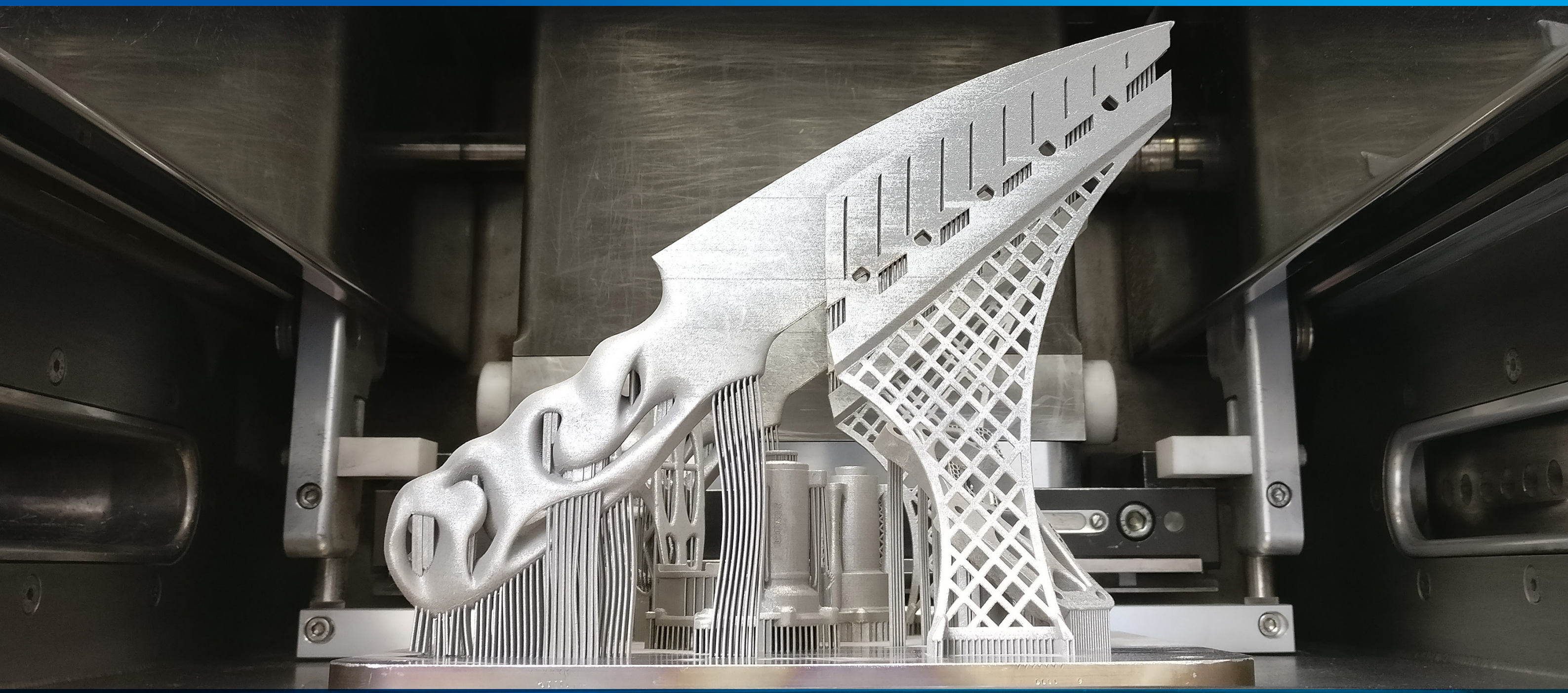
AMRC ADVANCED MANUFACTURING RESEARCH CENTRE / The University Of Sheffield.

Design and Prototyping Group
Case Study

Knife maker at the cutting edge of 3D printing technology



The titanium knives created by the AMRC's Design and Prototyping Group.

Traditional craftsmanship meets digital manufacturing for project to create bespoke, additively manufactured titanium chef's knife.

A highly respected Sheffield knife maker has put himself at the cutting edge of advanced technology by joining forces with the AMRC to design and develop a bespoke, 3D printed titanium chef's knife.

Stuart Mitchell, 48, has been making knives for more than three decades, cutting his teeth in the trade as a keen ten-year-old at his father's knee. He makes bespoke blades using many of the same tools his parents used before him in the same Victorian red-brick Portland Works workshop his family took on in 1980.

Despite his feet being firmly rooted in tradition as a craft maker, Stuart's curiosity about additive manufacturing made him want to find out whether the advanced 3D printing technology could be combined with his top quality knife making skills to create something truly beautiful and unique.

It led to a project with the Design and Prototyping Group at the University of Sheffield Advanced Manufacturing Research Centre (AMRC) to produce a titanium chef's knife to demonstrate the technology and allow Stuart to compare and contrast the end product with his own handcrafted knives.

The project was the subject of an exhibition called 'Digital Mesters: Advanced Manufacturing for 21st Century Knives' at the 2018 Festival of the Mind - the University's unique collaborative festival showcasing pioneering science, art, engineering and culture across Sheffield.

This project has been carried out by the AMRC as part of its HVMC-funded SME Reach Programme.

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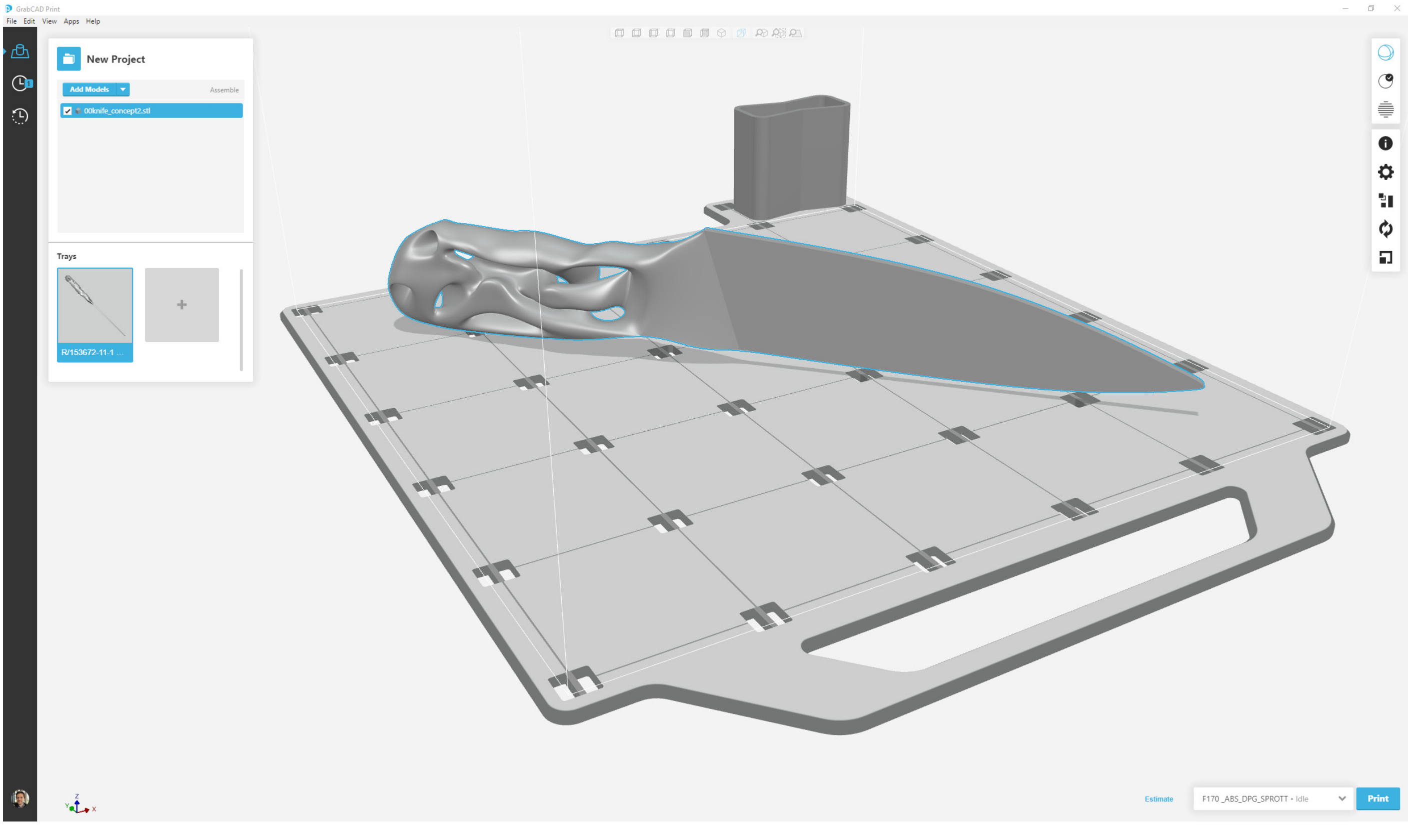

A GrabCAD print setup up of a concept knife model. At this stage the build orientation, supports and scan strategy is defined. Once the correct parameters are determined the knife is sliced and sent to a Fused Deposition Modelling (FDM) machine to be printed in polymer. Once 3D printed, this allows the designer to visualise the end concept cost effectively before moving onto metallic prototyping.

Design Strategy Manager for the DPG, Andy Bell, said: “We were curious whether we could 3D print a viable chef’s knife using a titanium alloy.

“This is design led disruption in the truest sense of the word; a craft maker applying advanced manufacturing technologies and exploring how this could change their business model now and in the future.

“Design methods allow us to explore, through different frames, how we can approach a wicked problem like the introduction of additive manufacturing to an organisation who would never normally approach this technology due to the high perceived risk, cost and knowledge gap.

“We can use design to change perceptions by understanding the way in which small businesses work, their needs and wants, and then developing a response to this in a risk-free way.

“The project has been about understanding what the opportunity is. We provided Stuart with an AM blank which he would normally make himself from sheet metal, grind it and sharpen it up. The difference with what we’ve done is integrating the blade and the handle, which was moulded and customised to a chef’s hand. We then delivered the printed knives to Stuart for finishing.”

Engineers at the AMRC’s Design and Prototyping Group used Autodesk’s Simulation Utility for Netfabb software to aid their design and AM build optimisation work for the additively manufactured knife.

Luke Hill, Project Engineer, said several AM build simulation packages were employed to analyse the distortion of the knife using a ‘standard’ support strategy. The results delivered by each package were analysed and it was decided that a non-conventional support strategy

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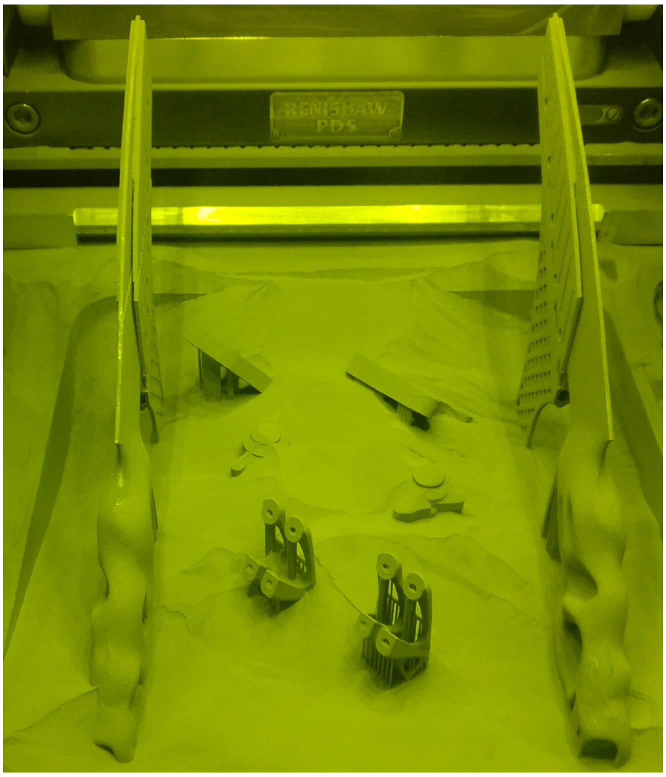
could also be applied in order to reduce distortion of the long blade section.

Simulation Utility for Netfabb was used to analyse the non-conventional support structure design due to its ability to simulate the influence of multiple parts on a build platform. This allowed engineers to tailor the support design methodology by creating the non-standard support structure that provided physical connection to the knife in addition to non-contact thermal shrouding.

Luke added: "Results delivered by the simulation package highlighted a likely reduction in distortion of the knife blade thanks to the thermal shroud support structure. The speed, ease of use, and multi-part simulation ability of Simulation Utility for Netfabb quickly gave confidence that both knives to be printed during the build would benefit from reduced blade distortion thanks to the novel support structure."



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Stuart Mitchell.

Above shows the knives during the additive manufacturing process and below the end result, complete with the novel support structures and thermal shrouding.

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Stuart - whose knives are used across the world in Michelin star restaurants and by members of the Royal family - took receipt of the AM knife at his workshop in Portland Works at the end of summer. He was struck by the quality of the piece.

“I was impressed by the profile of the blade – it replicated very well what I would do by hand, particularly the taper from the spine to the edge,” said Stuart. “It did need a degree of grinding to apply an actual cutting edge but the tolerances of the edge were good to start with, very fine. I didn’t realise it would print that fine.

“With the curvature and the detail in the handle, the hollowed out sections – I realistically can’t do any of that. It’s possible but not practical because there’s probably a week or more’s worth of hand work there. The fact that all that can be added or taken away, as it were, by changes to a CAD model and then adapted to suit – to increase or reduce weight – none of this I can do, it’s all very hands-on for me. Experience has given me a knowledge of the weight and balance of a handmade knife, what to expect and where to aim, there is also almost always a ‘suck it and see’ element though.

“I love the AM knife, it’s different and hasn’t been done before. Working in that very traditional way and to have something brand spanking new in the workshop is great - what’s not to like?

“What it perhaps also shows, particularly with all the advances in AM, is that there is still a place for what I do as well.

“An ideal product would perhaps marry the two.”

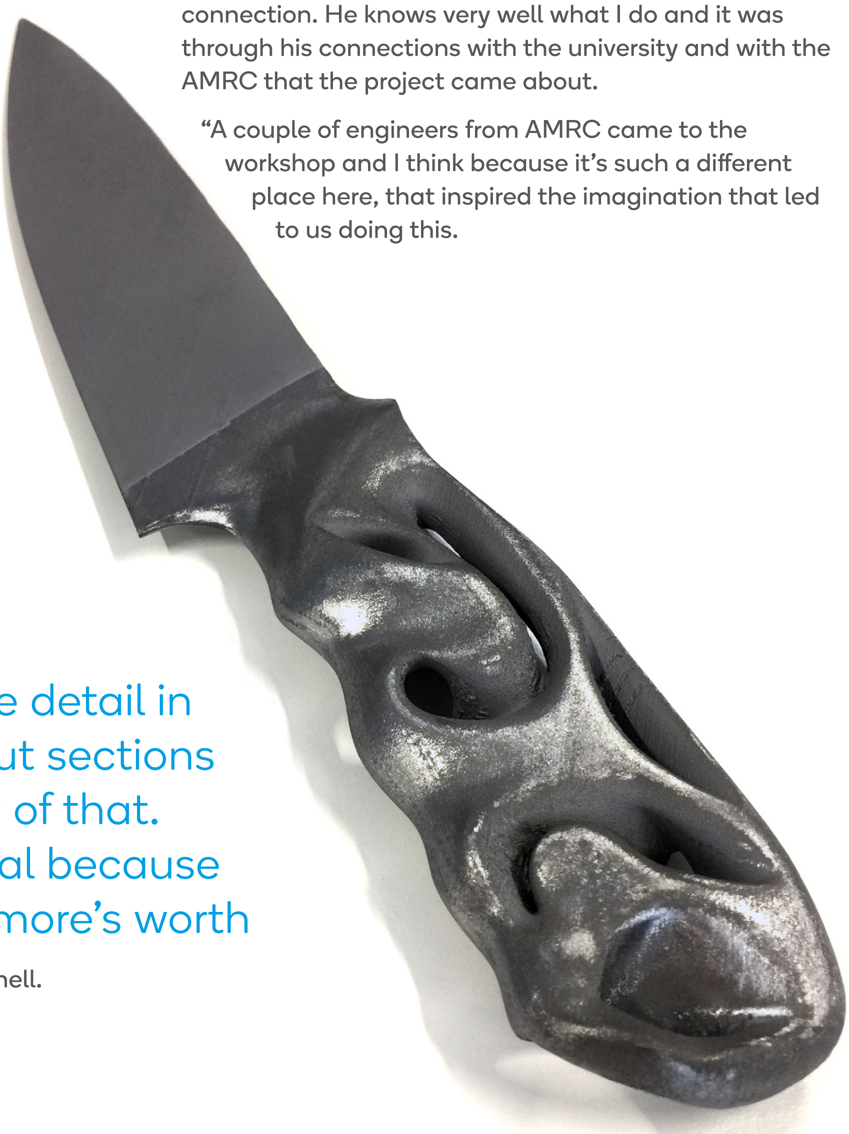
Stuart was able to access the expertise and state-of-the-art capabilities at the AMRC and benefit from a grant-funding scheme run by the AMRC specifically to help small to medium enterprises fund research projects, under the Catapult SME assistance scheme.

He said the idea for the project came about over a brew in his workshop.

“I didn’t know a lot about AM and it was curiosity really,” said Stuart, who began working full time as a knife maker at 15 working for his parents who taught him each aspect of the trade, from forging through to grinding and finishing.

“A good friend and colleague of mine, Professor Peter Marsh from the University of Sheffield, was the mutual connection. He knows very well what I do and it was through his connections with the university and with the AMRC that the project came about.

“A couple of engineers from AMRC came to the workshop and I think because it’s such a different place here, that inspired the imagination that led to us doing this.



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Stuart Mitchell in his Sheffield workshop holding the 3D printed knife blank, with a traditionally made steel blank (left) and the AM prototype (right) on the workshop table.

"The knife is designed around a chef's hand from Freeman College, Chris Harrison. I made a version of the knife how I would make it and this AM knife comes from that, it is the next generation.

"A chef can come to me and I can mould his hand and create a knife which is very close to the AM knife but that's it. There are bits then that I am restricted to do, the design features and different things. The limitations are that I am working by hand and the methods I use, which are the same as what my dad worked with when he was 15.

"The fact that working by hand doesn't have the accuracy of AM is part of the charm for me. A glaring inaccuracy is just that, and unacceptable, but when you look at a handmade object in hand, whatever it is, and you'd need to very accurately measure it to identify any imprecision, when your eye cannot detect it, there lies the beauty of hand made for me. It's practice over the years knowing what to look for."

Stuart first saw the potential of AM when a company printed the first full working composite wrench but at that point he couldn't see application for his craft.

"What's been restrictive up to now is all the materials that can be used to print – the polymers and such don't really have anywhere that I can take it, even for a handle, because sometimes it can be quite brittle," he said.

"I think the thing I saw change, was the materials that became available. All of a sudden then, when we're talking titanium, I started to think about how AM could work.

"Is it disruptive technology or does it enhance it? It's about how you see something. I think it can enhance it.

"I don't think it would be cost-effective for me to produce knives using AM but there might be aspects of that which could be married to aspects of what I do. Even if it's a more traditional metal blade to an additively manufactured grip or handle – I think there is maybe space for both to be married together."

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