MX3D prints outside the box

'Printing outside the box' is the philosophy of MX3D, the highly innovative R&D company that is going to 3D print a fully functional steel bridge in Amsterdam. Here CTO Tim Geurtjens and CFO Gijs van der Velden explain why MX3D uses additive manufacturing and robotic technology to print a metal bridge in mid-air.

By Jolanda Heunen

Based in Amsterdam, a city with many canals, what better object to 3D print than a pedestrian bridge? And in doing so, MX3D will show the world that it is possible to 3D print large-scale, functional objects using sustainable materials, whilst also allowing plenty of room for creative design. Many companies have already sent MX3D a request to have a bridge or another object printed and more than thirty artists and architects have shown interest in producing their work using MX3D's technology. As Chief Technology Officer Tim Geurtjens puts it: "Architects now see that they can really do something with this technology, and venture capitalists have also become aware of the possibilities. People tell us: 'Finally a company is taking 3D printing from the hobby stage to something useful'. This is great to hear because it is exactly why we started the project; we want to show the immense capabilities that 3D printing offers and we are positive that others will explore this potential as well once they see what can be created with the technology we developed."

Robots printing metal in mid-air

MX3D started using 3D printing ten years ago. At first they used the technique to print moulds and gradually they moved to printing actual shapes. By introducing robots to the process, the company opened the way to a whole new dimension in 3D printing: printing in mid-air. So how does this work exactly? Well, robot arms that are especially designed for the job first heat up the metal to a temperature of 1,500° C (2,732° F) and subsequently they weld the structure. "Drops of metal are deposited on top of each other," Mr Geurtjens explains. "The

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robot goes from one line to another, depositing one 1.5 millimetre layer of metal on top of another."

For the bridge in Amsterdam, the metal of choice is steel, however, MX3D has not yet decided which steel they are going to use. "This depends not only on costs but also on aesthetic matters," says Mr Geurtjens. "Stainless steel would sound like a logical choice, but we are still testing if this material would indeed be suitable." Regarding the use of stainless steel the costs also play a role in the decisionmaking process: "For printing stainless steel you need a more expensive gas plus the material itself is roughly three times as expensive as other steels."

Another option that MX3D is considering is to use galvanised steel, but Mr Geurtjens states that he doesn't particularly like the look of it. "I'm afraid it would look like a simple handrail, but then we can have it painted, of course."

The use of Cor-Ten steel has also been researched. "This is the steel that rusts straight away. It is also called 'weathering steel' and from a designer's perspective this metal could definitely make it to the 3D printers. There is, however, one major challenge in using this type of steel, namely that when it rains, the water that drips down will take accumulated rust with it into the canal. This could be a problem, particularly since there are a lot of expensive boats in Amsterdam and you don't want rusty rain dripping on them. Nevertheless, we are looking at ways to work around this."

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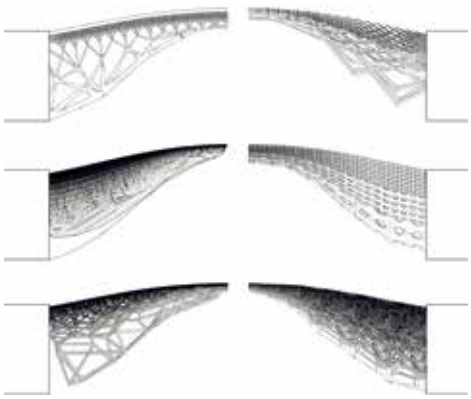
Live printing on location

The start of the actual printing will not depend on the choice of the steel, but rather on a number of other considerations. "The most important being that when the location has been decided upon, quite a number of bureaucratic approvals need to be taken care of before the printing can commence , though this has been calculated into the project planning." Mr Geurtjens' expectations are that the printing process will start in the spring of 2017. "Or even sooner if everything goes according to plan. Theoretically, if we prepare everything well and make good progress in the next year with developing the technique and the design, then our initial estimate would be that printing an eight-to-ten-metre bridge should take no longer than three months."



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This would mean that the bridge could already be in use in the summer of 2017. However, it is still uncertain where the actual printing will take place. One idea would be to print the bridge live, on location, having robots start on each side and meeting each other in the middle. However, there are a lot of reasons why live printing on location could prove to be too complex. If the location is too near to the city centre, for example, then it would be quite difficult to close off the canals and roads in order to establish a building site. "Plus we would need to shield the process from the wind that would otherwise blow the gas away," Mr Geurtjens explains. "And we would also need to shield the welding light to avoid people looking directly into it."

Plan B is fortunately just as attractive: printing the bridge in the new test facility at the NDSM shipping wharf. "An important plus for this option is that we can more easily demonstrate the process at work to people. At the NDSM shipping yard we can simply open the doors to the public and answer all their questions about the process as the robots are printing."

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Strength and design

Seeing the six-axis industrial robots from ABB at work is like watching magic happen in front of you. But the magic is cleverly designed, monitored, tested, and adjusted by a dedicated team of engineers and designers. Since a design is only as strong as its weakest point, the question of weak spots pops up. "We have definitely discovered a weak point," says Mr Geurtjens. "We had a PhD student from the Technical University (TU) of Delft who researched the material. For this we printed a lot of samples that were tested for things like yield strength. The results were in concordance with what we already expected: the material always breaks at the thinnest diameter. So this is the one factor that we certainly have to take into account, which for us means that it is really important to create more homogenised printed lines." The research also led to another very positive conclusion: the metal, once welded and printed, retains more than 90% of the original strength of normally produced steel. "In addition we found that there are almost no inclusions, the material is intrinsically good."

"We work closely together with welding experts, for instance from Air Liquide, which is also one of the partners in the project."

To improve technical aspects and optimise the whole printing process even further, MX3D continues to be busy with further research and development. "For this we work closely together with welding experts, for instance from Air Liquide, which is also one of the partners in the project. The smoother the process runs, the stronger the lines become." But the strength of this first 3D printed bridge is actually not a thing Mr Geurtjens worries about. "Safety is everything, and with the engineers we have on board and the expertise from our partners and sponsors, it will be fine."

Mr Van der Velden adds that the scientific research that the TU Delft started will be continued. "One researcher plus several interns will examine the whole process at our facility in order to scientifically explain the basis of our 3D printing technique. This will not only include life cycle analysis, but will also address matters like what the technique can be used for in the future. The TU is

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also going to predict potential problems and will calculate the ecological footprint of the technique."

The ultimate 3D printing project?

Mr Geurtjens: "If and when someone decides to colonise Mars, then we will definitely be able to print there. There is less gravity on Mars than on Earth, so it is possible to research how this would affect the technique. Also, the atmosphere for 3D printing on Mars would be beneficial as the level of carbon dioxide would be around 80 or 90%. There is practically no oxygen, which means that much less shielding gas would be needed than on Earth for the whole welding process. There is also a lot of iron on Mars so you could actually obtain the printing material on the spot. And since the work is done by robots, you don't even need to send people over there to do the work."
Mr Van der Velden has a more pragmatic approach: "We are open for business. I think the level of accessibility of our technique is high and this makes us somewhat different from other 3D printing companies. We focus on large-scale 3D printing at a reasonable price, which is not available at all at the moment, especially not for 3D printing with metals."

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MX3D looks forward to getting competition, however: "The competition is already out there, just perhaps not as visible as we are yet," says Mr Van der Velden. "We look forward to meeting good competitors. Competition keeps you sharp and makes you perform at your best. We know that we just have to continue doing what we are good at and be the best in what we do."

Mr Geurtjens adds: "Most companies that are out there at the moment are in the business for commercial reasons. We cannot live from air of course, but for us researching the 3D printing process itself is the most important thing; this is what interests us and we believe that if the process that we develop is good, the technique will sell itself and marketing opportunities will arise naturally."

Conclusion

Digital fabrication and design are evolving rapidly and when combined with robotic manufacturing, the possibilities are sheer endless. MX3D is paving the way, or rather printing the way to the future: MX3D is going to 3D print a metal bridge in the city of Amsterdam!

Tim Geurtjens

Tim Geurtjens studied mechanical engineering in Den Bosch, The Netherlands – a study he enjoyed but one in which he felt he wasn't able to use his creativity as much as he wanted. So after graduating he went to the Design Academy in Eindhoven, The Netherlands. Combining a strong technical education with a designer's view provided him with the perfect background to fit into the MX3D team.

Gijs van der Velden

Gijs van der Velden studied law at the Erasmus University in Rotterdam, The Netherlands. After graduating he worked as a lawyer, but then decided he wanted to join Joris Laarman Lab and MX3D, where he started with 3D printing chairs. He quickly grew into an organizer in the company and is now responsible for finances and general management.