Overview

This document details the 3D Printers construction and explains how this is related to the build quality. It also details the procedure for testing, set up and maintenance.

Construction

Frame

The printer frame defines the printer size and contains the printer components. The frame is fabricated from 25 mm square RHS steel.

The printer components are either attached directly to the frame screwed to the bars or grip the frame with brackets.

X and Y axis

Two motors are mounted at two corners of the top frame in motor mount brackets. There are idler brackets in the other two corners.

The top brackets contain pulleys to guide and contain the two belts that form part of the CoreXY mechanism.
Smooth 12 mm rods are connected between the brackets on the Y axis.
A gantry is mounted on the rods each side and two 12 mm rods are fitted between the Y gantry on which there is mounted the carriage.

The carriage has a stepper motor mounted on it for the direct drive extruder that has the Aluhotend fitted. Two or more fans mounted on the carriage keep the hot end heat sink cool and also provide the required turbulence around the newly laid melted plastic on the object.

Z Axis

The Z Axis is comprised of a Gantry running on two vertical 12 mm smooth rods. The challenge for the Z axis that supports the heated bed is for it to be very strong and rigid but not weigh so much as to affect the smooth descent required during the object build.

The solution to this is a structure consisting of threaded rods strengthened by plastic truss sections. Two cross lengths of RHS provide the rigidity required on which to mount the three 5 mm screws to which the aluminum bed is fixed.

The bed is heated by a bonded kapton heater and the temperature is monitored by a captive thermistor in the centre of the bed.

Power Supply

The power supply is mounted on the bottom of the frame.
The power supplies are solid state with no fan and an automatic cut out if tripped, providing low voltage to the printer.

Rumba Electronics board

The wiring of the components within the printer follows a star model:

- Low voltage from the power supply is fed into the electronics board
- Separate control wires lead from the electronic board to the stepper motors of the CoreXY mechanism.
- Separate wires lead from the electronics board to the Z Axis motor
- Separate heater and thermistor wires lead from the electronics board to the heated bed
- Separate wires contained within a split tube lead from the Rumba board to:

- o The extruder stepper motor
- o The nozzle heater and thermistor
- o The X and Y inductive sensors
- o Separate wires lead from the electronic board to Z Gap sensor on the top frame
- o The LCD Control unit with the SD card holder is connected by flat cable to the Rumba electronics board.
- The Rumba electronics board is mounted within a closed box with fans for cooling.
- Access is permitted to the on board USB socket of the Rumba board for firmware updates etc.

Spool holder

The spool-holder is designed to hold any known size of filament spool including the 3Kg European versions. The spool-holder can be mounted in different positions to suit requirements. The spool-holder is designed to enable quick changes of filament as required by users. The spool-holder axle has a profile designed to enable easy take up of filament from the spool with minimal resistance but preventing run-on leading to tangled filament. It also works well with badly finished spool rolls where the inside of the spool that makes contact with the axle is rough; the spool holder profile lets the spool rotate over the rough spots instead of causing feed problems.

The filament is fed up to the filament at the top of the frame inside PTFE tubing. The PTFE tubing describes a graceful arc to the top of the carriage allowing free moving and filament feeding to wherever the carriage is within the frame footprint.

Filament Cleaning

As the filament on the spool can be exposed to the air and the plastic can attract dust, it is important that the filament is properly cleaned before the filament enters the extruder / hot end. In the 3D Industries printers an efficient filament cleaner is attached to the frame and also used as an anchor point for the PTFE tube guiding the filament to the moving extruder. Once it has passed through the cleaner the filament is protected from any further contamination.

The filament cleaner has a cap that can be lifted away from the body to enable replacement / cleaning of the cleaning material.

Printing

The printing operation is as follows

- If it does not already exist the gcode file is generated from the CAD file and copied to the SD card that it inserted into the LCD Controller.
- The printer should be warmed up. This is done from the LCD controller by selecting "Prepare" – "Prepare PLA" then "Prepare PL1" for example. The bed will start heating to the required temperature as will the nozzle. The bed and nozzle actual and target temperatures are displayed on the LCD screen
- When the bed and nozzle temperatures have been reached, the nozzle can be wiped clean with a cotton cloth if required. A coat of spray adhesive is applied to the glass bed.
- The gcode file to be printed can be selected from the LCD controller and the object will start to print.
- With the default settings, a skirt; is first printed around the outside of where the object will be produced. The reason for this is to start the flow of plastic. If the bed had been leveled and Z gap had been previously adjusted then the skirt printing will finish and show an encompassing boarder and the object will be printed within.

While the object is being printed the progress and status is displayed on the screen:

- Nozzle actual and target temp,
- Bed actual and target temp
- Current X Y and Z position
- Speed of printer (100% is normal) current X Y and Z positions

- Last printer status

During printing the operator can have some interface and control of the printer.
- The nozzle temperature can be raised or lowered.
- The printer speed can be increased or lowered.
- Printing can be paused – then resumed after performing any intermediate actions

It is desirable that the printing of the first layers is at 100% as they need to properly stick to the glass bed, but for some objects (normally non complex objects) the printing speed can be raised to 125, 150 or even 175%. Familiarity and experience with the printer will be useful.

Build Quality

Firstly to recap on the methodology of how the object is created. Driven by the gcode files the software in the printer causes the carriage with the extruder hotend to move across the X and Y axis depositing plastic from the nozzle hole. Un-melted plastic filament either 1.75mm or 3.0 mm is fed into the extruder under software control as the un-melted plastic is pushed into the molten reservoir in the nozzle the melted plastic is ejected and the new filament is melted topping up the reservoir. The way the layer is printed depends on the settings but in general the outline of the layer is printed and then the printer fills in the layer either in a solid way or a less than solid way, honeycomb or even hollow.

Many systems use support material to manage this printing columns or other support. After the object is printed the support material is removed and the object cleaned up to reveal the intended object.

In general the objects printed by the 3D Industries printers do not require and support material, even for objects that involve upper layers of the object occupying a greater or different area than lower levels. This means that there is an overhang where the printer is apparently printing in mid air.

This is achieved by a combination of many factors:

- A very rigid frame (the welded square frame)
- The CoreXY mechanism to move the carriage over the x and y axis of the object while the object remains stationery
- The descent mechanism whereby the object descends within the printer for each layer printed.
- The accuracy possible where hundreds of layers of plastic have to be printed on top of each other to sub millimeter tolerances.

If the mechanism was used where the bed holding the object being printed was moved either in the X or Y direction for each print movement (and there could be hundreds of movements for each of hundreds of layers) then it is difficult to maintain the accuracy of the position where the plastic is deposited, the object can suffer from the effects of increasing inertia as it gets larger and heavier. However with the CoreXY mechanism the extruder moving on the X and Y axis is always subject to the same forces.

The moving of the object vertically very slowly for each layer is easier to control accurately compared to a mechanisms where the object is stationery vertically but the entire CoreXY mechanism is moved upwards vertically.

The Aluhotend has at least two fans associated with it on the carriage. One fan cools the heat sink of the hotend while the other fan or fans blow cool air in the vicinity of the object section being created. This helps to cool the molten plastic after it is deposited on a previous layer.

Where the current layer extends in the X or Y axis further than the previous layer (an overhang). The outline plastic deposited on each layer before the infill partially sits on the previous outline and some of the plastic extends over the edge where it is cooled and solidifies. The infill then forms a bond between the outline deposit and the previous layer. In order to continually producing the overhang the printer must move very accurate, the object must not move and all other mechanisms the cooling and so forth must work accurately together.

Testing

The LCD controller can be used to check:
- Control of the heated bed
- Control of the Nozzle
- Movement of each of the motors (X axis, Y Axis, Z Axis, Extruder)

The printer SD card under the folder "UTILITIES" contains several preset gcode files for testing of the printer.

- *"extrude"* Wait for the nozzle temperature to be reached first) The extruder will extrude 50 mm of filament
- *"extract"* Wait for the nozzle temperature to be reached first) the extruder will eject the filament
- *"homeall"* The carriage will be homed on the X axis, then the Y axis and then the Z gap

  - *"homex"* The carriage is homed on the X Axis
  - *"homey"* The carriage is homed on the X Axis
  - *"homez"* The carriage is homed on the X Axis

These gcode files can be run by selecting *"Print from card"* and selecting the appropriate gcode file.

Z Gap Adjustment and bed leveling

The Z gap is the distance between the nozzle tip and the bed to be printed on. This is typically about 0.2mm but the requirements can vary with different materials.

The bed leveling and Z Gap is set prior to delivery and checked when delivered. The following procedure is used:
- The distance between the nozzle and the bed is checked at the middle of the bed then to the left and to the right. The back bed screws are adjusted if necessary to correct this.
- The distance between the nozzle and the bed is then checked in the middle of the bed then to the back and to the front of the bed. The front screw is adjusted if necessary to correct this.
- The Z gap is then checked by positioning the nozzle in the centre of the bed and executing *"homez"* gcode. The nozzle should be almost touching the bed.
- At this point the bed leveling or the z Gap is only manually set by measurement.
- In the *"Utilities"* directory there is a *"cube.gcode"* file. This should be printed and the print observed. If the Z Gap is set correctly the skirt will be properly printed and stuck to the glass and the cube should print properly; after printing the cube should be stuck to the glass but can be removed with a sharp knock with the spatula. Larger objects should be left to cool first.
- If the Z gap requires adjustment then this can be done by turning the Z Gap adjustment knob anticlockwise to reduce the gap or clockwise to increase the gap.
- A slight problem of the bed leveling will not be noticed on a small object such as the cube, so a special file *"bedlevelcheck.gcode"* found in the calibration folder can be printed. This is designed to cover a bigger area on the build platform. The skirt will be printed as a big square and the evenness of this and the first layer of the print will show whether the bed is completely level. Depending on the deposit of the plastic on the bed the appropriate leveling bolt will need to be adjusted. It may or may not be necessary to re adjust the Z Gap if the bed was seriously out of level.

Maintenance

Very little maintenance is required but at regular periods depending on the use of the printer, it should be inspected as follows:

- Dust. Remove all dust from the frame and filament and components. A dust cover for the printer model is now available as an option from the 3D Industries web site.

- Check the following for looseness and tighten the clamps if necessary:
    - Power supplies
    - Spool holder
    - The four top frame mounts
- Lightly oil and wipe off surplus from:
    - The vertical threaded rod
    - The vertical smooth rods
    - The horizontal smooth rods.
    - The hot end in the extruder.
- Test print the bed level object and carefully watch the print operation and result.