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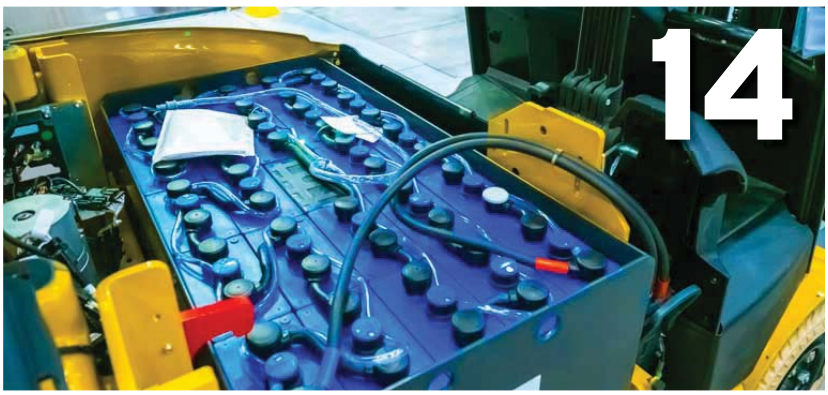

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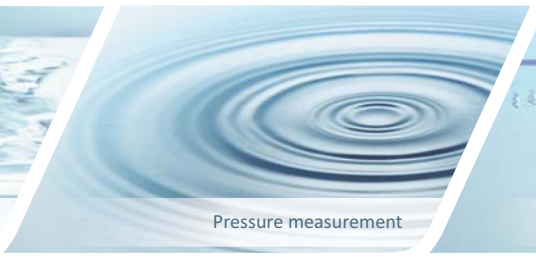
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From the Editor

By Rehana Begg, Editor-in-Chief

Finding Opportunities in Sustainability-Driven Production

Manufacturers embed sustainability and resilience principles into their operations to increase competitiveness and resilience.

MANUFACTURING AND PRODUCTION sectors are essential drivers for economic growth (making up 16% of global GDP), but pose serious environmental risks that must be collaboratively addressed. The industrial sector alone consumes about 54% of the world's total delivered energy.

With this awareness, manufacturers are embedding sustainability and resilience principles into their operations to increase competitiveness. It forces them to re-evaluate not only the way they think about and design products, technologies, processes and business models, but also how they optimize value created by those resources.

Consider the decarbonization agenda, where manufacturers are realizing that they need to go beyond the confines of their own carbon-neutral operations. In order to progress, each manufacturer would need to calculate their cradle-to-gate product carbon footprint (PCF)—a tricky undertaking, to say the least.

Members of the World Economic Forum's Advanced Manufacturing and Value Chains community have worked on a pilot project to develop a blueprint for securely exchanging PCF data along manufacturing and supply networks. But there are countless other ways to instigate resource efficiency, energy consumption and circularity at the practice level. The ability to extend the lifetime of robots is a standout example. ABB's sizeable robotics portfolio can vouch that up to 80% of a robot's components can be reused. Nearly all ABB robots used in the automotive industry get a second life and a fifth will get a third.

For this issue, we invited subject matter experts to highlight the sustainability dimensions to their solutions. As Adithi Murthy discusses in "Bringing Sustainability from the Boardroom to Ground Level" (page 14), no single measure can accomplish the comprehensive enhancements necessary to secure a sustainable future. Her contribution to the sustainability topic involves driving down energy costs and consumption by using smart sensing technologies to update system design.

Then, in two separate articles, *Machine Design*'s technical editor, Sharon Spielman, surveys sustainability in additive manufacturing. In "Advancing Sustainability in 3D Printing" (p. 20), she shows how 3D printing promotes lower carbon footprints when engineers create and test new designs with minimal material consumption. And in "Shaping Sustainability in 3D Printing" (p. 22), a use case on DfAM software developer Metafold reveals an unabashed interplay between sustainability and competitiveness.

For Eryn Devola, vice president of Sustainability for Siemens Digital Industries, sustainability should never be a "bolt-on solution." Instead, embracing a data-driven, digital twin methodology makes sense. (Read "Making Production Sustainable with Digital Tools," p. 16.)

These contributors demonstrate that a sustainability strategy requires holistic thinking—a commitment that extends from the drawing board to the shop floor and all the way through the value chain. ■

Tell us your sustainability story. Reach me at rbegg@endeavorb2b.com.

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Barely There: Replacing Manual Operations with Lights-out Processes

The concept of lights-out production—streamlining processes with the aid of robotics and automation—doesn't discount the need for people.

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Biomimicry in Medical Device Design

Novel microfluidics technology enable the development of medical device form factors that are easy for patients to use.

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Designs on a Circular Packaging Future

A report at Pack Expo 2023 cites the need for new materials, recycling capabilities and system architecture.

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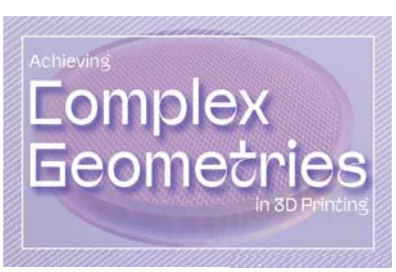

Achieving Complex Geometries in 3D Printing

The only provider of a cloud- and API-based 3D engineering platform looks to advance the mass adoption of industrial 3D printing, with sustainability at the forefront of its mission.

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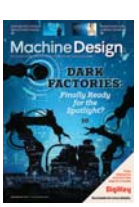

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2023 IDEA Awards: SiTime is the Big IDEA Winner

All votes have been tabulated, and now it's time to reveal the best new product innovations of 2023.

SiTime's SIT7910 temperature-compensated oscillator (TCXO) is the Big IDEA Winner in the annual IDEA Awards, presented by *Machine Design, Electronic Design, Power & Motion, Microwaves & RF* and *Vision Systems Design.*

After voters from all over the world cast their ballots, Winners and Honorees were crowned in 10 categories. The SiTime SiT7910 received the highest number of votes in all categories and received the Big IDEA designation.

"We know product innovation is important to our readers and to the larger supplier community. It is only through the continued innovations of technology, components and systems can manufacturing meet the challenges today and tomorrow," said Bob Vavra, senior content director for *Machine Design* and *Power & Motion*. "This year's winners, chosen by our readers, are a great example of how that innovation becomes products that advance the goals of manufacturers everywhere—a safer, smarter and better-connected manufacturing enterprise."

The 2023 IDEA Award winners are listed below.

BIG IDEA WINNER

SiTime
SiT7910

ADDITIVE & MATERIALS MANAGEMENT

Winner:
Protolabs
Instant Design for Additive Manufacturability (DfAM) Analysis

Honorees:
Phoenix Contact
clipx WIRE assist

Emerson
Branson GMX-HP Ultrasonic Metal Welder

AUTOMATION & CONTROLS

Winner:
Red Lion
N-Tron Series NT5000 Gigabit Managed Layer 2 Ethernet switches

Honorees:
Rockwell Automation
Allen-Bradley Micro850 Programmable Logic Controller Systems and Micro870 Programmable Logic Controller Systems

Emerson
CIP Utilities and Automated Reporting Analytics Package

COMMUNICATIONS

Winner:
Morse Micro
Wi-Fi HaLow SoCs

Honorees:
Microchip Technology
PIC32CX-BZ2 MCU Family

Texas Instruments
CC2340R5

COMPUTING

Winner:
Ambaralla
Ambarella's Centrally Processed 4D Imaging Radar Architecture for Autonomous Mobility Systems

Honorees:
Lattice Semiconductor
Lattice Avent

Texas Instruments
AM6xA

United States Postal Service

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"We know product innovation is important to our readers and to the larger supplier community. It is only through the continued innovations of technology, components and systems can manufacturing meet the challenges today and tomorrow." — Bob Vavra

DESIGN & OPERATIONS SOFTWARE

Winner

ECM PCB Stator Technology
PrintStator Motor CAD

Honorees:

Nexperia
Interactive Datasheets for MOSFETs

Nullspace Inc.
Nullspace EM

ELECTRIC DRIVES, MOTORS & COMPONENTS

Winner:

SiTime
SiT9396/7 Automotive Timing Family

Honorees:

ECM PCB Stator Technology
ECM Ultra-light, Premium Efficiency, Next Generation, 3hp Pump Motor

Danfoss Power Solutions
PC-GO propel solution

ELECTRONIC COMPONENTS

Winner:

SiTime
Elite RF SiT5376/SiT5377 Super-TCXOs

Honorees:

Point2 Technology
P1B120 Mixed-signal System-on-Chip (SoC)

Sun Hydraulics
ENERGEN

MACHINE VISION

Winner:

Tristar AI
Tristar AI

Honorees:

Net Results Group
MRO3i ver 4.0

Balluff
BVS IdentSensor

MOTION CONTROL

Winner:

Exair
1/2 NPT HollowStream Liquid Atomizing Nozzle

Honorees:

Bishop Wisecarver
DualVee RTU-H

Thompson Industries
Electrak XD

SENSORS & SOFTWARE

Winner:

Texas Instruments
ULC1001

Honorees:

Rockwell Automation
Allen-Bradley RightSight and VisiSight photoelectric sensors

Microchip Technology
LX34070 IC

OTTO Motors' OTTO 600. *Business Wire*

Rockwell Automation Acquires Clearpath Robotics: Accelerating AMR Deployments

AN ACQUISITION AGREEMENT signed between Rockwell Automation and Clearpath Robotics signals Rockwell's intention to supercharge its place as frontrunner in the "connected enterprise."

Rockwell is adding the Ontario-based company's AMR offerings and fleet management and navigation software to its portfolio.

Rockwell's press release noted that the addition of Clearpath's OTTO Motors' AMR capabilities, fleet management and navigation software will create a complete portfolio of advanced material handling solutions that will help customers increase throughput and reduce costs.

According to Interact Analysis, the market for AMRs in manufacturing is expected to grow about 30% per year over the next five years, with an estimated market size of $6.2 billion by 2027.

Rockwell noted that the acquisition is expected to contribute a percentage point to the company's fiscal 2024 revenue growth.

"Currently, AMRs have tended to hit the headlines in relation to their role in warehouses, including both e-commerce and distribution warehouses," said Ash Sharma, senior research director for robotics and warehouse automation at market intelligence firm Interact Analysis. "However, a huge opportunity exists in production lines which is where OTTO Motors has had success."

The analyst also said that Rockwell's aims for Clearpath—and particularly for OTTO Motors—are more wide-ranging than just warehouses, and they intend to expand deploying on factory floors. "If AMR deployment takes off on factory floors in a big way, as I believe it will, then we will see major growth for AMRs in this area," said Sharma.

Sharma likened the acquisition to ABB's acquisition of ASTI in 2021, and said there is more to come. "I fully expect to see most major industrial automation companies either acquire or organically develop mobile robot companies in the next few years," said Sharma.

Data from Rockwell's offerings and OTTO Motors' AMRs will be used to support artificial intelligence-powered Software as a Service information management applications, such as those by Rockwell's Plex and Fiix businesses.

Headquartered in Milwaukee, Rockwell said plans are to deliver "a unified solution for manufacturing, enabling autonomous execution and optimization to increase efficiency and allow for traceability and real-time adjustments." The combined technology will also complement the company's Kalypso production logistics consulting practice. Rockwell acquired Kalypso in 2020.

"Rockwell and Clearpath together will simplify the difficult and labor-intensive task of moving materials and product through an orchestrated and safe system to optimize operations throughout the entire manufacturing facility," said Blake Moret, chairman and CEO, Rockwell Automation.

BLDC Motors are Designed to Propel Medical Devices

The cost-effectiveness of brushless DC motors makes them favorable for the medical device sector.

AMONG THE MECHANICAL components that go into the design of the world's two million different kinds of medical devices, consider the motor to be an unsung hero.

Embedded inside a medical device, the motor's mechanical process is vital to the design and output specifications. It will need to undergo every bit of the same rigor and quality requirements as the device it powers.

Defining a medical device's unique application requirements—chief among which is placing the most important stakeholder (the patient) at the heart of the design—ensures the selection of the ideal motor for a given application.

Quality Dynamics and Specifications

Today, medical device motors are required to be small, lightweight, efficient, reliable and precise. They should also be arcless (no sparks in normal operation), offer high power density and high speed, and emit minimal noise. Applications may vary, from providing primary power in surgical tools to position control in robotic joints. A collaborative approach between the motion solution and design engineering teams from the outset is vital.

Torque, radial and axial load are three characteristics present in typical applications. A Portescap whitepaper, which describes the impact of these characteristics on motor selection in detail, frames the discussion around sterilizable brushless DC slotted motors and miniature motor applications.

- Torque load determines whether a motor can perform a task, while radial and axial load specifications determine how long the motor can perform the task. The characteristic torque and velocity in an application over the entire motion cycle must be known in order to achieve the necessary mechanical power without overheating.
- Radial load is the maximum force that can be applied to the shaft in a direction that is perpendicular to the motor shaft axis. Axial load, also known as the thrust load, is the maximum force that can be applied to the shaft in parallel to the motor shaft axis.
- Load conditions and misalignment have an impact on the strength—or mechanical rigidity—of the shaft, bearings and motor case assembly. Life expectancy of the motor is dependent on how much these specifications are exceeded over time. Mechanical and design engineers consider all variables during the initial design stages to ensure smooth operations down the line.

BLDC Motors Gain Traction

Brushless DC motors, or BLDC motors, are suitable in medical technology applications because they last longer than competing technologies, argues an article from *Machine Design's* archives (www.machinedesign.com/21829410), which also concisely explains their fundamentals.

A subset of commonly used DC motors, BLDC motors are synchronous (their rotor and stator magnetic fields rotate at the same frequency) and convert electricity to mechanical power. BLDC motors are equipped with a rotor that acts like a permanent magnet. They require no current, and rotation is achieved by changing the direction of the magnetic field produced by stationary coils. The control of BLDC motors can be done in sensor or sensorless mode, although sensorless control techniques are generally used when cost is a consideration.

BLDC motors are more reliable than brushed DC motors because they do not have any brushes to wear out and replace. Windings in BLDC motors are affixed to the housing, making it efficient at transferring heat away from the motor. BLDC motors tend to use less energy than other motor types and are widely used in applications due to their high efficiency and controllability.

Simple design, maintenance, minimal noise and clean operation are also cited as factors supporting the use of the BDLC motor in robotics, from steering systems in mobile robots to gripping arms and end-effectors.

There are downsides, too. According to Samuel Klein, an application engineer at Portescap, there's no such thing as a perfect motor. He noted that there are there are always losses in the transformation when electrical power is converted to mechanical power.

According to Samuel Klein, an application engineer at Portescap, there's no such thing as a perfect motor.

The three main types of losses created during the conversion are friction losses, copper losses and iron losses. The best motor designs are those that save energy, and can be achieved by optimizing the ratio between copper and iron losses, Klein said.

Designing Custom and Off-the-Shelf Motor Solutions

Motor and motion control systems need to be custom-engineered for each unique medical application. Understanding the speed and torque is merely a starting point for designing a custom motor or motion control solution. Other factors, such as the quality of motion, accuracy and repeatability, should also factor into the equation.

For some medical device manufacturers bringing new technology to market, the selection of the best motor for the application will depend on design engineers forging a harmonious relationship between the motion control technology and their own IP.

These applications may involve extensive mechanical assemblies. Where implementing a fully housed motor is not required, precision and motion control systems designers can provide standard BLDC frameless motors that are custom-configurable.

For example, Moog's Silencer series of inside rotor brushless DC motors were designed with MedTech in mind. The brushless design features bonded rare earth magnets and aluminum housings.

Silencer BN Series Brushless DC Motors from Moog Inc. are designed with options for electronic drives, encoders and gearheads, as well as Hall effect, resolver and sensorless feedback. *Moog*

German drive specialist Faulhaber extended its BXT flat motor series by adding matched gearheads as well as integrated encoders and speed controllers. *Faulhaber*

The motors range in diameters from 1.2 in. to 4.1 in. and lengths from 1.3 to 5.5 in. These motors offer continuous torque from 2.4 to 519 oz-in. and speeds up to 40,000 rpm. Options include electronic drives, encoders and gearheads, as well as Hall effect, resolver and sensorless feedback, noted Moog's online catalog.

Similarly, German drive specialist Faulhaber extended its BXT flat motor series by adding matched gearheads, integrated encoders and speed controllers that are exceptionally short in the axial direction.

The motors, touted for their innovative winding technology and optimized design, are just 14, 16 and 21 mm in length and can deliver torques up to 134 mNm, within a diameter of 22, 32 and 42 mm respectively, noted a press release.

For precise speed control or in the case of high requirements on positioning accuracy, diameter-compliant magnetic encoders or speed controllers were fully integrated into the housed motor variants, increasing the drive by just 6.2 mm.

These compact drive systems are suited for demanding applications and can be found in robotics, prosthetic joints, laboratory automation, pumps and medical technology, as well as aircraft cabin equipment.

Bringing Sustainability from the Boardroom to Ground Level

by Adithi Murthy, Product Line Director – Industrial Sensors & Switches, Sensata Technologies

Smarter use of sensing technologies can drive energy efficiency and enable electrification. Examples include heat pumps, battery chemistries and industrial sensing.

Sustainability is a paramount concern around the globe.

Numerous countries worldwide have established ambitious targets to curtail their greenhouse gas emissions, either through the Paris Agreement or other methods, complemented by goals driven by provinces, states or other local approaches.

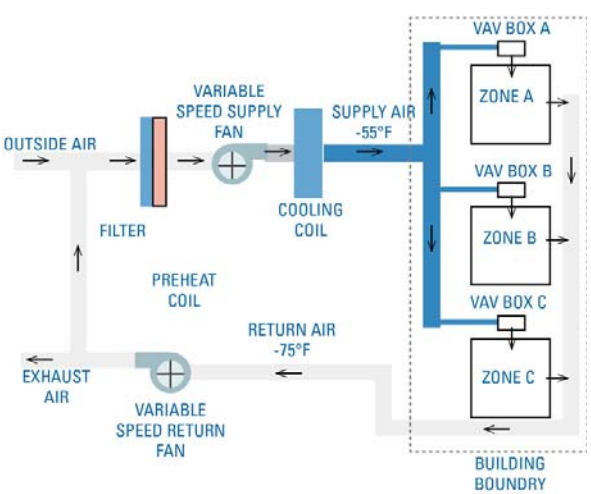
This emphasis on sustainability has also infiltrated the corporate sphere, with companies worldwide seeking to incorporate more eco-conscious decisions into their priorities. An impressive 81% of the world's leading companies consider sustainability as a crucial aspect of their corporate agenda, while in 2021, 90% of companies listed in the S&P 500 released a sustainability report.

In many ways, the push for sustainability is reaching a critical junction, where industrial sensing advances are pushing initiatives beyond the boardroom and onto facilities floors around the globe in a number of ways.

Focus on Facility Efficiency

Sustainability is one of the primary ways advances in sensing technology has been tied to efficient operations of individual facilities. Not only have more and more facilities added solar panels, electric charging stations and other features, but existing platforms have also undergone significant changes and improvements—starting with HVAC.

According to the United States Department of Energy, HVAC systems typically consume about 40 to 60% of a commercial building's total energy use, making these systems the best opportunities for achieving a reduction in energy costs and consumption.



The energy savings in this system design are driven by a reduction in fan usage, as they are often utilized at less than full capacity. It also results in reduced compressor wear and fan noise. *Images courtesy Sensata Technologies*

Updated system designs—such as variable air volume layouts—also allow for more efficient cooling compared to traditional systems. In a variable air volume design, the system maintains the air supply at a constant temperature while individual zone thermostats vary the flow of air to each space maintaining the desired zone temperature. This is unlike a constant volume system that maintains a constant volume of airflow to the space but changes the temperature of the air stream in response to space temperature changes.

The energy savings in this system design are driven by a reduction in fan usage, as they are often utilized at less than full capacity. It also results in reduced compressor wear and fan noise. While the specific energy savings of VAV systems vary based on a number of building and climate factors, some studies have found energy savings of 20-40% compared to constant volume systems.

Manufacturing facilities are also evaluating industrial heat pump designs, leveraging technology more commonly associated with residential applications.

Heat pumps work by extracting heat from the surrounding air, ground or water and transferring it to a refrigerant coolant. The coolant is then compressed—which significantly increases its temperature—and transferred to the location designated for heat. Heat is then extracted by either running air or water over the hot coolant.

Heat pumps are more efficient than traditional electric heaters because they use electricity to operate the compressor, pump and fans as opposed to a resistive heat source.

To operate properly, their program logic controller (PLC) needs temperature sensor inputs from multiple locations throughout the system. Depending on the purpose of the heat pump, these could include temperature readings of outdoor air, indoor air and refrigerant at multiple locations.

Electrification Impact Widening

The impacts of electrification have also expanded within the manufacturing and warehouse environment with electrified forklifts, scissor lifts and other pieces of industrial equipment.

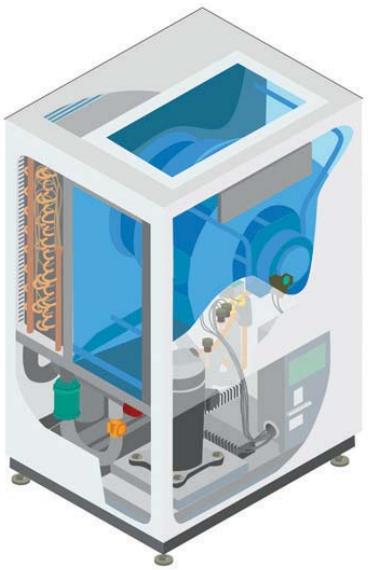
As has been seen with passenger vehicles, the advancement of lithium-ion and other battery technologies have dramatically shifted the balance between electric and gas/diesel models.

While equipment powered by lead acid batteries has been in the market for decades, those models carried a number of drawbacks. Batteries needed to be topped off with water, in addition to requiring extended charging cycles (with cool-down time), and performance degraded quickly during their working day.

New battery chemistries allow for on-demand charging without cool-down times or other drawbacks, allowing vehicles to charge in small stretches throughout the day and continue running through a 24-hr period with minimal downtime. The space previously reserved for battery storage and charging can also be repurposed for a more valuable use.

Global Sustainability Efforts Leverage Continued Technological Growth

The common thread in all these endeavors is a persistent drive towards intelligent and eco-friendly solutions, driven by a multitude of sensor applications.



For heat pumps to operate properly, their program logic controller (PLC) needs temperature sensor inputs from multiple locations throughout the system.

No single measure can accomplish the comprehensive sustainability enhancements necessary for the forthcoming decades. However, smarter sensing will play a pivotal role in creating a sustainable future by leveraging current technology to drive continual improvements while promoting new technologies that will continue to shape the future. ■

The impacts of electrification have also expanded within the manufacturing and warehouse environment with electrified forklifts, scissor lifts and other pieces of industrial equipment.

Making Production Sustainable with Digital Tools

A digital twin methodology that incorporates sustainability along with other operational parameters can bring manufacturers closer to their resource and energy consumption goals.

by Eryn Devola, Vice President of Sustainability, Siemens Digital Industries

For decades, commodification and globalization have driven manufacturing businesses toward greater efficiency and cost savings. But the environmental impact of these process decisions is growing in importance. In the pursuit of reduced carbon emissions worldwide, companies are seeking advancements to address the requirement of sustainability.

Even with decades of investment into lean and efficient manufacturing processes, global production still consumes vast energy resources (54% globally) while producing a fifth of global carbon emissions. Getting to net zero by 2050 will be a challenge, and that is only one facet of sustainability. Companies are also looking at improved resource efficiency, energy consumption and circularity. And businesses need to be making these changes while meeting the traditional drivers of time, quality and cost for their products.

The traditional manufacturing approach is not well-equipped to address the number of variables on the path to sustainable production. Instead, a digital twin methodology that includes sustainability along with other operational parameters provides the detailed insights into the production process needed.

Hanson Cement digitalized their production processes to make easier optimizations and upgrades for sustainability. *Hanson Cement*

To be successful, this approach should incorporate the collective intelligence across the entire value chain of a product and its lifecycle. Solutions must grow beyond plant-level optimizations, linking and analyzing data across the entire industrial operations—including supplier and partner ecosystems.

Tackling all of that at once is not feasible for every manufacturer, let alone entire industries, so it is important to understand some of the general concepts to implement in stages along the journey to sustainable production processes.

From firsthand experience as a manufacturer and as a trusted partner to customers around the world in nearly every industry, there are four key areas where industries need to focus while shifting to sustainable manufacturing:

- Energy use
- Flexible production and innovation
- Service engineering
- Production line planning and optimization

Each provides benefits to creating a profitable and sustainable manufacturing business, but with collective intelligence they can enable your business to become an industry leader.

Planning and Optimizing Production Systems

Making changes to an operational manufacturing line is a costly endeavor when every second spent idle has an associated opportunity cost. That is why the digital twin of the manufacturing environment is such a valuable tool. Using this virtual representation of the factory or line, engineers can explore a wide variety of optimization operations without interfering with production until the optimal solution is determined.

Moreover, a digital twin can also help to continuously improve existing systems by incorporating real data collected through Industrial Internet of Things (IIoT) sensors, and using that to predict the physical system's performance in the digital world and determine ongoing improvements. Analysis of this data provides a virtual representation of the processes and machines to better characterize and contextualize energy and production data.

This type of information constitutes the collective intelligence of lines, factories and enterprises; supplying your digital twin with this intelligence enables continuous optimization. The power is in its flexibility to be applied to nearly any sustainability goal within a manufacturing environment—energy efficiency, resource efficiency, machine longevity, repair scheduling, commissioning new equipment, etc.—for better sustainability outcomes.

Our customer, Hanson Cement, was able to digitally optimize and upgrade their low voltage cooling systems as it approached end-of-life with far more energy efficient motors. In addition to the inherent efficiency gains of the newer motors in the cooling system, they

deployed variable speed control to match the cooling needs and minimize the input power of the system more precisely. The change worked so well that it paid for itself after just a few months due to the energy savings—roughly £86,000 ($110,554) in annual savings on electricity.

Improving Energy Efficiency

Energy consumption is already an important metric for most manufacturing businesses as a major operational cost. Reducing consumption per manufactured product also has an obvious sustainability benefit. Whether a factory is using electricity from the grid or on-site fuel to power their processes, there is an associated carbon footprint. They may also be under pressure to track, optimize and report energy consumption to follow the ISO 50001 standards.

Improving energy efficiency can have almost instantaneous benefits by reducing the total cost and carbon output. Since many businesses are already familiar with managing engineering requirements, it is the "low-hanging fruit" to implement these processes for sustainability changes.

The rush for energy efficiency has been most notable in Europe with the spike in energy costs. In response, some are deploying intelligent drive systems as part of a digital systems approach to cut energy requirements by up to 60%. Others are investing further with enterprise-wide energy management solutions to pinpoint the sources of greatest consumption and address them in descending order. Even more are deploying production monitors to help automate load management by switching off or idling equipment while not in use.

For example, one of our major customers in the food and beverage industry has cut energy use in a single facility by 13% and saved €110,000 ($122,482) in the first year through plant efficiency improvements. We helped them implement an end-to-end digital solution that connects their machines and factory sensors to the edge and cloud systems for operation. In addition to the energy savings, they can also better perform predictive maintenance to nearly eliminate emergency downtime.

Having easy access to digital performance data will be key in optimizing machines, lines, factories and enterprises for sustainability. *Siemens*

Establishing Flexible Production

Flexibility and efficiency go hand in hand. Being able to quickly pivot and adapt to new market conditions with existing manufacturing assets can greatly reduce waste. Reusing existing machines and equipment is greatly beneficial in reaching sustainability goals. That flexibility might come from innovative manufacturing processes such as additive manufacturing, but it may also have a macro solution as is seen with modular production. Both of these solutions for flexible production allow facilities to be more easily retooled or reconfigured to manufacture any product on any manufacturing floor around the world.

YOU MAWO are a great example in deploying the flexibility of additive manufacturing and gaining sustainability benefits. Using a complete digital twin methodology of manufacturing, postprocessing, material handling and logistics, they are able to deliver custom eyeglasses to their customers. They 3D print frames to best fit the faces of customers as well as minimize material needed for structural rigidity. These choices created a 58% lower carbon footprint compared to conventional eyewear frames because of the material savings, as well as an improved time-to-market and future production scalability.

3D printed glasses frames from YOU MAWO. *YOU MAWO*

Promoting Service Engineering

Improving the longevity of equipment is yet another important focus area for creating sustainable production environments. Here again, this is not a new concept to manufacturers. Replacing machines is an expensive proposition, but so is conducting repairs at the last minute. By digitalizing these systems, maintenance cycles can be made more efficient in terms of time and resources. An Industrial IoT system connected to

the digital twin of the manufacturing line can let operators know when a machine has dropped below a certain efficiency threshold and is impacting energy use, production capacity, worker safety or any number of important metrics to operation.

The connection to the digital twin enables prediction on the impact of these changes and maintenance can become a deliberate process rather than a reactive operation. A business might repair or replace a fault-prone component during expected downtime events or adjust processes to minimize the component's chance of failure. Seeing these machines as long-term platforms provides businesses with another path to sustainable manufacturing. Instead of viewing these machines as disposable assets, keeping them operational provides more investment opportunities in the other concepts of sustainable manufacturing.

Real-World Example: Deployable Sustainable Production Solutions

While many digital tools available for improving manufacturing sustainability are still in the early stages of adoption, Siemens has brought them all together in a single digital-native factory in Nanjing, China. The Siemens Numerical Control (SNC) facility produces high-quality computer numerical control systems, drives and motors, and became a digital enterprise when it consolidated three production sites into one sustainable factory.

Using the approaches outlined above, they achieved some remarkable results:

- Doubled production capacity
- Increased efficiency by 20%
- Enhanced flexibility by 30%
- Reduced time-to-market by 20%
- Boosted space utilization by 40%
- Enhanced material flow efficiency by 50%

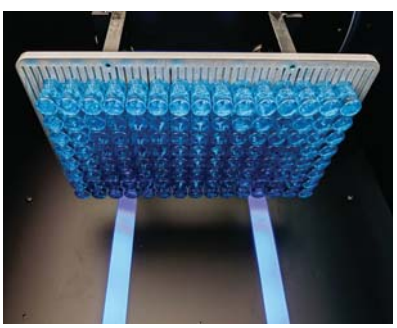
Equally important, the SNC facility further reduced plant-wide emissions with ground-source heat pump systems and photovoltaic arrays while decommissioning the most energy intensive machines on the floor in favor of newer models.

Making a manufacturing business sustainable is becoming a license to operate. The follow-through is the next important step to realizing the potential. It is important to understand that sustainability is not a bolt-on solution to existing processes. It needs to be present in every decision made throughout the product lifecycle and ecosystem. Fortunately, many of the best paths to sustainability already exist as profit incentives in today's manufacturing businesses ,and we will continue to help develop the digital tools to make it happen. ■

Advancing Sustainability in 3D Printing

Is 3D printing the path to greener manufacturing?

by Sharon Spielman,
Technical Editor, *Machine Design*



The digital workflow of 3D printing allows for easy exploration of alternative materials, which promotes lower carbon footprints and better circularity. *Images courtesy Nexa3D*

With 3D printing, designs can be created and tested with minimal material consumption, avoiding the need for expensive traditional tooling workflows.

Sustainability is a crucial consideration in today's design and manufacturing spaces, and there is potential for 3D printing technology to contribute to a greener future.

Glen Mason, manager of advanced innovation and industrialization at DeMarini, a division of Wilson Sporting Goods, and Lasse Staal, business development director of Nexa3D, spoke with *Machine Design* about additive manufacturing for the sporting goods space, and the discussion moved to sustainability.

Reducing Waste and Material Consumption

One of the significant advantages of 3D printing lies in its ability to minimize waste and reduce material consumption. Traditional manufacturing processes often entail building multiple tools, which results in significant material and cost investments. Mason says that 3D printing allows for iterative testing and design modifications without the need for extensive tooling.

He notes that by using a digital workflow and 3D printing, designs can be created and tested with minimal material consumption, avoiding the need for expensive traditional tooling workflows. The digital workflow also allows for easy exploration of alternative materials, which promotes lower carbon footprints and better circularity.

Reduce Carbon Footprint, Move Toward Circular Economy

3D printing enables manufacturers to work with a range of materials, including bio-based or those with circular potential, Mason says. In traditional manufacturing, changing the mold or tooling for different materials would be required, but with 3D printing they can test and compare multiple materials by adjusting the digital model. This flexibility promotes sustainability by reducing waste and empowering companies to make informed choices regarding material selection, Mason notes.

By replacing conventional pilot tooling with free-form injection molding, Staal says they can reduce emissions by as much as 75%, noting a third-party study by Deloitte. More efficient iterations avoid the need for wasteful practices, leading to energy, materials and cost savings.

This technology also impacts spare parts manufacturing. In industries where on-demand batches of one are required for spare parts, it is important to have a manufacturing system that allows for consistent production in the same material and process as the original part. With free-from injection molding, spare parts can be made using the same material and process, extending the lifetime of products while reducing costs and risks.

Shift Mindsets, Maximize Sustainability

There is a need to shift our mindsets and the industry needs to adopt greener practices. By moving away from preconceived notions tied to traditional manufacturing processes, companies can fully leverage the advantages of 3D printing, contributing to a sustainable and more environmentally conscious future. "The obstacle is the mindset, really, of the people involved. So, I think that's where I would like to see the most effort going into greening up our workflow here," Mason says. ■

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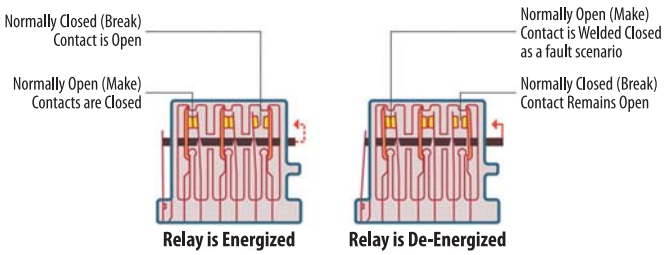
1 inch

1 inch

.4 inch

Altech Safety Relays use Forced-Guided Relay Contacts



Safety relays with forced-guided contacts are the core components for safety devices and are indispensable when designing safety circuits. Safety devices are designed to protect man and machine as demanded in OSHA CFR 1910 Regulations "General Requirements for All Machinery", and which is a mandatory requirement of the European Machinery Directive EMD 2006/42/EC.

Force guidance in a relay means that the contacts in a contact set must be mechanically linked together so that it is impossible for the NO (normally open) and NC (normally closed) contacts to be closed at the same time. The contacts are linked so that no one contact in a relay can change state without changing all the contacts in that relay. There must be a 0.5 mm minimum air gap between the open contacts for the entire service life of the relay, even when a relay part fails to function correctly.

APPLICATION EXAMPLES

- Two Hand Safety Devices
- Press systems
- Elevators and escalators
- Cranes
- Door and gate drive systems
- Printing and textile machinery
- Robots
- Stamping machines
- Medical equipment
- Signaling systems
- Emergency Stop Modules
- Safety door controls
- Pressure mat controls
- Light barriers and curtains
- Speed controls
- Monitoring devices
- Safety Gate
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DOLD

Shaping Sustainability in 3D Printing

A recent $1.8 million in seed funding is helping Metafold drive the mass adoption of a sustainable industrial 3D printing platform with its cloud- and API-based 3D engineering platform.

by Sharon Spielman, Technical Editor

In a conversation with Dr. Elissa Ross, co-founder and CEO of Metafold, the developer of a Design for Additive Manufacturing (DfAM) cloud-based software, *Machine Design* learns about the company's beginnings, the technology behind its computation engine, its impact on key markets and its commitment to sustainability.

Metafold originated two-and-a-half years ago as a spinoff from a consulting business called MESH Consultants Inc., which was launched by one of the co-founders, Daniel Hambleton, a mathematician who is the company's CTO. The third co-founder, Tom Reslinski, is an architect and Metafold's COO. Together, they leveraged the expertise of mathematicians and professionals in architecture, engineering and construction, and launched Metafold with a mission to provide digital infrastructure for 3D printing.

A mathematician by training, Ross says they recognized the need for new digital tools to support 3D printing manufacturing technology and address the limitations of traditional CAD systems.

"[CAD systems] were developed for conventional manufacturing, and they are excellent in those capacities," she says. "But when it comes to supporting high complexity, geometry—that is…what 3D printing is really great at—those same digital tools are traditional CAD tools. They don't offer what we need." This new technology addresses that, she says.

> *"[CAD systems] were developed for conventional manufacturing, and they are excellent in those capacities. But when it comes to supporting high complexity, geometry—that is...what 3D printing is really great at—those same digital tools are traditional CAD tools. They don't offer what we need."*

Dr. Elissa Ross is co-founder and CEO of Metafold, a developer of Design for Additive Manufacturing (DfAM) cloud-based software. *Images courtesy Metafold*

Platform's Core is its Geometry Computation Engine

At the center of Metafold's platform is its geometry computation engine, which Ross says enables the design and optimization of complex geometries for 3D printing. The web application offers capabilities for creating lattice

geometries, lightweight parts and high-surface area structures, she explains, and this opens possibilities for a range of industries where optimized structures are highly valuable.

One of the key strengths, she notes, is the material and process agnosticism. Users can access the software via the cloud and API, regardless of the hardware used for 3D printing. This flexibility allows manufacturers to optimize their additive manufacturing processes, whether designing lightweight aerospace parts or creating efficient heat exchangers.

"What we have come to learn and recognize is that in 3D printing, it's not enough to be…in a very small box," Ross says. "Customers are at a variety of different places in their additive manufacturing adoption journey. We need to meet them where they are at. So sometimes that involves just kind of helicoptering in and providing that design and geometry support, and other times that means really working out that combination of design for additive, the material, the process, even the post-process. How is it all going to fit together to provide the solution they're looking for?"

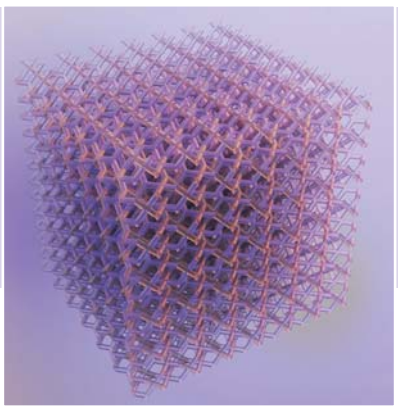
Commitment to Sustainability

At the forefront of Metafold's mission is its commitment to sustainability. By providing advanced geometry support, the company enables manufacturers to reduce raw material usage and produce lightweight and energy-efficient parts. With 3D printing's ability to optimize structures and increase surface area, industries such as biopharmaceuticals, process heating and carbon capture devices can benefit.

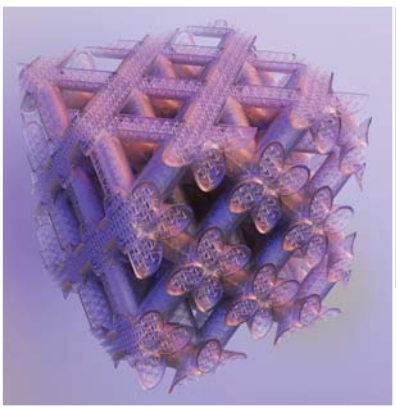
"Where I think additive manufacturing has so much potential in the sustainability space is in these process improvements," Ross says. "It's in creating those better heat exchangers. Another amazing example is in carbon capture devices… the more surface you put in contact with air, the more carbon you can pull from the air. So, 3D printing and its ability to produce these high-surface area highly optimized structures…[is] where the key potential for highly sustainable impacts [is] for 3D printing."

To help manufacturers realize these sustainable impacts, Ross says, "We absolutely need better digital tools so that we can plan them and design them and then finally execute them…We like to say that we help our customers become more competitive and more sustainable, because at the end of the day these things go hand in hand."

Metafold also recognizes the interplay between sustainability and competitiveness, helping customers to achieve both by choosing the additive manufacturing use cases that make sense economically and environmentally.



By providing advanced geometry support, Metafold enables manufacturers to reduce raw material usage and produce lightweight and energy-efficient parts.



Metafold's web application offers capabilities for creating lattice geometries, lightweight parts and high-surface area structures.

Flexibility allows manufacturers to optimize their additive manufacturing processes, whether designing lightweight aerospace parts or creating efficient heat exchangers like this one.

Large organizations are under a lot of pressure to improve their sustainability, especially in the manufacturing department, Ross notes. "But this needs to come with…a competition argument, a financial kind of bottom line, and we're here to support that…In other words, we choose the use cases of additive that really make sense," she says.

Software Integration, Looking Ahead

Metafold's subscription-based web application receives continual updates due to its cloud-based nature. The company offers free access for non-commercial use in education and supports startups working on clean tech problems.

When asked where she sees the 3D printing space in five years, Ross looks forward by first taking a look back.

"So, I think in five years' time, we will see even more of those applications come to life... The hardware and materials are coming along [at] an incredible pace...We're going to start to see...lots of things in our built environment being reconsidered and optimized, improved toward more sustainable and...just more efficiency over the long run. So, I'm super excited to just to check back in in five years and see where we're at."

"When I look back at the earlier days of 3D printing, I think we kind of got off to a bit of a false start with it in the sense that…there was this idea that 3D printing would replace conventional manufacturing, and every home would have a 3D printer. It was like the Star Trek replicator," she says. The ability to print whatever we needed on demand has not come to pass—and it's not going to, she says.

"This is not actually the end goal of 3D printing…Where I think we are going is greater clarity about those incredible applications of 3D printing, and the biopharmaceutical examples are really exciting to me because I think they have the potential to reshape a regenerative medicine," Ross says. She also notes the ability to optimize parts in industrial applications.

"So, I think in five years' time, we will see even more of those applications come to life…The hardware and materials are coming along [at] an incredible pace…We're going to start to see…lots of things in our built environment being reconsidered and optimized, improved toward more sustainable and…just more efficiency over the long run. So, I'm super excited to just to check back in in five years and see where we're at."

According to Ross, Metafold is focused on being the best digital tooling for additive manufacturing. "Our vision is to unblock ambitious engineers who want to make use of the full capabilities of 3D printing to realize innovative and transformative technologies. We are working at the 'interface of bits and atoms'—this is Neil Gershenfeld's phrase, and I think it is highly appropriate," she says. ■

Old-Fashioned Cooling Methods Inspire Modern Passive Cooling System

by **Rehana Begg**, Editor-in-Chief

Researchers revisit historical cooling mechanisms to inspire and investigate fresh ways to keep facilities and living spaces cool.

Passive cooling refers to technologies or design features that lower the temperature in spaces without the need for power consumption.

The strategy uses free, renewable sources of energy (wind and sun) to feed cooling and ventilation, so that the need to use a mechanical cooling system can be reduced or even eliminated.

With energy demand for active mechanical space cooling projected to double by 2050, researchers are investigating alternative means, such as passive cooling systems, to help reduce demand.

At Washington State University, for example, researchers have designed a 60-sq.-ft. chamber to test passive systems. Their prototype uses the combined effects of wind towers and water evaporation instead of electricity to cool spaces.

"Cooling is increasingly in demand in buildings, especially as the climate gets hotter," said Al-Hassawi, assistant professor in WSU's School of Design and Construction. "There might be inclusion of mechanical systems, but how can we cool buildings to begin with—before relying on the mechanical systems?"

Al-Hassawi, the lead author of the study published in the journal *Energies*, described how his team repurposed a shipping container into a solar-powered chamber. Electrical needs were supplied by photovoltaic panels and a battery bank; a mini-split heat pump provided primary heating, cooling and dehumidification control; and geofoam panels were used as interior insulation to moderate heat exchange with the outer environment and boost the efficiency of chamber environmental controls.

A 60-sq.-ft. chamber inside a shipping container can test passive systems that use wind towers along with water evaporation instead of electricity to cool spaces. *Washington State University*

> *"Cooling is increasingly in demand in buildings, especially as the climate gets hotter. There might be inclusion of mechanical systems, but how can we cool buildings to begin with—before relying on the mechanical systems?"*

In addition, the geofoam panels were clad with 22-gauge galvanized sheet metal, which minimized friction and turbulence, the researchers noted.

Completely independent of grid power, the chamber can be heated to a temperature range between 125 and 130°F year-round to test cooling innovations, measuring the

temperature, humidity and air velocity within and around a cooling system.

The researchers calibrated the chamber using the results of a full-scale experiment conducted on a passive, downdraft cooling system tested under the hot dry conditions of Phoenix, Ariz.

Heat transfer through direct evaporation of water dates back to ancient Egypt as one of the oldest means of passive cooling, pointed out the authors. More recently, innovations in wind tower design highlighted how a rigid media direct evaporative cooling system could be placed at the top of the tower, causing heavier, cooler air to drop downwards by gravity. This design, developed in the 1980s, was named the passive downdraft evaporative cooling tower (PDECT).

Passive Cooling System Simulator

Al-Hassawi's passive cooling system experiment creates a unique setting for simulating extreme conditions. "With smaller scale models, we can also do much quicker tests and get results sooner than having to wait on large-scale prototype construction," he said.

The paper noted that buildings consume about 60% of the world's electricity, with nearly 20% of that going to keep them cool. In the U.S., nearly 90% of residential homes and apartments use mechanical air conditioners. The concern with powering air conditioning units, said the authors, is that they rely on electricity that's often generated by fossil fuels, increasing carbon emissions.

Passive cooling systems are occasionally used in hot places like Phoenix, but Al-Hassawi argued that familiarity with passive cooling techniques is for the most part misunderstand.

A passive cooling strategy could be applicable both for existing or new construction, he said: "It's an older technology, but there's been an attempt to innovate and use a mix of new and existing technologies to improve performance and the cooling capacity of these systems."

The authors noted that research for testing passive cooling systems takes considerable investment and training. The test chamber offers a platform for experimentation and innovation, and Al-Hassawi is hopeful industry partners will take note of the design and its potential.

Students have already built prototypes of cooling systems using the passive downdraft cooling system, he noted. These will be tested in the coming semester. ■

CITATION

Al-Hassawi, O.D.; Drake, D. Innovations in Passive Downdraft Cooling Performance Evaluation Methods: Design and Construction of a Novel Environmental Test Chamber. *Energies* 2023, 16, 4371. https://doi.org/10.3390/en16114371

Hyster 4 wheel sit-down Class 1 Forklift. *Photos courtesy OneCharge Lithium Batteries*

Lithium Forklift Batteries Find Second Life in Solar Energy Storage

How end-of-life lithium cells used in forklifts were reincarnated for a solar array—buying an extra 10 years of expected use in the process.

by Maxim Khabur, Marketing Director, OneCharge Lithium Batteries

Lithium batteries are enabling the energy transition in many industries and are experiencing explosive growth in demand across many applications and geographic locations. At the end of their expected useful life of five to 10 years, lithium batteries are thoroughly tested and repurposed for less power-intensive applications, such as energy storage, and continue to work for another five to 10 years.

The low cost of the used lithium cells used in solar energy generation systems drives down the price of renewable energy for end-users. The repurposing of lithium batteries reduces waste and the energy required for recycling. These benefits make lithium battery technology the most sustainable power source on the market.

Cost and Waste Challenges

There has been a significant rise in the production of lithium-ion batteries, primarily due to their fast-growing use in electric vehicles, electric industrial equipment such as forklifts, power storage for renewable energy generation, emergency power storage for IT and telecommunications, medical equipment, home appliances and electronics.

As a result of a skyrocketing increase in demand, the cost per kWh for lithium batteries increased for the first time in 2022, leading to higher costs for the buyers of energy storage batteries in renewable power generating systems.

Even with the increasing rate of lithium battery recycling, there is a need to dramatically reduce the amount of waste from the anticipated influx of batteries reaching their end of useful life.

The Solution? Give Lithium-ion Batteries a Second Life

OneCharge started lithium forklift battery manufacturing in 2014 and most of its battery packs are still in the field, well beyond their five-year warranty term. But some batteries are shipped back to the company before the end of their useful life for various reasons, such as the end of a trial period or physical damage.

The story of one particular OneCharge 80V 360Ah LFP forklift battery began in a Hyster E55XN Class I sit-down lift truck, operating in a packaging facility of a fruit-producing company in the state of Washington. This was a demo project intended to evaluate the benefits of lithium batteries compared to the lead-acid variety. After the trial period, the facility ordered bigger-capacity 630Ah 80V lithium batteries and switched its fleet to single-battery multi-shift operations.

The demo battery came back to OneCharge, with many years of life left in each cell, but with no chance to be used in a new forklift battery again.

(Continued on page 38)

Smartville repurposes used lithium batteries to support domestic supply chain and manufacturing.

Solar energy storage installation site at South Mountain Park, City of Phoenix.

Moving a New Machine to Electric Drive

Frequently asked questions about battery options in electrification projects.

by Mirko Baggio, Director of Business Development, ZAPI GROUP

Electric battery car vehicle auto EV. *Cammeraydave | Dreamstime*

OEMs in the electric drive industry must consider what battery size is needed as early as possible in the design process to avoid costly customizations or alterations.

This compilation of frequently asked questions (FAQs) presents a brief overview of the considerations necessary to design an electric machine, focusing on battery selection, duty cycle determination and voltage requirements.

What is the first step in an electrification project for new machines?

A review of the entire vehicle architecture is a necessary first step in many electrification projects. This is true of hydraulic function conversions in mechanical projects or redistributing component locations. Another critical consideration is component sizing— the battery, electric motor, power and charging system should be top-of-mind in an electrification project.

What should an original equipment manufacturer (OEM) consider when selecting a battery?

Determining the acceptable duty cycle for the new machine is key to battery selection. Understanding the energy required will lead to the most appropriate battery selection. OEMs must also calculate battery sizing. The battery comprises up to 50% of the total machine cost, so proper selection is crucial to keeping a project within budget.

How is an acceptable duty cycle determined?

Typically, designers will begin planning the worst-case scenario duty cycle and then will work backward to determine the best choice. If available, telematics data from traditional machines (engine and hydraulics) can be useful as it gives designers concrete figures to help calculate the duty cycle required.

What if telematics data is not available?

This is often the case for machines that previously ran on internal combustion engines, as detailed energy consumption is not typically a consideration. In the absence of telematics data, calculations should be done using the vehicle and application specifications.

What data should OEMs collect to determine duty cycle?

Data points such as weight, speed, max grade, auxiliaries and field functions should be collected to create a working point matrix. This matrix can then be used to augment the worst-case duty cycle scenario and ensure that the OEM is not stuck with components that are too large or expensive for the machine, application or end-user.

Are there real-time testing options available once a duty cycle is determined?

Concept machines are an excellent option for testing an estimation matrix against real-time scenarios. These machines often have built-in logging frameworks, providing real-time data to the designers as the machine runs through different duty cycle scenarios. Experienced OEMs should have the capability to provide this type of testing.

What other considerations should OEMs focus on during this process?

There is often a tradeoff between performance expectations and the packaging constraint of the new machine. For instance, an OEM may start a project with performance expectations that end up not fitting with the battery type that best suits the machine, application or cost. OEMs should be prepared to adjust performance expectations based on real-time test data.

How does battery size affect an electrification project?

In the early days of vehicle electrification, batteries were much more cumbersome than they are today, which resulted in vehicles having to be designed around the battery size. Now, with more sizes available, the design and application usually take precedence. While many companies specialize in designing batteries, there are costs associated with customizing a battery for a particular application. Even with more sizing options, OEMs must consider what battery size is needed as early as possible in the design process to avoid costly customizations or alterations.

What role does voltage play in electrification?

From a consumer perspective, we have been "trained" to think that a higher voltage is better. However, this is not an ideal mindset for electrification projects, as it can lead an OEM to make inappropriate battery selections for their machine. Some applications may require a higher voltage, while others may benefit from a reduction in voltage size that is appropriate for its specific usage.

What is the voltage range seen across industries?

OEMs often aim for a voltage range below 60 volts. This range is considered safe by international standards, which aims to avoid system complications present in higher ranges. However, this range presents limitations from a power perspective, so it may not be suitable for all machines and applications. Another standard voltage threshold is 150 volts. OEMs that can stay below the 150-voltage range have a wider range of vehicle components at their disposal.

What can OEMs expect in terms of project length/timing?

Unfortunately, there is no one-size-fits-all answer for electrification projects, as timing varies from one OEM to the next. However, a good barometer for judging timing is to look at the amount of information available. If you have telematics data, your designers already have a head start. Without this data, you will need to budget more time at the beginning of the project before arriving at real-time testing. Investments such as the usage of third-party companies for system integrations can help to speed up the prototype and testing phases.

What is one piece of advice for OEMs embarking on their electrification journey?

It all comes down to torque and speed requirements. These requirements should drive component decisions in order to determine what levels of both are required for the specific machine, function and application. Focusing on the torque and speed requirements from the outset will set projects up for success and allow OEMs to arrive at optimal electric designs. A robust requirement planning phase, combined with in-depth knowledge of the application, will set an electrification project on a successful path. ■

Upgrading the Controls for a **Machine Builder's Cotton Press**

When a systems integrator received a request to modernize a cotton press, he discovered a new set of tools for dealing with an enduring machine.

by David Adams, Owner, Design Automated Controls

1. A cotton press with bale nearly bundled. Compressing the 480-lb bales requires significant tonnage and complex controls to ensure the machine output is consistent. *Images courtesy Design Automated Controls*

It is believed that cotton production originated more than 7,000 years ago. As a key component in global textiles for millennia, the various growing, harvesting and processing techniques have varied greatly. In contrast, the cotton gin and cotton baler (or baling press) machines have merely existed for about 200 years. A cotton gin separates out cotton fibers from seeds, while the press condenses and bales cotton lint and fibers for shipment *(Fig. 1)*.

Equipment like a cotton press is built to be mechanically serviceable for decades. But with global cotton production expected to be around 116 million bales in 2023, it is more important than ever for even legacy machines to be retrofitted to modern automation standards, ensuring reliable operation to meet the world's textile demand. Recently, Design Automated Controls, a systems integrator (SI) that works with clients of all sizes from multiple industries, was tasked with upgrading the controls for a machine builder's cotton press.

A Specification for Productivity

While the mechanics of the cotton press have been well-tested and refined over the years, a digital control platform with modern capabilities is a new consideration. With ever-increasing functionality available, this particular machine builder desired to swap out another manufacturer's legacy controller in favor of the Productivity2000 micro-modular programmable logic controller (PLC) family from AutomationDirect.

This PLC platform consists of controllers that are modular, rack-based and offer a plethora of input/output (I/O) options with substantial processing power suitable for complex operations *(Fig. 2)*. The hardware is complemented by a full suite of free programming software.

The request for the specific controller was driven primarily by the end-user, as the cotton press owner/operator had experience with the platform performing well in another machine at their facility.

Initially, the SI questioned the machine builder's request as the SI had no prior experience working with this machine control system and was not familiar with the Productivity platform. However, the desire to satisfy the customer prevailed and the SI began the process of converting the program from the legacy controller to the Productivity platform.

Try and Try Again

As is often the case when things are trialed for the first time, some unforeseen circumstances arose. The legacy program

2. The cotton press control console contains a Productivity Programmable Logic Controller from AutomationDirect. The rack-mounted chassis is expandable and compatible with discrete, analog and high-speed input/output modules.

obtained from the cotton press had been in service for many years and undergone a multitude of design changes. In fact, the version supplied to the SI turned out to be outdated and not fully compatible with the machine and some modifications it had undergone. Unfortunately, this was discovered only when it was time to commission the new machine, so a fix was needed fast.

The SI took this in stride and began evaluating options. After consulting with an experienced mechanic who was extremely familiar with the particular characteristics of the cotton press, it was decided to discard the original program and start from scratch. This turned out to be a good thing, for several reasons.

Aside from not being compatible with the latest machine functionality, the customer had worked with multiple programmers on a contract basis over the years to develop the original program. The program contained many idiosyncrasies and styles, was difficult to follow and was not optimized for performance. Fortunately, the new software platform proved to be easy to master. Within a few days, the new code was written and the machine was commissioned.

In addition to having an intuitive interface, the PLC platform proved to be powerful. So much so that when the machine was up and running the customer remarked that it was, "the best and smoothest running version to date."

Visualizing the Process

The primary operator touchpoint for any modern digitally controlled machine is the visualization interface on the control

console, sometimes in conjunction with traditional devices like pushbuttons. Customer specifications may dictate that specific products be used, such as human machine interfaces (HMIs).

While this may limit the choices available to systems integrators when they are developing the system architecture for the control system, they need to be prepared to select products from the allowable list that will perform and interconnect well *(Fig. 3)*.

Although there are several advantages—and often streamlined communications and configuration—to using intelligent components from one supplier, sometimes incorporating other brands is necessary. For this particular cotton press, the Productivity platform has proven rather flexible. Integrating components from other manufacturers may require an extra step or two, but it is certainly not difficult and is frequently accomplished with great success.

Rinse and Repeat

With the updated cotton press machine successfully up and running smoothly, along with positive feedback from both the customer and SI, the machine builder decided to standardize their cotton press control platform on the Productivity controller for future investments. They immediately commissioned the SI to repeat the process and develop a similar control scheme for similar models of cotton press that will be supplied for two additional customers. ■

3. The cotton press, with the touchscreen human machine interface (HMI) shown at left. The Productivity PLC from AutomationDirect integrates well with AutomationDirect C-More HMIs, as well as similar products from other manufacturers (shown).

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Schurter's Touchless Hidden Switch Offers Seamless Integration

The HS Series is designed for seamless integration. By incorporating a small opening in the user interface, the Time-of-Flight (ToF) sensor can be activated immediately. Key features of the THS switch series include a hygienic solution that can help prevent the spread of pathogens; water and daylight resistance, making it suitable for a range of environments; and the ability to calculate distances by emitting light beams and detecting their reflections. The switch is designed for easy installation. Because it can be concealed behind any material, design engineers have freedom in panel design. The switch has RGB multicolor surface illumination, which provides feedback to users. The illumination supply voltage ranges from 5 to 28 VDC. Schurter offers a Design-In Kit that allows users to test and adapt the THS switch with different materials and surface thicknesses. The kit offers customizable settings such as distance, time and illumination to meet specific requirements. The switch's versatile design and reliable performance is designed to help ensure functionality and aesthetic appeal.

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IDEC Corp. Offers Compact RC Series Industrial-Grade PCB Relays

The RC Series relays are designed to be mounted directly onto a PCB using through-holes and can be soldered using different methods, including wave, dip, robotic or hand-soldering. With a height of 16.5 mm or less, the relays have high voltage and current ratings relative to their size and weight. The RC Series replaces and upgrades the company's RJxV Series PCB mount relays. Key features of the RC Series PCB relays include coil voltage ratings from 5/12/24/48/110 VDC, equipped with contacts rated at 24 VDC and 250 VAC; a DPDT version featuring 8A contact ratings; a SPDT version that comes in 12A (standard) or 16A (high capacity) options; operability in temperatures from –40 to 85 C; and certifications from cUL, VDE, CQC and CE. They are available in a range of low-profile configurations and provide high-capacity power switching, performing reliably in challenging environments. Applications include appliance electronics, audio-visual components and OEM machine automation.

IDEC CORP.

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Beckhoff Integrates Ethernet-APL Technology with its ELX6233 EtherCAT Terminal

The concept of Ethernet-APL (short for advanced physical layer) aims to revolutionize communication within process technology plants by implementing an Ethernet-based system for the entire communication framework—from the field to higher-level control systems. Recognizing challenges such as massive plant footprints and specialized requirements in hazardous environments as well as limited network sizes and slow data transmission rates, the company has integrated Ethernet-APL technology into its modular terminal block portfolio. Key features of the ELX6233 terminal block include a compact device footprint; seamless mount in control cabinets; flexible and easy interconnection; improved cycle times in comparison to field switch solutions; and compatiblity with EtherCAT terminals, couplers and other devices.

BECKHOFF AUTOMATION

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AutomationDirect Offers LS Electric's XGB Programmable Logic Controllers

PLC manufacturer LS Electric partnered with AutomationDirect to offer controllers specifically designed for motion applications. The LS Electric XGB PLC family is designed to be versatile for flexible configurations. Users can choose to use a single PLC unit as a standalone controller with 32 built-in I/O points. Alternatively, they can add up to seven expansion modules to provide up to 244 additional I/O points. LS Electric offers several expansion modules to add extra discrete, communication, analog or motion control capabilities. The XBG PLCs key features include IEC programming to benefit a range of automated systems; it is also stackable to provide hardware options for specific requirements' super compact with integrated 2- or 6-axis pulse/direction motion inputs/outputs with a frequency up to 200 kHz. PLCs have Ethernet, serial and USB ports.

AUTOMATIONDIRECT

www.machinedesign.com/21272482

Bonfiglioli's Battery Mini-excavator Kit Successful in Global OEM Testing

The company announced the successful testing and validation of its advanced kit of products for battery-powered mini-excavators. The results of rigorous evaluations by multiple original equipment manufacturers (OEMs) across the globe reveal an improvement in energy efficiency, surpassing industry standards by at least 20%. Electric Swing Drive (700T Series) offers precision and power to the swing mechanism of the mini-excavator. By electrifying the rotation, energy efficiency is significantly enhanced, allowing for prolonged operation on a single charge. Electric Track Drive (700C Series) optimizes the performance of the track system, ensuring a low level of energy consumption and increased maneuverability. It seamlessly integrates with the machine, providing reliable operation even in harsh working conditions. Electric Motor for Pump Drive (BPM Series) is specifically designed to drive the arm, bucket and other challenging-to-electrify functions that are usually hydraulically driven. This minimizes redesign efforts while contributing to overall energy savings. Energy efficiency improvements achieved through the kit offer several advantages to construction companies and operators, including extended operating time, reduced downtime for recharging, increased productivity and significant cost savings over the lifespan of the mini-excavator.

BONFIGLIOLI

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Siemens Introduces SINAMICS S200 Servo Package for Future Manufacturing Applications

The SINAMICS S200 servo package includes the S200 drive and SIMOTICS S-1FL2 motor with standard or flexible cable options, providing motion control for standalone and networked machines. This package expands the SINAMICS drive offering, giving a range of application possibilities to the standard servo market. Key features of the servo package include: a built-in web server and one-button tuning, global standards, including UL, CE and SEMI 47; a security chip and UMAC protection; machine simulation fit for digitalization; and PROFITNET and Pulse Train versions of single-axis AC drive.

SIEMENS

www.machinedesign.com/21272250

(Continued from page 29)

Fortunately, in 2022 OneCharge partnered with Bluewater Battery Logistics to repurpose and recycle lithium forklift batteries. Bluewater tests and evaluates batteries, sending dead cells off for hydrometallurgical recycling. Other cells find new applications.

"Bluewater Battery evaluates a few variables to find the optimum way to repurpose the batteries for a second life and minimize the environmental impact," explained Steve Feinberg, CEO at Bluewater. "We look at the condition of the cells, geographical location for minimal shipping and our partners' expertise to repurpose batteries."

UC San Diego 500 kWh solar energy storage.

The batteries' new lives in secondary applications depend on how they fare in tests of voltage, ampere-hour (AH) capacity and various state of health (SOH) parameters. This is how the LFP prismatic lithium cells from the Washington demo battery got to battery purgatory at Bluewater, where they were analyzed and their next life was determined.

A Repurposed Lithium Forklift Battery

BlueWater partners with several companies building innovative solutions to repurpose lithium cells for various applications. One of them is HigherWire, which focuses on small- and medium-capacity users up to 50kWh, with a plan for 2023 to have a few thousand total kWh installed.

Since 2019, HigherWire has been acquiring used lithium batteries from forklifts, EVs and golf carts. The company accepts smaller 18650 cells from e-bike and scooter batteries, and even smaller cells from consumer electronics.

"It is really important to be able to accurately estimate batteries' SOH," said Trevor Warren, CEO of HigherWire. "We want to make the whole concept of repurposed lithium batteries more viable and drive the cost down."

Warren suggested that every battery needs a digital "passport" with reliable data on usage and current state. There are significant savings in labor and energy costs for testing the cells, as well as additional trust from the end-user.

Warren works with both B2B and B2C segments, providing power sources and helping with the design of solar energy generation systems for local governments and municipalities, as well as remote rural users or solar generators. HigherWire also sells 12V and 24V battery packs directly to end-users for RVs, fishing boats, portable and home reserve power packs.

A good example of the use of the HigherWire solution is through the pilot project with the City of Phoenix. "Here at the city, we want to be supporters of circular economy entrepreneurs helping our region transition from the linear economy and keep waste out of the landfill," said Amanda Jordan, Circular Economy project manager for the City of Phoenix.

Jordan is partnering with Higherwire on a pilot project to use remanufactured lithium batteries for solar panel energy storage to power lighting in South Mountain Park. The pilot kicked off on June 9 and will continue for one year. The major concern has always been the batteries' resistance to Arizona heat. "The positive outcome of this project will pave the road to the mass usage of second-life lithium cells as energy storage for the renewables [in Arizona]," Jordan said.

This is where the story of OneCharge demo battery ends. The lithium cells used in a forklift at the fruit packaging facility ended up in the energy storage for a solar array and are expected to work reliably for another 10 years.

The U.S. will surpass 1 million annual EV sales in 2023 and used EV batteries will provide used lithium cells for bigger-scale projects. "We work to directly repurpose EV battery packs across a few different OEMs," said Antoni Tong, CEO at Smartville, which currently has multiple grid-interconnected projects under development. "[Repurposing used lithium batteries] supports domestic supply chain and manufacturing," explained Tong.

Smartville's customers include commercial and industrial applications sized from a few hundred kWh to a few MWh. For example, UC San Diego uses its second-life battery energy storage system to store solar energy from 200-kW rooftop solar to reduce demand on the local utility grid after sunset and avoid peak electricity rates. The 500-kWh system built by Smartville also provides up to 48 hours of emergency backup power.

Recovery Process Leads to New Efficiencies

Energy transition, which plays a vital part in fighting climate change, is enabled in many aspects by lithium battery technology. Repurposing lithium cells at the end of their useful life for their main application to less-demanding applications does not just offset gigantic amounts of waste. The abundance of used lithium industrial batteries also fuels the creation of new businesses and reduces the price of solar energy from small rural plants to MWh installations, further accelerating the adoption of renewables. ■

Ad Index

R&D Spotlight: Stretchable, Flexible Li-Ion Batteries are a Natural Fit for Wearables

This fully stretchable fabric-based lithium-ion battery design consists of a conductive silver fabric as a platform and current collector.

by Rehana Begg, Editor-in-Chief

A TEAM OF RESEARCHERS at the University of Houston has designed and developed a prototype of a fully stretchable fabric-based lithium-ion battery.

The breakthrough lies in the use of conductive silver fabric as a platform and current collector, according to the paper published in *Extreme Mechanics Letters*.

The cutting-edge design of the lithium-ion battery is the brainchild of Haleh Ardebili, Bill D. Cook Professor of Mechanical Engineering at UH.

In prior work Ardebili's team successfully presented a proof-of-concept that rendered just the cathode to be stretchable. This research builds on that success by presenting the design, fabrication and characterization of the fully stretchable fabric-based lithium-ion battery.

"It seemed a natural next step to create and integrate stretchable batteries with stretchable devices and clothing," noted Ardebili. "Imagine folding or bending or stretching your laptop or phone in your pocket. Or using interactive sensors embedded in our clothes that monitor our health."

Solid Polymer Electrolyte Fabric-Based Battery

One drawback in the design of wearable batteries has been that they are conventionally rigid. This limits functionality and how devices can be embedded into the devices they power. The researchers also pointed out that those batteries use liquid electrolyte, which is flammable and may catch fire or explode under certain conditions.

In this work, the UH researchers have instead transformed rigid lithium-ion battery electrodes into solid polymer electrolyte wearable, fabric-based, flexible and stretchable electrodes.

University of Houston's Haleh Ardebili discussing bendable, flexible batteries with Navid Khiabani, a UH graduate research assistant. *University of Houston*

"The weaved silver fabric was ideal for this since it mechanically deforms or stretches and still provides electrical conduction pathways necessary for the battery electrode to function well," explained Ardebili, the corresponding author of a paper. "The battery electrode must allow movement of both electrons and ions."

Ardebili was interested in understanding the science behind stretching an electrochemical cell and its components. "This was an unexplored field in science and engineering and a great area to investigate," she said.

The authors stated in a press release that the science of coupling effects of mechanical deformation and electrochemical performance is an important field, and stretchable batteries provide a great vehicle for exploring the fundamental mechanisms.

The stretchable technology opens up the possibilities by offering stable performance and safer properties for wearable devices and implantable biosensors, they said.

There's More Work to be Done

The battery technology won't be coming to a supplier near you anytime soon. However, the researchers noted it does have applicability for powering up smart space suits, consumer electronics embedded in garments that monitor people's health and devices that interact with humans at various levels, according to the researchers.

"Commercial viability depends on many factors such as scaling up the manufacturability of the product, cost and other factors," Ardebili said in the press note. "We are working toward those considerations and goals as we optimize and enhance our stretchable battery."

The key is to prove that the product is reliable and safe. "My goal is to make sure the batteries are as safe as possible," she said.

The first author of the paper is Bahar Moradi Ghadi, a former doctoral student who based her dissertation on this research. Access the paper here: "Stretchable Fabric-Based Lithium-Ion Battery." (*https://doi.org/10.1016/j.eml.2023.102026*) ■

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