

3D printing is becoming a popular method of making models over here in the UK. I have had a printer for some eight years and have had some success and some dismal failures. In these articles I hope to pass on some of that experience to others so they might try the technique.

### Is it for you?

So what can it do? Well the first thing to remember is the parts will be in plastic. The melting point is around 200 degrees C, so not really for any areas subject to heat. Most materials are not suitable for long periods of immersion in water, they are bio degradable. Splash is fine. The maximum size of the part is dependent on your bed size, and these are getting bigger. The smallest size depends on the diameter of the head being used and the technique. Resin printers have a better resolution than filament printers. I have made all sorts of adaptors, small boxes, complete wagons and locomotives in Gauge 1, dummy axle boxes for my driving truck etc. It is a very versatile technique, see figure 1.



Figure 1

### Filament Printing

Filament printing is the most popular method. Basically plastic is melted in a head at 205 degrees C, deposited on a build plate through a small orifice where hopefully it sticks to either

the plate or previously extruded filament. Each layer is around 0.15mm thick and the head moves around the plate creating a shape in plastic. The next layer is then extruded on top of this and so on until the part is complete.

When considering what machine to get it is best to first realise what are the important features of the machine.

The distance between the head and the plate has to be consistent to within 0.05 mm say over the whole plate. The first machine I had was hopeless at this, see figure 2. The arm moved all over the place, the head could do nearly anything it liked and there is no way I could get the consistency I needed. On my second machine see figure 3 the bed moves in the Z direction, the head moves in X and Y. The Z is supported on two 12mm diameter ground steel rods with axial bearings, these ensure it is kept steady. On other machines the head moves in the Z axis. I have no experience of these but they seem to work fine.

Sometimes the head has to move very quickly. On my machine the head is relatively light so does not require a great deal of force to make it move. The x and y movement is controlled by stepper motors driving toothed belts. This is standard practice on most machines. On other machines the head moves for the x axis but the bed moves for the y axis. The bed is obviously much heavier and requires more force to make it move. I suspect it is not as nimble as mine. However others on the forum to which I contribute have success with these machines. It is certainly the method employed on most entry machines.

Size is important. What are you going to build? Build volumes are getting bigger but that comes at a price, the machine has to be more robust and tends to cost more.

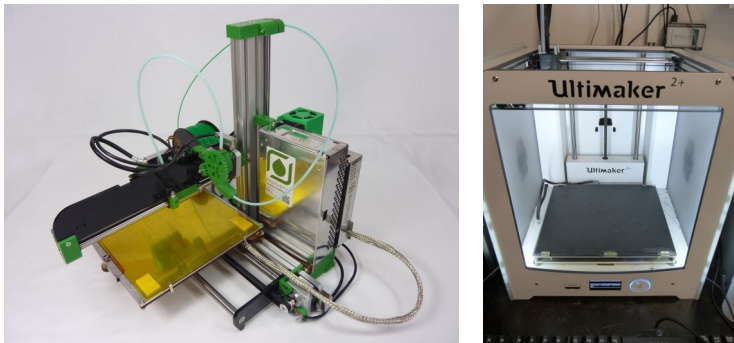
There are two diameters of filament, 1.75mm diameter and 2.85mm diameter. The accuracy on these is 0.03mm. There are also different types of material, PLA is the most popular and the only one I have experience of. There are numerous suppliers. My advice would be to stick with the one recommended by the printer manufacturer then when you have some confidence in the machine to start looking for a

cheaper source. There are lots of colours to choose from, I find the translucent harder to work with.

At the end of the day you pay your money and you make your choice. Ask others in the club if they have any experience of printing. Find a supplier with a good customer service. Many suppliers offer free slicing software for their machine and have a forum. All good things to have. The manufacturer of my first machine went out of business so no spares and no technical support.

**Your first prints** When you get your machine READ THE INSTRUCTIONS!!! Often there is some building work to do, make sure the major components are already built.

My second machine came fully built and was printing within 30 minutes, my first machine was a complete build and it took five months to print anything! Set the machine up, you need to level the build plate, set the nozzle height and load the filament as a minimum. There should be a test



First Printer (Left) and Current Printer

piece on the stick that comes with the machine, alternatively you may have to download it from a web site. Run this and you should be printing your first model, once again READ THE INSTRUCTIONS!! There are a number of videos on You Tube showing how to set the machines up, often it will be for the one you have bought.

The bed is normally a piece of glass, it has to be flat and float glass is very good for this. Often there will be a layer of something to aid the adhesion of the first layer. This is very important, if the first layer is not

right you might as well abort and start again. Tape, a spray and a frosted-glass finish are popular. I use something called BuildTak. This is a black plastic sheet that you stick onto the glass plate, I find it lasts a long time, over 12 months if I don't damage it and helps the first layer. Just as important is getting the part off at the end. The bed is heated and once it has cooled if you have got the nozzle height exactly right the part should come off easily. If it does not the nozzle may be too close. On most machines the nozzle height is set using a piece of paper or a piece of plastic card. I now use feeler gauges. I can alter the height to what I want and as an engineer I feel it is a bit more technical than using a piece of paper.

**Printing you own designs.** Obviously you want it to print what you want not a 25mm high model of a Dalek, though you will probably end up with lots of those. The machine runs on g code, this is produced by slicing software which requires a stl file. The latter is produced on a 3D CAD package or some other 3D software like SketchUp. If you can use 3D CAD you are more than half way there, if not then I suggest you look at Fusion 360 or SketchUp. I believe these are free and there are some sites on the web showing you how to use them. Figure 4 shows the drive unit I made for my Gauge 1 class 08.

Once you have your design you save it as a stl file and then open it in the slicing software. I use Cura but there are others, you just have to ensure that the parameters you set are correct for your machine. Most software, if not all are free. Often the supplier of the machine will suggest a slicing

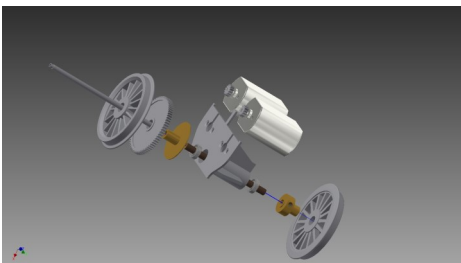


Figure 4

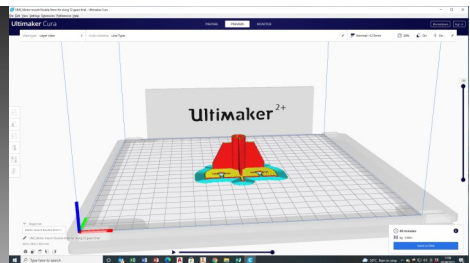


Figure 5

software to use and the parameters for it. Another factor to consider when buying your machine.

There are lots of things to consider when using the slicing software. Do you need adhesion aid? This is a brim of thin material 6mm or so wide all around the part, it helps to hold the part to the bed. Good for small parts but not required for larger pieces. Do you need support? Any overhangs will require supporting, the software will put this in for you. Which way up will you print it? This depends on shape. For instance a cab roof is better printed on end rather than flat, you will get fewer steps in the final part. All this comes with experience and knowing your machine, see figure 5 for the drive unit on the slicing software bed.

You should now be in a position to print your own designs.

**Printing** This is maybe the easiest bit if the printer is set up correctly. The printer reads from a SD card, it is possible to get machines that run off the network but this is not necessary. The g code is copied onto the SD card from your computer. Some machines only allow a maximum of twenty characters for the name which can be a problem. The code is then selected on the printer and the machine warms up. The bed needs to be at around 57 degrees and the head at 205. Once these temperatures are achieved a few millimetres of filament are extruded before the printer starts to print. Prints can take hours, I have a gauge 1 hopper wagon where the hopper takes 15 hours. So it is not a fast operation but can of course be left running overnight.

Once the printer has finished it lowers the bed to its lowest position and cools off. The screen tells you when it is safe to remove the print. Parts will need cleaning up, the brim needs removing as does any support material. Holes may need drilling out as they tend to become blocked and will be slightly undersize.

**Building Models** With all your parts printed it is time to fix them together. With experience you can get to making housing joints and tabs and slots to position the parts. These also give a stronger final model. I use Super glue to hold the various parts together. I did use epoxy but this is messy and tends to peel off the plastic. You may have to experiment with adhesives, the one I use is only £2 a bottle from Screwfix. There is some flash on the parts, this needs filing off to make a perfect fit. It also tends to come out slightly bigger than designed, the molten plastic

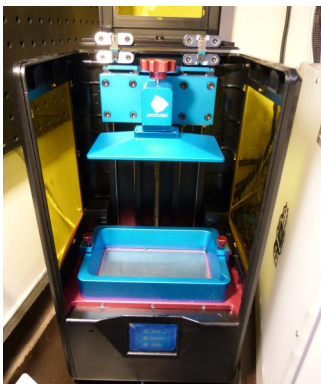
squeezes out from under the head.

Axles cannot run in the plastic, I tend to go for ball races nowadays. A 3mm ID ball race has a 6mm OD so I use those. The housing for it I do at 6mm but then have to drill it out as holes tend to come out undersize.

**Painting** You need to use an adhesion aid suitable for plastic, your local car body paint shop should be able to supply it in an aerosol can. One coat of this, one coat of primer undercoat and two coats of top should do the trick. I always use aerosol cans, Wilko do a basic colour range for £6 a can. For more authentic colours again the auto paint shop can help. The Kinross model railway group have a list of car paint colours that match railway colours. You have to find the manufacturers paint code for them but that is not too difficult on the Internet. I tend to go for an eggshell finish rather than gloss, coverage is normally excellent and one can will do over twenty gauge 1 wagons.

**Resin Printing** Resin printers are a more recent addition to the market, my printer is shown in figure 6. They work in a different manner to filament printers.

The printers have their own slicing software, this is free and provided by the manufacturer. It takes the same stl file as the filament printer. There are more options available, first layer exposure time, exposure time for subsequent layers, support etc. The suppliers of the resin put recommended times for these on the bottle and on their web site.



**Figure 6**

The resin hardens under UV light, one reason why it comes in a thick plastic container. On the printer the resin is held in a vat which has a transparent base. The base is actually an FLP (fluorinated ethylene propylene) membrane which is held taught across the vat by a number of screws. Under the vat is a LCD screen and below that is a bank of UV lights. To harden a section of the resin the LCD becomes a mask, some of it is black and other parts clear. This is done by polarising portions of the display electronically. The portion above

the clear section goes solid. The build plate then lifts and the next layer is built.

The main advantage of resin printers is the resolution, see figure 7. It is far better than filament printers. The build plate tends to be much smaller so it is only suitable for small parts. I do my W irons and axle boxes on the resin printer. There are two types of resin, water based and non-water based. I use the former as it is much easier to clean the part off when you remove it from the vat. You only need water not Isopropyl Alcohol which is horrible smelly stuff and expensive.

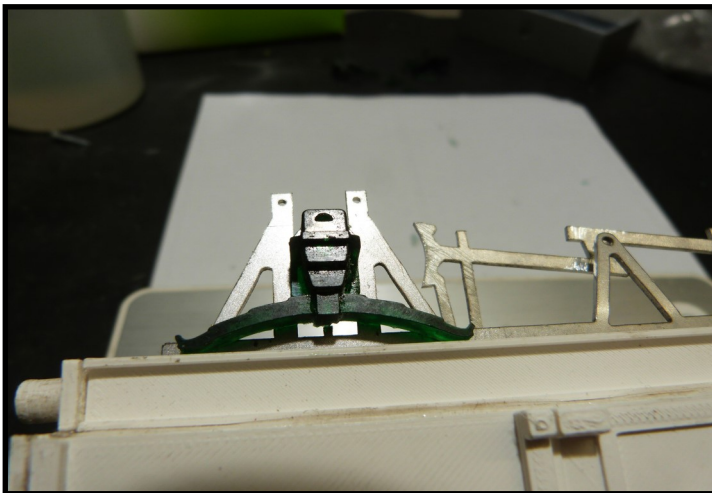


Figure 7

Once the part has been cleaned it needs to be cured. For this you need UV light, on a sunny day you can let the Sun do the work for you. We do not get many of those so a curing station is required. Some of these can have a dual use in that they can clean as well. Again plenty of videos on YouTube demonstrating this.

Resin printing is more of a black art. You cannot actually see if anything has been printed until it has finished, the part is in the vat. If the part does not stick to the build plate all you will get is a very thin layer of cured resin on the FLP in the bottom of the vat. This is normally because the build plate has not been levelled and zeroed correctly. It takes some

experience and there will be plenty of false dawns but eventually you will get there.

**Conclusion** I hope this has been some use to you and that you might consider 3D printing. One advantage is the space it requires. My printer is basically 600mm cubed, that is it. Filament printing is clean, resin is not!! Lots of mess! It is very rewarding to see something that was just a drawing on the screen come out as a fairly well detailed model in just a few hours. If you want it in another scale you can rescale on the slicing software, no need to redraw the parts.

I am sure that in the future drawing software that is easier to use will become available, at the moment it is a steep learning curve for those who have not used 3D software before. 3D printing will not be for everyone but it is here to stay in modern engineering and I certainly get a lot of pleasure out of it.