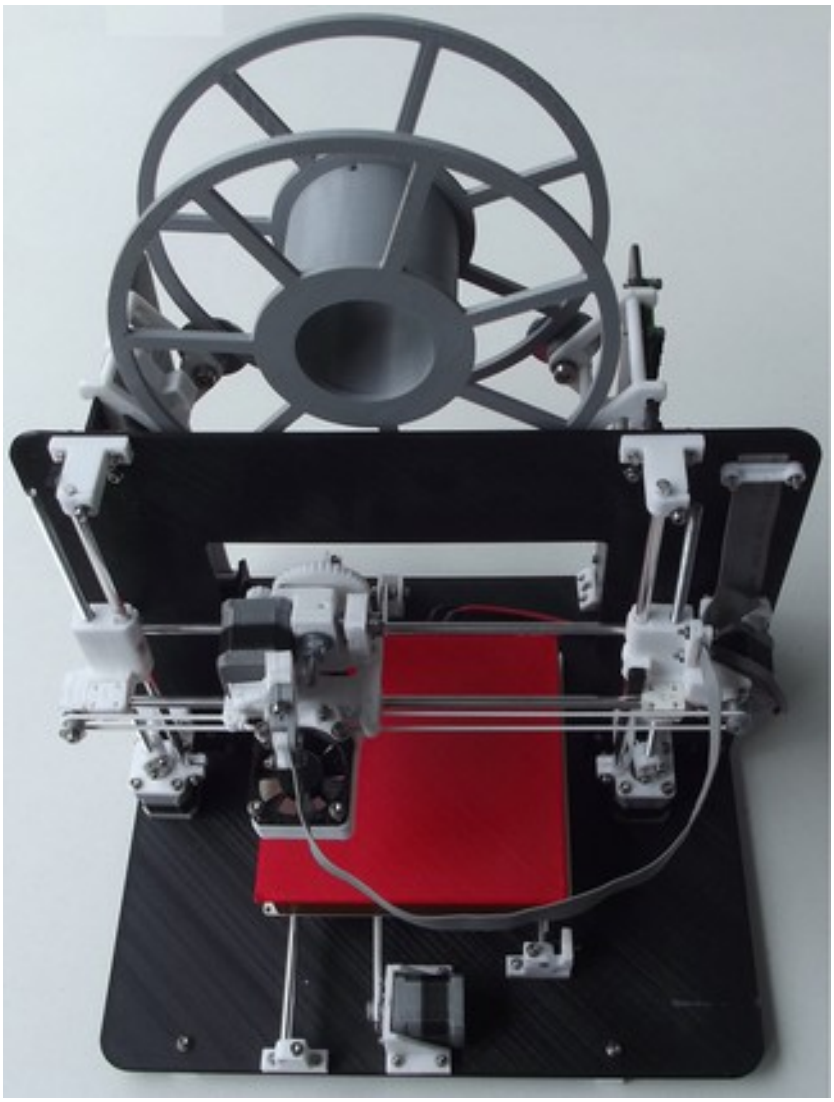
A Scale Model Of A Mendel90 3D Printer



Contents

A) Introduction

1. Why make a scale model of a Mendel90 printer?

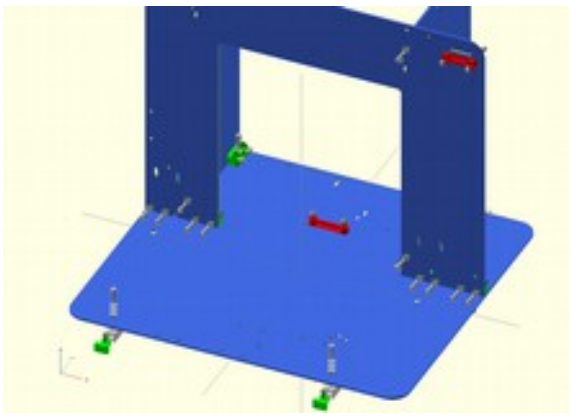
The original Mendel90 printer has about 8kg of weight. It is large and bulky to transport. It is not friendly to move around. If you move it anyway you could damage the calibration and have to recalibrate it before you start printing at the new place. Sometimes it is not even necessary to print anything while explaining a part of the printer – but when you moved it, calibration could be lost. Therefore I asked myself if it's possible to have a smaller model of a Mendel90 to show it to friends and have it with me when I need a model to explain 3D printing to novices.

2. How to get all parts in the right size?

Basically it is as easy as to rescale it to a proper size. Since the whole Mendel90 is defined as OpenSCAD scripts, it should be easy to do a rescale of all parts. I want to print the parts on a real Mendel90 printer, so I have a maximum build area of 200mm * 200mm * 200mm. The biggest parts are the baseplate, the gantry and the left and right stays. To print them, a scale factor of 0.4 (giving a scale of 1:2.5) will do. All other parts are smaller. Going smaller than 0.4 rises other problems like printing and handling the parts, inserting screws, washers and nuts. Aduld fingers are the limiting factor here. :-)

So I opened the main.scad file in OpenSCAD and did a full render. On slower machines this will take a few minutes. After the coloured model showed up, I tried to export it as a .stl file. This was not possible due to a “non manifold” error. Therefore, plan “B” came into place.

Many Mendel90 parts are already prepared to be printed. These parts are very easy to rescale. The M4 screws, washers and nuts will be substituted by M1.6 screws, washers and nuts. But there are parts inside the drawings – like the frame sheets – which are needed to be exported as .stl files. I opened the build manual and looked for every build stage, what is needed to build it. For example – the chapter 2 “Frame Assembly” needs a few printed parts, screws, washers, nuts and the dibond frame sheets. So I looked into the .scad files in the views folder where a view is rendered, having the frame visible. I found a “frame_assembly.scad” file which is exactly what I wanted. However the render contains more than just the frame sheets:



The next step was to eliminate all parts I do not need in this stage. The `Mendel90-`

master\views\frame_assembly.scad file uses Mendel90-master\scad\main.scad and calls there the module frame_assembly() wich starts at line 837:

```
module frame_assembly(show_gantry = true) {
    assembly("frame_assembly");

    translate([motor_end - x_motor_offset(), gantry_Y, ribbon_clamp_z])
          rotate([90, 0, 0]) {
                if(frame_nuts)
                      ribbon_clamp_assembly(x_end_ways,frame_screw,
                            frame_screw_length,
                            sheet_thickness(frame),
                            false, true, nutty = true);
                else
                      ribbon_clamp_assembly(x_end_ways,
                            frame_screw, frame_screw_length);
                }

    translate([X_origin, ribbon_clamp_y,0]) {
          if(base_nuts)
                ribbon_clamp_assembly(bed_ways, base_screw, base_screw_length,
                      sheet_thickness(base), false, true, nutty = true);
          else
                ribbon_clamp_assembly(bed_ways, base_screw,
                      base_screw_length);
          }

    place_cable_clips();

    frame_base();

    if(base_nuts) {
          for(side = [ left_stay_x + fixing_block_height() / 2 +
                sheet_thickness(frame) / 2,
                right_stay_x - fixing_block_height() / 2 -
                sheet_thickness(frame) / 2])
                      explode([0, 0, -15])
                            translate([side, 0,  -sheet_thickness(base)])
                                  tube_assembly();
    }

    if(show_gantry) {
          fixing_blocks()
          fixing_block_assembly($upper, $rear);
          frame_stay(true, eta);
          frame_stay(false);
          frame_gantry();
    }

    end("frame_assembly");
}
```

Now I placed an asterisk in front of every part I did not want to come into the drawing. For the baseplate, only the call frame_base() was left over. As a result, I got the frame sheet and stored it as a .stl file. I loaded the file into Netfabb Studio and did a rescale by the factor of 0.4. After that I translated the part to the origin, rotated it if necessary and saved it to an other folder. For the 4 frame sheets I repeated these steps to get all the frame parts.

```
module frame_assembly(show_gantry = true) {
    assembly("frame_assembly");

    *translate([motor_end - x_motor_offset(), gantry_Y, ribbon_clamp_z])
          rotate([90, 0, 0]) {
                if(frame_nuts)
                      ribbon_clamp_assembly(x_end_ways,frame_screw,
                            frame_screw_length,
                            sheet_thickness(frame),
                            false, true, nutty = true);
                else
```

```
                        ribbon_clamp_assembly(x_end_ways,
                              frame_screw, frame_screw_length);
                  }

      *translate([X_origin, ribbon_clamp_y,0]) {
            if(base_nuts)
                  ribbon_clamp_assembly(bed_ways, base_screw, base_screw_length,
                        sheet_thickness(base), false, true, nutty = true);
            else
                  ribbon_clamp_assembly(bed_ways, base_screw,
                        base_screw_length);
            }

      *place_cable_clips();

      frame_base();

      *if(base_nuts) {
            for(side = [ left_stay_x + fixing_block_height() / 2 +
                  sheet_thickness(frame) / 2,
                  right_stay_x - fixing_block_height() / 2 -
                  sheet_thickness(frame) / 2])
                        explode([0, 0, -15])
                              translate([side, 0,  -sheet_thickness(base)])
                                    tube_assembly();
      }

      *if(show_gantry) {
            fixing_blocks()
            fixing_block_assembly($upper, $rear);
            frame_stay(true, eta);
            frame_stay(false);
            frame_gantry();
      }

      end("frame_assembly");
}
```

Unfortunately the .scad files become more and more unusable with every part I eliminated. From time to time I switched back to the unchanged files.

3. How to print the parts?

Some sub-assemblies are printed together because it's easier to handle it. The x-motor assembly is one example. All the linear bearings are being printed already connected to their parts.

To make a scale model Mendel90, I wanted to have it in almost the same colours as delivered by nophead. So I printed the frame parts in black, the “printed parts” in white, the heated bed in red and so on. With a little luck, I managed to print the 5 stepper motors in grey-black-grey so they are looking almost the same as the original motors do. The same trick works for the Melzi board. I started with green and changed the filament at the beginning of the 4th layer to black.

I collected all the parts as .stl files and printed them in their suitable colour. During the build I realised some errors so I needed to print a few parts a 2nd time.

4. How to put the parts together?

The M1.6 screws do not exactly fit into the printed holes. Some need to be drilled a little. I mostly used a 1.5mm hand drill. The screws can then “find” their way through the parts. Some do not even need a nut on the other side when screwed gently in. To screw the stepper motors in place, I had to drill a 1.5mm hole into the top or bottom plate. Again, the screw found it's way through the motor.

A very clever substitute to the smooth rods are aluminium welding wires. The original rods have a diameter of 8mm giving a scaled diameter of 3.2mm. Aluminium welding wires are available in this size! A not so good ratio is the substitute of the M6 threaded rod. I used M3. M2.5 threaded rods would be better, but my local hardware store didn't have it on stock.

When ever it was possible, I screwed the parts together. Only a few parts needed to be glued. The printed motor shafts are very weak and broke apart only by looking at it – I swear! So I hot glued the Wades small gear onto the motor. The clamps for the smooth rods are too small to screw them together - these are glued as well.

Not all parts are printed to be used as they come of the print bed. Filing and sanding are necessary to some parts to fit together. Some nut traps need more force to let the nut in. Use a washer whenever it's possible and be patient when you use the force.

Mounting parts onto the real thing is straightforward. But can be difficult at the scale model. Assemble as much as you can apart from the frame.

B) Preparation

1. Tools you need

Basically you need the same tools as for building the real thing. The smaller tools will be used mostly. Additionally a set of files and drills are needed. I used a small flat and rounded file and drills with 1.5, 2, 2.5, 3 and 3.5mm diameter. A loupe is very handy as well as tweezers. A hot-glue or other glue for some parts are needed. Sometimes some smaller hands and fingers are useful if you have it “by hand”. :-)

2. Parts to buy

- M1.6 x 8mm screws, washers and nuts
- a few M2, M2.5 and M3 screws, washers and nuts
- M3 threaded rod
- ⌀ 3.2mm aluminium welding wire
- ⌀ 1.5mm elastic cord (as a substitute for the belts)
- (UDMA IDE) Ribbon cable 80 way

I did not count the screws, washers and nuts. Basically you can use the bom.txt nophead provided. Use the measurements for the rods and multiply them by 0.4 to get the scaled length of all parts.

Free the ribbon cable from the IDE connectors.

3. Print the parts colour by colour

Put as many parts as possible on the print bed together. The small parts won't print alone because it is too less time between the layers to let the before layer cool down. If you want to have coloured parts, pause the print at the right layer, move the print head 10mm to the top and as much sideways to be clear to change filament, by cutting the old and feeding the new into the extruder. Then move backwards the same length and down the 10mm. Unpause to continue the print. Advanced printer operators can cut and feed the filament a few layers earlier.

4. Cut the rods to length

Use the lengths out of the bom.txt, multiply them by 0.4 and cut them. Clean the cut with a file. Same goes with the threaded rod. Be careful not to damage the thread. It helps when you screw a nut or two onto the rod before the cut. Clean the cut with a file and unscrew the nut. This heals a damaged thread a little.

C) The Assembly

Basically you can do the assembly like it's described in the real thing manual. I'll try to mention here all the differences I discovered during my build.

Frame Assembly: The tube caps do not receive their nuts. They are inserted upside down and provide a nice way for the screws. However the screws are too long. Cut them by 2mm.

X Idler Assembly: The linear bearings need to be drilled a little so the smooth rods can move without any force. For the idler use a M2 screw and washer. The clamps are too tiny to use screws. Use the glue here.

X Motor Assembly: The linear bearings need to be drilled a little so the smooth rods can move without any force. The clamps are too tiny to use screws. Use the glue here. As well glue the microswitch onto the motor bracket. The Motor needs holes for the screws. Drill appropriate with a 1.5mm drill. Use as many ways from the ribbon cable as you are able to fit into the ribbon-clamp. The exact amount isn't important since it's a scale model. I glued the x_motor_ribbon_bracket onto the motor since the screw head doesn't fit into the hole. I glued a few ribbon ways to the motor as well.

Z Motor Assemblies: Be careful with the motor shaft. It is very weak! The z coupling only clamps to the threaded rod. It rotates free on top of the motor shaft. Use a M3 nut as a substitute of the brass nuts. Mine do not go into their nut traps on top of the x ends. They only need to be in line with the threaded rod and the motor.

Y idler assembly: Use a M2 screw as a substitute for the M4 bolt.

Y motor assembly: The Motor needs holes for the screws. Drill appropriate with a 1.5mm drill. Cut away the motor shaft and glue the pulley at place.

Y Carriage Assembly: The linear bearings need to be drilled a little so the smooth rods can move without any force. The elastic cord needs two holes at the both belt clips.

Print Bed Assembly: Screw the ribbon cable to the Y carriage since the screws are no more accessible after the next step. Glue the Y carriage, the heatshield and the printbed together.

Y Axis Assembly: Again, glue the microswitch. Thread the elastic cord the same way as the belt would go. Give it a knot on both ends so that you have enough tension. I used a figure-eight knot.

X Carriage Fan Assembly: Use M2 crews for the front – my M1.6 are long enough.

X Carriage Assembly: The linear bearings need to be drilled a little so the smooth rods can move without any force. The elastic cord needs two holes at the both belt clips. Thread the elastic cord the same way as the belt would go. Give it a knot on both ends so that you have enough tension. I used a figure-eight knot.

Hot end assembly: Either you print the hot end bi coloured or you glue the parts together.

Extruder connection pcb assembly: It's already printed together wit the d_motor_bracket. I had to use a knife to free as much of the connector to fit the other connector.

Extruder Motor Assembly: Cut away the motor shaft and glue the wades small gear at place.

Extruder Assembly: Unfortunately the wades big gear won't turn after mounting it. Please be careful. The wades idler block does not have springs. Again the M1.6 screws are too short here. Use M2 screws. They don't need nuts either.

Spool Holder Assembly: I used M3 screws as a substitute for the M8 ones.

PSU Assembly: Since the printed PSU does not have any screwholes, you need to drill them in. Glue the resistors in place.