PM Additive Manufacturing steals the MACH Show

Kenneth J A Brookes, *Metal Powder Report* Consulting Editor reports from MACH, the UK's machine tool exhibition.

MACH, the UK's national machine-tool exhibition held every two years, is the epitome of 'subtractive' manufacture, in which a chunk of metal, typically produced by casting or forging, is shaped into something useful by processes such as cutting and grinding. Held at Birmingham's NEC (the National Exhibition Centre), it mainly gives British manufacturers the chance to catch up with tooling developments launched at EMO, the World machine tool show in the previous year. Similar national shows take place in industrial countries around the world in even-numbered years.

In 2014, however, the MACH organisers placed a group of Additive Manufacturing specialists centrally in one of the halls. Most of the exhibits were based on metal powders and therefore of special interest to *MPR* readers, but we also managed to find a few items of the more conventional kind for such an exhibition. Here's a taster.

'Subtractive' manufacture

Since the majority of MACH 2014 visitors would not have been to the previous EMO, it was no surprise to find that the dozens of smart stands representing the UK tooling and tool materials industries (examples – Figures 1-5) were mainly displaying EMO products, including new releases, that where relevant I've already reported to *MPR* readers.

Even the few new products of particular interest to *MPR* readers seemed to have been press-released in good time for our previous edition. For example, Sandvik Coromant was featuring its new grade GC3330 for milling cast irons alongside its major EMO release of GC4325 and its more recently announced sibling GC4315 (Figure 6). The common denominator between all three grades is unidirectional crystal orientation, a technology that improves endurance, predictability and tool life in service. The crystal orientation in a CVD alumina coating is normally random, but in this process they all line up in the same direction, perpendicular to the top surface. This creates a stronger barrier in the cutting zone, enhancing wear resistance and cutting-edge stability.

Photo 1-5: Copyright © Kenneth J A Brookes 2014

Figure 1: Sandvik Coromant

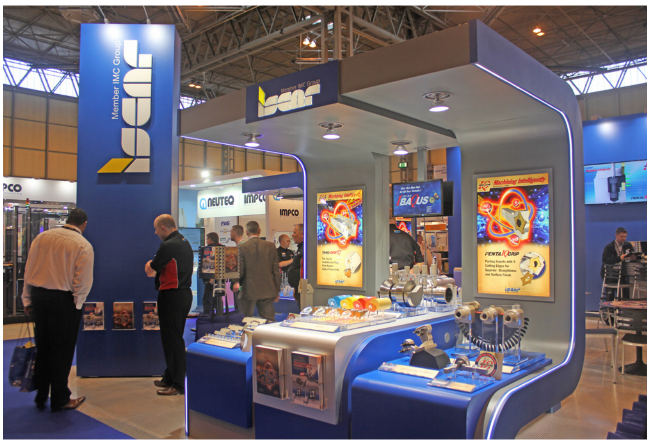

Figure 2: Iscar

Figure 3: Kennametal

Figure 4: Sumitomo

Figure 5: SGS

Figure 6. Sandvik Coromant's new insert grades with Inveio technology include GC4325 and GC4315 for steel turning (previously seen at EMO 2013) and GC3330 for cast iron milling.

Thus, whilst there were lots for most visitors to see in cutting tools and materials, there was little for me to report.

Additive manufacturing

University of Sheffield/Rolls-Royce

Though taking a relatively small but centrally located area in the exhibition halls, additive manufacturing certainly attracted a great deal of interest. Curiously, though, perhaps the most interesting exhibit for me was some distance away in the MTA Education and Training Zone. Here, in the University of Sheffield AMRC Manufacturing Transporter ('Mantra'), I found a couple of Rolls-Royce superalloy turbine blades made by AM and cut away to show their intricate internal structure (Figures 7-10). Thanks to high-efficiency internal cooling, blades of this design type can run at temperatures higher than the alloy's melting point. Oddly enough, Rolls-Royce had their own stand elsewhere in the exhibition, promoting the company's apprenticeships, but those manning it had not been informed of the AM exhibit starring Rolls-Royce products.

Renishaw

Sponsor of the Nottingham International AM Conference, Renishaw claims to be the UK's only manufacturer of an additive manufacturing machine that prints metal parts. Its pioneering process is capable of producing fully dense, complex parts from a range of metal powders, including tool steel, aluminium, titanium and Inconel. The laser melting technology involves fusing the metal powder in layer thicknesses ranging from 20 to 100 microns using a high-powered ytterbium fibre laser. The process is digitally driven, direct from 3D CAD data.

Its main exhibit highlighted the world's first 3D printed metal bicycle frame (Figures 11-12). Empire Cycles, based in Bolton, Lancashire, designed the mountain bike to take advantage of Renishaw's additive manufacturing technology, allowing the company to create a titanium alloy frame that would be both strong and light using topological optimisation. Individual sections have been bonded together and the new frame is some 33% lighter than the original (see *MPR* March/April 2014).

Renishaw has also contributed its knowledge in additive manufacturing to create key prototype parts for the Bloodhound supersonic car, also

Photo 7-10: Copyright © Kenneth J A Brookes 2014

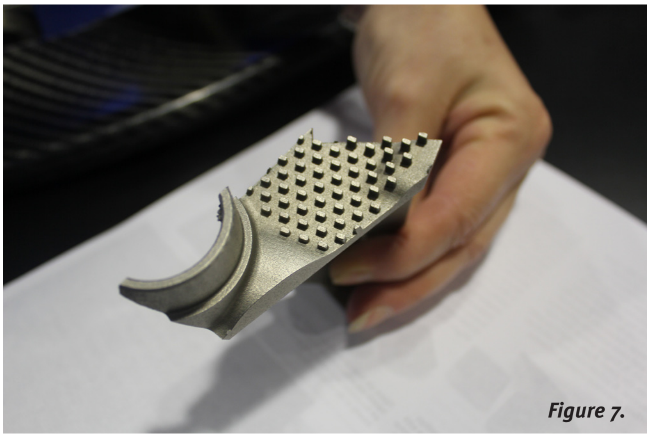
Figure 7.

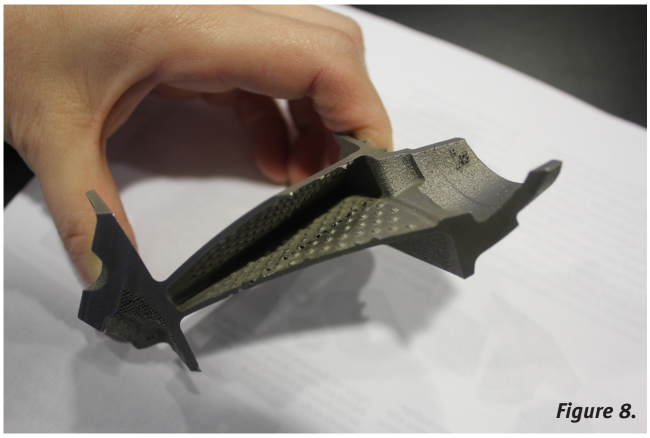
Figure 8.

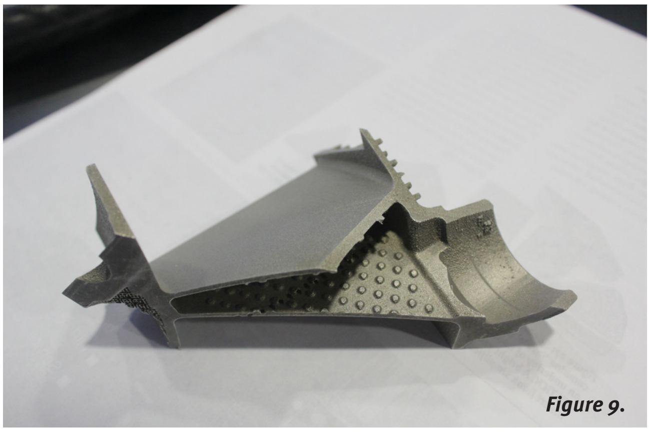
Figure 9.

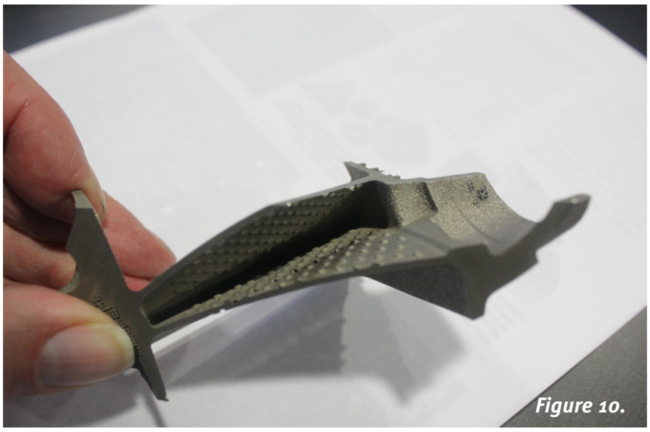
Figure 10.

Figures 7-10: Rolls-Royce superalloy turbine blades made by additive manufacturing and cut away to show their intricate internal structure.

displayed at the MACH 2014 show, which will attempt to break the 1000 mph speed barrier during Summer 2015. One of the most critical components is the nose tip for the car, subject to forces as high as 12 tonnes per square metre. To cope with such loadings, a prototype tip has been designed in titanium and will be bonded to Bloodhound's carbon fibre monocoque body which forms the front half of the car.

EOS

EOS Electro Optical Systems Ltd, based appropriately at the Innovation Centre, Warwick Technology Park, introduced at EMO the EOS M400 (Figure 13), an additive manufacturing system with a build volume of 400 × 400 × 400mm. It had previously been launched at the EuroMold exhibition in Frankfurt at the end of 2013. According to EOS, the machine transformed the AM process from a prototyping and small-volume production tool into a manufacturing centre for volume production of

Photo 11-12: Copyright © Kenneth J A Brookes 2014)

Figure 11-12: Empire Cycles' famed mountain bike with AM titanium frame, and a close-up of one of the tubular components..

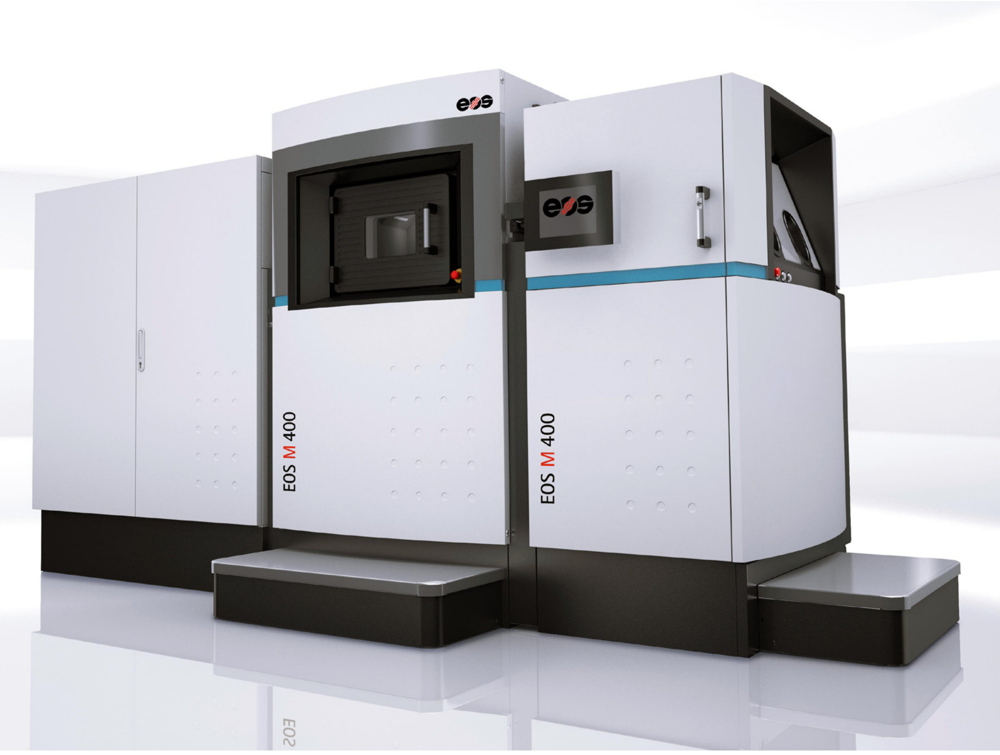

Figure 13 : The new EOS M400 for additively producing metal components in large volumes.

Photo: Copyright © Kenneth J A Brookes 2014

Figure 14: An oil separator for a racing car built in an EOS M400 from EOS Aluminium AlSi10Mg powder.

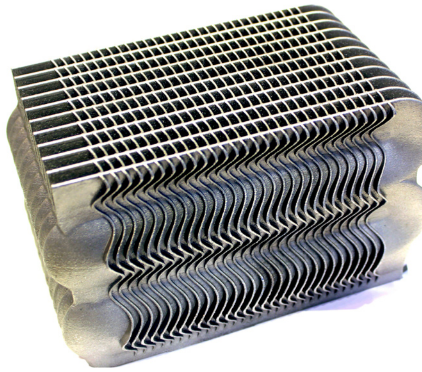

Photo: Copyright © Kenneth J A Brookes 2014

Figure 15: One of the most complex parts made in the EOS 400, this would be impossible by any other manufacturing process.

high-quality, industrial metal components, directly from CAD data. Parts were produced from metal powder, layer by layer. It was the first of a new generation, building on established metal AM machines in the company's range.

> "We are pursuing a platform-based strategy for metal AM technology"

The modular, extendable platform is aimed at industrial production applications, as the increased volume of the build chamber offers a choice of larger components, such as the oil separator illustrated (Figure 14), even more complex structures (Figure 15) or multiple smaller parts within a nested volume. In addition, the level of automation has been raised, commensurate with serial production.

EOS M400 delivers improved quality assurance and is easier to use, answering key requirements of customers. The basic EOS M400 is already available, with global distribution planned from the summer.

Dr Adrian Keppler, Managing Director of EOS, said: "We are pursuing a platform-based strategy for metal AM technology and are able to support customers from the research and development phase through to series production. EOS M400 represents the key to industrial production, as it takes our existing EOSINT M270 and M280 technical benchmarks a step further.

"The new system supports users not only in the context of productivity, but also in actual manufacturing applications, as we shall be expanding the platform with additional performance modules."

Within a year, automated unpacking should be available for the EOS M400. With this system extension, an exchangeable frame including components and residual powder can be moved, following the build process, from the process station to the unpacking station. Here, loose and excess powder will quickly be cleaned away by programmable rotation and vibration.

The first extension to the basic model, with its corresponding processes, will initially be offered with EOS Aluminum AlSi10Mg and EOS Nickel Alloy, aimed at the automobile and aerospace sectors. Processes for tool steel and titanium are still in the development phase.

The EOS M400 has a single laser with maximum output of 1000 watts. From 2015, EOS is also planning to offer the EOS M400-4, which will have four lasers. While the single-laser version opens the way for the development of new applications, the focus of the multi-mode variant lies in achieving

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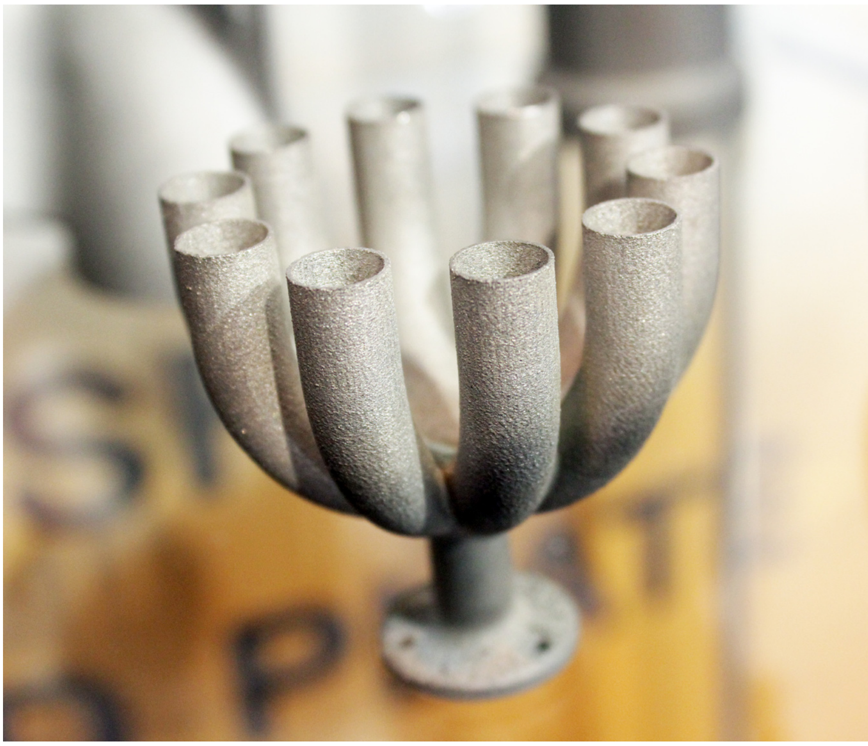

Figure 16: 10-way gas manifold, built by Croft additive manufacturing.

Photo 17A-17B: Copyright © Kenneth J A Brookes 2014

Figure 17A-17B: Two-part gated pipe component, complete and disassembled.

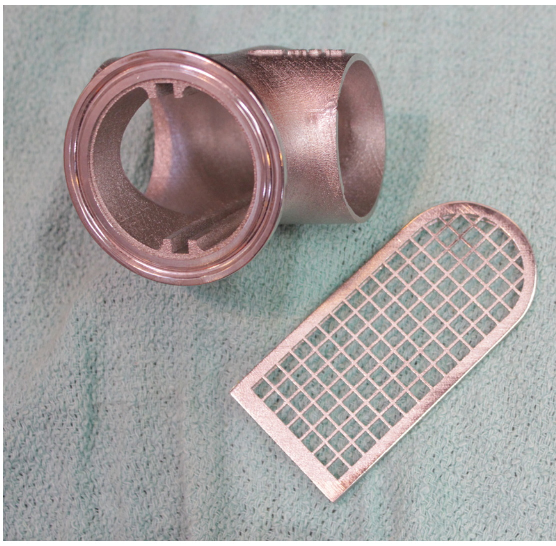

Figure 17B.

productivity increases in qualified production processes.

Croft Additive Manufacturing

One of the most advanced British companies in the additive manufacturing industry, Warrington-based Croft adopted the process very successfully as a means of making reliable, more efficient and longer-lasting filters of all kinds. Neil Burns of the company will be speaking on this subject at the forthcoming International AM Conference in Nottingham, UK. With experience, the firm has expanded into other fields (Figures 16, 17 and 18).

Although the company uses both 'additive manufacturing' and '3D printing' interchangeably, it seems to prefer the more descriptive expression 'metal layer additive manufacturing' (MALM). The lengthier description, by now well-known to powder metallurgists, is of 'a process of laying metal powder on a bed and then using a computer-controlled laser to melt and fuse the metal at the required points. On completion of the process, the excess powder is removed and recycled, leaving the solid metal in the required form.' Although there are other methods of employing metal powders, including feeding though jets in a disposable liquid or plastic carrier, or using electron beams instead of lasers, that of Croft is still the most popular. I for one will look forward to improving my AM knowledge at the coming Nottingham Conference – not to mention others at Salzburg and Orlando.

Photo: Copyright © Kenneth J A Brookes 2014

Figure 18: Decorative "pumpkin-faced" AM demonstration piece by Croft.