IDI Composites International Webcast:
Composite Materials: Designing and Innovating In Real World Applications
11/17/16

Thank you Jeff, good afternoon and thank you to our webinar attendees.

This afternoon, we intend to do several things:

1) We will explain what a thermoset composite is and how it differs from metals and thermoplastics.

2) We will demonstrate the benefits that are provided by thermoset composites that are not offered by traditional materials.

3) We will show you some real-world applications and how and why innovative companies are thermoset composite solutions to convert from traditional materials.

Thermoset composite materials have a number of performance benefits.

We will explain these benefits and how they perform in real world applications that are familiar to you and help you gain a clear understanding how thermoset composites perform.

Listed here are some of the key attributes that can be designed into a thermoset composite.

These attributes are important across a wide variety of industries.

You can find thermoset composites utilized as a primary performance material in numerous industries like electrical and safety as well as the transportation and building & construction industry just to name a few.

First I would like to give you a bit of information about who we are.

IDI is a global formulator and manufacturer of thermoset molding materials. Founded in 1966, we're celebrating our 50th anniversary this year.

We focus on gathering information from new clients regarding the key performance characteristics and metrics of their individual applications and work with those clients to develop an innovative materials solution to help them optimize the performance of the application or provide them some sort of competitive advantage.

Our headquarters and US manufacturing facility are located in the US in Noblesville, Indiana, just north of the state capital of Indianapolis.

This is a 120,000 square foot facility that houses our 3i Composites Technology Center and our composite manufacturing for the US and Canadian markets.

Here is a picture of our manufacturing facility for sheet and bulk composite materials.

We will talk a bit later in the presentation about our 3i Composites Technology Center.

One of our key value propositions is our ability to deliver a standardized thermoset composite solution throughout the world.

We have six manufacturing locations throughout North America, Europe and the Asia Pacific region that produce either exclusively bulk and sheet materials, or some combination of both.

With the six manufacturing facilities, there has existed, and continues to exist, a tremendous need for us to easily transfer material and manufacturing technology between the different locations.

We have excelled at for the last 30 plus years.

We have numerous examples of a composite solution that was developed in one part of the world, which later required the transfer of that specific material and process technology to another manufacturing location in another part of the world.

Because these facilities have standardized manufacturing processes, that transfer of technology can easily be achieved.

Each location has a dedicated team of commercial and technical representatives that are familiar with the technology that is available at all of our other locations.

We are the only merchant supplier of these particular materials in the world that has this extensive global footprint.

Our fiber-reinforced composites consist of several product lines including sheet and bulk form, and a high-performance structural thermoset composite line.

We utilize a number of different thermoset resins including unsaturated polyester, vinyl ester and epoxy as well as both fiberglass and carbon fiber reinforcements in either sheet, uni-directional or discontinuous form.

Enough about IDI Composites International’s strength and size, now let's talk a little bit about the kinds of materials, we make.

So, what is a thermoset composite?

It consists of two major components: The first is a fiber reinforcement that blends both strength and stiffness to the material. This would be either fiberglass or carbon fiber.

The second component is a polymer resin system that irreversibly cures to impart primarily toughness.

It also provides other properties like corrosion resistance and UV stability.

Now one of the key attributes of our materials are their ability to flow.

This attribute eliminates the need to die-cut the material to the exact size of the mold when you make a part.

The thermoset composite consists of the previously mentioned polymer, a fiber reinforcement and then typically you add additional material such as a mineral filler in some instances, and a catalyst system.

In some instances, you may add a small amount of a specialty thermoplastic or other specialty additive to give you a particular attribute such as wear resistance or thermal conductivity.

With a fiberglass reinforcement, the material can be pigmented to give you some really nice molded-in-color attributes. We'll have an example of this later in the presentation.

Carbon fiber, if you know it at all, obviously limits your ability to impart colors other than black.

These thermoset materials are cured with high pressure and heat. It's this high pressure and heat that pushes the chemical resin portion of the composite into an irreversible chemical reaction that forms and insoluble polymer network.

Two key components of a thermoset composite are:

One, it provides one the ability to mold a net shape. There is very little or no need for machining of the final part.

Because of the flowable nature of these materials, you can mold intricate geometries.

Design features such as ribs, very deep draws, and pins, are all possible design options for a particular part.

It also allows one to consolidate parts thus eliminating some SKUs.

Secondly, as mentioned, you eliminate the need for secondary operations. There is no need to do things like drill a hole in the part for a bolt or fastener. Those sorts of features can be molded into the net shape.

If, by design, a series of fasteners are required to be embedded in the part, those fasteners can be insert molded into the part with these materials.

For those of you that are not familiar with the thermoset polymer portion of the composite, its chemical nature can be described by the term cross-linking.

This cross-linking that occurs between the polymer chains creates a rigid molecular structure.

And it's one of the key characteristics that allows a thermoset composite material to withstand prolonged exposure to high temperatures. A thermoset material cannot be melted or reshaped.

In addition to different reinforcement types, you have numerous choices when it comes to the thermoset polymer portion of the composite material.

Some of the chemical terms that you've probably heard used for thermoset material are things like unsaturated polyester, epoxy, vinyl ester and even urethanes would be considered a viable material for these thermoset composites.

It is possible to utilize a combination of thermoset resins within a composite product. So, for instance you could combine a vinyl-ester with a urethane or perhaps an epoxy with some other thermoset material.

What this does is it allows one to customize a thermoset composite material to meet a particular set of performance attributes required for a specific application and can help meet cost targets.

While the resin acts as a glue to hold the strength imparting reinforcement in place, it also can impart important performance characteristics like surface hardness, electrical insulation or stiffness and can provide some base level of UV stability.

As I mentioned earlier, these materials are designed to flow under heat and pressure.

These materials are processed by two methods: compression molding or injection molding.

The method utilized to mold a net shape is dependent upon several things, the two most common factors being the number of parts required and the geometry of the part being molded.

At this point I will ask my colleague Kevin Cahill to take you through some of the physical and performance differences between a thermoset composite and metal.

Thanks Jeff…

I'm Kevin Cahill, and I will provide some information on the advantages that drive innovative designs to convert from conventional material to thermoset composites.

Thermoset Composites are continuing to replace steel in a wide variety of applications. Structural Composites can match the high strength of steel, but they are 4 to 8 times lower density. This allows composites to significantly outperform steel in applications that benefit from lighter weight.

Thermosets also eliminate a number of corrosion issues, and can have superior impact resistance and vibration damping. Composites also simplify or eliminate the complexity of painting and plating that is required for steel.

Part shapes can be optimized with molded composites designs that are more complex than stamped steel, and significantly lower manufacturing costs than cast, forged, and machined steel components. It is common to replace complex assemblies of steel components with a single molded composite part.

Structural Thermoset Composites can achieve strengths that are more than 2 times higher than aluminum with less than half the density. They can also be significantly better in resistance to impact and permanent deformation than aluminum.

Thermosets are better at resisting chemicals, and environmental corrosion than aluminum. They don't produce abrasive oxides that generate fretting fatigue failures that can lead to catastrophic failure in aluminum components.

The images here show aluminum fretting fatigue cracks initiated by environmental and galvanic corrosion that can occur… even when the aluminum is painted or plated.

Thermoset composites have several advantages over thermoplastic materials, and some advantages are time dependent. Thermoplastics often creep, which is a process of weakening and deforming over time when placed under load at elevated temperature.

This is caused by polymer chain movement in the thermoplastic part and can cause the part to fracture… or can cause an assembly to become loose or deform to an unusable state. The thermoset crosslinking creates a permanent shape, and resists creep deformation and failure. The elevated temperature performance and predictability of thermoset composites, can make them significantly less complex to use in design and analysis phases of product development.

27. A Thermoset that has the same properties as a thermoplastic at standard temperature, typically retains those properties at a significantly higher temperature than the thermoplastic. Even a low cost polyester thermoset will outperform a nylon 66 plastic as shown in this example chart. Here you can see the thermoplastic has lost 20% of its stiffness at 120 degrees C while the thermoset retains stiffness well over 160 degrees C.

28. The thermoset composite's ability to retain strength and modulus at higher temperatures
allows the part to retain its shape and dimensions at elevated temperatures. The example graph shows unsaturated polyester thermoset compared to thermoplastics that significantly deform at 150C.

This type of compressive creep deformation would cause assemblies to fail, and this is one of many reasons why thermosets are chosen over thermoplastics in applications with elevated temperatures.

Jeff will now give some real-world application examples that use thermoset composites.

29. Now we will jump into some examples of how some innovative companies have converted from traditional materials to a thermoset composite solution.

Throughout these examples you will see the words inquiry, ideas and innovation. This is an outline of the application development and innovation process that we utilize to ensure we are focused on optimizing the performance of a customer's application and staying focused on providing them a competitive advantage.

At the end of each example, we will show you a summary of the material that is used in that part or application.

One of our key missions is to help innovative customers go beyond the value limitations that exist with conventional materials.

To that end, we're focused on developing solutions for customers. However, we have a large number of standard products that have been used in numerous applications with similar performance requirements.

I would encourage you, at the end of the session, to go to our website, idicomposites.com, and look at the characteristics of some of the products that we provide.

30. The first example is a composite shipping pallet.

I'm sure that all of you are familiar with the general size and characteristics of a wood pallet.

They tend to take a lot of abuse and can disintegrate rather quickly.

If you have ever had a weekend bonfire, you know they tend to burn rather quickly.

On any given day, there are in excess of 2 billion pallets in use in the United States alone. That's a lot of pallets that have to be repaired or discarded because of their inherent poor physical performance.

In this case, we had a client was looking for a solution that would help them out perform traditional wood pallets.

The client's concept involved the shipment of goods on a reusable pallet that incorporated RFID tracking technology to monitor the shipment of goods. It would help their clients answer the question of "what inventory do I have and where is it?"

The application had some very specific performance requirements.

The first, and most obvious, was the ability to withstand heavy loads. This pallet is 40 inches by 48 inches which is the standard pallet footprint recommended by the Grocery Manufacturers Association. So, it's expected to carry loads of up to approximately 1 ton.

The second key requirement is flammability.

Now there are a number of fire prevention and protection organizations that oversee the flammability requirements of various articles. The National Fire Protection Association is an example. So, if you imagine a warehouse full of pallets, either with or without goods on them, you can easily understand the need for flammability standards.

Additionally, the client had a goal of utilizing this pallet for the conveyance of food and pharmaceutical goods. So, some sort of indirect food contact compliance was needed as well.

Our team of chemists and engineers made a number of various materials for this.

It was necessary to balance the weight of the pallet with the strength requirements but still be able to utilize the additives and ingredients necessary to meet the flammability specification.

We also had to consider the use of materials that would meet the indirect food contact requirements.

What the client and us developed together was an unsaturated polyester fiber glass containing material that meets the industry flammability standard. The standard is outlined in Factory Mutual fire certification standard FM 4996.

The picture shown on this particular slide is not the actual test required to meet that particular standard, but it is intended to give the viewer an idea of the scale of the test necessary to meet this particular standard.

Along with this flame requirement was the need to have a durable and dimensionally stable part. This pallet can carry loads of greater than 1500 pounds and can make numerous round trips without repair.

We were also able to achieve the indirect food contact requirement by utilizing ingredients that comply with the Code of Federal Regulations Title 21 that outlines indirect food contact substances.

The results of our collaboration with this client resulted in a returnable sanitary pallet that because the thermoset composite material is both moisture and mold resistant, allows this pallet to be steam sanitized.

The use of materials that meet the CFR Title 21 guidelines allow the pallets to be used to carry both food and pharmaceutical items.

It's dimensional stability and strength allows it to be used multiple times within the customer's RFID tracking system.

So, as everyone I'm sure is familiar with a pallet in general, hopefully you can begin to understand the physical properties and the physical nature of these thermoset composites and get an idea of the size of part that can be made with these materials.

We've also shown a brief summary of the material at the bottom of the slide. I would encourage you to go to our website, idicomposites.com, for more information on that and other materials that we manufacture.

The second application that I want to present is a thermoset composite fan blade.

This particular application was quite challenging because the entire assembly, hub, blades and all, is 84 inches in diameter.

The traditional aluminum assembly is used as an engine-cooling fan in very large mining trucks.

Because these trucks are used both in and out of mining tunnels and live a good portion of their life inside of a mining pit, they can experience some really corrosive environments.

Now we mentioned earlier that one of the issues that can be associated with metals is the development of abrasive oxides and galvanic corrosion. That was one of the issues that this particular client experienced from time to time.

Additionally, we mentioned that thermoset composites, that are suitable for structural applications, can be 4 to 8 times lower in density than some metals but still match the strength of those metals.

To give you some idea of the difference in those densities, aluminum, depending on the alloy, can have a density, in grams per cubic centimeters, of 2.4 – 2.8. So approximately 2.5 times heavier than an equal volume of water.

A thermoset composite material will have a density, in grams per cubic centimeters, between 1.0 – 1.8.

Steel will have a density of 7.6 – 8.0; again, depending on the alloy.

This potential weight savings was a key component in the client's push for a thermoset composite option for this assembly.

Now we mentioned as well, that these materials can be molded into a net shape, thus eliminating the secondary operations that were required for the metal assembly.

And because it spins at a relatively high Tip speed, vibration and impact resistance is a must for this particular part. If you dent or bend a metal piece on this assembly, you have really thrown off the vibration and harmonics of the assembly.

Our chemists and engineers worked with the client and came upon the idea for a series of high-reinforcement containing structural thermoset composites to insure the necessary strength and vibration criteria were satisfied.

The use of a vinyl ester resin system helped us address the corrosion issue that the client experienced with some of their aluminum assemblies.

The corrosion resistance of vinyl esters has been well known for decades. They're used in the chemical industry, minerals processing industry, pulp and paper industry and water and wastewater industry to prevent premature failure of components because of corrosion.

Fiberglass provides the appropriate strength and stiffness to insure vibration resistance and structural integrity.

In the end this particular thermoset composite innovation provided the client with a couple of key benefits.

1) It eliminated many of the manufacturing steps and secondary operations that are required for the use of metal parts. All of the holes and connection points were molded directly into the blade. Thus, a reduction in assembly labor as well.

2) It eliminated part count. The client saw a 75% reduction in the number of required parts per fan from 250 parts per fan to 60 parts per fan.

3) It helped maintain the structural integrity of the blades at a tip speed of over 450 mph.

   Because the thermoset composite will not dent or bend, the vibrational properties of the blade are not affected if there is an impact at these high tip speeds.

4) The density differences between aluminum and the thermoset composite offered a substantial weight savings for the assembly.

It's important as well with this particular application to talk a little bit about how we developed such a large fan assembly in a cost-effective manner.

It doesn't make sense to build a production size tool early in the development process.

One of the things that we provide clients with in our 3i Composites Technology Center, which we will talk about in a little bit, is the ability to do prototype molding.

We worked with the client to do some FEA simulation and fatigue analysis on a smaller prototype blade design.

This allowed us to try blades made with several different materials throughout the project, and it also help us get a handle on part design and charge pattern for the eventual manufacturing of the blade.

You will see some of these prototype parts in a short video that we will show in a few minutes.

This allowed us to do prototype testing to determine fitness for use ahead of spending additional money to build a large full-scale production tool.

The third application that we want to demonstrate is an application that I'm sure many people have seen throughout the communities you live in; it is a thermoset composite tactile plate.

This particular application arose out of US government mandated requirements associated with the 1990 Americans with Disabilities Act.

The ADA required states and communities to make Public Accommodations that eventually lead to the need for safety tactile plates.

The key performance components with these particular parts are:

1) You have to be able to make a part that is flat. The part has to be flat upon installation.

2) The material has to be compatible with concrete, which is alkaline. Some level of chemical resistance is required.

3) It has to maintain its dimensional stability within the various temperature cycles it will experience.

However probably the most important criteria associated with this is both the color of the part, which is varied by state and community, and the parts ability to maintain that colorfastness throughout prolonged outdoor exposure.

These parts are typically embedded in the concrete and removing and replacing them can be quite troublesome.

We have worked very closely with both our clients and our supply base to ensure a thermoset composite solution that maintains both dimensional stability and color stability after numerous years of exposure outdoor.

This is an example of a standard product line, our S51, glass fiber reinforced UV stable sheet molding compound, that has been customized to meet the specific color requirements called out by the individual state or county regulatory agency.

The last few examples that we want to show consist of some automotive applications.

Our thermoset composite materials, in both bulk and sheet form, have been utilized for a number of years to make valve covers, headlamps for forward lighting and exterior automotive parts.

Now anyone that drives a car can understand the need for a headlamp assembly to maintain its optical integrity. Car design is also advancing the need for materials that can maintain their dimensional integrity in very complex geometries.

Likewise, a valve cover, which is fastened to the top of an engine, can experience large temperature swings. It utilizes a gasket to maintain a tight seal to prevent leakage of engine fluids.

It's very easy to understand the requirements necessary to insure the structural integrity of a part like a valve cover.

Thermoset composite materials have allowed the design of a part with very tight tolerances, like a headlamp or valve cover, and allows those parts to maintain those tight tolerances and stiffness upon exposure to the types of environments that would be seen with these particular parts.

Additionally thermoset composite materials are utilized in high-grade appearance applications.

Our colleagues at our manufacturing facilities in Europe and Asia supply a number of materials in sheet form that are used on automobile exteriors.

If you look at the part shown in the lower right corner, you can begin to understand how the use of these materials help eliminate secondary operations and waste associated with the stamping of metal parts.

These thermoset materials can be painted in a number of different paint systems, and as mentioned before, are also available in a variety of densities between approximately 1.0 to 1.5 g/cm^3.

Aluminum is approximately 2.5 g/cm3. With the push toward light weighting of automobiles, thermoset composites can add some real advantages.

This slide shows another example of an appearance grade thermoset composite utilized in a rear deck lid.

This particular assembly includes both the external skin, which is painted, and the interior substructure.

The interior substructure adds the strength and stiffness required for this application. The thickness of the interior part will be a bit more than the exterior part. So, you can understand why the lower density of the composite material is important.

Even with the thicker interior part, the thermoset composite offers a 30% weight savings over the equivalent aluminum assembly, and is painted to a high gloss class A finish.

We think it's important for you to understand how we develop some of these particular materials. So, we would like to do is introduce you the IDI 3i Composites Technology Center; we would like to talk with you a little bit about some of the things that we do in the center in order to bring some of these innovations to our clients.

One of the key strategies that we utilize is to work with innovative customers that seek to go beyond the value limitations of conventional materials.

We have a short video that will give you an idea of some of the capabilities that we possess within our facility. It will show you how some of these materials are manufactured and how we pursue the prototype parts process within the Technology Center.

<< 3i Composites Technology Center Video is available online at idicomposites.com >>

The mission of this center is to deliver customer solutions that optimize performance and provide a competitive advantage.

The process we use takes us from problem inquiry, through solution ideas, and into a production ready state with the new innovation, hence the 3i name.

What you saw in the video is our materials development machine.

The machine base is heated throughout, which gives us a lot of flexibility to utilize a number of thermoset resins.

We also have the capability to run both fiberglass & carbon fiber in either a woven mat, unidirectional or discontinuous form.

This machine gives us tremendous flexibility to make a variety of unique materials as well as our standard sheet materials.

While we are not a commercial molder, we do have 100+ years of combined molding expertise on staff.

Our goal with our molding capabilities in our technical center is to help clients get their innovation to market faster and more cost effectively through the use of prototype molding capabilities.

While we do not typically own the design of a client's particular part, we do have some basic CAD capabilities that can be utilized to assist with part design.

We have an analytical lab for testing during throughout the development process.

We can do basic physical evaluations: Flex, Tensile & Impact Performance; and we can do that at elevated, ambient and sub-ambient temperatures.

We can do Compositional analysis by Infrared spectrophotometry and we have access to a wide range of analytical & evaluative ASTM methods.

The key is to help customers move from the test coupon phase to the production part as seamlessly as possible.

This particular slide is a summary of the key capabilities that we focus on within our 3i Composites Technology Center.

If you have additional questions about any of this or you want to make an inquiry, you can find additional information on our website, idicomposites.com.

We hope the webinar has provided an insight into how you can make Composites Perform for your next application. We'll now take some questions.