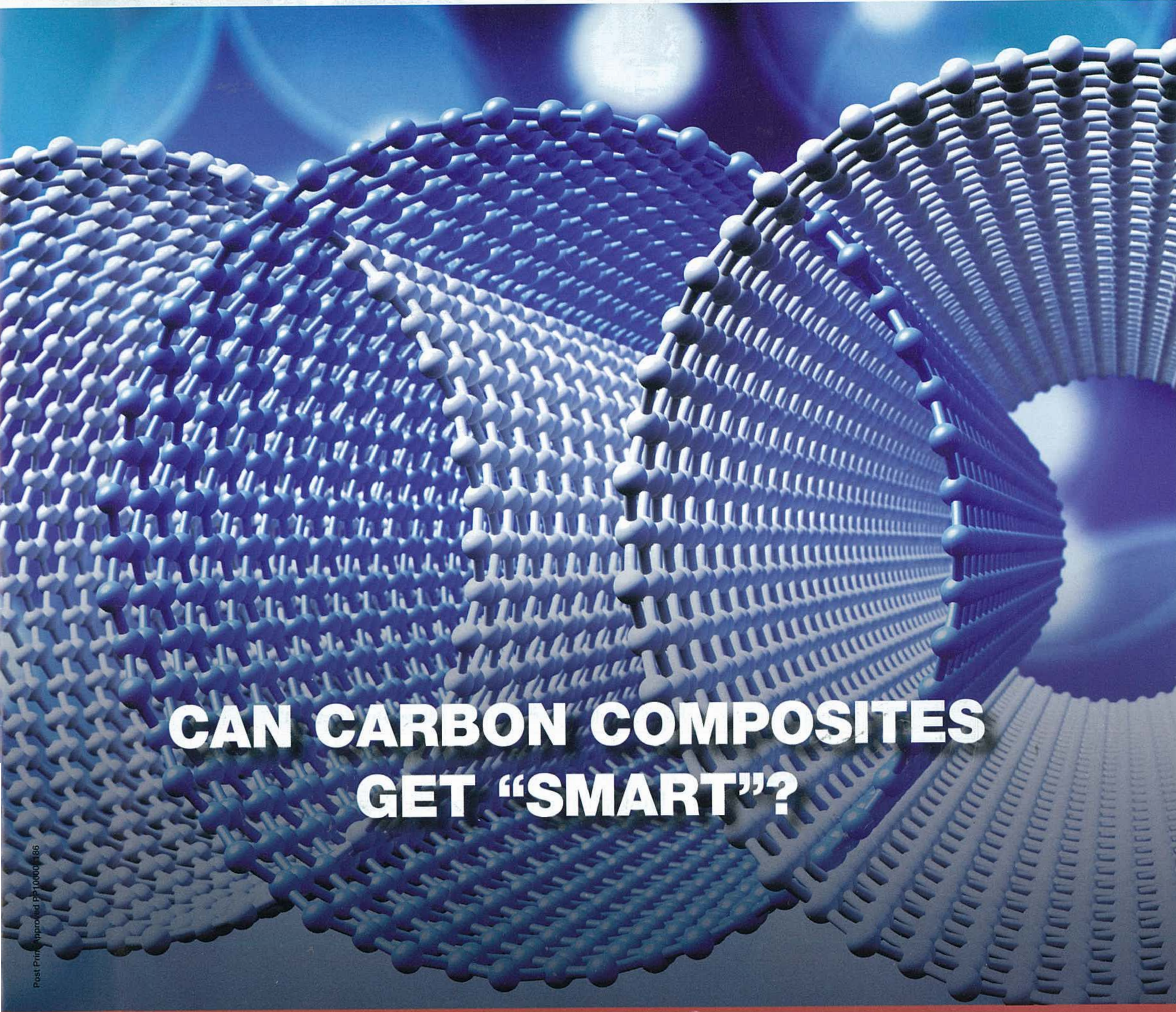
FEBRUARY/MARCH 2019 | VOL.72 NO.1 | Est. 1953

www.pacetoday.com.au

PACE

PROCESS & CONTROL ENGINEERING



CAN CARBON COMPOSITES GET "SMART"?

Post Print Approved PP10000[illegible]186

EXCLUSIVE: Uni students win award for hull cleaning robot

Bringing "smart" carbon composites into the fourth industrial revolution

Recent research is exploring how graphene can be used to enable innovative processing and performance monitoring functions in carbon fibre composite structures. Dr Nishar Hameed talks to **David Loneragan** about how he and his team are making these materials "smart".

Dr Nishar Hameed has been working at Swinburne University of Technology in Melbourne for two years. In November 2018, he received the Young Tall Poppy Science Award for his research on advanced composite materials, an area he has been working on for some 10 years.

Carbon fibre composites have been frequently used in the aerospace sector, primarily due to their light weight. More than 50 per cent of the structural components of the latest Boeing 787 Dreamliner are made from this material, making the aircraft lighter and enabling greater fuel efficiency. Now the automotive sector is looking to incorporate these composite materials into passenger vehicle parts to make lighter cars that use less fuel.

While the demand for composites is on the rise in the automotive industry, challenges exist in manufacturing large volumes of these materials. Another challenge, which Hameed and his team at Swinburne's Manufacturing Futures Research Institute have been tackling, is how to provide composites with multi-functionality, and, in particular, so-called "smart" functionality.

"What we are doing is exploring how to convert a part or structure made from composite material into one that can inform us about structural changes that are happening within the material for other functionalities, such as energy storage, data storage or connectivity," said Hameed.

"My research is primarily into composite materials and structures that are able to self-power and communicate information that lets us know what is going on within these structures and materials – for example, about their durability, their performance and the damage they might have sustained."

"By using graphene nano-platelets we can convert a 'dumb' composite – one that doesn't share any information – into a 'smart' composite that communicates vital information about the structure."

Hameed said that these "smart" composites can be created through the integration of highly conductive nanomaterials such as graphene that enable the structure to act as its own sensor. "We are not talking here about traditional sensors that need to be attached or printed on to pre-existing structures, but structures that are themselves already sensors," he said. "By using graphene nano-platelets we can convert a 'dumb' composite – one that doesn't share any information – into a 'smart' composite that communicates vital information about the structure."

One of the main areas where these smart composites will find application is in automotive manufacturing. But, according to Hameed, there are many opportunities across other industry sectors.

"We've just completed a project on a smart mining screen that can be used in the mining sector. These are composite structures, which are used for filtering coal," Hameed explained. "They are suitable because these composite parts can be placed deep in the ground, or in remote areas, which are for the most part inaccessible to workers, or difficult for them to access. The smart composite mining filter is able to remotely provide important information, such as whether it is functioning properly or whether it has sustained any damage."

This kind of application points towards the impact of smart composites could have in the wider manufacturing and processing space. As the materials are able to effectively operate as sensors,

The team from Swinburne University are working on how to give composite "smart" functionality.

they are able to collect data and information about the performance of the processes.

"One of the projects I have been working on relates to the real-time monitoring of the manufacturing process for composites themselves. It's very much the same technology, but it is being used in a different approach, this time involving graphene-enabled components in the production of composites," Hameed said.

The information that can be gathered through this process monitoring, such as on optimal temperature and pressure and material flow, can help eliminate defects in composite materials. "Ordinarily, as these composites are multi-component systems or hybrid systems, where three or more materials are mixed together, it is often the case that defects will be formed in the manufacturing process, leading to imperfections and inconsistencies," said Hameed.

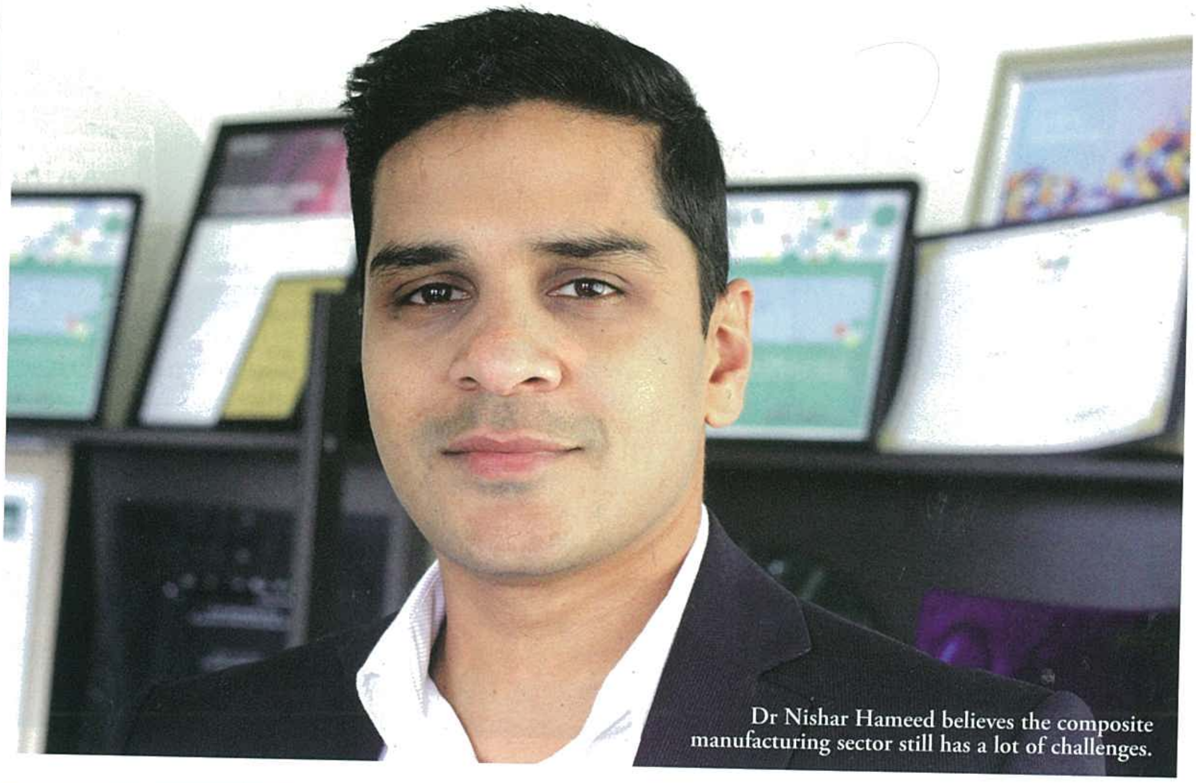
Additionally, the optical fibres that have traditionally been used to monitor the process of composite manufacturing also cause defects to the material, as these fibres are much thicker than the fibres in composites.

Using nano-materials such as graphene means that this issue is eliminated, Hameed said. Furthermore, having a smart manufacturing process that can be monitored in minute detail means that the consistency and quality of the material can be maintained. Because sensors are integrated into the material, it means that performance data will be continued to be recorded. "It's like having a digital passport within the composite that enables you to record data, both during and after manufacturing," said Hameed.

"There's actually a double-advantage: on the one hand, graphene can reinforce your composites so that they have better mechanical properties compared to a traditional composite. On the other hand, you have the integration of smart functionalities within a single combine.

"There are challenges, of course. For instance, how do you balance the mechanical and smart functions of a composite? You need to have the right formulations and the right engineering techniques to be able to carry this out effectively. This is an area where we are doing a lot of research."

While composite materials have a highly established supply chain,



Dr Nishar Hameed believes the composite manufacturing sector still has a lot of challenges.

"One of the areas of focus for us is to really help this process along. We are studying graphene so that we can understand its structure properly and enable better provision of the right types of graphene for the right applications,"

there are challenges to the commercial production of smart composites. Hameed said the benefits of graphene in the enabling of smart functioning in composites is that they can be produced in large volumes at a relatively low price. However, the commercialisation of graphene products is still in its early stages. "One of the areas of focus for us is to really help this process along. We are studying graphene so that we can understand its structure properly and enable better provision of the right types of graphene for the right applications," he said.

Hameed indicated that his team would be pressing forward in integrating a number of innovative ideas they have been working on to date. "We are primarily focused on bringing composite manufacturing up to Industry 4.0 standards. The sector still has many challenges in front of it," he said. "In many respects, composite manufacturing is still Industry 2.0; the process is still frequently carried out by manual labour."

Bringing composite manufacturing into the fourth industrial revolution would mean making strides in automating the process, according to Hameed. Swinburne University will be establishing Australia's first Industry 4.0 test lab focused on composite manufacturing. "In about six to eight months, we will have a fully established lab where we will have a digital and efficient process that will be a world-first – a completely innovative 3D printing approach for making carbon fibre composites," Hameed said.

Hameed and his team have also been working on rapid-cure epoxy resins. Epoxy usually takes many hours to cure to make composite parts, which has been a challenge for creating large volumes of the materials for commercial production. The Swinburne researchers have recently developed a new solution where epoxy can cure within 50 seconds.

Hameed said these different projects – the development of smart functionalities, digital manufacturing technologies, automation processes and a rapid-cure resin system – are parts of the wider puzzle that his team is fitting together in order to bring composite manufacturing into the fourth industrial revolution.

"We are trying to fit these areas together, so that we have a completely automated Industry 4.0 process to rapidly manufacture smart composite material. That is the ultimate goal we want to achieve.

"And this requires a multi-disciplinary approach. We are bringing together people from many different areas of research and speciality.

"This is the ultimate goal of the Manufacturing Futures Research Institute, where we have individuals from different disciplines all working together to address manufacturing challenges for Australian industries." PACE