

PRINTING BICYCLES

Pekka Ketola explores 3D printing, a technology which in the not too distant future could have fascinating implications for bicycles and how they're made.



Intricate detailing on the EADS bike (ABOVE) and on lugs and hubs from German company Vorwaertz (RIGHT).



Photos: www.vorwaertz.com

What is 3D printing?

3D printing, also known as additive manufacturing or rapid prototyping, is a fast-emerging technology which lets you create physical objects from digital files, in the same way that inkjet printers print text onto paper. Layers of material are deposited by a computer-controlled machine, building up the object in thin 'slices' which fuse together to create the 3D solid.

As a technology, 3D printing has been around since 1980. In the early days it was mainly used to make rough models and prototypes from wax and soft materials. But things are different now. Users can print finalised products using numerous materials including titanium, stainless steel, plastics, glass, wood and ceramics. The variety of materials possible is increasing all the time, and combinations of different materials can also be printed together, opening up further possibilities.

Consumer printers (typically priced below US \$3000) mostly use plastics of various types, but

industrial printers (priced over \$7000) offer more freedom when it comes to materials.

The largest printed objects to date are houses and airplane wings. The smallest objects can be printed at the nano scale, atom by atom.

Printing of metals, such as titanium, is still slow and expensive, while printing with plastics is faster and cheap (material cost is around €25 per kg). The cost of printing is however falling steadily.

3D printing is a technology which may force us to change the way we think about manufacturing, design and distribution. And as bicycles are already a global manufacturing industry, 3D printing is well placed to have a major impact. Let's look at what form this might take.

3D printing for bikes

3D printing opens up new ways to create, develop, repair and personalise bikes. It's much easier to change the computer file between printing each bike or part than it would be to alter a traditional manu-

facturing production line. So every print job could, with just a little extra programming, be a one-off.

Bike builders have already been active in exploring the possibilities. For example:

- ♦ thingiverse.com, a catalogue for sharing 3D printing files, provides almost 300 bike-related items, created by bike builders. The selection is growing every day, and covers everything from light mounts to preliminary designs for printable hub gears.
- ♦ EADS, a Bristol based company, has created titanium bike parts including dropouts, working with bike company Charge. See: youtu.be/tkwd2YXNy9I
- ♦ EADS have printed a complete bike too, although as a technology demonstrator more than as a practical product in its own right. See our main picture and: youtu.be/hmxjLpu2BvY
- ♦ Parts to personalise bikes, specifically super-intricate lugs for framebuilding, have been printed from stainless steel. See: youtu.be/HwJwcnV-wso
- ♦ Trek Bicycles has created functional bike

parts, including suspension components, bar ends, frame parts, helmet models and more. See: youtu.be/7w2wB6hW-0l

- ♦ Fairings for velomobiles could be printed, although I'm not sure it has yet been done, probably for cost and material reasons. Similar structures have, though, been printed for cars and motorbikes. Search for the Urbee 3D printed car, for example.

- ♦ Motorbikers have also been experimenting with 3D printing, and share many of the possibilities outlined in this article.

As you can see from these examples, 3D printing for bicycles has so far been limited to specific components and research projects. The main limitations so far are the cost per item and the material properties of the finished item, neither of which can yet compete with the current highly optimised materials and production processes.

But 3D printing is catching up fast, while established technologies are not showing anything like the same speed of development. It may take a decade, or a few decades, but many manufacturing experts are convinced that 3D printing will be able to close the gap, making it a practical option even for highly engineered, lightweight items like bicycles.

Jump to the future

So, how might bike builders apply 3D printing in the future?

Let's imagine there is no problem with resources, such as money or time, and that all technology invented to date (3D printing devices and printing materials) is freely available to manufacturers in the bicycle business. This frees us up to think beyond the immediate obstacles. What could we do?

The frame

A 3D printed bike frame can take any shape: it's not limited to structures defined by manufacturing

processes or materials. Each frame can be unique and personal: perhaps made to perfectly fit each individual customer, rather than just in a few different sizes.

It would also be easy to produce variations on a favourite frame. Carrier racks, child seats etc can be seamlessly integrated rather than just bolted on.

With no welds in the structure, there should be considerable potential to save weight. More gains could perhaps come from using robust bone-like or lattice structures, or one-piece hollow monocoques.

Functional parts could be embedded in the frame as part of the printing process, too, reducing the parts count. By layering steel and titanium, bearing surfaces or even moving mechanisms can be printed. So brake levers for example could be integrated with bars and stem, and the cables could run neatly in pre-made channels within the structure.

Personalisation

Ergonomic design could, with 3D printing, reach a whole new level. Parts could be easily tailored and scaled for any individual rider. Grips could be moulded to fit your hand, for example, and pedals to match your shoe or foot size.

Of course, all kinds of holders, mounts and connectors could be easily created so that gadgets, lights and other accessories to suit the owner can be easily integrated.

New materials could also be used, such as wooden grips or ceramic decorations, moulded into place by the 3D print being assembled around them.

Personalisation would be limited only by the imagination, and by how much effort the customer was willing to exert in customising a bike. If short of time, one would just choose a suitable design from an online design library.

Bikes for riders with disabilities would benefit hugely from the technology. Currently adaptations have to be made as one-offs, in small batches, or using limited kits of special parts. With 3D print-

ing, a wide variety of 'standard' solutions could quickly be developed, and developing new adaptations would be much easier too. Test designs could be quickly drawn up and 3D printed to check how well they work, refined and re-printed, a much faster development cycle than is possible now.

Distribution

Both frame designs and parts could easily be shared worldwide, as they're simply digital files. A bike brand could quickly establish a global business by selling their designs; there are already online marketplaces where files can be shared and sold.

Spare parts would also become easily available worldwide, even impossible-to-find ones for antique bikes. You'd just search the catalogue, order the 3D file, and have it printed locally.

Bike dealers and parts distributors would be spared the need to keep a vast count of spares in stock: instead they'd just be printed on demand. Assuming, that is, that the sort of 3D printer a bike shop could afford to use is capable of printing high-grade metals to tight tolerances. We're a long way from there...

3D printing today

So what's the state of play today when it comes to 3D printing and bikes? Certainly it doesn't make sense to 3D print parts which are already easily and cheaply available already – and in fact this covers most parts of normal bikes!

So it's for special parts, or custom designs, where 3D printing may first be useful. Sadly, using any material except soft plastic is expensive, which further cuts down the area of application. In reality, it's now used most extensively for prototyping, allowing several test parts to be made before finalising the design for conventional production.

But there's also a thriving hobby user scene, and to join in you don't need to own a printer or even be an expert in 3D modeling. Everything is available online. Sites such as www.3ders.org list a variety of companies who can 3D print your designs and send them to you by post. If you do want to print with your own printer, an investment of around €2000 is needed.

There is also a wealth of free 3D designs online at sites such as thingiverse.com and shapeways.com. If you prefer to create your own parts, there are free 3D design programs (for example Google Sketchup). You can also make models via a 3D scanner, or even with your smart phone, using a 3D modelling app (see for example www.123dapp.com).

So you can start playing with 3D printed parts right now, without any investment other than time! Currently the limitations mean that most people are experimenting with accessory mounts of various types, although some are more bold!

The dangers

While the possibilities are attractive, it's worth noting that the technology also lets consumers bypass many of the safety checks which are built into the

Charge's titanium printed dropouts are tidy, although arguably made with 3D printing more for PR than technical reasons.



Photos: www.chargebikes.com

current system. Companies protect their reputations and avoid being sued by testing their bikes thoroughly, carefully controlling materials and manufacture, and providing after sales service via dealers. All of that can be 'skipped' by 3D printing.

If a 3D printed bike fails and an injury results, who is liable? How are bike designed online quality-checked? How can the quality of safety-critical printed materials (for a bike frame, for example) be guaranteed, when just about anyone can use their own printer?

It's easy to imagine that some sort of 'reputation' system will work online as a partial answer, but I suspect these issues will find their own solutions in time as the technology develops, and probably in ways we can't anticipate now.

Is it legal?

The question of intellectual property also becomes problematic when anyone can, for example, 3D-copy a bike design seen on the street with just a few camera clicks, and then produce a similar part on a printer.

Legal systems worldwide are still working out how to deal with 3D printing. Currently, user communities such as thingiverse.com encourage the free sharing of ideas and designs, but they do allow users to set restrictions. If the history of Internet has taught us anything, it is that people like to share. People will share their 3D bike designs online, and other people will remix and improve the designs.

But when the corporations get involved, it doesn't take too long for a framework to be put in place which allows profits to be made and protected. When this happens, 3D printing will really have arrived...

My predictions

In a few years, the bike industry and the culture of building and maintaining bikes will change. This future is already here in the form of early adopters, trials and experiments. My predictions are:

1. That any bike builder will be able to design and produce new bikes, parts and special accessories in small volumes. Experimenting and prototyping will be fast and cheap. We will see very exciting bike designs and structures.
2. Bike repair and maintenance services will change radically, as all parts will be available almost instantly, if not via the company's own printer, via a printer in the same city. Fixing special and antique bikes will be easy and economical.
3. Local bike manufacturing will boom, with the help of local printing houses. Business models will be revolutionised.
4. Cycling communities will be active in designing and sharing bike parts worldwide.

I can't wait for the future to arrive!

Pekka Ketola



BESPOKED 2013

Readers William Horsley and Ronald Fraser report from the third 3rd UK Handmade Bike Show, also known as 'Bespoked Bristol'.

The show was staged in buildings conveniently adjacent to Temple Meads train station in Bristol city centre, in mid-April. We attended on the Saturday, and we were pleased to see that this cycling niche is clearly popular across all age ranges, although almost exclusively amongst men, judging by the attendees.

There were a good number of exhibitors, including international brands such as Schwalbe, Brooks and Sapim, and larger volume manufacturers such as Brompton, Moulton and Condor. But the majority of exhibitors were small scale British frame builders. Alongside them were frame builders from America, Ireland, Hungary, Italy and Japan amongst others, and a sprinkling of small scale clothing, accessory and component manufacturers.

The main theme was of truly exquisite examples of frame building skill and artistry, but we have homed in what we think would be of most interest to *Velo Vision* readers.

There were two cargo bikes, a Renwick from Cornwall which was of the rear cargo bay design with 20" wheels, and a front cargo bay design from Titchmarsh of York, on which the craftsmanship was truly excellent [see the article in this issue for more details – Ed].

My own favourite innovation was the Loop Wheels from Jelly Designs of Nottingham. This design has the potential to be a real game-changer in my opinion and these will be on sale soon, apparently [indeed, and these deserved a separate article too! – Ed].

Another theme was wooden bikes, with two bamboo models and two machined laminar types on display. I



remain unconvinced of the advantages, but I can still admire the skill and craftsmanship. Woodelo of Ireland won the 'Best new builder' award for their six-piece wooden bike frame, an award which was, ironically, sponsored by Columbus of steel tube fame.

A much more practical and probably affordable way to incorporate some wood into your bike is to go for



bespoke wooden mudguards with aluminium frames, such as those produced by Bristol local boys Cofa Engineering. These are made to order and cost about £100 per pair, although the actual price will depend on finish, length, timber, and even anodising. The Cofa Engineering team were also showing their Flip-Flip, a very simple 'why-didn't-I-think-of-that' design for a large durable fluoro-reflective back pocket insert which can be subtly hidden when not in use.

The X frame bike by Paulus-Quiros, a small bike-building team from west Wales, also caught my eye. In my opinion the PQ bikes were the most exquisite and beautifully finished bikes in the show and that was really saying something as there was some tough competition. The X frame bike was a quirky demonstration of their frame building skill and is meant to be particularly useful for tall and heavy riders. If you have to ask how much, then you can't afford it!

After I managed to drag myself away from drooling over the PQ bikes I found myself looking at some nifty engineering from Trykit tricycle builders of Oxfordshire. Trykit will build you a tricycle from scratch or convert your standard diamond frame bike using their two-wheel drive cassette free-hub system. To demonstrate their skill they had on show a touring tandem with twin rear disc brakes, a racing tricycle with aero bars and wheels, and a more conventional single seat tourer, as well as the all important rear axles as shown in the picture.

Another favourite of mine was a Cherubim concept bike from Japan (see main picture). This was notable for its bizarre but ornate handlebars and very pretty integrated rear rack. The whole bike was also beautifully finished. I am not sure what sort of luggage might be compatible with the rear rack. Enquiries about the handlebar design did not yield any particular information; it is, apparently, purely aesthetic with no specific function in mind.

Knowing how popular Bromptons are with *Velo Vision* readers I did some digging and found that the design remains essentially unchanged but some minor tweaks and adjustments have been made following customer feedback. So you will now find brake levers with improved comfort and which provide more space on the handlebar for bigger grips, and a new two-piece chainset with standard fittings for easier upgrade or replacement.

Overall the show was excellent but perhaps a victim of its own success. It might well have outgrown its current home, as it became cramped at times and was difficult to get the attention of exhibitors. But, at less than £10 entry and with value amenities and interesting exhibits, it left a good overall impression!

William Horsley (words)
Ronald Fraser (photos)

Next year's dates are yet to be announced: watch the show's website at www.bespokedbristol.co.uk for details in due course.

MAIN PHOTO: This Cherubim frame from Japan was the author's favourite.

ABOVE: Wooden mudguards in a variety of styles and finishes displayed by Cofa Engineering of Bristol.

BELOW: The 'X frame' from builders Paulus-Quiros is intended for taller riders.

BELOW RIGHT: Trykit specialise in making parts for tricycles, usually of the upright variety. Two of their rear axle sets are shown here.

