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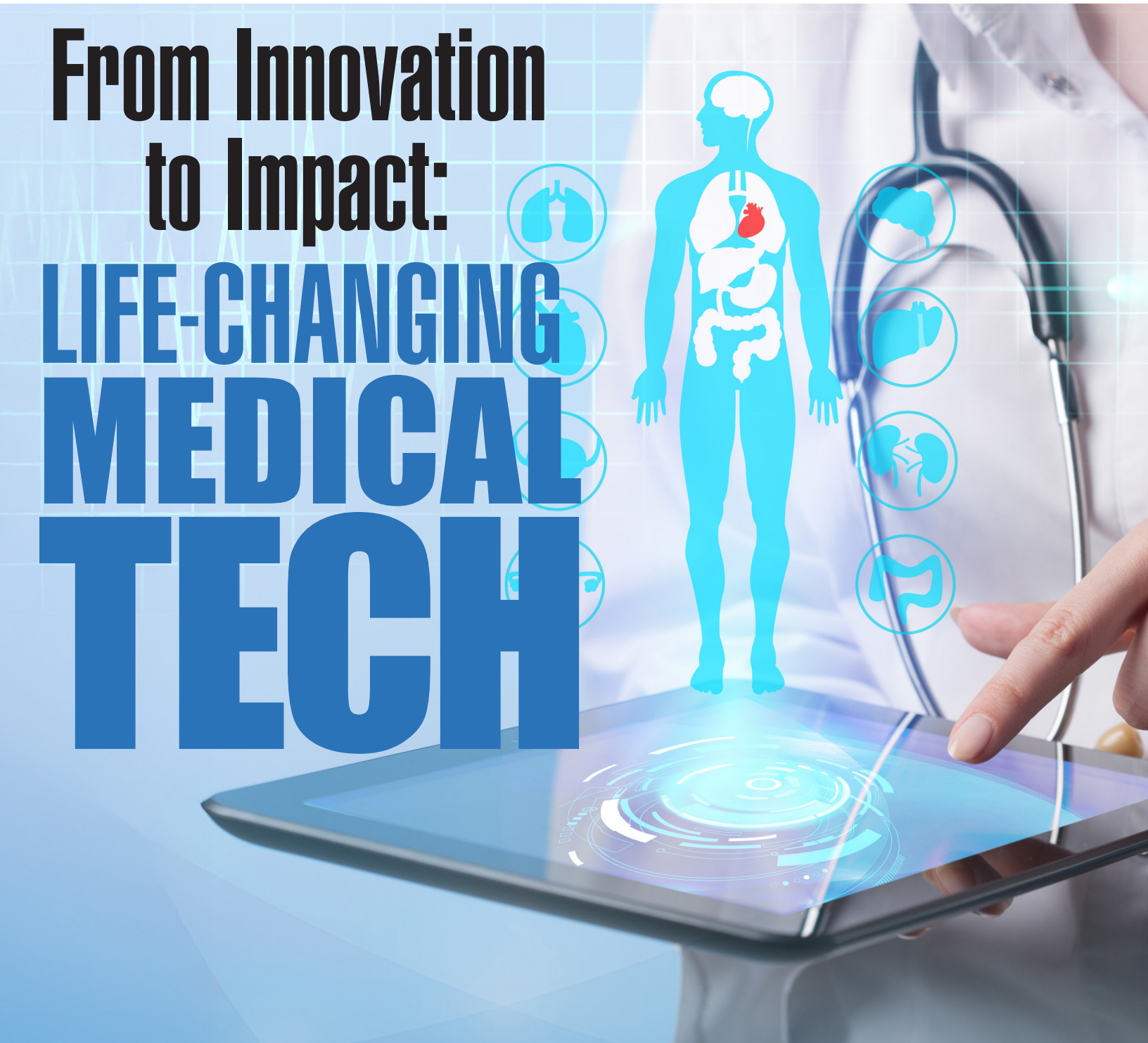

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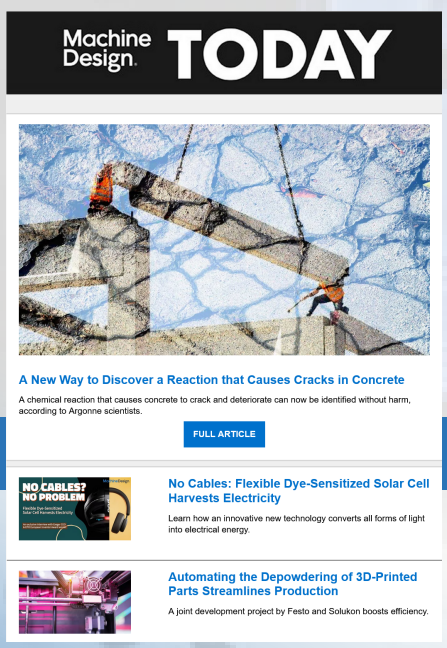

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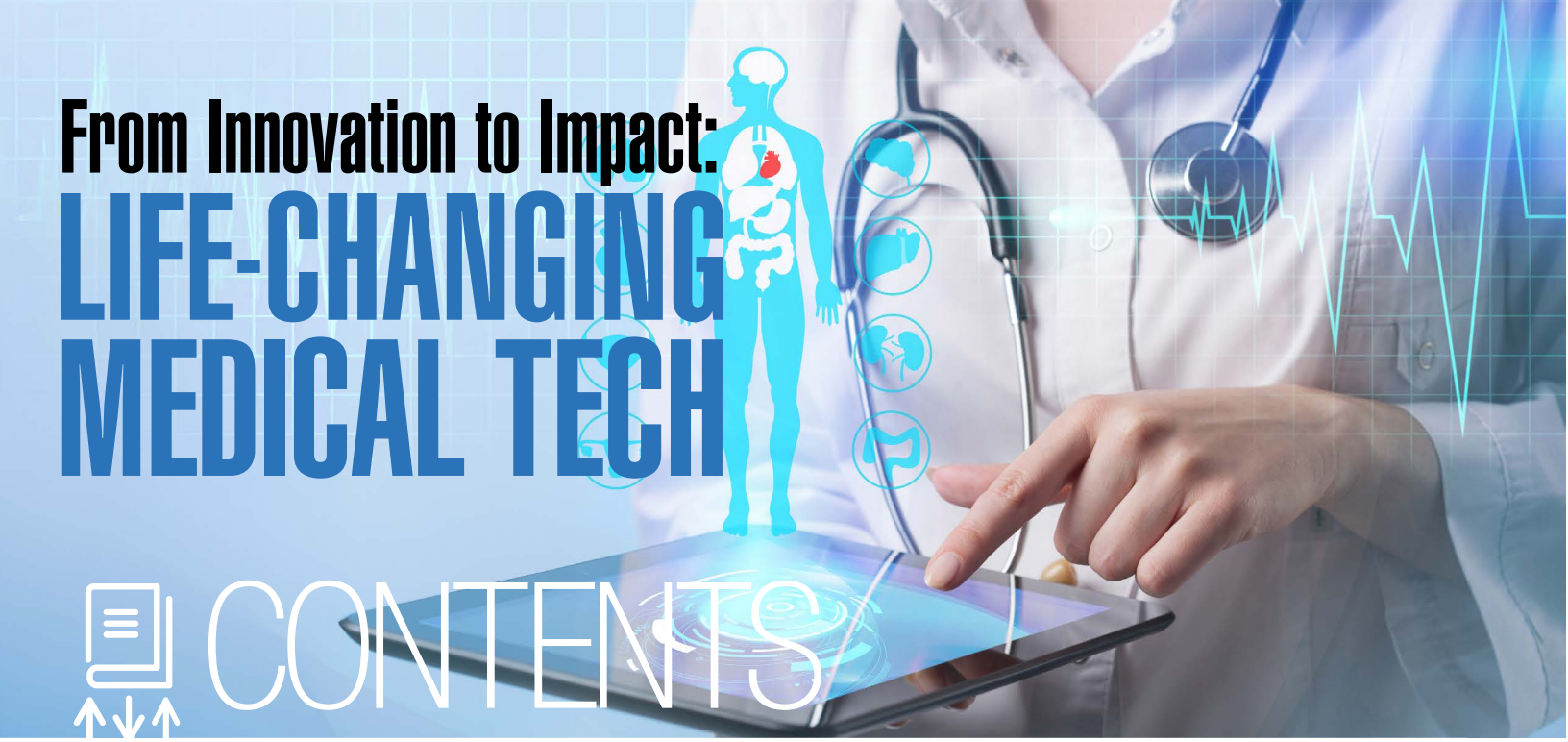

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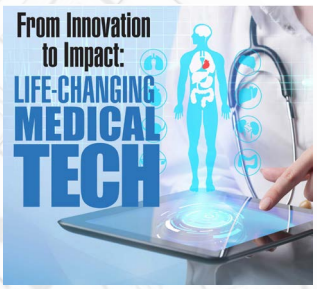

EDITORIAL

The Evolution of Medical Technologies Yields Life-changing Results

REHANA BEGG, Editor-in-Chief, *Machine Design*

Rehana Begg,
Editor-in-Chief
Machine Design

With machine learning and artificial intelligence leading the charge, MedTech rushes into a new era.

During *Machine Design*'s medical devices takeover week (Feb. 24 to March 2), contributors were asked to submit content pertaining only to this niche. The rush of content—ranging from articles, videos and Q&As—brought together perspectives from decision-makers and subject matter experts whose careers and livelihoods depend on transforming not only the medical devices industry, but the individual lives they ultimately serve.

This content represents a mere sliver of what could be relevant at this point in time. There are an estimated 2 million different kinds of medical devices on the world market, categorized into more than 7,000 generic devices groups by the World Health Organization.

Our sources confirm, however, that the demand for new technology is underpinned by key drivers such as the adoption of artificial intelligence and machine learning. These advancements, in turn, support the transition to personalized and precision medicine, as well as sustainable design and production practices. The challenges—regulatory requirements, cost of R&D, supply chain disruptions and geopolitical uncertainties—are not new, but their intensity constrain overall value creation and profitability.

If covering the engineering behind medical devices ever feels routine, it's a sign we need to look closer—because innovation, creativity and breakthrough ideas are always unfolding. In our cover story, *Machine Design*'s technical editor, Sharon Spielman, relays the story of the Living Heart Project, which brings into reality the first simulated 3D heart model, or virtual twin, in a clinical setting. The work achieved by Dr. Steve Levine in creating a virtual twin of his daughter Jesse's heart is nothing short of remarkable and pioneers the adoption of computational modeling and simulation into cardiovascular medicine.

Spielman also filed a story about a fully robotic surgery that helped save an engineer's life. CGI's Lance Brown, a designer of gears for small power transmissions in robotics, said he couldn't have known the role the gears would one day play for his own daughter Vanessa.

"Serendipity in design illuminates the beauty of invention and innovation in engineering, where unexpected designs become literal lifelines," reflected Spielman.

These are powerful stories that both inspire and reinforce the significance of our work.

Let us know if you have a similar story to share. Reach me directly at rbegg@endeavorb2b.com.

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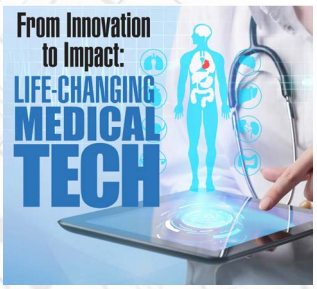
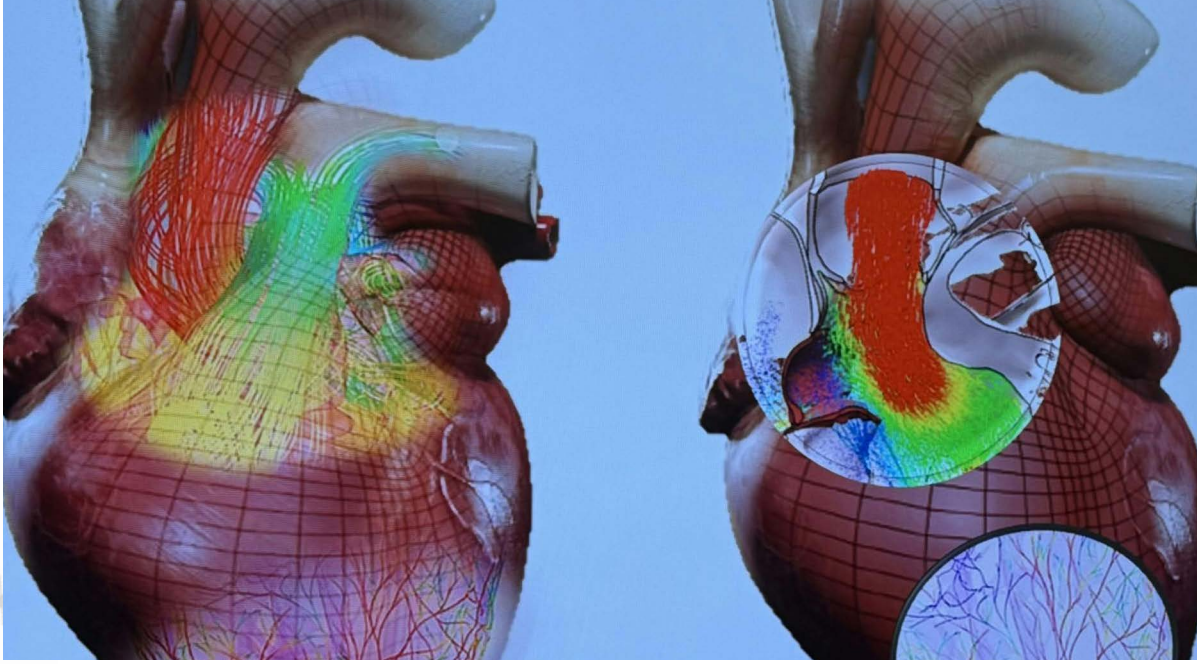




Dassault Systemes

CHAPTER 1:

Virtual Human Modeling: From Concept to Life-Saving Technology

SHARON SPIELMAN, Technical Editor, *Machine Design*

The very simulation technology that Dr. Steve Levine dedicated his career to developing became a literal lifesaver for him, with the help of his daughter—who also happened to be the inspiration for the Living Heart Project, which just celebrated its 10-year anniversary.

In a remarkable twist of fate, the very technology that Dr. Steve Levine dedicated his career to developing became a literal lifesaver for him. As the senior director of virtual human modeling at Dassault Systemes, Levine spent nearly 15 years pioneering the concept of virtual twin human experiences.

The Birth of Virtual Twin Modeling

When Levine first began exploring virtual human modeling, it was largely uncharted territory. The concept, although still emerging, was rooted in a vision of harmonizing products with life.

"At the time, we were bringing life or experiences to products, so you didn't just look at them and see how they looked. You can experience how they had to simulate the performance of the product," he said during a press conference at 3DExperience World on Feb. 24. "I was leading the strategy for our simulation brand…and was challenged at the time to imagine how to simulate not just a product experience, but life experience, and that led to what we know are calling 'virtual.'"

The evolution of the Living Heart Project emerged from a real-world need. Levine's daughter Jesse was born with a rare heart condition known as dextrocardia, where the heart is mirrored from its normal position. As she grew, her condition posed significant uncertainties for her health and treatment options, leaving doctors looking for potential risks and complications.

Witnessing the limitations of traditional medicine firsthand propelled Levine to create a virtual twin of Jesse's heart. This groundbreaking project—the Living Heart Project—aimed to provide insights before any medical interventions were considered.

Drs. Jesse and Steve Levine are living proof that virtual human modeling can save lives. The Living Heart and Living Brain projects are making incredible inroads in the medical field. Sharon Spielman

The Power of Collaboration

The success of the Living Heart Project was not the result of a single expert, but rather an extensive collaboration among roughly 165 organizations worldwide—comprising thousands of individuals—including regulatory bodies like the U.S. FDA. Launched in 2014, the project aimed to create a sophisticated virtual model that could predict heart behaviors and test potential treatments without risk to the patient.

The endeavor not only pulled together cardiologists, engineers and researchers, but also focused on overcoming the complex regulations surrounding medical technologies. Through years of perseverance, the project garnered the FDA's support, enabling the use of virtual twins in clinical settings and enhancing the accuracy of medical treatments.

Real-Life Implications

Jesse was able to thrive into adulthood, and her transition into medical training as a pediatric neurologist reflects the personal investment both she and her father have in this innovative space. One day, as Dr. Jesse Levine was preparing for her rotations, she received an e-mail from her father that would change their lives. The e-mail contained a head CT of his brain, where the findings indicated a pituitary macro adenoma—a large tumor pressing on critical structures in his brain.

The senior Levine, who was deeply immersed in the virtual twin technology he had spent years developing, now faced a personal crisis. Armed with her medical knowledge and training, Jesse Levine investigated her father's condition diligently. Knowing the urgency of the situation, she quickly identified the need for a comprehensive understanding of her father's complex anatomy, which led her to leverage the very virtual twin technology he had pioneered.

From Living Heart to Living Brain to More

Levine's surgery was a delicate operation, particularly due to the tumor's location and its entanglement with critical structures such as the optic nerve and blood vessels. By utilizing a virtual twin model of his brain, the surgical team was able to develop a strategic plan that allowed them to visualize and navigate his intricate anatomy precisely.

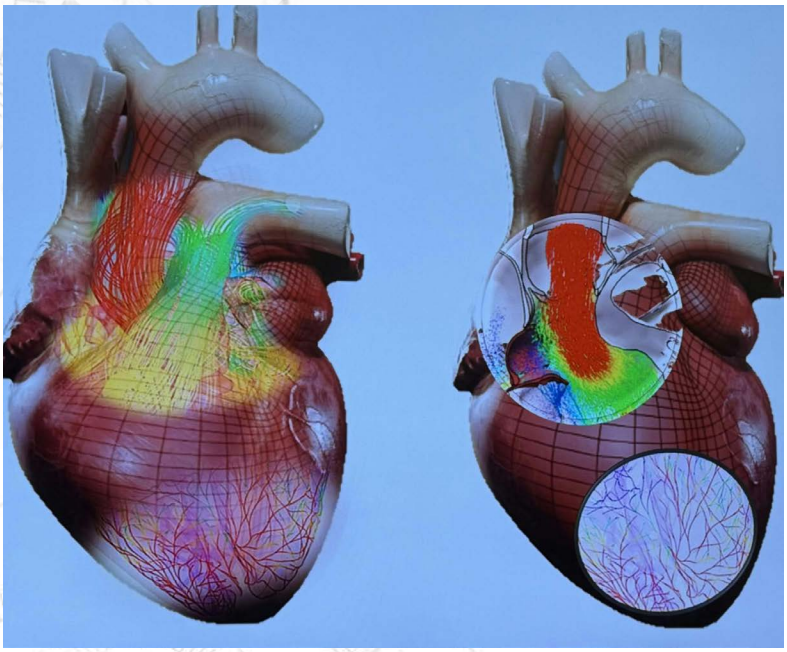
This technology not only facilitated a less invasive approach but also transformed the nature of surgery itself. During the operation, which lasted about 12 hours, the surgeons relied on the virtual model to guide their movements. Instead of traditional open surgery that would involve significant cranial manipulation, they used a minimally invasive approach: navigating through the nasal passages to access the tumor.

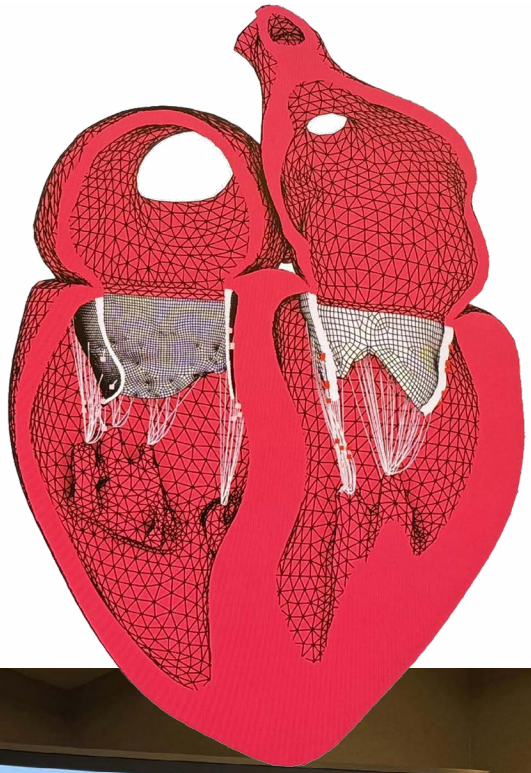
The convergence of personal and professional challenges sparked an innovative approach toward addressing medical issues. Jesse's advocacy and her first-hand experience with the healthcare system allowed them to navigate a crisis with hope and resourcefulness, and that is how the Living Brain Project was born.

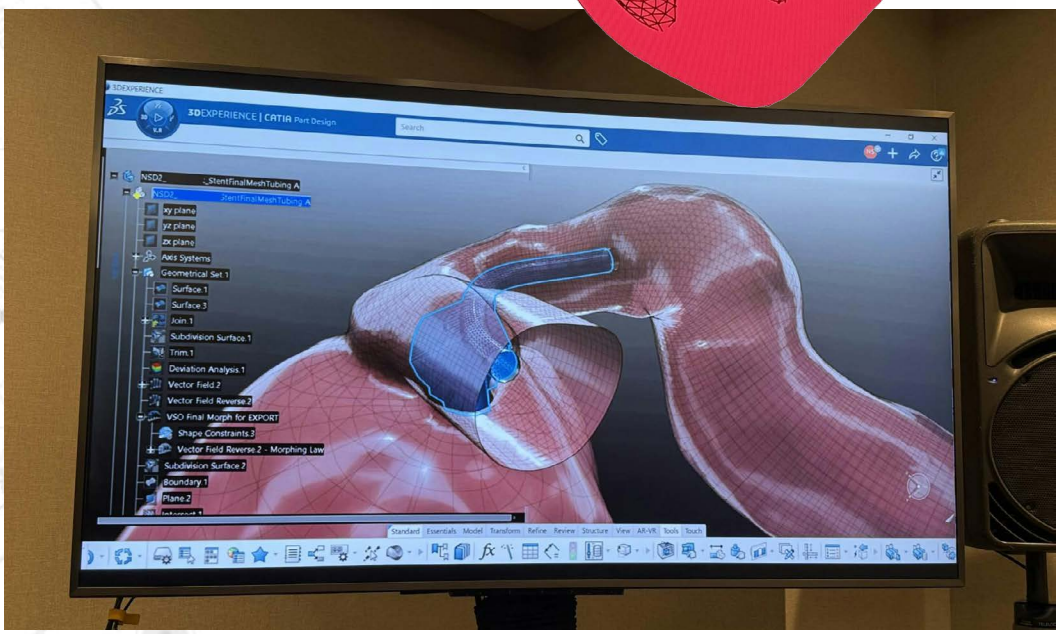
Levine reflects on this fortunate alignment of circumstances: “I lived. I’ve spent a lot of time with the community and often spoke about the value of the virtual twin, not just to the medical side, but to the patient side.

“I represented the patient’s perspective, largely as the father of an actual patient, and the importance of understanding what’s happening to you, the anxiety that you go through as a patient,” he continued. “Being able to actually understand it—have Jessie take me through it very systematically—I knew what my risks were.”

As the Living Heart Project celebrates its 10th anniversary, Levine outlines an ambitious future for it beyond just the heart. The team is now exploring virtual models for other vital organs and parts of the body, such as the liver, lungs, kidneys, joints and eyes. The next phase involves refining these models to make them adaptable and parametric, allowing

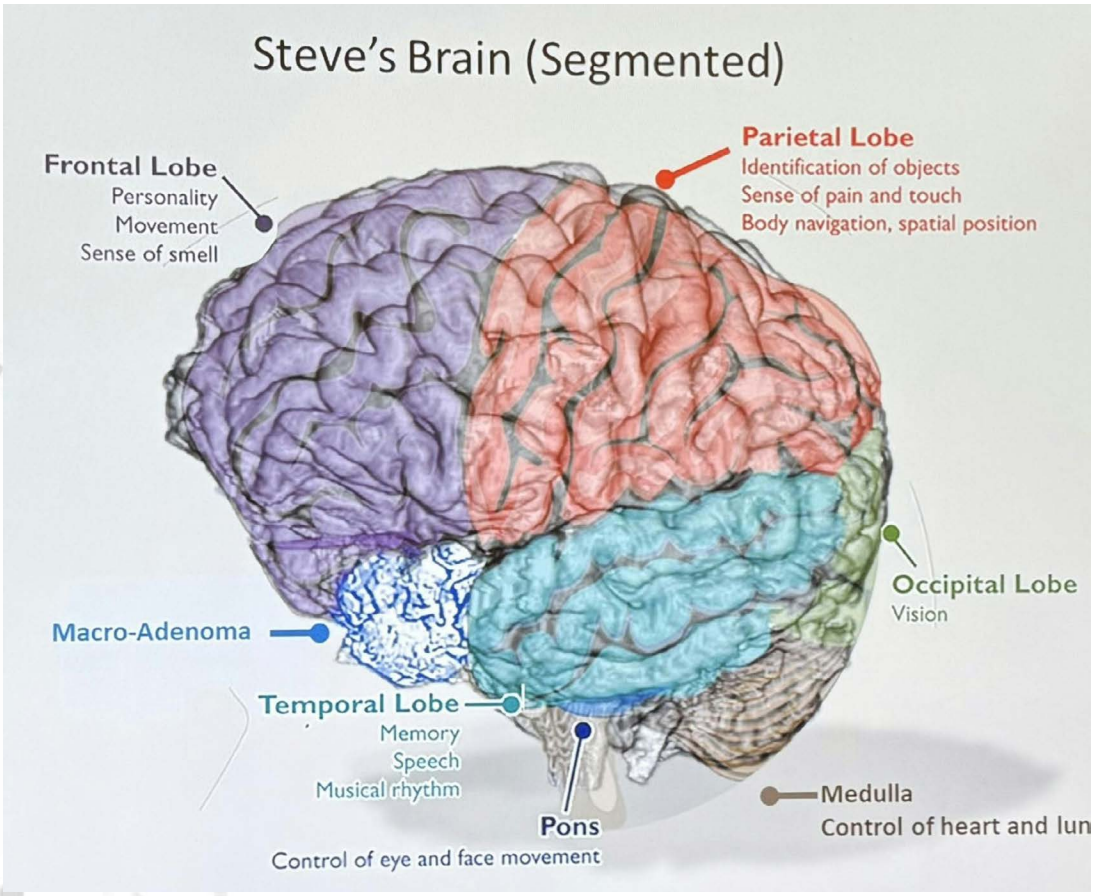






Being able to operate on a simulation of a patient heart repeatedly before undergoing the procedure on the actual patient facilitates the best possible patient outcome.

Dassault Systemmes



This simulation of Dr. Steve Levine's brain allowed the large mass to be worked on virtually before the intricate surgery was performed.
Dassault Systemes

for faster and more efficient simulations.

"We've now created what's called a parametric version…where you can change the size, the shape, the depth, all the different features to really push them up, which means the time to craft it, to make it look like your heart, or my heart, goes down from days to minutes," he announced. "It also then becomes more accessible to machine operations."

We have heard about being AI-enabled, Levine said, "so it now speaks the language of the computer…If we needed to do surgery on Jesse, we could then use our new heart to say, okay, perform 1,000 surgeries on her. The computer could do that. Now we don't need a doctor to do that and then tell us which one would be the best outcome, not just while she's lying on the table, but we could also then say what will happen if she exercises, when she's sleeping, when she's running, jumping. We can do all of that."

This means that instead of days, crafting a new model may take minutes, paving the way for unprecedented possibilities and personalized medicine. Levine and his team also have their sights set on problems like space-related health issues, collaborating with NASA to ensure astronauts maintain their sight during extended missions. This multidimensional approach shows the versatility and potential of virtual human models to address a range of medical and scientific challenges.

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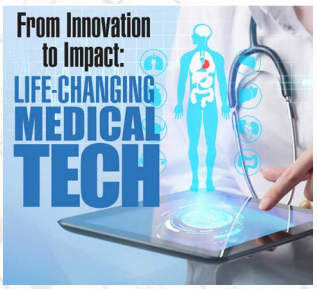


Evgeny Nekrasov

CHAPTER 2:

Extrusion Takes Some New Turns: Better Design Options in Inline Tubing Dies

TOM BALDOCK

A design engineer at Guill Tool & Engineering calls out features and design improvements in inline tubing dies.

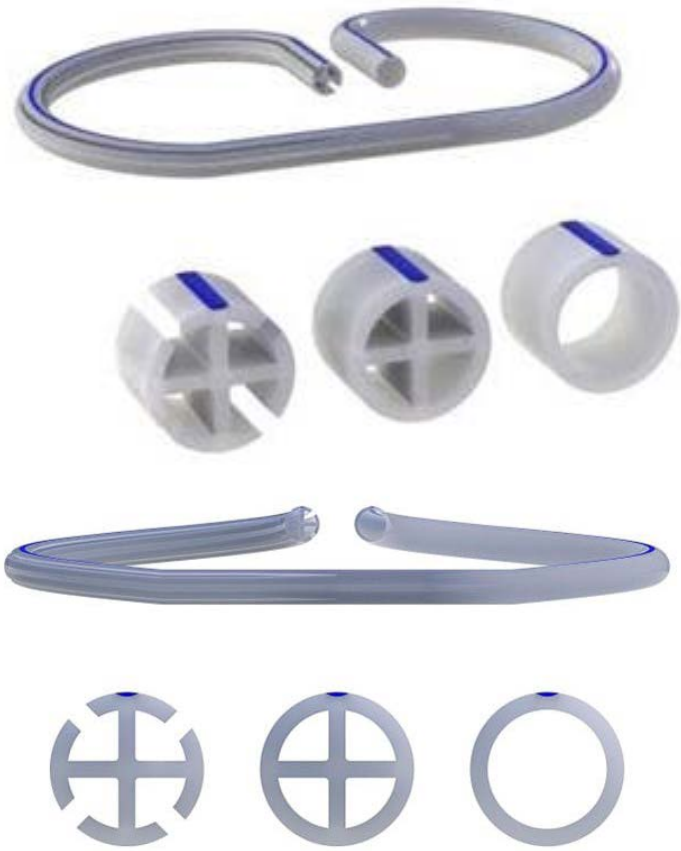
Technology in the medical devices field is constantly evolving and often requires an extensive array of medical-grade tubing in a variety of materials and thicknesses. Guill Tool & Engineering designs and manufactures custom extrusion tooling for medical tubing and other products.

Guill Tool & Engineering's micro medical tooling, for instance, can extrude tube thinner than a human hair, .008 in. or finer per revolution, and can be used to keep procedures as non-invasive as possible. Other models are used to produce tubing for feeding applications, including nasogastric and jejunal tubes.

The company has achieved a series of successes in the areas of multi-layer dies and, most recently, a reciprocal tubing die for wound draining that reconfigures the internal chambers of the tubing to accommodate drainage.

Drain tubes can be inserted prophylactically to prevent or remove the accumulation of fluid in a wound. Alternatively, such tubing can also be therapeutically inserted to evacuate an existing collection of fluid in a wound. Fluid is removed in order to treat or prevent infection and promote wound healing and patient comfort. Drain tubes can also be used to diagnose post-operative complications such as an anastomotic leak or hemorrhage. The Guill Tool design has unique features that eliminate the need to weld or otherwise join sections with different profiles together.

"Our automated extrusion process drastically changes the extruded profile in production, with no need to join separate sections of internal profiles," said Tom Baldock, sales manager, Guill Tool & Engineering.



Internal configurations of different designs used on wound drain and surgical tubing no longer require separate sections to be extruded, then joined. The Guill reciprocating head design produces various profiles within the tubing in a constant production run. Guill Tool & Engineering

A Reciprocal Tubing Die Featuring Linear Reciprocating Assembly

Guill Tool, which is based in West Warwick, R.I., has engineered this new reciprocal tubing die with various features unique to the product. The traditional tip-and-die assembly is replaced with a linear reciprocating assembly that changes the tube's profile within a given length. This process is repeated throughout a single extrusion run without interruption. Cutting capability, in association with the extrusion speed, cuts the finished product to length.

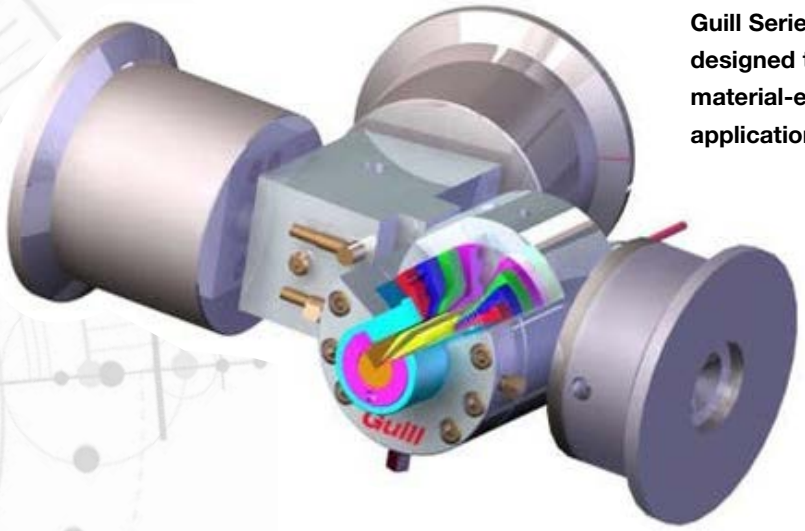
While cost and value stream activities are reduced, quality is actually improved. Only one extrusion run is needed to produce a finished product, as opposed to multiple extrusion runs with tooling changes along with a manual assembly operation to connect different tubing shapes via sonic welds or other methods of joining. Guill's new reciprocating head eliminates this entire assembly operation. It also eliminates in-process inventory. Thus, there is no need for storage of various tubing shapes and connectors needed for assembly, fulfillment of orders and replenishment of finished goods.

Furthermore, the reciprocating head eliminates a connecting piece and allows JIT production and products made-to-order. Lastly, it reduces total run time from receiving the order to shipping the product.

In the multi-layer extrusion arena, a primary focus of Guill Tool over the years, the company has also introduced the latest generation of its Series 800, the 2-to-6 layer extrusion tooling designed to produce the highest quality, highest material-efficient 1/8 in. to 6 in. OD tubing for medical and surgical applications. The redesigned Series 800 produces flawlessly smooth extrusion and layer definition of Fluoropolymer and other materials for all multi-layer, multi-lumen medical tubing. The design further allows thin layer combinations of polymers and adhesives to .02mm or less.

Guill offers its extensive line of crossheads and inline tubing dies in fixed and adjustable centers, for single or co-extrusion applications. The tooling is designed to process all compounds and features the company's patented, precision Feather Touch Concentricity adjustment, the Seal Right System, which combines with the Feather Touch system to eliminate polymer leaking. The company also offers its unique spiral flow distribution system.

Guill tooling is produced with rigorous computer simulation of the flow channels using Computational Fluid Dynamics (CFD) programs, resulting in optimum uniform flow with no weld lines.



Guill Series 800 is 2-to-6 layer extrusion tooling designed to produce the highest quality, highest material-efficient 1/8 in. to 6 in. OD tubing for medical applications. Guill Tool & Engineering

New Series of Inline Tubing Dies for Hose and Pipe Offers Improved Extrusion Performance

Guill Tool's new Series 900 of inline tubing dies offers improved extrusion performance and capabilities to customize at standard, off-the-shelf prices. The new series is applicable to extrusion of hose or pipe ranging from 0.005 in. (0.127mm) to 8.0 in. (635mm) in diameter for all types of OEM, food service, automotive, industrial, telecom and medical applications in polymer or rubber.

The Series 900 technology offers the following benefits:

- Achieves concentricity or "product roundness" which greatly reduces material usage compared with other types of extrusion tooling
- Spiderless inline-designed heads results in no spider lines and allows room for more air—thus eliminating cold legs, which can inhibit product output
- Runs 1-5 layers simultaneously
- Engineered for a multitude of applications—including special fluoropolymer applications

A key technical highlight of the Series 900 is a patent-pending FeatherTouch adjustment in the die holder and a cartridge-style ball assembly that does not require the loosening of retaining screws to make adjustments. Additional unique benefits of the Series 900 include Guill's Seal Right Systems, a positive seal, which eliminates leakage between deflectors, along with easy self-alignment that reduces operator error during assembly and is adaptable to a variety of specific extruder layout configurations.

"This series offers a standard platform design of the head with specific characteristics that are unique to individual applications included at no additional charge in the cost of the tooling," said Baldock. "This is a tremendous benefit to a company that requires

Guill Series 900 inline tubing dies from Guill Tool & Engineering Co., Inc. for hose and pipe has a patent-pending FeatherTouch adjustment in the die holder and a cartridge-style ball assembly that does not require the loosening of retaining screws to make adjustments. Guill Tool & Engineering

precision tooling with custom benefits at a standard off-the-shelf price. That certainly helps our customers' bottom line," said Tom Baldock, Guill sales manager.

Guill Tool also manufactures tips, dies and breaker plates using state-of-the-art computerized CNC machining and EDM equipment. As well, engineering services using the latest CAD systems are available for custom-designing extrusion tooling products such as crossheads, tips, clamps, flanges, forming rolls, spiderless inline dies, dies, swing gates, breaker plates, special equipment and sizing dies.

Guill Tool received ISO certification in 1995. The first major extrusion tooling company to meet international standards, Guill Tool has long been recognized as one of the leading established designers and manufacturers of custom extrusion tooling for applications including wire, cable, fiber optics, medical tubing, wood composites, automotive tube, plastic compounding, custom applications, rubber, profile, industrial pipe, hose/tube, blow molding, and food and packaging.

Founded in Rhode Island in 1962 by A. Roger Guillemette, Guill Tool was established as a job shop supplying tips, dies, crossheads and replacement parts to the wire, cable or wire and cable, plastic and rubber industries in New England. Later, Guill Tool became a supplier for the entire United States and Canada and today enjoys a worldwide market presence.

Technology in the medical field is constantly evolving and often requires an extensive array of medical-grade tubing in a variety of materials and thicknesses. Guill specializes in working with clients to design and manufacture Custom Extrusion Tooling to produce an unparalleled range of the highest quality medical tubing in the industry. The company's Micro Medical tooling can extrude tube thinner than a human hair, .008 in. or finer per revolution, and can be used to keep procedures as non-invasive as possible. Other models are used to produce tubing for feeding applications, including nasogastric and jejunal tubes.

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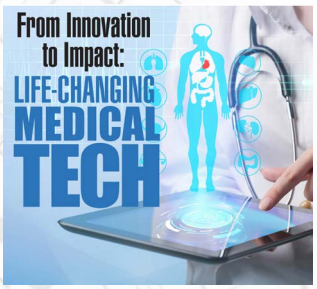

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CHAPTER 3:

Two Demonstration Machines Address Multiple Medical Device Manufacturing Competencies

SARAH SPELTZ, Marketing Manager, *Hahn Automation Group*

Two innovative demonstration systems from Hahn Automation Group showcase the potential of advanced automation in medical device manufacturing. The first integrates various technologies from MedTech device manufacturing, and the second showcases vision systems and robotics for precision components.

As medical devices become smaller and more complex, automation solutions continue to be a critical factor in helping MedTech manufacturers achieve precision, efficiency and scalability. Hahn Automation Group, a leader in end-to-end automation systems, has developed two demonstration machines that showcase the potential of advanced automation in medical device production. These systems address key challenges faced by manufacturers and offer innovative solutions to improve productivity, quality and flexibility.

Dual-Sided Assembly and Test Solutions: Maximizing Flexibility and Efficiency

This first system showcases a dual-sided assembly and test solution that integrates various technologies from MedTech device manufacturing and medical plastics material handling. This system demonstrates Hahn Automation Group's focus on flexibility, precision and efficient use of valuable floor space.

Innovative Design and Capabilities

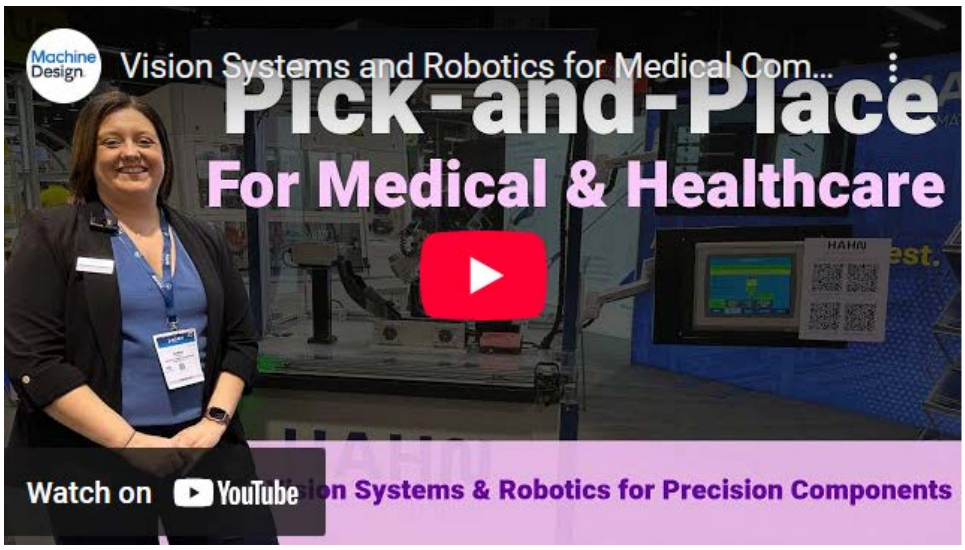
The dual-sided system features:

Multi-product flexibility. One side of the demonstration system is dedicated to COC (Cyclic Olefin Copolymer) syringe assembly, while the other handles pacemaker assembly, showcasing adaptability to different product requirements. In an actual production environment, a system like this would allow for multiple product types and/or the combination of assembly and test functionality on the same piece of equipment.

Advanced motion control. The cell features a multi-carrier magnetic system as well as

a flexible link conveyor system—both offering ideal transport in cleanroom applications.

Efficient space utilization. The innovative carrying approach improves operational dynamics by enabling multidirectional transport, allowing multiple functions with a single piece of equipment. In real-world applications this would significantly minimize footprint, risk and cost.



Incorporating vision technology, a semi-automated production line station from Hahn Automation Group demonstrates how to balance operator involvement with automation.

Hahn Automation Group

Syringe Handling Process

The syringe handling side of the system demonstrates comprehensive assembly, material handling and quality control capabilities. Here's how it works:

1. At the first station, the syringes are moved either from left-to-right or from right-to-left via the multi-directional carrier.
2. Once positioned, a sensor verifies part presence and performs a series of measurements.
3. The carrier moves the syringes across multiple stations that simulate plasma activation of inner surfaces and silicone oil coating.
4. Finally, a handling unit performs plunger placement and removal.

Pacemaker Assembly Process

The pacemaker assembly side showcases a complex assembly procedure:

1. O-rings of varying sizes are loaded into a FlexiBowl feeder where they are separated and picked by a Stäubli robot and inserted into the housing of a demonstration pacemaker located in the first station.
2. The pallet is moved by the carrier to a vision system that confirms the placement of the O-ring.
3. The system then moves to an adhesive station where the machine simulates dispensing and UV curing.
4. The multi-directional carrier then moves the assembled device back to the vision system for a final inspection.

Maximizing Technology Integration

This demonstration system integrates technologies from industry leaders such as FESTO, Siemens, KEBA, Stäubli, AFAG, ARS FlexiBowl, Keyence and Schunk—demonstrating just a few of the established partnerships that help to advance the overall solution.

By combining the capabilities of these providers with Hahn's 30+ years of experience in MedTech manufacturing, the demonstration highlights how manufacturers can perform more than 13 complex manufacturing processes in a single cell that is less than 420 cubic feet.

Vision Systems and Robotics for Precision Components

Hahn Automation Group's second showcase system highlights the use of vision systems and robotics for handling precision components such

In this demonstration system, stents have features such as varying ID/OD (inner diameter/outer diameter). The vision system and robotic components help ensure the parts are placed accurately. Hahn Automation Group

as stents. This machine addresses four key questions frequently asked by medical device manufacturers:

How to Determine the Right Level of Automation

The system demonstrates a semi-automated production line station, balancing operator involvement with automation. This approach is often ideal for processes that require human interaction but involve delicate materials or tedious tasks that are prone to error.

In this demonstration system, the stents have features such as varying ID/OD (inner diameter/outer diameter) that are hard to detect with the human eye, thus the vision system and robotic components help ensure the parts are placed accurately.

How to Adjust Product Design for the Use of Vision Systems

Hahn's involvement throughout the product development process in real applications allows for flexibility as products evolve—providing tips that may improve manufacturability.

The demonstration system highlights this capability with features such as:

- Filters and backlighting during pick-and-place operations that allow cameras to detect stents regardless of orientation

Hahn Automation Group's cell features a multi-carrier magnetic system as well as a flexible link conveyor system. The advanced motion control demo showcases flexibility, precision and efficient use of floor space. Hahn Automation Group

- Measurement sensors for outer and inner diameter verification
- Geometric analysis of post-production notches to confirm stent orientation

How to Improve Operator Productivity and Consistency

By automating error-prone tasks, the system significantly enhances operator productivity and consistency. This targeted approach to automation focuses on processes that are both susceptible to errors and suitable for machine handling.

In the demonstration equipment, the stents are marked with words that form a statement when placed correctly onto LED bars. The vision system helps ensure the words are right-side-up and in the correct order. In a MedTech application, the words may represent a pin or a blade—any component where both placement and orientation are critical to the function of the device.

A dual-sided demonstration depicts both demo syringe assembly and pacemaker assembly. This image highlights the pacemaker assembly side, where O-rings of varying sizes are loaded into a FlexiBowl feeder.
Hahn Automation Group

How to Leverage Production Scale-up Strategies

The root of scaling-up production is always to evaluate the goal manufacturers are trying to achieve—time, quality or capability.

The system demonstrates how automation can impact each of these through:

- Reduction of errors and rejects, naturally improving cycle times.
- Faster processing in a smaller footprint compared to manual operations.
- Automation of tasks that machines can perform more efficiently than humans.

Achieving Scale Through Cutting-Edge Technologies

Hahn Automation Group's innovative demonstration systems showcase the potential of advanced automation in medical device manufacturing. By addressing key industry challenges and integrating cutting-edge technologies, these solutions pave the way for more efficient, precise and scalable production processes. As the medical device industry continues to evolve, Hahn Automation Group remains at the forefront, providing manufacturers with the tools they need to stay competitive in an increasingly demanding market.

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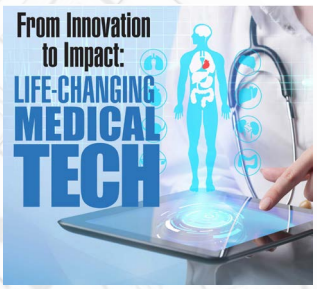


Courtesy Sculpteo

CHAPTER 4:

Integrating Advanced Technology, Additive Manufacturing for Better Accessibility

SHARON SPIELMAN, Technical Editor, *Machine Design*

A collaboration between Sculpteo and JIB combine advanced 3D printing with eye-tracking technology, empowering individuals with severe disabilities to interact with their environment and communicate effectively.

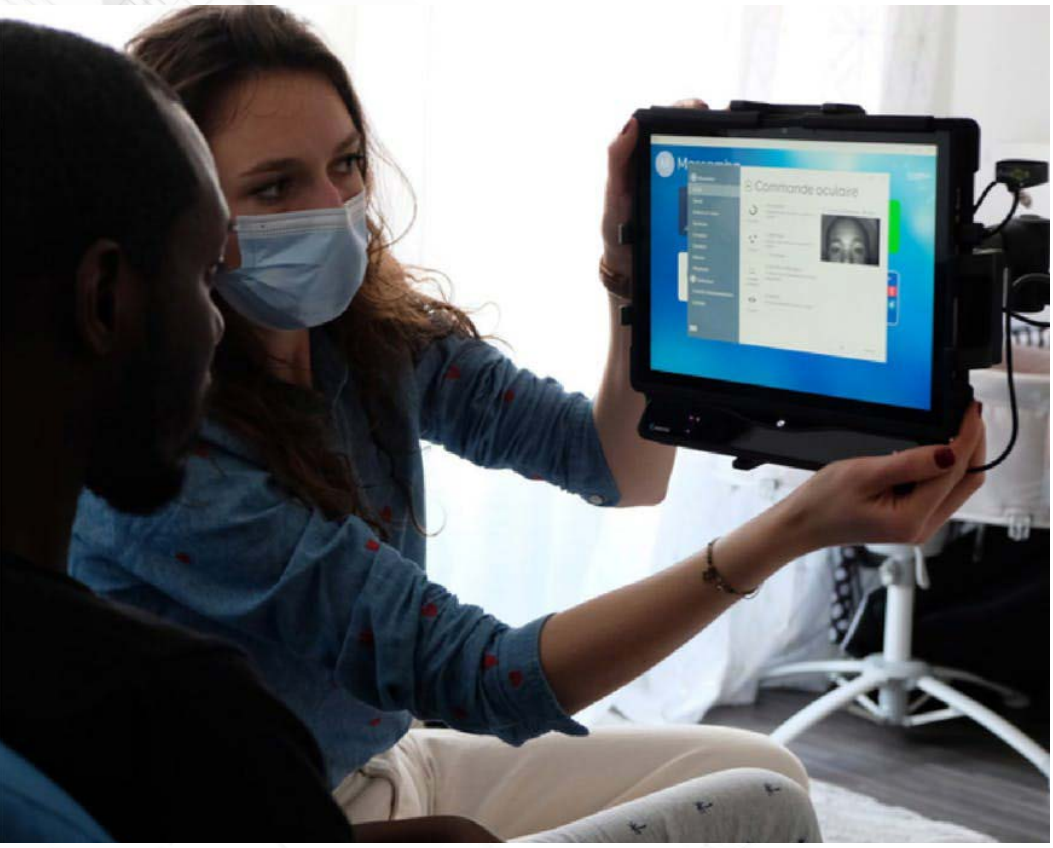
Equipment, software and product systems that are used to increase, maintain or improve the functional capabilities of persons with disabilities make up the umbrella term "assistive technology". In this market, breakthroughs in 3D printing have streamlined workflows and changed time-sensitive processes into rapid solutions.

This progress in additive manufacturing has allowed for complex geometries to be produced on-demand, and in the case of one collaboration, is benefiting individuals with neurogenerative diseases or severe motor disabilities. JIB and Sculpteo are working together to provide a device that integrates an eye camera with a tablet and custom case for user interaction with technology.

The Companies Behind the Innovation

JIB, co-founded by Thomas Groell, focuses on bridging the gaps between technology and disabilities. With a mission to adapt mainstream technology for individuals who require specialized solutions, JIB has navigated the complexity of environmental control and communication for those with physical limitations. The company's journey began more than six years ago with the goal of providing adaptive technologies and solutions to individuals who find themselves marginalized by conventional tech products.

Sculpteo, led by CEO Alexandre D'Orsetti, is a 3D printing service provider established in 2009. Sculpteo began with the aim of democratizing industrial additive manufacturing via an online platform, which subsequently expanded to focus on several verticals, including medical applications. By offering design support and advanced production capabilities, they play a role in the rapid development of new, user-centric assistive technologies.



Progress in additive manufacturing has allowed for complex geometries to be produced on-demand and, in the case of a collaboration between JIB and Sculpteo, is benefiting individuals with neurogenerative diseases or severe motor disabilities. Courtesy Sculpteo

The Device and Its Benefits

The collaborative output of JIB and Sculpteo is a tablet-based communication device that utilizes eye-tracking technology specifically designed for individuals who are unable to communicate verbally or utilize traditional input methods. The device functions by interpreting the user's eye movements, allowing them to navigate interfaces and interact with their environment using pictograms or a virtual keyboard.

This not only empowers those with severe motor disabilities but actively enhances their quality of life by facilitating communication with caregivers and family members. Children, for instance, benefit from augmentative and alternative communication (ACC) systems, which assist in language learning and social interaction through intuitive pictograms.

Design and Development Challenges

One of the core challenges in developing this device was the integration of the eye-tracking system with varying tablet types. Because many users employ different tablets, it was necessary to design a flexible casing that could adapt to the dimensions and configurations unique to each model.

As Groell said, the design must account for the frequent updates and changes in tablet models, requiring continuous revisions to create a casing that fits perfectly and supports the eye-tracking technology's functionality.

Each adaptation is made feasible through the capabilities of 3D printing, allowing Sculpteo to produce customized designs on-demand. This flexibility not only supports production but also addresses the specific needs of each user without necessitating large inventory stocks.

Tech Integration and User Experience

The hardware integration of the eye tracker and tablet effectively allows for real-time communication. The eye tracker, located beneath the tablet and enclosed within the casing, connects to the tablet through a hub that facilitates peripheral connections. This design ensures that user experience remains seamless, allowing individuals with disabilities to interact with the device intuitively.

The software is important to the success of this technology; the combination of firm-

Because many users employ different tablets, it was necessary to design a flexible casing that could adapt to the dimensions and configurations unique to each model. Courtesy Sculpteo

ware from the eye tracker supplier and additional communication software developed by JIB creates a cohesive interface tailored to users' unique interaction patterns. This is especially significant for those who cannot utilize traditional input methods, as the gaze-based navigation system requires interfaces designed specifically for eye tracking.

The materials used to create the case needed to be adaptable and resilient, so the device shell is produced using thermoplastic polyurethane (TPU), which offers flexibility and durability. D'Orsetti says that TPU is resistant to abrasion, which is essential for devices used in environments like medical institutions, where robustness is vital.

Future Direction, Impact

Looking ahead, JIB and Sculpteo are committed to further refining their product offerings. Plans include developing new prototypes that integrate additional features such as enhanced battery life and audio outputs, which are particularly beneficial in educational settings where external noise may be a factor.

The partnership shows how innovation can create meaningful change in the lives of individuals with disabilities. Their focus on user-centric design and adaptability shows the potential of collaborative efforts in tackling barriers faced by underserved populations in today's tech landscape. As the boundaries of what assistive technologies can achieve are pushed, technological advancements are impacting lives by enabling individuals to communicate, learn and interact more freely with the world around them.

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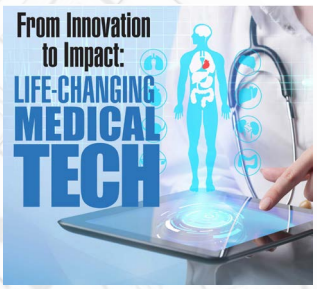

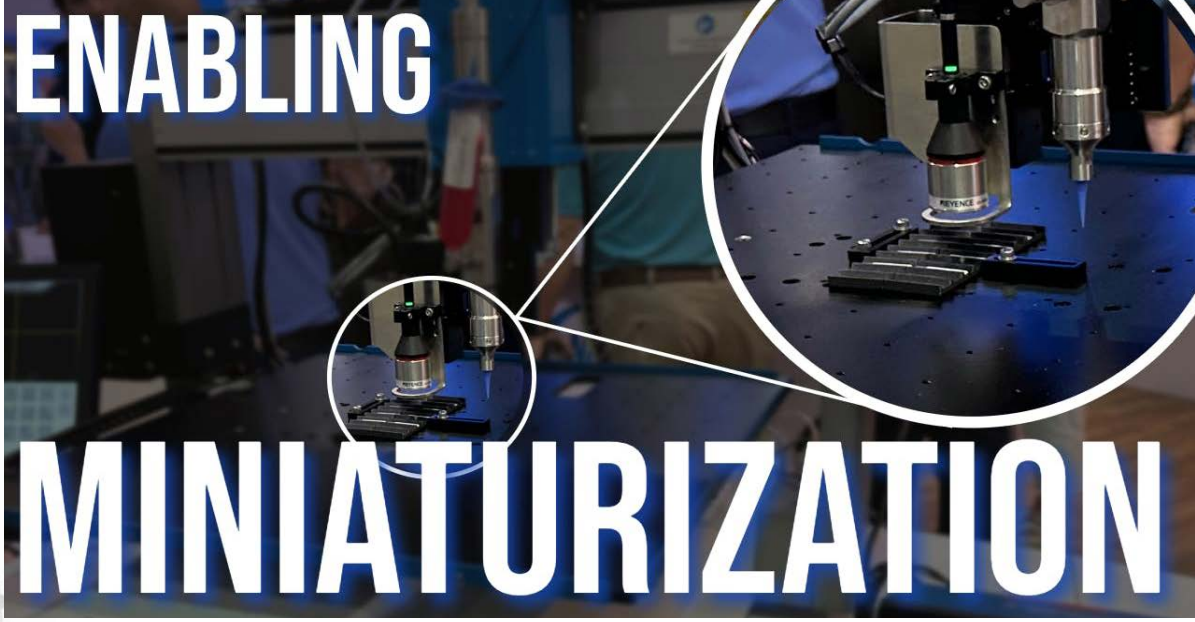

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CHAPTER 5:

A Race to the Micro Pushes the Device Assembly Envelope

MARK O'SHEA, Senior Manager, Business Development, *Nordson EFD*
AHMED KHAN, Global Product Manager, Precision Fluid Dispensing and Automation, *Nordson EFD*

The medical device industry heads toward smaller products, next-level quality and new assembly challenges.

Smaller. Lighter. Innovative. Medical device designers often use these three terms to describe the trends driving their current and future product development. Of these requisites, smaller has become a fixation for next-generation designs, especially in the catheter business. The ability to micro-mold plastics and access tiny electronics are critically important for making components smaller.

Across the board, there are many good reasons for reducing the size of medical devices, such as requiring less space for storage and transportation. More importantly, micro technology promises lower healthcare costs through less intrusive and invasive procedures, leading to less recovery time for patients and reduced hospital stays. Less invasive surgical procedures offer many benefits such as less surgery trauma, lower post-operation risks and fewer patient clinical visits.

The push towards the micro in the medical device industry is also a significant economic opportunity. According to a recent report from BCC Research, the global market for medical device technologies is expected to grow from $810.4 billion in 2024 to $1.3 trillion by the end of 2029, at a compound annual growth rate (CAGR) of 9.8% from 2024 through 2029. As the industry continues to push toward smaller than ever devices, the ablation catheter sector is breaking solid new ground with industry partners.

Precision Device Assembly and Micro Fluid Dispensing Technologies

One such partner is the fluid dispensing technology supplier. As manufacturers produce smaller and smaller catheters, quality control becomes an even bigger issue. While many professionals in the quality business focus on physical precision in the production of these components, there is another critical piece of the equation. Medical device manufacturers

must rely on precision jetting and micro fluid dispensing technologies to actually assemble these high-quality ablation catheters. Enter the fluid process engineer.

The Fluid Process Engineer

Fluid process engineers have a deep knowledge of fluids, viscosity and how to dispense each liquid to meet the most stringent of specifications. These engineers investigate touchpoints along the development path to troubleshoot and solve fluid assembly issues and integrate automated precision dispensing solutions that reliably and repeatedly place micro amounts of fluids onto a material or substrate.

Professionals in the fluid dispensing field are also laser-focused on high precision and quality control, such as the placement of microdots during the assembly of ablation catheters. Micro assembly applications can be very complex depending upon the type of fluid or adhesive and its viscosity. Once the fluid reaches the material or substrate, it must be able to restructure and recover to keep it from spreading and contaminating other components on the substrate.

The thixotropy of fluids is a major factor in successful micro-dispensing for a variety of applications. Thixotropy is a material property that depicts how some fluids and gels become less viscous when agitated but return to their original state over a period of time. Hence, expertise in fluid control is often invaluable to medical device manufacturers, who may not have this expertise in-house.

Micro-Dispensing Tech for Catheter Development

An ablation catheter is a thin tube inserted through a blood vessel into the patient's heart. Catheter ablation is a minimally invasive treatment for fast heartbeats. The medical term for this is cardiac arrhythmia. Ablation is a technique used to strategically destroy abnormal tissue that could be causing an irregular heartbeat and restore proper function to the heart. This procedure is also known as cardiac ablation or radiofrequency ablation.

Contemporary ablation catheter designs are pushing the boundaries of material and manufacturing capabilities. A modern catheter that was once 2 mm in diameter is now 1 mm in diameter or smaller. These catheters can deliver pacemakers into the body and

Many specialty device manufacturers select manual dispense solutions to make exact, repeatable micro-deposits on or between delicate surfaces. These solutions provide contamination-free and static-free performance and purity necessary for medical device manufacturing. Nordson EFD

offer stenting, valving, suturing and pacing properties. These micro-sized devices also benefit from being placed close to the area in the body where they operate best.

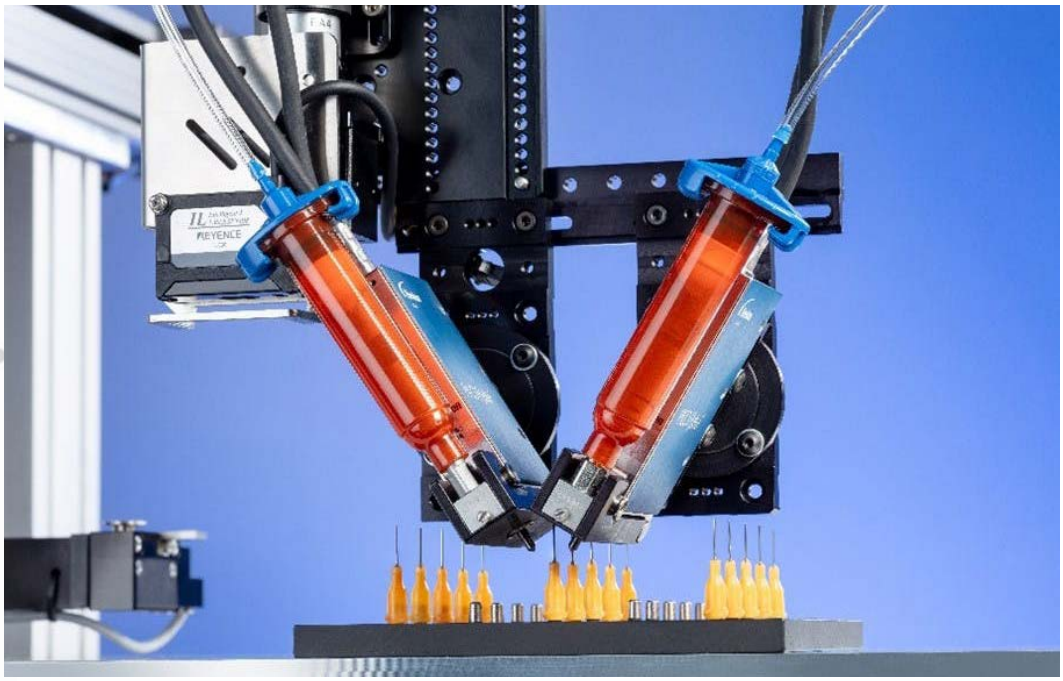
Device manufacturers focus on capability, scalability and sustainability to make micro engineering catheters function well. The key aspect of a micro catheter is its thin walls and subassembly design, which plays a dynamic role as all components must flawlessly fit together. The use of rapid prototyping, micro plastic molding technologies and metrology technologies are all tools in the toolkit to ensure quality assurance.

During product development, fluid process experts step in at the critical and costly assembly stage. Dispensed adhesive microdots are 300-400 microns in diameter, which is roughly the thickness of 5-6 human hairs. To achieve these miniscule deposit sizes, sophisticated fluid dispensing technologies are necessary. Advances in fluid jetting make minimally invasive specialty catheters possible. In the future, precise technologies for dispensing small lines and dots at the micron level will be crucial.

Innovation Steps in

Based in East Providence, R.I., Nordson EFD is a veteran player in the fluid dispensing sector. The company's PICO Nexus jetting system provides real time insights for data-driven process control and assembly. Designed for smart factory readiness, it connects fluid dispensing to Industry 4.0 efficiencies.

Users can control, manage and monitor jetting functions at the point of dispense via Industrial Ethernet protocols from a human machine interface (HMI) of their choice. The IIoT innovation lies within the machine's ability to provide extreme precision and repeat-



Jetting, or non-contact dispensing solutions offer micro deposit capabilities—as small as 0.5 nL—that can be applied precisely at up to 1000Hz continuously. These capabilities, coupled with micron (µm) level stroke adjustment, are ideal for sophisticated non-contact applications.

ability with its self-regulating calibration for improved valve-to-valve jetting performance.

Specifically, the solution's micro deposit capability—as small as 0.5 nL—can be applied precisely at up to 1,000Hz continuously. These capabilities, coupled with micron (µm) level stroke adjustment, are ideal for sophisticated non-contact applications such as advanced cardiac catheter manufacturing.

The product's web-based interface enables remote programming and on-demand inspection of fluid dispensing functions from a personal computer, laptop and other mobile devices, a dramatic boost for productivity. The controller is a compact design employing standard 24V and DIN-rail mounted plug-and-play technology to optimize production space utilization, especially where multiple valves are required. The solution also provides another rung of security for each system in the dispensing ecosystem.

Valve Technologies also Enable Precision

Needle valves are an essential tool for putting fine dispensing fluid lines and dots onto substrates. Ablation catheter manufacturing frequently requires microdots as small as 150 µm (0.15 mm; 0.006 in.) diameter. Nordson EFD has designed a line of valves that enable dispensing in tight spaces at more complex angles. These contact valves are different from non-contact valves like the PICO Nexus system because they must come in contact with the dispensing surface to apply a fluid. This makes them slower than jetting systems, but no less reliable or accurate.

For applications requiring deposits down to the fractions of a microliter, there is a line of valves that provide pneumatical operation and control. Catheter fabricators often choose

Needle valves are an essential technology for enabling manufacturers to build smaller medical device components—empowering organizations to deposit microdots as small as 150 µm (0.15 mm) (0.006 in.) diameter. Nordson EFD

this valve type because it dispenses consistent microdots as small as 0.18 mm (0.007 in.) diameter and is unaffected by entrapped air in fluids.

Nordson's small gauge standard spray valves can apply a precise, uniform spray pattern up to 30% smaller than standard spray valves. The valve makes spray patterns as small as 3.3 mm (0.13 in.) and as great as 19 mm (0.75 in.) in diameter. A mini spray valve also provides the kind of precision needed for ablation catheter production with spray control in uniform patterns as narrow as 1 mm (0.04 in.) wide with accurate edge definition.

Hand-Held Fluid Dispensing Still Needed for Catheter Production

Automating the precise movements necessary to build an advanced ablation catheter is oftentimes impossible. Many highly skilled people perform the extremely precise movements necessary on these small workpieces.

To apply dispensing fluids manually, Nordon EFD's specialized dispensers and chamfered tips are used to exact, repeatable micro-deposits on or between delicate surfaces. In the 33-ga size, the tips are capable of consistently making a 0.10 mm / 0.004 in. line of dispensed fluids. These solutions provide contamination-free and static-free performance and purity necessary for medical device manufacturing.

The Challenges Ahead

As engineers find success in new ablation catheter designs, other areas of the life sciences industry are looking to mirror those achievements. It is now routine to see smaller implantable devices for managing heart rhythm, pain and blood pressure. What these devices share in common lies within the build of the device. The ongoing challenge is to make ever more minute fluid deposits for their assembly as the requirement is for nanoliter and smaller deposit sizes. This is a significant change in manufacturing moving from microliters to nanoliters, with deposit sizes specifically at 4 nanoliters.

The long game for the development of medical devices like catheters is clearer, though. As global demand continues to rise, more efficient production approaches are necessary. Automated systems are integrating micro fluid dispensing technologies to keep up with this progress.

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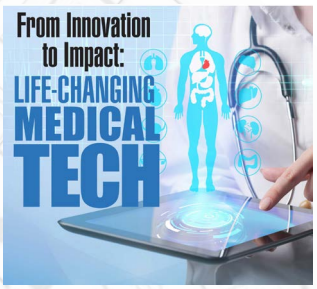


Freudenberg Sealing Technologies

CHAPTER 6:

Tiny Titans: Micro Parts Make a Big Impact

DOMINIK LINDER, specialist, design engineering, *Freudenberg Sealing Technologies*
TOBIAS GUTSCH, product manager, *Freudenberg Sealing Technologies.*

Micro parts are indispensable components. A look at material selection and requirements for medical (for ventilators), dentistry (drills) and laboratory equipment (HPLC systems or pipetting robots)

Small components with a big impact—this best describes the innovative micro parts from Freudenberg Sealing Technologies. The main areas of application for these tiny components with external dimensions up to ~20 mm are fluid handling valves, pumps, mixers and small electric motors, such as those used in medical technology. Wherever hygiene, safety and precision play a decisive role—from anesthesia machines to dental drills—micro parts make an indispensable contribution to safe and efficient use.

Material Challenges in Micro Part Manufacturing

Micro part manufacturing is a highly specialized field that requires careful consideration of precision, materials, tooling, cost and scalability. Advancements in technology, such as improved tools and techniques, are continuously helping to overcome some of these challenges and enable manufacturers to meet market requirements.

The selection of materials for micro part manufacturing is a critical aspect that directly influences the performance and reliability of the final product. Specialized materials such as FKM (fluorelastomer), FFKM (perfluoroelastomer) and EPDM (ethylene propylene elastomer) are tailored to meet the demands of various industries, including the medical technology, food & beverage and automotive sectors.

FKM, which is characterized by good chemical resistance and temperture resistance up to 200°C, is ideal for environments with aggressive media. FFKM offers very high chemical resistance and reliably withstands temperatures of up to 230°C, making it ideal for high-demand environments where durability is essential. EPDM on the other hand, is particularly resistant to ozone, UV radiation and hot water, making it best suited for environments with moisture and steam elements.

Elastomer Compounds in Different Media					
	EPDM	NBR	HNBR	FKM	FFKM
Water	++	+	+	(+)	++
Suds	++	+	+	(+)	++
CIP/SIP	+	-	(+)	++	++
Air	++	+	++	++	++
Greases	-	+	+	++	++

Key: ++ very good, + good, (+) satisfactory, 0 moderate,—not suitable

This wide variety of materials makes it possible to develop customized sealing elements for different applications, whether in medical technology, food and beverage industry or the automotive sector, where maximum precision or hygiene are crucial. The high durability and reliability of micro parts make a decisive contribution to ensuring the safe operation of devices even under extreme conditions. While challenges in micro part manufacturing exist, the potential for these parts to make an impact is immense.

Making an Impact: Ventilators in the Medical Industry

Micro components, typically measuring less than 20 mm, are essential in preventing leaks and ensuring the smooth operation of critical applications, particularly in medical devices where miniaturization is a key trend. As components continue to shrink, the demand for smaller valves and valve components intensifies. In this evolving landscape, precision is paramount to maintain functionality and reliability in these miniature systems.

The valve anchor, for example, controls the flow of anesthetic gases in anesthesia machines to enable the precise dosing, which is essential for patient safety. Made from a combination of metal and FFKM, the valve anchor can withstand even the most aggressive anesthetic gases, which is crucial for the long-term safety and function of the devices.

Another device in the operating theater that micro parts support is the ventilator. In this application, a miniature flipper valve seal enables the precise control of the required volume of respiratory gases. The seal made of FKM or EPDM impresses with its high media resistance. The high-quality material combination ensures a long service life even under extreme conditions and ensures millions of switching cycles without any loss of performance.

Making an Impact: Drills in Dentistry

In addition to applications relating to surgical procedures, micro parts play a key role in dentistry, such as the brake and sealing disk, which was specially developed for use in dental drills. The combination of sealing and braking

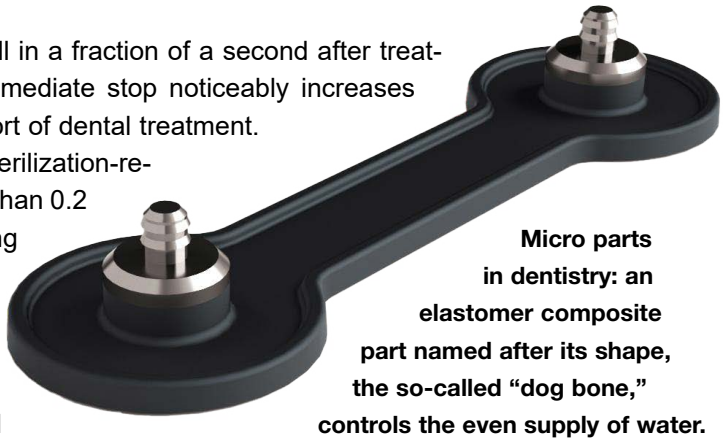
As components continue to shrink, the demand for smaller valves and valve components intensifies. With a total height of less than 9 mm, the valve anchor controls the flow of anesthetic gases in anesthesia machines to enable the precise dosing, which is essential for patient safety. Freudenberg Sealing Technologies

Micro parts play a key role in dentistry, such as the brake and sealing disk, which was specially developed for use in dental drills.

Freudenberg Sealing Technologies

function stops the dental drill in a fraction of a second after treatment is completed. This immediate stop noticeably increases patient safety and the comfort of dental treatment.

Made from durable and sterilization-resistant elastomers, the less than 0.2 mm thick brake and sealing disc can withstand extreme loads at high speeds without losing its function or sealing performance. In addition, the brake and sealing disk prevents media from flowing back into the handpiece and thus contributes significantly to the hygiene of the treatment.



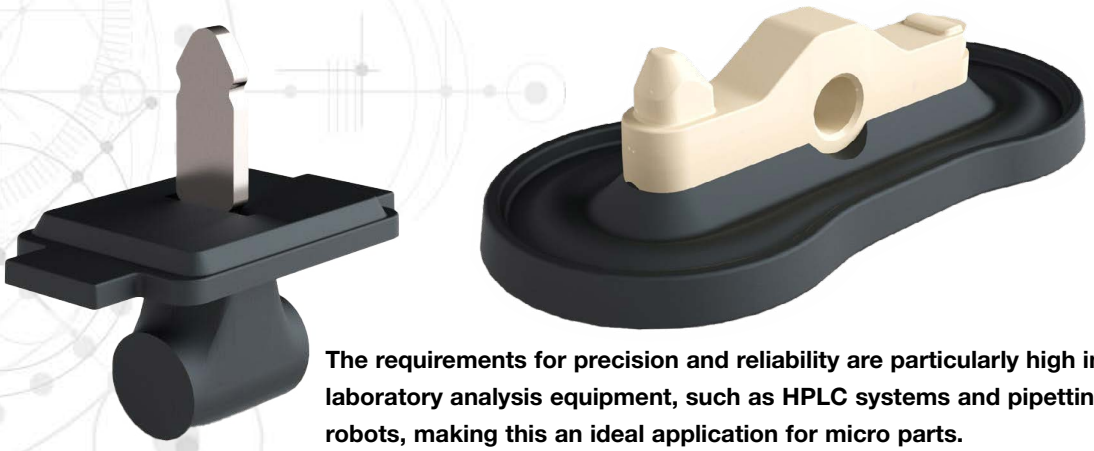
Micro parts in dentistry: an elastomer composite part named after its shape, the so-called "dog bone," controls the even supply of water.

Freudenberg Sealing Technologies

Another application in this area is the hygienic preparation of drinking water for the dental treatment unit. An elastomer composite part named after its shape, the so-called "dog bone," controls the even supply of water.

Making an Impact: Laboratory Analysis Equipment

The requirements for precision and reliability are particularly high in laboratory analysis equipment, such as HPLC (high performance liquid chromatography) systems and pipetting robots, making this an ideal application for micro parts. In these functions, hammer seals and rocker valves ensure precise control of the liquid dosage and prevent leaks that could lead to falsified analysis results. The rocker valve ensures precise control of the liquid dosage during the automatic pipetting process, while valve seat seals in HPLC devices



The requirements for precision and reliability are particularly high in laboratory analysis equipment, such as HPLC systems and pipetting robots, making this an ideal application for micro parts.

Freudenberg Sealing Technologies

prevent leaks and thus ensure reliable results.

In addition to their use in pumps and valves, micro parts are also used in small electric motors to seal rotating parts and ensure the performance of the motors. The precision and robustness of the materials used ensures that the seals retain their function even at high speeds and under extreme loads.

Making an Impact: Future Considerations

The future of micro parts is exciting and holds great potential in a variety of industries. These tiny components are essential in advancing technology, improving product performance, and enabling new applications across sectors. The focus is on new areas of application, improving production technologies and researching new materials that guarantee even greater durability and reliability in use. Trends driven by environmental considerations and technological advancements are especially topical.

PFAS and micro parts: The family of per- and polyfluoroalkyl substances (PFAS) is facing intense scrutiny. Starting in May 2025, U.S. companies that have manufactured PFAS in the U.S. or imported PFAS, or semi-finished or finished products containing PFAS between 2011 and 2022, will be subject to a reporting rule. Individual states are also starting to restrict the use of PFAS or require reporting. The scope and schedules vary significantly from state to state.

The materials in question for seals, such as PTFE and FKM, are high-performance materials: they have a long lifetime and a high temperature resistance; they are resistant to reactive media and resistant to wear. Freudenberg Sealing Technologies is currently evaluating whether there are alternatives to these materials in its products.

However, the company expects that there will be very few cases, if at all, where a 1:1 substitute is currently available that meets performance, service life, and other requirements for use in products. A substantial portion of the company's compound portfolio is already based on FKMs produced without the use of fluorinated surfactants or manufacturing aids. The remaining portion of compounds will adopt the new technologies.

Hydrogen-emergent applications. Another notable example of how micro components are driving technological innovation can be found in hydrogen-emergent applications, particularly in the hydrogen production process through electrolysis. In this context, Freudenberg Sealing Technologies plays a pivotal role by providing advanced sealing solutions for electrolysis stacks. These stacks utilize electricity to split water into hydrogen and oxygen—a process that takes place within a specialized unit called an electrolyzer.

The demand for precise and reliable seals in these systems has spurred the development of a broad range of sealing solutions, including O-rings, gaskets and integrated 2K-component sealing products. Freudenberg Sealing Technologies' ability to customize the design and material properties of these seals for the harsh and dynamic conditions of electrolysis applications has been crucial. The main objective is to effectively contain electrolytic liquid, hydrogen and oxygen, ensuring that each element stays within its designated place throughout the process.

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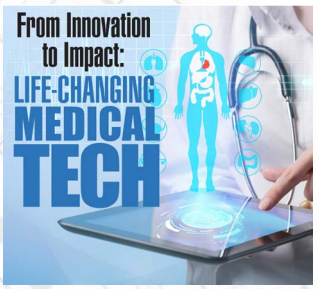


Courtesy Bio3DPrinting

CHAPTER 7:

3D Bioprinter Is Advancing Personalized Medicine and Tissue Engineering

SHARON SPIELMAN, Technical Editor, *Machine Design*

Electrospider from Bio3DPrinting is shaping the future of bioprinting, tackling challenges like vascularization, and navigating regulatory landscapes.

In a press conference held at 3D Experience World in Houston (Feb. 23-26), *Machine Design* learned about the Electrospider from Bio3DPrinting. The company was spun off from Italy's University of Pisa, where Roberto Rizzo, president of Solid World SRL, a distributor of Solidworks and user of 3D Experience, saw the potential in biomedical technology and the possibilities for bioprinting to improve patient outcomes.

Solid World has collaborated with the University of Pisa over the years, which has resulted in several innovative projects. These include the creation of the Electrospider, a 3D bioprinter capable of producing three-dimensional human tissues—reportedly, the first machine able to do so.

When *Machine Design* asked about the types of 3D printing technology that the Electrospider uses, we learned that its unique multi-tool print head synchronizes several bioprinting methods to create intricate structures with diverse biological materials.

Aurora De Acutis, president of Bio3DPrinting, explained the five different 3D bioprinting technologies:

1. **Extrusion of hydrogen.** This is a method that uses hydrogen for specific applications.
2. **Extrusion of thermoplastic material.** This allows for printing with materials that can be melted and shaped.
3. **Extrusion of thermal-sensitive materials.** This category includes cells and other biological materials that could be printed at controlled temperatures.
4. **Extrusion of photosensitive materials.** These materials can harden when exposed to certain light wavelengths.
5. **Electro sputter technology.** This is a unique feature of the Electrospider that dis-

Aurora De Acutis, president of Bio3DPrinting, and Roberto Rizzo, president of Solid World SRL, spoke with Derek Lane from Dassault Systemes' global programs and industries about the Electrospider bioprinter at a press conference held at 3D Experience World 2025.

Sharon Spielman

tinguishes it as the first bioprinter capable of combining electro sputter with other established printing technologies.

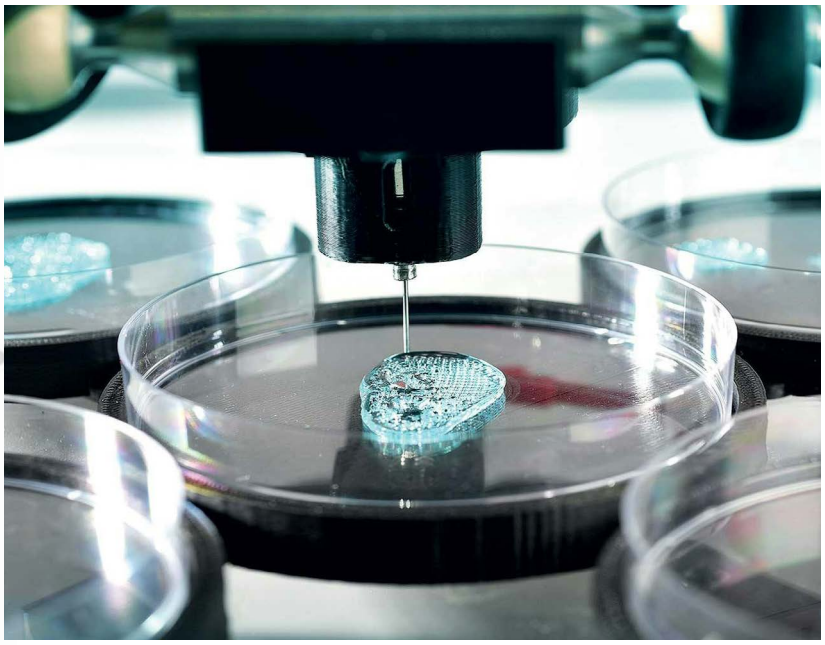
The ability to print multiple types of cells and materials represents a significant leap forward in bioprinting technology. De Acutis said the size of the printer is comparable to a refrigerator, and that its design was a challenge that was overcome using Solidworks design platform, allowing meticulous design and simulation processes that ensured seamless operation.

She also explained the bioprinter knows what to print using a structured "printer pipeline." It begins with medical imaging, where specific regions that need regeneration are identified. From there, a cast model is created. This model generates a logical file that can be adjusted to meet the requirements of the bioprinting technology being used. Once the file is ready, it is uploaded into the printer, which then operates autonomously without further intervention, beginning the printing process according to the provided instructions.

Applications for Healthcare

The Electrospider is primarily being utilized in oncology where it can replicate cancer cells for drug testing. This personalization of medicine allows for the customization of treatment to the individual patient's needs, aiming to significantly improve the efficacy of cancer therapies. The technology also has potential applications in treating genetic diseases, where traditional methods often fall short due to the limited size of the patient population for clinical trials.

De Acutis noted that one of the main hurdles facing the development of complete organs through bioprinting is ensuring proper vascularization, the network of blood vessels needed for tissue survival and function. While the Electrospider can currently print small tissue samples, De Acutis said, ongoing research aims to overcome the technical challenges of scaling



The Electrospider uses a unique multi-tool print head to create intricate structures with diverse biological materials.

Bio3DPrinting

up to entire organs, such as hearts or kidneys. The integration of vascularization algorithms into the design process is a key focus for future versions of the machine, Rizzo added.

Regulatory and Ethical Considerations

As bioprinting technology advances, so do the associated regulatory and ethical challenges. Companies and regulators face the complicated task of defining how bioprinted organs and tissues should be classified, whether as living or non-living materials. While some countries have begun allowing clinical trials with bioprinted tissues, much remains to be done globally to establish clear guidelines, according to De Acutis. “It’s not a technology issue,” she said. “It’s more [of an] ethical and legal [issue].”

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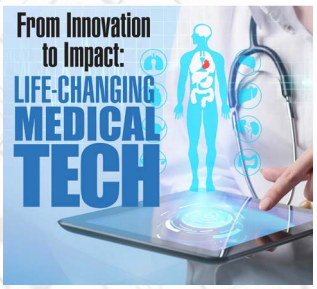

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CHAPTER 8:

Plastic Bearings Leader Talks Trade Show Triumphs and Tariff Troubles

REHANA BEGG, Editor-in-Chief, *Machine Design*

Felix Brockmeyer, president & CEO of Igus North America, a market leader in plastic bearings and energy chains, weighs in on tariff woes at MD&M West 2025.

Tariff and trade tensions between the U.S. and Canada was a major talking point when *Machine Design* visited the igus booth at the MD&M West Show in Anaheim, Calif. (Feb. 4-6).

There is no way to determine what the exact impact of tariffs could be on individual companies, but the consensus was the impact on industry as a whole could be rapid and significant.

Headquartered in Cologne, Germany, igus GmbH has branches in more than 35 countries, including the U.S. and Canada, Mexico, Brazil and China. For multinational companies like igus, the material impact to its established competitive advantage could be significant, according to Felix Brockmeyer, president and CEO of igus North America, who weighed in on how his company was strategizing its cross-enterprise response.

Scenario-based Planning is Crucial to Being Ready to Act

Overall, for the past four years, igus has actively worked to localize manufacturing by bringing its core production elements into three regional markets: Europe, Asia and the Americas, said Brockmeyer.

“One way or the other, the trends of deglobalization or the trends of being more national-focused was coming and we already knew that,” said Brockmeyer. “We’ve invested heavily to be independent. But the severity that we saw in the last couple of weeks surprised us as well.”

Making decisions have become nearly impossible, he said, “because every 24 hours there is different information out there. So, you react and then you slow down and then you react again.”

Preparation is a Work in Progress

Igus has been decentralizing its molding operations in North America for the past three years. Most of the components are manufactured in the U.S., Brockmeyer said. In addition, igus has worked on localizing raw material supplies and to be "somewhat ready" if European supplies are not available—regardless of whether that's due to tariffs or war in Europe.

Generational changes—engineering workforce leaving the workforce in Europe—have been a trend for about five to six years, said Brockmeyer, who immigrated from Germany and was appointed to the CEO role at igus Inc. in October 2022. "The knowledge is disappearing in Europe, and we need to rebuild it here," said Brockmeyer. "With a little bit of foresight, we started that."

Still, the igus team was not fully prepared for the political tensions between the U.S.-Canada-Mexico, according to Brockmeyer. The company has a large team in Mexico and in Brazil with production and warehouses. "Last year we ramped up storage in those locations," he said. On the Canadian side, igus has an office in Toronto and 30 people in the field.

"Just this morning we had multiple customers come by that are feeling pressure to now, within 30 days, spin up certain production operations in Canada and not be at risk of potential tariff conflict," pointed out Brockmeyer. "We are supporting this with immediate meetings. We're setting up calls and meetings from here on the show floor. Our team in Canada is standing by. We're feeding them information."

Brockmeyer added that igus has the luxury to source inventory from Europe into Canada, should supply from the U.S. into Canada become difficult. "We have a variety of footprint options, but you have to be very, very quick," he said. "The No. 1 question I got this morning is, 'do you have these robots in inventory?' This is usually not a question I get because people have more time. Time, all of a sudden, is something that they don't have."

For Brockmeyer, the big worry for delegates visiting his booth was localizing supply chain—either from Canada into the U.S. or the U.S. into Canada. "It surprised us all."

Felix Brockmeyer's Quick Overview of What igus Brought to MD&M West 2025

During the quick meet-up at the Igus booth at the MD&M Show 2025, *Machine Design* asked Felix Brockmeyer, president of Igus North America, for a two-minute overview of what the motion plastics company brought to the show.

Machine Design: **What's the main theme or focus of the booth?**

Felix Brockmeyer: "Enjoyneering" is once again the focus of the booth demonstrations. We show all our products that enable motion without lubrication, sustainable motion. On the automation side, we're introducing a virtual community where automation engineers can learn from each other and learn from our experts in a virtual community style."

MD: **Why does igus exhibit at the MD&M West?**

FB: At the MD&M West show, especially with the MedTech side, we're showing off 3D printing capability and rapid prototyping capabilities. The materials are FDA compliant and can also be 3D-printed, machined and lend themselves well to prototyping.

We've had a lot of interest also in powder coating material. We have an FDA-compliant powder coating material, and FDA compliance material for wear resistance. So, that's a big focus on that side.

We have our cleanroom cable solutions that we always show on top of that. We have a lot of pick-and-place operations that we started on the medical side where our low-cost automation really is a is a good player.

MD: **Igus is a leader in motion plastics. What can you tell us about your mechanical components, for example, bearings, at the booth?**

FB:I would say there are two areas there. We have our bushing side, which is really for pivoting and slow motion, and then we also have plastic ball bearings that are constructed from the self-lubricating clean material.

We have brought our Xiros product line, which is often used in medical devices. It is washdown capable, FDA compliant.

On the bushing side, we operate with roughly 72 different raw materials that, given the environmental circumstances, we can pick and choose temperature, chemical resistance, load and so forth. We have a lot of variety when it comes to varying and pivot points.

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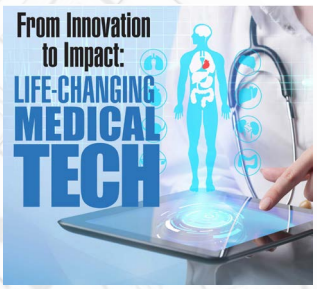

Courtesy Ascential

CHAPTER 9:

Q&A: Internet of Medical Things: How Ascential Supports the Medical Devices Industry

REHANA BEGG, Editor-in-Chief, *Machine Design*

Anupam Girdhar, divisional CEO of Ascential Medical & Life Sciences, discusses the role of digitalization in shaping MedTech manufacturing, hardware-software integration and tariff implications.

Medical equipment and devices play an essential role in most patient interactions. The MedTech industry is driven by evolving regulations, digital transformation, data analytics, artificial intelligence, automation and the shift toward value-based healthcare.

The United States remains the world's largest medical device market, leveraging strengths in microelectronics, telecommunications, instrumentation, biotechnology and software development to maintain a competitive edge. Analysts project the U.S. market is expected to experience a steady growth rate of 5.19% annually (CAGR 2025-2029), pegging the market volume of $233.51billion by 2029. In 2023, U.S. medical device exports surpassed $103 billion, highlighting the industry's global impact and ongoing growth.

These factors hold resonance for Anupam Girdhar, divisional CEO of Ascential Medical & Life Sciences, a company that combines advanced automation with deep-bench expertise in medical device assembly and complete commercialization services.

Editor's note: The following Q&A has been condensed and edited for clarity.

Machine Design: **How is Ascential supporting the medical devices industry in managing data?**

Anupam Girdhar: We have started an initiative called Ascentialytics. It's a software platform that we developed in-house. There are several ways in which we are employing it for helping our customers. The first thing is we use the software to collect the right information from our various tools, instruments, devices and so on. [Part of it] is just as simple as building dashboards, but the real interesting part starts when our Ascentialytics software, which is the intelligence inside, ends up analyzing all this information to improve

the reliability, the productivity, the yield for the customer.

When we produce the physical product, we have started to embed the Ascentialytics in it so that customers can have a much more reliable product and solve various [tasks] that the product is intended to do.

MD: **Can you discuss the long-term influence of embedded systems? We're seeing the growth of hardware-software integration—that is, linking the physical components of a device with the software that controls its functionalities. Will software ever replace hardware or mechanical components?**

AG: What's happening is that we are adding [software] to our large machinery and so on. However, if you look at something very simple, such as a CGM (continuous glucose monitor) or even a simple sensor that goes and sits in a vein as an implant, you now don't need this big honking blood pressure machine. You don't need a temperature monitor. You don't need something to prick your finger with and so on. Suddenly, with one tiny sensor, you've got all that information, and you've replaced three big [mechanical] devices.

I think that is fascinating because both miniaturization and the sensor detection capabilities bring together the replacement, which reduces the footprint of the factories, which reduces steel consumption, which reduces so many things that I think you're going to see a very different, different industry in 15-20 years.

MD: **Shawn DuBravac, Ph.D., CFA, delivered a keynote at MD&M West 2025 in which he suggests that industry is going from digitization to datafication. Can we talk about the quality of data and how you're working to consolidate good information, valuable information?**

AG: It's a fascinating topic. I live in San Francisco and I just see so much good stuff happening. It's a pity that sometimes we get worried about the FDA regulations and so many other things that go on in healthcare that these things become a little bit of an afterthought.

But now the idea of pulling out the data from an instrument, which is a treasure trove, provides so much information. In the past, you would not even pull out those signals. And even if you pull those out, we would not have the right means to develop the pipeline of that data and store it and then, more importantly, do something with it.

So, we have made good progress in terms of making our instruments data ready. Just like you had in the olden days, design for manufacturing and so on, now it's more likely "Design for Data" and "Design for AI," so that your instruments are capable of at least spitting out the data. And once you have that, then you can do meaningful use cases.

For example, if you see failure rates that are very high in a certain instrument, you now know exactly how to pull that data out. And in fact, that's being collected in real time, but then, how to analyze it and how to pinpoint the issue.

You can even have images, where the camera is taking images, and you see immediately that there's something wrong in a certain image. And now the AI can read what's going on based on the recurring usage.

I'm very excited about the phase we are in because now it's time to take that data and use it for something productive.

MD: **It's changing the business model, too. With AI, you have new opportunities for the product itself—whether it is a measuring instrument, whether it's [a] wearable device—to completely transform the way businesses go to market. Talk a little bit about what happens behind the scenes.**

AG: If you think of how these products are developed from concept all the way to produc-

tion, some of it is how we design these products—like using this data and feeding the user requirements—and how it's actually used in the field, at what temperature and what use case. That is the one idea that we start to bake in early in the design.

But once the product is being developed, there is so much that we can do with digital twins as well as the way we apply the data to increase the reliability of the process, as well as make sure that the yield improvements are there at the end of the process. And then finally, when the product is in the market, using this data to for better usage of the product and to enhance its use cases.

I have been trying CGM. Not that I needed it, but I just wanted to try it. I'm fascinated at how data has modified my behavior towards food. So, I think it's just the starting point for a lot of these kinds of use cases.

MD: **You've touched on how automation can spur the growth in personalized medicine. For Ascential, what are some of the big challenges that you have to face in 2025?**

AG: I think a couple of challenges have become much more intense this time. For example, the increase in productivity. I think making sure that the costs are lowered, that's become very important. One is, you saw the inflation, right? That's hurting the margins of companies.

Second is the shortage of labor. The employment rate is good, but at the same time that makes it difficult to find the right people, which in one way encourages automation. So, that's the other challenge—that we have both to find good talent for our own companies, but then also address customers' challenges around a dearth of labor.

The third challenge, I would say is the unpredictability around the global environment. So for example, you probably heard a lot of experts talking about what tariffs will do, but it's anybody's guess because it's such a complicated world. While somebody who may be making things in U.S. may feel that may be good—and it may actually be good for them. But there are repercussions in terms of how our customers' demand will pan out. If our customers are more skewed to countries that have tariffs, their demand will slow down, which will impact us. So, it's going to be pretty complicated to unwind all this. But from our side, what we can do is just be ready for that.

MD: **And what does that mean?**

AG: So I'll tell you a little bit about the strategic discussion that we are having at our end. And I'm sure the entire industry is having those right now—these strategic plans, reviews and updates based on this.

Firstly, I think if we keep the customer in front of us in terms of as an example, we one of our value propositions for our customers is proximity. We are located in Minnesota. We're located here in Oregon, in San Diego, Costa Rica, Ireland, Malaysia and Singapore.

The whole point is that wherever our customers need us, we are there. If customers shift their demand from one place to another, we are making sure that we have the right systems, processes, supply chains to serve them there. I don't know how the tariffs will shift the demand, but what I know is whatever it does, at least we'll be ready.

So that's one. And then the other thing that we are doing is we are making sure that we are reevaluating our supply chain. If something like that happens, which is much more detrimental to our business, we have backup supplies to take care of. So those are a couple examples that we are taking care of.

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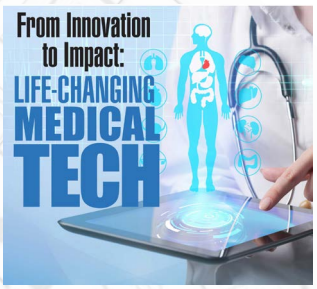

Bosch Rexroth

CHAPTER 10:

Bosch Rexroth Expands VarioFlow Conveyor System with Belt Variant

SHARON SPIELMAN, Technical Editor, *Machine Design*

The modular conveyor system aims to empower medical device manufacturers to achieve a high throughput, especially for transportation of oversized and bulk materials.

Bosch Rexroth's addition to its comprehensive VarioFlow conveyor system is designed for the smooth transport of fast-moving consumer goods (FMCG), pharmaceuticals and healthcare products.

Its modular belt chain features a fine-meshed surface that is almost completely closed and flat, which enables the mass transport of unstable or bulk film-packed products, like small sealed-edge bags, as well as larger items, such as packs of paper towels or toilet paper. The system is versatile enough to handle products that are inherently stable, even allowing for sideways protrusion in horizontal sections.

Customization and Modularity

The belt conveyor has standard modular belt widths of 406 mm and 608 mm, with scalable cross connectors that enable system integrators to customize belt widths using identical components. The basic elements of this modular system include the base unit for the drive, a return unit, section profile and both vertical and horizontal curves. This design allows for conveyor lengths of up to 30 meters and speeds of up to 40 m/min, all powered by a single drive.

The VarioFlow plus and VarioFlow belt share identical system components such as product guides, leg sets and drive kits. This modularity aims to streamline inventory management and simplify maintenance.

Streamlined Configuration with MTpro Software Tool

The company's free and intuitive software, MTpro, supports users throughout the entire process—from selection and configuration to the ordering of Rexroth products. The Layout Designer within the software tool enables users to create complex constructions and system layouts. Additionally, the integrated evaluation function facilitates a thorough design check, eliminating the need for third-party assessments and further reducing engineering times.

Machine Design wanted to learn more about the particulars, so we reached out to Krupa Ravichandraan, sales product manager, VarioFlow plus & ACTIVE Shuttle, and TJ Tatum, digital sales specialist, Bosch Rexroth.

Editor's Note: Questions and answers may have been edited for style and clarity.

***Machine Design*: What are the implications of the conveyor's speed capabilities on production throughput, particularly for bulk and oversized medical device packaging?**

Ravichandraan Krupa

Ravichandraan Krupa: VarioFlow Belt can currently run at a maximum speed of 40m/min., which empowers medical device manufacturers to achieve a high throughput especially for transportation of oversized and bulk materials.

Due to the flat modular plastic chain design with interlocking belt modules, medical device packages will be transported safely without any damages, which reduces number of rejected products and thus increases production quality throughput. This belt design allows transportation of flexible packages with uneven surfaces and packages with small attachments or protrusion without any hazard of catchpoints and damages, thus reducing equipment downtime and product waste.

Due to the chain, drive unit and slide rail design, a single drive unit can pull a maximum of up to 30 m or around 100 ft. of chain which means customers will have [a fewer] number of motors per mile of conveyor, which is a huge cost saving when miles of conveyors are used in a factory floor to transport packages. This also translates to less inventory of motors in stock, less maintenance, and more energy savings.

The load capacity is 8.8 lb./in. across the width of the conveyor. Bulk or mass flow of products is possible on the 420 mm (16 in.) and 622 mm (24 in.) wide conveyor systems. Flat chain design allows for large and wide products to overhang from the conveyor without the need for wider chains and larger motors. Custom width options are also available.

The VarioFlow Plus conveyor can run at a maximum speed of up to 120 m/min. (390 ft./min.) for special applications and up to 60 m/min. (200 ft./min.) for standard applications. One of the fastest conveyors in the market to reliably transport delicate products safely without any damage.

***MD:* Can you elaborate on the features of the MTPro software and how it aids in the configuration and engineering of the VarioFlow belt conveyors?**

RK: The software allows the usage of macros to draw conveyors quickly, a stretch command to see three orthogonal levels, the ability to create leg sets and add lateral guides, and a chain tension calculator for system layout.

MD: **How does the integration of smart design features in the VarioFlow system facilitate quicker assembly and installation?**

RK: The VarioFlow Belt conveyor design features modular framing construction that allows for easy and quick assembly. Width of the conveyor can be modified by changing the cross-connectors connecting the two side frames of the conveyor and by adding or removing support profile in between. The modular belt chain is made of small belt modules that are interlocked through a single pin that makes it easy to assemble chain or modify the chain width. With little training, VarioFlow Belt conveyor can be built from zero to completion in a matter of hours for a relatively small conveyor system.

Disassembly of chain is easy, as well. There is no need for any special equipment to disconnect/remove the chain. When the conveyor is stopped and safe to work, lift the chain slightly and use a screwdriver to remove the pin connecting the chains modules to disconnect the chain for any maintenance activities. It is equally convenient to disassemble modular conveyor framing to change conveyor width to retrofit if needed.

Drive and return kits are configurable with stainless steel side frame designed to support the gearmotor kit. Rexroth supplied gearmotors allow for easy change in orientation of motor in the field, if necessary, without having to modify gearbox oil or entering a new part number for new orientation.

Leg sets are made of MGE profiles with aluminum or stainless-steel construction. This allows for quick and easy assembly and elevation changes. The framing has t-slots to attach guide rails mounts, sensors, stops and other accessories easily.

MD: **What feedback have you received from engineers and system integrators regarding the usability of MTPro, and how have those insights influenced recent updates or improvements?**

TJ Tatum

TJ Tatum: Overall, the feedback has been incredibly positive. MTPro has helped reduced design time, quickly generate a bill of materials and provide a CAD output.

The MTPro macro “handle” features allow users to quickly draw a system. Leg sets and guide rails can be easily added with a simple click of a button.

MD: **Can you discuss any case studies or applications where the VarioFlow conveyor has significantly improved operational efficiency in medical device manufacturing?**

RK: There was this application where VarioFlow was used to transport medical device optical products. Due to an NDA, we cannot share the name of the customer or the product. The customer was using manual loading, manual unloading, offline inspection stations and inefficient conveyors taking up majority of the floor space before they approached Rexroth.

Rexroth reviewed the requirements and developed an efficient solution, which allowed optimal flow of materials across the workstations, reduced the number of motors required, optimized floor space for workers by using overhead conveyors and created space for worker connectivity.

VarioFlow Plus conveyor design allowed a smooth flow of products with less friction, minimized catchpoints, and thus reduced downtime due to unplanned interruptions in material flow.

The conveyor has been running for more than a decade with the original conveyor frame even today. All that the customer had to replace was the chain links, slide rails, etc. as necessary.

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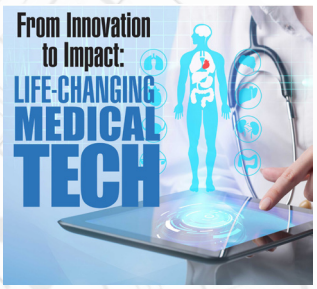

Sharon Spielman

CHAPTER 11:

Breakthroughs in Medical Manufacturing: Highlights from MD&M West 2025

SHARON SPIELMAN, Technical Editor, *Machine Design*

The MD&M West Show in Anaheim, Calif., brought together industry leaders to showcase the latest innovations in medical manufacturing. From high-power nano drives to advanced stainless steel applications and next-gen inspection solutions, these breakthroughs are driving efficiency, reliability and sustainability in the medical device industry.

The MD&M West Show, held Feb. 4-7 in Anaheim, Calif., showcased cutting-edge advancements in medical manufacturing technology. Industry leaders presented innovations in high-power drives, stainless steel applications and inspection equipment—all aimed at improving efficiency, reliability and sustainability. *Machine Design* was on-site to capture these demos.

Copley Controls' High-Power Nano Drive

Dean Crumlish, senior applications engineer at Copley Controls, introduced the company's latest high-power nano drive, a significant leap in performance with 100 amps RMS and 140 amps peak, up from 35 amps. Designed for large motors and advanced robotics, the drive features:

- Compact, lightweight design
- Advanced thermal management
- High efficiency (99%) and REGEN output
- Compatibility with AC and DC power sources Crumlish emphasized its use in medical robotics, AGVs and brushless DC motors, with modular designs available for OEMs to ease integration and reduce costs.

Eagle Stainless: Pioneering Stainless Steel Applications

Robert Bubencik, Jr., president of Eagle Stainless Tube and Fabrication Inc., highlighted the company's expertise in stainless steel tubing for medical applications. Eagle Stainless specializes in:

Sharon Spielman

- Small-diameter tubing
- Just-in-time deliveries and Kanban systems
- Custom fabrication, including bending, welding and laser wire EDM

Bubencik also discussed the benefits of 300 series Austenitic stainless steels (metal structure is obtained primarily by adding nickel)—particularly their biocompatibility, recyclability and versatility. With 100% recyclability, these materials align with the industry's growing emphasis on environmental sustainability.

Cognex Corporation's Next-Gen Inspection Solutions

Eric Hershberger, principal applications engineer at Cognex Corporation, showcased the latest in inspection technology, demonstrating:

- **DataMan 290:** A next-gen barcode reader with a user-friendly interface
- **L38 3D Head Laser Camera:** A factory-calibrated inspection tool with edge learning capabilities
- **3801 Camera:** High-speed inspection processing
- **475 Verification System:** Ensuring barcode readability for ISO compliance
- **Low-Cost Vision Sensor:** A simple, real-time evaluation tool for production lines These tools enhance quality control in manufacturing, ensuring precision and efficiency.

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