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AEROSPACE & DEFENSE TECHNOLOGY™

The Engineer's Guide to Design & Manufacturing Advances

SAE INTERNATIONAL®

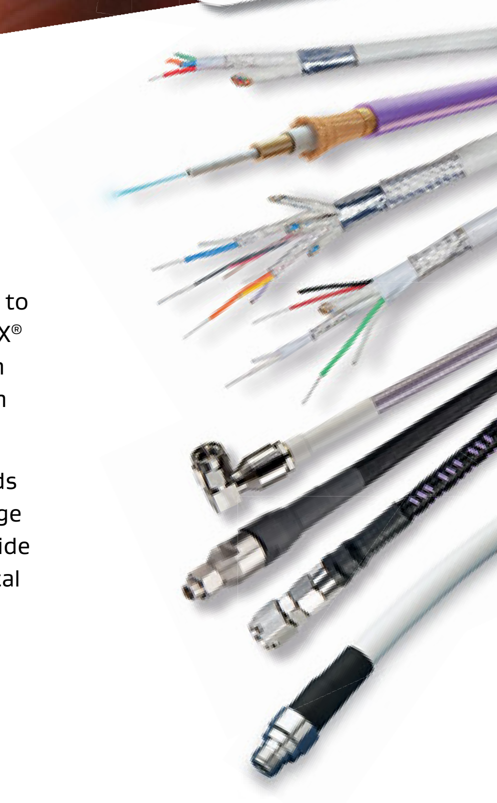
Reducing the High Cost of Titanium

Streamlining Post-Processing in Additive Manufacturing

Tips for Reducing Error When Using Eddy Current Measuring Techniques

From the Publishers of TECH BRIEFS


SOLVING TODAY'S
AND TOMORROW'S
ROTARY WING
CHALLENGES.



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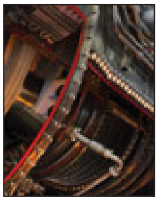

Titanium has long been a key material in aerospace applications, especially engines, due to its high strength-to-weight ratio and ability to resist heat and corrosion. It's one drawback to date is that it's expensive to produce, but that may soon change thanks to a new patented electrochemical process that significantly reduces material waste. To learn more, read the feature article on page 12.

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Engineered Solutions for *Enclosure Sealing and Insulation*

In the aerospace and defense industries, enclosure sealing and insulation needs to meet challenging and complex requirements. For example, the EMI gaskets that are used in military touchscreens must shield sensitive electronics from electromagnetic interference (EMI) while providing electrical conductivity and ensuring environmental sealing. These enclosure gaskets must also cushion the unit from mechanical shock and avoid interfering with the display's touch function.

Custom enclosure gaskets can meet these and other requirements, but designers need to specify the right materials and manufacturing methods. Unlike commodity rubber, specialty elastomers come with higher prices and minimum order quantities (MOQs). If part features such as holes, notches, or chamfers are required, manual gasket cutting may not be able to achieve the required degree of precision. Poor-quality cuts don't just suggest poor workmanship; they can result in sealing or insulation failure.

Designers also need to comply with the aerospace standards or military specifications listed on part drawings. Manufacturing at an AS9100D certified facility may be required, too. Meeting all of these demands can add considerable costs, which is why outsourced fabrication is now used with many projects. Examples of these engineered solutions include finished gaskets for EMI shielding or high flex-fatigue resistance, and custom insulation for heat and noise control.

EMI Shielding and Flex-Fatigue Resistance

With the proliferation of sensors and electronics, many enclosure gaskets need to provide a combination of sealing, shielding, and shock absorption. Thanks to innovations in material compounding, gasket materials can combine the advantages of elastomers with the electrical properties of metals. Silicones, a family of synthetic elastomers, offer thermal stability over a wide temperature range and resistance to ozone, water, and sunlight. When packed with metal or metal-coated particles, silicone sheets and rolls can provide EMI shielding and electrical conductivity.

Older particle-filled elastomers could be too hard or too brittle, but newer EMI silicones come in durometers as soft as 30 Shore A. During gasket cutting, these materials won't stretch or become deformed. Connector holes align properly, and the material's structural properties support greater tear resist-

Water jet cutting can create precise holes, notches, and chamfers to accommodate fastener heads and enclosure features.

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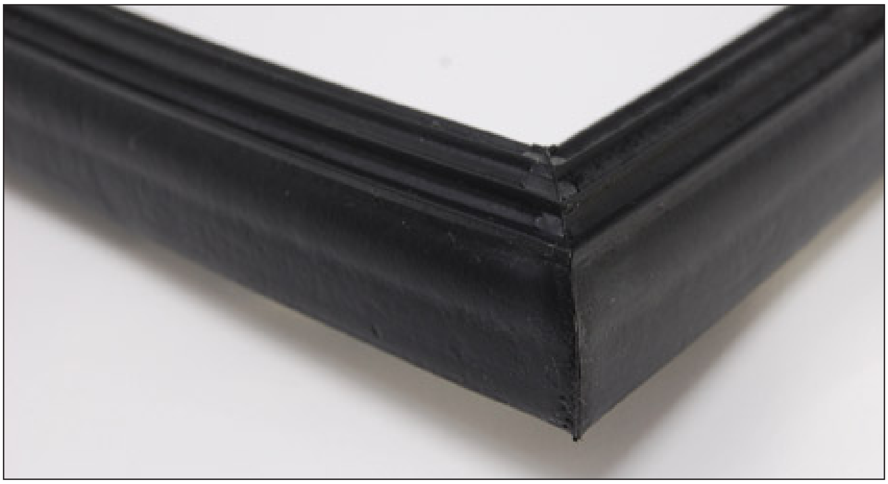

EMI enclosure gaskets support the use of electrically conductive adhesives. Enclosure designers have a choice of bonding methods.

ance – a key consideration for gaskets with thinner walls. For shielding applications where Z-axis conductivity is required, EMI enclosure gaskets support the use of electrically conductive adhesives. Designers who choose an engineered solution can also specify an adhesive backing for ease-of-installation.

Importantly, enclosure designers now have a choice of fill materials. Historically, many EMI gaskets were filled with silver or silver-aluminum particles. Today, nickel-graphite particles can provide silver-like connectivity. These gasket materials cost less than silver-filled compounds and can meet the lettered

Acoustic and thermal insulation can absorb sounds, dampens vibrations, reflects radiant heat, or resist the spread of fire.

requirements of MIL-DTL-83528, a U.S. military specification.

For cost-effective fabrication, water jet cutting can be used. Unlike manual cutting, water jet equipment limits mis-cuts and material waste. Fluorosilicones have physical and mechanical properties that are similar to silicones, but provide improved resistance to fuels, oils, and solvents. In some aerospace and defense applications, fluorosilicone enclosure gaskets are required because of the splash of jet fuel, deicing fluids, or cleaning agents. During compound selection, designers can choose compounds that meet SAE AMS standards, or that meet the EMI shielding requirements of the MIL-DTL-83528 specification.

Silicone compounds have many desirable properties, but some have inadequate flex-fatigue resistance – a measure of a material's ability to withstand repeated flexing or bending without cracking. That's a problem in aerospace and defense, where materials with high flex-fatigue resistance are needed for door seals, window seals, and the vibration-isolating mounts for alternators, compressors and assembly bolts. Aerospace and military enclosures need gaskets with high flex-fatigue resistance, too.

During material selection, designers can specify materials that meet the full requirements of the A-A-59588 3B specification – with no exceptions for flexural testing. This standard from the U.S. General Services Administration (GSA) references the DeMattia Flex Resistance Test, which measures crack growth in inches over thousands of flexural cycles. Some A-A-59588 3B materials aren't fully compliant, however, so it's important to partner with a fabricator that can source certified 3B materials.

Gasket fabricators differ in terms of manufacturing capabilities, too. In addition to the cutting method, designers need to consider the best way to bond rubber gaskets. Hot splicing requires clean, straight cuts but support higher production volumes. By contrast, vulcanization is more forgiving since the cuts don't have to be smooth and precise. Cold bonding is a manual process that's performed with a brush or an adhesive or glue. It's ideal for low-volume quantities, but cold bonded gaskets won't last as long as hot spliced ones. Molding is the only bonding technique that can create rounded corners.

Thermal Protection and Noise Control

In addition to rubber gaskets, aerospace and military enclosures need insulation that can absorb sounds, dampen vibrations, reflect radiant heat, or resist the spread of fire. Depending on the application, designers can specify thermal, acoustic, or thermal-acoustic products. These engineered solutions feature multi-layered structures and can meet FAR 25.856, which defines requirements for materials that are installed in an aircraft's sides or underneath the flooring. Thermal, acoustic, and thermal-acoustic insulation is also used in ground support equipment (GSE).

Acoustic insulation absorbs, transmits, or redirects sound waves – vibrations in the air that pass-through objects and result in audible noise. There are four main types of acoustical materials: absorbers, barriers, dampers, and facings. Sound absorbers are made of open cell acoustical foams, typically polyester, polyurethane, urethane, or melamine. Sound barriers are also made of foams but are denser. Vibration dampers come in extruded vinyl, asphalt-impregnated paperboard, metal

Ground support equipment (GSE) contains several enclosures, including the cabin, that require sealing and insulation.

Thermal, acoustic, and thermal-acoustic insulation are all used in GSE. GSE gaskets need to withstand wind, water, a range of service temperatures, and possible contact with jet fuel and de-icing fluids.

foil, or fiberglass. Facings include materials that resist dirt, mildew, abrasion and chemicals.

Thermal insulation also comes in a variety of materials with specific properties. Examples include Mylar films and aluminum foils that reflect radiant heat, melamine foams that resist fire, and vinyl rubber that meets UL 94 V0 flammability requirements. Like acoustic insulation, these thermally insulating materials are laminated together in a sandwich-like structure. They can also be combined with sound absorbers, dampers, barriers or facing materials for noise control. To support temporary or permanent fastening, custom insulation can be taped or used with a pressure-sensitive adhesive (PSA).

The engine bay insulation that's used with GSE provides several examples of engineered solutions. To keep heat and noise in the engine bay from reaching the cabin's interior, thermal and acoustical materials are layered together, laminated, and then water jet cut into precise geometries with part features such as notches and bolt holes. Some thermal-acoustic insulation consists of an aluminum facing or metallized Mylar that's laminated to a sound-absorbing foam. The facing reflects radiant heat and resists engine oil, but also withstands the soap and water used in engine washdowns.

Engine bay insulation can also use lightweight, melamine fire-resistant foams that are laminated to facing materials and supplied with PSA liners. Open-cell melamine foams combine high-temperature resistance with strong sound-absorbing properties. Another type of engine bay insulation sandwiches a layer of silicone foam between a reinforced fabric facing and a removable PSA liner. Along with chemical and oil resistance, this type of insulation resists mildew.

The GSE cab or cabin where an operator sits is another type of enclosure with custom insulation. If the vehicle uses a headliner, the insulation's facing material may feature small holes for enhanced noise control. Sound absorbing foams that resist moisture, dirt, and petroleum products are heat laminated to these vinyl facings, which come in custom colors. Rubber flooring isn't generally associated with enclosure sealing and insulation, but floor mats that are water jet cut conform to contours and help to absorb sound.

Enclosure designers need to meet multiple requirements for aerospace and defense applications. Material selection, manufacturing capabilities, AS9100D certifications, and standards like MIL-DTL-83528, A-A-59588 3B, and FAR 25.856 are just some of the factors to consider. By choosing a value-added manufacturer instead of a component supplier, designers can find engineered solutions for superior sealing and insulation. For mission-critical applications, the requirements are for nothing less.

This article was written by Roberto Naccarato, Sales Manager, Elasto Proxy (Boisbriand, Quebec, Canada). For more information, visit ***http://info.hotims.com/73000-500.***

Tips for Reducing Error When Using Eddy Current Measuring Techniques

Inductive eddy current technology is an extremely versatile non-contact method for measuring an object's position, distance, or vibration. Unaffected by environmental contaminants or target finish characteristics, these sensors can operate in a vacuum or in fluids, so they work well for dirty applications, like those with oil or dust present. To get the most out of eddy current sensors, follow these tips for reducing errors that can affect a measurement's accuracy.

Eddy Current Measurement Basics

Inductive eddy current sensors operate by generating a high frequency electromagnetic field about a sensor coil, which induces eddy currents in a target material. Eddy current sensors require a conductive target (usually some sort of metal), and sensor performance is affected by target material conductivity. Nonconductive material between the sensor and the target is not detected. The sensors do not require a ground connection to the measuring system. Measuring distance is typically 30-50 percent of sensor diameter.

Inductive eddy current sensors have a large spot size compared to other technologies. They also have a higher frequency response, an advantage when measuring something moving very fast. This can make them a better choice than contact technologies like linear variable displacement transducers (LVDTs), which can interfere with the dynamics of the object being measured. Touching something that is moving to make a measurement adds mass, slowing down the system so it is not being measured at the actual speed.

Eddy current performance is affected by temperature changes, but can ignore contamination that would foul up laser triangulation/LED, ultrasonic, or capacitive measurement technologies.

Sources of Error

Care must be taken to avoid common error sources associated with eddy current sensors. If not, users may not get a good measurement, may get more error than can be tolerated for the application – or they may not be able to get any measurement at all.

The main sources of error in eddy current measurement sensors include:

- Selecting the wrong circuit type
- Presence of another metallic object near the target
- Temperature variations or environmental conditions that affect measurement accuracy
- Multiple sensors mounted in too close a proximity
- Incorrect mounting

Tips for Reducing Errors

1. *Select the Right Circuit*

Eddy currents can be interpreted and processed into useful information in signal

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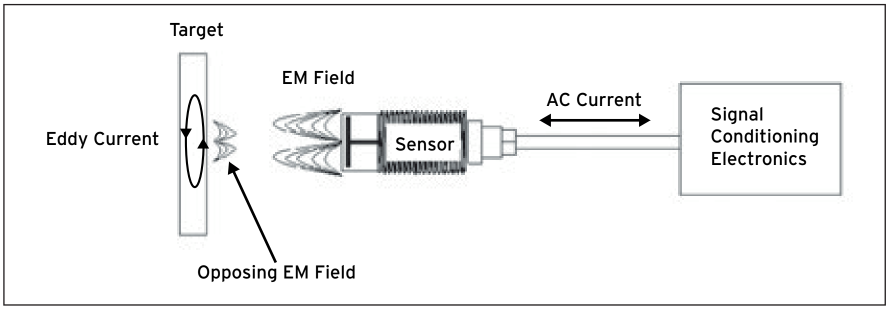
conditioning electronic circuits. Kaman uses three popular types of these circuits to process the signal:

- Colpitts circuit – single channel analog position measuring systems
- Balanced bridge circuit – single ended and differential analog linear position measuring systems
- Phase circuit – single/multiple channel analog high precision position systems



Each signal conditioning circuit type has distinct characteristics, so users should look for the one that performs best in a given application. To select the right circuit, begin by looking at the measurement – what kind are you taking? Is it single or differential? Look at the target – is it magnetic or non-magnetic? Knowing this information will go a long way to setting users on the path to reducing error.

For example, when the *Colpitts circuit* is used as a position measuring device, the sensor coil becomes the inductor in the oscillator circuit. When the sensor coil interacts with a conductive target, the oscillator frequency and amplitude vary in proportion to the target position. This variation is processed into an analog signal proportional to displacement.

Kaman typically recommends Colpitts circuits for low-cost, general purpose measurements where linearity is not required. They can be a good choice for fuel injector testing, valve lift measurements, shaft or cylinder run out and vibration, and machining and grinding.

With a *balanced bridge circuit*, the target movement causes an impedance change in the sensor coil. This change of impedance in the coil is measured by the demodulator circuit, linearized by a logarithmic amplifier, and then amplified in the final amplifier stage.

In the single ended configuration, the systems are a good choice for both ferrous and non-ferrous targets, including general purpose linear position measurement, laboratory, research and development, testing, metrology, and factory process control.

Differential bridge systems are frequently the best choice for fast steering mirror (FSM) position applications, pointing and tracking in night vision and laser systems, control systems for active vibration monitoring and control systems, and photolithography stage positioning and control.

If a *phase circuit* is used, the effects of eddy currents are not only amplitude related, but also phase related. This circuit is based on phase detection using pulse width modulation (PWM) techniques. Typical recommended applications include stage positioning in atomic force microscopy (AFM), Z-axis positioning in photolithography equipment, laser optics positioning, precision grinding, and semiconductor wafer transport mechanisms.

2. Adjust for the Presence of Another Metallic Object Near the Target

Measuring one metallic object when another metallic object is too close is a major source of error. This may depend upon the material, the size of target, and the measurement range. For example, it may be especially difficult to measure if the target is conductive but very small and thin and difficult to get close to. The potential for error will also depend upon how much material is required to interact with the eddy current field.

For example, in a racing engine research and development application, a Kaman customer wanted to ensure they were getting the correct engine stroke and were developing a system to test how various conditions would affect the stroke. They were trying to measure a piston moving, but there was another piston in close proximity and the measurement was "seeing" both pistons.

In this case, Kaman recommended mounting one sensor behind the piston and one in front of it. Each sensor was used to measure half the stroke. The end user was able to get closer to the piston with a smaller sensor that did not "see" the other piston.

3. Adjust and Calibrate for Temperature and Conditions

Be sure to calibrate the system in the environment in which it will be operating. Calibrating in one environment and then placing it in another may induce errors.

High and low temperatures have the potential to change the measurement. A measurement that is excellent at room temperature may change when taken at 500°F or at 1000°F. To adjust for this, if measuring across a wide temperature range, users should perform calibrations to show what error may exist at different temperatures.

For example, one recent customer was taking several measurements of blades inside a large gas turbine. The system is optimized for the key measurement, which is taken at 800-900°F, but also takes measurements at room temperature as the turbine is beginning operations. The measurement could be accurate at one or the other of these points – but not both. For this system, Kaman developed a sensor that was accurate at the higher temperature, and then used mathematical calculations to develop curves providing information on the error to be expected at the room temperature measurement.

Environmental conditions are also an issue in cases where there are multiple moving pieces and the system is trying to read only one. If the sensors pick up another moving metal object, one may be able to place another piece of metal in between to shield it. The fixed object absorbs the signal but one can still see the moving target. In short, the fixed piece simply becomes part of the environmental conditions and one can calibrate around it.

For applications that measure on a rotating target like a shaft, the surface velocity of the shaft can also affect the measurement. As it spins faster, it may look like a smaller target. Again, mathematical calculations can be developed to account for the size of the target, the material it is made of, and how fast it is moving to ensure that a proper measurement can be made using an eddy current sensor.

4. Avoid Multiple Sensors

Two or more sensors mounted in close proximity to each other may result in their electromagnetic fields intermixing, which may cause interference and reduce measurement accuracy. This interference is in the form of “cross talk,” resulting in beat notes whose frequency will be the difference between the frequencies of the oscillator in each unit.

5. Pay Attention to Mounting

The quality of any measurement depends on the mounting fixture. The amount of conductive material in or near the mounting fixture will have an impact on system performance. Mounting the sensor in a material that absorbs too much of the field results in measurement errors. For example, mounting an eddy current sensor inside a large steel block and recessing the sensor would absorb the field so it would be hard to measure.

A sensor is “side-loaded” when its field interacts with conductive material other than the target. Shielded sensors reduce this effect. For optimum performance, keep conductive material out of this field if possible. Perform in-situ calibrations if conductive material other than the target will be in the sensor’s field.

To eliminate the possibility of error, make sure the sensor is mounted so it is aimed as squarely at the target as possible. It should not be recessed and there should be nothing in its way to absorb the signal. If possible, mount the sensor inside a plastic block.

In addition, the target and sensor should be parallel to each other. Some non-parallelism can exist without inducing significant error. A non-parallelism of up to 3 degrees will increase nonlinearity less than 0.5 percent of full scale. Non-parallelism of 10 degrees will increase non linearity approximately 4 percent of full scale.

6. Allow for a Certain Amount of Errors

One final tip is to accommodate room for error. If one is looking for a measurement at half-inch, try to ensure the measurement can be made at three quarters of an inch, so there will be room to work within. Account for temperature errors by performing measurements with systems ahead of time to understand the shifts that may take place at higher temperatures, and be able to adjust for errors that may occur at different temperatures.

The goal should be to reduce errors to as low as possible. To ensure the best measurement with eddy current technology, select the right sensor, calibrate it carefully for the temperature and environmental conditions it will be operating in, and make sure to mount and position the sensors properly.

This article was written by Kevin Conlin, Business Development Manager, Kaman Precision Products (Middletown, CT). For more information, visit ***http://info.hotims.com/73000-501***.

Reducing the High Cost Of Titanium

Titanium is neither a precious metal nor rare, yet among industrial metals it has the reputation for being very expensive. It's the fourth most abundant metallic element and the ninth most abundant of all the elements in the earth's crust. Its commercially useful oxide ore occurs in the minerals rutile and ilmenite and numerous iron ores, and exploitable ore deposits are liberally scattered around the world in Australia, Canada, India, Malaysia, Norway, Russia, South Africa and the U.S. But due to its properties and high cost it has often been referred to as unobtanium.

With such great abundance why is titanium so expensive?

There are two primary reasons. First, the cost of chemically extracting titanium from its ore, then turning it into ingots is very high. Second, processing the metal from ingot to finished mill products generates large amounts of expensive waste.

Typically, 15 – 40% of the starting ingot material becomes scrap during required conditioning steps. Titanium's reactivity at high temperatures with oxygen and nitrogen contributes to the high cost in both cases.

Among major structural metals, titanium is the youngest. Unlike iron, of which the first known artifacts shaped by humans date to approximately 3200 BC, titanium was not even identified as an element until the late 1700s. And it was not until 1937 that Luxembourg inventor Dr. Wilhelm J. Kroll developed a process demonstrating that it could be produced commercially. The Kroll process chemically reduces titanium tetrachloride with magnesium. Producers then either acid leach or more commonly vacuum distill the resulting sponge-like material to remove impurities and form the metal. After Kroll's demonstration, another eleven years of process development was required by the U.S. Bureau of Mines before the first commercial titanium sheet was produced.

How Titanium Is Produced

Titanium metal is produced from ore to mill product in three general steps:

- the chemical reduction of ore to sponge (the agglomerated granules resemble a sea sponge);
- melting the sponge (often in combination with titanium scrap) to form an ingot;
- and lastly, converting the ingot into saleable mill products.

The chemical process of refining the ore to metallic sponge is a complicated multi-step, high temperature batch process that is labor, energy and capital intensive. In spite of attempts to improve upon it, the process has remained basically the same since its inception.

Turning sponge into ingot is complicated and regardless of which melting method is used—vacuum arc re-melting (VAR), electron beam cold hearth melting (EBCHM), or plasma arc melting (PAM)—it is highly energy intensive. Like the ore chemical reduction process, it must be done in a vacuum or inert atmosphere to control reactive contamination that would compromise the metal's structural integrity.

The last step, thermo-mechanical conversion of titanium ingot into mill products—bar, plate, sheet, rod, and so on—is done in much the same manner as other metals. But, again, the metal's highly reactive nature plays a critical role. The metal is heated to the appropriate temperature, processed to the next incremental size or shape (mainly via forging or rolling), allowed to cool, conditioned and inspected. Then the process is repeated until the final mill form and size is reached. However, when exposed to air at high temperatures the metal is reactive, absorbing additional oxygen and nitrogen, forming a hard, brittle, shell-like oxygen-enriched phase of the metal called “alpha case” over the entire surface. The mechanical properties of the alpha case layer are greatly reduced from the parent metal. Additionally, as the metal cools, surface cracks form which can extend into the material to a depth of 5% or more, and they too are covered with alpha case. Unless the alpha case layer and the cracks are removed, additional thermo-mechanical processing will simply drive the cracks and defects more deeply into the metal, compromising its performance and fatigue properties, causing even greater yield losses at the next conditioning step.

Conventional Conditioning

The process for removing alpha case and surface defects and preparing the metal for the next hot forming step is called “conditioning”. Alpha case is tenacious and hard and the most widely used method of conditioning titanium traditionally has been grinding, often followed by acid pickling.

The removal of metal by grinding with a rotating abrasive wheel is a slow process governed by physics. The arc of the grinding wheel can only contact the material being conditioned in a small patch. The contact patch pressure must be carefully controlled as the wheel rotates and moves laterally. Too little pressure and the process is inefficient. Too much pressure generates excessive heat creating a new layer of alpha case. The round wheel can only remove a narrow strip of material as it moves the length of the surface. It then indexes for the next pass and repeats the process until the entire surface has been reduced by the depth of the wheel’s arc. The total surface grinding process is repeated as many times as required until the surface appears crack-free. Pickling is often subsequently used to clean the surface and reveal cracks and other defects covered over and hidden by metal smeared during grinding. The material is then either returned to the auto grinder for additional grinding, or hand ground if the revealed defects are shallow. Both conditioning methods are dangerous and generate hazardous waste.

The industry also sometimes uses machining, either bar turning or milling, to condition titanium, but the machining process is more costly, even slower, and removes excessive prime material. Machining is usually only employed where the producer requires a smoother surface than can be obtained from grinding and/or pickling, such as when an ultrasonic inspection follows the conditioning step.

These conventional conditioning processes have been used virtually since the beginning of titanium production because they worked and were pretty easily understood. Of course, they were developed and have been fine-tuned by different producers to meet their own needs (the amount of conditioning required after hot working depends on numerous factors including melt source and method, hot process and amount of

As-forged incoming material displaying cracks and alpha case, requiring conditioning.

The same material fully conditioned by the MetCon process, ready for forging or rolling. Crack tips have been removed and more parent material preserved than by traditional conditioning methods.

reduction). But the basic processes have been accepted and have not changed much since the early days of titanium production. Accordingly, conditioning processes have remained relatively low-tech and until recently no one has figured out a way to improve upon them. Yet the cost of the material lost to waste in conditioning is one of the largest contributors to the cost of the material sold.

New Conditioning Process Improves Yield

A new conditioning process is finally reducing costs for titanium producers. The process replaces traditional full surface grinding, machining and acid pickling conditioning steps with lower loss electrochemical treatment steps. The patented electrochemical process, developed by MetCon, LLC, improves ingot to finished product yield by 10% to more than 20% and represents the largest cost reduction breakthrough for titanium in more than a quarter century. In addition, the process offers greatly accelerated throughput and is truly environmentally green, providing additional production cost and safety benefits.

MetCon removes the alpha case layer using a newly developed, patented, electrochemical process. The key benefit of the process is the ability to remove precise amounts of surface material from titanium forms using rectifier control. Instead of removing all material down to the level of the deepest crack tip, as done by mechanical methods, the MetCon process electrochemically removes a much thinner layer, which includes the vertical surfaces of the cracks. Due to the nature of the process, the edges of cooling cracks are attacked preferentially, eroding them without removing adjacent bulk metal. The cracks are opened and their edges are smoothed and feathered to blend with the surrounding metal. Unlike traditional acid pickling where cracks are simply etched deeper along with removal of the surrounding metal, the crack tip remains at the original depth in the MetCon electrochemical process. The process also electrochemically conditions the crack tips, rounding and blunting the sharp points. The conditioned, feathered and rounded alpha case-free prior defects "heal" on the next hot working step rather than propagating further into the material.

The subtractive procedures of surface grinding, machining, and acid pickling remove with each conditioning step from 3 to 7 volume percent of the piece being processed, depending on the depth of the cooling cracks. In comparison, the MetCon process removes much less material—just 0.5 to 3% per conditioning step. Between ingot and finished mill product there are typically three to four hot working steps that require conditioning, and some products require more. Since the savings on each conditioning step are cumulative, the MetCon process can give a titanium producer as much as 20% or more additional finished material to sell. The increased saleable metal comes from the same size starting ingot with essentially no increase in manufacturing costs.

Alternatively, since the MetCon process reduces conditioning waste, a titanium producer could apply significantly less starting material, whether that be sponge, ingot or billet, to produce the same output volume of finished product and the same amount of sales income as they would using conventional conditioning techniques. Taking this approach, the MetCon process substantially increases the producer's finished product output capacity while requiring no melt shop or raw material capital investments.

A Faster Process That Is Also Green

The MetCon process is substantially faster and much safer than traditional conditioning processes. The common techniques of grinding or machining remove small amounts of material with each pass as the removal device, grinding wheel, or machine tool slowly moves down the workpiece. Grinding processes generate heat as they turn solid metal into swarf or dust that is an explosion hazard and must be carefully controlled and removed from the air (the bursts of white color you see in fireworks displays are often produced by burning titanium particles). Titanium machining chips from milling and turning conditioning steps are highly flammable and the cause of numerous catastrophic plant fires. Because the conventional processes are limited by physics as to how much material is removed at a time, they must be repeated numerous times over the entire surface, on all faces of the material, until reaching the bottom of the deepest cracks. Only one surface of one piece can be conditioned at a time by one machine, and the traditional processes are very time consuming.

Elevated temperature acid pickling is also used in conditioning, often in conjunction with the mechanical processes. Final product pickling is often required by customers' specifications as a final surface cleaning. Pickling can also deal with smeared deposits caused by the grinding or machining operations that routinely conceal material flaws. If these flaws are not revealed using a secondary pickling step, they will be discovered in downstream processing steps or during sonic inspection where they are more costly to address, cause even greater yield losses, or far worse, where they can compromise large amounts of expensively processed material. But the acids used (typically hydrofluoric and nitric) are among the most dangerous known.* From production to delivery, use, and disposal, they must be handled with elaborate precautions and expensive hazardous materials apparatus to minimize inherent danger. For worker safety the air must be scrupulously scrubbed where the acids are used. Even with such precautions, equipment and structures have short lifespans due to corrosion.

In contrast to grinding or machining, the MetCon electrochemical process takes place with the material submerged in electrolyte in a large tank. The material is subjected to a range of electrical currents and voltages that remove the alpha case and open the cooling cracks, rounding and blunting the crack tips. The electrochemical process itself is inherently much faster than traditional mechanical grinding or machining. Because the piece is submerged, the MetCon process has the substantial advantage of conditioning all surfaces simultaneously. Plus, as many pieces can be treated at one time as fit into the tank. Current tanks accommodate full heat quantities (condi-

Technician checks electrochemical bath temperature as material is loaded into tank. The green MetCon process environment requires none of the extreme hazmat precautions typically associated with pickling.

MetCon conditioned material ready for the next process step.

tioning an entire heat at one time is a breakthrough) and there are no technical restrictions to scaling the tank sizes larger. Material is ready for the next forming step five to 50 times faster than by traditional conditioning methods, greatly accelerating work-in-process cycle times and relieving a typical production bottleneck. In addition, for operations that rely on a pickle to reveal defects after a grinding operation, this new process eliminates the need for that entire processing step, cumulatively taking weeks out of the traditional processing time.

Since the process is electrochemical, it generates no hazardous grinding or machining dust, swarf, or chips. Material removed is absorbed by the electrolyte. The proprietary MetCon electrolyte is a weak acid comprised predominantly of water with small amounts of a fluoride salt and a carboxylic acid (a solution closely related to a highly diluted common household cleaner mixed with orange juice). Very limited chemical handling precautions are required, and no hazardous material equipment is necessary in preparation, storage, or use.

The process takes place in an open environment. No hazmat suits are required and neither the electrolyte or the process has any impact on air quality. Because nitric acid is not employed (as is typical with the standard titanium pickle of HF-HNO_3) there are no NOx emissions or NOx regulatory challenges, which have resulted in titanium pickling facility closures in recent years. The electrolyte's benign nature allows neutralization to be easily done in-house before public sewer disposal, complying with all local, state and federal environmental standards. Because MetCon electrochemical conditioning is truly a green process, the extensive and expensive safety and hazardous material concerns required in conventional conditioning and pickling processes simply do not apply.

Seeing Is Believing

As with any innovative new process, titanium producers have approached the MetCon process with caution and in some cases skepticism. It is always difficult to alter thinking and habits that have been ingrained for many years, especially when the new process and its procedures challenge traditional teaching. However, as long-experienced industry technologists have become more familiar with the MetCon concept, their thinking has changed, particularly when they've had the opportunity to see their own material being conditioned by this new process. As one recognized industry expert said, "Observing the process while standing nearby in street clothes¬—no hazmat precautions required—is eye-opening. Seeing the results and doing the math clearly demonstrates the savings possible."

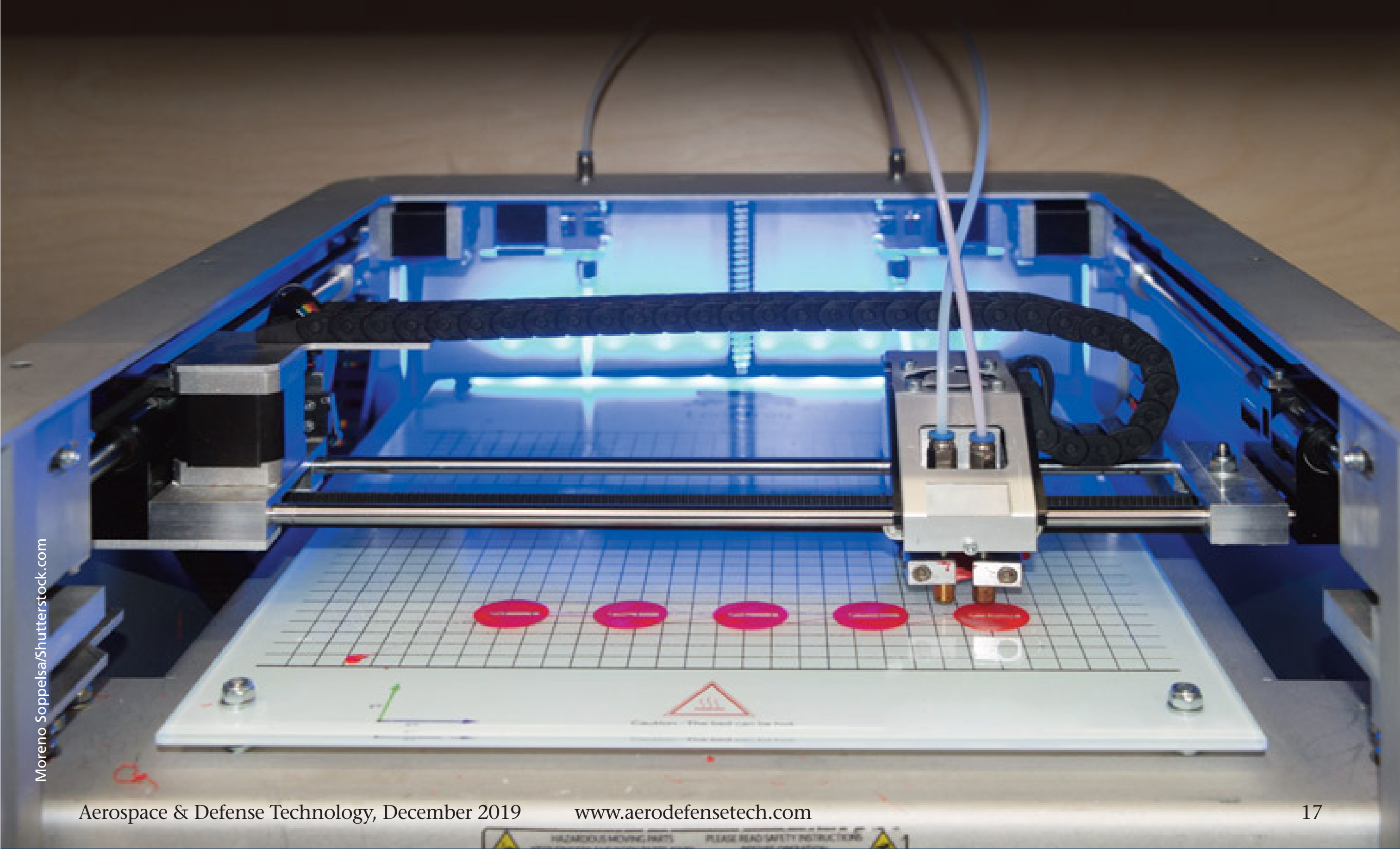
This article was written by Kurt Faller, President and Chief Executive Officer, MetCon, LLC (Monaca, PA). For more information, visit ***http://info.hotims.com/73000-502.***

* Pam Koontz, Environmental Health & Safety, University of Tennessee, Knoxville. http://docplayer.net/23171840-Pam-koontz-environmental-health-safety-university-of-tennessee-knoxville-hydrofluoric-acid-safety.html

Streamlining Post-Processing in Additive Manufacturing

Undoubtedly there are many benefits associated with the use of additive manufacturing (AM) as a production technology. On a pan-industrial basis, manufacturers exploit the fact that through the use of AM they can not only build complex parts, in one piece, which were previously impossible, but they can also build stronger, lighter-weight parts, reduce material consumption, and benefit from assembly component consolidation across a range of applications. These advantages have all been well documented during the last 10-20 years as AM has emerged as a truly disruptive technology for prototyping and production, and are invariably seen as being enabled by the additive hardware that builds the parts. In reality, however, this is a partial picture, particularly for serial production applications of AM. AM hardware systems are actually just one part – albeit a vital part – of an extensive ecosystem of technologies that enable AM, both pre- and post-build.

By focusing just on the AM build process, a fundamental part of the production process chain is often overlooked, namely the post-processing steps once the part is out of the AM machine. Manufacturers using (or considering using) AM for serial production applications need to first identify the appropriate additive process for their targeted application. From there the post-processing requirements must be identified and focused on, otherwise the use of AM as a viable alternative to traditional manufacturing processes may end up being negated completely.



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Post-Processing for AM

Post-processing is actually an umbrella term for a number of stages that AM parts may need to go through after they come out of the AM system and before they are fit for purpose. The term "post-processing" is often used interchangeably with "finishing", which is somewhat confusing. With many processes there are a series of essential post-processing steps that must be undertaken prior to the AM-produced part finishing stages. Thus "finishing" is actually a subset of post-processing, not a term that should be used interchangeably with post-processing.

Post-processing can include any or all of the following:

- Excess Material Removal
- Curing / Heat Treatment
- Support Removal
- Machining
- Surface Finish Processes (such as bead blasting)
- Coloring
- Inspection

So saying, post-processing is often the elephant in the room when it comes to the uptake of AM as a production tool. For AM production applications, post-processing is a considerable element of the overall cost-per-part, and can be anything up to 60% of total cost depending on application. Support removal and other post-processing activities are often labor-intensive and, therefore, cost- and time-consuming. In addition, there is often a necessity for post-processing to enhance final part characteristics in terms of functionality or aesthetics.

The PostPro3D BLAST process can achieve consistent surface finish on non-line of sight organic lattice structures.

EOS PA2200 material smoothed and coloured in one step. This is an engineering valve application, where sealed surfaces are critical to prevent fluid ingress.

This is why the issue of post-processing is so important when looking at the viability of AM for serial production, because it is often the area where the technology falls down as a competitive manufacturing technology. The post-processing conundrum needs to be confronted head on with an ecosystem approach to each individual application from end to end. This means joining the dots from product conception through to final product.

To a certain extent, post-processing can be cauterized by a focus on design for AM (DfAM) to reduce the necessary post-processing steps. Success here will depend on how well the designer understands the intricacies of the AM process and the specific capabilities of the AM system they are using, how to orientate the parts in the machine(s), and how to generate optimal support structures for build and removal. In general, post-processing requirements for a given application depend on the geometry of the component and how well it is designed for manufacturability using AM.

However, regardless of how well a product is designed for AM, it cannot negate the need for post-processing for all AM processes. The problem is that for an industry that calls itself disruptive, manufacturers are still largely post-processing parts the same way they did 100 years ago, with the requirement of significant manual intervention. And it is this that is slowing the whole process chain down for production applications of AM.

A New Approach to AM Post-Processing

The fundamental mission of Additive Manufacturing Technologies (AMT) Ltd is to confront this problem head on through the development of a series of innovative digital and automated post-processing solutions that increase efficiency and reduce the overall time and costs of production with AM, specifically with polymer AM processes and thermoplastic materials.

There can be no argument about the increased number and improved nature of the thermoplastic materials palette available for AM processes in recent years. Alongside these material developments, the AM systems that produce thermoplastic parts have also significantly improved in resolution, accuracy, repeatability and overall quality, and they are therefore consistently meeting industrial requirements for exacting prototyping, tooling, and some production applications.

However, the critical mass of production applications remain lower than they otherwise might be due to previously mentioned limitations placed on the overall process chain by the post-processing phase. This is because powder-bed processes — which require significant powder handling and removal post build — also invariably require infiltration operations, as well as finishing processes, particularly if aesthetics are important alongside the strength advantages that laser sintering offers. If colored parts are required, then this is also applied at the finishing stages of post-processing.

With filament thermoplastic material processes, the very nature of the AM process (no matter how refined) results in a stepping effect. The traditional post-processing steps required to eliminate these process-specific results are considerable, costly, and time consuming. However, an automated post-processing solution for smoothing high volumes of thermoplastic polymer parts to an injection molded surface quality would remove one of the biggest hurdles to the serial production process chain. Here we are talking about parts 3D-printed using laser sintering, Multi Jet Fusion, high speed sintering, and fused deposition modelling processes for specific material types including Polyamide/Nylon, flame retardant Nylon, glass filled Nylon, ULTEM, PMMA, TPU, and TPEs.

This is exactly the solution that AMT envisaged, developed, and commercialised with its PostPro3D® range of hardware, which integrates new systems, software and virtual services. The simplicity and speed experienced by the user belies the intelligent and complex capabilities of the system, which is built on the proprietary BLASTTM process.

Simplicity is the key. Post-build, the 3D printed parts can be removed from the machine, loaded onto a rack, and

The PostPro3D machine from Additive Manufacturing Technologies.

placed into the PostPro3D® post-processing chamber. The user then selects the appropriate program and the process starts and runs for 90-120 minutes, after which the parts can be removed, inspected, and are fit for purpose.

For anyone that is wondering what happens to the parts during those 90 to 120 minutes, they are subjected to a physiochemical process that involves converting a proprietary but wholly safe solvent into vapor under precisely controlled vacuum and temperature conditions. In turn, this precisely refines the surface of each part to ensure a perfectly smooth finish, equivalent to that of an injection molded part. Moreover, the process also seals and strengthens parts, essentially improving their mechanical properties — such as elongation at break — compared with how parts were when they came out of the 3D printer.

The intelligence of the PostPro3D® systems goes beyond their physical process capabilities however, as they have been designed to be connected through an IIoT network, where vital data is analyzed in real-time. This allows for new insights on process performance, which can subsequently be shared among the global fleet of PostPro3D® machines, and made available via software updates to continually upgrade performance, all while protecting individual IP. Moreover, this connectivity capability also allows for integration with other intelligent devices and workflow automation software across the production process chain.

Summary

What all of this points to, I believe, is the continued need to work towards developing whole process chains that will help to convince AM users, and potential AM users, that the transition to AM for an increasing number of production applications is worthwhile and not nearly as complex as it may have been, even a few years ago. This demands a unified approach — across the AM sector itself — to develop more capable and connected systems, while simplifying the overall process to provide economically viable, automated solutions. This can be achieved through partnerships and collaboration.

Automated turnkey hardware for post-processing is certainly a huge step forward for the post-processing stage of the production process chain with AM. However, there are still more steps to take, in terms of wholly connected, customized, end-to-end digital manufacturing systems.

This article was written by Joseph Crabtree, CEO, Additive Manufacturing Technologies Ltd (Sheffield, UK). For more information, visit ***http://info.hotims.com/73000-503.***

Software-Defined Analog Filters: *A Paradigm Shift in Radio Filter Performance and Capability*

Among the most abundant components in all wireless system designs, analog RF filters are used to block interference from various internal and external sources. Limited spectrum divided among an ever-increasing number of users is further driving the need for these ubiquitous but in some ways anachronistic devices. Currently, interference is quite common among cellular base stations, satellite systems, radar installations, and other types of access and backhaul communications systems. Traditional filters are unable to cope with the requirements; in many cases, most often due to insufficient guard bandf. For example, in some international locales, LTE base stations and satellite receivers share the L-band frequencies. At around 3.5 GHz, 5G operators, CBRS radios, and military radars are trying to co-exist. To address this in-band interference, a new, tunable filtering technology is entering the marketplace, uniquely blending the best of both analog and digital technologies.

Conventional Analog Filter – A Glimpse Back in Time

The wireless ecosystem has thrived during a period of exponential technology advancements, bringing dramatic advances in products and services for operators, enterprise users, and consumers alike. This includes moving from vacuum tubes to transistors to integrated circuits; the development of trunked, cellular, and digital radio systems; and the growth of unlicensed devices for consumers.

Yet analog RF filters, essential for combating interference and ensuring efficient use of radio spectrum resources, are still based on analog-era technology with significant performance, size, weight, and manufacturing limitations. RF filters are well-suited for legacy applications such as large, static infrastructure but when it comes to next-generation applications like consumer devices, advanced military communications equipment, or cutting-edge 5G networking devices, they fall significantly short.

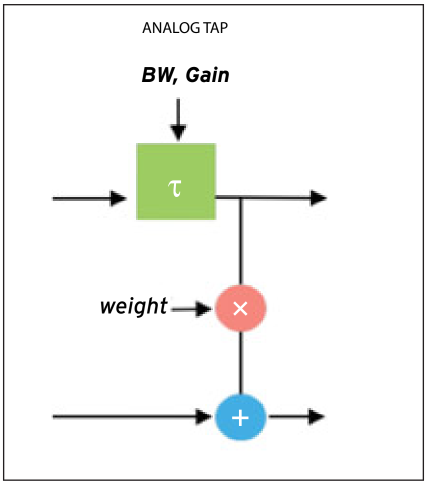

Figure 1. Diagram of a Finite Impulse Response (FIR) filter.

Conventional radio filters require a transition or guard band — a range of frequencies over which losses decrease from the rejection band (where unwanted signals are blocked) to the pass band (where desired signals are allowed to pass). In practice, a guard band is a stretch of spectrum that must be sacrificed to accommodate the coarse behavior of conventional filters.

Another conventional analog filter limitation is that they are inherently frequency-specific and must be designed and manufactured for each and every unique application. If an application requires rejecting signals on different frequencies at different times, then a filter bank — a device containing multiple filters that can be switched in and out of the circuit — may be required.

The primary problem with conventional filters, however, is that they often fail to provide enough signal rejection. This occurs in a number of scenarios: the interfering signal is too close in frequency to the desired signal, the source of the interfering signal is too close to the receiver, or the interfering signal is simply too powerful.

Digital Filter – Sufficient for Legacy Implementations

Digital filters, based either on Finite Impulse Response (FIR) or Infinite Impulse Response (IIR) architectures, are widely available and are commonly used as part of practically any digital subsystem. They offer immense flexibility in their ability to shape the signal. By nature, these filters operate on digital samples of the original analog signal. Simply put, before any digital manipulations can be applied to the signal, they must be sampled and converted to digital representation. This process is not only time-consuming but it also degrades the resolution (the dynamic range) of the original signal, since Analog-to-Digital Converters (ADCs) have a finite number of bits of resolution.

Once available in digital representation, the digital filter (essentially a set of mathematical manipulations of the samples) can be applied. This process, again, takes time since every addition or multiplication consumes CPU cycles. Inherently, digital processing introduces latency in the data path that must be

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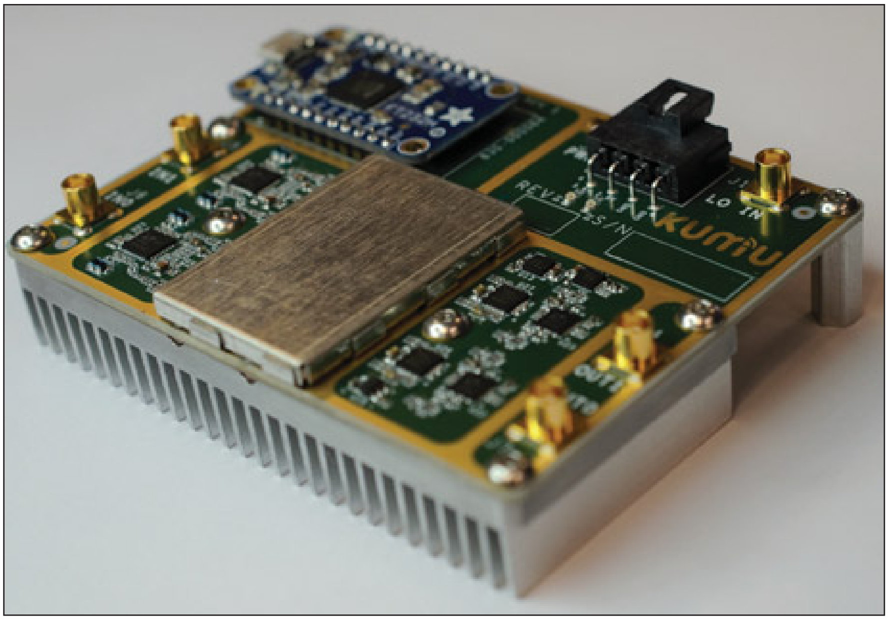


Figure 2. Kumu Networks' KU1500 RF integrated circuit.

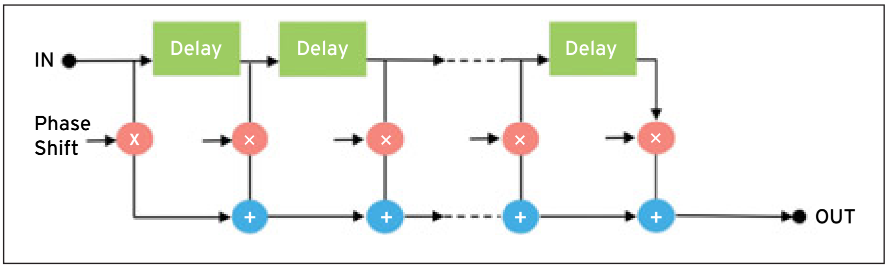


Figure 3. The software-controlled analog filter is a multi-tap implementation in which each tap packs an adder, multiplier, and delay element.

accounted for in the application. This often represents a challenge to RF applications given the propagation speed of the native analog signal. Finally, if the desired output of the system needs to be an analog RF signal (as in any transmitter), the digital samples have to be converted yet again, this time back to analog representation using Digital-to-Analog Converters (DACs) — further contributing to undesirable latency.

Software-Defined Analog Filters – A New Paradigm

The perfect RF filter would combine the no-latency, no-sampling characteristics of analog devices with the configurability and flexibility of digital implementations. The wireless electronics industry has been steadily progressing toward digitally controlled analog devices; for example, digitally controlled attenuators and phase shifters are extensively used in radars and other beam-forming applications. Implementation of filters, attenuators, and phase shifters is not enough — delay elements are also necessary; for instance, as part of an IIR or FIR (Figure 1) structure.

Analog delay elements are difficult to miniaturize — they typically rely on materials where waves are propagating slower than typically used conductors. The choice of material is a delicate balance between insertion loss and physical size/weight. Clearly, such solutions are not possible to implement in a low-cost CMOS IC. This is especially true for wireless applications where propagation delays necessitate long delay elements in the range of hundreds of nanoseconds or even microseconds, in aggregate.

As the only commercially available solution to embed long delay elements in a standard CMOS chip, the Kumu Networks KU1500 RFIC changes the existing paradigms (Figure 2). The software-controlled analog filter designed for wireless applications is essentially a multi-tap implementation in which each tap packs an adder, multiplier, and delay element (Figure 3). By adjusting the weights of its multipliers through a digitally controlled API, any desired filter response can be configured.

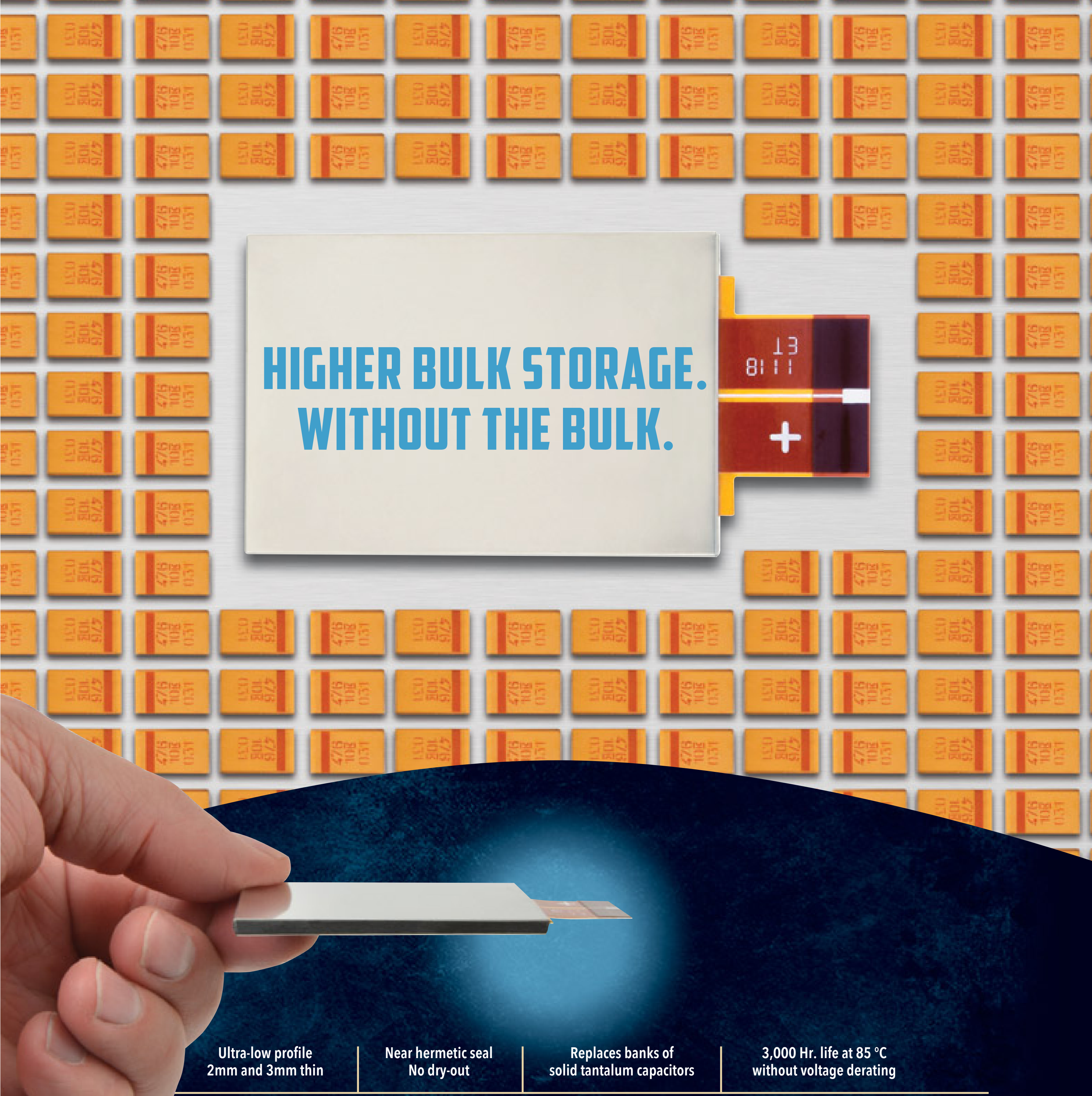
The software-defined analog filter was originally developed for Self-Interference Cancellation applications where the interferer is co-located next to the receiver. This is achieved by continuously modifying the response of the multi-tap analog filter to match the self-interference, using a tuning logic that estimates the self-interference channel. Traditional filter applications are obviously much simpler than that and can be handled with static configuration of the filter for the desired response.

Conclusion

For many legacy applications, conventional filters are cheap, reasonably small, and do an acceptable job. But in other applications, conventional filters fall short. A digitally controlled analog filter separates itself in environments where guard bands are unavailable or where spectrum cost dictates their elimination. Such filters could contribute dramatically to improved spectrum utilization. Additionally, self-interference cancellation based on these filters offers the ultimate solution for packaging multiple co-located radios into a small form-factor device, while sustaining total frequency agility across the entire band.

Using this technology, radios can communicate simultaneously using nearby, immediately adjacent, or even overlapping frequencies — a problem that actually occurs in the billions of mass-market devices that currently attempt to support both Wi-Fi and Bluetooth.

This article was written by Joel Brand, VP of Product Management at Kumu Networks, Sunnyvale, CA. For more information, visit ***http://info.hotims.com/73000-509****.*


HIGHER BULK STORAGE.
WITHOUT THE BULK.
Ultra-low profile
2mm and 3mm thin
Near hermetic seal
No dry-out
Replaces banks of
solid tantalum capacitors
3,000 Hr. life at 85 °C
without voltage derating

SDR Interface for the NeXtRAD Multistatic Radar System

NeXtRAD is a dual-band, dual-polarization, multistatic radar system under development at the University of Cape Town (UCT) in collaboration with University College London (UCL). The primary mission of the system is to collect multistatic data of small radar cross-section maritime targets embedded in sea clutter.

NeXtRAD is a multi-sensor network comprised of three stations (or nodes) separated by several hundred meters, all focusing on a common target area as shown in Figure 1. Only node 0 generates and receives radar signals, while nodes 1 and 2 are receive only. The system requires a usable bandwidth of 50 MHz to achieve a range resolution of three meters. Each node has dual-polarized L- and X-band antennas (IEEE definition) with a 10-degree beam width.

This arrangement effectively forms a pair of bistatic radars in combination with a monostatic radar, which means that target data can be simultaneously acquired from three perspectives. This topology has advantages over single-sensor radars. NeXtRAD is a more capable version of NetRAD, a single-frequency, multistatic radar developed by UCT and UCL.

During the early stages of the NeXtRAD project, Pentek's Cobalt® Model 71621 transceiver system was identified as a suitable software-defined radio (SDR) interface for the system. The early stages of the development of NeXtRAD used Pentek's Model 71621 module as the digital transceiver of the system in a monostatic configuration.

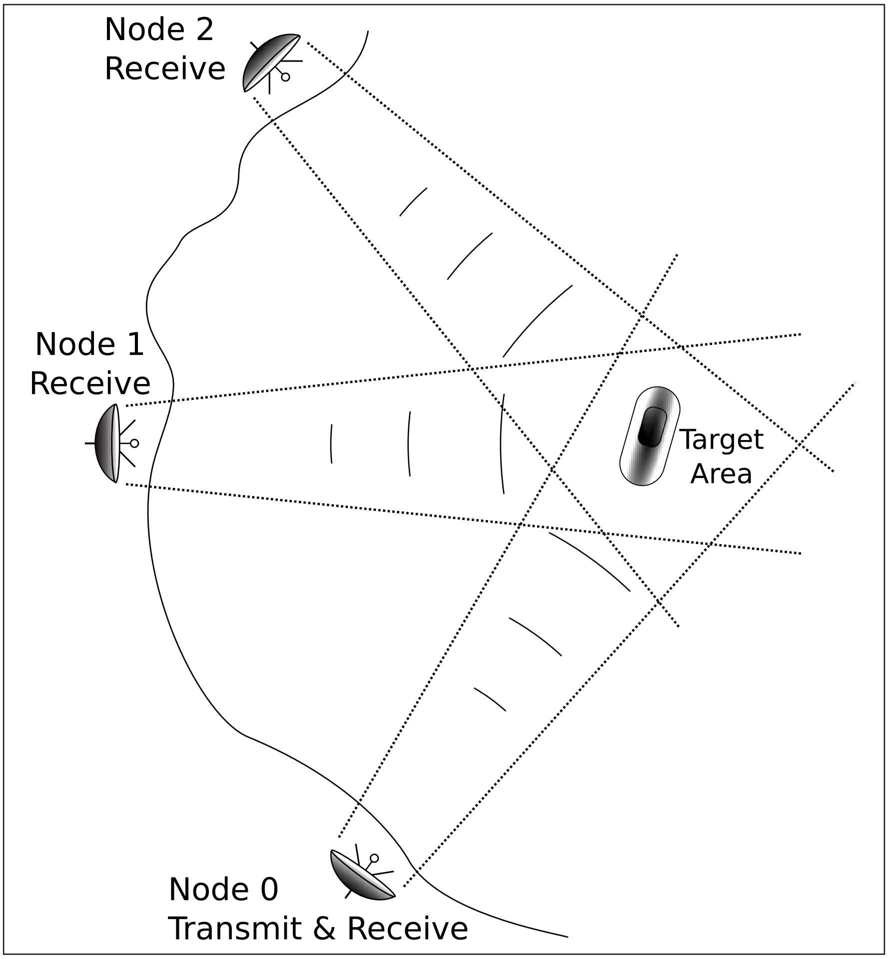


Figure 1. Typical deployment configuration of NeXtRAD.

NeXtRAD System Overview

The active node of the NeXtRAD multistatic system consists of the following (Figure 2):

- Software-defined radio (SDR) interface
- Radio frequency (RF) receiver and transmitter
- FPGA-based timing control unit (TCU)
- High-power amplifier

Pentek's Cobalt Model 71621 (Figure 3) was selected as the SDR interface because it is well-suited to the radar's requirements, providing three A/D converters and a dual-channel 800 MHz D/A converter.

NeXtRAD is a pulse-Doppler radar, which requires that waveform generation and digitization be fully coherent at each node. To achieve coherency, each node is supplied a very stable 10-MHz reference signal from a local GPS-disciplined oscillator (GPSDO), which is distributed via a frequency distribution unit (FDU) to the Cobalt module and to the receiver exciter (REX). This ensures that there is no phase drift between oscillators in a given node, and that the relative phase of oscillators between any two nodes is constant.

The Cobalt module can be configured to accept the 10-MHz signal from its front-panel SSMC clock input. The GPSDO also supplies a trigger pulse that precisely synchronizes the start of a radar measurement. After an initial trigger event from the GPSDO, the TCU takes over and delivers the trigger pulse to the Cobalt module at the pulse repetition frequency (PRF).

Signal Planning

The transmitted pulse is generated by the Cobalt module in the active node of the sensor network. The system employs linear frequency-modulated pulses with 50-MHz bandwidth and duration of 1 to 10 microseconds, at a PRF from 1 to 2 kHz. The Cobalt module is able to supply the 50-MHz

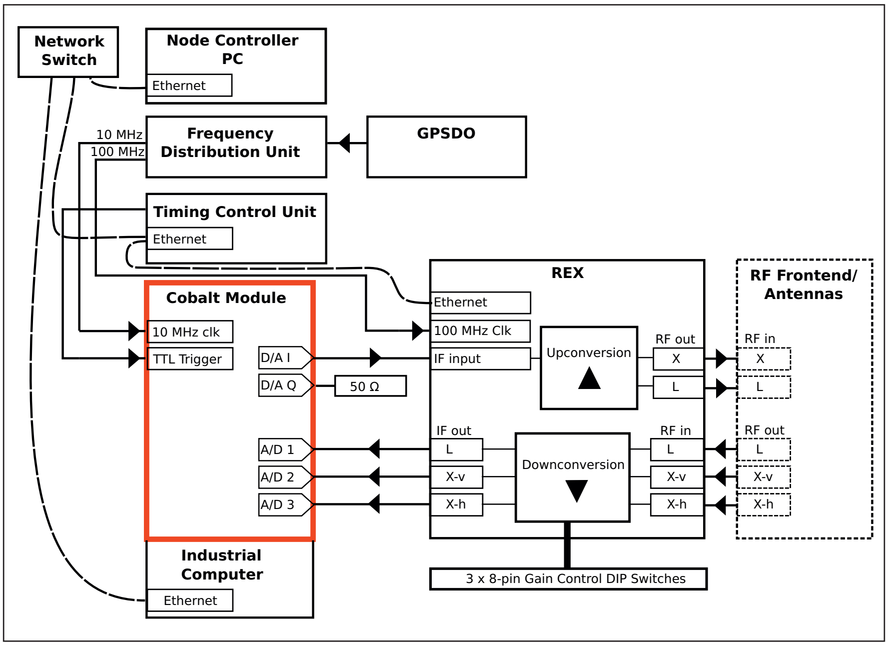


Figure 2. A system block diagram of the transmitting node of NeXtRAD.

Figure 3. Cobalt Model 71621.

bandwidth signal on a 125-MHz intermediate frequency (IF) at a 720-MHz output frequency from one of its two available 16-bit D/A output channels. The REX upconverts the IF waveform to either L- or X-band. After amplification, the waveform is transmitted via the appropriate antenna to illuminate the target area with either vertical or horizontal polarization.

Transmitted energy is scattered in many directions by the target scene. Antennas at each node location intercept only a tiny fraction of that energy. The L-band signal is captured in either vertical or horizontal polarization, and two X-band channels simultaneously record both polarizations. Receivers in each node amplify and downconvert the received signals to the 125-MHz IF analog signal. A dedicated A/D channel on the Cobalt module records the single L- and two X-band waveforms.

In NeXtRAD, the waveform engine on the Cobalt module stores a variety of waveforms in the onboard DDR3 RAM. Waveform generation is triggered by an LVTTL rising edge delivered to the trigger input on the Cobalt module's front panel. The data input rate to the Texas Instruments DAC5688 D/A module is 180 MSPS. The digital upconverter (DUC) in the D/A translates the spectrum from 0 Hz to the IF. With an interpolation factor of 4, the output sample rate of the DAC is increased to 720 MSPS. The intermediate frequency signal is then upconverted to RF by the REX for amplification.

On the receive chain, the RF signal received at the antennas is downconverted to the IF for digitization by the A/D modules on the Cobalt module. The same trigger signal is used to initiate digitization at each pulse. The ADC is tuned to sample at Fs = 180 MHz. This places the incoming signal in the second Nyquist zone and results in the spectrum being translated to the first Nyquist zone from 0 to Fs/2, i.e., from 30 to 80 MHz.

Tuning the digital downconverter IP core on the Cobalt module to 55 MHz and setting the decimation factor to 2 translates the incoming signal to DC and produces IQ samples at Fs/2 = 90 MHz. The downconverted, 16-bit complex samples are then transferred via the PCIe 8x interface to the host computer's memory for post-processing.

An important consideration for the coherency of the radar is that the numerically controlled oscillators in the digital upconverter of the D/A and the digital downcovnerter IP core on the FPGA need to be reset to a known value on each rising edge of the external trigger. If this is not done, an unpredictable phase term is introduced to the IF signal from the D/A, and also to the discrete baseband signal generated by the digital downconverter (DDC).

The phase of the digital sine and cosine terms generated in the DUC and DDC can be reset to zero on rising edges of the external trigger with proper configuration of the control registers for the DAC5688 and the DDC IP core. This ensures that phase offsets introduced to the radar signal on generation or digitization can be ignored in post-processing as they do not vary between pulse repetition intervals.

Initial Testing and Results

The controller software for the Cobalt module was developed using Pentek's ReadyFlow software libraries in conjunction with an arbitrary waveform generator, spectrum analyzer, and an oscilloscope. The digitization and waveform generation chains were developed and tested in separate controller programs before

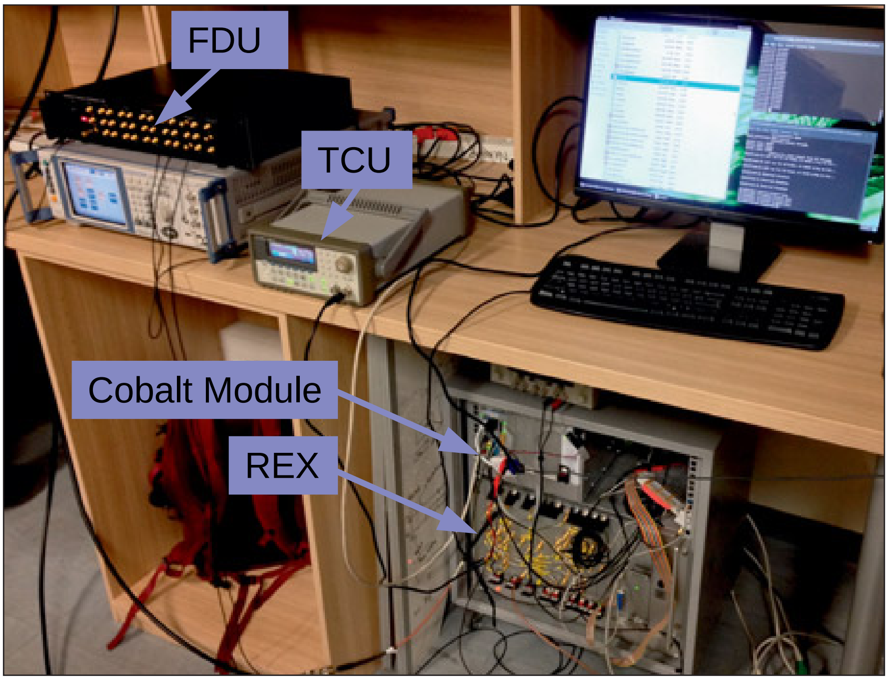


Figure 4. The hardware testing setup for the low-power prototype. Labeled are the frequency distribution unit (FDU), the timing control unit (TCU), the Cobalt module, and the receiver exciter (REX).

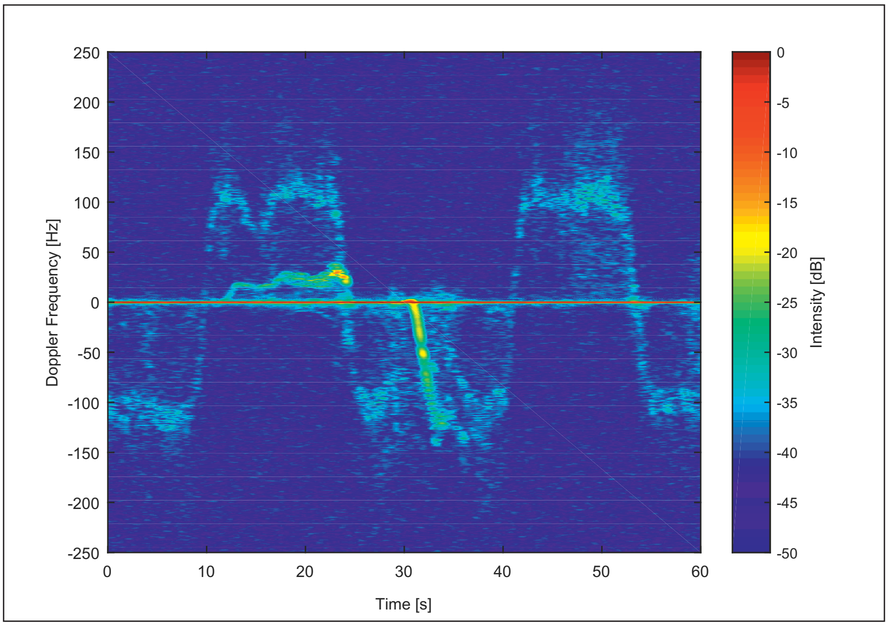


Figure 5. A time against Doppler-shift of a moving human target at approximately 75 m range using an X-band signal.

fusing these programs into a working source. A simple IF loop-back test using one of the D/A output channels and a signal splitter was sufficient to do most of the development required for the digital transceiver before introducing the REX and other subsystems.

The hardware configuration shown in Figure 4 was used to test a low-power (<24 dBm transmit power) benchtop prototype of the active node, using an AWG to supply a rising-edge trigger to the Cobalt module and signal generators to supply synchronized reference signals to the REX and the Cobalt module. Using this system, it was possible to detect moving targets by their Doppler shift at close range, as shown in Figure 5. This data shows the Doppler shift of a moving human target at approximately 75 meters from the transmitter, using a 0.5 microsecond duration pulse with 50 MHz of bandwidth. Radial target velocity v and Doppler shift are related by the equation

$$v=c/2(Fd/Fc)$$

where c is the speed of light, Fd is the Doppler shift, and Fc is the carrier frequency. With Fc = 8.5 GHz (X-band) and Fd = 100 Hz at t=5s in the graph of Figure 5, the target is inbound at approximately 1.7 m/s. The large object seen moving from approximately 10 to 22 seconds and then from 30 to 32 seconds was a car backing out of a parking bay and driving away.

Passive nodes are essentially identical to the active node, except for the transmitters, which are not needed. Using virtually the same controlling software for the Cobalt module in the active node, passive nodes can record waveforms at precisely the same moment as in the active node.

Summary

The initial testing of the Cobalt module in the active node of the system demonstrated that the Pentek Model 71621 was well-suited to a pulse-Doppler radar application. With the required additional hardware, the passive nodes can be introduced to the network with minor alterations to code for the active node's digital transceiver. Overall, the Cobalt module met the requirements for phase stability and bandwidth and it was easily integrated with the existing receiver exciter for the active node.

This article was contributed by Pentek, Upper Saddle River, NJ. For more information, visit ***http://info.hotims.com/73000-510.***

Electrodeposition of Metal Matrix Composites and Materials Characterization for Thin-Film Solar Cells

Metal matrix composites, which consist of silver-multiwalled carbon nanotube-silver, layer-by-layer stacks, can electrically bridge the cracks (>40 µm) that appear in semiconductor substrates and the composite grid lines.

Air Force Research Laboratory, Kirtland Air Force Base, New Mexico

The current trend in both space and terrestrial photovoltaics is to implement high-efficiency, thin-film-based solar cells to reduce weight and materials cost while improving performance. For space photovoltaics, multi-junction (MJ) solar cells have been used almost exclusively due to their high efficiency and high radiation hardness. The efficiency of state-of-practice triple-junction (TJ) cells used in space today is approximately 30% under 1-sun Air Mass 0 (AM0) spectrum.

Multijunction technology involves stacking different bandgap subcells electrically and optically in series, connected by tunnel junctions, to effectively capture and utilize the solar spectrum. State- of-practice TJ cells consist of $GaInP_2$ and (In)GaAs subcells grown lattice-matched via metal organic vapor phase epitaxy on an active Ge substrate.

In recent years, for improved performance over the state-of-practice TJ cells, other cell architectures are being explored, such as inverted metamorphic multijunction (IMM) solar cells. Figure 1 shows a schematic view of IMM cell architecture, where InGaP and InGaAs subcells are sequentially grown on a lattice-matched substrate. After completing the growth, only the stack of active layers is exfoliated and transferred to a lightweight handling substrate, where the stack is inverted, such that the InGaP layer faces the sun. This new architecture eliminates the use of Ge substrates, as well as the Ge bottom cell found in traditional TJ solar cells, providing better current matching, higher efficiency, and lighter weight.

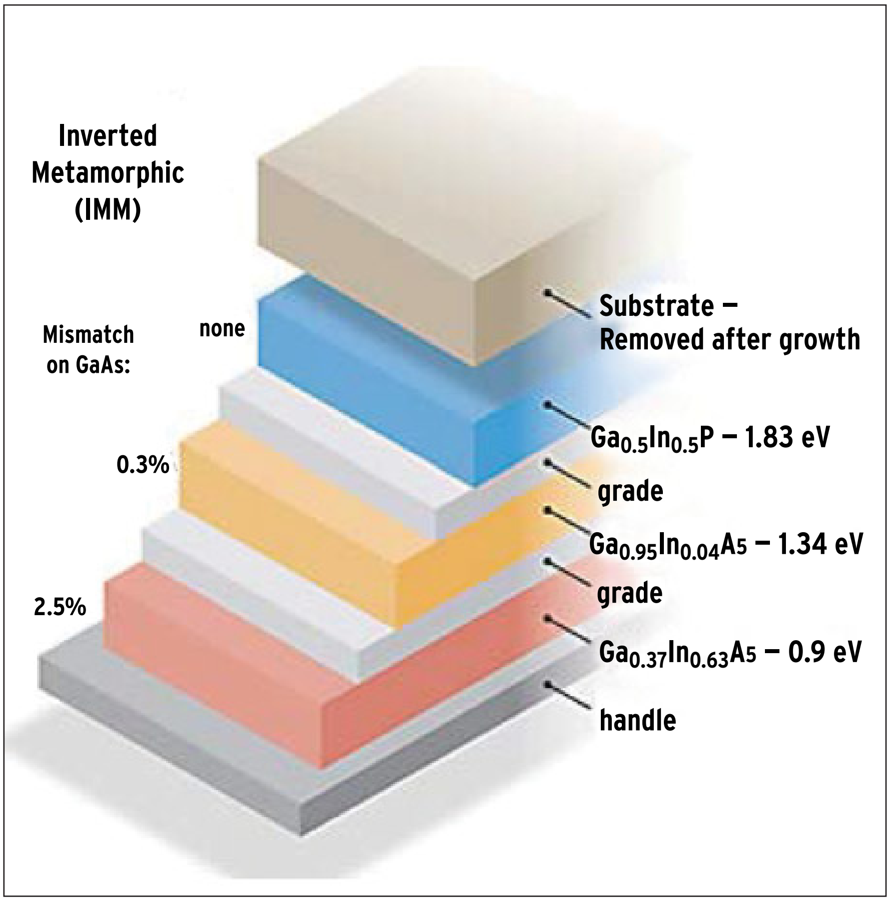


Figure 1. Schematic architecture of IMM cell

As the cells become thinner, however, it is expected that cell fracture will be a greater concern when these thin-film cells are subjected to thermomechanical stress, such as prolonged temperature fluctuations encountered in low earth orbit operation. The mismatch in thermal expansion coefficients of semiconductor and metal is an inherent engineering problem.

To minimize the detrimental effects of severed metal busbars and gridlines on solar cell performance, this research explored incorporating multiwalled carbon nanotubes (MW-CNTs) into silver (Ag), forming a metal matrix composite (MMC). It was discovered that with proper CNT surface functionalization and judiciously designed composite microstructure, the CNTs in MMC gridlines can electrically bridge gaps greater than 40 µm. The scanning electron micrograph (SEM) images in Figure 2 conceptually demonstrate this composite engineering strategy, where the CNTs mechanically and electrically bridge the gaps in severed MMC gridlines, providing redundant electrical conduction pathways.

Only 9-µm-wide gaps are shown here because of the practical diffi-

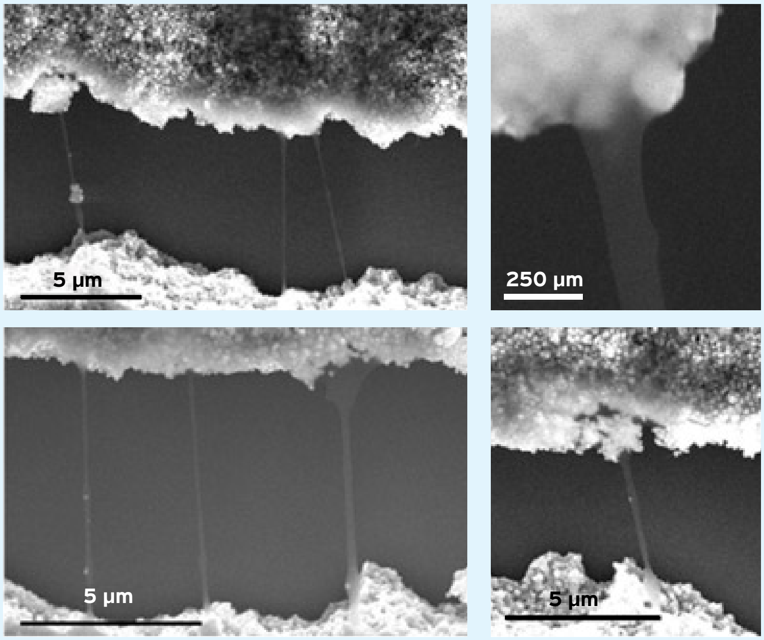


Figure 2. SEM micrographs of CNTs bridging gaps

culty of transferring fractured samples with large gaps into the SEM vacuum chamber. In addition to gap-bridging, this research demonstrates that the MMC gridlines, which are strained to failure by greater than 40 µm displacement, can "self-heal" to re-establish electrical conduction, when the gap is closed. This self-healing is proven to be repeatable over many strain-to-failure/closed-gap cycles. Most importantly, preliminary device characterization on MMC-enhanced commercial TJ cells has shown substantially improved crack-tolerance compared to the cells with conventional evaporation-based metallization.

This work was done by Sang M. Han of the University of New Mexico for the Air Force Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Materials category.*** AFRL-0279

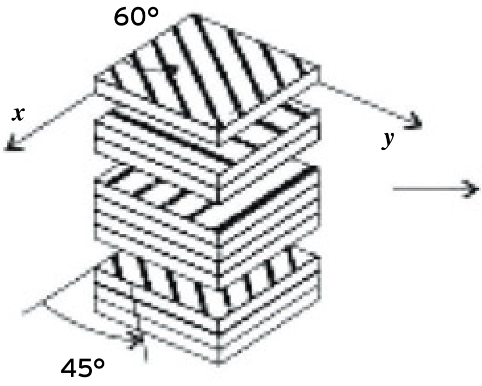
Sensing Applied Load and Damage Effects in Composites with Nondestructive Techniques

Comparing and correlating piezoelectrically induced guided waves, acoustic emission, thermography, and X-ray imaging to determine the effects of applied load on a composite structure.

Army Research Laboratory, Aberdeen Proving Ground, Maryland

Composite materials are desirable for aeronautical and aerospace applications for many reasons including their high strength-to-weight ratios, fatigue and corrosion resistance, design adaptability, and performance capabilities in harsh environments. Because of these qualities, composites are useful in many applications such as in armor, helmets, and helicopters, and as structural components.

However, when in-service, composite materials experience very different damage mechanics than metals. Performance and quality of composite materials can suffer from fatigue, environmental conditions, and external damage just as metals can, but due to their inherent complexity and the difficulty of detecting damage in composites with traditional inspection tech-



60
90
90
0
0
0
0
45
45
45

Example of a layup of a laminated [$45_3/0_4/90_2/60$] composite of unidirectional plies, with schematic (left) and stacking order (right) niques, maintaining and guaranteeing the safety of composite structures is a challenging problem.

Strategies such as structural health monitoring (SHM), a system with which to monitor a structure in real time, are particularly useful for composite materials, because they combat these difficulties by giving warning of any changes to the system. Implementing reliable SHM strategies into composite structures will allow the Army to fully take advantage of the performance capability of composite materials while increasing efficiency by saving time and expense on repair, decreasing the need to take structures out-of- service for inspection, decreasing the occurrence of sudden failures, and extending the lifetime of composite structures by enabling efficient maintenance.

This project studies damage progression in composite materials as monitored by multiple techniques used in nondestructive inspection to further understand the material itself and the capabilities of various nondestructive evaluation (NDE) techniques. Correlating and validating NDE strategies for sensing damage and operational effects on composite materials will add to the knowledge of composites and efficient strategies to monitor these materials and use them to their full capabilities.

There are many types of composites used in industry based on materials such as glass fiber, Kevlar, and carbon fiber combined with various types of epoxy. Carbon fiber-reinforced polymers are particularly useful in necessarily low-weight but high-strength applications. Unidirectional prepreg composites, which have fibers oriented in the same direction held together by an epoxy matrix, are one of the most commonly used of these materials. Individual plies can be oriented and stacked together to create a laminated composite structure with specific material properties. The accompanying figure illustrates an example of a laminated composite of unidirectional plies. In this way, a designer can create a composite laminate with tailored material properties necessary for a specific application.

This unique design capability and adaptability coupled with potential high strength-to-weight ratios make composite materials extremely desirable for high- performance applications. However, composites have relatively complicated and situation-dependent damage mechanics. Composite materials experience multiple damage types that can occur together or in sequence to contribute to a weakened structural state or final failure. The main modes of failure are matrix cracking, delamination, fiber breakage,

and fiber buckling, which all can contribute individually or together to the progressive degradation, weakening and final failure of a composite structure. In fatigue loading, the types of failure that predominantly occur and are a signal of potential areas for final failure are matrix cracking and delamination.

This work was done by Colleen Rosania, Mulugeta A. Haile, Natasha C. Bradly, Asha Hall, Michael Coatney, and Fu-Kuo Chang for the Army Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com under the Materials category.*** *ARL-0224*

Technology Impact Forecasting for Multi-Functional Composites

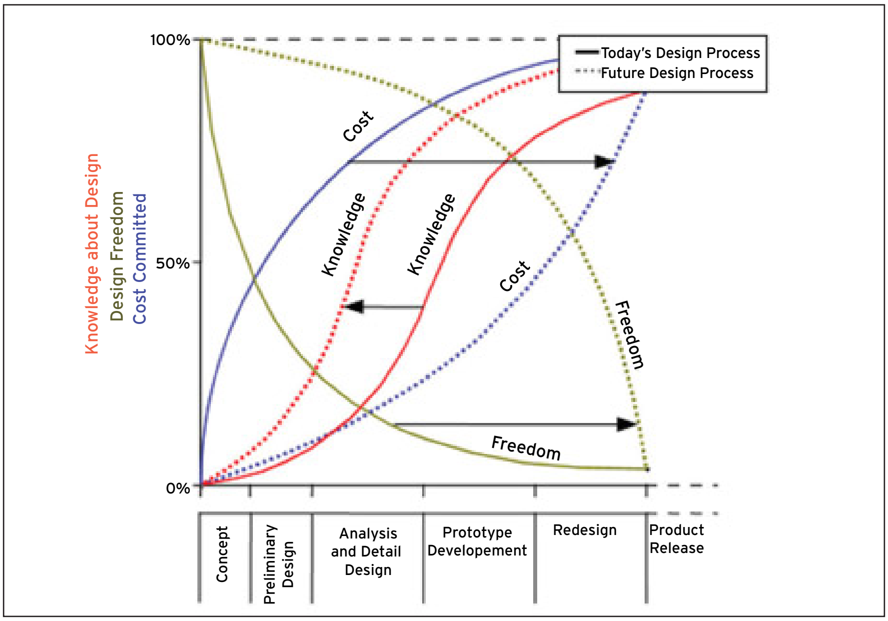
Multi-functional composites offer a possible solution to the conflicting design goals of making new aircraft lighter, stronger, faster, and more environmentally sustainable.

Air Force Research Laboratory, Arlington, Virginia

To survive within today's stringent economic environment, aircraft design, particularly military aircraft design, has been experiencing a paradigm shift from an emphasis on design for optimum performance to design for system effectiveness. As a consequence, designers and manufacturers are increasingly considering the addition of new technologies to aircraft design to reduce their cost, increase their operating capacities, and optimize new capabilities.

For next generation aircraft design, there are many innovative technologies to be developed that are financially constrained. However, infusion of a new technology (or technologies) are leading to another challenge: how does this new technology affect the aircraft system both in capability and economically?

This is especially difficult because this new technology may not be completely defined until product implementation and service exposure occur. But in today's tight economic and limited resources environment, it is not possible to allow the designers to try out every technology on the aircraft system as this will result in low efficiency, time consumption, and cost ineffectiveness. This issue is leading to another question: how to select an appropriate technology for the aircraft system before committing to the expense and risk of its full development?



Design Freedom Variation in Time

Obviously, it is essential to understand the benefits and/or penalties of a new technology to the system response before it is selected in order to reduce the research risk and budget. Therefore, designers need a forecasting environment which is able to rapidly assess the technical feasibility and economic viability for a given system before the technology is selected.

In addition, the life cycle phases of an aircraft design include conceptual, preliminary, detailed design, production, service and retirement, as shown in the accompanying figure. In the conceptual phase of the aircraft design, the design freedom is fully open for designers, yet only limited information is available for the new aircraft design. However, as design decisions are made, the design freedom rapidly decreases, while cost commitments increase. Therefore, the key to success is "making educated decisions (increased knowledge) early on and maintaining the ability to carry along a family of alternatives (design freedom)".

In response, a new methodology process known as Technology Impact Forecasting (TIF) has emerged, which is able to rapidly assesses the technical feasibility and economic viability of a new technology for a given system before this technology has been selected, thereby giving direction to further resource allocation. This technique was developed about ten years ago and has mainly been applied to aircraft systems. TIF is a probabilistic method that not only emphasizes modelling and assessing the impact of technology infusion on a given baseline system, but also seeks to bring more knowledge about the system at an earlier stage of the design process. Although a solid background in initial TIF methods has been developed to mid Technology Readiness Levels (TRL), it has never been applied to extremely low TRL technologies. Therefore, one of the goals of this research will be to assess whether the TIF process can be applied to low TRL technologies, or even to a notional technology, and still provide useful guidance for decision-makers, or whether the process needs to be substantially modified in order to be useful.

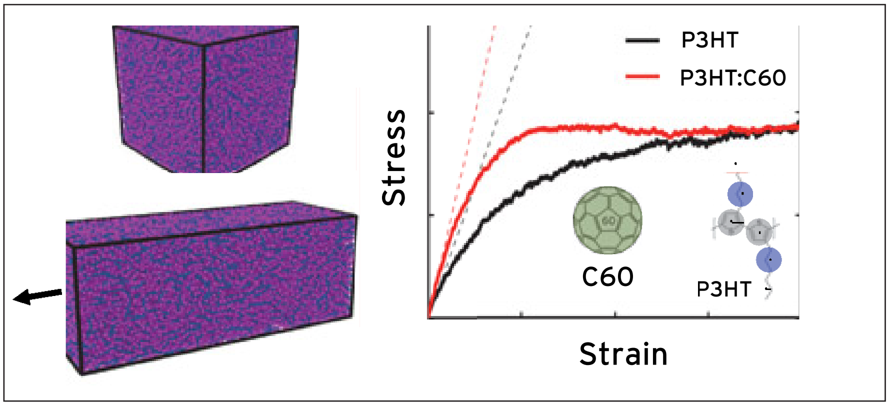
This work was done by Danielle Soban of Queen's University Belfast for the Air Force Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Materials category.*** *AFRL-0280*

Molecular Engineering for Mechanically Resilient and Stretchable Electronic Polymers and Composites

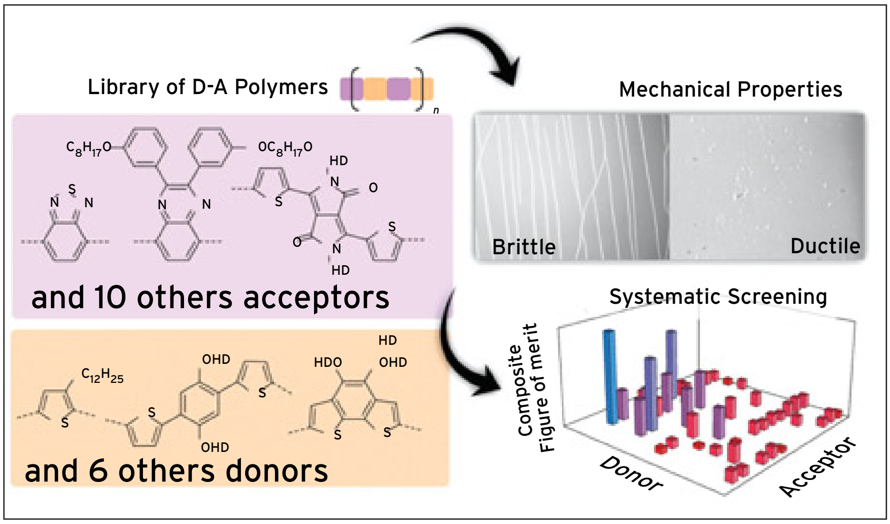
Establishing the design criteria for elasticity and ductility in conjugated polymers and composites by analysis of the structural determinants of the mechanical properties.

Air Force Research Laboratory, Arlington, Virginia

The ability to predict the mechanical properties of organic semiconductors is of critical importance for roll-to-roll production and thermomechanical reliability of organic electronic devices. This research describes the use of coarse-grained molecular dynamics simulations to predict the density, tensile modulus, Poisson ratio, and glass transition temperature for poly(3-hexylthiophene) (P3HT) and its blend with C_{60}. In particular, it is shown that the resolution of the coarse-grained model has a strong effect on the predicted properties.



Visualization of coarse-grained molecular dynamics simulations on polymer:fullerene bulk heterojunction films. The plot shows the stiffening of C_{60} fullerene (anti-plasticization) on the mechanical properties of P3HT simulated with a three-site coarse-grained model.



Schematic drawing indicating a library of donor-acceptor low-bandgap conjugated polymers comprising 13 different acceptors and 9 different donors. The mechanical properties were measured and the structural determinants of stiffness and brittleness were elucidated.

It was found that a one-site model, in which each 3-hexylthiophene unit is represented by one coarse-grained bead, predicts significantly inaccurate values of density and tensile modulus. In contrast, a three-site model, with one coarse-grained bead for the thiophene ring and two for the hexyl chain, predicts values that are very close to experimental measurements (density = 0.955 g cm^{-3}, tensile modulus = 1.23 GPa, Poisson ratio = 0.35, and glass transition temperature = 290 K). The model also correctly predicts the strain-induced alignment of chain, as well as the vitrification of P3HT by C60 and the corresponding increase in the tensile modulus (tensile modulus = 1.92 GPa, glass transition temperature = 310 K).

Although extension of the model to poly(3-alkylthiophenes) (P3ATs) containing side chains longer than hexyl groups—nonyl (N) and dodecyl (DD) groups—correctly predicts the trend of decreasing modulus with increasing length of the side chain measured experimentally, obtaining absolute agreement for P3NT and P3DDT could not be accomplished by a straightforward extension of the three-site coarse-grained model, indicating limited transferability of such models. Nevertheless, the accurate values obtained for P3HT and P3HT:C_{60} blends suggest that coarse graining is a valuable approach for predicting the thermomechanical properties of organic semiconductors of similar or more complex architectures.

The mechanical properties of low-bandgap polymers are important for the long-term survivability of roll-to-roll processed organic electronic devices. Such devices — e.g., solar cells, displays, and thin-film transistors — must survive the rigors of roll-to-roll coating and also thermal and mechanical forces in the outdoor environment and in stretchable and ultra-flexible form factors. This research measured the stiffness (tensile modulus), ductility (crack-onset strain), or both, of a combinatorial library of 51 low-bandgap polymers.

The purpose of this study was to systematically screen a library of low-bandgap polymers to better understand the connection between molecular structures and mechanical properties, in order to design conjugated polymers that permit mechanical robustness and even extreme deformability. While one of the principal conclusions of these experiments is that the structure of an isolated molecule only partially determines the mechanical properties — another important codeterminant is the packing structure — some general trends can be identified. Fused rings tend to increase the modulus and decrease the ductility. Branched side chains have the opposite effect. Despite the rigidity of the molecular structure, the most deformable films can be surprisingly compliant (modulus ≥ 150 MPa) and ductile (crack-onset strain ″ 68%). The project concluded by proposing a new composite merit factor that combines the power conversion efficiency in a fully solution processed device obtained via roll and roll-to-roll coating and printing, and the mechanical deformability toward the goal of producing modules that are both efficient and mechanically stable.

This work was done by Darren J. Lipomi of the University of California, San Diego, for the Air Force Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Materials category.*** *AFRL-0278*

Heavy Dump Truck

Mack Defense
Allentown, PA
1 (800) 866-1177
www.macktrucks.com

Mack Defense is partnering with Crysteel Manufacturing on the U.S. Army M917A3 Heavy Dump Truck (HDT) contract to provide specialized dump bodies that provide several key safety and functionality features to meet the specialized needs of the U.S. Army.

Developed in close collaboration with Mack Defense, the Crysteel dump body for the M917A3 is designed to provide maximum durability, safety and functionality out in the field. Crysteel engineers developed an integrated touchscreen control module, which places key safety and functionality information at the operator's fingertips. From this integrated hub, the driver is able to control the hoist, tailgate, tarp, thermostatic body heater system, material control system, the inclinometer and the onboard weigh scale.

The Mack Defense M917A3 HDT is based on the commercial Mack Granite model and has been optimized to meet the current needs of the U.S. Army. Mack Defense added heavier-duty rear axles, all-wheel drive, increased suspension ride height and incorporated other rugged features to ensure the M917A3 is capable of meeting the demanding payload and mobility requirements set by the U.S. Army HDT program. An armor cab was also engineered which utilizes all the comfort and amenities of a commercial truck, while adding force protection to keep occupants safe in hostile environments.

The 94,500 lb vehicle is powered by a Mack 13 liter, MP8 440 engine that produces 440 HP and maximum torque of 1660 lb-ft, delivered through a sturdy Allison 4500 Gen5 with prognostics 6-speed transmission. The front suspension consists of a Meritor MX-810 axle riding on a taperleaf spring suspension (parabolic) in the axle-forward position. Rear suspension consists of P600/Pro Tec Series 50, 76,800 lb Meritor 34836 mounted on a Primaxx Pax 792 high stability 76,800 lb. suspension. The trucks wheelbase is 243-inches with 75-inches of overhang.

The first five trucks were delivered to the U.S. Army in June of this year.

For Free Info Visit ***http://info.hotims.com/73000-460***

Metal-Plated, High-Temperature Plastics

Semplastics
Orlando, FL
(407) 339-0879
www.x-materials.com

Imagine a material that lightens fuel loads and cuts costs every time a rocket blasts off from the launch pad. Space Florida recently awarded Orlando-based Semplastics a Phase 2 grant to continue working on a unique material that has the potential to transform the aerospace and space industries.

Semplastics, through its X-MAT® division, is working with Israeli partner Polymertal to create a lightweight plastic that can be coated with metal. The final hybrid product would be lightweight and would be able to withstand high temperatures at the same time. The resulting material would be stronger than plastic, but lighter than traditional metal parts. It would have greater resistance to friction and wear and could withstand high pressures. In other words, the hybrid would be unlike any material currently on the market.

As part of the ongoing research, Semplastics is experimenting with ways to cut production costs. The $500,000 Space Florida grant allows the X-MAT® division to explore modifying the high temperature plastics to enable 3D printing.

X-MAT®, the Advanced Materials Division of Semplastics, officially launched in 2013. The company developed a revolutionary high-performance material that combines some of the best properties of metals (electrical conductivity), engineering plastics (lightweight) and ceramics (high operating temperature), leading to a number of partnerships with organizations such as NASA, Space Florida and the NETL.

In addition to its potential space and aerospace applications, the hybrid material also has a future on earth from high-temperature seals to engine manifolds for high-performance cars to fireproof roof tiles, lightweight space mirrors, battery electrodes and 3D printing ceramics. The material could also be used as EMI shielding for helmets and other equipment.

For Free Info Visit ***http://info.hotims.com/73000-463***

Robotic Helicopter

Steadicopter Ltd.
Migdal HaEmek, Israel
+972-4-9592959
www.steadicopter.com

Steadicopter, one of the companies involved in the Rotary Unmanned Aerial Systems (RUAS) industry, recently unveiled its next generation Black Eagle 50 advanced lightweight unmanned robotic helicopter. New capabilities include an inertial navigation system with no dependence on GPS, as well as support for naval missions.

Steadicopter's Black Eagle 50 unmanned helicopter has been upgraded with several additional new features and is tailored for naval missions with its robust mechanical and electronic capabilities that support flight in maritime environmental conditions. The company also recently signed a cooperative agreement with Israel Shipyards for the marketing of the Black Eagle as part of the defense, intelligence and surveillance systems installed on its OPV (Offshore Patrol Vessel) family. The OPV vessels, based on the Nirit Class SAAR 4.5, are heavily armed with advanced weapons systems and can be equipped with helicopter carrying capability.

The Black Eagle 50 features a special inertial navigation system capability, based on input from the system's inertial and other sensors. Through a unique smart navigation algorithm, this input enables the continuation of the flight and the mission without relying on GPS giving the Black Eagle 50 a significant advantage in GPS-denied areas.

In terms of mission capability, the Black Eagle 50 is a VTOL (Vertical Take-Off and Landing) robotic observation system, suitable for tactical maritime and land Intelligence, as well as Surveillance, Target Acquisition and Reconnaissance (ISTAR) missions. A data link connects the aircraft with the ground controller, enabling the transmission of live video and data between the two. The system has a steady hovering endurance of up to 3 hours and flight endurance of up to 4 hours.

At only 27 kg, the Black Eagle 50 is extremely lightweight and compact, with a maximum take-off weight of 35 Kg, and payload capacity of 5 Kg. It has a communication range of up to 150 km, depending on the client's requirements, and a service ceiling of up to 10,000 ft. Its total length is just 2540 mm, while its maximum air speed is 70 knots (126 Km/h) with a cruising speed of 45 knots (81 Km/h).

For Free Info Visit ***http://info.hotims.com/73000-464***

S-Band Radar Systems

Northrop Grumman Corporation
Falls Church, VA
(703) 280-2900
www.northropgrumman.com

Aircraft, missiles, rockets, mortars and artillery in the wrong hands pose an increased risk to the safety of U.S. service members, allies and civilians. These threats can be sophisticated or improvised, coming from hostile nations and non-state actors alike. The challenge of countering the wide range of threats is being met by systems with advances in integration, gallium nitride semiconductor technology and radar expertise.

Northrop Grumman recently announced a new generation of integrated air and missile defense (IAMD) systems incorporating gallium nitride-based microelectronic components. Gallium nitride (GaN) components operate more efficiently, unlocking cost and performance benefits that can include enhanced system sensitivity and reliability. Consequently, Northrop Grumman, with government partnership, has invested more than $350 million in GaN development, and this investment has seen the integration of GaN into a wide variety of land, air and space-based military radar systems.

Highly reliable and high-bandwidth GaN radars can perform multiple missions simultaneously, from air traffic control to fire control, while giving operators a complete picture of what is happening in each sector. To provide an

optimal defense against airborne threats, warfighters need a single, unambiguous view of the battlespace and a network of sensors and shooters than can identify and neutralize targets. Designed to function as part of any net-centric command and control (C2) system, these versatile radars can detect and share data about incoming hostile fire and cue interceptors.

The combination of Northrop Grumman's software-defined radars with other powerful systems on the C4ISR network give the warfighter a potent advantage, leading the Department of Defense to integrate Northrop Grumman's radars with its C2 systems. The Army and Marine Corps announced recently that they are working together to bring Northrop Grumman's S-band ground radar into the Integrated Battle Command System. The Marine Corps has further plans to demonstrate the radar with Iron Dome, a system that the Army is acquiring for interim cruise missile defense. The Army has stated that missile defense is one of its top modernization priorities.

Northrop Grumman's radar systems have been tested during hundreds of hours of realistic combat scenarios in the lab, at the range and in complex joint exercises. It is the combination of open architecture, C2 integration and the power of GaN that allow Northrop Grumman's S-band radars to deliver a new level of protection and situational understanding for warfighters.

For Free Info Visit ***http://info.hotims.com/73000-462***

Tank Destroyer Vehicle

MBDA Missile Systems
Hertfordshire, UK
+44 (0)1438 752000
www.mbda-systems.com

MBDA and PGZ (Polska Grupa Zbrojeniowa), a holding company established by the Polish government to unite more than 30 Polish state-owned defense industry companies, recently unveiled a new tank destroyer armed with the Brimstone precision strike missile. PGZ Companies and MBDA also signed a statement of cooperation to confirm readiness to cooperate on offering this solution to both Poland and export markets, recognizing that the combination of MBDA's Brimstone missile with PGZ's armored vehicle expertise offers the best solution for Poland's tank destroyer requirement from a military capability, sovereignty and industrial perspective.

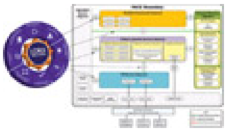
The most important part of the Joint Statement of Cooperation is MBDAs' declaration that Brimstone missile technology and know-how will be transferred to PGZ, with MESKO SA responsible for missile production. This co-operation is another field of the business relationship developed on the strategic cooperation between PGZ companies and MBDA.

The flexibility of the integration solution and ease of integration with the existing Polish targeting systems makes it flexible to be installed onto or within multiple Polish platforms, including those from WZM SA, HSW SA and Obrum, in any configuration and number of missiles.

This development comes in response to Poland's requirement for a tank destroyer that is able to counter massed armor formations. With its long-range, all-weather performance, ability to defeat active protection systems (APS), salvo-firing and moving target capability, Brimstone is uniquely able to meet this challenge. The system is capable of engaging line-of-sight and non-line-of-sight targets, with a choice of engagement modes using digital targeting data provided over standard secure military networks fully interoperable with NATO.

For Free Info Visit ***http://info.hotims.com/73000-461***

Tool Suites for FACE Conformance



With the latest release of the LDRA tool suite, LDRA (Wirral, UK) delivers FACE Conformance Tool Suites, enabling cost-effective development and verification of high-assurance, FACE-conformant software. These new software tool suites automate the process of evaluating software for conformance with each version of the released FACE standard (e.g., version 2.1.1 and 3.0), while at the same time enabling developers to improve the quality of their software through traceability, static and dynamic code analysis, and unit and system-level testing.

LDRA Conformance Tool Suites for FACE V2.1.1 and V3.0 include these new capabilities: Integration of the 2.1.1 and 3.0 FACE Conformance Verification Matrix (CVM) into the LDRA tool suite; FACE conformance workflow management; test management of the FACE coding standard and low-level test of pertinent FACE requirements; objective traceability from FACE architectural segments (e.g., IOSS, OSS, PCS, PSSS, TSS); automated analysis of FACE requirements conformance through static code analysis; and invocation and results capture of the 2.1.1 and 3.0 FACE Conformance Test Suite (CTS) for submission to FACE Verification Authorities.

For Free Info Visit http://info.hotims.com/73000-477

Metal 3D Printing

Digital manufacturing company, Protolabs (Minneapolis, MN), has launched production capabilities for its metal 3D printing service. The new capabilities use secondary processes to improve the strength, dimensional accuracy, and cosmetic appearance of metal parts. As part of the launch, enhanced inspection reporting is also available.

Protolabs uses direct metal laser sintering (DMLS) technology to 3D print metal production parts. Once parts are built, several secondary options like post-process machining, tapping, reaming, and heat treatments are possible, and quality control measures like powder analysis, material traceability, and process validation are taken.

For Free Info Visit http://info.hotims.com/73000-472

Clamshell Socket for 1mm Pitch Xilinx FF896

Ironwood Electronics (Eagan, MN) recently introduced a new high performance BGA socket for 1mm pitch BGA 896 pin Xilinx ICs. The CG-BGA-4027 socket is designed for 31 × 31mm package size and operates at bandwidths up to 27 GHz with less than 1dB of insertion loss. The socket is designed with an easy-to-open clamshell lid mechanism. The socket also features an integrated compression plate that retains force during various environmental conditions, and a heatsink with fan for dissipating 6W. The contact resistance is typically 20 milliohms per pin. The socket connects all pins with 27 GHz bandwidth on all connections.

The CG-BGA-4027 sockets are constructed with high-performance and low-inductance elastomer contactor. The temperature range is -35°C to +125°C. The pin self-inductance is 0.11 nH and mutual inductance of 0.028 nH. Capacitance to ground is 0.028 pF. Current capacity is 2 amps per pin.

For Free Info Visit http://info.hotims.com/73000-486

Conduction-Cooled 1U/2U Rackmount Servers

General Micro Systems (GMS) (Rancho Cucamonga, CA) has launched the industry's first sealed, fanless, conduction-cooled rackmount servers with artificial intelligence (AI) and mil-circular (38999) connectors for superior ruggedness in the most demanding defense and aerospace applications. The American-designed, sourced, and manufactured TITAN, a fully configurable server, also uses up to four of Intel's latest 2nd gen Scalable Xeon® processors, with all features coming together in a 1U or 2U chassis.

In addition to boasting 96 total cores, the unique 4-way, quad-socket, Intel 2nd gen Scalable Xeon® processors are ideal for high-performance computing (HPC), symmetric multi-processing (SMP), NUMA architectures, AI, data mining, image processing, and more. TITAN is available in both air-cooled and conduction-cooled versions. In addition, available "keyed" 38999 military-style connectors ease installation and maintenance, and radically increase the mean time between failure (MTBF) as compared with flimsy COTS connectors.

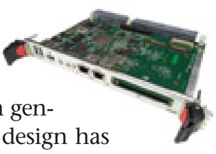
For Free Info Visit http://info.hotims.com/73000-478

Large Format Dispensing Robot

Dispense Works Inc. (McHenry, IL) offers several large format dispensing systems. The RD2500 — manufactured in the U.S. — is the most flexible large format dispensing table available. This robot combines a smart work bench with a built-in precision overhead servo XYZ gantry system. A unique design feature is the 25 full-length slots in the T-Slot table base plate providing multiple fixturing possibilities for most applications. Under this table surface, the actual machine base is fabricated from steel tubing, and then ground to a specified flatness. Standard machine can travel at over 32 inches per second and is available in the following travels: 100" × 50" (2500mm × 1250mm) and 50" x 50" (1250mm × 1250mm).

For Free Info Visit http://info.hotims.com/73000-498

VITA 46 Processor Module



VadaTech (Henderson, NV) announced the VPX752, a processor module (VITA 46) for general purpose processing in demanding applications. Based on the Intel 5th generation Xeon-D processor, the efficient SoC design has low power consumption and integrated PCH technology. The module provides quad 10GbE XAUI on P1 and PCIe Gen3 x16 (dual x8 or quad x4) on P2, together with quad GbE to P4. The GbE is software programmable on each port to run as 1000Base-Tx or 1000Base-BX. It also provides Dual 100/1000/10 G to the front panel, together with video out and dual USB 3.0 which can be used to implement a user interface for ease of maintenance.

The VPX752 provides 32 GB of DDR4 memory with ECC and Flash for the OS. The BIOS allows booting from on board Flash, off-board SATA, PXE boot and USB. The module has a single XMC slot, optionally VITA 42 or VITA 61, for additional I/O. The XMC I/O is routed to P5/P6. The board also has dual isolated RS-422/485 in addition to the single RS-232.

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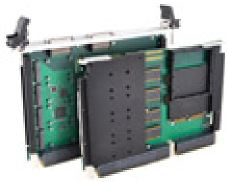
VPX 6U Carrier Cards



Acromag (Wixom, MI) expanded their OpenVPX solutions with the new Model VPX4520 and VPX4521 6U carrier cards providing mezzanine slots for one XMC and four mini-PCIe or AcroPack I/O modules. The XMC module site can host a network communication, FPGA, GPU, SBC, or other I/O signal processor card. The four AcroPack slots provide a rugged PCIe mini card interface for a mix of analog, digital, serial, and other I/O functions. A PCIe Gen 3 ×16 interface connects to the VPX bus either via the data plane or expansion plane. Convection and conduction-cooled versions are available with support for extended temperature ranges from -40 to 85°C. Air-cooled models offer front panel access to the I/O while conduction models route all signals to the rear backplane connectors.

Designed for critical, high-performance computing applications, Acromag's VPX carrier boards and I/O modules are suitable for use in military, aerospace, laboratory and industrial applications. Typical applications include data acquisition and control, test and measurement, simulation, and communication operations. For broader flexibility with 3rd-party modules, the XMC site is available with either VITA 42 or VITA 61 connectors. Support for upstream and downstream PCIe links provides compatibility with prXMC single board computers.

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Linear DC Resistance Spot Welding Power Supplies

Amada Miyachi America, Inc. (Monrovia, CA) now offers the DC1013-T and DC613-T Series of linear DC resistance spot welding power supplies, manufactured by their sister company MacGregor™. The DC1013-T and DC613-T Series incorporate statistical process control (SPC) data collection and reporting capability via Ethernet. The high performance 1000 ampere (A) precision linear DC spot welding power supplies combine touch panel integrated database process control and monitoring with a high-accuracy, zero ripple linear transistor output stage that delivers ultra-fast 10 micron per second (µs) dynamic process response rates, with absolute closed loop 1 A incremental accuracy and repeatability.

Offering high-speed, ultra-low ripple closed-loop output control, the DC1013-T and DC613-T Series provide consistent welding process definition and control. Operators can select constant current, voltage, and power modes with programmable multi-pulse combinations in 1A steps up to 1000A. Programmable part and weld checking is coupled with optional displacement and force limit checking. The DC1013-T offers three-phase operational variants, while the DC613-T supports single-phase operations.

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Robot Cell

The Fastems (West Chester, OH) RoboCell One is an easy-to-configure robot cell primarily designed for handling heavy workpieces weighing up to 176 lbs. (80 kg) and for automating up to two machine tools of the same type – either lathes or milling machines. The RoboCell One has been specifically developed for the flexible production of different batch sizes including a wide variety of components. A special feature of the robot cell is an optional, automated gripper change system for the flexible handling of workpieces and the simple implementation of new components – without interrupting production operations. The robot can accordingly be fitted with single, double, or special grippers. Up to six different grippers may be used for handling workpieces in specific production operations.

A single robot that can be operated in one linear axis is able to supply two machines with workpieces in a flexible manner. Further, different products can be simultaneously produced by using both machines together. To accomplish this scenario, the robot automatically changes its grippers for loading/unloading the respective unit. The result is optimal use of machine capacity, even when orders are frequently altered.

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Robotic Drill

Methods Machine Tools, Inc. (Sudbury, MA) has announced the introduction of the new FANUC RoboDrill ecoPLUS, offering a larger 21 tool capacity and increased speed via an optional 24,000 rpm spindle. Two ecoPLUS models are available, including one with a larger X-axis travel and table size.

The ecoPLUS D21MiB has a working cube of 19.7" × 15.7" × 13" (500 mm x 400 mm x 330 mm).The ecoPLUS D21LiB offers travels of 27.6" × 15.7" × 13" (700 mm × 400 mm × 330 mm). Standard features on both systems include a 14.75 HP (peak) 10,000 rpm or 24,000 rpm direct drive spindle with precision-enhancing thermal compensation, HRV control and a 21-station tool changer. The ecoPLUS D21MiB has a table size of 25.6" × 15.7" (650 mm × 399 mm) and the ecoPLUS D21LiB offers a table size of 33.5" × 16.1" (951 mm x 409 mm). Both machining centers have rapid traverses to 1890 ipm (41 m/min), accelerations/decelerations to 1.5 G, 0.9-second tool changes (tool-to-tool), rigid tapping to 5,000 rpm; and high-speed reverse tapping (up to 20 times faster than infeed). Each are equipped with a FANUC 31i-B Nano CNC with simultaneous 3-axis control.

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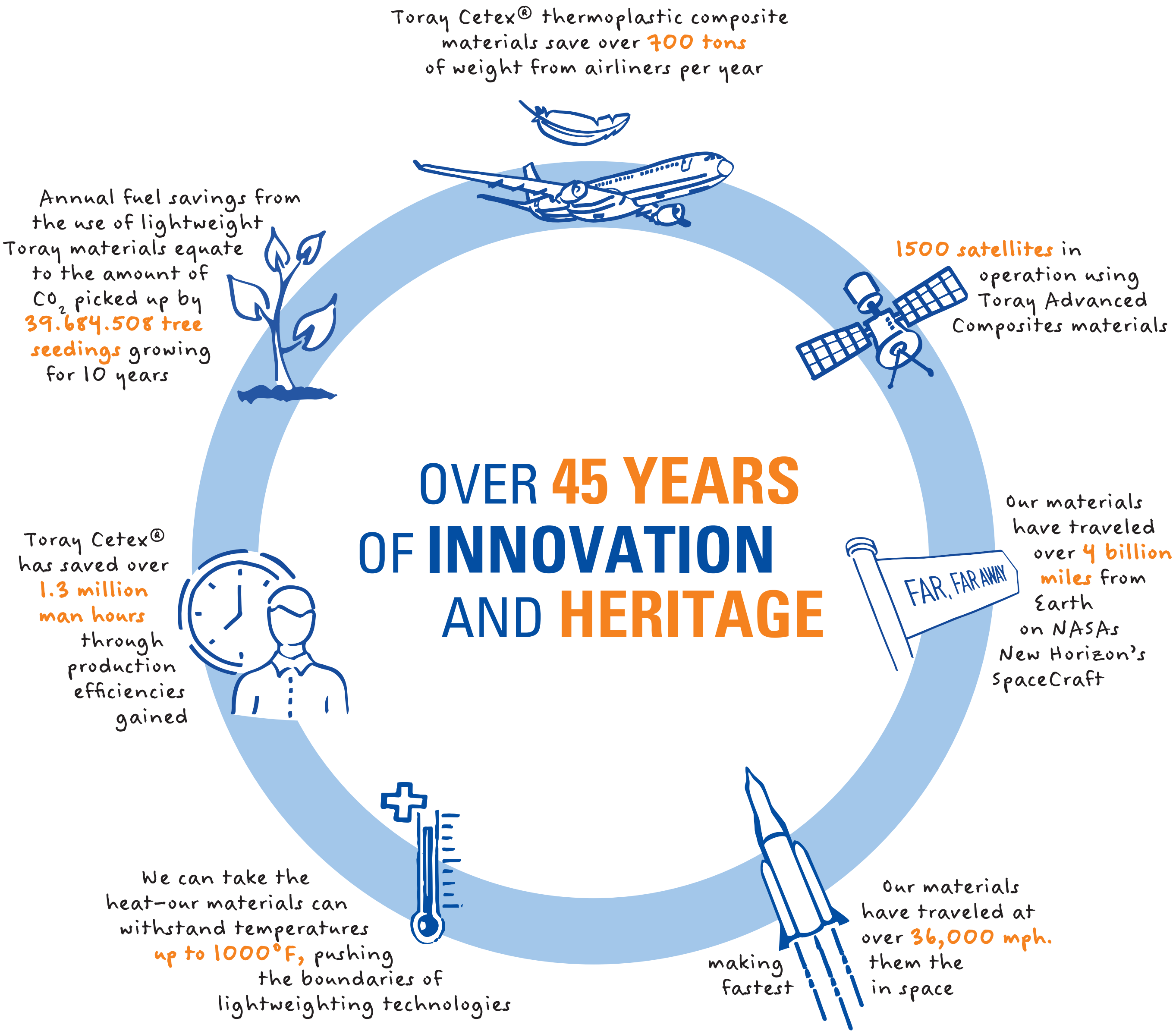

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December 2019

AEROSPACE MANUFACTURING AND MACHINING

A new manufacturing process that enables large monocoque components, particularly those produced by superplastic forming (SPF) from very thin material, to more accurately retain their shape on cooling, could have a major impact on the future of airframe manufacturing. To learn more, read the feature article on page IIa. (Photo: Katrina Brown/Shutterstock.com)

Supplement to *Aerospace & Defense Technology*

One of two 2000-ton SPF presses, complete with semi-automatic tool and component loading equipment, manufacturing latest-generation aircraft panels.

New Manufacturing Process for Monocoque Components

Rhodes Interform (Wakefield, West Yorkshire, England) has developed a new process that enables large monocoque components, particularly those produced by super plastic forming (SPF) from very thin material, to more accurately retain their shape on cooling.

Super Plastic Forming (SPF)

SPF is a process where titanium or aluminium sheet is formed at elevated temperatures of 1000°C and 500°C respectively into complex shapes utilizing pressurized gas as the forming medium. At the super plastic phase of the material, very large extensions, up to 2000%, are possible. This allows certain complex shapes to be hot formed that would otherwise be impossible to achieve by modern cold forming techniques.

In circumstances dictated by the component design, superplastic forming occasionally operates in conjunction with diffusion bonding (DB), a process that utilizes similar elevated temperatures and pressures to create a fully homogenous molecular joint.

Overview of the Process

The manufacturing process for monocoque components involves diffusion bonding of multiple layers of titanium sheet at selected points, and then superplastically forming them using argon gas to inflate the sheets into the shape of a hollow die. This process is extremely temperature and pressure sensitive. At the point the ambient temperature argon forming-gas is admitted into the heated component, the gas expands, increasing its volume, and hence, its pressure, if not adequately controlled.

One of the most critical phases during the press cycle, is when the component has been formed by gas inflation and then needs to be cooled prior to extraction from the press. At this stage, very low-pressure argon gas is passed through the component (purging) to ensure no oxidization of the internal faces takes place while it is at elevated temperatures. If the purge gas pressure is too high, the component will overinflate and lose its shape as soon as the dies are opened. If the purge gas pressure is too low, the ambient air pressure will implode the component.

Achieving the correct balance is further complicated because the cooling component reduces the gas temperature/volume, and thereby lowers the

associated internal gas pressure. With operational experience, compensatory gas pressures can be fine-tuned to allow for such internal variables, although external factors have traditionally been more difficult to control.

One such external variable is ambient atmospheric air pressure, which can significantly affect the final shape of the component and take it out of tolerance. In the case of larger components with relatively thin membrane sheets, this can become a major operational problem.

Existing Technology — Applications and Challenges

Through 35 years of continuously working with blue-chip aerospace companies around the world and addressing their individual requirements, Rhodes Interform has developed a flexible, accurate, gas management system to improve its range of high-temperature superplastic forming presses.

Their current multiform line gas circuits rely on state-of-the-art, electronically controlled, gas pressure reducing valves. These valves, one in each form line, have onboard proportional integral derivative (PID) controllers to achieve extremely accurate pressure regulation and control to within 0.1 Bar. This level of control is more than adequate for the vast majority of superplastic formed components.

More recently however, particularly to accommodate the continuous drive to lightweight aircraft, components are being designed with very thin membrane aerofoil skins and a large surface area. The skins are thus extremely susceptible to very small changes in forming pressure.

One recent example was an aerospace component comprised of four layers — one relatively thick lower layer to obtain structural stiffness, two intermediate layers to offer sectional stability, and a relatively thin upper layer that formed the aerofoil surface. The challenge was how to prevent the relatively thin upper layer from distorting during the cooling process.

Although the part appeared to form accurately and consistently, the structure always failed the final critical dimensional checks. By a process of elimination, mainly derived from checking the tooling and the press process parameters, it became apparent that the structure was unstable and moving during the cooling process. Investigation concluded that the thin upper aerofoil layer, being the weakest part of the structure, was subject to a myriad of varying pressures and forces, resulting in surface distortion. Realizing the problem was occurring during the component cool-down phase, the process elements at that point were investigated further.

When a component is cooling from the elevated forming temperature, normal procedure is to introduce a small positive argon gas pressure into the cavity of the component to prevent the ingress of atmospheric oxygen that could promote oxidization of the internal structure. If this argon pressure is too high it will tend to inflate the component, and if too low the component could, as previously indicated, implode.

The challenge was to control the pressure under varying situations, primarily including:

- Fluctuating ambient air pressures.
- The contraction of the cooling gas and the resultant reduction of pressure inside the component during the cooling process.

Finding a Solution

The team realized that to address this issue, it would be necessary to secure a very low gas supply pressure that would be directly related to the varying ambient atmospheric air pressure. It was noted that the low-pressure purge gas admitted into the component during the cooling process was normally exhausted to the atmosphere via an open bulkhead connection situated on the top of the gas control cabinet. It was therefore proposed that the exhaust line should be fed into a vertical pipe, which extended up and through the roof of the building and out to the atmosphere. The length of the vertical pipe, calculated to support a fixed column of gas, could therefore generate the very low pressure the team was striving for.

When applied in the field, not only did the vertical pipe length generate the pressure head required at the component, but it also served as a reservoir of gas to backfill the component when the internal gas volume reduced as the cooling gas contracted. Critically it was also able to compensate for fluctuating ambient air pressures that were negatively impacting the component tolerances.

In essence therefore, Rhodes Interform's solution uses a gas manometer principle in the form of a vertical, open-to-atmosphere vent pipe, for controlling the gas pressure. This ensures a constant low pressure gas supply, which self-compensates to changing ambient air pressures and keeps the material in a constant shape once formed in the mold.

This novel method of gas pressure control allows for the more accurate production of complex shapes and greater control when diffusion bonding multiple layers of thin titanium sheet.

This article was written by Peter Anderton, Technical Director of Rhodes Interform/ Group Rhodes (Wakefield, West Yorkshire, England). For more information, visit ***http://info.hotims.com/73000-523***.

This 1200-ton SPF press manufactures aircraft panels for the Chinese aerospace sector.

Changing How the Aerospace Industry Makes Parts

Technology that increases production rates and part quality, while reducing setup times and costs, is seeing a surge in demand within the aerospace sector as the commercial aircraft backlog continues to grow.

An example of this technology is being developed in the UK by MSP, a company that specializes in precision software and part manufacturing solutions. Their systems work alongside manufacturers worldwide to refine their traditional, longstanding processes, directly leading to reductions in setup and production time, sometimes from days to a matter of minutes, and cost savings routinely running into millions of pounds sterling. Furthermore, as their products can be installed on a manufacturer's current system and operated by an existing workforce, these savings can increase manufacturing capacity by three or four times - crucial for manufacturers committed to improving the efficiency of their processes.

MSP's core patented NC-Checker and NC-PerfectPart products are the key to achieving these gains in efficiency within manufacturing processes, and with the addition of a third product to the suite in the coming months, AutoClock, the production process is set to be completely automated and error-free for the first time. MSP's systems are widely used by companies across the global aerospace sector to aid the manufacture of a wide range of parts including landing gear, skins, engines and interior composite components.

MSP has saved over £20 million for BAE Systems on two high profile projects, including the F-35 Lightning II.

NC-Checker is machine tool benchmarking software that analyzes the movement of the probe tip to ensure it is correctly calibrated and confirmed in five-axis. Otherwise, errors at this stage could affect how accurately parts are machined. The software then performs a series of checks, including rotary and linear axis tests, to produce accurate, easy to understand reports. These 'benchmark reports' show whether a machine is within tolerance (or not) and can be used by maintenance teams to plan preventative maintenance and decide when to take the machine down to use Ballbar, Laser Calibration or update the machines pivot points. NC-Checker is also capable of showing if a machine has improved after a maintenance intervention by benchmarking the machine before and after any work.

NC-PerfectPart eliminates errors associated with part production on a machine tool. Following NC-Checker's benchmarking, the software first measures the part to check its condition of supply. If there is too much distortion, or not enough material to create a 'good part', the part process can be stopped from the outset. These measurements are then used by the software to calculate what the part alignment should be and the controller is automatically updated to compensate for any discrepancy between the part location and the machining program. All errors due to misalignment are eliminated and the software has a proven record of cutting scrap rates to zero and increasing production by 500%.

Real World Applications

Both products have been involved in projects of all sizes and scales for aerospace companies worldwide, but their work in two BAE Systems fighter jet projects, the Eurofighter Typhoon and F-35 Lightning II, has been particularly significant in the success of NC-Checker and NC-PerfectPart and MSP's growing global presence.

The Eurofighter Typhoon project, which was MSP's first-ever commission following its formation in 2002, faced difficulty with its process for aligning the canard wing on the machine due to the manual setup procedure. The part would have to be located manually within the fixture and then, once machined, be turned over and relocated again to machine the other side. This process had to be repeated twice, using a different fixture each time. Due to the manual measurement and multiple stages involved, it took 7 days to produce one part, 20-30 hours of which was machining time. The rest was setup time. Furthermore, turning the part over caused a cusp or 'ridge' to form on the leading edge of the part. Subsequently, one in ten parts were sub-optimal, with the other nine requiring an element of rework, in some cases as much as 22 hours.

After seeing the capabilities of NC-PerfectPart and against a target of 770 parts to make in three years, BAE Systems worked with MSP to design a new process for fixturing the canard wing. Due to the versatility of NC-PerfectPart, the original fixtures could be replaced with a single vacuum fixture, removing the need for turning the part and using multiple fixtures. The process was reduced to four hours 38 minutes, made up of four hours machining time and 38 minutes setup time. No sub-optimal parts were produced and no rework was necessary. In two years, 1,100 perfect parts were made, and due to the time saved, they gained 50% extra machine time which could be used to make other parts – without any investment in extra machine tools required. Over £20million was saved by BAE Systems in five years.

MSP's automated systems eliminate errors associated with part production on a machine tool.

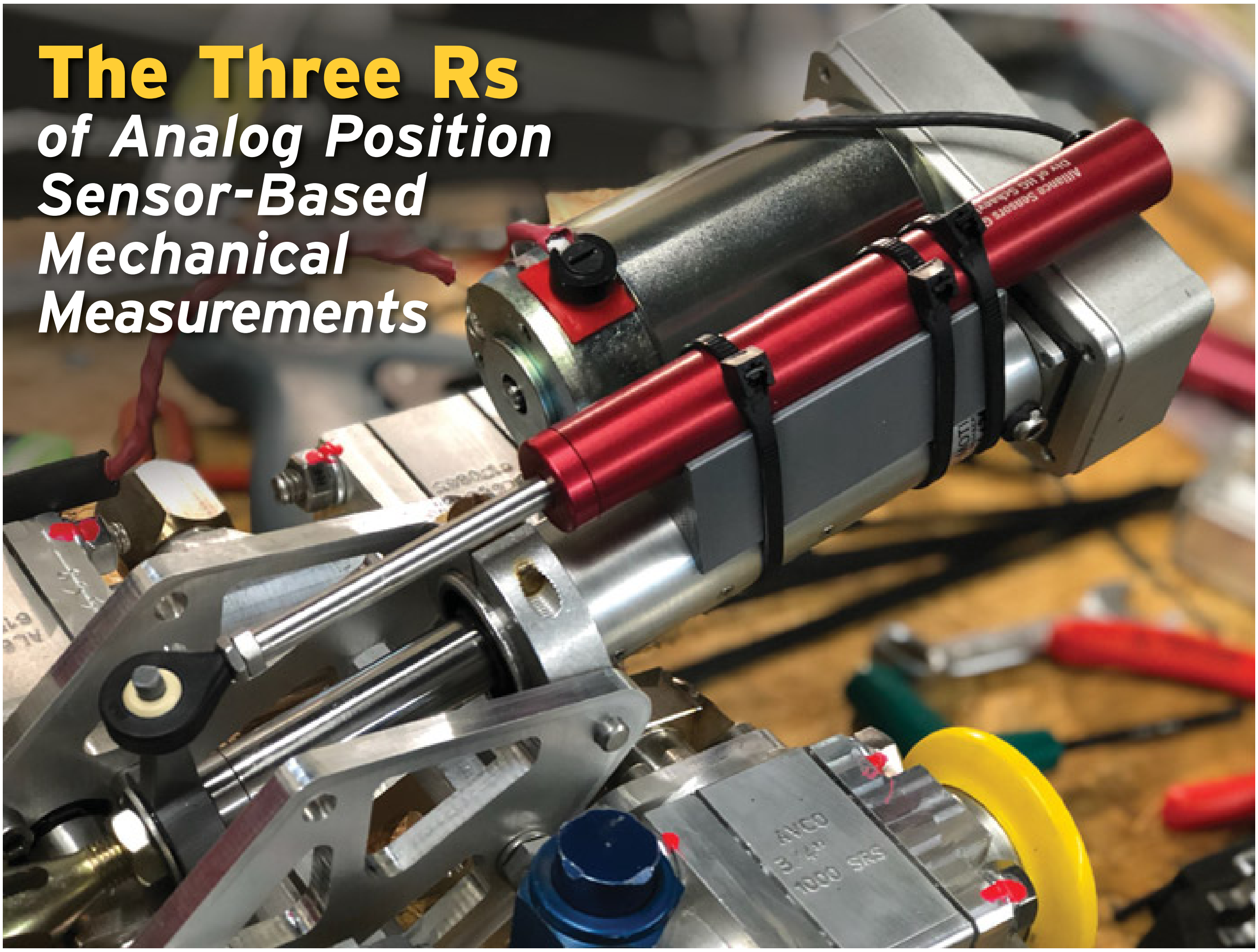
Following the success of the Eurofighter project, BAE Systems approached MSP again to help streamline production of all F-35 skins including the Nozzle Bay Doors (NBD) for the F-35 STOVL (Short Take Off Vertical Landing) variant. A critical step for this was developing the fixture to allow the doors to be machined to tight tolerances despite their complex and varying shape.

Traditionally, complex components similar to the NBD are held in place on fixtures such as vacuum, hydraulic or mechanical fixtures, but in this instance, any of these would have distorted the configuration of this component. Instead, using NC-PerfectPart's ability to automate part setup, the BAE Systems engineering team developed an innovative setup technique, known as sticky fixturing, a simplified way to hold a component in its free state while it is machined. Part setup was reduced from days to minutes and, again, led to savings above £20million over the lifetime of the project for BAE Systems.

The introduction of MSP's third product, AutoClock, completed the automation process, eliminating inaccuracies at the very start of the machining process by automating probe calibration – something which had not previously been possible. The release of AutoClock came in response to the widespread problem of inaccurate manual clocking and its potential to lead to inaccurate probe calibration, something that can affect machine accuracy and ultimately lead to poor part quality.

This article was written by Peter Hammond and Tony Brown, Co-Founders, MSP (Alnwick, Northumberland, UK). For more information, visit ***http://info.hotims.com/73000-524***.

The Three Rs of Analog Position Sensor-Based Mechanical Measurements



Those of us old enough to remember the "good old days" recall that grade school focused on learning the 3 R's: reading, 'riting, and 'rithametic. In the world of sensors, there are also 3 R's: Repeatability, Resolution, and Response. As important as these sensor parameters are, there is often confusion in the mind of users about exactly what they mean and in what ways they tend to interact with each other. This article will attempt to explain the 3 R's for position sensors and dispel any confusion that might exist.

Definitions

Repeatability is a measure of the variation between outputs of a sensor-based measuring system for repeated trials of an identical mechanical input in a constant environment. Common practice is to use at least three repeated inputs, but five or more identical inputs are considered to be an even better sample for determining this parameter. Repeatability is usually evaluated by applying an averaging process to the variations in output values observed for the multiple trials. It is typically specified as a percentage of Full Scale Output or Full Span Output (FSO), but sometimes it is specified in absolute terms such as parts per million or fractions of the mechanical units applicable to the

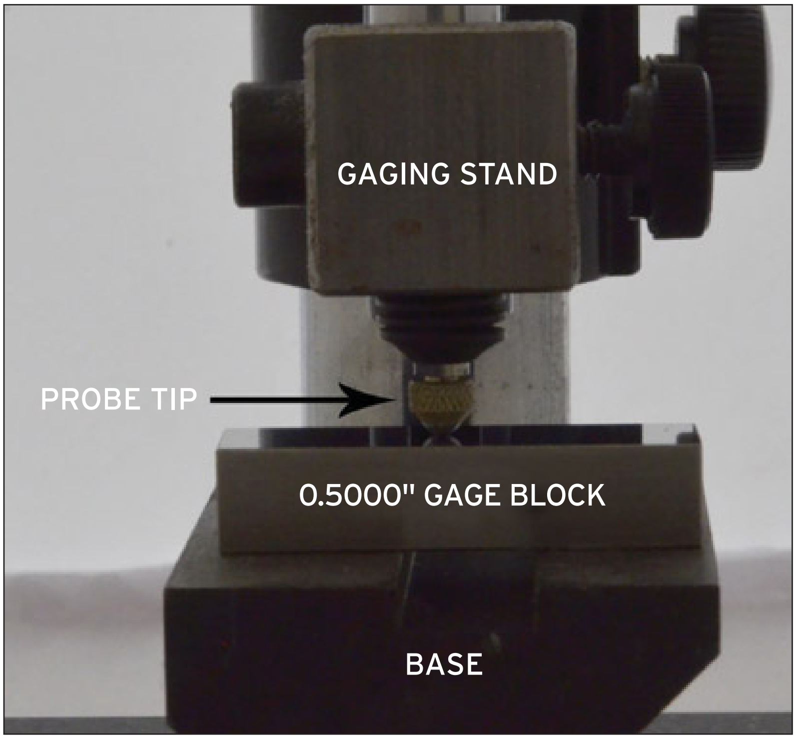


Figure 1. Sensor Repeatability Testing Apparatus

Figure 2. An LR-19 series LVIT (Linear Variable Inductance Transducer) position sensor installed on a crimping machine.

actual sensor-based measurement.

A constraint on repeatability measurement is that the trial inputs have to be applied in the same way, usually from a lower value to a higher value, to eliminate any effects from hysteresis. Hysteresis error is a measure of the difference in system output when the mechanical input is rising up to the desired input value from a lower value compared to an identical input coming down from a higher input value to the desired value. For most contactless position sensors, hysteresis error is smaller than repeatability error.

An example demonstrating repeatability can be seen in Figure 1, which shows a spring-loaded position sensor in a typical gagging stand being calibrated with a precision gage block of 0.5000-inch dimension. The sensor delivers an output of 0 to 10 Volts DC full scale for 0- to 1-inch of probe movement. The tip of the sensor is moved inward to allow the gage block to be inserted between the tip and a flat base, and then released to contact the block. In five trials, system outputs are: 5.0012, 5.0016, 5.0013, 5.0010, and 5.0015 Volts DC. The average value is slightly over 5.0013 Volts and the maximum variance is ±0.0003 Volts, which is equal to ±30 ppm of FSO, or 0.003% of FSO.

Resolution is a measure of the smallest change in the input to a sensor-based measuring system that will produce a measurable change in the electrical output from that system. While this may seem like a fairly simple concept, it is impacted by factors external to the sensor itself, the most significant of which is the signal-to-noise ratio of the system's analog output. Electrical noise present on the system's output can reduce the effective resolution of the system by masking any small changes in the sensor's output. For example, if the sensor's resolution specification is 0.25 mV, but the system output noise and ripple is 2 mVp-p, clearly sensor output changes smaller than 2 mV will not be discernable within that noise. Thus, the actual system resolution is only about 12% of what the sensor resolution specification offers.

Like repeatability, resolution is often specified as a percentage of Full Scale/Full Span Output (FSO) but may also be specified in absolute terms like fractions of the units of the actual sensor measurement, or, in digitally-augmented measurements, in bits, which is just a fractional measure expressed in powers of 2, as found in computers. Thus 10-bit resolution is one part in 1024 (210), 12-bit is one part in 4096 (212), etc.

Response denotes a sensor-based measuring system's performance under dynamic input conditions, that is, when the system's mechanical input is changing rapidly. It is particularly important to recognize that response is a measuring system parameter, not merely a sensor parameter or specification.

In practice, there are several ways to characterize response, typically based on whether the system is a first order or second order system. Traditional analog systems have used Bode plots to show frequency response and phase lag for repetitive inputs. For step function response, three times the system time constant is a typical measure of dynamic performance. In digital sampling systems, the update rate for a specified number of bits is one of the preferred measures of response. Regardless of the choice of how to specify response, the ultimate purpose is to understand how well the measuring system can respond to a changing input before the system's output becomes inaccurate, unusable, or unstable.

Interactions

From the foregoing definitions, it is easy to see that a system's repeatability could easily be affected by its resolution. If the measuring system's resolution is inadequate, it would likely be a significant limiting factor to excellent measurement system repeatability. In practice, sensor repeatability may be excellent, but measuring system repeatability cannot be any better than that permitted by the system's resolution.

While the interaction of repeatability with resolution in a measuring system is pretty easily understood, the interactions of resolution and response are not so straightforward. When the system's mechanical input is changing rapidly, the effects of resolution on system output are usually masked by the larger effects of decreased system output due to limitations imposed by the system's dynamic response. But if the mechanical input to a position measuring system changes slowly or intermittently, especially in a jerky way, then the effects of stiction (static friction) come into play.

Typically, the effects of stiction in position measuring systems can be non-linear and are often not very repeatable, so determining or characterizing system resolution can be much more complicated, if even possible. And because the system resolution interacts with system repeatability, as was noted above, measurement errors can increase substantially, particularly if the system is providing position feedback for closed-loop control. Of course, any effects caused by stiction will also appear as non-linearity in the sensor's output. But because stiction effects are not very repeatable, digital linearization techniques to offset the non-linear effects will not be practical.

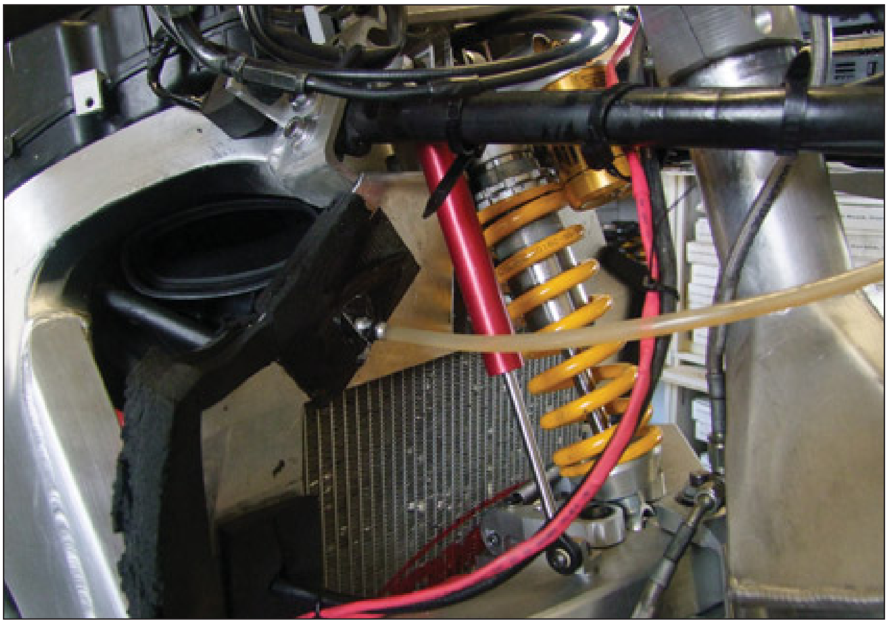


Figure 3. An LR-19 series LVIT (Linear Variable Inductance Transducer) position sensor installed in a vehicle suspension system.

For this reason, efforts to reduce stiction are usually necessary to minimize any measurement errors caused by stiction in very slow-moving or intermittent-motion positioning systems. These efforts can involve applying techniques such as "dither", a low amplitude signal of high frequency that is input into the system to supplant stiction with much reduced dynamic friction, or by decreasing friction on the moving surfaces of the sensor by improving their surface finishes and by coating them with a lubricant.

This article was written by Edward Herceg, Chief Technology Officer, Alliance Sensors Group (Moorestown, NJ). For more information, visit ***http://info.hotims.com/73000-525***

How Augmented Reality *Can Modernize* Aerospace And Defense Manufacturing

You've probably heard about augmented reality (AR) in the context of consumer entertainment: video gaming, virtual tours, or interactive displays. But AR for enterprise business is here. It's no longer an emerging technology, or a novelty; businesses are using AR to overhaul processes, drive efficiencies, reduce manufacturing errors, and improve their bottom line.

Manufacturers of all types are using AR to bring critical information directly to their workforce across industries including industrial equipment and machinery, consumer packaged goods, and even aerospace and defense. Is AR mature enough for adoption in companies that are launching satellites and building new spacecraft? Absolutely. In fact, the technology is uniquely positioned to meet the highly specialized needs of the aerospace industry.

Accuracy Is Mission-Critical

While nearly no company likes to talk about it, the failure rate in manufacturing components or systems is an indisputable fact. Some industries, like consumer electronics, might tolerate a failure rate of 5 percent, or even higher, factoring in returns or repairs as an acceptable cost of doing business. But in an industry like aerospace and defense, the acceptable failure rate number needs to be zero, or as close to zero as realistically possible. Human error at the factory can lead to severe consequences that impact the outcome of an entire project. Downtime can be costly, especially when downstream processes get held up.

Augmented reality is the ultimate "measure twice, cut once" reference check. It brings precise, intuitive instruction into the real world. Augmented reality can help engineers see immediately if they're about to drill into the wrong spot or install a fastener upside down. Compare that to the decades-old standard for repair or assembly: printed manuals and reference guides. Digital versions are an upgrade, making references searchable and reducing time to find the needed manufacturing or repair info. AR brings the information engineers or technicians need as an overlay into the real world, in real time. As a result, technicians are better equipped to diagnose possible errors before they happen and more accurately complete manufacturing procedures. And bigger picture, it reduces downtime and improves efficiencies.

When done right, AR helps accelerate time-to-information when accuracy is essential. Technicians can access critical reference material that helps them make the right decisions exactly when they need it. Consider a complex assembly process with thousands of steps, like assembling a satellite. Without AR, technicians will spend a considerable amount of time examining diagrams, consulting manuals, or reviewing static guides and then doing mental mapping of these paper instructions onto the real world components of whatever they are

AR helps accelerate time-to-information when accuracy is essential. Technicians can access critical reference material, such as step by step instructions, that help them make the right decisions exactly when they need it. (Image credit: Scope AR)

A Lockheed Martin technician using AR manufacturing instructions created with Scope AR's WorkLink platform. (Image credit: Lockheed Martin)

building, which leaves a lot of room for error or misinterpretation.

A good example of this is Lockheed Martin. Since they began using AR in their Space Systems division to help manufacture spacecraft, including NASA's Orion Spacecraft, they have realized significant ROI including a 95% reduction in the time it takes technicians to interpret drawings and text instructions.

Create Experts, Share Expertise

In aerospace and defense, the workforce consists of highly specialized SMEs that live and breathe intellectual property – designs, processes, equipment – all of which is highly proprietary. Unlike, say, auto repair, there's no universal Chilton's manual for repairing one company's proprietary spacecraft. Companies invest considerable amounts of time and resources in training expert engineers and technicians on their specialized machines and tools.

Augmented reality is an ideal way to build and share expertise with the people who use and add to a company's unique intellectual property. The technology brings an inherent ability to more easily and quickly share expert knowledge, meaning you can use AR to maximize the investment in creating a company's SMEs. As mentioned above, Lockheed Martin's Space Systems division is using AR to ensure spacecraft are built with the highest precision and accuracy.

Beyond the reduction in time-to-information, the team has also experienced an 85 percent reduction in overall training required through the use of AR. Training your workforce on a process that used to take eight hours could now take 45 minutes through the use of augmented reality. An executive at Lockheed Martin said that with AR, engineers don't just see how things work, they can more fully understand a new process and can make better-informed decisions along the way.

In fact, Lockheed Martin has seen a 42% improvement in overall productivity as a result of their use of AR instructions created with the use of AR software from Scope AR.

AR platforms go beyond contextual overlays to deliver work instructions to technicians in-the-moment. Integrated platforms can also connect technicians with an SME to communicate real-time instructions or help troubleshoot an equipment error. If you can record AR-supported remote assistance, training, and troubleshooting sessions, they become valuable, reusable assets to help others gain expertise in a scalable way.

Security Is Everything

For any company working in the aerospace and defense sector, security needs to be unassailable. The safety of a nation's population might depend on it. Security also protects your most sensitive intellectual property, tradecraft, and proprietary design plans and equipment. If you're evaluating a new technology, it first needs to conform to your organization's specific, stringent security protocols. Don't let strict policies or deployment requirements deter you from leveraging AR to drive value to your organization. In fact, several companies in the aerospace and defense industry have some of the most compelling and advanced applications of AR today.

Partner with IT early to ensure the AR technology you're evaluating can integrate into your organization's existing infrastructure. It's also important to find an AR solution that works with the hardware devices that are already governed or approved for use within your closed systems - whether that's wearables, smartphones or tablets. Despite some misconceptions, augmented reality is enterprise-ready and has reached a maturity stage to meet even the most rigorous security protocols and keep your data and proprietary content that AR often leverages, such as 3D or CAD models, as well as detailed manufacturing instructions, safe.

What Augmented Reality Does Best

We're starting to see more companies every day using AR to help solve problems for enterprise business. When you can simplify a process in one location – or on one team – you can often scale it to other areas of your business. As a matter of fact, due to the success of their Space Systems team's initial deployment, Lockheed Martin is now expanding their use of AR into all four business units of their organization across a variety of use cases.

If you're looking to get started with an AR project at your company, here's the best way to get started. Partner with leadership early and ensure your AR project fits within all existing information security protocols. Find a use case where AR can help your specialized workforce do their jobs more efficiently and effectively. Focus on a single process where you can use AR to speed up critical time-to-information or reduce downtime. Measure the value and evaluate ROI. If you see value, expand and repeat across other manufacturing applications or even extend to new business units that could benefit from the technology.

This article was written by Scott Montgomerie, CEO and Co-Founder, Scope AR (San Francisco, CA). For more information, visit ***http://info.hotims.com/73000-526.***

Marking Aircraft Components

Numbers are critical to the smooth functioning of the international aerospace industry. Regulatory authorities such as the Federal Aviation Authority (FAA) and the US Department of Defense (DoD) mandate that aero components be permanently marked to ensure authenticity and traceability throughout the supply chain and into service.

Although, marking adds no intrinsic value to a component and forms no technical functional purpose, it is central to the smooth operation of the industry. It allows components to be correctly tracked, identified, assembled, maintained and positioned. Marking also helps address issues such as the use of counterfeit parts in the supply chain which have been implicated in a number of air accidents.

Setting Standards

Typically, the requirements for marking aircraft components are set out in international standards such as the Unique Identification Marking (UID) standards established by the DoD. However, these markings also fall under general civil aviation certification requirements.

Under FAA rules, for example, the requirements for the identification and registration markings on engines, engine components, and items such as propellers are set out in 14 CFR, Part 45. Under these rules, manufacturers that produce, for example, propellers, propeller blades, or hubs under a type certificate or production certificate must mark each product or part. These regulations also cover the identification of certain replacement and modified parts produced for installation on type-certificated products.

These markings must be placed on a non-critical surface, where they cannot be defaced or removed during normal service, or be lost or destroyed in the event of an accident. In addition, there are a series of requirements establishing the information that must be contained in the markings. For instance, under FAA rules the data included in the identification must contain the manufacturer's name, the model designation, serial number, type certificate number and production certificate number, if there is one, and for aircraft engines, the established rating.

In addition, the FAA approves components produced by some manufacturers under its Parts Manufacturer Approval (PMA) scheme, which is a combined design and production approval for modification and replacement parts. Again, under FAA rules, all manufacturers of PMA parts must permanently and legibly mark each item with the PMA holder's name, trademark, symbol, or other FAA approved identification and the unique part number, as well as the letters “FAA-PMA”.

Alongside mandated markings, individual manufacturers have their own marking specifications that detail how the mark should be applied, formatted, and positioned, as well as adding various critical engineering details such as how parts are assembled in the engine.

Alongside FAA rules for marking, there are also specific standards that detail requirements for the qualities of the physical marks. For instance, SAE

International's AS9132 marking standard defines the uniform quality and technical requirements for marking of metallic parts using 2D Data Matrix symbol coding, as used within the aerospace industry. The unique data matrix code may also provide a link to additional information concerning its manufacture that allows precise traceability, such as in the case of part failure. This data may include details such as the source of the materials used in the manufacture, as well as which operator and even which specific machine was used in the manufacture of the part.

Similarly, DoD UID markings must meet standards set by the International Organization for Standardization (ISO). The ISO 16022 standard specifies general requirements for component marking covering items such as data character encoding, error correction rules and decoding algorithms, as well as requirements to ensure electronic reading of the Data Matrix is possible. The marking processes covered by this standard include common techniques such as dot peen and laser etching and measures characteristics such as the size of the dots, the angle of distortion and any center offset.

Making a Mark in Aerospace

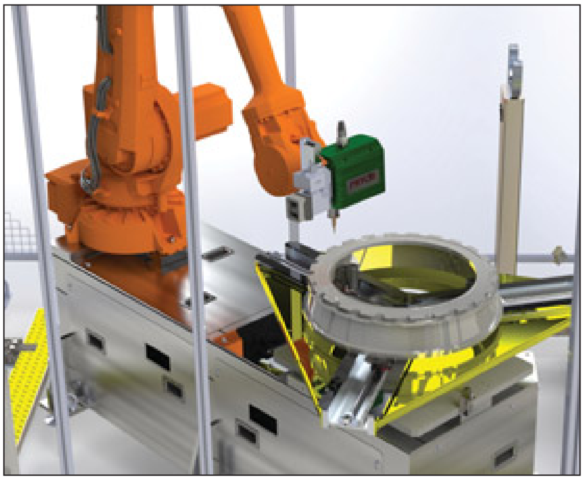
Although the requirements for component marking are clearly set out under FAA and similar regulatory authority rules as well as international standards organizations, execution of the marking process can nonetheless represent a significant challenge for manufacturers. For example, aircraft components such as those found in jet engines can feature complex geometry and may also be extremely costly, in excess of $100,000 in some cases. Badly placed or poorly executed marking can result in a very expensive failure if components are effectively deemed worthless.

Historically parts have been marked using manual processes and even today, some low-cost, short run components may still be marked using manual handheld tools. However, for larger and more costly components, which need multiple marks to be applied in specific locations, a more precise, robotically-controlled marking process may be required. For example, large aero engine components such as disks, rings, blades and bladed disks (also known as blisks) may require 15 or more marks to be made at different locations and within positional tolerances of 0.1 mm or less. With a typical aero engine containing hundreds of parts that need to be marked this way, manual marking would effectively be impossible. In addition, many of these components are round or cylindrical, making precise marking all the more challenging.

Instead, robotic multi-axis marking tools are used to apply component identification marks. As components have grown in both size and complexity, robotic marking tools have also evolved. For example, initially dealing with relatively small parts, marking heads were fixed and the component was grasped by the machine and manipulated to the appropriate orientation for marking. This improves accuracy and allows multiple marks to be made across the surface of the part to very tight tolerances.

Today, the robotic control typically takes place on the marking head itself and Pryor's system, for example, works with parts up to 1.2-meters in diameter. Even larger components could be handled if required. For the aero industry, the robots are usually fitted with dot peen marking heads, but lasers or scribes may also be used for component marking if appropriate.

The dot peen process, in which a hard stylus is repeatedly projected forward using electricity or compressed air as the head moves, induces far less stress in the component being marked than alternatives such as scribing. In addition, dot peen can produce marks through any coatings or films that may have been applied to the component. For aircraft component manufacturers, these are key considerations.



Robotic marking tool prepares to inscribe a circular component.

In a typical scenario, an aero component is moved into a 'marking cell' where it is loaded onto a rotary table and clamped in place. An operator scans a unique ID associated with the component that is linked to the plant manufacturing system and ensures the correct data is applied. Software can automatically create the correct unique identifiers, such as serial numbers or the necessary 2D Data Matrix codes. Having produced an appropriate marking schedule, it is then executed by the robotic dot peen head.

Robotic marking systems can ensure aircraft components are marked efficiently and accurately while still meeting all relevant regulatory and OEM standards. Using such a system allows a cumulative history of a component to be built up over time as it moves through the various stages of the production process and throughout its in-service lifespan. Ultimately this supports better traceability and root cause analysis in the event of a failure. In addition, as aero engines become larger and more complex in the drive for efficiency, component marking is set to become still more challenging for manufacturers.

With large components such as blisks set to become even more sophisticated and, therefore, more expensive, the impact of poor quality marking will continue to grow in importance. Robotic systems allow individual components to be marked correctly and to specification on the first attempt. This means the manufacturing process for aircraft components can be much more efficient.

*This article was written by Alastair Morris, Vice President of Pryor Technology Inc. (Ashland, VA). For more information, visit **http://info.hotims.com/73000-527**.*

NEW PRODUCTS & SERVICES

Metal-Spinning Machines

MJC Engineering (Huntington Beach, CA) is a custom machine tool builder that specializes in metal-spinning machines for such applications as sheet spinning, flow forming, wheel spinning and rotary forging. Recently, the company built a series of metal-spinning machines for GKN that are producing lip skins for the engine housings on Boeing 777X and 737MAX aircraft. It uses advanced CNC from Siemens and robotic handling technology, plus its proprietary servopump-controlled Green Power™ hydraulic power unit that saves up to 40% on energy.

In operation, the machine takes the overhead crane-loaded 270" diameter blank, fixes it to the tailstock of the machine and rotates it on a 150HP motor-driven spindle, then progressively applies heat via the gas torch on the robot arm. Raytek thermal imaging cameras closely monitor the heat readings over the entire surface to create multiple control cones. When inconsistencies are detected, the heat is appropriately adjusted in real time by the controllers. The heated material is then formed over the mandrel into the desired size, with out-of-round conditions ranging from 8½" to 9" typically. Siemens Simatic S7 PLC technology is included.

For Free Info Visit http://info.hotims.com/73000-470

Horizontal Machining Center

Mitsui Seiki's (Franklin Lakes, NJ) HPX63 II 4-axis horizontal machining center, an improved version of the company's proven HPX63 unit, features a 70-percent-faster rapid feed rate of 54 m/min that produces shorter cycle times, and a 14 percent reduction in shop floor footprint (now 5,554 mm × 3,530 mm) to maximize manufacturing facility space. Capable of machining workpieces as large as 1,050 mm × 1,050 mm (diameter x height), the HPX63 II machining center is engineered to process medium-size precision parts. Pallet size is 630 mm square and maximum table load is 1,200 kg. Positioning accuracy and repeatability are +/- 0.001 mm (one micron).

X-, Y-, and Z-axis strokes are 1,000 mm, 800 mm, and 900 mm respectively. An 18.5/15 kW (30 min./continuous) spindle utilizes ISO 7/24 50-taper tooling and provides rotation speeds from 15 rpm - 6,000 rpm as well as 600 Nm maximum torque. The B-axis rotary table offers high torque and acceleration. A 60-pocket automatic tool changer accommodates tools up to 500 mm long and 125 mm in diameter (265 mm diameter without adjacent tools), weighing up to 25 kg.

For Free Info Visit http://info.hotims.com/73000-471

Servo-Electric and Sheet Hydroforming Presses

Beckwood Press Company (St. Louis, MO) a manufacturer of hydraulic and servo-electric presses, automation systems, and the Triform line of specialty forming equipment, recently showcased their latest innovations in precision forming technology with two new presses.

The first machine, a 4,000 lbf (2 ton) EVOx servo-electric press, is ideal for light-duty applications requiring high precision, cleanliness, and efficiency. Featuring three modes of operation, the press can achieve positional accuracy to within +/-0.0005". The data acquisition system records key performance metrics at a rate of 1000 samples per second.

The second machine, a Triform model 610-20-3 deep draw sheet hydroforming press, is designed for low-volume, high-mix part production. The pressurized rubber diaphragm easily forms complex net-shaped parts over a single, un-mated tool while diaphragm pressure and punch position are tightly controlled (to 1% of full scale and +/-0.002" respectively). The proprietary "In-Sight" tool easily develops the perfect recipe for any deep drawn part.

For Free Info Visit http://info.hotims.com/73000-496

Automation Cell

INDEX (Noblesville, IN) has announced that the iXcenter automation cell is now available with its C Series of highly productive turning centers. Docked to the machine and easily slid aside to enable unobstructed access to the work area, iXcenter supports fully automatic machine operation and flexibly manages raw material and finished parts.

iXcenter features a space-saving vertical storage system with up to 22 stacked pallets measuring 600 mm × 400 mm. Pallets are loaded with blanks at the top of the system, while pallets with finished parts can be removed at the bottom. Downstream processes such as cleaning, measuring, deburring and more can also be integrated directly into the cell. The system's 6-axis robot can handle materials and parts to a maximum weight of 6 kg.

INDEX's C Series of machines includes the C100 and C200, which respectively accommodate bar stock of 42 mm and 65 mm or 90 mm. These production turning centers feature two or three turrets to offer extremely high efficiency and complete machining of complex parts. The machines can optionally apply two Y axes to the main spindle or one Y axis on both the main and counter spindles, allowing cycle times of complex operations to be minimized.

For Free Info Visit http://info.hotims.com/73000-480

Microwave Rotary Joint

A dual-channel Ka-band microwave rotary joint designed by Link Microtek (Hampshire, UK) is playing a crucial role in a new stabilized antenna platform developed by Italian firm ADS International S.r.l. (Annone di Brianza LC, Italy) for high-end satcom-on-the-move (SOTM) applications. Typically mounted on vehicles for either commercial or military use, the new ADS system features a low-profile radome that houses a 4-port, wideband flat-panel waveguide-array antenna together with ancillary hardware. The dual circular polarization system operates at 19.2-21.2GHz in Rx and 29-31GHz in Tx.

Key to operation of the ADS antenna system are two Link Microtek rotary joints – one for azimuth and one for elevation – which enable RF signals to be fed from the static side of the system to its rotating side. The central transmit channel of each rotary joint is implemented in WR28 waveguide and delivers up to 50W of microwave power (CW) over the frequency range 29 to 31GHz with an insertion loss of just 0.5dB and a VSWR of 1.3:1.

For Free Info Visit http://info.hotims.com/73000-487

Roughness and Contour Measurement System

Mahr Inc. (Providence, RI) announced the addition of the variable-drive MarSurf VD series, which enables roughness and contour measurements to be performed on the same machine. The operator can easily and quickly change between a high-precision roughness probe system or a highly dynamic contour probe system, depending on the measuring task.

The drive units of the MarSurf VD series move the probe with positioning speeds of up to 200 mm/s, making surface measurements up to 40 times faster than predecessors. All Z-axis columns on the MarSurf VD series are fully CNC-capable with fast positioning speeds of 50 mm/s. It is available in drive unit sizes of 140 mm and an industry-first 280 mm to allow for the measurement of applications that were previously impossible.

The VD Series features a large mounting plate with 50 mm bore pattern, 60 mm Y adjustment, and Z-axis of 350 mm or 600 mm. All probe arms feature a quick-change magnetic mount to ensure the fastest changeover time, as well as extra security allowing the probe to "break away" in the event of an accidental collision.

For Free Info Visit http://info.hotims.com/73000-497

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