work with spark plasma sintering of ceramics, so I often think of metals as soft, like taffy. But at the high speeds you're colliding these materials, do they act more brittle?
3. At the rates of solidification and collision, do the locally joined regions take on an amorphous structure?

Thanks for your time.

ispydrogas

(1) There are possible ways we could use surface treatments to join materials. Removing the native oxide is always the big problem. Joining would be very easy in deep space! But I don't have any really strong ideas here.

(2) At these high speeds, materials often exhibit fluid-like behavior. because the imposed stresses can be much greater than the flow strength of the material. However, various systems may act differently, and sometimes brittle behavior can be induced by high strain rates or low temperatures.

(3) Our materials, we think, do not melt, except for possibly a very, very narrow (~100 nm) region at the interface. At those regions, the structure is very complicated, and further detailed characterization is needed.

How similar to explosive forming is this? Mixing powdered of titanium, aluminum, and magnesium, and then blowing them up was a great way to make composites but quality control was pretty low...

purduephotog

This is very similar to explosive welding, which is a big thing. Just no explosives, and can be done in a factory.

As a recent graduate in the manufacturing field, I can understand the lacking innovators in the engineering field in the Americas. I, as well as my fellow graduates were instructed well, but solely on existing principles, not so much on process innovation and it shows in our personal project work. In our senior projects a majority of people made minor tweaks to existing designs or designed parking garages to combat our campus's parking issues. I was the only one that ventured on a topic that I couldn't find much research on, the logistics of using 3d printed materials as a cast mold to allow for fairly quick rapid prototyping in metal. A project that was rewarding in that I learned so much that I wasn't able to in the conventional classroom.

This leads to my question, how would you suggest an engineer in industry contribute to something like this? What steps should be taken to help innovation that you are suggesting? Thank you for your time.

MaximumtheZinc

Regarding the question of what an engineer can do to innovate, there are two parts to this: first, they need the freedom to try some interesting experiments, and often some financial support to afford the required toys. This can lead to some interesting ideas. Secondly, innovation is really all about bringing these ideas to the broader world. We are still in the early part of our journey. For a technology like ours

to succeed, we need to make hundreds of welds of a particular type to demonstrate statistical control, and we also need to understand how the equipment will fit on a factory floor. These are big problems, and real innovation takes a village.

Some of the ideas here seem like they are tailor made for the aviation industry. Millions and millions of poprivets... If it weren't for that darn aluminum oxide and need for absolute perfection. Are your processes able to deal with this? How much weight do you think could be saved from a single jet if they could use welds vs conventional fasteners?

Can the process be adapted for field use?

Any ideas on home/individual use for general purposes (or more specific like pipes or race cars)? What would it look like?

tarjan

We'd love to replace rivets!!!

Much weight could be saved by replacing rivets with welds. It turns out that for a vehicle like a 737, thousands of dollars are saved in fuel costs over the life of an aircraft per pound of weight reduction. And the reason rivets are often used is that they are more predictable in fracture and fatigue than welds often are. That said, many companies are now studying the use of friction-stir welding for aircraft applications. This process, like the one we are promoting, is a solid-state process that gives higher strength joints and can weld many materials that would otherwise be un-weldable due to their solidification structures.

What are the benefits of impulse manufacturing compared to conventional method of welding?

ForsakenFury

See the lecture here: https://www.youtube.com/watch?v=9H3M8yLKNjY&spfreload=10

...Big benefits are all related to the fact that we do not melt the material. This gives higher strength and no distortion, and the ability to join two dissimilar metals.

Hi Glen,

How feasible is it to retrofit current manufacturing robots/assembly line to your new technology?

Mekongpepsi

Thanks for the question! Near the end of our video: https://www.youtube.com/watch?v=9H3M8yLKNjY&spfreload=10 we show our vision of how a VFAW spot-welder can be married to the end of a robot. We think this is quite practical, and the great benefit is that aluminum to aluminum, steel to steel, or dissimilar combinations such as aluminum to steel, could be joined with a single system. This allows great flexibility for those in charge of the automotive plant.

In your lecture video, at 22:10, you claim the weld is between copper and tungsten, and yet the slide sais Cu Ti (copper and titanium). Which is it?

Furthermore, how likely would you say it would be that someon could perform some variation of the foil

vaporisation welding at home in their garage? What would be the easest way to do it (metals to weld, foil to vaporize, etc.)? What would be the most difficult part? If it is possible, how much would you estimate it would cost?

Edit: Also thank you for answering our questions! And if i come across as rude or petulant regarding the Cu-Ti thing, know this is the opposite of my intentions. In fact, I'm fully expecting that the percieved error is actually due to my own ignorance somehow!...

skurksugga

Yes, cranial flatulence. Ti is indeed titanium.

See my above answer about doing this at home. It's a very ambitious garage project, but some reddit users may be very ambitious!

What material is the most challenging to work with?

steelcatcpu

The techniques we are using intrinsically work well for ductile materials -- materials that are truly brittle, like ceramics, are not amenable to our technique.

The vaporizing foil actuator seems like a really neat technology, but as you note in your video, it fuses material only in local regions where the impact angle and velocity is just right. On the other hand, explosive welding, with it's moving wave front, appears to overcome this problem.

So here's the question (and apologies if this has already been beaten to death in your circles): Can a vaporizing foil actuator be made which vaporizes along a moving front, so that the joint can be fully-filled like explosive forming, as opposed to ring-shaped as you presented in the video. I don't know the first thing about these vaporizing foil actuators, but it seems like even if you can't make the foil vaporize in a moving front, maybe you can make it V-shaped in cross-section to at least simulate a moving wave-front.

Wild idea number 2: Make the foil actuator corrugated, so that maybe you can get a cascade of linear joints. The corrugations also act as a natural stand-off control mechanism, so that the gap between the foil and flyer is more easily controlled.

Anyway, that's some very cool stuff you're working on, and thank you very much for that video. Those waves you show at the joint interface really geek me out!

rocketfuel4dinner

As you can probably tell, we are at the early stages of all this. And the ideas that you offer are all valid ways forward. We are mostly worried about controlling the collision by modifying the initial geometry, but we may also be able to stagger charges or use other chemical influences to cause a rolling impact.

Collision welding, from your site:
https://iml.osu.edu/sites/iml.osu.edu/files/styles/osu_crop_4x3/public/Wavy%2520interface.jpg?itok=btbo0iXF

1. How do you get the "wrap-around effect" to wrap around so far?
2. Is the wrapping-around of material done as a sort of mechanical joinery process sort of like

dovetailing wood together?

Thanks!

throwaway_holla

We think this is a classical Kelvin-Helmholtz instability. Google it. Have fun!

I got an E-mail with a article about this last week. I work for a company that repairs, services and rents welding and cutting equipment. I'm not actually able to watch your video just yet because in at work but I did have a couple questions for you.

1. From what I remember of the article the process is supposed to be similar to spot welding only less heat transfer to the part, less energy required to make the weld and better joining of dissimilar metals. If thats correct is there a plan in the future for use of this technology in other process outside of spot welding?

2. The article mentioned something about pressure and the 2 pieces being welded coming together at (x) MPH, I can't remember the exact number but it was really fast. What causes that? Are you using machinery to create that pressure or is something involved in the burning velocity or pressure created by the aluminum foil burning?

3. Right off the bat the first thing that came to my head is that it seemed like a small scale version of explosion welding, only instead of using explosives using aluminum foil. Also cold welding came to mind. Is there any similarities to those processes of welding.

Thanks for your time.

AJAX1904

You are correct, the process is much like explosion welding. We can get speeds well over a km/s (about 2,000 mph). However, if the impact is too fast it causes significant melting at the interface. We want to create a solid-state weld. Our pressure is produced by a rapid phase transformation from solid to gas of an aluminum foil driven by a massive current pulse.

In the early 60's Rocketdyne developed this process for explosive forming & welding to replace chemical explosives, since the energy released could be controlled. The voltage charge on the cap bank would be used to fire the ignitron bank when it reached a set point. A.G. Kimbrough, AWS Life Member

CaptnAndy

In the mid-90s, I spent my sabbatical at Rocketdyne's sister organization, Rockwell Science Center. I'm unaware of this work. If you can post any details, I'd love to look at them!

I've read about this in the previous press releases, so two questions:

1.) Electrolysis? If you're welding dissimilar metals this way, aren't you going to have novel corrosion problems, particularly around electrolytes (salt water etc.)?

2.) Innovation. Is there any way for universities to do practical, applied work in process innovation? They seem to avoid it like the plague.

I work at a competing institution (about six hours west, if it matters) in a slightly different field of engineering and practical work and innovation is sometimes compared with prostitution by P&T committees when compared with arcane publications and huge NIH/NSF grants - it's very frustrating. How do we change minds?

LateralThinkerer

This is a good question!

(1) This is related to galvanic corrosion, for which there is fairly well-developed corrosion science (which I am not an expert at, but have referred to elsewhere in this AMA).

(2) There is something of a culture war going on in universities (maybe not quite a war) where traditional academics like to think about high-impact papers that are very much based on physics. This is good, but not everything that we need. I feel very fortunate that there are many people that see the real need for innovation here at Ohio State, including my Dean of Engineering, David Williams. He and I and many others see the need to do things that our stakeholders really value, and innovation coupled with economic development are near the top of that list. And there are many discrete things we can do that contribute to those larger goals.

Keep fighting the good fight!

What kind of capacitors are you using? How do you charge them? What's an exemplary configuration of such a capacitor bank? What does the output impedance look like? What aging effects do you observe in your devices? Do you see any hint on differences in current peak shapes that are not due to aging? Do you believe in so called "burn in" of parts (dielectric properties changing with use)? What's the coolest thing that blew up in your lab? What's your favorite capacitor?

Radioactdave

Good question. You're clearly into this!

There's more here than I can answer. Good places to start are my students' theses. I think Jason Johnson has a published design for a capacitor bank he built as part of his PhD thesis. Details at iml.osu.edu. Regarding pulse shapes, what's interesting is the vaporizing foil pulses do not ring. This can actually improve capacitor life.

Your intro cites top rate academic research in the US but only a marginal job of process innovation. Note also you are a professor of materials science engineering. In your opinion, do the materials science engineering graduate research labs lack an essential element of industrial design? Does Ohio State include industrial design in the materials science labs? Or would you advocate another approach, perhaps linking materials labs with (US based) industry partners to provide a more effective transfer of research to practical manufacturing? What factors are needed to prevent the research being immediately transferred to overseas manufacturers, as other posters in this thread have alluded occurs with their work?

shiningPate

You bring up many interesting issues in your question. There is often a conflict between innovation and impact, with depth and focus. Materials science generally has been a deep and focused discipline that sticks within the bounds of applied physics, mathematics, and mechanics. That said, we're finding that often we have to design new materials and processes for specific applications. This is what industrial design and "design thinking" brings us.

We have a particularly collaborative faculty here at Ohio State. And I've interacted with Carol Gill and other faculty in Industrial Design. The place where materials meets design is often in discrete products, and Professor Blane Lilly of the Dept. of Mechanical Engineering collaborates with industrial design to envision new products and processes.

Regarding overseas manufacturing, we often overvalue the idea and undervalue the infrastructure and people that are needed to produce stuff. As things become more automated, the cost of labor will become relatively unimportant.

What are the size limits of this and ease of implementation? Cost versus conventional methods? Where is it currently used?

My manufacturing plant tries to use a robotic welder to weld 3" diameter canisters to a 5" diameter or so plate (carbon steel, 1/8" thick). However, the robot is very finicky and I believe we spend more time tinkering with the robot and it's sensors instead of actually producing parts.

If your technology could be implemented into a simple press to essentially push two parts together in a easy way that an operator could understand and repeatably perform, then that's a win.

thepeter

It takes a long time before any advanced technologies become really "easy." But like the iPhone, they often get there. The fundamentals of our process are simple and straightforward, but we have a lot of work to do before it's a routine and simple manufacturing process.

Could this technique be used to create a diffusion couple? I.e. could it weld a piece of Fe and Pd together so that across several microns we get a constant change in composition?

hugoshtiglitz

Yes, it could. We can make very discrete interfaces, and use this in diffusion studies. Because it's low-temperature and very fast, it creates a very good starting structure.

Is the process making use of a common foil material?

Or did I miss the material type in the video?

whips_are_cool_now

Thanks for the question! A lot of material to cover in the time available to the video. The material is standard aluminum at about .005 inches thick. Just like Reynolds Wrap, but a little bit thicker. We make the shapes hundreds at a time, by waterjet cutting stacks of metal.

Thank you for taking your time to do this AMA. I am an Engineer that works with ASME pressure vessels and work with many of the methods you are currently researching. I have a few questions:

FCAW has been permitted by Sec IX for many years. Equipment end users are just now coming around to permitting Flux Core for pressure boundary welds. Even after lengthy approval processes required by the ASME committee, it takes significant time to convince those buying equipment to use new process and procedures. Do you believe that there is an overabundance of caution for adding of new techniques by industry?

Do you work with groups such as ASME when doing your research?

I am currently working on a project attempting to line a high pressure reactor with Hasteloy B3. This metal does not react well when explosively bonded clad materials are attempted (DMC/Noble clad will not supply). Weld overlay is cost prohibitive and roll clad is also unavailable. Does the vaporizing foil or laser impact method you are developing have any residual cracking issues with materials you have investigated?

Glazed_Annulus

We are still at early stages, but are worried about eventually getting our techniques to be recognized by standards and certifications. Our technique works for materials of about 5 mm thick and under right now. We are a long way from making boilers or pressure vessels at this stage. Explosives do a better job with thick sections, and the folks at Nobel Clad are the right ones to work with.

I work for a stud welding company which uses capacitor discharge stud welders, which discharges the capacitors and creates an electric arc between the stud and surface material. It doesn't seem as if your processes would do the job any better than that, they seem like a more complicated process than simple stud welding.

In what fields, or industries, do you see your processes working better than the current methods than they are using?

EDIT: Clarification.

GratefullyGodless

Big difference: the process we are developing is solid-state welding. Traditional capacitor discharge processes melt the material.

LOL! I think i worked on this project back in the late 90's. I worked with Kushner making the coils and housings. You guys kept blowing them up. ;) The housings were G10. Man did I learn to hate that stuff. How are you doing professor?

Pyrokuda

All true!

Email me separately, please. Who is this?!?!

The foil technique, all that goes away is the foil. Much better than before.

What type of insulating material do you use to contain the current to the foil? Are there design challenges associated with the connectors between the foil and the voltage source? Thank you

MalteseBarley

Foil and insulation design is a big deal. Short answer: The best polymers are those that contain the voltage well, and decompose to non-toxic fumes (polyethylene) to keep the contacts from sparking, a relatively large contact between the foil and the electrode is needed.

I wrote my bachelor's thesis on this at TU Darmstadt last year.

maxman1313

Can you please send a link to your thesis? I'd love to look at it!

How did you develop the process of planning and implementation for this very innovative research you have? Is there a specific model you used?

Michael_Scotts_Tots

The beauty of my job is every day is different and we keep reevaluating and re-planning. No script or model. Another great thing, is I am blessed to work with a lot of really smart and passionate people.

Thanks for doing this AMA! As a PI, what advice would you give PhD candidates? How do you come up with new ideas/approaches?

Since your research has direct practical applications, does your lab do contract work, and do any of your students seek industry internships for practical experience? If so, how has that gone? I do computational modeling of materials and would like to see the industry side before graduation.

Codes4Nailpolish

Good questions!

As a PhD candidate, it's important that you go deep into a topic. But also, it's important that you understand how your work connects to the broader world. Just make sure that your work is somehow on the path that benefits the human condition, and all is good -- you will find a job.

First off O-H! As a current Electrical Engineering undergraduate student at OSU currently looking to do research, this is absolutely fascinating. As you said the U.S. doesn't do a very good job of implementing processing and manufacturing technology such as what you are researching on. Do you think this is caused by our country's attitude towards manufacturing? To me it seems like most people stop at the issue of outsourcing our manufacturing but fail to consider other solutions such as the innovation you do. This being said, how does the U.S. make the changes necessary to accomplish this?

TheStork74

Thanks for finding our work interesting! We're appreciative that we can do such fun things every day.

The world is changing. Automation is becoming inexpensive. The most sustainable products, like produce (food), are made locally and not over-produced. I see manufacturing coming back to the US so long as we can produce the people that it takes to design, build and maintain the next generation of manufacturing equipment. This equipment will be agile, easily re-programmed, and give us a new generation of sustainable products.

Partnerships among universities, community colleges, industry and economic development associations will be needed to define what kind of workforce we need and provide the financial wherewithal to get there.

Thanks for the opportunity, Dr. Daehn!

Every time I hear about your work getting materials science into high school classrooms I get really excited. I had the opportunity last year to show one of these classes around where I work. They were an interested, engaged and bright group. What brought you into working your field into the K-12 classroom? Where is materials engineering in high schools now? (In Ohio and nationally.) Where do you see high school and engineering in the future?

Is there any need for heat treatments or aging in solid-state welding? (Or is that a major motivation: a weld that has ideal microstructure with no need for additional processing?)

How can a young engineer in the manufacturing industry get involved?

Thank you.

stcamellia

Wow.. Could go on and on here. Materials engineering belongs in high school classrooms. It is a natural integrator of the Science, Tech, Math and Engineering of STEM. Thanks to work with the ASM Materials Education Foundation's Materials Camp for Teachers program, there are now many high schools that have materials science in high schools. It works well for the schools, teachers and students. It can fill the whole pipeline of jobs from technicians to PhD's. Check our their site: http://www.asminternational.org/about/foundation/teachers/teacher-camps , and my related material: https://sites.google.com/site/osumse6700/.

This is all worthy of another AMA. Maybe the good folks at Reddit can have me, or someone else from these programs, back some day.

I'm a welder by trade/degree and do take the academic aspects of it maybe a bit more seriously than the average guy who makes puddles and sparks for a living.

You seem like the right team to maybe crack the nut of welding in space (which is probably going to become more and more important as we do the Mars thing). Have you ever invested any thought into 0g welding, which is apparently a huge pain in the ass, but for a few esoteric stopgap techniques?

ModestGoals

We're still trying to find great applications here on Earth. I'm sure they exist. Part of the issue with any of these specific applications has to do with the exact geometry that one needs to join. Also, having a capacitor system in space may have some issues. I'm happy to try to figure it out!

Fascinating work and compliments for very good presentation.

Electrical isolation using conformal shrinking or expansion, I get -the insulating material is not compromised - great application. How does that work in your 'spot welding' applications? From another answer I gathered "it does't, use galvanically similar metals".

Is it possible to layer intermediate metals in the joint? Something like 316SS/CuNi/Al? Sort of a distributed corrosion?

bigtips

You are on the right track... Details start to matter. The other thing to point out is for corrosion you also need an electrolyte (i.e., it has to be wet, etc.). Some things are dry and stay that way. This is all part of good designer durability.