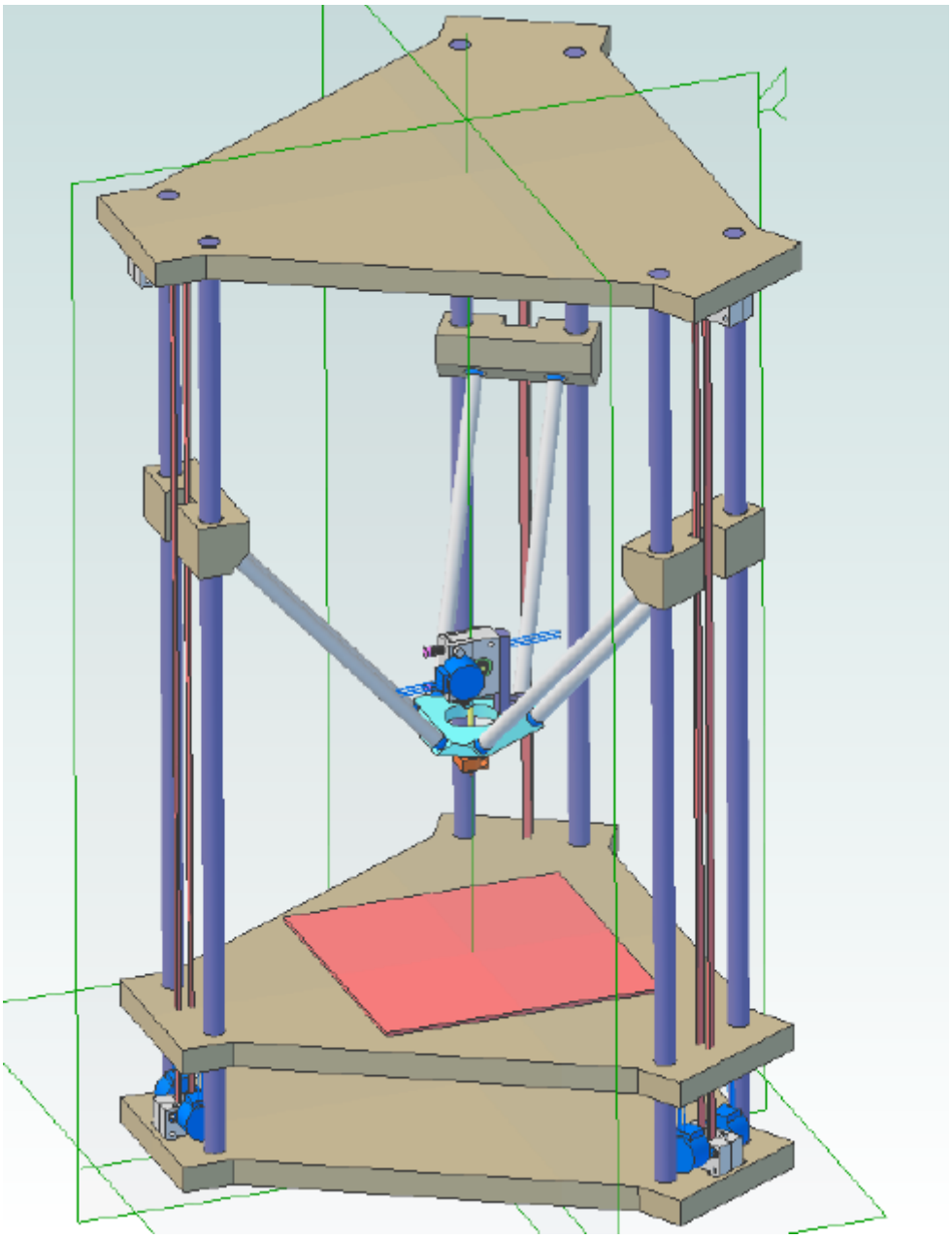
A different 3D Delta printer design



Printing Volume: 200x200x H=230.
Printing design speed: 80mm/sec.
Printing design positioning accuracy: 0.05 mm
Hot plate foreseen
Build in progress 01-09-2014

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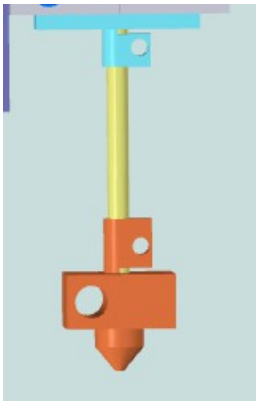
1x The new hot end design:

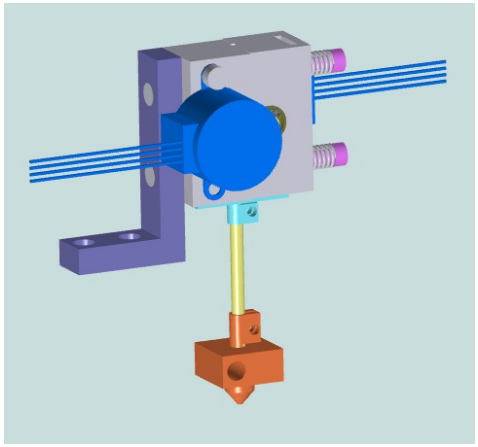


Ideally the Hot End is build out of 9 parts:

- 1x Copper / Brass head (0.4 / 0.5mm)
- 1x Ceramic tube 3.96 x 2.36 x 50 mm
- 1x Ceramic tube clamp / bracket
- 1x Heater resistor
- 1x Thermistor
- 4x M4x12 Bolts DIN 912

The ceramic tube will insulate the Hot End from the extruder and will help to concentrate the heath in the Hot End.
This optimized design will reduce the use of energy and reduce the usage of stacked up waste like a fan, brackets for the fan, a cooling barrel, etc.
The weight reduction will contribute to the total assembly of the world's smallest Filament feeder with Hot End (Feeder + Hot End = Filament Extruder).

1x The World smallest filament feeder design:



Ideally the Filament feeder is build out of 17 parts:

- 1x Stationary feeder body
- 1x Sliding feeder body
- 2x Knurled Filament infeed rollers
- 4x Bearings di=5
- 2x Central shafts d=5h7
- 2x Modified 28JYB-48 stepper motors. (modified to bipolar)
- 1x Mounting bracket
- 2x Compression Spring
- 2x M4x20 Bolts DIN 912
- Epoxy as consumable

The shafts of the Stepper motors 28JYB-48 are d=4.9 mm and therefore can't be aligned straight forward; one need to use a proper jig in order to align the motor shaft with the knurled Filament feeding rolls. Having them positioned in the jig while the epoxy you are using is curing (>8 hours) is the proper way to go. (Feeder body can be used as jig ☺ but pay attention please)
** One of the methods ** Preassemble left body with a blank shaft d=5h7 instead of the motor and install the knurled rollers centered by the temporary shaft who is on his turn centered by the ball bearings. Fix the knurled rollers in place with hot melt. Remove the shaft d=5h7 and fill knurled roller hole d=5 with epoxy. Assemble the motors in place and let cure for 8 hours. Pay attention for epoxy leakage or other contamination. Do the same with the right body assembly. Remove the hot melt after the epoxy curing period.

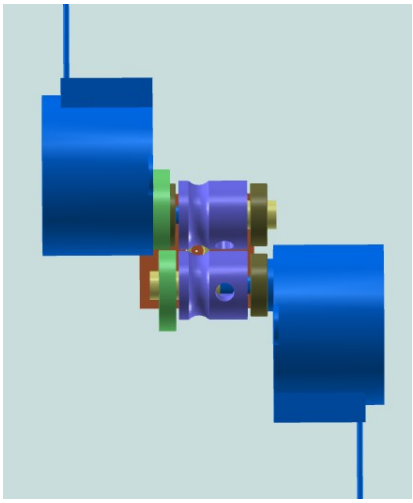
When defining the design parameters I noticed that the traditional (?) Filament feeders do use an elephant to kill a mosquito. When calculating the Filament infeed force I found out that the torque supplied by two little modified stepper motors like the 28JYB-48 would be more than sufficient enough to do the job at 80mm/sec printing speed (1.7mm Filament) when the right Hot End is in place with condensed heath. To modify a 28JYB-48 to bipolar, please

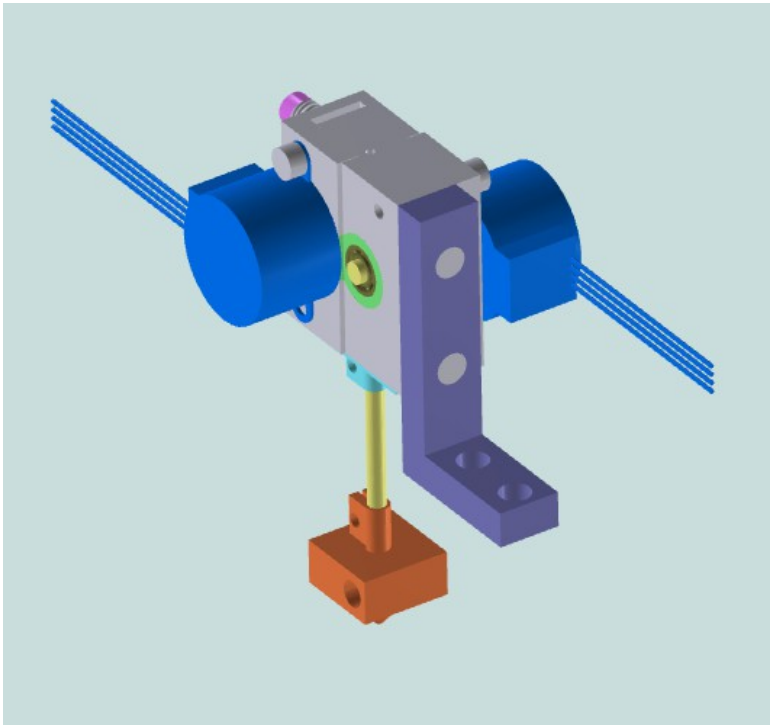
lookup YouTube or Google, it's doable in less than 60 seconds. After this modification the step-angle doubles but isn't an issue because of the reduction of the gearbox i=64. The torque though doubles too what comes to use of course.

The choice of these motors did drive the whole design more or less in a specific direction. So, ones again to all our big friends, "Less is More".

The two steppers do turn in the same direction, having both an infeed knurled Filament roller; both are pushing the filament into the Hot End; 1+1=2 ☺. And yes the motors are facing each other because when feeding 1.7mm Filament the motors do not fit side by side with infeed rollers of 12 mm. (Not exactly an issue but I just mention it because some readers are really picky)
Because these motors do use about 0.2 to 0.3 Amps, most of the stepper drivers do not bather driving two of these stepper motors at the same time; again a big saver in cost, materials and complexity.

And there it is, a Filament feeder including the stepper motors that fit's in 60x60 mm envelop (2.36"x2.36")
Combined with the new Hot End design, we are looking at a total weight under 0.25 Kg (0.551 lb, 8.81 oz)
The D18_EBOT_DOUBLE_STEP_EXTR can be used in every 3D plastic part printer but is specially designed for the use with Delta printers because of the very low inertia of the assembly. Delta printers now do not need the clumsy and expensive side Filament Feeder anymore what makes the filament in-feed more precise and efficient with positive consequences in regard to print layer quality.





2x3=6 The Delta Printer Arm:

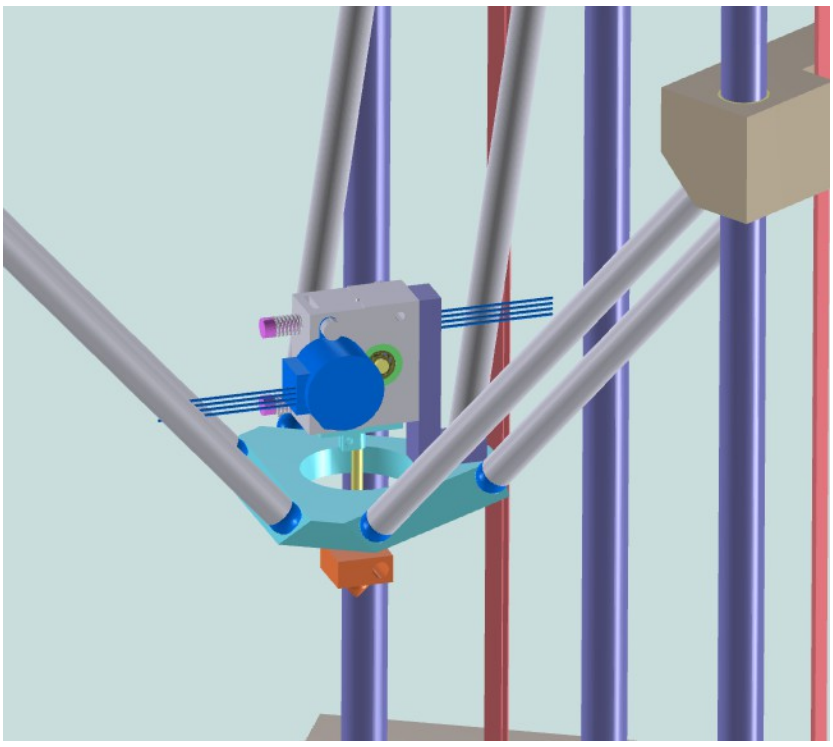
Ideally the Printer Arm is build out of 5 parts

- 1x Aluminum tube DO=12 Di=10 L=240
- 2x Steel ball D=12
- 1x Pull spring d=1 Dm=7.4 Lo=49
- 1x Steel wire d=0.3
- Epoxy as consumable

It's hard for me to justify carbon tubes for my Delta printer Arms design because in theory only pull and push forces are working in parallel with the tubes.

The only argument of interest for using carbon tubes would be the total resulting inertia as influence on the motor torque. For now I'm not motivated enough to do the calculation exercise and will go with 240mm long aluminum tubes DO=12 mm Di=10 mm. The principle of the Printer Arm design is not influenced by the choice of tube materials.
On both ends of the tube, a steel Ball D=12 is glued in with epoxy, what results in a total length of 258.4mm, center to center (10.17322"). A gluing jig is used to assure a precise length with a max tolerance of +/- 0.02mm.

The "Hot End" center platform of the Delta Printer receives, with a center distance of 60mm, two Arm assemblies positioned in spherical holes R=6 and the same geometric design and positioning is to be found on the opposite side of the Arm, in the linear guide blocks. Each couple of Arms is kept in place with a Pull spring d=1 mm, Dm=7.4 mm Lo=49 mm and a steel wire d=0.3 mm centered in between a pair of Arms. (~25 N pulling force)



Other Ball joint designs have been studied and I did came to the conclusion that in regard to virtual play, real play, assembly stack up tolerances, total stiffness and costs, the above described design outperforms most other designs in all aspects. (At least in the DIY environment)

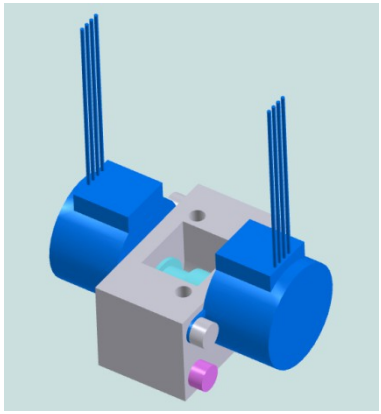
3x linear guide block:

Ideally the linear guide block is build out of 3 parts

- 1x HDF or alternative block 80x40x32
- 2x Glycodur bearing bush Di=16x16

A HDF block get precisely machined with extra attention for the 2x spherical shapes (R=6) for positioning the Printer Arms and special attention for the two bearing bush holes.
A CNC jig is foreseen in order to create sets of three exactly the same pieces.

3x Belt drive mechanism:

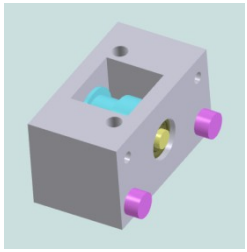


Ideally the Belt drive mechanism is build out of 12 parts

- 2x Modified 28JYB-48 stepper motor
- 1x HDF Body front
- 1x HDF Body back (mirror)
- 2x Ball Bearing d=5 D=11 s=3
- 1x 2GT Pulley 20 teeth's
- 1x 2GT 6mm belt L=1.200 mm
- 2x M4x16 Bolt DIN912
- 2x M4x12 Bolt DIN912
- Epoxy consumable

Two modified 28JYB-48 stepper motors are facing each other, and mounted against a body part centered by a ball bearing.
When both preassembled bodies are mounted against each other, a toothed belt Pulley is positioned and glued on both shaft ends from the stepper motors. A mounting jig is used to assure correct alignment of motor shafts and pulley. (Read filament feeder design for more details!)

3x Belt driven mechanism:



Ideally the Belt drive mechanism is build out of 8 parts

- 1x Central shaft d=5h7
- 1x HDF Body front
- 1x HDF Body back (mirror)
- 2x Ball Bearing d=5 D=11 s=3
- 1x 2GT Pulley 20 teeth's
- 2x M4x16 Bolt DIN912

The belt driven mechanism is a copy of the "belt drive mechanism"; the motors are replace by a single central shaft d=5h7.
When both preassembled bodies are mounted against each other, a toothed belt Pulley is positioned and fixed on the central shaft. A mounting jig is not needed in this case because of the precise dimensions of the parts.
This assembly will remain the same in case the "belt drive mechanism" will change.

6x Anodized Aluminum tubes:

Ideally the Guiding tubes are made from Anodized Aluminum tubes.

- 2x Anodized Aluminum tube DO=16 Di=13 L=700

Two Anodized aluminum tubes DO=16 Di=13 L=700 are the printer guides at the three corners of the delta printer.
Anodized material in combination with the Glycodur bearing bushes in the guide blocks is the optimum combination

in regard to wear and friction coefficient.
The top plate, the bottom plate and the working surface plate (base plate) do have CNC precise drilled holes in order to receive the 3x 2x tubes.

1x Top plate 1x Base plate 1x Bottom plate:

- 3x MDF plate

These three plates are equal except for the Base Plate that misses the three pockets for the Belt Drive and Belt Return units. Further the Base plate has distance holders holes for the Hot Plate

1x Filament reel holder:

A Filament reel holder is placed on top of the Top plate

1x controls and accessories:

- 1x Beaglebone Black plus BeBoPr++ plus Pepper Stepper
- Power supply ATX > 300 watt (12V, 5V, 3.3V)
- Powered USB hub
- HDMI Screen + mouse + keyboard
- Machinekit LinuxCNC software

Calculation of the force needed to move the sliding blocks at maximum acceleration: