Issue 9 | 2023/Q3

AM CHRONICLE

Asia Pacific | India | Middle East | Africa

3D Printing Voice of the Region

FEATURE ARTICLE

Landscape of Additive Manufacturing in Middle East

Middle East Focus

Rethinking Manufacturing with Large Scale Additive Manufacturing at Al Seer Marine

Sustainability

3D Printing as an enabler of Sustainability

Construction 3D Printing

Concrete 3D Printing for Mars Habitat

www.amchronicle.com

PUBLISHER

CNT Expositions and Services LLP
126 A, Dhuruwadi,
A. V. Nagwekar Marg,
Prabhadevi, Mumbai - 400025,
Maharashtra, India.
Tel : +91 22 2430 6319
E-mail : editor@catnewtech.com
www.amchronicle.com

CO-FOUNDERS

Dilip Raghavan
Aditya Chandavarkar

EDITOR

Aditya Chandavarkar

EDIT & DESIGN

Amol Thakur

ADVERTISING

Ankush Matai
+91 22 2430 6319
marketing@catnewtech.com

SUBSCRIPTION

The AM Chronicle Journal is a quarterly publication in the digital format (and in print format upon request). No charges are levied for subscription. However, this is subject to change at our discretion, without prior notice.

EDITORIAL

Emerging Additive Manufacturing in the Middle East

The landscape of additive manufacturing is dynamic and always changing with the advent of new technologies, materials, applications and opportunities. The Middle East region has progressively embraced AM technologies, creating opportunities for innovation and economic growth across diverse sectors. The Middle East Additive Manufacturing Market is valued at USD 0.20 billion in 2022 and is expected to reach USD 1.06 billion by 2030, with a CAGR of 22.9% from 2023 to 2030. This special issue of AM Chronicle is dedicated to growth of Additive Manufacturing in the Middle East, highlighting various aspects of technology in the region.

This year, we are also hosting the first edition of AM Conclave Middle East in Abu Dhabi on 13-14 September 2023. AM Conclave Middle East brings together industry leaders, researchers, policymakers, and entrepreneurs under one roof and acts as a catalyst for collaboration, meaningful discussions, and catalysing the growth of AM in the region. The two-day conference and showcase has participants from over 15 countries, 25+ global speakers, and more than three hundred international delegates.

In line with our commitment to providing business insights into additive manufacturing, AM Chronicle has played an essential role in highlighting the unique developments within the Middle East AM landscape. Our special content series on AM Chronicle highlights the Middle East's regional landscape and technological development. Moreover, we have also introduced the AM Chronicle Middle East Newsletter—a platform designed to keep our readers abreast of the latest trends, breakthroughs, and opportunities emerging from the Middle East.

This issue 9 of AM Chronicle discusses articles on additive manufacturing in the Middle East. "Concrete 3D Printing for Mars Habitat" discusses the scope of construction additive manufacturing for space. "How Metal Additive Manufacturing is Reshaping Aerospace, Medical, and General Engineering" offers a comprehensive outlook on the application of metal additive manufacturing in diverse sectors. Additionally, the article "Innovative Advances in Additive Manufacturing by the Technology Innovation Institute (TII)" discusses some of TII's research and contributions in additive manufacturing.

As the Middle East region embraces innovation, collaboration, and the power of technological advancement, we witness a future where AM plays a pivotal role in shaping industries, economies, and aspirations. Through the pages of this edition, we attempt to showcase the progress achieved and the potential yet to be unlocked.

Aditya Chandavarkar
Co-Founder - AM Chronicle

ADVISORY BOARD

Dr. Alexander Liu
Head Additive Manufacturing Programs - Asia Region, ASTM International

Dr. Jayaprakash Jaganathan
Professor,
Vellore Institute of Technology

Dr. Sastry Y Kandukuri
Global Practice Leader - Additive Manufacturing, DNV

Dr. Satya Ganti
AM Materials Science Team Leader, Baker Hughes

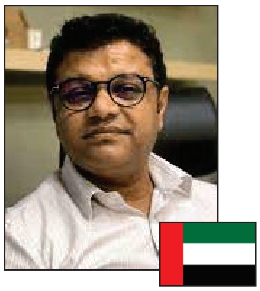
Manoj Pillai
AVP Commercial, AM
Falcon Technologies International LLC

Vaman Kulkarni
Freelance Consultant, Ex Director- Honeywell Technology Solutions.

Ahmed Adel
CEO
Mogassam 3D

Dr D Kesavan
Assistant Professor
IIT Palakkad

Benjamin Moey
Managing Director
I2Mavericks Holdings Pte Ltd



Suneel Kashyap
Director
LAYERX 3D Printing

Dr Ajay Kumar
Assistant Professor
IIT Tirupathi

Ankit Sahu
CEO and Founder,
Objectify Technologies Pvt Ltd

CONTENTS


TII
Technology
Innovation
Institute
CREATING NEW OPPORTUNITIES FOR YOUR TOMORROW
At Technology Innovation Institute, we are pushing the boundaries of applied research with the real world of tomorrow in mind. We are making a difference to the future the UAE and our planet by working at scale and at speed across ten research centers. We work with excellence and curiosity. We don't simply ask 'why?', we ask 'why not?' and 'what if?'.
From state-of-the-art facilities in Abu Dhabi to global partnerships. We catalyze change in the fields of alternative energy, advanced materials, autonomous robotics, biotechnology, cryptography, digital science, directed energy, propulsion and space technologies, secure systems and quantum engineering.
Discover more about the vital questions we're asking at tii.ae

Landscape of Additive Manufacturing in Middle East

Aditya Chandavarkar

Outlook of Additive Manufacturing Technology in the Middle East

In recent years, the Middle East has witnessed a surge in the adoption of additive manufacturing (AM), across various sectors. From healthcare and dental applications to aviation, defense, oil, gas, energy, and beyond, the region is experiencing a transformative shift driven by the potentials of this revolutionary technology. This article delves into the insights and advancements observed in different industries across the Middle East, highlighting the role of AM in shaping a new era of innovation and growth.

Notable Additive Manufacturing Advancements in the Middle East

In Middle east several Government and Private initiatives have been taken to forward the additive manufacturing technology in the region. The UAE government has put programs in place to encourage additive manufacturing's adoption and growth because it realizes the enormous potential of the technology.

The Dubai 3D Printing Strategy and the Dubai 3D Printing Strategic Alliance are two notable government efforts. His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai, announced the Dubai 3D Printing Strategy in 2016. In accordance with the strategy by 2030, Dubai plans to become the top 3D printing metropolis in the world.

Minister of Industry and Mineral Resources, Bandar I. Alkhorayef at NAMI's center of additive manufacturing

In order to take advantage of the possibilities of this cutting-edge technology, Austria and the United Arab Emirates (UAE) have worked together to develop partnerships in additive manufacturing. These initiatives show a shared dedication to technical innovation across diverse industries. His Highness Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum, the Crown Prince of Dubai, announced in 2020 the formation of the Dubai 3D Printing Strategic Alliance (DPSA), a government-led effort. To hasten the uptake and application of 3D printing technology, the DPSA brings together governmental organizations, academic institutions, and 3D printing businesses from around the globe. Other notable initiative is the opening of the Emirati 3D Printing Center of Excellence by Tawazun Council represents a significant development in the UAE's pursuit of cutting-edge technology. The center intends to maximize 3D printing's potential across a range of industries, with an emphasis on aerospace and defense.

Over the past few years, Egypt has seen a steady increase in the use of additive manufacturing. The additive manufacturing industry in Egypt is seeing impressive growth and potential thanks to technological advancements and a rising interest in innovation. An ever-evolving example of application of additive manufacturing is medical 3D printing. This is assisting in raising the standard of medical care in Egypt. Metal additive manufacturing has been used by the Egyptian British Bureau for Additive Manufacturing Services (EBBAMS) to meet a variety of medical industry requirements.

The National Research Centre (NRC) is a government-funded research organization that is actively engaged in 3D printing research. A group of researchers at NRC are creating 3D printing technologies that can be applied in numerous sectors of the economy.

Saudi Arabia has started a quest to adopt this cutting-edge method of production after realizing the enormous potential of additive manufacturing. The market for 3D printing is expected to rise from its current estimated value of $58 million to $134 million by 2025, at a rate of 18% annual growth, according to Invest Saudi. Bandar Al-Khorayef, Minister of Industry and Mineral Resources, spoke at a panel discussion on "Dealing with the Unpredictable Economic Consequences of 4IR Technological Progress" during the second LEAP Tech Conference, which had the topic "Into New Worlds" and was held in Riyadh. Introducing its cutting-edge additive manufacturing facility, NAMI, a major innovation-driven firm in Saudi Arabia, has demonstrated the Kingdom's dedication to digitization and industrial advancement. under the sponsorship of Bandar I. Alkhorayef, Minister of Industry and Mineral Resources, and H.R.H. Prince Abdulaziz bin Salman.

A Center of Excellence for Additive Manufacturing has been established by KACST, a national research and development agency. The Saudi Arabian Ministry of Investments has given Immensa Technology Labs permission to use additive manufacturing. The National Industrial Development and Logistics Program (NIDLP), which prioritizes industry 4.0 with industrial 3D printing and attracts foreign companies like Immensa to the Kingdom to localize advanced manufacturing technologies, and "Vision 2030" are both in line with this license, which is the first of its kind to be granted in Saudi Arabia.

Turkey has emerged as a key regional player in additive manufacturing for Middle East with a growing focus on industries like aerospace, automotive, and healthcare. The country's commitment to technological advancement is evident through initiatives such as the "Turkey's 2023 Vision," which emphasizes the development of high-tech industries, including 3D printing.

The Oman's government's "Oman Vision 2040" outlines a strategy to diversify the economy, with AM playing a crucial role. The country is investing in research centers and educational programs to nurture a skilled workforce capable of harnessing the potential of 3D printing.

Qatar is mainly utilizing additive manufacturing to reshape its construction sector and beyond. The government's "National Vision 2030" emphasizes sustainable development and economic diversification, with AM contributing to these goals. Additionally, Israel's reputation as a technological powerhouse extends to additive manufacturing as well. The Israeli government's focus on innovation and research has paved the way for significant advancements in AM. The nation's aerospace and defense industries are utilizing 3D printing to produce intricate and high-performance components, enabling Israel to maintain its competitive edge.

The Jordan's government's commitment to innovation is evident through initiatives like the "Jordan Vision 2025," which prioritizes knowledge-based industries. The policy is helping regional AM companies to come up as an global player.

Additive Manufacturing for Healthcare, Defense, Energy and Aerospace in Middle East

Due to the adoption of 3D printing technology, the Middle Eastern healthcare sector is going through substantial change. With never-before-seen precision, customized medical implants, prosthetics, and even surgical guides are being made, improving patient care and results in Middle East.

Use of additive manufacturing at Médecins Sans Frontières (Doctors Without Borders), Credits: Al Jazeera

A hospital in Jordan run by Médecins Sans Frontières (Doctors Without Borders) offers 3D-printed prosthesis to Syrian patients who have been injured in battle. For patients who have had amputations or limb injuries as a result of combat, the use of additive manufacturing technology makes it possible to create personalized prosthetics that improve their mobility and comfort. The hospital offers a quick and affordable option by using 3D printing, cutting down on wait times and giving people in need of specialized care. The effort serves as an example of how technology may improve the lives of war victims by restoring their mobility and raising their standard of living in areas that have experienced conflict.

The market for orthotics and prosthetics in the United Arab Emirates is established, and highly qualified individuals collaborate closely with orthopedic physicians and hospitals. In the UAE alone, there are about 25 clinics that specialize in O&P devices. Insoles, Ankle Foot Orthoses (AFO), Knee and Ankle Foot Orthoses (KAFO), Night Splints, Cranial Helmets, Scoliosis Braces, and Immobilizer Devices are the main products manufactured.

In the United Arab Emirates, the market for orthotics and prosthetics is well-established, and skilled professionals work closely with orthopedic clinics and hospitals. There are roughly 25 clinics specializing in O&P devices in the UAE alone. The major items produced are insoles, ankle foot orthoses (AFO), knee and ankle foot orthoses (KAFO), night splints, skull helmets, scoliosis braces, and immobilizer devices.

A good example is Emirates' design and development of video monitor covers. Emirates is creating TV monitor shrouds using selective laser sintering (SLS), a novel 3D printing method. In comparison to older shrouds, the newer shrouds for video monitors have shown to function better.

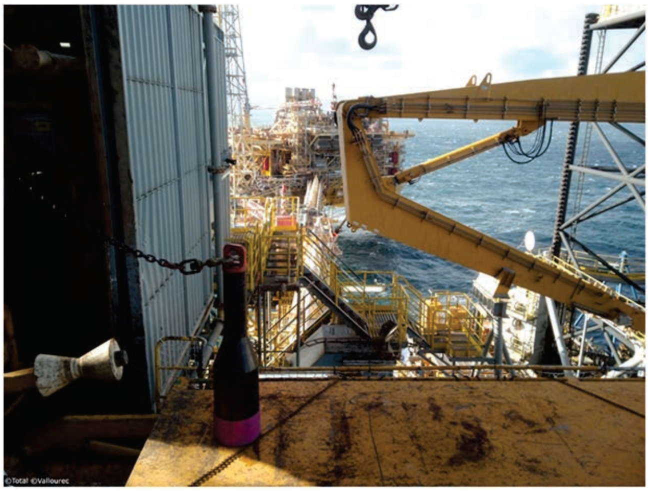
Figure 1: Video Monitor Shrouds by Emirates, Source: 3D Systems

AM has become a game-changer in the rapidly developing aviation and defense industries, enabling the quick manufacturing of complicated components, cutting down on lead times, and offering cost-effective solutions. The essay examines how the Middle East's aviation and defense sectors are using additive manufacturing to improve operational readiness, optimize supply networks, and even push the limits of aircraft design. AM is reaching new heights in the Middle East, with applications ranging from compact yet durable parts to simplified maintenance procedures.

The oil, gas, and energy sectors have long been considered to be centered on the Middle East. Additive manufacturing, often known as 3D printing, has become a game-changer in several industries due to the quick development of technology.

In order to specify safety and efficiency requirements for 3D printed items in the oil and gas and general energy production sectors, DNV issued a technical standard (DNVGL-SE-0568) in March 2023. The standard intends to encourage the industry's adoption of additive manufacturing (AM) technology so that it can improve productivity and cut costs.

Sensors and other electronics may be seamlessly included into tools and constructions thanks to additive manufacturing. With the use of this capacity, data gathering and monitoring are improved, allowing for real-time condition monitoring, preventative maintenance, and improved operating efficiency.



The 3D printed water bushing (lower left) on board the EIG Elgin-Franklin rig. Photo via Vallourec.

The 3D printed water bushing (lower left) on board the EIG Elgin-Franklin rig. Photo via Vallourec.

Oil and gas company Vallourec has 3D printed the first ever pressure-containing energy component in Middle East. The component, known as a water bushing, is utilized to stop hydrocarbon surges from wells while they are being built. It was created utilizing 3D printing technology called Wire Arc Additive Manufacturing (WAAM), which provided a whole new level of geometric freedom.

In conclusion, additive manufacturing is reshaping the landscape of industries across the Middle East. From healthcare and aviation to energy and beyond, the region is harnessing the power of 3D printing to drive innovation, enhance efficiency, and foster sustainable growth. As the Middle East continues to embrace additive manufacturing, it is positioning itself as a global leader in technological advancement, propelling industries into a future defined by creativity, precision, and boundless possibilities.

ABOUT THE AUTHOR

Aditya Chandavarkar

Managing Editor, AM Chronicle

Aditya Chandavarkar is a established entrepreneur with business interests in manufacturing, innovative technology, training and consulting. Among other activities he the Co-Founder of Indian 3D Printing Network and is a subject matter expert on 3D Printing/Additive Manufacturing with good grasp of Additive Manufacturing trends in the Region including India, APAC, Middleeast and Africa.

Rethinking Manufacturing with Large Scale Additive Manufacturing at Al Seer Marine

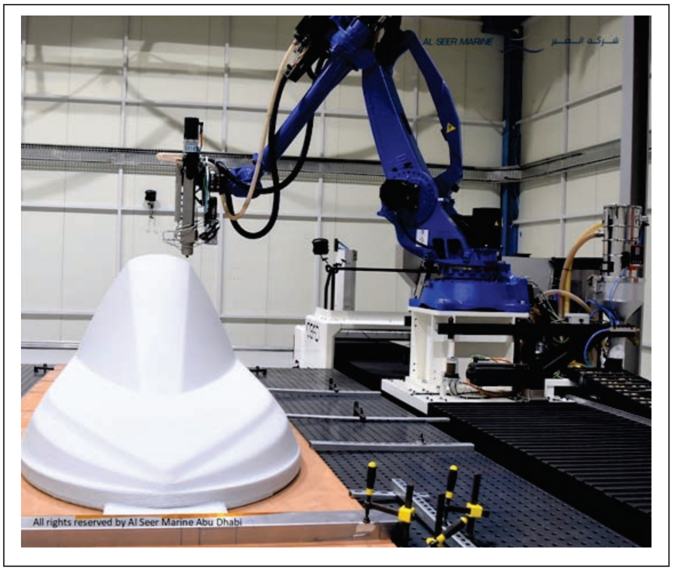
AM Chronicle Editorial Team

This article explores how Al Seer Marine is harnessing additive manufacturing to enhance efficiency, cost-effectiveness, and innovation.

Al Seer Marine, a prominent company that has adapted additive manufacturing to solve various engineering challenges and create new market opportunities. This article explores how Al Seer Marine is harnessing additive manufacturing to enhance efficiency, cost-effectiveness, and innovation to fulfill technical requirements in industry.

Large Scale Additive Manufacturing

Large-scale 3D printing is a revolutionary technology that has the potential to transform multiple industries, from manufacturing and construction to aerospace and healthcare. With the ability to create objects of significant dimensions, large-scale 3D printing opens up new possibilities for innovation, customization, and cost-effective production.



One of the key advantages of large-scale 3D printing is the ability to create complex and intricate designs that were previously difficult or impossible to manufacture using traditional methods. The layer-by-layer additive manufacturing process allows for the fabrication of intricate geometries, internal cavities, and lightweight structures with optimal strength-to-weight ratios. This is particularly valuable in industries like aerospace and marine where lightweight and high-performance components are critical.

Additionally, large-scale 3D printing promotes sustainability by minimizing material waste. Traditional manufacturing processes often generate significant waste due to subtractive methods, whereas 3D printing adds material only where it is needed.

One of the primary applications of large-scale 3D printing in Al Seer Marine is the production of molds and complete vessels, ship components and spare parts. Ships require a wide range of specialized parts, and traditional manufacturing methods often involve long lead times and high costs. With large-scale 3D printing, these parts can be produced on-demand, reducing inventory requirements and enabling more efficient maintenance and repair operations.

Large Scale Additive Manufacturing Process

Large-scale additive manufacturing involves a series of steps to transform a digital design into a physical object. The first step in additive manufacturing is DFAM, DFAM focuses on optimizing the design to take advantage of the capabilities and constraints of the 3D printing process. Designers consider factors such as support structures, material usage, and part orientation to maximize the efficiency and functionality of the final printed object.

After the design is finalized, computer-aided manufacturing (CAM) software is used to prepare the design for printing. This includes slicing the 3D model into a series of horizontal layers, determining the toolpath for each layer, and generating the instructions for the 3D printer.

The sliced design is converted into machine-readable instructions, often in the form of G-code, which is a language understood by 3D printers. G-code instructions specify the movement, speed, and temperature settings for the printer. Prior to printing, virtual simulations may be performed to validate the design, identify potential issues, and optimize printing parameters.

Further, the process parameters are defined based on the specific 3D printer and material being used. These parameters include nozzle type, print speed, layer height, infill density, and cooling settings. With the design prepared and process parameters set, the large-scale 3D printing process begins. The 3D printer follows the instructions from the G-code, depositing or curing the material layer by layer to build the object.

Once the object is printed, post-processing steps may be necessary. This can include removing support structures, sanding or smoothing the surface, applying coatings or finishes, and performing any required secondary operations, such as drilling or threading. Quality assurance is an essential step in large-scale additive manufacturing for Al Seer Marine. It involves inspecting the printed object to verify dimensional accuracy, structural integrity, and surface finish.

How Al Seer Marine adopts Large Scale Additive Manufacturing for In-house requirements

CEAD Mega II at the Al Seer Marine Facility in Abu Dhabi

Industries often faces challenges in maintaining a vast inventory of spare parts due to cost, storage limitations, and obsolescence risks. Additive manufacturing provides the ability to produce spare parts on-demand, eliminating the need for extensive storage and reducing downtime. With 3D printing, Al Seer Marine can manufacture spare parts as needed, ensuring availability and reducing lead times, ultimately improving maintenance efficiency and vessel uptime.

Additive manufacturing enables rapid prototyping, allowing marine industry professionals to quickly create physical prototypes of molds, structural parts, and components. This capability facilitates Al Seer Marine's design verification, functionality testing, and iterations. Rapid prototyping accelerates the development process, reduces time-to-market, and enables quicker design iterations for optimal performance and fit.

Additive manufacturing at Al Seer Marine is also used to create molds for composites. This can help to reduce the cost and lead time for producing these parts. In addition to this, changes in mould making is also easy. Additionally, AM is also used to produce complex structure parts for marine vessels. This helps to improve the strength, stiffness, and weight of these parts.

Out-house Markets for Large Scale Additive Manufacturing

The MRO (Maintenance, Repair, and Overhaul sector can benefit greatly from large-scale additive manufacturing. Rapid production of critical components reduces downtime and eliminates the need for maintaining large inventories. With the ability to 3D print intricate parts with high accuracy, Al Seer Marine can offer efficient and cost-effective MRO services to their clients.

The space industry demands lightweight, high-performance components that can withstand extreme conditions. Large-scale additive manufacturing enables the production of intricate and lightweight structures, making it an ideal fit for space agencies.

The railway sector in the UAE and GCC regions is experiencing significant growth. Large-scale additive manufacturing can support the production of customized railway components, such as lightweight interior parts, brackets, and connectors. By employing this technology, Al Seer Marine can offer rapid prototyping, reduced lead times, and cost-effective manufacturing solutions to railway operators.

The automotive sector constantly seeks new ways to improve vehicle performance and efficiency. Large-scale additive manufacturing can contribute to this goal by producing lightweight yet robust components, such as engine parts, chassis components, and customized interiors.

The security and defense industry requires advanced and highly specialized equipment. Large-scale additive manufacturing can address the demand for customized, complex components used in defense applications, including drones, military vehicles, and surveillance systems.

Large-scale additive manufacturing offers creative possibilities for art and culture projects. From large-scale sculptures to intricate installations. Al Seer

Marine can contribute to the fusion of technology and creativity, pushing the boundaries of artistic expression.

Robotic Additive Manufacturing System at Al Seer Marine

The additive manufacturing facility at Al Seer Marine has a 36-meter-long robotic 3D printer, developed by CEAD. The printer is called the Mega II and uses a pellet extrusion process to create composite parts. It is capable of printing parts up to 36 meters long, 4 meters wide, and up to 3 meters high. The printer is currently being used to print boat hulls, and molds. Al Seer Marine uses the printer to produce a variety of other marine and industrial components in the future. The Mega II is the largest 3D printer in the world and is a significant development in the field of additive manufacturing.

ABOUT THE AUTHOR

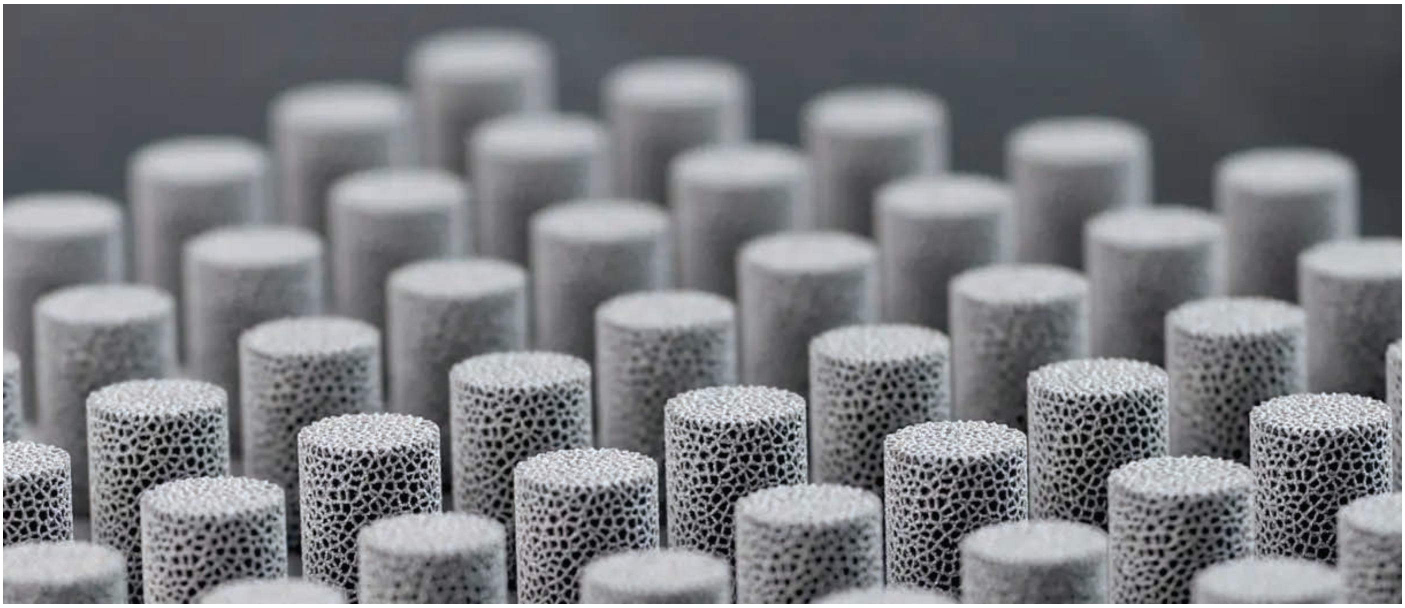
AM Chronicle Editorial Team

The AM Chronicle Editorial Team is a collective of passionate individuals committed to delivering insightful, engaging, and accurate news and stories to additive manufacturing audience worldwide.

An In-Depth Look Into Additive Manufacturing Part Qualification Strategies

Yash Parikh

Understanding Quality assurance for additive manufacturing



What is qualification and why does it matter for AM parts?

Quality assurance (qualification) is one of the critical requirements for additively fabricated parts intending to replace qualified structural and machinery components. The **qualification process** refers to the requirements that are tied to individual parts, machines, materials, and process parameters based on overall risk, and put into place to ensure the integrity of an application. As a result, qualification can be achieved by showcasing statistical equivalence based on testing many randomly selected parts across multiple builds and powder lots. Part qualification leverages the individual performance of a single part for a given material regardless of the machine it was built on.

Product certification and accreditation guidelines are in place for the parts manufactured conventionally (e.g., casting, forging), whereas AM components require a unique set of rules and certification schemas. With only a handful of standards focusing on inspection and certification for AM products, fast adaption to qualify AM parts depends on gathering evidence of processing history, process outcomes, and feedstock evaluation, amongst other sensor and manufacturing data. Regulatory bodies, research labs, and standard bodies are continuously publishing and updating technical guidelines to assist in the certification and qualification of AM parts based on the research and experience we are forging as an industry. Several steps are taken to ensure and demonstrate that printed parts adhere to the same qualification and certification requirements as their conventional counterparts.

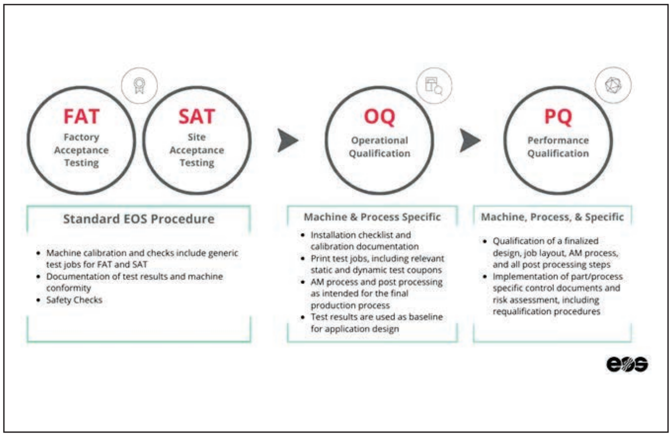
What are installation, operation & performance qualifications?

Qualification of AM parts can be done in many ways. Based on different methodologies, one can extract three high-level phases on the path toward qualification.

1. **Installation Qualification (IQ) –** the first qualification involves gathering evidence where all critical aspects of the process equipment and ancillary system adhere to OEM specifications. IQ typically includes two parts, Factory Acceptance Testing (FAT), usually done at the OEM's site before the hardware is shipped, and Site Acceptance Test (SAT), performed at the customer's site during the installation. The builds performed during FAT and SAT are generally identical to demonstrate performance equivalence before and after hardware shipment. Standard EOS procedure for IQ involves running generic and/or custom test jobs based on customer requirements for FAT/SAT and performing necessary safety checks and machine conformity tests.

2. **Operational Qualification (OQ) –** this qualification is where necessary process controls are established to maintain stable material performance and demonstrate that material specification requirements can be satisfactorily met. It also involves building test jobs with static and/or dynamic test coupons to demonstrate effectiveness and reproducibility and to form the baseline for application design. These jobs are designed with the end application requirements in mind.

3. **Performance Qualification (PQ) –** this involves locking the part-specific design, job layout, process inputs, and necessary postprocessing steps to obtain consistent printed parts over time. The first article inspection/testing results are often essential when applying for the certification requirements. Based on the volume of production parts, the concepts can be extended to calculate process capabilities and implement strategies for statistical process control to achieve higher robustness.



The challenges of qualification

The lack of clarity with AM qualification standards can be challenging since guidelines and procedures seldom help customers set up their qualification protocols. For example, over a dozen standards for qualification for AM parts are used for aerospace, automotive, and medical industries. By contrast, guidelines for qualifying AM parts used in semiconductor or oil and gas industries are limited and still being developed. If not implemented correctly, the qualification process could incur increased downtime and added test and printing costs, as each qualification phase demands considerable resources. Creating control plans for materials and processes, defining qualification protocols, and generating cost-effective test plans that produce safe and high-quality parts can be challenging without guidance from experienced AM qualification specialists.

Tackling part qualification

Qualification is a challenging step to tackle for customers both experienced and beginning their 3D printing journey alike. Although it can be done independently, it can cause delays in production, additional certifications, and increase time to market for organizations with multiple standardizations. The applied engineering and training unit at EOS, known as Additive Minds, has dedicated specialists for this step in the AM process. As ambassadors to additive manufacturing, preparing customers and mitigating the challenges of qualification are important steps in preparing outside organizations to leverage 3D printing to the fullest.

More about the Additive Minds qualification strategy

The Additive Minds qualification strategy relies on reducing the repeated testing of individual components and assisting customers in speeding the qualification timeline by incorporating the lessons learned over the past three decades – eliminating the reinventing-the-wheel experience for our customers. The EOS team engages with custom-made, critical-to-quality (CTQ), Process Failure Mode Effect Analysis (PFMEA) workshops that provide vital insights into customers' readiness for the qualification. Additive Minds also infuses the use of digital tools, such as process simulations, advanced robotics, artificial intelligence, machine learning, remote monitoring, and augmented reality and virtual reality (AR/VR) with EOS printers to support customers developing a robust platform to enable the accelerated transition to qualified printed parts.

Qualification going forward

In the AM industry, a qualified part means repeatable, reproducible, predictable, and consistent part performance with the ability to scale for mass production. While AM technologies continue to mature, the emphasis for the next decade is on producing qualified parts for diverse applications in large quantities, which are crucial for this manufacturing method to be widely adopted by traditional industries.
If you are interested in discussing your organization's qualification strategies process, please reach out to the Additive Minds team today.

Original Source: Additive Manufacturing Part Qualification. (2023, March 10). EOS. https://www.eos.info/en/blog/part-qualification~b~11803

ABOUT THE AUTHOR

Yash Parikh

Ph.D., Process Engineering Consultant of EOS North America

Yash Parikh is a process engineering consultant at EOS North America. In this role, his primary responsibility is to provide guidance and support to EOS consumers in effectively implementing AM technology within their organizations.

Concrete 3D Printing for Mars Habitat

Dr. J. Jayaprakash and M. P. Salaimanimagudam

Discussion on the future of Mars habitats using concrete 3D printing

Design by Hassell for NASA 3D Printed Habitat Challenge

The future of Mars habitats using concrete 3D printing is promising, with significant potential for cost savings, customizability, and safety compared to traditional construction methods.

The notion of colonizing Mars has been a dream of scientists, engineers, and entrepreneurs for several decades. However, in recent years, there have been significant strides in developing the technology needed to make a human presence on the red planet. Concrete 3D printing technology has received much attention in the digital world due to its potential benefits include high level of automation, minimal wastage, and robustness. Moreover, this technique can be used to construct habitats on Mars. The Red Planet's harsh and inhospitable environment requires structures that can withstand extreme temperature fluctuations, high levels of radiation, and atmospheric pressure that is much lower than Earth's. This 3D printing technology also allows building structures on the Red Planet without transporting large amounts of building materials from Earth. Instead, the abundant materials on Mars such as Martian soil, rock, and ice could be used to produce the concrete mixture on-site.

The use of conventional methods in the construction of habitats on Mars is not feasible due to the harsh environment. Mars is a planet with high level of radiation making it difficult for humans to survive without the protection of human habitat. The cost and logistic challenges of transporting traditional building materials and equipment from Earth to Mars is uneconomical. Concrete 3D printing, however, offers a solution to these challenges using locally available materials and autonomous robots for the construction process. Mars has abundant deposits of regolith, which is a mixture of sand, gravel, and dust that covers the planet's surface. Regolith can be processed into a form of concrete called "Marscrete," which can be used to build structures (1).

Another advantage of concrete 3D printing is the potential for increased speed and efficiency in construction. However, the conventional construction methods require a significant amount of time and, human labor, which is not feasible on Mars due to the inhospitable environment and limited resources. The use of concrete 3D printing could significantly reduce the amount of materials that need to be transported from Earth to Mars, enables the creation of large and complex structures without relying on expensive and resource-intensive launches. Overall, the use of concrete 3D printing has the potential to revolutionize human exploration and settlement on Mars by enabling the creation of functional, sustainable, and cost-effective habitats.

In addition to the benefits of using local materials and autonomous construction, concrete 3D printing also offers a high degree of design flexibility. The layer-by-layer deposition of concrete allows for the creation of complex and organic structures that would be difficult or infeasible to build using conventional construction methods. This opens new possibilities for designing habitats that are optimized for the ambient conditions of Mars.

Challenges of concrete 3D printing for Mars habitat

Despite the potential benefits of concrete 3D printing for Mars habitat construction, there are still many challenges that need special emphasis to make this technology feasible. One of the biggest challenges is the development of a 3D printing system that can operate in the extreme conditions of Mars. In addition, the system must be able to operate autonomously with minimal human intervention, as it may not be feasible to send human operators to Mars to oversee the construction process.

Mars has a gravity of 3.721 m/s2 and an average atmospheric pressure of 655 Pa, with a thin atmosphere. However, the planet is exposed to harmful radiation due to the low atmospheric density. The temperature on Mars varies greatly depending on location, season, and time of day, with a range of -153° to 20° Celsius. One Martian year is equal to 687 days on Earth. Mars has a different daily and seasonal cycle than Earth due to its longer rotation and orbital period. These extreme planetary conditions pose a challenge for engineers to develop materials that can withstand the harsh environment, including resistance to erosion, corrosion, and radiation, while having a low working temperature range and being non-ferromagnetic. Materials used for space habitats must act as radiation shields to protect human life.

The study conducted at Northwestern University (1) focuses on the formulation of 3D printable Marscrete. Marscrete is composed of Martian soil of seventy-five percentage and twenty-five percent of molten sulfur by heating in the range of 120° to 140° C in the form of viscous slurry, and it shows better mechanical properties than conventional sulfur concrete. The addition of mission-recycled polyethylene fibers ensures the buildability of 3D-printing Marscrete. It also highlights the rheological behavior of fresh printable Marscrete and its structural performance.

Molten sulfur mixed with grains can be used for space construction due to its accessibility and recyclability. It does not require water and hardens rapidly. However, high temperatures can cause to fail, and synthesizing sulfur is a challenge. Sulfur may be present on the Martian surface, but melting under vacuum conditions remains a challenge. Sulfur concrete can withstand extreme conditions in space, however the production process must be designed well. Researchers have been exploring the use of different binders and additives, such as sulfur and iron oxides to improve the durability and strength of Martian concrete. Iranfar et al. [2] have explored the potential of geopolymer as the best binder for construction on Mars with consideration of fourteen technical criteria with the utilization of the Multi-criteria decision-making system.

It is also challenge to ensure that the 3D printers should have the potential to work efficiently in low-gravity and harsh environment of Mars. Developing a robust 3D printers with the ability to withstand harsh conditions enables the creation of large, complex structures that provide ample living and working space for astronauts, and offer protection from the harsh Martian environment.

There are, of course, significant technical challenges to overcome in using concrete 3D printing for Mars habitats. Developing robust 3D printable material that can withstand harsh Martian environments with structural efficacy is a crucial part of Mars habitation. Finally, ethical and legal considerations need to be considered when designing and constructing habitats on Mars. The habitats must be designed to minimize the environmental impact on the planet, and any waste generated during the construction process must be properly managed. In addition, the construction of habitats on Mars must be done as per international space law and other legal frameworks to ensure the responsible and sustainable use of space resources.

Future of concrete 3D printing for Mars habitat

Despite these challenges, there has been significant progress in developing concrete 3D printing technology for Mars habitats in recent years. NASA. in 2018, awarded a $14 million contract to AI Space Factory, a New York-based architecture and technology firm, to develop a 3D-printed habitat design for Mars. The resulting design, called Marsha, uses a cylindrical shape and a double-layered shell to protect against radiation and provide insulation and is intended to be printed using Martian soil.

In addition to NASA, several private companies are also working on developing concrete 3D printing technology for Mars habitats. For instance, ICON, a construction technology company based in Austin Texas has developed a 3D printer called Vulcan, that is capable of printing a 2,000 square foot house in 24 hours using locally sourced materials. The company has partnered with NASA to explore the use of Vulcan for building structures on Mars.

Overall, the future of Mars habitats using concrete 3D printing is promising, with significant potential for cost savings, customizability, and safety compared to traditional construction methods. While there are still some technical challenges to overcome, ongoing research and development in this area are likely to lead to increasingly sophisticated and effective 3D printing technologies for use on Mars and beyond. As the researchers continue to explore the potential of space exploration and colonization, concrete 3D printing is likely to play an increasingly important role in shaping the future of human habitation in the cosmos.

References

[1] Matthew Troemner, Elham Ramyar, Raul Marrero, Kavya Mendu, Gianluca Cusatis, Marscrete: A Martian Concrete for Additive Construction Applications Utilizing in Situ Resources, in: 17th Biennial International Conference on Engineering, 2021.
[2] S. Iranfar, M.M. Karbala, M.H. Shahsavari, V.

Vandeginste, Prioritization of habitat construction materials on Mars based on multi-criteria decision-making, Journal of Building Engineering. 66 (2023). https://doi.org/10.1016/j.jobe.2023.105864.

ABOUT THE AUTHOR

Dr. J. Jayaprakash

professor in Department of Structural and Geotechnical Engineering, School of Civil Engineering, Vellore Institute of Technology, Vellore, India

Dr. J. Jayaprakash is a professor in Department of Structural and Geotechnical Engineering, School of Civil Engineering, Vellore Institute of Technology, Vellore, India. He earned his Masters in Structural Engineering from NIT, Trichy and PhD from the Universiti of Putra Malaysia. He has more than 16 years of academic and research experience in British Institution, ASEAN and Indian Institutions.

ABOUT THE AUTHOR

M. P. Salaimanimagudam

PhD research scholar in Department of Structural and Geotechnical Engineering, School of Civil Engineering, Vellore Institute of Technology, Vellore, India

M. P. Salaimanimagudam is a PhD research scholar in Department of Structural and Geotechnical Engineering, School of Civil Engineering, Vellore Institute of Technology, Vellore, India. Salai did his M.Tech in Structural Engineering from SASTRA, Thanjavur, India. He is pursuing his Doctoral Research in the field of Topology-optimized digital fabrication of concrete structures.

How Metal Additive Manufacturing is Reshaping Aerospace, Medical, and General Engineering

About Shree Rapid Technologies (SRT)

Applications of metal AM in aerospace, medical, and general engineering and impact on innovation, efficiency, and production.

Metal additive manufacturing is a transformative technology driving the industry 4.0 revolution in the 21st century. Metal AM Technology has transformed various industries but profoundly impacted the aerospace, medical, defense, automobile & engineering sector. The transformation is the result of the ability of metal additive manufacturing to create complex geometries, easier to work with difficult to process materials, and shorter time to market with functional end use parts.

Metal additive manufacturing is classified into several categories, but laser powder bed fusion (LPBF), also referred to as direct metal printing (DMP) or direct metal laser sintering (DMLS) is the most proven & widely adapted technology. LPBF is known for its ability to manufacture high-performance parts by providing design flexibility and increased accuracy.

This article explores the applications of metal additive manufacturing in aerospace, medical, and general engineering and highlights its significant impact on innovation, efficiency, and production.

Medical Industry

The medical industry has witnessed a significant transformation with the integration of metal additive manufacturing. It has opened up new possibilities for personalized patient care, surgical procedures, and biomedical research. One of the early applications of metal additive manufacturing in the medical sector was to develop customized implants and prosthetics based on individual anatomy. With the recent developments in materials science and high-precision machines, highly accurate Orthopedic implants can be manufactured in large volumes.

Manufacturers of standard implants benefit from the high repeatability and 24/7 production of this printer. Source: 3D Systems

Another application of metal additive manufacturing in the medical industry is the development of custom surgical instruments and guides. In the case of complex surgery, using custom surgical instruments and guides designed especially for doctors and patients reduces the chances of human error. They also help to improve the quality of medical procedures, resulting in improved quality of life for the patient.

The DMP Flex 350, Source: 3D Systems

Direct metal printing solution has demonstrated its ability in multiple applications for the healthcare Industry. The 3D systems DMP Flex 350 and DMP Flex 350 Dual are popular solutions adapted by all major engineering giants in the medical sector. It is a high-precision and performance machine capable of 24/7 productivity. It comes with a build volume of 275 x 275 x 420 mm (10.82 x 10.82 x 16.54 in) with Vacuum and removable print module concept offers more flexible solution for multi material handling to avoid cross contamination and purest of inert atmosphere with <25 PPM oxygen content to avoid material degradation especially for material like titanium, reduced material waste, greater speeds for production, shorter set-up times, and very dense metal parts with excellent mechanical properties.

Aerospace Industry

The aerospace industry was one of the earliest adopters of metal additive manufacturing technology. The advantages of additive manufacturing over traditional manufacturing methods and its ability to create complex shapes were the key drivers for adopting metal additive manufacturing in aerospace.

Metal additive manufacturing enables the production of complex, lightweight, strong, and durable structures. This reduces the overall weight of aerospace components, resulting in improved fuel efficiency and enhanced performance. Furthermore, the ability to consolidate multiple parts into a single 3D-printed component reduces assembly complexity and increases reliability.

25 fuel nozzles printed in a single print run on the DMP Factory 500. Source: 3D Systems

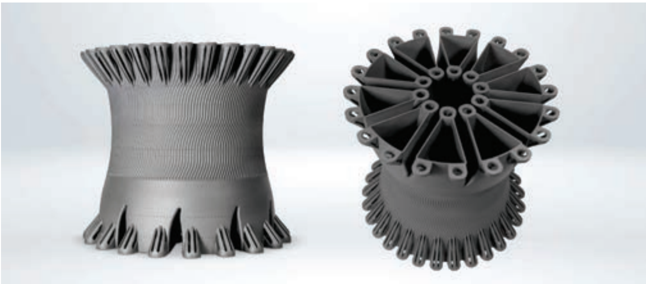
Rapid Prototyping and Tooling using metal additive manufacturing have also helped the industry significantly. Using metal additive manufacturing for functional prototypes has resulted in shorter product development times and faster innovation. In most cases, the use of metal additive manufacturing has eliminated the tooling requirement, resulting in huge cost reduction also. In some cases, metal additive manufacturing has helped to create quick tooling solutions for the aerospace sector.

General Engineering

In general, engineering metal additive manufacturing provides unprecedented design freedom, reduces costs, and accelerates product development. One of the most common applications is the development of functional prototypes for design development and testing. The technology also finds its application in low volume or batch production (pilot runs), which is required to make adjustments for final production.

The DMP 500 Factory Solution, Source: 3D Systems

The DMP Factory 500 Solution is a modular system with its trademark Vacuum concept that helps in highly pure inert atmosphere, the uniquely designed Removable print module (RPM) and enables easy & quick switchover of production build jobs and Multi laser solution developed for manufacturing large seamless parts. It is also equipped with the De-powdering Module (DPM) and the Powder Recycling Module (PRM) designed to efficiently de-powder parts on build platforms and automatically recycle unused powder materials to prepare the RPM for the next build. The DMP Factory 500 Solution ensures high productivity through a larger build volume (500 x 500 x 500 mm) and high throughput enabled by three 500-Watt lasers. The DMP 500 ecosystem can be used to set up a digital factory which can be run autonomously for 24/7-part production. This solution can be effectively used in aerospace and general engineering industries requiring high volume production of bigger parts.



3D printed seamless large part using Nickel alloy on DMP Factory 500

Metal additive manufacturing for spare parts and repairs is an emerging area. It enables the on-demand production of spare parts, eliminating the need for extensive inventory and reducing downtime. Recently, several organizations have conducted research experiments to use metal additive manufacturing to repair expensive components. Interestingly, repairing parts using metal additive manufacturing reduces the repair cost and ensures quality.

One critical step in metal additive manufacturing is selecting a suitable machine for industrial requirements. Several parameters, such as build volume, laser, speed of production, etc., are required to study to make the right purchase decisions. The engineering team at SRT ensures that the customer's requirements are understood and that the correct solution is provided. To experience direct metal technologies, you can visit the Shree Rapid Technology Experience center in Mumbai. The team of trained engineers at the center provides all the guidelines and suggestions required for the successful customers' journey towards metal additive manufacturing.

Shree Rapid Technologies is an authorized partner of 3D Systems providing solutions to wide range of industries.

ABOUT THE AUTHOR

Shree Rapid Technologies (SRT)

Shree Rapid Technologies (SRT) is a pioneer in 3D Printing Technology and incorporated in 2007. They are specialized in cutting-edge technology into 3D Printing, 3D Scanning and Measurement that enables us to design, validate and create precise and intricate 3D prototypes and end use parts. They cater to variety of applications in multiple industries line Aerospace, Automotives, Bio Printing, Dental, Jewellery, Machine Tooling, Medical Devices, Service Bureaus, etc.

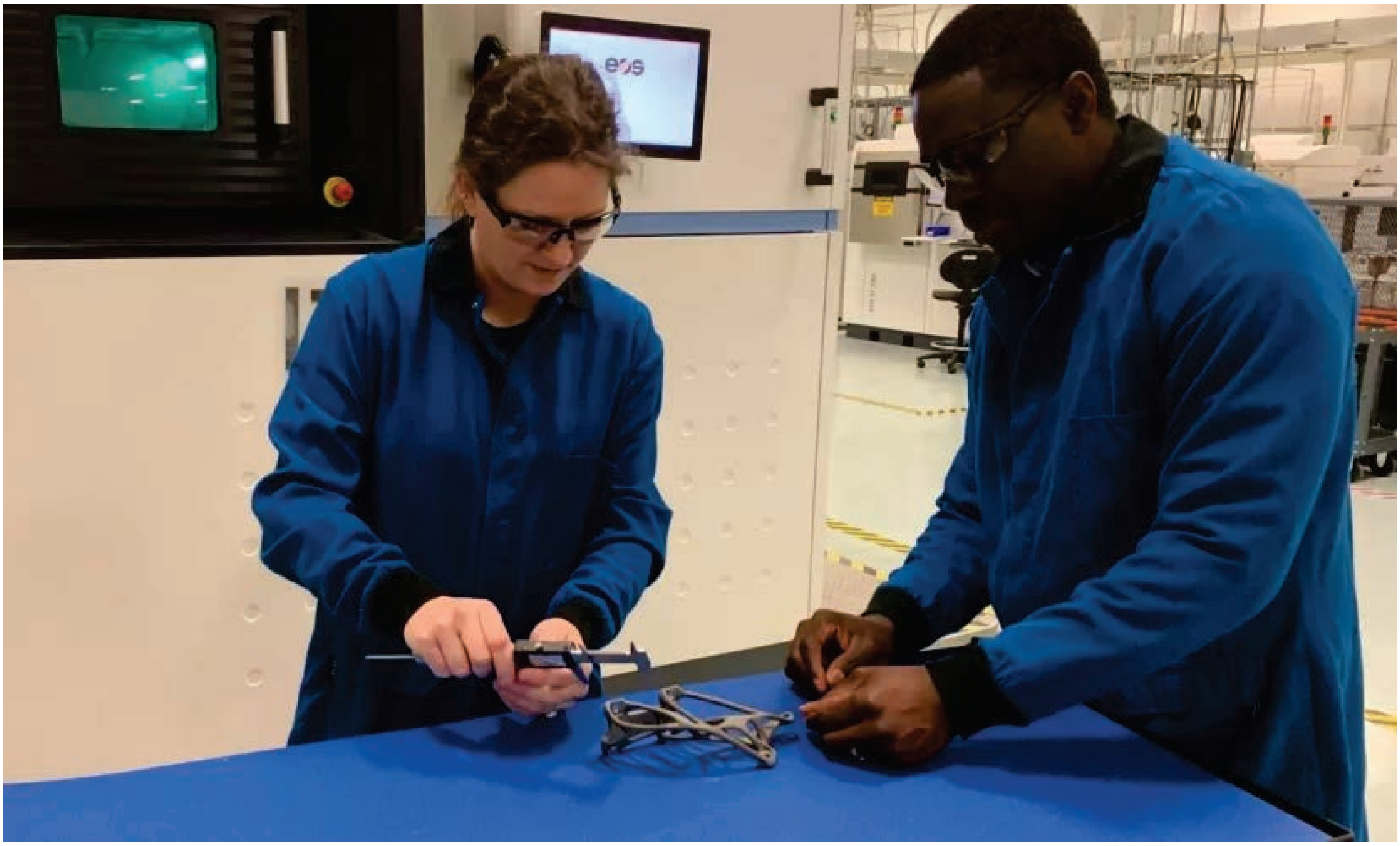
Their state-of-the-art Customer Innovation Center (CIC) is laced with advanced 3D Printers, 3D Scanners, Metrology and Inspection.

To visit the experience center or any other query kindly mail at : marketing@shreerapid.com
Contact Number: (+91) 7208843624 / 022-67415403
To Know more visit: https://www.shreerapid.com/

How 3D printing really helps accelerate sustainable manufacturing

Dr. Melissa Orme

Role of 3D Printing as a Tool for Sustainable Manufacturing



3D-printing technologies have evolved from a means to produce tools and prototypes rapidly at a lower cost to a way of solving complex engineering design problems. Increased design freedom associated with 3D printing has enabled manufacturers to create differentiated products with greater functionality and enhanced durability, all while reducing cost and lead time.

Highlights

- 3D-printing technologies have evolved from a means to produce tools and prototypes rapidly at a lower cost to a way of solving complex engineering design problems.
- 3D printing – also known as additive manufacturing

– offers a way to reduce the environmental impact of manufacturing and develop more sustainable products.

- Expanding the use of 3D printing in aerospace and other industries will help lessen the environmental impact of manufacturing.

Now, 3D printing – also known as additive manufacturing – offers a way to reduce the environmental impact of manufacturing and develop more sustainable products. Manufacturing accounts for 12% of the world's global greenhouse gas emissions, according to The Center for Climate and Energy Solutions.

3D printing can be more sustainable than standard manufacturing technologies because it involves less material, fewer machining operations and creates smaller amounts of scrap. Its lighter and often more geometrically flexible designs make environmentally-sound product innovations possible in industries ranging from aerospace to medical devices to sporting goods.

Sustainable manufacturing

To understand the extent of the positive effect that additive manufacturing can have on the carbon footprint of manufacturing, consider the millions of parts in an aeroplane. At Boeing, we conduct life cycle assessments to quantify the impact that our aircraft have on the environment from the moment materials are mined to part fabrication to when an aircraft is retired from service.

When 3D printing was used to produce over one thousand brackets in the galleys of our 787 Dreamliners, we found we could cut the carbon emissions, waste to landfills and hazardous materials, water and energy used for these parts by between 30 and 39%. Instead of creating the bracket from a large metal block and machining away excess material, we created the part by feeding titanium wire into a plasma field that efficiently melted and layered the material, creating a solid form. The speedier and more material-efficient process decreased the water, material and energy consumed, while reducing excess material waste and lubricants used in standard machining processes.

In a different example, we lessened the carbon footprint associated with manufacturing and assembling a satellite's payload by consolidating tens of thousands of components. We eliminated thousands of secondary fasteners that otherwise join individual components by printing them as one piece. We also removed other features, such as welds and brazes prone to failure with an additive manufacturing process called powder bed laser fusion.

With this technology, a laser beam irradiates successive layers of powder thinner than a human hair, one layer at a time to make a three-dimensional object. Each layer corresponds to the geometry of a 'sliced' computer model of the part to be printed, where the slices in the model are the same thickness as the printing layer thickness. The laser melts the powder, causing the powder particulates to blend together before they rapidly solidify into a solid form. A new layer of powder is then applied, repeating the process until the part is made.

This 3D-printing approach not only lowered the carbon emissions and waste from manufacturing the components that comprise many critical aspects of the satellite. It also eliminated the carbon emissions involved with fabricating, warehousing, transporting, inspecting, testing and assembling the secondary fasteners that were no longer used.

Sustainable products

Thanks to its more flexible geometric design capability and reduction of material waste, additive manufacturing is inspiring environmentally sustainable product innovations. In aerospace, 3D printing makes it possible to build lighter and more fuel-efficient aircraft.

For example, we reduced the weight of a complex fire detector bracket flown on our Boeing EcoDemonstrator aeroplane used to develop and test new technologies by 31% by optimising the bracket's design and printing it with laser powder bed fusion. The new optimised 3D-printing design enabled us to make a lightweight component that would be impossible to manufacture with traditional means.

Since the traditional manufacturing process for this part relied on sheet metal and did not require significant material or machining resources, the carbon footprint from using 3D printing for manufacturing was slightly higher than standard manufacturing processes. But the lighter 3D-printed part lowered the fuel burn and carbon emissions of the aircraft over its lifetime in service by 19%, far outweighing the small increase of carbon emissions during 3D printing.

With 3D printing, defect-prone welds were also eliminated along with the quality issues. The previous traditional manufacturing processes for the part included sheet rolling, laser cutting and joining metal with welds in 12 places, often resulting in quality issues that needed to be corrected.

A more sustainable industrial age through 3D printing

To be sure, additive manufacturing does not always decrease the environmental impact in the manufacturing plant. Companies must evaluate the value of introducing 3D printing, especially when converting components that do not traditionally require significant material and machining resources. Efforts to incorporate design changes now possible with 3D printing that add value and lead to greener operations during part service, such as weight reduction or increased durability, quality and performance, should be undertaken and incorporated.
We are just beginning to tap the full potential of 3D-printing technologies for a greener and cleaner manufacturing era. It's already clear that additive manufacturing is critical for the future of more sustainable flight. Aircraft will become even lighter in weight, more streamlined and fuel-efficient as we use 3D printing to create parts that conform to oddly shaped cavities within an aeroplane. And, new and recycled materials will be introduced that require fewer environmental resources to recycle.

Expanding the use of 3D printing in aerospace and other industries will help lessen the environmental impact of manufacturing. Given the urgent need to reduce greenhouse gas emissions in our efforts to mitigate the climate challenges ahead, introducing additive manufacturing into our processes will lead to a greener means of developing sustainable innovations and products.

The article is reprinted from World Economic Forum blog, titled "How 3D printing really helps accelerate sustainable manufacturing" published on Jun 6, 2023 under the creative common license.

ABOUT THE AUTHOR

Dr. Melissa Orme

Vice President of Additive Manufacturing, Boeing

Melissa Orme, Ph.D. belongs to that small group of engineers who have participated 'hands-on' in the field of Additive Manufacturing before the term or even the industry of "Additive Manufacturing" existed. Her career has been divided between academia, tech startups, and large corporate executive leadership.

Innovative Advances in Additive Manufacturing by Technology Innovation Institute (TII)

AM Chronicle Editorial Team

The article describes the additive manufacturing initiatives and research at the Technology Innovation Institute (TII)

The Technology Innovation Institute (TII) is a leading global research center dedicated to pushing the frontiers of knowledge. One of the areas of research at TII is additive manufacturing, also known as 3D printing. TII has several additive manufacturing initiatives underway, aimed at developing new technologies and applications for this rapidly growing field.

TII's additive manufacturing initiatives are making a significant impact on the global technology landscape. The centre's research is helping to develop new additive manufacturing processes and materials that are more efficient, cost-effective, and versatile. The innovation lab is helping to accelerate the development of new additive manufacturing applications in a variety of industries. And the entrepreneurship programme is helping to create new additive manufacturing businesses that are driving economic growth and job creation.

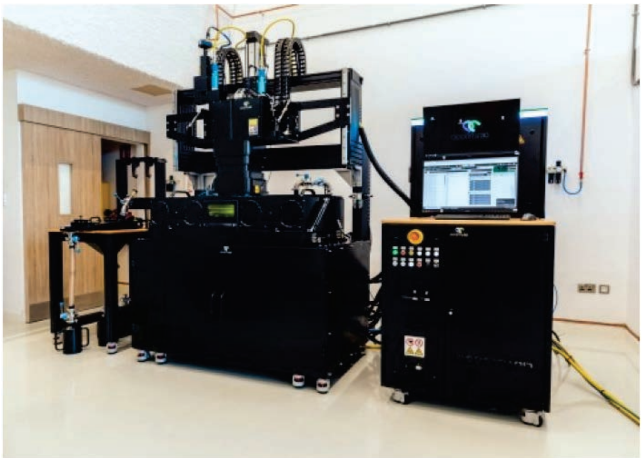


Figure 1: A complete Additive Manufacture platform at TII with capability of working with different materials, 2 high power lasers with capability of working with up to 4 lasers, that allows in-situ heat treatments, Source: TII

TII's work in additive manufacturing is helping to make the technology more accessible and affordable, and it is driving the development of new and innovative applications. TII is a leading force in the global additive manufacturing community, and its work is helping to shape the future of manufacturing.

One of TII's additive manufacturing initiatives is the development of new materials for 3D printing. TII researchers are working on developing new materials that are stronger, lighter, and more durable than traditional 3D printing materials. They are also working on developing materials that have specific properties, such as high conductivity or flame resistance.

Research Works on Additive Manufacturing at TII

The paper "Incorporating the Roles of Feature Size and Build Orientation in Laser Powder Bed Fusion Process Simulation for the Prediction of Mechanical Properties" by TII's team investigates the effects of feature size and build orientation on the mechanical properties of parts fabricated by laser powder bed fusion (L-PBF). The authors developed a finite element model to simulate the L-PBF process and used it to study the effects of different feature sizes and build orientations on the temperature distribution, residual stress, and tensile properties of the parts. The results showed that feature size and build orientation have significant effects on the mechanical properties of L-PBF parts. Smaller feature sizes and build orientations that favor the fusion of powder particles lead to improved mechanical properties. The paper provides valuable insights into the factors that affect the mechanical properties of L-PBF parts and can be used to guide the design and optimization of L-PBF processes.

In other study conducted by TII's team, they investigates the feasibility of conducting in-situ heat treatments during PBF-LB of AlSi10Mg parts. The authors found that it is possible to in-situ direct age the material by increasing the printing time from 5 hours to 11 hours while printing at 220°C. This resulted in an increase in hardness and strength of the parts. The authors also found that it is possible to in-situ solution heat treat the material by using build plate temperatures between 450°C and 500°C for 11 hours. However, this resulted in a reduction in ductility of the parts. The research paper investigates the feasibility of conducting in-situ heat treatments during PBF-LB of AlSi10Mg parts. The authors found that it is possible to in-situ direct age the material by increasing the printing time from 5 hours to 11 hours while printing at 220°C. This resulted in an increase in hardness and strength of the parts. The authors also found that it is possible to in-situ solution heat treat the material by using build plate temperatures between 450°C and 500°C for 11 hours. However, this resulted in a reduction in ductility of the parts.

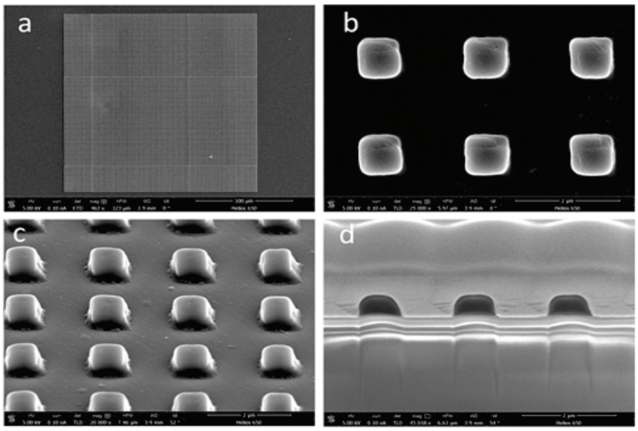


Figure 2: SEM images of the 3D-printed microcubes, Source: Lee S, et. al.

In other study conducted by the Advance materials research center at TII, researchers investigated the use of 3D-printed microcubes as drug delivery vehicles for catalase. 3D-printed microcubes are small (800 nm in length and 600 nm in height) and uniform in size, making them well-suited for targeting macrophages passively. The authors concluded that 3D-printed microcubes are a promising new drug delivery system for catalase and other therapeutic proteins.

TII's additive manufacturing initiatives are making a significant impact on the field of 3D printing. TII's research is helping to develop new materials, processes, and applications for 3D printing, which is making this technology more accessible and useful to businesses and industries around the world.

References

- Phutela, C.; Bosio, F.; Alhammadi, A.; Alshehhi, N.; Kindleyside, L.; Aboulkhair, N.T. Incorporating the Roles of Feature Size and Build Orientation in the Process-Structure-Property Relationship for Additively Manufactured Parts. Metals 2023, 13, 151. https://doi.org/10.3390/met13010151
- Bosio, F., Phutela, C., Ghisi, N., Alhammadi, A., & Aboulkhair, N. T. (2023). Tuning the microstructure and mechanical properties of AlSi10Mg alloy via in-situ heat-treatments in laser powder bed fusion. Materials Science and Engineering: A, 145268.
- Lee S, Lee DW, Rajput N, Levato T, Shanti A, Kim TY. 3D-Printed Microcubes for Catalase Drug Delivery. ACS Omega. 2023 Jul 20;8(30):26775-26781. doi: 10.1021/acsomega.3c00789. PMID: 37546651; PMCID: PMC10398707.

ABOUT THE AUTHOR

AM Chronicle Editorial Team

The AM Chronicle Editorial Team is a collective of passionate individuals committed to delivering insightful, engaging, and accurate news and stories to additive manufacturing audience worldwide.

Large Scale Additive Manufacturing redefining Yacht Manufacturing

Caracol

Role of Large-format additive manufacturing to solve marine manufacturing challenges

Additive manufacturing is driving a transformation across air, land, and sea travel. While the aerospace and automotive industries have already embraced this technology to accelerate product development and improve component efficiency, its implementation is now becoming widespread in various companies within these sectors. However, the marine and maritime industries have been slower to adopt additive manufacturing, but a shift is underway, thanks to innovative companies in this space and Large Scale Additive Manufacturing .

Caracol, an Italian specialist in additive manufacturing. Caracol is utilizing its cutting-edge large-format 3D printing technology to lead the way in marine 3D printing applications. Their Heron AM system is proving to be a game-changer in creating more sustainable, efficient, and customized structures for water vessels, including luxurious superyachts.

With the progress being made by maritime players and additive manufacturing companies, the industry is witnessing the profound impact of 3D printing on the marine industry. This technology has impact on water vessels designed, manufactured, and operated, opening up new possibilities.

Initial Years of Additive Manufacturing in Maritine Applications

Over the past few years, there has been a growing fascination with additive manufacturing's potential in the maritime and marine sectors. Major players in the industrial maritime sphere are actively exploring and adopting this technology for spare part production and structural repairs. By incorporating AM, maintenance processes for large ships can be accelerated, leading to minimized downtimes and smoother logistics operations.

The marine sector, which includes sailboats, racing boats, and yachts, has also warmly embraced 3D printing. Within this domain, we have witnessed numerous instances of AM's application, such as the creation of large-scale molds for yacht structures and the direct production of lightweight components for racing boats. Moreover, 3D printing has enabled the customization of yacht parts, including large superstructures.

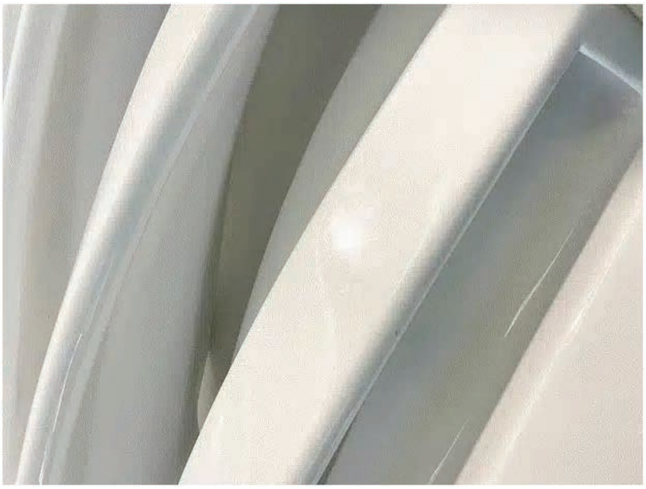
It is intriguing to note that additive manufacturing seamlessly aligns with several other trends prevalent in the marine industry. These trends include the utilization of carbon fiber-reinforced polymers (CFRP), the exploration of sustainable materials, and the adoption of more efficient energy systems, like hydrogen fuel cells. All of these developments are propelling the industry forward in its quest to manufacture faster, higher-performing watercraft while also fostering greater sustainability. The convergence of these innovations promises a brighter and more eco-conscious future for maritime and marine applications.

Role of Large Scale Additive Manufacturing (LSAM)

Large-format additive manufacturing (LFAM) has emerged as a pivotal force driving advancements in marine 3D printing applications, surpassing other technologies in its significance. Given the substantial size requirements of boats, especially larger vessels, the capability to print on a large scale becomes indispensable. Beyond its sheer size capacity, LFAM offers several other advantages in the marine sector, which are as follows:

- Complex Component Production: LFAM facilitates the creation of intricate components that are optimized for both weight and performance, ensuring superior functionality.
- Agile Customization: The agile nature of LFAM allows for scalable and cost-efficient part customization, catering to specific requirements without compromising on quality.
- Streamlined Assemblies: Large assemblies can be consolidated into single-piece parts through LFAM, thereby reducing post-processing and assembly steps, leading to enhanced efficiency.
- Accelerated Production: LFAM expedites production schedules by directly printing parts, eliminating the need for expensive tools or molds, thus reducing time and costs.
- Material Compatibility: LFAM supports a wide range of durable and marine-ready materials, including sustainable options like recycled polypropylene with glass fiber reinforcement, promoting environmental responsibility.

As a result of these benefits, LFAM finds extensive usage in various marine applications. It is employed in the production of racing boat parts, meticulously engineered to optimize weight and speed. Moreover, LFAM contributes to the creation of composite hulls or hull molds and plays a significant role in fabricating customized luxury yacht structures that cater to specific client preferences. The technology's suitability for these areas is enhanced by its ability to efficiently handle small-batch production needs. The adoption of LFAM in the marine industry continues to push the boundaries of innovation and craftsmanship.



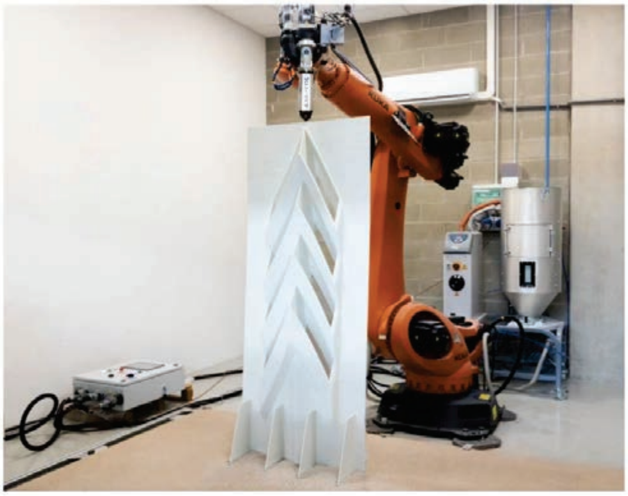
Detail of finished air grid after protective gelcoat

Caracol's Heron AM platform stands out prominently among LFAM technologies. Developed entirely in-house by the Caracol team, this LFAM solution employs a 6-axis robotic arm equipped with a compact extruder. Using polymer or composite pellet materials, the system can precisely and rapidly deposit material, enabling the construction of large-scale structures. What sets the Heron AM system apart is its adaptability; it can be customized to suit a diverse range of project requirements and shop environments.

The combination of Caracol's Heron AM platform and its robust materials, such as recycled PP and ABS + CF or GF, has proven immensely successful in marine applications. The technology has been effectively employed to manufacture significant marine components, including boat tooling, prototypes, and end-use superstructures. Numerous international enterprises, Tier 1, and Tier 2 OEMs have leveraged this technology to advance their marine projects, attesting to its efficiency and reliability.

Heron AM and reduction in lead times

Caracol has directed its attention primarily towards the yachting industry, reaping the benefits of LFAM, which include enhanced design freedom, customization options, improved fuel efficiency, shorter lead times, and cost optimization. In the luxury market of yacht and superyacht production, where bespoke designs are highly valued, AM has proven to be a perfect match. It enables luxury vessels to effortlessly incorporate one-of-a-kind fittings and superstructures that precisely mirror the client's individual preferences, elevating yacht performance and overall appeal.



Heron AM finishing production cycle of marine air grid

This Caracol case study perfectly exemplifies the opportunities and advantages presented by its Heron AM LFAM solution for yacht makers. Collaborating with international boatbuilders, Caracol successfully facilitated the production of lightweight 3D printed air grids on a significantly expedited timeline compared to traditional manufacturing methods.

Air grids entail intricate designs that incorporate non-flat geometries, serving the purpose of controlling air flow in specific ways. Typically, these components are manufactured using a labor-intensive lamination approach, involving molds and various fiberglass or metal sheet working processes like laser cutting, bending, and machining. This multistep process can take up to 10 weeks to yield the final product.

Given the complexity of superstructure design and the limitations of conventional production methods, air grids emerge as an ideal use case for LFAM, particularly

Caracol's Heron AM solution. The robotic LFAM system employed by the company is capable of printing at various angles, including 45°, and adeptly fabricates intricate, hollow structures with remarkable ease. This advanced technology has revolutionized the production of air grids, streamlining the process and significantly reducing lead times for enhanced efficiency.

A sea-worthy technology

Undoubtedly, with LFAM specialists like Caracol actively collaborating with customers in the maritime and marine industries, the widespread adoption of 3D printing for boat production is inevitable. The close partnership between technology providers and industry players ensures that the benefits and potential of 3D printing become increasingly apparent and accessible to all sectors, including racing boats, cruise ships, and superyachts. As this collaboration continues to flourish, 3D printing will gradually transition from being an innovative approach to becoming a standard and integral part of boat manufacturing processes. The future holds great promise for the normalization of 3D printing in the marine industry, revolutionizing the way boats are designed, built, and operated.

Caracol a specialist in Robotic Large Scale Additive Manufacturing (LSAM) is joining the upcoming AM Conclave event, as one of the premium sponsor. The company plans to showcase their cutting edge technology at the event for wide range of industries.

ABOUT THE AUTHOR

CARACOL

CARACOL

Caracol is an provider of Large-Format Robotics Additive Manufacturing platform, which have integrated hardware and software solution, developed in-house.

3D Printing as an enabler of Sustainability

AM Chronicle Editorial Team

Discussion on 3D printing as an enabler of Sustainability

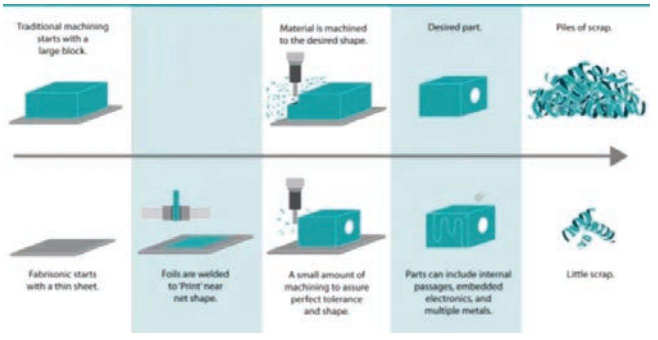
In the modern era, technological advancements have drastically transformed industries, sustainable development is one of the major challenges that mankind is facing. Several technologies are seen an potential solutions for resolving sustainable challenges. One of such promising technology is additive manufacturing or 3D printing. 3D printing has not only revolutionised production processes but has also emerged as a key promoter of sustainability across various sectors.

COP28 UAE will take place from 30 November to 12 December 2023 at Expo City, Dubai in the United Arab Emirates. By hosting COP28, the UAE is focusing on practical and positive solutions that drive progress for the climate and the economy, as well as provide relief and support to vulnerable communities. The UAE intends to make COP28 highly inclusive, reflecting the views of all geographies, sectors, and constituencies. With the upcoming event in mind, this special insight article throws light on some of the aspects of 3D printing in sustainability.

The Environmental Advantages of 3D Printing

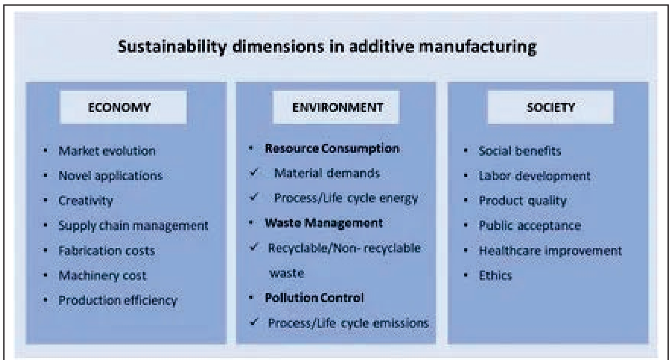
Additive manufacturing minimizes material waste by using only the exact amount needed for production.

Traditional manufacturing often leads to significant material wastage during the cutting and shaping processes, whereas additive manufacturing builds objects layer by layer, optimizing material utilization. Traditional manufacturing processes, such as injection molding and CNC machining, require a substantial amount of energy to shape and mold raw materials. In contrast, additive manufacturing significantly reduces energy consumption by building objects layer by layer without the need for extensive machinery or excessive heat.



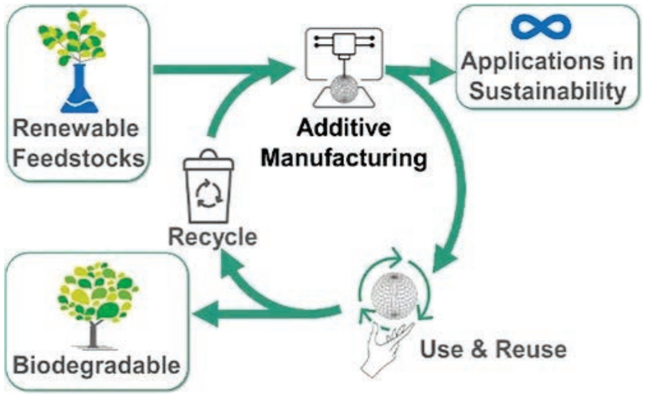
Comparison of Traditional and additive manufacturing processes, Source: Miriyev et al. 2016.

Additive manufacturing enables localized production, reducing the need for long-distance transportation of goods. This reduces the carbon footprint associated with shipping and transportation, as well as the associated emissions. The design freedom offered by additive manufacturing allows for the creation of complex and lightweight structures. These optimized designs reduce the overall weight of objects, leading to fuel savings in applications such as aerospace and automotive industries.



Sustainability Dimensions of Additive Manufacturing, Source: Mehrpouya et al.2021

Additive manufacturing facilitates on-demand production, enabling companies to manufacture products as needed, reducing excess inventory and the waste that often accompanies it. This process is having significant advantage on enhancing the sustainability of various sectors.



Green Additive Manufacturing, Source: Sanchez-Rexach et al. 2020

Green additive manufacturing is an emerging concept that uses biodegradable and renewable materials for additive manufacturing. In this method, source materials such as filaments, resins and metal powders are sourced from sustainable & renewable sources, enhancing the overall sustainable impact on additive manufacturing.

Case Studies of Sustainability improvement using additive manufacturing

With regard to medical advancements, companies specializing in medical devices are now crafting customized hip implants that possess the ability to stimulate bone regeneration. These implants feature intricate porous internal structures, a feat previously unattainable through conventional manufacturing methods. This innovation not only enhances patient outcomes but also underscores the transformative potential of additive manufacturing in healthcare.

In the aerospace sector, the Air Force has harnessed the power of 3D printing to fabricate replacement metal parts on-demand. By sidestepping the need for extensive and expensive inventories or enduring protracted waits for components sourced from hard-to-find suppliers, this agile approach ensures rapid and efficient maintenance, thereby bolstering operational readiness.

Meanwhile, General Electric has orchestrated a paradigm shift in the aviation industry with their additively-manufactured fuel nozzle for commercial airplane engines. By consolidating a once multipart assembly into a single component, the company has achieved a substantial 30 percent reduction in production costs. Moreover, this innovation has yielded a nozzle that is not only 25 percent lighter but also boasts an impressive fivefold increase in durability, exemplifying the manifold advantages of additive manufacturing in terms of efficiency, performance, and sustainability.

Challenges and Future Outlook

While additive manufacturing holds immense promise for promoting sustainability, there are still challenges to overcome. Material sustainability, recycling of 3D printed products, and the energy consumption of certain high-performance additive processes are areas that require continued research and development. As technology advances, additive manufacturing is expected to become more accessible and efficient, further driving its adoption across industries. Collaborative efforts between researchers, industries, and governments can play a crucial role in addressing challenges and maximizing the positive impact of additive manufacturing on sustainability.

Additive manufacturing is a significant tool to create a more sustainable future. By minimizing material wastage, reducing energy consumption, enabling localized production, and promoting design optimization, additive manufacturing is helping industries and advancing sustainable practices. As the world continues to grapple with environmental challenges, the role of additive manufacturing in driving positive change cannot be overstated. Its ability to combine cutting-edge technology with eco-conscious practices makes it a cornerstone of sustainability in the digital age.

References

- Miriyev, A., Kalabukhov, S., & Frage, N. (2016, March). Ultrasonic additive manufacturing of dissimilar material systems: method, post-processing and properties. In Proceedings of the Fraunhofer Direct Digital Manufactruing Conference (DDMC2016).
- Mehrpouya, M., Vosooghnia, A., Dehghanghadikolaei, A., & Fotovvati, B. (2021). The benefits of additive manufacturing for sustainable design and production. In Sustainable manufacturing (pp. 29-59). Elsevier.
- Sanchez-Rexach, E., Johnston, T. G., Jehanno, C., Sardon, H., & Nelson, A. (2020). Sustainable materials and chemical processes for additive manufacturing. Chemistry of Materials, 32(17), 7105-7119.
- https://www.whitehouse.gov/cea/written-materials/2022/05/09/using-additive-manufacturing-to-improve-supply-chain-resilience-and-bolster-small-and-mid-size-firms/

ABOUT THE AUTHOR

AM Chronicle Editorial Team

The AM Chronicle Editorial Team is a collective of passionate individuals committed to delivering insightful, engaging, and accurate news and stories to additive manufacturing audience worldwide.

Can 3D printing cut shoe footprints?

Heather Clancy

The article elobrates the advantages of 3D printing technology to make the footware industry sustaianble

How many shoes live in your closet? I stopped counting at 30 pairs, although in my defense, I've been wearing and repairing some of them for two decades.

Setting aside my questionable consumer habit, these official shoe stats are even more concerning: Of the estimated 20 billion to 24 billion pairs of footwear produced annually on a global basis, a significant number of them — potentially 95 percent — eventually walk their way into landfills. That number looms large for circular economy entrepreneur Elias Stahl, CEO and co-founder of three-year-old startup Hilos, which uses 3D printing technologies to produce the "platform" for shoes as they are ordered. (As Stahl tells it, the name "represents the versatility of the technology, from highs to lows.")

Stahl, most recently vice president of products for social impact agency Handshake Partners, said he was motivated by the “insane amount” of waste he has observed in traditional manufacturing models. Many machines for shoe and apparel production, Stahl notes, haven't been redesigned in a century — he describes them as “the last gasp” of U.S. product consumption models built on cheap overseas labor and a relative disregard for waste. “This is too big of a problem not to solve,” he told me.

Hilos, based in Portland, Oregon, in March raised $3 million in early funding for its process to rewrite the rules for shoe production using 3D printing technologies — a model already being used by shoemaker Helm to make bespoke mules that retail for $225 per pair. (Not exactly a mainstream offering.) Its investors include two former executives from Nike: Eric Sprunk, retired COO, and Greg Bui, retired vice president of global footwear sourcing and manufacturing. Both are actively engaged with Hilos, although Stahl is cagey about their exact involvement — Bui is leading “a rapid scale-up of the technology” (according to the company's public statements) and Sprunk is an adviser.

Allure of additive manufacturing

Hilos is using 3D printing to change how the platform of a shoe — the part that bears the brunt of your personal footprint and, for that matter, the carbon one — is created. It doesn't own the printers outright, instead, it partners with GKN Additive, using its facilities in California and Michigan, Stahl told me. Rather than being assembled from multiple layers glued or cemented together, the Hilos “printed” platform is created as one part that combines insole, midsole, outsole and heel. The “upper” of the shoe — in the case of the aforementioned mules, it's veg-tanned leather — is attached using cables. According to Stahl, there are a number of benefits to this approach (the data is from an analysis referenced a bit later in this essay):

- The use of noxious glues is reduced, although it still uses about 1 gram per pair.
- The number of parts required can be dramatically reduced from an average of 65 to just five components per shoe. The number of steps required for assembly is reduced from 360 down to 12. That means it takes about an hour of labor to assemble rather than the typical estimate of four hours.
- The shoes can be produced “on demand” once they are ordered, cutting down on wasted inventory that never finds its way off the shelf.
- The shoes are easier to disassemble at the end of their wearable life.

Hilos teamed with the Yale University Center for Business and the Environment, BASF, HP and Additive Manufacturing Technologies to calculate the environmental impact analysis for its approach, which is the source for some of those claims. The startup also says its process can reduce the water consumption needed to produce a pair of shoes by up to 99 percent compared with traditional manufacturing, while reducing greenhouse gas emissions by 48 percent. About 29 percent of the CO2 reduction is related to parts reduction, 20 percent comes from switching to on-demand production and the rest comes from the product's circularity, according to the analysis.

By the way, the evaluation specifically compared the Helm Emmett mule design with the Veja Esplar sneaker, with a fully leather upper.

One last thing to point out: If you compare the emissions of the two shoes on a part-by-part basis, the analysis suggests that the emissions for 3D printing are actually 10 percent to 17 percent higher. “Only when a complete assembly of the shoe is taken into account does the overall carbon efficiency of 3D printing stand out,” according to the analysis.

There's another factor to take into account: What the Hilos platform is made out of. It's not necessarily a material an audience of sustainability professionals readers would consider sustainable over the long term — the substance is a thermoplastic polyurethane powder from BASF. (Hence, BASF's participation in the analysis.) When I asked Stahl if Hilos plans to use recycled or bio-based materials to create its shoe platforms, he said Hilos hopes to refine its production and disassembly approaches first.

Does Hilos represent a turning point for the use of additive manufacturing in the fashion industry? That's clearly for brands to decide, as the startup pitches its approach — I can imagine it working mainly for some really specific footwear. But given those advising its business model, this startup is taking a step in the right direction.

ABOUT THE AUTHOR

Heather Clancy

VP, Editorial Director at GreenBiz Group

Heather Clancy, vice president and editorial director at GreenBiz, specializes in chronicling the role of technology in enabling corporate climate action and transitioning to a clean, inclusive and regenerative economy. An award-winning journalist, she started her journalism career on the business desk of United Press International, and her articles have appeared in Entrepreneur, Fortune, The International Herald Tribune and The New York Times.

Can 3D printing become a sustainable way to close the global housing gap?

Luis Triveno & Olivia Nielsen

How can 3D printing help to resolve the challenges of sustainable housing

From Malawi to Mexico, construction companies are utilizing 3D printing technology to break new ground on housing projects. 3D printing could be our century's revolutionary printing process, similar to the significance of Gutenberg's printing press in the 1400s. In 2016 the United Arab Republic, which imports upwards of 70 percent of its labor, became the first country to promote 3D printing in its construction industry, setting a 25 percent target by 2030. Habitat for Humanity built its first 3D house in Virginia last year in half the time – and 15 percent less cost– than a traditional wooden structure. A Texas-based start-up that has already delivered more than two dozen 3D-printed concrete structures in the US and Mexico – half of them to house homeless or extremely poor people – has recently lined up upwards of $200 million from eager investors who believe that such unicorns have the potential to disrupt an industry ripe for change.

This new technology has fired up the imaginations of affordable housing advocates around the world who see producing new and resilient housing quickly and affordably as a "game-changer." The housing sector is ripe for change with over 1.6 billion people living in substandard housing and another 100 million homeless today. The odds that this latest breakthrough in printing technology could revolutionize the industry and fill the housing deficit will depend on its ability to initiate change and offer net benefits in at least the following three areas:

Beyond brick and mortar and across the housing value chain

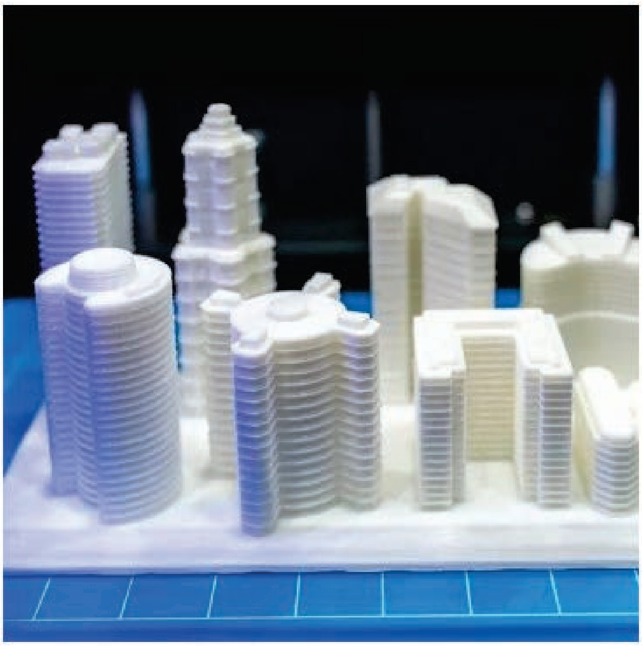
When it comes to affordable housing, every dollar counts. 3D printing promises to dramatically cut construction time and costs (around 15%). However, for 3D printing to truly reach its potential, it will require a lot more investment to enable further cost reductions as well as greater flexibility. Major barriers remain: few housing experts are familiar with the technology and regulators have yet to adapt building codes and permit processes; innovations will also be required across the housing sector's complex value chain regarding land use, infrastructure, and access to finance. In many urban areas, for example, the cost of land is far more expensive than the cost of construction. 3D construction has focused on single-family housing, therefore going vertical will be critical to solving the global deficit.

Employment

Historically, the introduction of new technologies has caused shifts across job markets, and 3D-printed housing will be no exception. Automation has been canceling low-skilled jobs for decades in rich countries. For emerging economies, where construction jobs are important, 3D printing may be a greater threat – wiping out the jobs of skilled bricklayers around the world. Yet advocates are quick to counter that more than half of those bricklayers could be trained for higher-paying jobs operating and maintaining the 3D printing machinery or developing new software. Innovations have benefits and downsides, but the most successful changes tend to have net positive benefits. There is already encouraging preliminary evidence revealing the shift to 3D printing for housing enables more women to participate in the construction industry.

Climate change

In Malawi, 3D printing reduced construction waste almost tenfold and reduced CO_2 emissions by up to 70%. It also reduced transportation emissions when building in remote areas (by as much as two tons per home!), revealing its potential for helping to solve the rural housing deficit. Building technology alone will not stall climate change without smarter urban planning, wider access to transportation, and an increase in housing density. The climate savings of the greenest house on the periphery of a city will be consumed in a household's costs to commute to jobs in the inner city. 3D printing has proven it can build single-family houses faster and cheaper than traditional methods. The next challenge is to produce high-rise, green multi-family buildings.



The global housing deficit is a massive problem that will require much more innovation than just 3D printing.
The global housing deficit is a massive problem that will require much more innovation than just 3D printing.
If you think of the solution to the housing deficit as an iPhone, 3D printing is still only a state-of-the-art screen. Other comparably innovative new parts will also be required, such as: regenerating urban centers, better

and greener solutions for transportation, new methods of financing, and different kinds of housing tenure. The full solution will require disruption across the full housing value chain.

It is now up to those of us committed to solving the global housing deficit to come up with the policy ideas that will steer construction companies and investors eager to disrupt the housing industry. Together we could catalyze another printing revolution that will produce safe and affordable housing – while invigorating urban areas, creating new jobs, and protecting the planet.

The article is reprinted from World Bank blog, titled "Can 3D printing become a sustainable way to close the global housing gap?" published on Jun 6, 2023 under the creative common license.

ABOUT THE AUTHOR

Luis Triveno

Senior Urban Development Specialist

Luis Triveño is a Senior Urban Development Specialist. Currently based in Jakarta, he is the Sector Coordinator for Urban, Resilience and Land in Indonesia.

ABOUT THE AUTHOR

Olivia Nielsen

Principal at Miyamoto International

Olivia Nielsen is a leader of Miyamoto International, currently working on massive, global projects for resiliency, financing and construction in pre- and post-disaster conditions.

Construction 3D Printing and its Impact on the Labor Market in Middle East

Chinmay Saraf

The article reviews research papers which elaborates the potential impact of construction 3D printing

The construction industry is one of the largest and most important industries in the world. However, it is also one of the least digitized and most labor-intensive industries. This has led to low productivity and high costs. Labor shortage is common in countries of Middle East like UAE, Oman, Qatar and others.

3D printing, is a rapidly emerging technology that has the potential to revolutionize the construction industry. 3D printing allows for the construction of complex structures with high precision and repeatability. This can lead to significant productivity gains and cost savings. In addition, 3D printing can be used to create structures that are not possible with traditional construction methods. This could lead to new and innovative designs that improve the performance and sustainability of buildings.

The authors of this article conducted a review of the literature on 3D printing in construction. They identified the potential benefits and challenges of 3D printing for the construction industry. They also discussed the impact of 3D printing on the labor market.

Impact on Labor Market

The construction industry is also facing a number of challenges, including a shortage of skilled labor, low productivity, and high costs. 3D printing has the potential to address some of these challenges. In the study, the authors discuss a number of factors that will influence the impact of 3D printing on the labor market in the construction industry. The authors of the article discuss a number of factors that will influence the impact of 3D printing on the labor market in the construction industry.

3D printing can be used to automate many of the tasks that are currently performed by manual labor, which could lead to an increase in productivity and a decrease in the need for unskilled labor. In addition, 3D printing can be used to create complex structures that are not possible with traditional construction methods, which could lead to new and innovative designs.

However, 3D printing could also have a negative impact on the labor market in the construction industry. 3D printing could lead to the displacement of some low-skilled workers, as well as the creation of new jobs for skilled workers in 3D printing. It is important to carefully manage the transition to 3D printing in the construction industry to ensure that the benefits of 3D printing are realized and that the negative impacts on the labor market are minimized.

The adoption of 3D printing in construction will require a reassessment of the design and work processes, as well as the organizational structures. It is not yet clear whether 3D printing will reduce the number of architects, engineers, and constructors needed to design and plan a construction project, or if it will only reduce the number of craft workers on the jobsite. However, it is clear that new skills will be required to adopt 3D printing within an organization.

It is important to note that there is still some debate about the extent to which 3D printing can be used in construction projects. Some experts believe that the potential savings of 3D printing have been overstated, as individual walls, floors, roofs, and other building elements must still be fastened together using conventional methods, such as bolting or joining parts together.

Although 3D construction printing is expected to reduce the need for human resources, it will still require workers with specialized skills in both masonry and digital technology. These workers will be responsible for detecting glitches in the digital model during the masonry construction process.

The cost of 3D printers is a major barrier to adoption in the construction industry. However, the cost of 3D printers is expected to decrease as the technology matures. The availability of skilled labor is another barrier to adoption. However, this barrier can be addressed by training workers in 3D printing.

The regulatory environment is also an important factor that will influence the impact of 3D printing on the labor market. In some countries, there are regulations that restrict the use of 3D printing in the construction industry. These regulations will need to be addressed before 3D printing can be widely adopted in the construction industry.

Overall, the impact of 3D printing on the labor market in the construction industry is uncertain. However, there is potential for 3D printing to lead to both positive and negative impacts on the labor market. It is important to carefully manage the transition to 3D printing in the construction industry to ensure that the benefits of 3D printing are realized and that the negative impacts on the labor market are minimized.

Conclusion

This research provides a comprehensive review of the potential benefits and challenges of 3D printing for the construction industry. The authors also discuss the impact of 3D printing on the labor market.

The authors found that 3D printing has the potential to improve productivity, reduce costs, and create new and innovative designs in the construction industry. However, there are also some challenges that need to be addressed before 3D printing can be widely adopted in the construction industry. One of the main challenges is the high cost of 3D printers. However, the cost of 3D printers is expected to decrease as the technology matures. Another challenge is the lack of skilled labor in 3D printing. However, this challenge can be addressed by training workers in 3D printing.

Various studies also suggests that 3D construction printing can significantly reduce the number of laborers needed in construction, potentially saving up to 50–80% in labor costs. This could help to solve the labor shortage problem in countries that rely heavily on migrant workers for construction, such as the United States, United Arab Emirates, Qatar, Malaysia, and Singapore.

The authors of this article conclude by discussing the future scope of 3D printing in the construction industry. They believe that 3D printing has the potential to revolutionize the construction industry. However, they also believe that there are some challenges that need to be addressed before 3D printing can be widely adopted in the construction industry.

Overall, 3D printing has the potential to revolutionize the construction industry. It has the potential to improve productivity, reduce costs, and create new and innovative designs. However, there are some challenges that need to be addressed before 3D printing can be widely adopted in the construction industry. These challenges will be addressed in the future, and that 3D printing will have a positive impact on the construction industry.

The article is review of research paper titled "A Review of 3D Printing in Construction and its Impact on the Labor Market" published in MDPI Journal Sustainability.

Source: Hossain, M.A.; Zhumabekova, A.; Paul, S.C.; Kim, J.R. A Review of 3D Printing in Construction and its Impact on the Labor Market. Sustainability 2020, 12, 8492. https://doi.org/10.3390/su12208492

ABOUT THE AUTHOR

Chinmay Saraf

Technical Writer, AM Chronicle

Chinmay Saraf is a scientific writer living in Indore, India. His academic background is in mechanical engineering, and he has substantial experience in fused deposition-based additive manufacturing. Chinmay possesses an M.Tech. in computer-aided design and computer-aided manufacturing and is enthusiastic about 3D printing, product development, material science, and sustainability. He also has a deep interest in "Frugal Designs" to improve the present technical systems.

3D printed parts could benefit oil & gas, offshore and maritime supply chains

Sastry Yagnanna Kandukuri

The article looks at top benefits and barriers of AM for improving oil & gas, offshore and maritime supply chains

Trust is key to unlocking additive manufacturing's potential for your business. We look at the top benefits of, and barriers to, this technology, and how DNV can help your sector to use it to become safer, more efficient and more sustainable.

A potential revolution in design, manufacturing and distribution

Additive manufacturing (AM), a sophisticated development of 3D printing, could transform how products used in projects and operations are designed, manufactured and distributed. Through its Global Additive Manufacturing Technology Centre of Excellence in Singapore and global network of experts, DNV has broad perspectives and detailed insights into how AM can help these sectors to become safer, more efficient, and cleaner. Here are just five big reasons why we believe AM has great potential to do this. We also summarize barriers to its uptake and how our collaborations with industries, governments and academia are tackling these.

Five big reasons why additive manufacturing could disrupt the oil & gas, offshore and maritime sectors' supply chains.

1. Shorter lead times
2. Less storage or inventory
3. Lower carbon footprint
4. Boosting innovation
5. Enabling new business models

Enabling shorter lead times, less storage and reduced inventory

AM could shorten lead times for sourcing parts and reduce the need for costly storage space on platforms, rigs and vessels as digital files replace physical products needed to keep assets operational. Many operators tie up huge sums of capital in inventory that may never be used and can become obsolete over time. The digital files store computer code that controls precision 3D printing of items. Say you need mission-critical parts to be available promptly in Brazil, but they are stored in Norway. You might invest in secondary storage in Brazil. With AM, though, digital instructions for 'printing' the part could go to a nearby AM company in Brazil, or directly to where it is needed. Lead times could be cut from months to days, avoiding expensive operational downtime. This model could address supply-chain issues such as costly and lengthy retooling of manufacturing equipment to fulfil urgent orders; and, the time and cost involved in sudden design changes or project cancellations. In summary, AM technologies could bring scalability, speed, customization and on-demand production with minimal or no retooling. This could assist the oil & gas, offshore and maritime industries to become leaner, more agile, and to remain competitive.

Reducing carbon footprints

AM could help the oil & gas, offshore and maritime industries decarbonize operations in the energy transition. Distributed just-in-time production close to or exactly where products are required reduces transportation needs. This in turn means less exhaust emissions, including greenhouse gases.

AM generally produces less waste than conventional methods that usually involve machining away material from a large piece of metal. In contrast, AM adds only material that is needed, and co-locating it with recycling of materials could boost local circular economies. One example could be turning used plastics and scrap metal into new feedstock powders and wires for AM.

Enabling technological innovation

AM supports innovation by enabling rapid iteration of physical objects during R&D. Combining it with modern information and communications technology lets designers, original equipment manufacturers (OEMs) and end users collaborate more efficiently from wherever they are. AM could also be better than traditional manufacturing methods for handling more complex designs, and for using unconventional and new materials. It needs less or no retooling of manufacturing equipment. It could also enable novel repair methods such as building up new layers of material on eroded areas. This could extend the safe and efficient operation of ageing assets and reduce the lifecycle cost of equipment.

Innovation can extend to the business models of supply-chain participants. Some oil and gas operators are interested in the concept of shortening supply chains by installing AM manufacturing capabilities on their own assets and sites. OEMs embracing AM could look to sell access to their designs and models rather than selling equipment and spare parts. They might consider asking end users to pay monthly subscriptions for printing high-use spare parts, or one-off downloads of digital code for manufacturing larger components.

Enabling new business models

Some OEMs see AM offering potential to recapture market share from non-OEM parts sold in 'grey' markets where distribution of the 'real' parts is absent or lengthy. OEMs could instead supply digital files securely to selected local resellers equipped with AM capability to reproduce parts legally and safely. It would reduce the cost of parts and boost availability. But who would be responsible for the part working, and for how long? Who would offer the warranty? How can an OEM remain comfortable about its name being on the part? The key issues here and in other aspects of AM are trust and assurance.

AM is already disrupting supply chains in automotive, aerospace and consumer products. It is in its infancy in the oil & gas, offshore and maritime sectors as they ponder challenges similar to those that confronted Netflix in the transition from DVDs to online streaming of video. As well as novel profit/cost models, the supply chain is grappling with intellectual property (IP) and usage rights for OEM designs, and standardization of technology interfaces.

Other potential challenges include batch inconsistency of materials for AM, variation in hardware, differing environmental and operational conditions, and regulatory change. Just as with physical stock, digital inventories will need assurance schemes including meeting cyber-security standards.

Creating trust in additive manufacturing

Faced by a wide range of challenges, trust is the key. AM needs a systematic qualification process, standards, and specialized knowledge towards qualification and certification of 3D-printed components and materials. Without standardization or guidelines, printed parts and components in oil & gas, offshore and maritime industries could raise the risk of unexpected or premature failures due to inherent variation of mechanical and metallurgical properties associated with the AM parts. Printed parts or components that were not properly identified and tested during the qualification and/or certification process could lead to unexpected functional performance behaviour. As such, non-standard practices for testing parts raise the probability of overall material costs rising compared to the traditional manufacturing route.

Through our global network of laboratories and experts, we help customers to identify how AM could add value to their businesses by addressing these barriers and enabling a safe introduction to the oil & gas, offshore and maritime industries.

Collaborating to maximize benefits of additive manufacturing

The challenge now is to get all stakeholders in the oil & gas, offshore and maritime industries talking and looking at the best ways to ensure that everyone in the sectors benefits from AM, a potential game changer. DNV has initiated several joint industry projects with customers globally in certification and qualification areas of AM for reconditioning old parts or creating on-demand new spare parts, and for fabrication of large-scale structural parts. This includes Sembcorp Marine, Maritime Port Authority, Anglo Eastern shipping, Wartsila, Baker Hughes, Carpenter, Chevron, Equinor, Shell, Total, BP, and others, to name a few.

DNV's ongoing global joint industry projectsh

Joint Industry Projects	Customers	Location
Pilot Project on Technology Readiness of AM for repair applications in Maritime and Oil & Gas Industry Sectors	sembcorp marine; Nanyang Technological University; NAMIC; DNV·GL	Singapore
Feasibility study of structural support nodes using Laser Assisted Additive Manufacturing (LAAM) Technology	sembcorp marine; A*STAR; NAMIC; DNV·GL	Singapore
Feasibility of Additive Manufacturing for Marine Parts	JIP Lead Research Performer: DNV·GL; JIP Partners From SSA: Anglo-Eastern, PIL, BSM, CMA CGM, Thome Group, Eastern Pacific Shipping, Wilhelmsen, OSM, Zeaborn; JIP Collaborators: Wärtsilä, sembcorp marine, SpareParts 3D, ivaldi; JIP Project Initiators And Key Stakeholders: MPA, NAMIC, SSA	Singapore
Sour service and Seawater CP performance of Additive Manufacturing 718	Arconic; Baker Hughes; Chevron; Carpenter Technology; Dresser-Rand A Siemens Business; Siemens; TechnipFMC	Colombus, US
ProGRAM	Operators: bp, equinor, Shell, Total; Contractors: SLM, TechnipFMC, Kongsberg, Siemens; Fabricators: ArcelorMittal, voestalpine, Additive Industries, HIPtec, ivaldi, aidro, vallourec, Quintus	Oslo, Norway

Original Source: 3D printed parts could benefit oil & gas, offshore and maritime supply chains - DNV. (n.d.). DNV. https://www.dnv.com/oilgas/laboratories-test-sites/article/3D-printed-parts-could-benefit-oil-gas-offshore-and-maritime-supply-chains.html

ABOUT THE AUTHOR

Sastry Yagnanna Kandukuri

Senior Principal Specialist

Dr. Sastry Kandukuri is a passionate and experienced digital materials and manufacturing technology professional with Doctorate/Maters/Bachelor degrees in Metallurgy and Materials Engineering and Masters degree in Computer Science coupled with more than 20 years of diverse experience in Maritime, Oil & Gas and Manufacturing sectors.

AM NEWS

Woodside Energy joins collaboration aimed at standardising digital supply of spare parts

This initiative, in conjunction with ConocoPhillips, Equinor, Shell, TotalEnergies, Vår Energi, and software provider Fieldnode, is set to establish a network for supplying spare parts manufactured as and when needed.

Woodside Energy is aligning with several leading energy companies to launch a digital inventory standard for on-demand spare parts production.

The collaboration will help increase the efficiency of the digital ecosystem. This means reduced lead times, decreased total cost of ownership, minimised waste, and shorter shipping distances. Furthermore, the project will enhance the security and sustainability of the supply chain.

Areas of focus for this partnership include standardising qualification processes and developing a commercial model that supports mass customisation and a superior value proposition for all entities in the network.

To reach these ambitious goals, the partners will gradually invite their current suppliers, independent additive manufacturers, and other potential collaborators to the platform over the project period. This collective effort will enable comprehensive technical and commercial solutions testing and populate the digital inventory.

"We are one year into the project and achieved significant advancements in key areas, such as creating commercial models and standardising qualification standards. Welcoming Woodside Energy as the sixth operator in this joint effort offers an excellent chance to validate further and ensure our solutions meet the demands of the energy industry," says Martin Andersson, the project manager at Fieldnode.

The foundational technical solution is the Fieldnode platform. Co-developed with Equinor and TotalEnergies, it enables streamlined management of supply networks and facilitates shared supply chain resources among oil and gas operators.

Daniel Kalms, Chief Technology Officer at Woodside Energy, sees the opportunity for the sector.

"The potential for on-demand manufacturing is something Woodside Energy identified some time ago, and joining this collaboration signifies our commitment to maximising the benefits of additive manufacturing. On-demand manufacturing of spare parts has many advantages. It allows for greater flexibility and responsiveness to changing needs, reducing the dependency on pre-made inventories, and enhances operational efficiency," he said.
The ongoing collaboration will allow further development of industry standards, bolstering a reliable and eco-friendly supply of spare parts.

Dubai Municipality issues first construction license of villa using 3D printing technology

Dubai Municipality announced its issuance of the first construction license for a private villa using 3D printing technology. The villa will be printed in one session and will be located at Al Awir 1 area in Dubai. A four-meter-

high structure will be printed in a single session, and the villa construction work that started recently will be as part of an unprecedented global project. The villa is expected to be completed by October 2023 and will be built entirely from locally sourced concrete.

These procedures enhance the aspirations of Dubai and support the objectives of the Dubai 3D Printing Strategy 2030. The strategy aims to increase the percentage of implemented 3D printed buildings in the Emirate to achieve a minimum rate of 25% by 2030.

Eng. Mariam Al Muhairi, Acting CEO of the Buildings Regulation and Permits Agency at Dubai Municipality said: "Dubai Municipality has issued the emirate's first construction license for a private residence built with 3D printing technology. This project aims to encourage contractors, engineers, investors, and real estate developers to adopt and use technology in their building operations. The Municipality further offers support and facilities to monitor and control the usage of this innovative technology in building and construction, in line with the Dubai 3D Printing Strategy and Decree No. (24) of 2021 Regulating the Use of Three-dimensional Printing in Construction Works in the Emirate of Dubai, which aims at increasing the percentage of buildings implemented and printed using the 3D technology by no less than 25 per cent by 2030."

The use of 3D-printed construction achieves a variety of economic and environmental benefits, including lower construction costs and shorter construction time by shortening the supply chain for construction work, ease of construction of complex shapes structures, the use of sustainable raw materials and recycled materials in construction and environmental preservation by reducing the proportion of tailings resulting from construction work. As it does not necessitate a huge number of personnel on site, 3D printing technology is faster and more accurate than traditional methods of construction.

Dubai Municipality launched a variety of technical activities specialized in 3D printing technology last year, including construction engineering consultancy activity with this technology, construction contracting activity with 3D printing technology, and manufacturing concrete for construction using this technology.

NAMI Unveils State-of-the-Art Additive Manufacturing Facility in Saudi Arabia

Photo Credit: NAMI

NAMI, a leading innovation-driven company in Saudi Arabia, announced the launch of its state-of-the-art additive manufacturing facility, showcasing the Kingdom's commitment to digitalization and industrial advancement. Under the patronage of HRH Prince Abdulaziz bin Salman and Minister of Industry and Mineral Resources, Bandar I. Alkhorayef.

NAMI's new additive manufacturing facility, equipped with cutting-edge technology and infrastructure, aims to facilitate the manufacturing sector in the Kingdom. This facility will serve as a pivotal hub for advanced research, development, and production, fostering innovation and growth in the rapidly evolving field of additive manufacturing.

Photo Credit: Artem Korotygin

Additive manufacturing has emerged as a disruptive force in modern manufacturing. By enabling the production of complex designs with enhanced efficiency and reduced costs, this technology holds immense potential to drive Saudi Arabia's industrial sector towards greater competitiveness on a global scale.

The patronage of HRH Prince Abdulaziz bin Salman and Minister Bandar I. Alkhorayef underscores the significance of NAMI's endeavor and its alignment with the Kingdom's vision for a technology-driven economy. The initiative by NAVI will unlock new opportunities, strengthen local industries, and contribute to the global manufacturing landscape.

About NAMI

National Additive Manufacturing & Innovation Company "NAMI" is a Saudi company located in Riyadh, funded as a joint venture between industry-leaders 3D Systems and Dussur a strategic industrial investment firm owned by Saudi Arabian Public Investment Fund, Saudi Aramco, and SABIC. We aim to become the leading digital manufacturing platform transforming product creation methodology from conventional ways to additive manufacturing and accelerate the adoption of 3D printed products by facilitating the access to reliable industrial grade capabilities and application engineers from various fields. We create sustainable value for bringing industry-leading application expertise and the broadest range of printing solutions to maximize local adoption of 3D printing. To save our clients the time they would normally spend sourcing quotes, alongside our technical partner we developed an AI-based pricing algorithm providing instant quotations for a wide range of 3D printing technologies, materials and post-processing methods. Learn more about us at www.nami3dp.com.

Disclaimer: This news is intended for informational purposes only. The information contained herein is subject to change without notice.

Dubai Electricity and Water Authority uses 3D printing to build over 1,800 spare parts

Dubai Electricity and Water Authority (DEWA) built over 1,800 spare parts for its power generation, transmission and distribution divisions at its 3D printing lab, which saved the DFM-listed utility 509,658 UAE dirhams ($138,773) in 2021 and 2022.

DEWA said in a statement that the 3D printing facility, located in within its Research and Development (R&D) Centre, utilises over 20 materials covering various engineering applications, including metal and high-performance thermoplastics.

It said the average time to provide printed spare parts is just four days.

"Through our R&D Centre, we are keen to develop 3D printing technologies, additive manufacturing, and other innovative technologies that are used internally to print spare parts for devices and equipment. This reduces procurement time and cost, extends the lifespan of these devices, and promotes innovation," said Saeed Mohammed Al Tayer, Managing Director and CEO of DEWA.

Waleed Bin Salman, Executive Vice President of Business Development and Excellence at DEWA added that 3D printing technology helps tackle challenges posed by equipment obsolescence, spare parts no longer being manufactured or sold, and high costs associated with replacing the entire system.

Since its launch, the R&D Centre at the Mohammed bin Rashid Al Maktoum Solar Park has filed 23 patents, of which three have been granted. The statement said three of the filed patents are specifically related to 3D printing.

About DEWA

The Dubai Electricity and Water Authority is a public service infrastructure company that was founded on 1 January 1992 by Sheikh Maktoum bin Rashid Al Maktoum. The objective of the state-run company is making available to the people of Dubai an adequate and reliable supply of electricity and water. As of end of 2019, DEWA employs a workforce of 11,727 employees and provides 915,623 customers with electricity and 816,580 customers with water.

3D Systems & Dussur Create Joint Venture to Expand Additive Manufacturing in Saudi Arabia

3D Systems (NYSE:DDD), the leading additive manufacturing solutions provider, and the Saudi Arabian Industrial Investments Company (Dussur) have signed an agreement intended to expand the use of additive manufacturing (AM) within the Kingdom of Saudi Arabia and surrounding geographies, including the Middle East and North Africa. The announcement was made during a ceremony in Riyadh on March 29, 2022. The purpose of the new Joint Venture is to enable the development of Saudi Arabia's domestic additive manufacturing production capabilities, consistent with the Kingdom's 'Vision 2030,' which is focused on diversification of the economy and long-term sustainability. The Center for Innovation and Additive Manufacturing will initially focus on energy, with planned expansions into other industrial sectors as well as healthcare solutions.

Highlights

- Mission is to support large-scale adoption of additive manufacturing across major market verticals including energy, industrial, aerospace, and healthcare segments
- Supports Saudi Arabia's 'Vision 2030' goal of economic diversification which is central to long-term sustainability
- 3D Systems brings industry-leading application expertise and the broadest range of printing solutions to maximize local adoption of additive manufacturing

Commenting on the new Joint Venture, Dr. Jeffery Graves, president and CEO, 3D Systems said, "Our partnership with Dussur will accelerate the adoption of additive manufacturing in the region, enabling diversification of the Saudi Arabian economy. While the energy segment will be one area of focus, a broad range of applications across industrial, aerospace, and healthcare segments will be addressed. We are excited about the partnership and believe it will provide a strong foundation within the Kingdom to expand local engineering and manufacturing and encourage green energy sources."

The joint venture follows a selection process in which 3D Systems was chosen due to its breadth of additive technology as well as depth of application expertise. Modeled upon 3D Systems' application development and advanced manufacturing sites located in Littleton, Colorado, and Leuven, Belgium, the new facility is expected to open in late 2022 and is meant to include a breadth of plastic and metal 3D printing technologies as well as 3D Systems application engineers who bring deep industry-specific expertise. The customer innovation and advanced application facility will benefit from the Kingdom's strategic geographic location at the crossroads of important international trade routes between three continents and represents another step to cement the Kingdom's position as a unique regional logistical hub for global seaborne trade.

"Establishing in Saudi Arabia the first Center for Innovation and Additive Manufacturing with a world-class player such as 3D Systems will unlock further localization initiatives across the supply chain," said Dr. Raed Al-Rayes, CEO, Dussur. "This partnership is linked to Dussur's mission to support the Kingdom's industrialization journey and localize disruptive technologies that will revolutionize the way we think of manufacturing. We are looking forward to commencing our work with 3D Systems to contribute to the security of supply in the region and build local capabilities for the jobs of the future."

About 3D Systems

More than 30 years ago, 3D Systems brought the innovation of 3D printing to the manufacturing industry. Today, as the leading additive manufacturing solutions partner, we bring innovation, performance, and reliability to every interaction – empowering our customers to create products and business models never before possible. Thanks to our unique offering of hardware, software, materials, and services, each application-specific solution is powered by the expertise of our application engineers who collaborate with customers to transform how they deliver their products and services. 3D Systems' solutions address a variety of advanced applications in healthcare and industrial markets such as medical and dental, aerospace & defense, automotive, and durable goods. More information on the company is available at www.3dsystems.com.

About Dussur

The Saudi Arabian Industrial Investments Company ("Dussur") – owned by Saudi Arabian Public Investment Fund, Saudi Aramco, and SABIC – is a strategic industrial investment firm that partners with world-class experts to form state-of-the-art joint ventures includes M&A in the industrial sectors. Dussur executes regional and international industrial investments, creating value for its partners and shareholders. Learn more at www.dussur.com.

ELASTIUM launches first fully 3D Printed Sneakers

The company aims to disrupt the $500 billion footwear industry by producing fully 3D printed footwear from 100% recyclable foams.

ELASTIUM, an emerging UAE-based 3D printed footwear startup, today announces the launch of its first fully 3D printed sneakers made from 100% recyclable foam. Founded in 2021 by engineer, inventor, and tech entrepreneur Robert Karklinsh, ELASTIUM combines lattice structures and the most advanced materials used in the footwear industry – foams – to break free from the limitations of traditional manufacturing and create sustainable, personalized, and truly comfortable 3D-printed footwear.

ELASTIUM's sneakers feature lattice-structured low-density thermoplastic elastomer (TPE) foams fabricated by a proprietary granulate extrusion 3D printing technology making their sneakers soft and comfortable, like Crocs for example, yet providing cushioning and resilience comparable to high-performance sneakers.

"We are thrilled to unveil our world's first fully 3D printed foam sneakers," said Robert Karklinsh, founder and CEO of ELASTIUM. "Traditional shoe manufacturing is extremely slow, capital-intensive, and unsustainable. 22 out of 23 billion pairs of shoes produced each year end up in landfills, where they may take hundreds of years to decompose. At ELASTIUM, we are redefining footwear production making it rapid, on-demand, localized, and sustainable. We are also democratizing the footwear industry by providing a platform for individual creators and brands which will eventually make footwear production as easy as publishing an app on the App Store."

Combining FGF tech and high-performance foam

To produce its sneakers, ELASTIUM uses a proprietary fused granulate fabrication (FGF) foam 3D printing technology. Because the material cost is by far the most expensive component in fully 3D printed footwear, the cost-effectiveness of the ELASTIUM process, directly using industry-standard raw materials in the form of granules, is unrivaled by any FFF or SLA/DLP foam 3D printing processes. It is also extremely versatile supporting multi-material printing in a wide range of densities, from fully dense materials down to densities as low as 0.14 specific gravity.

Unlike other 3D printed footwear manufacturers or brands that use 3D printed parts in their shoes, often relying on basic unfoamed materials, including hard-to-recycle photoresins, ELASTIUM goes further by using high-performance, lightweight, soft, and resilient TPU foams and combining them with lattice structures to create comfortable, high-performance, durable and machine washable 3D printed sneakers that you can wear with or without socks.

AI-generated and digitally owned

The first "ELASTIUM-1" model features a mono-material design that was first generated by AI, then refined and recreated in 3D by a footwear designer.

Each pair of ELASTIUM sneakers is printed on-demand, which eliminates the costs associated with traditional footwear manufacturing, including the myriad in-between steps of mold making, sewing, gluing, storage, etc., and significantly reduce carbon emissions. In addition, the sneakers are made from TPU foam that can be recycled into a new pair.

ELASTIUM-1 will be sold not only as limited edition sneakers but also as one hundred NFTs which will give their owners a right to order and reorder physical pairs even after the initial volume is sold out. These NFTs represent one of the first true applications of the concept of digital ownership as their holders practically become the owners of the design who can trade their rights of transferring the digital asset into the physical realm at any time.

The current ELASTIUM-1 model comes in twelve color options and 16 sizes with adjustable fit options and will be available for pre-order both as a physical pair and NFT on the company's website. Additional models are currently in development and will be released throughout 2023.

C3D Printing Production launches Middle East's first large-format 3D printing facility in Dubai

C3D, one of the Middle East's most innovative printing production company, has launched the region's first large format 3D printing facility in Dubai to support the fast-paced demand for additive manufacturing, which is shaping the industrial sector. With a strong focus on sustainable manufacturing and innovation, C3D is set to meet the rapidly growing demand for additive manufacturing in the industrial sector.

With a focus on reducing waste and promoting eco-conscious production. C3D has brought the first Weber additive printing machine, which is one of its kind in the Middle East. The Weber DX25 utilizes advanced, sustainable materials and groundbreaking manufacturing techniques by incorporating recycled and biodegradable materials into the printing process, With a build volume of 1600 × 1200 × 1300 mm^3, will be able to meet the UAE's expanding demand for 3D printing and provide innovative solutions to clients across various industries.

Samuel Thomas, Founding Partner of C3D, said: "Additive manufacturing is shaping the future of the manufacturing industry like no other technology today. Based on digital 3D design data, even complex and large-volume components can be produced quickly and cost-effectively using various 3D printing technologies. At C3D, we are committed to providing our customers with the latest and most innovative solutions. The Weber additive printing machine is a perfect example of this commitment. A differentiating strength of the new technology is that the recycled plastic granules are used as the raw materials and are completely sustainable. Any product manufactured can thus be completely broken down, based on its utility or for modification, and entirely new products can be manufactured."

Babu Radhakrishnan, Founding Partner of C3D, added: "We were inspired to launch this pathbreaking technology here in Dubai, led by the visionary leadership of His Highness Sheikh Mohammed bin Rashid Al Maktoum, UAE Vice President and Prime Minister and Ruler of Dubai, who has always emphasized the importance of technology in driving progress and innovation in the UAE. Today, the UAE has made tremendous strides in the field of technology, becoming a global leader in many areas. From artificial intelligence to renewable energy, the UAE has demonstrated its commitment to creating a better future for its people and for the world. C3D is proud to be a part of this vision."

With the addition of Weber additive printing machine to its portfolio, C3D will further strengthen its ability to support customers in their quest for excellence. C3D is a part of Chrysels Group of Companies and is a pioneering name in the visual merchandising and signage industry.

C3D Printing Production is dedicated to incorporating the latest trends in manufacturing and advertising, and the addition of this machine reinforces this commitment. With its advanced technology, the new machine is capable of producing large-scale, high-quality prints at a rapid pace.

Dubai's DEWA R&D Centre registers its 7th patent for 3D printing adhesive device

Dubai Electricity and Water Authority (DEWA) has announced the registration of a new patent for an adhesive device for 3D printers.

The device developed by Dubai Electricity and Water Authority (DEWA) distributes the adhesive material on the 3D printing plate, ensuring that the printed material sticks securely to the build plate. This is the seventh patent registered by DEWA's Research and Development Centre (R&D).

The R&D Centre is responsible for supporting innovation in all production and operational areas and has published 134 research papers at international scientific conferences, journals, and peer-reviewed publications.

The Chief executive officer of DEWA, Saeed Mohammed Al Tayer, emphasised that this achievement supports DEWA's efforts to develop advanced infrastructure and specialised in 3D printing and additive manufacturing. The organisation uses 3D printers to produce prototypes and spare parts for its generation, transmission, and distribution divisions, and to digitize its inventory.

The R&D Centre's efforts are part of Dubai's 10X initiative, launched by His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President, Prime Minister and Ruler of Dubai, which mandates the city to be a global leader that is ten years ahead of all other cities. The initiative supports the Dubai 3D Printing Strategy, which aims to make Dubai a global hub for 3D printing technology by 2030.

Waleed Bin Salman, the Executive Vice President of Business Development and Excellence at DEWA, stated that the R&D Centre has enriched the scientific community with specialised research and developed the capabilities of its researchers. This, in turn, enhances Dubai's position as a global hub for research and development in solar power, smart grids, water and energy efficiency, and capacity building in these areas.

DNV and Siemens Energy to collaborate on 3D printing

DNV and Siemens Energy's global additive manufacturing (AM) business unit are joining forces to create a quality assurance platform for the 3D printing industry.

Siemens Energy's experts in Finspång, Sweden, have developed the first generation of the AM Cockpit platform providing automated, reliable quality control of the 3D metal printing process. In turn, DNV has developed the Independent Quality Monitor (IQM) platform – a customer portal that continuously quality-assures digital solutions.

By combining these two solutions, DNV can launch a commercial solution for the AM manufacturing industry – ensuring that 3D-printed parts can easily be compared to a so-called approved master print. The combination also makes automated and remote process certification possible.

The AM Cockpit collects sensor data streams and powder bed images from the manufacturing process in powder bed fusion 3D-printers. It then generates a digital summary of each printed part, highlighting problematic areas of the print.

In parallel, the IQM has been developed as part of the EU-project InterQ, aiming at zero-defect manufacturing. The solution monitors data quality continuously through newly developed algorithms and compliance logic.

“Succeeding in AM industrialisation relies on a successful digital transition. The combination of the AM Cockpit and the IQM is a significant step forward for additive manufacturing,” said Klas Bendrik, Chief Digital and Development Officer at DNV.

By industrialising the combined solution, DNV aims to become the global energy sector's preferred choice for digital risk management.

Senior Engineer and AM specialist, Stian Gurrik, said: “The benefits of 3D-printing, when used properly, can include reduced material waste, quicker production, cost savings and the ability to produce complex and customised parts.”

As a pioneer in AM, Siemens Energy has been a global front-runner in designing and 3D-printing key gas turbine components that enable power plant owners to increase their plant's efficiency and significantly reduce carbon emissions today.

“Thanks to its design freedom, AM is the core technology that allows Siemens Energy to develop and modify gas turbines to run on green fuels, such as hydrogen”, said Hans Holmström, CEO of Siemens Energy in Sweden.

“With decades of experience in industrialising additive manufacturing, Siemens Energy is an excellent partner for DNV in advancing quality assurance of additively manufactured parts”, added Manish Kumar, Head of business development, strategy and sales of Siemens Energy Additive Manufacturing Business.

The quality of a printing process can be visualised with the digitalised quality assurance method of the AM Cockpit and the IQM. As a result, the end user can be confident that the process meets the necessary quality standards.

Research and Development News

NTU Singapore launches three new satellites to test 3D-printed satellite parts

Three new satellites with 3D-printed satellite parts built by Nanyang Technological University, Singapore (NTU Singapore) have blasted off into orbit, which will be used to conduct orbital experiments such as testing 3D-printed parts in space, measuring atmospheric data, and evaluating new space materials.

The satellites – VELOX-AM, ARCADE and SCOOB-II – serve as demonstrations of NTU's leading capabilities in satellite engineering and undergraduate space engineer training. Since 2011, NTU has successfully built, launched and operated 13 satellites, including these three launched on Sunday morning (30 July) by the Indian Space Research Organisation on the Polar Satellite Launch Vehicle.

The launch vehicle also carried a microsatellite from NTU spin-off Aliena, which will test a next-generation propulsion engine.

Both VELOX-AM and ARCADE are micro-satellites weighing 22kg and 27kg respectively, developed in collaboration with NTU's partners. SCOOB-II is the second cube satellite designed and built by NTU students under the Student Satellite Series, which offers engineering undergraduates real-world learning opportunities on satellite design.

Professor Luke Ong, NTU Vice President (Research), said: "Progressing towards microsatellites in the 25kg range allows NTU to meet application and mission-specific requirements more effectively. The University's satellite development programme involves leveraging the multi-disciplinary expertise of NTU faculty and researchers from various schools in contributing to the advancement of Singapore's space industry. Additionally, NTU collaborates closely with local and international partners to introduce innovative technologies to further enhance the capabilities of Singapore's space sector."

Mr Ronald Tong, Acting Executive Director, Office for Space Technology & Industry (OSTIn), said: "The successful launch of NTU's satellites marks another milestone in Singapore's space journey, harnessing our strengths in science, engineering, manufacturing and undergraduate education. The launch reflects Singapore's robust space research community and will contribute to various applications including the study of the Earth's atmosphere. As Singapore's national space office, OSTIn will continue to support the development of our space ecosystem, including the nurturing of more science, technology, engineering, and math (STEM) talent."

NTU and A*STAR to test 3D-printed parts in space onboard the VELOX-AM

The VELOX-AM (Additive Manufacturing) satellite is a collaborative endeavour with Singapore's Agency for Science, Technology and Research (A*STAR) aimed at testing, for the first time, how additive manufacturing, or 3D-printed parts, can be used effectively to produce complex satellite components.

The 50 cm x 30 cm x 50 cm satellite carries a 3D-printed main structure panel. NTU built the satellite body, while A*STAR's Advanced Remanufacturing and Technology Centre (ARTC) developed and 3D-printed structural parts that have undergone rigorous high shock requirement tests to simulate the forces of a satellite launch.

These 3D printed parts were produced with an end-to-end manufacturing process, ensuring the consistent performance of components to withstand extreme space environmental conditions. A*STAR's Institute of High Performance Computing analysed the mechanical performance to determine how the 3D printed parts will react to forces during launch and while in orbit.

Another 3D-printed experimental payload onboard the VELOX-AM is a functionally tested module which houses a phase-change material to allow better satellite thermal control. This material changes its form between liquid and solid states to absorb and release heat energy, aiding energy conservation.

Dr David Low, Chief Executive Officer at A*STAR's ARTC, said: "Leveraging advancements in additive manufacturing, A*STAR has produced complex satellite components that meet the design, functionality and performance requirements that allow the VELOX-AM to withstand large forces during launch, and to maintain high performance while in orbit. This collaboration with NTU Singapore presents an exciting opportunity to study how 3D-printed parts can function in space. We look forward to more of such collaborations, to unlock the potential of advanced manufacturing capabilities in supporting Singapore's space missions."

The last experiment VELOX-AM is conducting in space revolves around shape-memory polymers, which are materials that can hold 'memories' of their previous shapes. These materials can be deformed, such as by twisting or folding, and can return to their original shape by applying heat to them.

This technique holds promise for applications on solar panels and antennas. For instance, solar panels can be folded very compactly to be brought up onto a space station, where they can be heated to unfold back to their original, larger size.

Studying the atmosphere with ARCADE (Atmospheric Coupling and Dynamics Explorer)

The ARCADE (Atmospheric Coupling and Dynamics Explorer) satellite aims to measure data for atmospheric coupling studies.

The 32 cm x 32 cm x 32 cm satellite is an international collaboration with partners from Germany, India, Taiwan and the United States. It is the fourth satellite in the International Satellite Program in Research and Education (INSPIRE) series, an international consortium of space¬faring universities.

The satellite carries four instruments: an imager for atmospheric gravity waves; a plasma probe for measuring ionospheric plasma density and velocity; an atomic oxygen instrument to study atomic oxygen degradation of materials at low Earth orbit; and an optical imager for Earth imaging.

Also onboard the satellite are newly developed flexible perovskite solar cells, which will be used in experiments to test their performance in Low Earth Orbit for potential applications in curved, rollable solar panels.

In conjunction with its electric propulsion thruster, the satellite can deorbit into a region of space that has been very rarely explored. This ambitious mission aims to perform experiments and meet scientific objectives at a fraction of the cost of larger missions usually performed by bigger satellites that are usually above 400kg, or almost twenty times heavier.

SCOOB-II – training of future space engineers

SCOOB-II is the second satellite built under NTU's Student Satellite Series which aims to provide real-world satellite learning opportunities for engineering undergraduates. The first satellite, SCOOB-I, was launched in July 2022, where it successfully demonstrated space technologies developed by students at NTU's Satellite Research Centre (SaRC) such as sensors to observe the Sun.

Also developed at SaRC, the 4.1kg shoebox-sized

SCOOB-II satellite carries a payload which demonstrates advanced electronics test operations in space. Measuring 34cm x 10cm x 10 cm, SCOOB-II, as a continuation to SCOOB-I, has an additional two deployable solar panels that will help to generate about three times the power generated from SCOOB-I, allowing it to carry a more power-demanding payload. SCOOB-II also carries an improved attitude determination control system that helps the spacecraft point at the sun to absorb maximum solar energy to charge its onboard battery.

NTU final-year PhD student Saleem Amitha has worked on both SCOOB-I and SCOOB-II since 2019. The experience led her to gain extensive knowledge and hands-on expertise in various aspects of satellite design, development, and testing, together with an in-depth understanding of different satellite systems.

Ms Amitha said: "I feel an incredible sense of pride and excitement knowing that my work will soon be in space. The opportunity to see the culmination of my efforts and expertise manifested in a tangible form, orbiting the Earth, is truly awe-inspiring. Throughout my journey, I encountered various challenges and problem-solving opportunities, which have further strengthened my skills in troubleshooting, adapting to unforeseen circumstances, and collaborating effectively within a team of experts."

NTU spin-off Aliena's new satellite to test all-electric propulsion engine

On top of the three NTU satellites, a microsatellite carrying a cutting-edge propulsion engine from NTU spin-off Aliena was also successfully launched on Sunday morning.

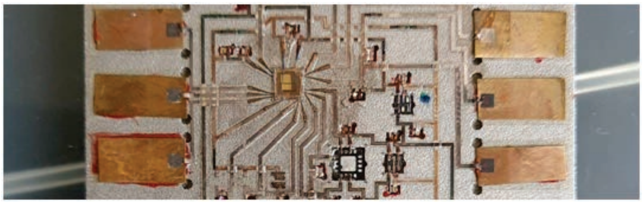
The ORB-12 STRIDER will be used to demonstrate next-generation propulsion systems through the world's first multi-modal all-electric propulsion engine.

This engine comprises Aliena's flagship multi-stage-ignition compact (MUSIC) Hall thruster, the first of its kind to be developed locally in Singapore. The thruster uses an electric field to accelerate ions from the propellant, allowing the engine to consume a fraction of power compared to traditional engines in manoeuvring the satellite in space.

Aliena chief executive officer and co-founder Dr Mark Lim said: "It is with great pride that we see the ORB-12 STRIDER manifested alongside satellites from our co-founders' alma mater, NTU Singapore. This launch will provide space legacy to our systems to drive further commercial traction, and gather orbital data that will be beneficial as we gear up for our flight on an NTU mission at Very Low Earth Orbit."

The ORB-12 STRIDER satellite was developed under an international collaboration coordinated by Singapore-based Aliena, including Orbital Astronautics (United Kingdom) as bus providers and Aurora Propulsion Technologies (Finland) as subsystem co-developers.

NASA's Goddard, Wallops Engineers Test 3D Printed Electronics in Space



A printed circuit that flew on the SubTEC 9 technology test flight from NASA's Wallops Flight Facility in April sits on display during the Goddard Field Day event. Credit: NASA / Karl B. Hille

Today's small spacecraft pack sensors, guidance and control, and operating electronics into every available space. Printing electronic circuits on the walls and structures of spacecraft could help future missions do more in smaller packages.

Engineers successfully tested hybrid printed circuits at the edge of space in an April 25 sounding rocket flight from NASA's Wallops Flight Facility near Chincoteague, Virginia. Electronic temperature and humidity sensors printed onto the payload bay door and onto two attached panels monitored the entire SubTEC-9 sounding rocket mission, recording data that was beamed to the ground.

The experiment by aerospace engineer Beth Paquette and electronics engineer Margaret Samuels of NASA's Goddard Space Flight Center in Greenbelt, Maryland, sought to prove the space-readiness of printed electronics technology.

"The uniqueness of this technology is being able to print a sensor actually where you need it," Samuels said. "The big benefit is that it's a space saver. We can print on 3-dimensional surfaces with traces of about 30 microns – half the width of a human hair – or smaller between components. It could provide other benefits for antennas and radio frequency applications."

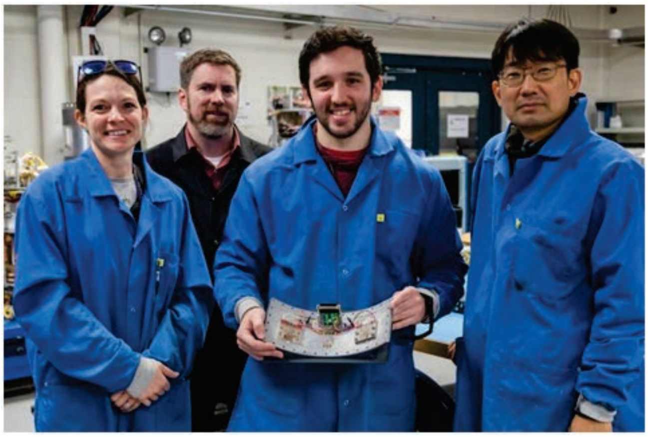
They worked with colleagues at NASA's Marshall Space Flight Center in Huntsville, Alabama, who developed the humidity-sensing ink. Partners from the University of Maryland's Laboratory for Physical Sciences (LPS) created the circuits.

Printed circuits allow a new level of functionality for smaller spacecraft, ever more common for both near-Earth and deep space missions, said Wallops electronics engineer Brian Banks. "The hybrid technology allows for circuits to be fabricated in locations that would typically not be available for conventional electronics modules," Banks said. "Printing on curved surfaces could also be helpful for small, deployable sub-payloads where space is very limited."
LPS engineer Jason Fleischer designed and printed the circuits for the April flight using printers capable of producing electronic traces thinner than the human eye can see.

The SubTEC-9 launch marked a turning point in LPS's development and validation of printed-circuit technology, he said.

"Every part needs to work throughout the flight," Fleischer said, "and a successful data return means all the circuits were up and working. I'm excited for this success as well as getting on another rocket and having more successes."

The team has printed electronic circuits on a variety of materials, including around curves and corners and on flexible parts. In another investigation, they printed X-ray instruments on flexible strips of Kapton plastic. The team is developing guidelines to make it easier for mission and instrument engineers to adopt these circuits.



Engineers prepare the first hybrid printed electronic circuits to fly into space in a lab at NASA's Wallops Flight Facility. Team lead Beth Paquette (left) stands with Jason Fleischer of the Laboratory for Physical Sciences (LPS), holding the curved metal plate with their printed electronics test assembly. Donghun Park, also with LPS, stands at right, while Wallops Electronics Engineer Brian Banks brings up the rear.
Credits: NASA / Berit Bland

Improvements in Function and Performance

The SubTEC 9 sounding rocket sits ready to fly at NASA's Wallops Flight Facility in April.
Credits: NASA / Dan Paquette

Printed circuits provide a significant advantage in predictability and stability in antenna connections and design, Samuels said. "We can print the antenna on a curved surface like the outside of a rocket or spacecraft, increasing the angles at which it can send and receive signals in space."

Traditional antenna connections are made by a process called wire bonding, which melts a metal wire to the antenna and then bonds it to the signal processing electronics. The process can be messy and inexact, Samuels said, making it difficult to make the best use of precision antenna technology.

"It's a bit like a sewing machine with metal thread," she said. "There are entire conferences focused on the potential failure mechanisms from wire bonding. The idea of being able to replace this with printed connections is, therefore, a massive improvement."

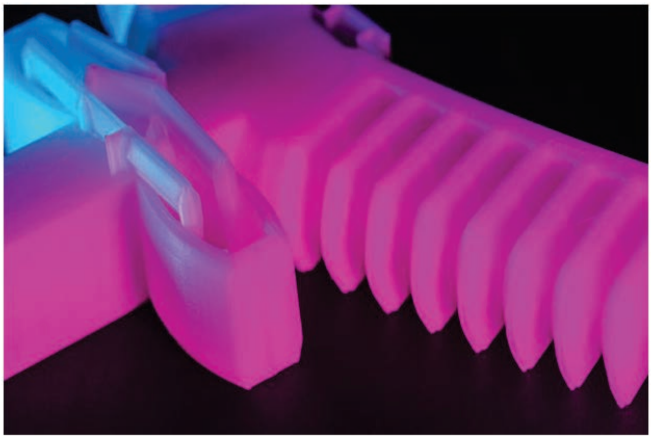
Paquette said future missions could print temperature sensors throughout the vehicle's interior surfaces. For a small investment, such a mission could better understand how heating and cooling affect the whole spacecraft as it passes close to the Sun, for example.

Their work attracted the attention of engineer Ryan McClelland at NASA's Goddard Space Flight Center in Greenbelt, Maryland. McClelland pioneered NASA's use of Evolved Structures, spacecraft parts designed by artificial intelligence. "I imagine you could use their printed electronics to add functionality to parts that may have been designed by AI and 3D-printed themselves or even manufactured in orbit."

Watching the SubTEC-9 launch, the team was thrilled at the opportunity to retrieve their experiment and data while advancing a technology that could offer new flexibility in spacecraft design.

"We're really excited about the fact that this rocket test will prove our printed sensors," Samuels said.

This 3D Printed Gripper Doesn't Need Electronics To Function



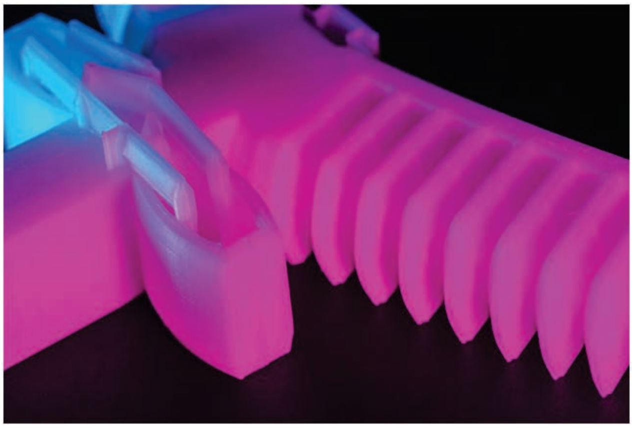
Close up photograph of part of the new robotic gripper that functions without electronics. Soft robotics holds the promise of allowing robots to interact safely with huma

The device developed by a team of roboticists at the University of California San Diego, in collaboration with researchers at the BASF corporation, who detailed their work in a recent issue of Science Robotics. The device is printed all in one go and can pick and release objects. This soft robotic gripper is not only 3D printed in one print, it also doesn't need any electronics to work.

The researchers wanted to design a soft gripper that would be ready to use right as it comes off the 3D printer, equipped with built in gravity and touch sensors. As a result, the gripper can pick up, hold, and release objects. No such gripper existed before this work.

"We designed functions so that a series of valves would allow the gripper to both grip on contact and release at the right time," said Yichen Zhai, a postdoctoral researcher in the Bioinspired Robotics and Design Lab at the University of California San Diego and the leading author of the paper, which was published in the June 21 issue of Science Robotics. "It's the first time such a gripper can both grip and release. All you have to do is turn the gripper horizontally. This triggers a change in the airflow in the valves, making the two fingers of the gripper release."

This fluidic logic allows the robot to remember when it has grasped an object and is holding on to it. When it detects the weight of the object pushing to the side, as it is rotating to the horizontal, it releases the object.



Close up photograph of part of the new robotic gripper that functions without electronics.

Soft robotics holds the promise of allowing robots to interact safely with humans and delicate objects. This gripper can be mounted on a robotic arm for industrial manufacturing applications, food production and the handling of fruits and vegetables. It can also be mounted onto a robot for research and exploration tasks. In addition, it can function untethered, with a bottle of high-pressure gas as its only power source.

Most 3D-printed soft robots often have a certain degree of stiffness; contain a large number of leaks when they come off the printer; and need a fair amount of processing and assembly after printing in order to be usable.

The team overcame these obstacles by developing a new 3D printing method, which involves the printer nozzle tracing a continuous path through the entire pattern of each layer printed.

"It's like drawing a picture without ever lifting the pencil off the page," said Michael T. Tolley, the senior author on the paper and an associate professor in the UC San Diego Jacobs School of Engineering.

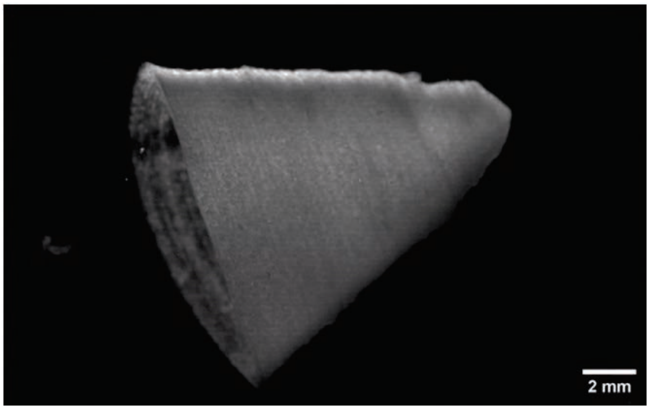
This method reduces the likelihood of leaks and defects in the printed piece, which are very common when printing with soft materials.

The new method also allows for printing of thin walls, down to 0.5 millimeters in thickness. The thinner walls and complex, curved shapes allow for a higher range of deformation, resulting in a softer structure overall. Researchers based the method on the Eulerian path, which in graph theory is a trail in a graph that touches every edge of that graph once and once only.

"When we followed these rules, we were able to consistently print functional pneumatic soft robots with embedded control circuits," said Tolley.

Desktop Digital Fabrication of Autonomous Monolithic Soft Robotics Devices with Embedded Fluidic Control Circuits

Fiber-infused ink enables 3D-printed heart muscle to beat



3D-printed heart muscle beating through fiber-infused ink

Over the last decade, advances in 3D printing have unlocked new possibilities for bioengineers to build heart tissues and structures. Their goals include creating better in vitro platforms for discovering new therapeutics for heart disease, the leading cause of death in the United States, responsible for about one in every five deaths nationally, and using 3D-printed cardiac tissues to evaluate which treatments might work best in individual patients. A more distant aim is to fabricate implantable tissues that can heal or replace faulty or diseased structures inside a patient's heart.

In a paper published in Nature Materials, researchers from the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) report the development of a new hydrogel ink infused with gelatin fibers that enables 3D printing of a functional heart ventricle that mimics beating like a human heart. They discovered the fiber-infused gel (FIG) ink allows heart muscle cells printed in the shape of a ventricle to align and beat in coordination like a human heart chamber.

“People have been trying to replicate organ structures and functions to test drug safety and efficacy as a way of predicting what might happen in the clinical setting,” says Suji Choi, research associate at SEAS and first author on the paper. But until now, 3D printing techniques alone have not been able to achieve physiologically-relevant alignment of cardiomyocytes, the cells responsible for transmitting electrical signals in a coordinated fashion to contract heart muscle.

We started this project to address some of the inadequacies in 3D printing of biological tissues.

Tarr Family Professor of Bioengineering And Applied Physics, Head of The Disease Biophysics Group At Seas, Senior Author

The innovation lies in the addition of fibers within a printable ink. “FIG ink is capable of flowing through the printing nozzle but, once the structure is printed, it maintains its 3D shape,” says Choi. “Because of those properties, I found it's possible to print a ventricle-like structure and other complex 3D shapes without using extra support materials or scaffolds.”

To create the FIG ink, Choi leveraged a rotary jet spinning technique developed by Parker's lab that fabricates microfiber materials using an approach similar to the way cotton candy is spun. Postdoctoral researcher Luke MacQueen, a co-author on the paper, proposed the idea that fibers created by the rotary jet spinning technique could be added to an ink and 3D printed.

“When Luke developed this concept, the vision was to broaden the range of spatial scales that could be printed with 3D printers by dropping the bottom out of the lower limits, taking it down to the nanometer scale,” Parker says. “The advantage of producing the fibers with rotary jet spinning rather than electrospinning” – a more conventional method for generating ultrathin fibers – “is that we can use proteins that would otherwise be degraded by the electrical fields in electrospinning.”

Using the rotary jet to spin gelatin fibers, Choi produced a sheet of material with a similar appearance to cotton. Next, she used sonification – sound waves – to break that sheet into fibers about 80 to 100 micrometers long and about 5 to 10 micrometers in diameter. Then, she dispersed those fibers into a hydrogel ink.

This concept is broadly applicable – we can use our fiber-spinning technique to reliably produce fibers in the lengths and shapes we want.

The most difficult aspect was troubleshooting the desired ratio between fibers and hydrogel in the ink to maintain fiber alignment and the overall integrity of the 3D-printed structure.

As Choi printed 2D and 3D structures using FIG ink, the cardiomyocytes lined up in tandem with the direction of the fibers inside the ink. By controlling the printing direction, Choi could therefore control how the heart muscle cells would align.

When she applied electrical stimulation to 3D-printed structures made with FIG ink, she found it triggered a coordinated wave of contractions in alignment with the direction of those fibers. In a ventricle-shaped structure, “it was very exciting to see the chamber actually pumping in a similar way to how real heart ventricles pump,” Choi says.

As she experimented with more printing directions and ink formulas, she found she could generate even stronger contractions within ventricle-like shapes.

“Compared to the real heart, our ventricle model is simplified and miniaturized,” she says. The team is now working toward building more life-like heart tissues with thicker muscle walls that can pump fluid more strongly. Despite not being as strong as real heart tissue, the 3D-printed ventricle could pump 5-20 times more fluid volume than previous 3D-printed heart chambers.

The team says the technique can also be used to build heart valves, dual-chambered miniature hearts, and more.

“FIGs are but one tool we have developed for additive manufacturing,” Parker says. “We have other methods in development as we continue our quest to build human tissues for regenerative therapeutics. The goal is not to be tool driven – we are tool agnostic in our search for a better way to build biology.”

Additional authors include Keel Yong Lee, Sean L. Kim, Huibin Chang, John F. Zimmerman, Qianru Jin, Michael M. Peters, Herdeline Ann M. Ardoña, Xujie Liu, Ann-Caroline Heiler, Rudy Gabardi, Collin Richardson, William T. Pu, and Andreas Bausch.

This work was sponsored by SEAS; the National Science Foundation through the Harvard University Materials Research Science and Engineering Center (DMR-1420570, DMR-2011754); the National Institutes of Health and National Center for Advancing Translational Sciences (UH3HL141798, 225 UG3TR003279); the Harvard University Center for Nanoscale Systems (CNS), a member of the National Nanotechnology Coordinated Infrastructure Network (NNCI) which is supported by the National Science Foundation (ECCS-2025158, S10OD023519); and the American Chemical Society's Irving S. Sigal Postdoctoral Fellowships.

3D printing biodegradable sensors and displays with nanomaterials

An elastic material that changes color, conducts electricity, can be 3D printed and is also biodegradable? That is not just scientific wishful thinking: Empa researchers from the Cellulose & Wood Materials laboratory in Dübendorf have produced a material with these exact properties on the basis of cellulose and carbon nanotubes.

The researchers started with hydroxypropyl cellulose (HPC), which is commonly used as an excipient in pharmaceuticals, cosmetics and foodstuffs, among other things. When mixed with water HPC is known to form liquid crystals. These crystals have a remarkable property: Depending on their structure – which itself depends on the concentration of HPC, among other things – they shimmer in different colors, although they themselves have no color or pigment. This phenomenon is called structural coloring and is known to occur in nature: Peacock feathers, butterfly wings and chameleon skin get all or part of their brilliant coloration not from pigments, but from microscopic structures that “split” the (white) daylight into spectral colors and reflect only the wavelengths for specific colors.

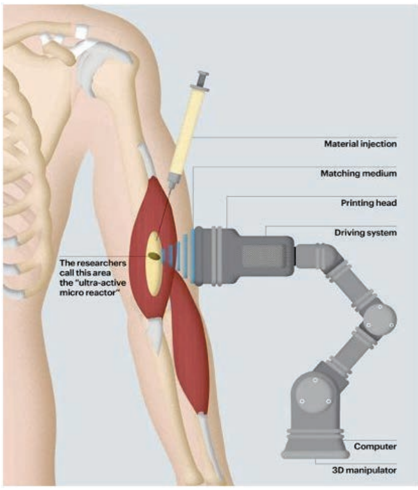
The structural coloring of HPC changes not only with concentration but also with temperature. To better exploit this property, the researchers, led by Gustav Nyström, added 0.1 weight percent carbon nanotubes to the mixture of HPC and water. This renders the liquid electrically conductive and allows the temperature, and thus the color of the liquid crystals, to be controlled by applying a voltage. Added bonus: The carbon acts as a broadband absorber that makes the colors deeper. By incorporating a small amount of cellulose nanofibers into the mixture, Nyström's team was also able to make it 3D printable without affecting structural coloring and electrical conductivity.

Sustainable sensors and displays

The researchers used the novel cellulose mixture to 3D print various potential applications of the new technology. These included a strain sensor that changes color in response to mechanical deformation and a simple seven-segment display. “Our lab has already developed different disposable electronic components based on cellulose, such as batteries and sensors,” says Xavier Aeby, co-author of the study. “This is the first time we were able to develop a cellulose-based display.”

In future, the cellulose-based ink could have many more applications, such as temperature and strain sensors, in food quality control or biomedical diagnostics. “Sustainable materials that can be 3D printed are of great interest, especially for applications in biodegradable electronics and the Internet of Things,” says Nyström, head of the laboratory. “There are still many open questions about how structural coloring is generated and how it changes with different additives and environmental conditions.” Nyström and his team aim to continue this line of work in the hope of discovering many more interesting phenomena and potential applications.

Concordia researchers make breakthrough in 3D printing



A rendering of how direct-sound printing could work inside the body. Illustration by Judith Lacerte.

3D printing usually relies on the force of light and heat to create objects, but researcher Muthukumaran Packirisamy and his team have discovered how to do it with ultrasound waves, known as direct-sound printing. The use of sound waves enables objects to be printed in hard-to-reach spaces such as the interior of an airplane, or even inside the human body.

Direct-sound printing can create objects in places that related technology can't reach.

Direct-sound printing harnesses energy from a process called cavitation, explained Mohsen Habibi, another researcher on the project. Cavitation occurs when a substance is stimulated by force – from heat, light, or in this case, sound – and small bubbles begin to form. “As an engineer, we are taught that cavitation is bad,” Dr. Habibi said, since you normally wouldn't want air pockets in a piece of machinery. In this case, it's necessary. “The vital component is to produce bubbles using sound waves, then drive the reaction in a path that actually creates an object at the end,” he said.

It's similar to how resin is used to preserve plants or insects – but instead of having to pour the resin in one go and seal the object after, direct-sound printing can be done beyond the barrier, in a matter of seconds.

One of the major implications for direct-sound printing is in the medical field. Current iterations of 3D printing are mainly used to create models of body parts or medical devices, to be used for teaching or to help educate patients preparing for surgery. Direct-sound printing could be used for something like inserting a medical device into a patient's body without needing to break the skin. Dr. Packirisamy, an engineering professor and director of Concordia University's optical-bio microsystems lab has been hearing from medical professionals keen to learn more about the work; he said it affirms just how much the technology is needed.

“This technology can do something that so far can't be done with other technologies … so it's important for us, how we shape it into real products and future applications.”

European Space Agency Develops World's First 3D Printed Integrated Flex Pivot Position Sensor

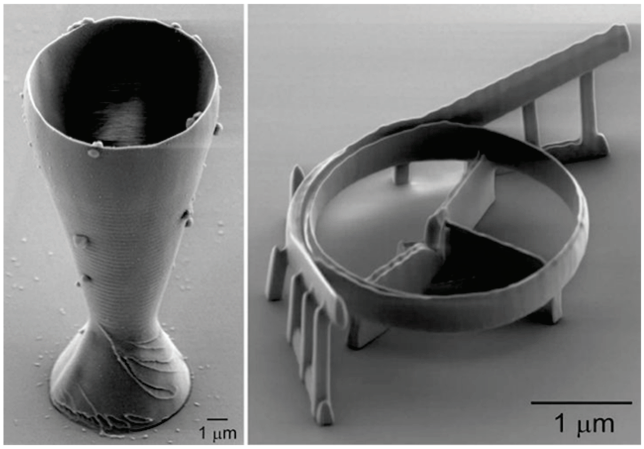

Tape Hinge

A TDE funded activity, performed by CSEM (Switzerland), successfully designed and manufactured the first ever tribology free (providing potentially infinite life) flexible mechanism element with built-in electrical signal transfer and sensing technology. Each flexible element contained custom printed strain gauge sensors and electrical transfer lines (including printed connectors) for positioning and potentially health monitoring. Additive Manufacturing (AM), three-dimensional (3D) printing techniques, were used throughout.

The flexible structures are representative of complaint mechanisms, such as, flexible pivots and tape springs for the deployment of solar panels and antenna booms. Two different breadboards were designed and tested raising the technology readiness level from two (application formulated) to four (functional verification). Aerosol Jet Printing was also shown to be a promising technique for integrating sensors, especially when combined with additive manufacturing.

Contract 4000132312 closed in 2022. The results were presented at the 2023 Technology Sharing Day. A follow-on activity, known as EU-ATTRACT, also performed by CSEM will develop a 3D printed heat pipe with embedded temperature sensors for the cooling and monitoring of advanced detectors.

World's smallest wine glass toasts to nanoscale silica 3D printing



Left: The tiny, 3D-printed wine glass. Right: An optical resonator, an example of a fiber optics component that can be 3D printed through the new techniqueKTH Royal Institute of Technology

Scientists have created the world's smallest wine glass, narrower than a human hair. Made out of actual glass, the model is a test run of an advanced new 3D-printing process that could help make nanoscale glass components for electronic and optical devices.

Visible only with a scanning electron microscope, the wine glass stands just a few dozen micrometers tall. And it wasn't alone on that tiny stage – the team also created mini models of a spiral, cantilever, an array of needles, an optical resonator, and the logo of the university behind the project, KTH Royal Institute of Technology.

Similarly tiny works of art have been 3D printed in the past, including a boat and a series of incredibly detailed nano-sculptures that are all small enough to fit on a human hair. But this new batch was all made of silica glass, in a demonstration of a new printing technology for tiny glass structures.

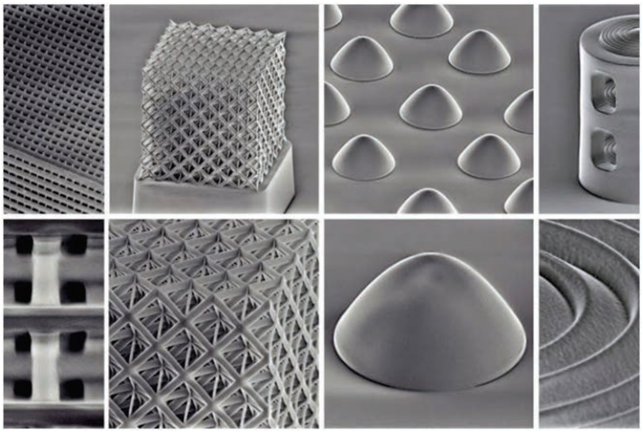
The process starts with a small pool of a material called hydrogen silsesquioxane (HSQ), which contains the ingredients needed to form silica glass (silicon dioxide). To do so, the liquid is zapped with laser pulses that each last mere trillionths of a second, which causes the HSQ to crosslink into silica glass at the focal point of the laser. The process was able to create voxels (3D pixels) as small as 65 x 260 nanometers, allowing the system to print the object right in the HSQ.

The team says this technique is far more efficient than existing 3D-printing methods for glass, which usually require high temperatures for long periods. As a bonus, the objects made this way can still withstand high heat during use.

It isn't, however, just the dawn of an impressive new art form. The researchers say it could be used to make much smaller, more precise glass components for optical systems, such as lenses or resonators. In fact, these components can be 3D printed directly on the tip of a fiber optic cable.

"The backbone of the internet is based on optical fibers made of glass," said Kristinn Gylfason, co-author of the study. "In those systems, all kinds of filters and couplers are needed that can now be 3D printed by our technique. This opens many new possibilities."

UC Irvine engineers invent a way to 3D print optical-grade glass at the nanoscale



A UCI-led team of engineers developed a method to 3D print glass micro- and nanostructures. Scanning electron microscope images show nanolattice structures on upper left to parabolic microlenses on upper right. The bottom row shows close-in details of the microscopic images, with a detail of a nanostructured Fresnel lens element on the lower right. Jens Bauer / UCI, KIT

Innovation enables on-chip manufacturing for technologies in medicine, communications and other applications

A research team led by scientists at the University of California, Irvine has developed a new low-temperature method for 3D printing optical-grade glass, opening the door for microelectronic systems with high-resolution, visible-light nanophotonics capabilities.

The innovation is the subject of a paper published recently in Science.

A new generation of technologies for use in medicine, navigation, communications, remote sensing and other applications could be enabled by the combination of high-precision optics and microelectronics. But traditional methods for printing optical glass require high-temperature sintering that would cause damage to the materials that make up those very platforms.

"This work paves the way for on-chip manufacturing," said lead author Jens Bauer, who began this project as a UCI research scientist in materials science and engineering, and who now leads the Nanoarchitected Metamaterials Laboratory at Germany's Karlsruhe Institute of Technology. "For pretty much any chip that can sustain 650 degrees Celsius, it will be possible to print high-quality, clear glass micro- and nanostructures directly on the chip." explained Cameron Crook, a UCI research fellow in materials science and engineering and co-author of the study.

The team's work at UCI and KIT involved the use of a 3D-printing process called two-photon polymerization, or direct laser writing. The method enables the creation of intricate nanoscale structures but previously mostly involved formations in plastic using printer-friendly polymer resins. 3D printing with optical materials such as silica glass has required the sintering of nanoparticles at temperatures of more than 1,100 degrees Celsius, hot enough to bond materials without liquifying, but too hot for deposition on semiconductor chips.

The researchers' solution was to use as ingredients a liquid resin built around "polyhedral oligomeric silsesquioxane," or POSS, molecules, which contain tiny glass clusters comprised of only a handful of atoms. They combined POSS with other organic molecules to enable effortless 3D printing. The resulting crosslinked pre-glass polymeric nanostructure was heated in air to a temperature of 650 degrees Celsius, stripping off organic components to form a continuous glass nanostructure.

"The obtained glass parts of highest-ever resolution, down to 97 nanometers, were chemically perfectly pure and of optical-grade quality," Bauer said.

He added that this technique can be adjusted to include materials beyond silica glass, unveiling entirely new powers in integrated circuits. The researchers have applied for an international patent for this innovation.

The research team included Tommaso Baldacchini at Irvine-based Edwards Lifesciences Inc. Funding was provided by the German Research Foundation, and imaging support was furnished by the UC Irvine Materials Research Institute.

Mighty Oak Medical Revolutionizes Spinal Surgery Outcomes with 3D Printing

Mighty Oak Medical uses HP 3D printers to make patient-specific surgical guides and bone models. (Photo courtesy of Mighty Oak Medical)

Mighty Oak Medical, a medical device development company that specializes in creating and commercializing spinal technologies, announced a technical partnership with HP for 3D printed healthcare applications produced using HPs Jet Fusion 5200 3D printers. Applications currently being manufactured include Mighty Oak's cornerstone product FIREFLY, a patient-specific pre-surgical planning and navigation platform. Mighty Oak has achieved FDA clearance and CE-mark for FIREFLY's 3D printed medical models and 3D printed surgical guides to deliver incredible value for patients, surgeons, and the healthcare system, trailblazing a new era of personalized care.

Highlights

- Mighty Oak Medical and HP collaborating on patient-specific 3D printed models and guides manufactured using HPs Jet Fusion printers.
- Mighty Oak Medical provides surgeons with enabling technologies that improve operating room efficiency and make spine surgery safer.
- New efficiencies in turnaround times for 3D printing achieved by bringing manufacturing in house.

Mighty Oak Medical's FIREFLY solution increases precision and safety, while reducing efficiency challenges common in spinal fusion surgery, by providing surgeons with accuracy to-the-millimeter concierge pre-surgical planning done in 3D on virtual renderings of patients' spines. 3D printed anatomical models and disposable guides are then used by surgeons to drill, tap, and place pedicle screws quickly and safely, making spinal surgeries more successful and less stressful. Now, with HP's industrial Multi Jet Fusion technology, FIREFLY is streamlining and reducing printing turnaround time, meaning even more patients can benefit from an elevated level of personalized care.

"It was important for us to maintain our focus on the spine and develop innovative solutions that make surgical procedures safer and more efficient," said Heidi Frey, President at Mighty Oak Medical. "We have always viewed 3D printed, patient-specific solutions as an ideal way to achieve those two objectives, and now, thanks to HP's 3D printing technology, the healthcare industry is undergoing a massive transformation in terms of the solutions, patient experience and outcomes new 3D printed medical devices can provide."

With an eleven-year history of applying additive manufacturing technologies to enhance and produce spinal technologies and medical devices, Mighty Oak Medical is no stranger to the benefits of 3D printing or the pain points associated with spinal surgeries. Spinal fusions, a typical treatment option for fractures, deformities, or instability in the spine, typically involve the use of pedicle screws to provide extra strength and support. However, if placed incorrectly, patients could experience critical injuries including damage to the spinal cord. While robotic solutions exist to alleviate the errors associated with freehand pedicle screw insertion, this technology is expensive and has a steep learning curve to its use. Mighty Oak's familiarity with 3D printing technology resulted in the FIREFLY complete navigation system for streamlining the surgeon's workflow and reducing screw placement time.

Since installing HP's Jet Fusion 5200 printers directly onto its factory floor, Mighty Oak Medical is experiencing unprecedented efficiencies — all while improving replicability and consistency in pedicle screw placement and achieving 99.7%1screw placement accuracy. These hyper-personalized patient-specific guides eliminate intra-operative radiation exposure for both surgical staff and patients, and the maintenance and technician costs associated with other solutions. HP's 3D High Reusability PA 12 material offers excellent strength, detail, and surface finish with higher contrast, allowing surgeons to check for anomalies and gaps as well as read markings easier in an OR environment.

"Mighty Oak is currently leading the charge towards a more advanced medical device and orthopedic industry with its FIREFLY solution," said Greg Elfering, Head of Americas Go-to-Market, HP Personalization & 3D Printing. "We are excited to partner with Mighty Oak to maximize the benefits of HP's 3D printing solutions for healthcare applications. By minimizing costs, enabling personalization, and improving efficiency and accuracy of care for patients, Mighty Oak and HP are demonstrating how the power of innovation can positively impact patients and the healthcare industry." For more information about Mighty Oak Medical, please see here.

About Mighty Oak

Mighty Oak is an established leader in patient-specific solutions for the spine. Our mission is to become the premier provider of end-to-end patient-specific technologies for spinal surgery worldwide by harnessing advanced data analytics and additive manufacturing to make surgery customized, safer, and more predictable. For more information, please contact info@mightyoakmedical.com or visit www.mightyoakmedical.com.

About HP

HP Inc. is a technology company that believes one thoughtful idea has the power to change the world. Its product and service portfolio of personal systems, printers, and 3D printing solutions helps bring these ideas to life. Visit http://www.hp.com.

COMPANIES WE WORK WITH

EOS | imaginarium | ARK EMPOWERING LIVES | SRT SHREE RAPID TECHNOLOGIES | MATRIX NANO मैट्रिक्स नैनो | Redington

ADVAITECH STUDIOS LLP | SCHRAFFUR STUDIOS LLP | CONCEPT TO DELIVERY PLASTIPACK create anything | stratasys | SLM SOLUTIONS | 3D SYSTEMS

SOLBERG Filtration • Separation • Silencing | 3idea Imagine Create Print | amace® | SEDAXIS Advanced Materials Pvt Ltd. | INDO-MIM COMPLEXITY SIMPLIFIED | hp

SAHAS | LODESTAR 3D Building Factories of the Future | cubein | RUSSELL | OBJECTIFY | wipro | wipro 3D

fabheads | Desktop Metal | PRIMAEAM | IMMACULATE 3D | CRAFTECH ADDITIVE SOLUIONS LLP. | anisoprint

formlabs | TEKNA | materialise innovators you can count on | MOLYWORKS MATERIALS CORPORATION | Markforged

3D MSS Advanced Manufacturing Solutions & Services | neumesh | PICASO 3D | Epitum fastest way to your idea | COLLIN LAB & PILOT SOLUTIONS | FORM3D

ETEC | AMUSE | SHAREBOT | SINTERIT | SARTO ELECTRO Equipments Pvt. Ltd.

m4p | 4DS The Additive Manufacturing People | adroitec ...enabling you to leap forward! | ADDITIVE 3D | MAGFORMS | VEER-O-METALS Pvt. Ltd. Delivering Excellence

VELO 3D | VERDER scientific | ZEISS Seeing beyond | BASF We create chemistry FORWARD | Tesscorn | PDS PARAMETRIC DESIGNS & SOLUTIONS | FRACKTAL WORKS

H3D Expert on Metal 3D Printing | FARSOON TECHNOLOGIES | nLIGHT | UnionTech Create your imagination | kreator | CRENNOVATIONS | VISUAL i imagine the real

mekuva TECHNOLOGIES | MANGLAM ELECTRICALS BUILD TO ADAPT | WELDWELL® A single source for welding solutions | ADDERE ADDITIVE MANUFACTURING | Trokut SOLUTIONS

HEXAGON | ALTEM TECHNOLOGIES | Global Axis | SENTESBiR | FORMALLOY

tvasta | CTARS | Intech additive solutions | ADDITIVEMINDS ACADEMY | 3D MSS Advanced Manufacturing Solutions & Services

CONCLAVE
MIDDLE EAST

Advancing the Additive Manufacturing Ecosystem in the Middle East

September 2024

Media Partner

CHRONICLE

www.amconclave.com