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FIRST FOR TECHNOLOGY & INNOVATION

Tech Trends 2019

The Engineer's key commercial partners offer their take on the next 12 months

The year ahead – our take on 2019

After a stormy 12 months, *The Engineer* offers its view on topics that will dominate industry next year. Jon Excell reports

Tech Trends 2019

Welcome to Tech Trends 2019, a special digital supplement of *The Engineer* in which some of industry's key movers and shakers offer their take on a few of the topics that look set to dominate industry debate over the next 12 months: from continuing efforts to meet the sector's skills shortage to the rise of e-mobility and the disruptive impact of technologies, including additive manufacturing and augmented reality.

It is something of an understatement to say that 2018 has been a turbulent year and the geopolitical events of the past 12 months – most notably lingering uncertainty over Brexit – have had an undeniably negative impact on UK industry, with many manufacturers cutting spending plans and sounding stark warnings over the possible consequences of leaving the customs union and European single market.

Despite this, the pace of technological change in the UK has continued largely unabated. And while most engineering and manufacturing businesses we've spoken to over the course of the past couple of years would happily turn the clock back to those uncomplicated pre-referendum days, there's a growing sense that technology – in particular processes and techniques that can help boost manufacturing productivity – will play a key role in helping the UK adjust to the outcome of Brexit.

In many respects, as we look ahead, 2019 can be expected to offer more of the same: rapid technological change, greater adoption of the digital processes that are reshaping manufacturing and, quite possibly, greater political and economic uncertainty.

So, before we hear from this issue's sponsors and contributors, here's *The Engineer*'s view on some of the themes and projects that will loom large in 2019.

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The Factory of the future

Until relatively recently, Industry 4.0 was a nebulous term that many UK manufacturers struggled with. Our own online polls on the topic over the years have pointed to plenty of confusion over what it actually is and whether it has any relevance beyond the world of deep-pocketed Tier 1s and OEMs.

But this is now changing. Increasingly, there are tangible examples of what Industry 4.0 means in practice and how manufacturers are using it exploit the benefits of a host of so-called digital manufacturing techniques – from augmented and virtual reality and digital twinning to additive manufacturing and co-botics – and to improve the efficiency, flexibility and productivity of their operations.

Expect to see the UK play a key role in the development of driverless and connected vehicles

As we look ahead, one specific technology that we can expect to hear a lot more about over the next 12 months is 5G, which will underpin the next generation of mobile networks, and which many think will become a key enabler of industry 4.0: improving data management and transfer speeds and enabling more secure and greater collaboration between end users and suppliers.

Electric and connected vehicles

It is no exaggeration to say that the automotive sector is currently going through a period of profound revolutionary change, with electrification and driverless technology – both fringe concepts only a decade ago – now at the heart of many manufacturers' plans for the future.

Building up expertise in these areas has been a key priority for the UK sector, something which was reflected by the shortlisted entries in the automotive category of *The Engineer*'s annual awards

Finalists here included HVEMS-UK, a major Warwick Manufacturing Group-led effort to build up the UK's electric powertrain manufacturing capability, and the ultimate winner of the award, UK Autodrive, the UK's largest ever real-world trial of connected and autonomous vehicles.

With technology advancing so rapidly, connected and electric vehicles will continue to be a major area of coverage for *The Engineer* throughout 2019.

Crossrail

The Engineer has followed the £15bn Crossrail project closely since its inception. Now, after almost 10 years, 26 miles of tunnelling, 15,000km of cable laying and the extraction of enough rubble to create a nature reserve twice the size of the City of London, it is finally approaching the finishing line.

Despite encountering delays, the project has ticked off a number of key milestones over the course of the last 12 months or so: installation of its more than 50km of track was completed in September 2017 and by May 2018 all of the overhead power equipment had been put in place. In the same month, the railway came to life for the first time as engineers began testing the new route's fleet of trains – built in the UK by Bombardier Transportation – on a section between Abbey Wood and Canary Wharf.

The completed infrastructure will be handed over to Transport For London (TFL) over the course of 2019 and the central section of the line will start carrying passengers in the autumn.

Meanwhile, as Crossrail approaches completion, the capital's next mega-tunnelling project, the Thames Tideway scheme, a £4.2bn 'super-sewer' designed to prevent millions of tonnes of untreated sewage flowing into the Thames each year, will start to take shape.

The most significant change to London's sewers since Joseph Bazalgette's 82-mile-long sewer network opened in 1865, Thames Tideway's 25km-long, 7m-diameter tunnel will run around 66m beneath the Thames and connect to the combined sewer overflows that are located along its banks.

These were originally designed to release overflow sewage into the river during heavy storms, but the strain that the ageing sewer system is now under means that this happens on a weekly basis even if there are no storms. The new tunnel will intercept this waste before it enters the river, carrying it east towards the Lee Tunnel, which will transfer the sewage to Beckton sewage treatment works.

Brexit

Finally, if there's one prediction that we can be absolutely certain of, it's that the outcome of the 2016 referendum will continue to dominate industry discourse in 2019.

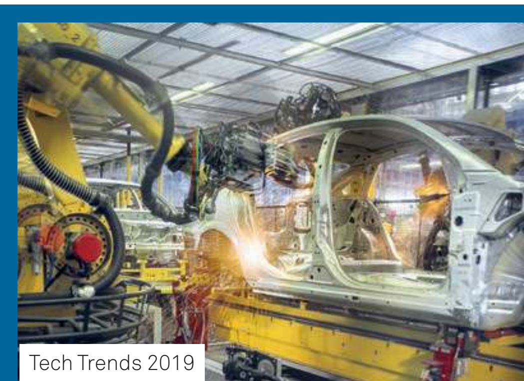
Will Theresa May's Brexit plan make it through the Commons or will opposition within her own party finally bring her premiership to an end? Will the country face the prospect of a general election? Will the UK crash out of the EU without a deal? Or will the 2016 result be sanity-checked via a second referendum. Astonishingly, at time of writing – with just four months to go before the UK's stated leaving date – not one of these outcomes could be ruled out.

Throughout 2018, industry's frustration at the uncertainty surrounding the UK's future relationship with the EU has become ever more pronounced. Perhaps unsurprisingly, the UK automotive sector – which sits at the heart of complex, pan-European supply chains and operates just-in-time manufacturing processes that depend on the frictionless movement of goods across borders – has been the most vocal critic, with the UK's major car-makers halving investment in new models and equipment. 2019 should be, hopefully, the year in which the shape of this future relationship finally becomes clear. Clarity is something every sector of industry badly craves if it is to continue to innovate, grow and compete on the world stage. ■

Taking a look at the

An integrated systems approach to factory automation promises much but also opens the industrial environment to challenges already familiar in the IT space. Analog Devices reveals all.

When every sensor and actuator becomes part of an integrated and connected environment, data security must be built in to every node in the network to eliminate potential points of unauthorised access



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The technologies that comprise what has come to be known as 'Industry (or Industrie) 4.0' have been the subject of much attention – almost as much, it might be said, as that other overworked expression 'internet of things'. Unlike some previous buzz-word topics, however, this is not a futuristic, months- or years-away matter but is happening 'for real' at impressive and accelerating speed.

Factory owners and managers are being driven in this direction by several distinct forces. There is the ever-present demand to increase efficiency and productivity and, set against that, the realisation that the era of low-cost, labour-intensive, offshore (from the Western perspective) manufacturing is drawing to a close.

This should not have come as a surprise. In societies that have been industrialising at a faster rate than ever seen before, the personal aspirations of those workforces were sure to follow the same trajectory. Willingness to perform repetitive tasks for low rates of reward quickly disappears.

At the same time, the (most welcome) increase in prosperity drives demand for manufactured goods and for more product versions specific to new markets.

Increasing levels of automation are essential to meet demands for manufactured goods from established and emerging markets.

At the same time, available technologies make feasible an entirely new level of automation compared to what has gone before. Industry 4.0 promises agile production that delivers greater output, flexible manufacturing that can seamlessly build different product variants without interrupting operations, safe co-working between skilled human operators and tireless robotics ('cobots'), fully instrumented facilities that are immune to shutdowns due to unexpected machine failures, and much more.

The most agile factory equipment manufacturers will thrive in this fast-changing environment as they develop increasingly connected and intelligent systems which help factories to become more flexible and safer, while maintaining security as they extend connectivity.

Semiconductor technology is at the heart of this new generation of industrial automation equipment, providing the processing, control and sensing functions that are required to operate effectively in connected environments.

Semiconductors provide affordable MEMS devices that make pervasive sensing possible and the connectivity that makes the totally-connected factory a reality.

They provide the interfaces between the real and the electronic, the analog and the digital domains and the processing power to make sense, in real time, of the torrents of data gathered (see www.analog.com/industrialautomation and www.analog.com/).

Analog Devices (ADI), which has always thrived at the intersection of the analogue and digital worlds, has a close-up view of the technology changes that new factory automation equipment calls for (click here for further information).

Its expertise in the fields of sensing, signal conditioning, digital signal processing, wired and wireless connectivity and software exactly match the challenges that its industrial customers face, enabling it to develop application-oriented solutions that help customers innovate through technology while offering the guaranteed long-term availability of parts vital for the industrial marketplace.

There is now more potential than ever for rich new applications of data analytics, such as machine health monitoring and preventive maintenance (click here for further information on applying MEMS devices and click here for more information on Condition Monitoring).

At the same time, the increasing use of programmable hardware and software-defined electronics functions enables rapid reconfigurations of factory processes and tools.

So, which technologies in the analogue and digital semiconductor worlds are going to enable this new model of factory automation?
click here for further information

Sensors – the key to machine health monitoring

MEMS sensor technology is enabling the development of new sensor types that are small, robust, able to precisely measure vibration and motion and deployable in large numbers.

For instance, low-noise, wide-bandwidth accelerometers offer the high precision and accuracy required to identify subtle changes in the vibration signature of a machine.

Coupled with sensor analytics software, these devices enable equipment operators to pinpoint the source of a potential failure long before it occurs and to apply preventive maintenance measures in good time.

Sometimes termed condition monitoring, the concept is not new but, as with many aspects of Industry 4.0, mass deployment and universal connectivity open up entirely new ways of working.

Machine health monitoring is an application that is not confined to conventional factory settings. Mobile or remote industrial equipment may use a wireless connection to report diagnostic information and operating status to a central controller. Running on battery power or intermittent power sources such as solar energy, this kind of application requires a very low-power sensing solution.

factory of the future

High-speed connectivity on the factory floor

The proliferation of sensors throughout factories and process plants is generating vast flows of real-time data.

Legacy communication protocols between sensor nodes and PLCs, such as 4-20mA control loops, are giving way to ultra-fast industrial variants of the Ethernet protocol, enabling increasing integration of Operational Technology (OT) infrastructure in the factory with Information Technology (IT) in the enterprise. With connectivity comes the need to ensure that the future factory's networks are secure against attack (click here for more information on Cybersecurity in the connected factory and this link on trends in industrial Ethernet).

OEMs need to future-proof their system implementations, so that they support not only industrial Ethernet protocols in use today, but also the emerging Time-Sensitive Networking (TSN) Ethernet standard, which is likely to become the standard wired networking technology for real-time industrial communications (click here for a video clip which outlines the operation of TSN).

ADI provides a solution that supports multiple Ethernet protocols without the need for hardware re-design.

Robust, wireless sensor network technologies are also required for connecting sensor nodes in locations that are hard to reach with physical wiring. Wireless network technologies such as SmartMesh and WirelessHart, which are designed to operate in tough IoT applications, provide a proven and high-performance method of connecting industrial automation equipment without wires.

Safety systems for autonomous machines

Autonomous vehicles and cobots offer huge scope for widening the application of automation in factories and warehouses.

The challenge for industry is to guarantee safety, ensuring autonomous machines are fully environment-aware. Advanced radar and LiDAR technologies are raising the standard of accuracy and precision in object and proximity detection and 3D mapping applications (click here for further information).

Configurable production processes

The factory of the future must be capable of quick adaptation to new demands and new workflows. The key is to build flexibility into industrial automation technology products at the architecture level. One approach which can support this need for flexibility is 'software-defined I/O' which can be configured as analogue or digital, and input or output, without altering wiring.

Pushing at the boundaries of today's technology, ADI already supplies a robust and flexible industrial output solution, which enables full software configurability of the analogue output to support a variety of industrial standards.

Integrating analogue, digital and software

The development and production of industrial automation equipment is becoming an increasingly high-tech undertaking, with the ever-present pressure to get to market quickly with new, more sophisticated designs.

Analog Devices' response is to provide customers with an integrated offering, providing market-oriented solutions for applications including, among others, machine health monitoring, high-speed connectivity, safety and security systems.

It will do so by combining analogue, mixed-signal and digital components with firmware and software, enabling automation systems makers to respond rapidly and effectively to the intensifying technological and economic challenges of today and tomorrow. ■

Cybersecurity in the connected factory

Cybersecurity concerns in industrial control systems (ICS) have the potential to delay the adoption of Industry 4.0. The factory becomes a complex networked system – with internet connectivity – and acquires all the vulnerabilities that can afflict any such system: hacking, data and intellectual property theft, ransom attacks ... the list is familiar. Traditionally, factory automation systems have relied for protection on isolation – essentially stand-alone configurations with no, or very limited, interfaces to external IT systems or the internet, where traffic can be monitored.

Industry 4.0 is all about connectivity throughout the manufacturing chain and outwards to many layers of IT systems. This means increased access to the data to expand transparency, reduce network planning, lower CapEx, reduce OpEx, improve bandwidth and optimise machine interworking.

Isolation is not an option. Systems cannot be protected at their external interfaces (although that is required, also), they must be inherently secure. Traditional countermeasures applied to the system, such as firewalls and placing a device behind a locked door, are counterintuitive to the goals of Industry 4.0.

The emerging automated factory also has distributed intelligence, with localised computing resources pre-processing data for transmission upwards in the hierarchy.

Any and all of these become part of the potential 'attack surface'. Appropriate solutions for every step of a design are readily available – secure processors, with secure-boot sequences and hardened operation, together with end-to-end encryption of all data and command paths, for example – but a strategic approach is required to ensure they become part of the culture of Industry 4.0 (click here for further information).

The engineers developing solutions for industrial control systems have likely not seen significant cyber security requirements at the device level. A product lead working on devices in a factory might dismiss cybersecurity as an IT problem. However, the traditional methods for securing industrial control systems will no longer be sufficient in Industry 4.0. The challenges of ICS cybersecurity will ultimately delay the adoption of Industry 4.0 if companies do not have a strategy to address device security at the edge. In order to adopt and capitalise on Industry 4.0, cybersecurity needs to be a critical part of the business plan.

Analog Devices recognises the challenges that Industry 4.0 is bringing to the market. ICS cybersecurity standards and guidelines are in place or being established to secure the factory but they do not provide guidance on how to accelerate Industry 4.0 initiatives.

With Internet Protocols (IP) extending to the edge, attack vectors increase as well the incentive to attack newly connected edge devices.

Before, attacking an edge device had limited effect. With the extension of IP in the factory, previously benign devices open new attack vectors into more critical factory infrastructure.

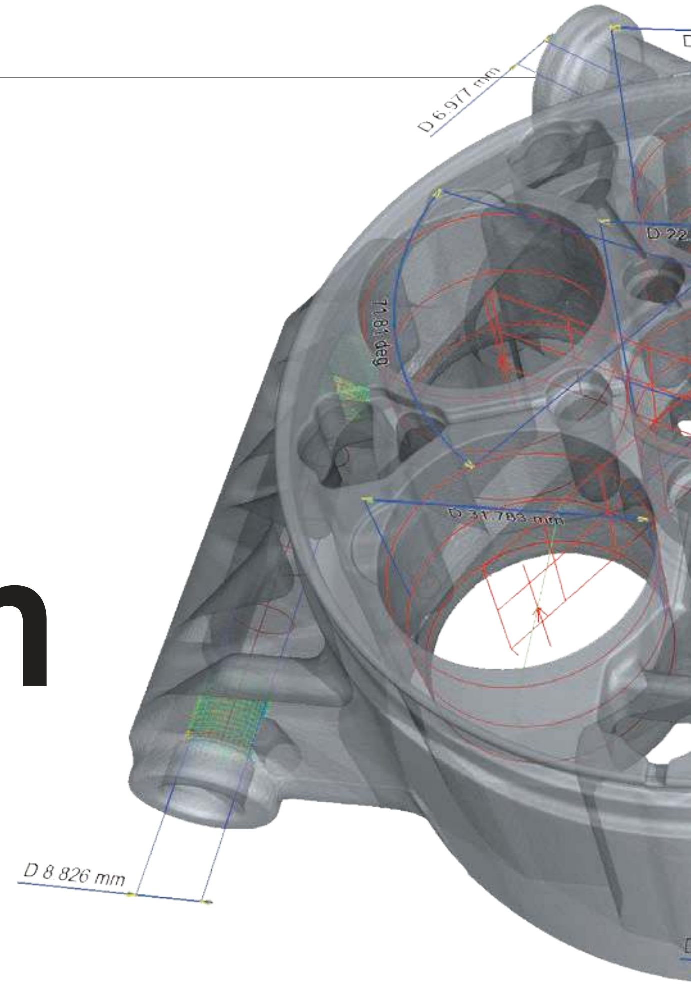
It is ADI's mission to enable its customers to more rapidly adopt Industry 4.0 solutions by extending the secure edge and making it easier to implement security.

Analog Devices is in a unique position to extend the secure edge, building on a traditional market space at the physical edge, where the real world is translated into digital signals and data is born. This gives us the opportunity to establish trust in data by providing identity and integrity much earlier in the signal chain and establish a new definition of the secure edge.

Rather than being implemented at gateways, PLCs, or even servers, as in the industrial control systems security framework, the prospect of driving the secure edge lower in the signal chain is enticing because it enables higher confidence in the decisions that are being made from that data.

The earlier identity and integrity can be established in the signal chain, more trust and confidence can be placed in the data that is driving decisions.

Bringing AM into the mainstream



North Star Imaging on how advanced qualification and testing methods are helping to develop additive manufacturing

Additive manufacturing (AM) has rapidly expanded into nearly all industries with projections of growth continuing in the double digits for the next decade. AM carries with it the ability to expand product performance, reduce design-to-product-cycle times and drive down total product cost. AM methods and technology continue to advance in both capabilities and quality while providing more options in metals and polymers as well as many hybrid materials. With AM, yesterday's impossible is truly today's opportunity.

One common denominator across all areas of AM is the need for qualification of the AM process and product. The performance of some AM products can be critical in sustaining human life as well as assuring the function and protection of equipment valued at millions of dollars.

Flight-critical metal AM products are rapidly replacing products manufactured with conventional manufacturing processes, such as castings, forgings and weldments. Cast medical implants are being replaced with metal and polymer-based AM products with characteristics that make them superior in their biological attachment within the body while employing materials optimal for biocompatibility.

Numerous other industries have successfully begun to employ the use of AM in their manufacturing of performance-critical products.

With any relatively new or changing process, there can be a painful learning curve as we gain the knowledge of the controlling process variables and their optimisation for manufacturing productivity and quality. AM is not exempt from these growing pains. However, there are technologies that have dramatically helped accelerate the development process.

Shifting of technologies for evaluation of product integrity

When we pick up an AM product, visual and other surface evaluation methods provide some general assessment as to whether we have a quality product. But what lies under that surface is often what is most critical. Typical non-destructive testing methods used for casting inspection may not be appropriate for some of the AM processes and alternative methods will need to be employed. Ultrasonic testing (UT) can sometimes be used in evaluating a product's internal integrity, yet many AM product geometries, surface conditions and grain structures do not lend themselves to the UT process.

Digital radiography (DR) and film radiography have been found to be successful in the evaluation of some AM metal products but they don't have the image quality to adequately identify some of the common AM discontinuities in other parts. For most critical metal AM products, computed tomography (CT) has become the go-to technology for evaluating parts for internal integrity. ***Figure 1*** compares DR and CT images of a metal AM product, displaying levels of clarity that CT provides for detecting small discontinuities.

Validation of Product Integrity

Any method used to evaluate a product for internal integrity should be qualified and validated for a specific product. A common method of qualifying a CT technique and validating product integrity is by creating multiple reference quality indicator (RQI) parts.

When possible, these RQIs are printed with intentionally generated discontinuities and anomalies representing what could potentially occur within the specific AM process. The RQI is typically made from either an actual product, a section of a product or a close representation of a product. A minimum of two RQIs are typically created and CT scanned.

One of the RQIs is then cross-sectioned, typically in multiple areas to confirm the type and size of features correlate with the CT scan data. Additional discontinuities or anomalies identified in either the CT scan or the cross-sections are cross-validated. This process helps understand and define the limitation parameters for detectability using CT. The remaining RQI should be used to continually monitor the performance of the CT scan process over time.

Growing advances of in-Situ monitoring

Significant advancements have been made in the area of in-situ monitoring of AM during the printing cycle. Many metal powder bed fusion (PBF) systems are equipped with one or multiple types of in-situ sensors monitoring each fusion layer of the melt pool for variation or anomalies that may contribute to a non-optimal condition within the product. Extensive work is being done for it to be capable of spatially plotting this data in a three-dimensional format tied to the geometry of the product. This data may be very useful, but only when it can first be correlated to a specific outcome within the product, such as a discontinuity. This correlation can be valuable in predicting the product quality during the build process.

Initially, the painstakingly slow and incomplete process of cross-sectioning

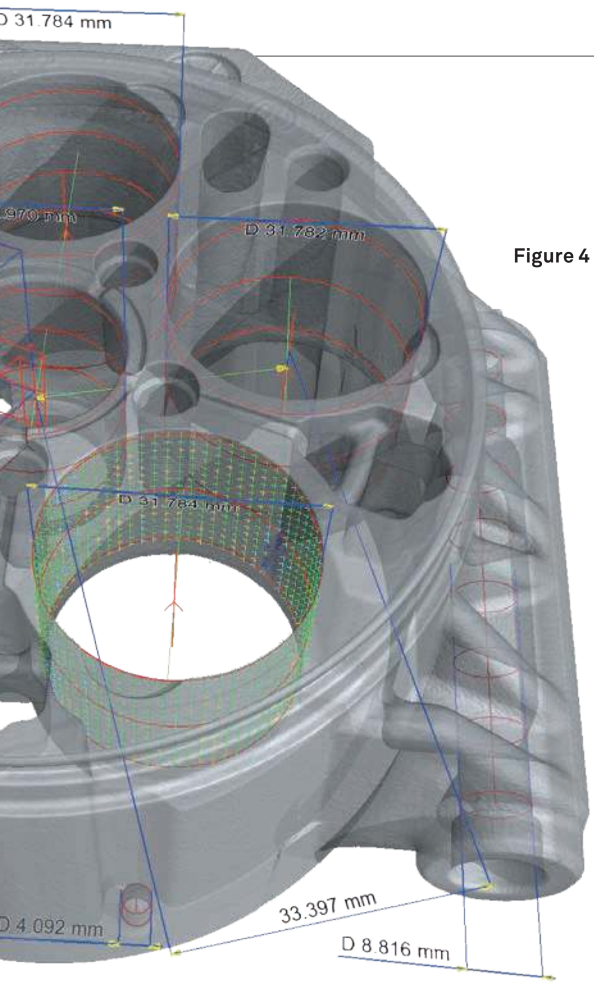


Figure 4

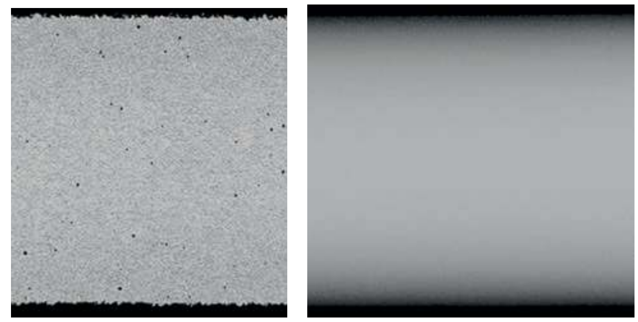


Figure 1

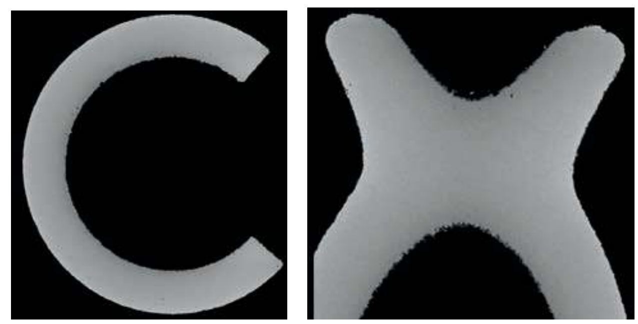


Figure 2

a product was the primary way of providing this type of correlation. For many AM products, CT has now become the method of choice in validating the in-situ process and making the above correlations. The layer-by-layer data collected from in-situ detectors can be used to generate a 3D data set of information that can be spatially correlated to the 3D CT scan and any associated product anomalies. This provides a powerful method of assessing what type of discontinuity a specific in-situ monitored event produced within the product and its precise location.

This combined approach can help provide a higher level of confidence in the in-situ monitoring. The ideal is that the in-situ monitoring process would consistently identify any event within the build that will cause an unacceptable condition and then either stop the print or correct the condition and continue.

This could drastically reduce the amount of scrap or reworked product that is identified later with CT inspection and, for some products, may be able to reduce inspection to a sample or eliminate CT inspection requirements. Any reduction in inspection should be addressed cautiously when relying on only in-situ monitoring technologies as they also have their own tolerances of measurement and detection. The need for further improvement is still evident by the simple observation that, even when some in-situ monitoring predicts no rejectable discontinuities, some parts are still found to contain defects detected by CT scans (see ***Figure 2***).

Some critical products will always require 100 per cent inspection using CT, but the more we can learn from the combination of CT and in situ monitoring, the more likely a case can be made for a consideration of process and product CT sampling.

Considerations in the use of mechanical property test coupons

Another method of monitoring the effectiveness and quality of a PBF AM build is through using destructive testing of coupons to assess a product's mechanical properties. However, even when shear, compression and fatigue sample coupons are printed at the same time on the same build set as a part or parts, product geometries and wall thicknesses often vary significantly from the coupons. This approach, therefore, does not always produce a valid representation of the material properties of the product itself but can still provide some useful data. It is, therefore, recommended that metallography and mechanical property testing be performed on the representative coupons as well as on actual product to identify if there is an adequate representation from the coupons.

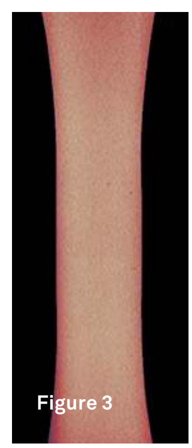


Figure 3

It's also becoming more common practice that all test coupons be CT scanned before testing to identify the types of discontinuities that are present, as this can dramatically impact the mechanical property results (see ***Figure 3***). A new hybrid version of this process is in-situ CT. In this process, the load cell equipment is integrated within the CT system. Multiple CT scans are performed while the sample coupons are under load, providing the ability to capture 3D data of the sample's internal structure movement through the point of failure.

Metrology of complex AM products

Many AM product designs are taking on complex geometries with internal features and chambers that are not accessible for conventional measurement methods, such as contact coordinate measurement machines (CMM). CT is now successfully solving this problem and is used to retrieve internal and external metrology data of AM products for product acceptance (see ***Figure 4***), while also providing data in monitoring build variability within a specific AM machine. Some innovative PBF AM equipment providers are also providing means of retrieving metrology data layer by layer during a product build. CT can be further used to validate and monitor this process by comparing the final as-built data to the CT scan full metrology data.

Upcoming uses of CT in AM

CT is beginning to be used to validate and further improve upon AM product design and print simulation models by performing an as-built CT scan of the product and comparing it to the original simulation print model.

Conclusion

CT is increasingly being applied in assisting the AM manufacturing process in the evaluation of product integrity, in-situ monitoring validation, product qualification, process monitoring, metrology, HIP processing qualification and print simulation model design validation and improvement.

As AM processes and methods continue to evolve, the application and capabilities of CT and other technologies are expected to continue to grow to support the rapidly expanding demands of one of the most exciting manufacturing processes of all time. ■

On the road towards zero emissions

01

By developing solutions and employing production-ready technologies for low- and zero-emissions, automotive supplier Schaeffler is helping to significantly cut pollution and greenhouse gas emissions

Governments around the world are pursuing more stringent emission control regulations to continually improve air quality in urban areas. Since September 2017, for example, the European Union has required Real Driving Emissions (RDE) tests measuring emissions in real-world traffic and no longer merely on test benches. China, on the other hand, is planning to establish fixed quotas for electric vehicles with zero local emissions.

The technologies needed to meet these requirements are available. Schaeffler already has several production orders for its very compact and powerful electric drive systems. At the same time, there is a need to design future internal combustion (IC) engines for even greater efficiency and lower emissions.

Looking forward, Schaeffler anticipates electrified powertrains for vehicles to continually increase over the next few years. By 2030, as much as 30 per cent of all new cars could be using all-electric traction systems.

In this case, only 30 per cent would exclusively be equipped with an IC engine and 40 per cent would have a hybrid powertrain. Even in this extreme scenario, two in three new vehicles would still have an IC engine on board.

Variable valve timing

The dynamic timing of the engine's valves is an important influencing variable. The reason is that a major proportion of total emissions is produced in acceleration phases. Engine designers can effectively counter this by short-term adjustment of the opening and closing times of the intake valves through which air and re-circulated exhaust gas flow into the cylinder. To enable fast adjustment even in dynamic driving modes, Schaeffler has developed an electric camshaft adjuster and successfully introduced it into volume production.

Using electromechanical technology, it is now possible to adjust the camshaft at a crankshaft angular velocity of 600 to 800 degrees per second. This adjustment is even possible in the opposite direction to the engine's rotation. The hydraulic systems that have been widely used so far are slower by a factor of two to 10, depending on engine speed and temperature.

01 The Schaeffler system 48 V concept car uses a 48-volt onboard electrical system to make all-electric driving possible at low speeds.

02 Variable camshaft timing system from Schaeffler.

Less consumption and lower emissions

These advantages are also provided by systems that shut off one or more cylinders in low-load driving conditions. As a result, the cylinders that remain active operate in a more efficient load range. The hydraulic-switchable valve tappet developed by Schaeffler allows individual cylinders to be deactivated. In 2018, the first three-cylinder engine using such a system from Schaeffler went into production. A dual-mass flywheel with an integrated pendulum-type absorber – another product developed by Schaeffler – prevents negative effects of the temporary two-cylinder operation on acoustics, vibration and harshness (NVH) performance.

Providing the right technologies for global markets, each with differing needs, is a challenge. Three concept vehicles demonstrate how Schaeffler is finding the right technology mix for each market worldwide.

Europe: 48-volt system

Today, vehicles must combine comfort, driving dynamics and suitability for everyday use with minimum environmental damage. With the Schaeffler System 48 V concept car, Schaeffler is pushing the boundaries of 48-volt hybridisation. While other hybrid vehicles operate with high voltages, Schaeffler uses a 48-volt onboard electrical system in this vehicle in order to make all-electric driving possible at low speeds. The drive is based around an electrified rear axle that complements the front-wheel drive internal

combustion engine. An additional belt-driven starter generator is connected to the engine, which also operates at 48 volts.

Electric axle

Aside from the electric axle drive for the Schaeffler System 48 V concept vehicle, Schaeffler has also developed other hybridisation options, such as the 48-volt hybrid module and belt drive solutions for 48-volt belt starter generators. The two-speed electric axle drive is integrated into the vehicle, ensures a high starting torque and also allows all-electric driving.

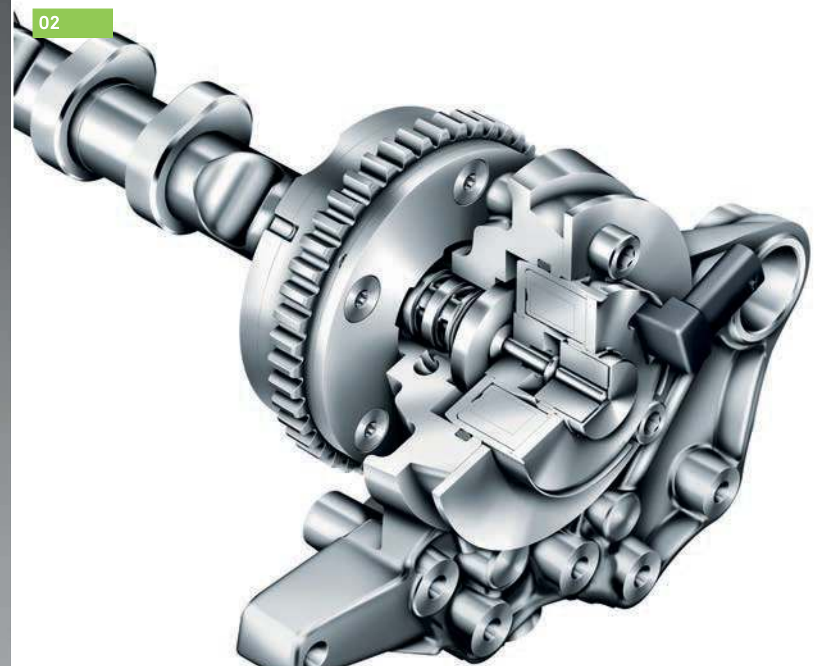
48-Volt hybrid module

As an alternative to the electric axle, the hybrid module can be integrated into automatic transmission vehicles. Schaeffler has developed a hybrid module for vehicles with manual transmissions. An automated impulse clutch that shifts rapidly allows the implementation of a 48-volt electric motor between the internal combustion engine and the transmission. Engaging this clutch allows the internal combustion engine to be started via the electric motor.

Electrification in the belt drive

Schaeffler has a third approach: mechanical systems for belt drives in vehicles with belt starter generators. High-performance electric motors are connected to the crankshaft using a belt. This means that the internal combustion engine can be started and assisted by the electric motor during acceleration. The vibrations that occur in the belt drive are reduced by the pulley decoupler developed by Schaeffler. If the belt pulley decoupler is supplemented through the addition of an electromagnetic actuator, the starter generator can also drive the air conditioning compressor when the engine is switched off.

02



Decoupling tensioner

The decoupling tensioner (RSEMP) ensures that the starter generator operates efficiently during load cycles. The decoupling tensioner is mounted on the starter generator in a space-saving way, replacing the two tensioning elements that would otherwise be required in the belt drive.

China: full hybrid powertrains

For a rapidly growing economy like China, global warming and increasing scarcity of fossil fuels create significant challenges for the automotive industry. The Chinese central government introduced ambitious regulations to push down passenger vehicle fuel consumption to 5L/100km by 2020. In light of China's ambitious environmental targets, the Schaeffler Efficient Future Mobility China concept vehicle demonstrates Schaeffler's vision and the ability of full-hybrid powertrains in the near future.

The demo vehicle incorporates several new developments from Schaeffler:

■ The P2 high-voltage hybrid module can superimpose the internal combustion engine's torque in hybrid operation and allows all-electric driving.

■ With its wet and dry double clutches, Schaeffler always has exactly the right solution for every drive train concept. The new design with a hydrostatic clutch actuator provides maximum efficiency.

■ The camshaft performs no other task than to control the opening and closing of the valves. In the Schaeffler demo vehicle, these times are not fixed but can be adjusted variably by a unit fitted on the engine to suit the respective driving situation. Schaeffler manufactures such actuators in large volumes today.

Mobility for India

Mobility is vital for India, but it must also be affordable. Schaeffler's Efficient Future Mobility India demo vehicle is based on an economical small car with a manual transmission.

The vehicle integrates a selection of Schaeffler powertrain technologies that make it possible to reduce fuel consumption and CO_2 emissions while improving driving comfort.

Constant braking and pulling away are part of everyday motoring in Indian cities and, as a result, coupling and changing gear, too.

Schaeffler's electronic clutch management provides significantly greater comfort at moderate cost. A small, electronically-controlled actuator takes over the driver's footwork. Clutch actuation is carried out by an actuator, which means the clutch pedal is omitted.

This leaves only the accelerator and brake pedals – a set-up already familiar from vehicles with automatic transmission. ■

What are the trends skills and training ir

Findings from the IET's latest Skills Survey highlighted that skills supply is a leading concern for employers. On the positive side, over half (52 per cent) of the engineering companies questioned are currently recruiting, but almost the same amount (46 per cent) report difficulties recruiting staff with the right skills, and a quarter (25 per cent) have observed skills gaps in their current workforce.

Respondents also noted that they have found it harder than ever to recruit suitably qualified senior engineers. Plus, 70 per cent said that new graduates had not met their expectations regarding quality of skills and knowledge.

"Students aren't necessarily coming out of university with the right skills for employers right now, so there's an immediate training need as soon as they hit the workforce," notes Martin Davies, head of digital learning and development at the IET.

In addition, with the increase in digitisation and automation, more firms than ever are looking to introduce or extend their use of digital technologies.

The survey highlighted that 75 per cent of those that plan to do so will need to develop new skills in their existing workforce and 44 per cent said they would need to recruit new skills.

> "We're seeing more of a blend of learning"
> Martin Davies

"As we know, this industry – and therefore the workplace – is changing. We're seeing lots happening around digitisation of manufacturing, for example, and not all companies will have personnel with these skills," Martin highlights.

Stepping up to the challenge

Employers are responding to these challenges in a number of ways, including using training programmes to help recruit and retain staff.

"We're facing a massive shortage of engineers in this country, and training and development is a brilliant recruitment and retention tool," says Martin.

"Having great training and a continuous professional development (CPD) programme in place is a great thing to show to potential recruits. When you ask someone why they joined a particular company, one of the things they're likely to point out are great training opportunities," he notes.

Improving diversity in the workplace is also important.

With just 12 per cent of the UK's engineers being female, employers are providing more flexible working opportunities that appeal to women and are running dedicated returners programmes to help women – and men – return to the sector after taking a career break via training and mentoring support. Companies with these already in place include Atkins, O2 and Tideway.

Training trends

Beyond recruiting staff, successful engineering firms understand that continuous workplace learning is critical to business success. In recent years we have seen a trend towards more flexible training solutions, with a shift away from face-to-face training in favour of e-learning and virtual classrooms.

"We're seeing more of a blend of learning these days," says Martin.

"A lot of the companies we're working with at the moment are delivering a real mixture of digital and face-to-face training. This has been a wider market shift but, within the engineering sector, it had been slow to take off. Now when we talk to companies, mobile learning is particularly on the increase."

Many engineering firms have already embraced blended and flexible learning. Bechtel, for example, has been offering online courses via its Bechtel University for more than a decade.

In 2017, it also began working on its massive open online courses, which have the advantage of being able to accommodate large numbers of learners.

Another trend is around how people want to learn.

Engineers particularly like the ability to take their learning in bite-sized chunks and have the flexibility to study in their own time.

"There's a real market trend for bite-size learning; it's something that really appeals to engineers. You don't have to sit in front of a computer for an hour now; you can study for five

s shaping n 2019?

With employers struggling to recruit suitably qualified engineers at all levels, the importance of skills and training is at the forefront of engineering companies' minds

– writes the IET

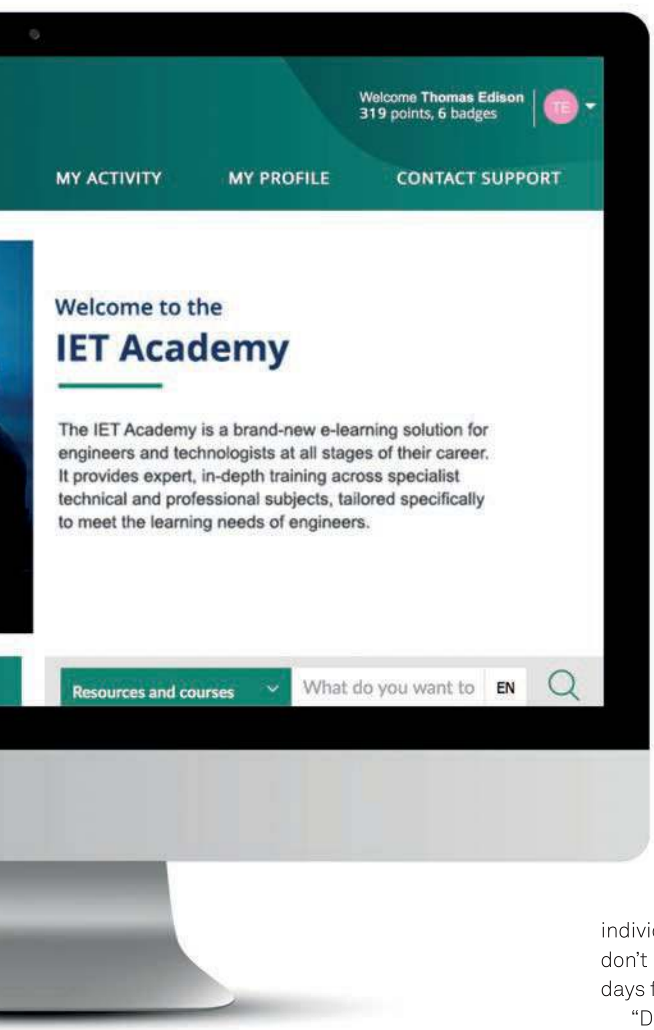
minutes, go off and do something else then come back and start where you left off," Martin says.

Ricardo uses online training for its 'lunch and learn' events; short training courses held in-house over lunch breaks, which are recorded and shared online.

"We run a minimum of these once a month, where subject matter experts from the business deliver 60- to 90-minute long talks," says Oonagh McPhillips, head of organisational development at Ricardo. "We have a room for the event, bring in lunch for the physical attendees and then many others join remotely via Skype.

"The sessions were recorded but originally we weren't sure of the value of doing so. However, we posted them on our learning management system and discovered that it was brilliant for our overseas staff, particularly those in the US or Japan working in different time zones. Many employees would watch these or download them as podcasts to listen to later.

"We also found that staff would discuss the events with colleagues, leading to more people going on to the system later to watch them."



Gamification of training has also risen. This is being integrated into more and more training services and products, where users earn points and badges as they learn, providing motivation.

"Millennials particularly like this aspect, where they can post their badges and achievements on their LinkedIn or Facebook profiles," Martin notes.

The growth of e-learning

E-learning and online training continue to grow in popularity. According to a recent report by Technavio, e-learning courses are forecast to grow at a compound annual rate of almost 11 per cent by 2020.

In addition, their use within the science, technology, engineering and maths (Stem) sectors is becoming more widespread, with Findcourses.co.uk citing engineering and industry, IT, oil and gas, energy and automotive, and logistics as four of its top 10 audience industries.

So why is e-learning becoming so popular? Martin points out a key driver is cost saving.

He says: "E-learning offers lots of benefits to both companies and individuals. For one, the cost is lower, as employers don't need to pay for staff to stay in a hotel for three days for face-to-face training.

"Despite people balking at the price of an online course, you need to consider the overheads for face-to-face training.

"It can be easily blended into your current training too. We're not saying get rid of your L&D department, but we think a blend is really important."

"The most obvious benefit is how flexible the learning is," continues Vio Krajacic, learning and development manager for Bechtel's Global Infrastructure Business. "Online classes can be taken or retaken any time, anywhere, depending on the employee's availability. It reduces the cost of learning, as employees and facilitators don't need to travel."

"It also offers some great, deep reporting opportunities," Martin adds. "You can track your users, see pass rates immediately and compare staff – how did they get on in that course? Who did well, who struggled? You can see how they're getting on and provide encouragement and support as needed. In terms of ROI, there are lots of benefits from e-learning."

■ Want to find out more about the benefits of e-learning and read examples of engineering firms embracing it? Check out the article Flexible e-learning is leading a revolution in the way we train our engineers

■ To find out more about the IET Academy, click here

■ To see how the IET Academy platform works, watch the video here

IET Academy

A huge variety of flexible learning tools are now available to businesses, including everything from open education resources such as YouTube through to custom-made e-learning solutions.

To support the engineering sector specifically, the IET has developed an e-learning solution of its own: the IET Academy.

Offering organisations access to high-quality, 'any time, anywhere' technical and professional training, the IET Academy covers a broad range of engineering disciplines and provides trusted training content developed in partnership with leading UK universities and industry organisations on specific – and often complex – engineering subjects.

Current course topics on offer include fundamentals of telecoms, an introduction to management, renewable energy integration and computing ethics.

Future-proof engineering with AR, MR and VR

Tech Trends 2019

Engineering software specialist Theorem Solutions explains how the adoption of so-called mixed reality technologies is helping manufacturers close the gap between the digital and real world

The hype around augmented (AR), mixed (MR) and virtual (VR) reality has been steadily building over the past 12-18 months and shows no sign of fading in 2019. It seems like the tech companies are constantly rolling out new devices with better graphical performance.

Most new devices and apps have been made with gaming and social media audiences in mind. However, recent trends towards the digitising of manufacturing with the Internet of Things and Industry 4.0 have caused industry to consider AR, MR and VR for industrial use.

The use of AR, MR or VR (collectively known as XR) in engineering and manufacturing is still in its infancy, but while integrating more modern, innovative technology into existing workflows involves investment and is time-consuming to begin with, in the long run it will save manufacturers money and cut lead times by improving processes.

In the current climate of constant technological advancement and economic uncertainty, organisations may need to find new ways of getting the job done quicker but cheaper.

So as a relatively new way to interact with engineering data, where will AR, MR and VR take us in 2019?

The device race

It is important to recognise that this is a dynamic market. Given the scale of the companies involved – Microsoft, Google, Apple, Facebook etc – competition is fierce and, as history would suggest, any device from these tech giants is bound to be a success. But there are other, smaller AR, MR and VR specific companies which could be worth watching in 2019.

Currently, there are a vast number of headsets and devices available (over 100 across AR, MR and VR), and users are spoilt for choice, which does not necessarily make it easier when trying to decide which device and technology work best for you.

The devices that hold dominance over the current enterprise market are as follows:

■ VR: Oculus Rift (Facebook), Vive (HTC), Gear (Samsung)

■ AR: Apps for AR will work on most smartphones and tablets. Other devices include the DAQRI headset and Google Glass – which is making a comeback with Google Glass 2 – and offerings from Epson, Vuzix and ODG.

■ MR: Microsoft leads the market on MR devices at the moment with the HoloLens headset. HoloLens 2 is rumoured to be released in 2019 but it faces competition from the much-hyped Magic Leap, which has recently released its first headset with the potential to be big in 2019.

Spatial computing

The new trend of using holograms in MR is also known as spatial computing. What spatial computing does in essence is enable users to see 3D CAD data at full scale and in context.

Traditionally with 3D CAD, although it is 3D data, you are looking at it through a conventional 2D screen. Whether it is a tablet or a large display, you are still looking at it through a 2D medium.

With regards to products designed in CAD on a 2D screen, attempting to consider and visualise the impact of changes in the context of a full-size product in the real world can be challenging. With spatial computing, it is at full scale and in context.

As a result, the understanding of the product is enhanced substantially when the content is displayed in a familiar environment, rather than a totally digital environment.

Closing the gap between the digital and physical world presents an opportunity to exploit the power of digital product development and digital manufacturing as a competitive advantage. To download our white paper, XR: The Cognitive Gap, click here

01

01 Closing the gap: Work with engineering data at full scale and in context

02 Be device and data-agnostic to future-proof your investment

Digital twin

Another use for these technologies with 3D CAD assets relates to elements of the digital twin. Until recently, the only way to gain detailed information

Theorem Solutions

The technology

Virtual reality: VR has been around for a long time, used commercially by large aerospace and automotive organisations in CAVEs and Powerwalls for over 30 years. It is becoming more accessible through new headsets on the market (think HTC Vive and Oculus Rift). VR is a 100%, fully immersive experience. Everything you see in the environment is completely digital; you cannot see the real world at all.

Augmented reality: Made mainstream by the popularity of Pokémon Go and Snapchat, AR is the most accessible of the technologies and can be used on most smartphones and tablets, but there are also smartglasses and headsets that enable hands-free interaction. Digital content is overlaid on to the real world so you can view and interact with the content in the environment you are already in.

Mixed reality: MR can sometimes get banded in with AR and, while there are some similarities – interacting with digital content in your real-world environment – the main difference is that MR displays your content in 3D holographic form. You can walk around and interact with your data at full scale as if it were actually in the room in front of you.

02

about the status of products and industrial equipment was to be in physical proximity and have the ability to inspect it.

Today, AR and MR are making it possible to virtualise this task by creating and maintaining a digital representation – the digital twin – of any piece of real equipment, product or industrial plant.

Digital twin spans a number of technologies – one is sensors in products, equipment or machinery, the other is computing to collate and collect data, and then analyse and filter that data out.

Where these devices come into play is when you want to visualise the digital representation of your machine tool or product and see it overlaid on top of your physical asset – your actual car, machine tool etc – and add to that data which has been collected by the sensors so you can see on the machine where there might be problems.

The ultimate vision for the digital twin is to create, test, build, operate and service products and industrial equipment in a virtual environment, so that only when they get to where they perform to requirements are they physically manufactured.

Next steps in 2019

One of the definite trends in 2019 will be companies wanting to move from learning and understanding these technologies to actually defining and undertaking specific-use cases – figuring out how AR, MR and VR can be used as part of a design process, production build or training activity, or using them in a production layout activity. And you are going to see applications come on to the market to address those requirements.

Companies need to implement a use case where they can run it on many different devices, and they need to be device and data-agnostic, i.e. whatever data they generate for a particular use case they need to create so that they can use it on the next generation of devices.

That is a trend people are beginning to grasp, rather than tie themselves to one particular type of technology or device.

In 2019, companies will start to use different devices, multiple devices and technologies so they can protect themselves in the longer term and future-proof their investment.

As new hardware comes out, users will be able to carry on their use case in production and continue to get benefits once the device market changes and evolves.

Although investing in new technologies like this can seem a risk to begin with – especially if you are not sure how they will fit in to your workplace – using AR, MR and VR in engineering and manufacturing workflows is already being adopted by leading-edge companies and is changing the way people are working towards the future. Will you get left behind?

About Theorem

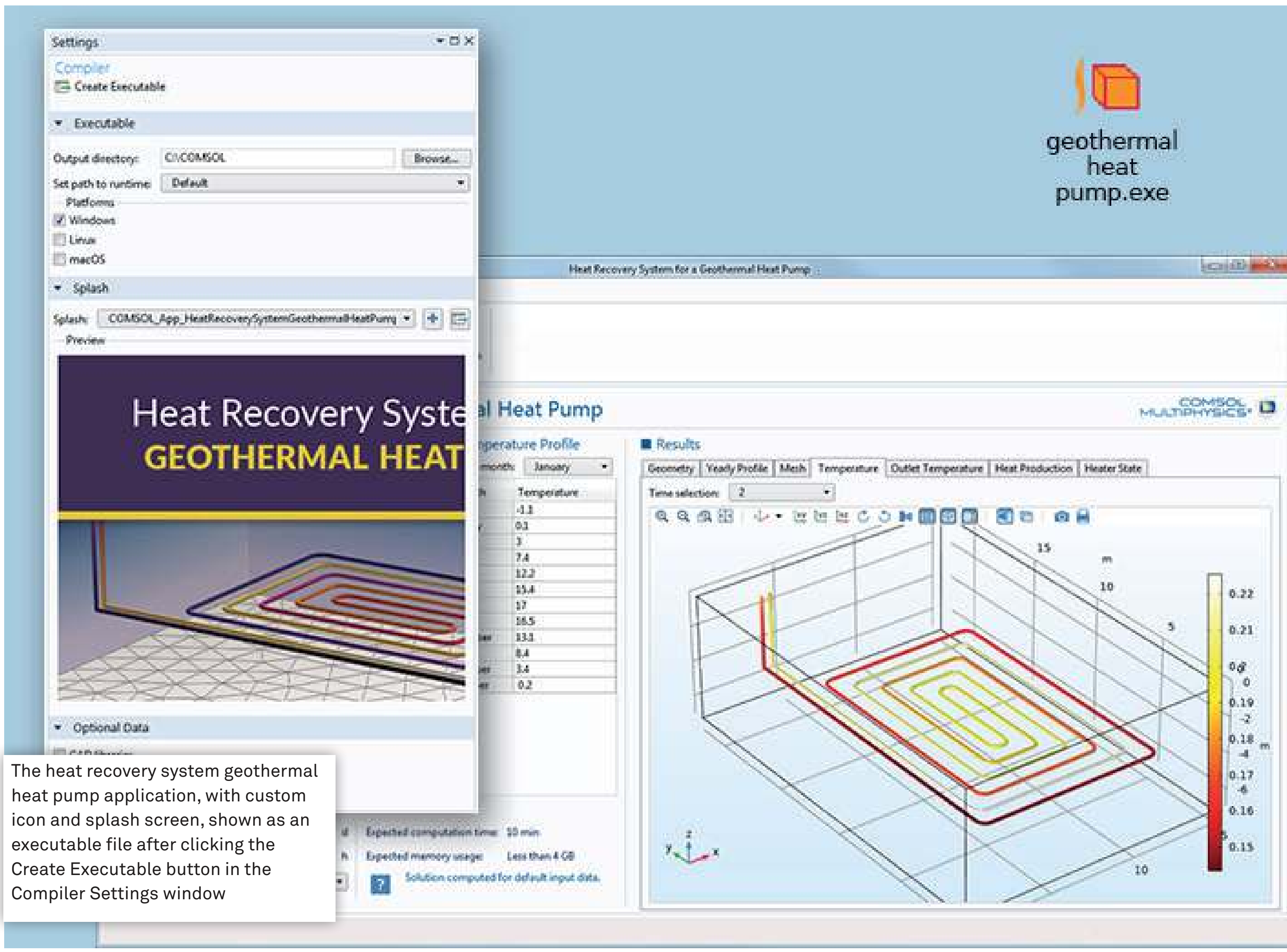
Founded in 1991, Theorem's products and solutions enable engineering and manufacturing companies to leverage their CAD and PLM assets in other parts of their business, primarily via data sharing with downstream processes and suppliers.

Theorem provides products for engineering and manufacturing companies to improve their design, engineering and manufacturing processes by utilising CAD and PLM assets in innovative augmented, mixed and virtual reality experiences.

- For more information, visit digitalrealities.com
- To download our white paper, XR: The Cognitive Gap, click here

Collaborate to innovate with simulation applications and digital twins

Digital twins, deployed through a centralised resource or as compiled simulation applications, help design engineers shape tomorrow, writes Brianne Christopher, content manager, COMSOL Inc.



The heat recovery system geothermal heat pump application, with custom icon and splash screen, shown as an executable file after clicking the Create Executable button in the Compiler Settings window

Multiphysics software is invaluable for simulating designs, devices, and processes in engineering, manufacturing, and scientific research. One of the greatest challenges of incorporating simulation into product development is making it accessible to everyone involved. COMSOL turns this challenge into an opportunity with tools for creating and deploying simulation applications and digital twins.

For simulation to be beneficial to the broader organisation, it must be accessible in two distinct ways. First, team members in R&D, manufacturing, laboratory testing, and design should be able to run analyses without relying on simulation experts. The Application Builder, available in the COMSOL Multiphysics® software, makes this possible. Applications provide all collaborators with the capability to perform simulations, avoiding bottlenecks in the development process.

Simulation should also be accessible in the field so engineers can run real-time analyses onsite. This is possible by deploying applications through COMSOL Server™ and COMSOL Compiler™. COMSOL Server™ provides centralised access to simulation for specialists, design teams, R&D teams, and more. COMSOL Compiler™ makes simulation accessible in an even broader sense.

Simulation engineers can use this new product to compile applications into standalone executable files that can be deployed to anyone, anywhere. Application users can open a compiled application and run their own simulations without a COMSOL® licence or internet connection.

Industry engineers and researchers are already accelerating product development by building numerical simulation applications and distributing them throughout their organisations. For example, one materials science company uses COMSOL Server™ to deploy applications to the right contributors at the right time, helping their teams collaborate in the development of innovative products.

Widespread access to simulation applications and digital twins allows design engineering teams to tap into their greatest asset: each other. ■