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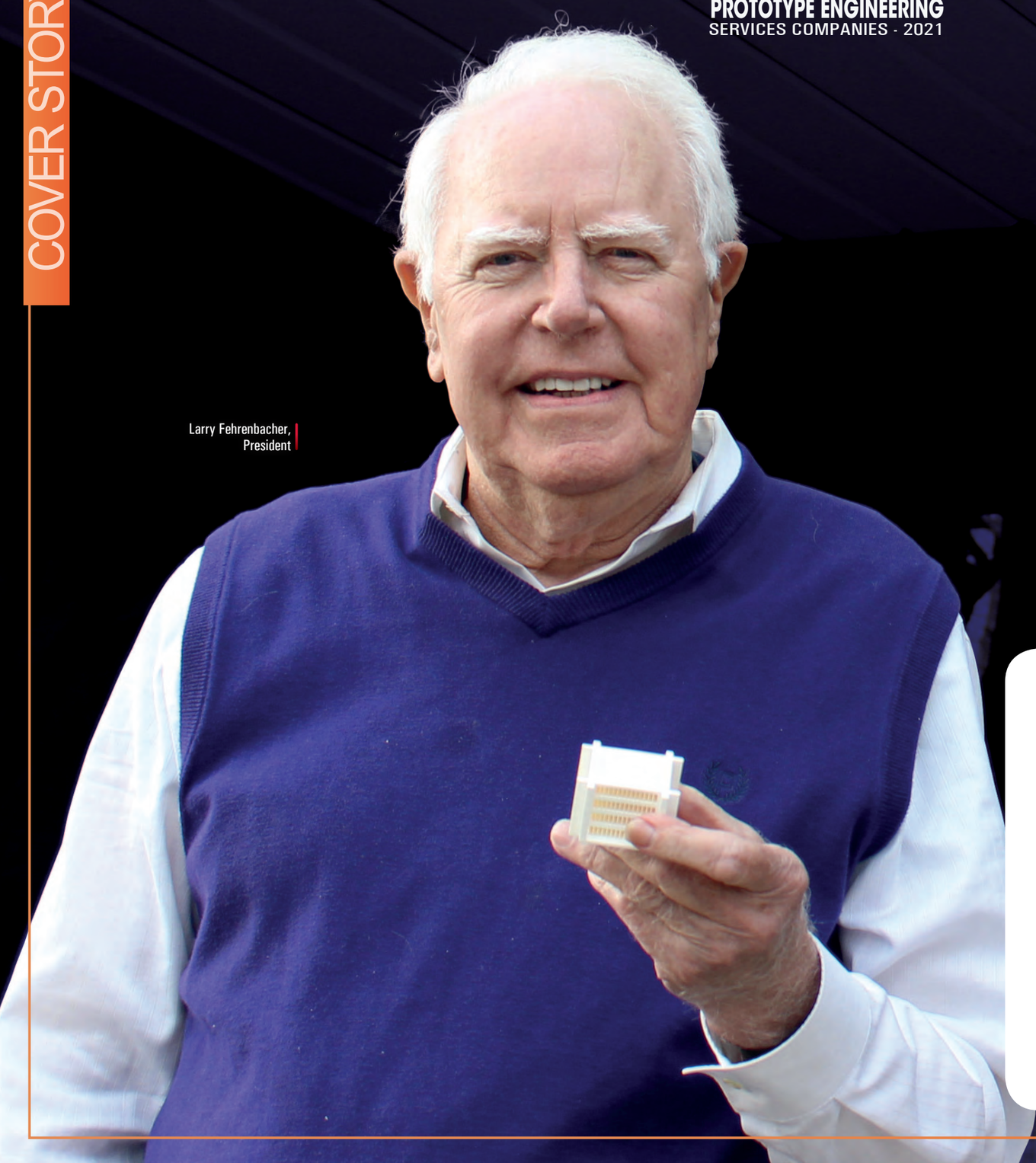
MANUFACTURING TECHNOLOGY INSIGHTS TOP10
PROTOTYPE ENGINEERING
SERVICES COMPANIES - 2021



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ADDITIVE MANUFACTURING PROTOTYPING AND PRODUCTION FOR NEXT-GENERATION APPLICATIONS

Dr. Larry Fehrenbacher, president of Technology Assessment & Transfer, Inc. (TA&T), dedicated 20 years of his life to strengthening the technical capabilities of the U.S. Air Force as an active duty military officer. While he gained immense knowledge, skills, and experience as an advanced materials researcher and technology manager in the Air Force, his passion for sports played the seminal role in carving a visionary leader out of him in the Additive Manufacturing (AM) arena. As a successful player/coach for Air Force and Armed Forces Basketball Teams, he acquired values that he carries to this day. Getting the fundamentals right, extracting top performance from his team, treating each player differently to optimize individual and team performance, and employing new methods to outplay the opponent were his keys to success.

He and his wife Sharon founded TA&T in 1983 to develop advanced materials and technologies and get them out of the laboratory environment into the real world. Subsequently, Fehrenbacher has used these sports-related qualities to tackle the roadblocks in turning lab research into tangible products and services across aerospace, defense, energy, and medical industries.

"When TA&T started 3D AM work in 1995, I decided to focus on the development of functional ceramics instead of mere plastic-based prototypes," says Fehrenbacher. TA&T has emerged as a photopolymerization AM specialist that develops unique and diverse ceramic components. The company has pioneered several ceramic formulations by adroitly blending specific polymers, various ceramic powders, dispersing agents and UV catalysts to facilitate rapid prototyping and production of advanced ceramic products.

One of the major advantages of using TA&T's technologies is the marked reduction in time and cost in bringing new products to market. TA&T's implementation of Digital Light Projection (DLP) photopolymerization technology enables rapid turnaround of prototype designs that speeds up functional testing and new

product introduction. Another unique advantage includes the prototyping and production of intricate small components that cannot be manufactured by conventional processes. A significant TA&T example was the AM fabrication of the complex ceramic NASA Heater housing for the Sample Analysis Module that is currently analyzing soil chemistries for Mars Rover Curiosity.

In summary, the key advantages of DLP AM are lead time savings for new designs, high resolution feature size and dimensional accuracy, design freedom, cost savings due to tooling elimination, shorter development cycles, and low volume production savings especially with complex parts.

ONE OF THE MAJOR ADVANTAGES OF USING TA&T'S TECHNOLOGIES IS THE MARKED REDUCTION IN THE NUMBER OF DIVERSE COMPONENTS THAT NEED TO BE DEVELOPED SEPARATELY

TA&T has carefully knitted a string of services around rapid prototyping and additive manufacturing to meet the end-to-end needs of its clients for production and process innovation. The services include material characterization and processing as well as consulting services that meet clients' material requirements. The company has kept its services attractive and beneficial by walking in lockstep with the evolving technology landscape. It has consistently expanded into new areas of emerging technologies via government funded R&D contracts and unique private sector customer applications.

Setting the Foundation for Highly Efficient Aerospace & Defense

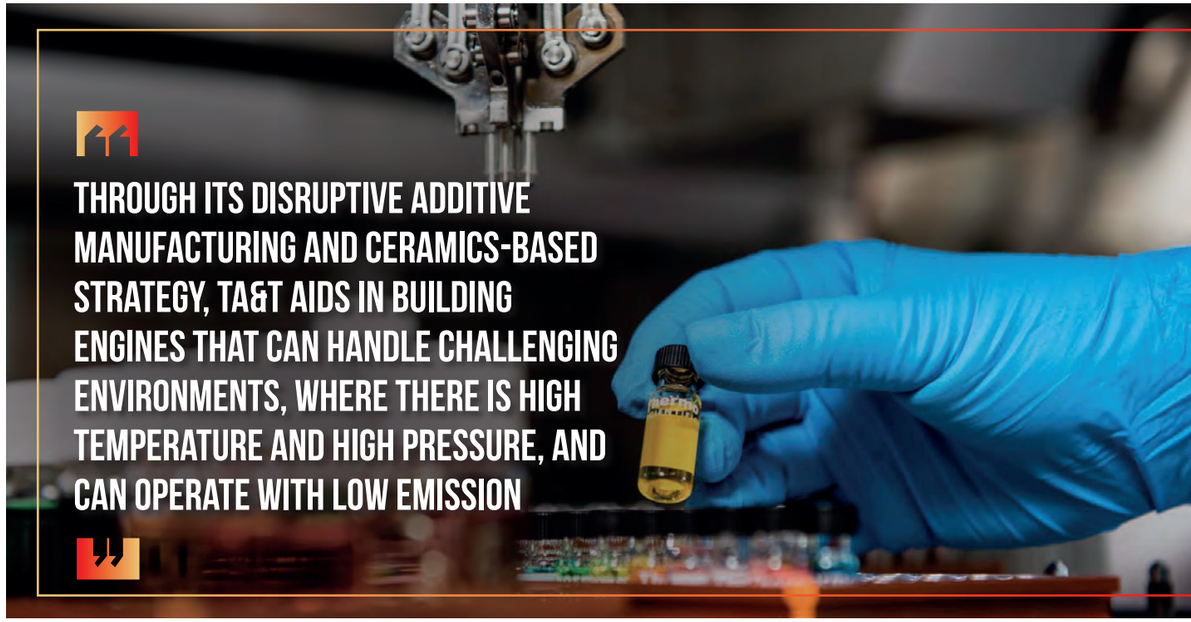
Fehrenbacher and his team are excited about the long history of joint innovation efforts and cross-licensing agreement with the manufacturer of aircraft engines and avionics, Honeywell Aerospace. The development of AM fabrication of Ceramic Cores with complex cooling holes that are used in molds for casting single crystal Turbine Blades was successful in achieving first article inspection. "We couldn't be prouder of our project with Honeywell where we were the industry-first to successfully complete first article inspection which sets the stage for production," says Fehrenbacher. Honeywell is mutually excited about the payoff of this DLP AM technology in reducing the time and resources for new blade designs that will generate new engine market opportunities. Another significant benefit for Honeywell and other OEMs is the DLP fabrication of blades for legacy engines whose drawings have been compromised or lost. By just taking a 3D image of the blades the same casting core can be built using AM without the costly, time consuming effort associated with new tooling.

In addition, there is a great amount of enthusiasm in TA&T and Honeywell as they continue efforts to push ceramic AM and advanced ceramics deeper into aerospace and defense product engineering and production. "The latest joint program is focused on the development of ceramic heat exchangers—something that Honeywell had been interested in for many years as an alternative to metal heat exchangers," says Fehrenbacher. The advantages over metal heat exchangers such as inconel include: higher thermal conductivity, better heat transfer, higher temperature operation and resistance to corrosive environments. AM enables fabrication of more complex designs with higher heat transfer and reduced volume, a capability that can't be achieved with conventional sheet metal fabrication. Successful culmination of this project will lead to production scale up with sizeable benefit for both Honeywell and TA&T.

A Stream of Innovations Underway

There are many active projects that TA&T is working on across industries. One of the key developments funded by the Department of Defense's combat logistics support agency, the Defense Logistics Agency (DLA), is AM fabrication of the ceramic core and mold in one piece for casting turbine blades. This is a disruptive technology since it will completely replace injection molding based tooling, which requires multiple parts for a core-mold combination. With respect to the healthcare industry, the National Institutes of Health is working with TA&T on AM fabrication of lithium disilicate and zirconia dental restorations. With this innovation, medical professionals can take a 3D image of the cavity and build the restoration directly to required dimensions in contrast to milling blocks of ceramics into the final dimensions. This project is being supported by the University of Maryland School of Dentistry that performs multi-dimensional measurements of the dense restotation parts and provides feedback on geometric accuracy and quality. A complete suite of mechanical property measurements is also underway.

Smith+Nephew, a medical technology company, is using TA&T's DLP technology to rapidly develop new, complex medical devices made out of ceramics. TA&T has been able to turn around multiple designs with dozen to hundreds of parts in a week for the company. Once the designs are finalized, the company goes into production using



conventional injection molding. Based on the production throughput advances with DLP technology, TA&T is discussing the possibility of limited production runs with medical device companies.

Another area that most organizations ignore is transparent ceramics. At present, TA&T is working on the AM of transparent ceramics for missile domes and lenses for targeting pods used on a military aircraft. TA&T is using spinel and transparent silica extensively in this pursuit, even as the company is excited about the growing demand for ceramics across industries.

"We get requests for special items almost every week," says Fehrenbacher. "Interestingly, researchers from the University of Michigan are developing the ceramics-based antennas for satellites both for military and commercial applications. TA&T's ceramic AM is an enabling technology and represents a potential breakthrough for these unique and complex designs.

Another major technology thrust area for TA&T, that does not involve AM at this stage, includes advanced Ceramic Matrix Composites (CMCs) and thermal-environmental barrier coatings (T-EBCs) for advanced turbine engine designs with new levels of efficiency, performance and operational cost benefits. There is a huge demand from large OEMs such as GE, Pratt and Whitney and Rolls Royce for these advanced materials. TA&T is currently working with GE on higher temperature CMCs and T-EBCs for CMCs to develop more fuel efficient, low emission engines.

Celebrating the Spirit of Commitment and Competence

The leadership's qualities of visionary thinking and attention to detail have enabled TA&T to bridge the gap between the laboratory and marketplace. "Our values are powered by world-class research, development and prototyping capabilities; manufacturing for low to medium-volume defense and aerospace markets; and material and process technologies licensing to high-volume manufacturing companies," adds Fehrenbacher.

Fehrenbacher attributes the company's success to the committed and talented team that has pulled out all stops to meet the client requirements and deadlines. "They have gone beyond the expectations to make sure we achieve our R&D goals and deliver products on time if not earlier," says Fehrenbacher. "I am so grateful for their persistence and a win-win attitude."

Drawing lessons from his coaching experience, Fehrenbacher leads a team in which individuals are strongly connected with each other and are driven by honesty and hard work. The team is skilled at turning every risk into a successful opportunity. With such a team, Fehrenbacher rides the rapid prototyping and AM tide using DLP photopolymerization's bright future as the applications and demands grow. Other areas primed for growth are high-temperature Ceramic Matrix Composites and T-EBC coatings for turbine engines, rocket propulsion, hypersonics, and other high-temperature applications. This is only the beginning of what can be achieved through rapid prototyping and AM, and TA&T envisions helping more organizations adopt these technologies and stay at the leading edge of innovation.