AUTOMATIC TOOL CHANGING SYSTEM FOR MHI3D PRINTER

Mehta Heino Industries Oy

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ABSTRACT

The aim of this thesis was to develop a process for introducing an innovative automatic replacement and mechanism system (i.e., an additional automatic tool changing mechanism) for changing the filament extruder nozzle of the MHI3D printer, so that it can be quickly and easily replaced at any time. This thesis was commissioned by Mehta Heino Industries Oy located in Otaniemi,Espoo.

This system's housing is located on the printing machine's cabinet inner side wall with a specific number of hot end units ready to be selected as required. These units have nozzles of different size diameters, for example, 0.4 mm, 0.35 mm which can be selected if and when required before or during each operation. The idea is to develop this automatic process for next version of the MHI3D Printer.

As expected, the g-code will be programmed to command the extruder head to move to the replacement mechanism housing and deposit and/or select the required nozzles as is needed for creating the 3D printed model.

As a result of creating this thesis, an automatic tool changing system for MHI3D printer has been developed.

Keywords MHI3D printer, automatic tool change, extruder

Pages 36 pages including appendices 8 pages

TABLE OF CONTENTS

1 INTRODUCTION 1
1.1 Basics of 3D Filament Printing 1
1.2 Mehta Heino Industries Oy – Background 2
1.3 Objective 4
2 MECHANICAL DESIGN PROCESS 5
2.1 Problem identification and research 6
2.2 Design Specifications 7
2.3 Possible Solutions 7
2.3.1 Solution 1 9
2.3.2 Solution 2 10
2.4 Select the best possible solution 12
3 DESIGN PROCESS 14
3.1 3D Modelling 14
3.1.1 Nozzle 14
3.1.2 Heatsink 15
3.1.3 Heating Block 15
3.1.4 Cooling Fan 16
3.1.5 Motor 16
3.1.6 Arm plate 17
3.1.7 Lever 17
3.1.8 MK8 drive gear 18
3.1.9 SmCo magnets 18
3.1.10 Coupling plates 19
3.1.11 Hotend Hanger 19
3.1.12 Heat Break 20
3.2 2D Drawing 20
4 AUTOMATIC MECHANISM 22
5 MATERIAL SELECTION 22
6 DESIGN FOR MANUFACTURABILITY AND ASSEMBLY (DFMA) 23
6.1 Manufacturing 24
6.2 Assembly 24
7 COST ANALYSIS 25
8 CONCLUSION 25
REFERENCES 27

LIST OF FIGURES

Figure 1: MHI3D Printer 2
Figure 2: MHI 3D Printers without automatic tool changing system 3
Figure 3: Detailed information on the MHI3D printer, showing it with manual tool changing system 3
Figure 4: Mechanical design process 6
Figure 5: Sketch of solution 1 8
Figure 6: Hotend assembly of solution 1 9
Figure 7: 2D drawing of solution 1 9
Figure 8: Sketch of solution 2 10
Figure 9: Coupled hotend assembly and its housing 11
Figure 10: Hotend Assembly with coupling and lever 12
Figure 11: Hotend Housing (Another half) 13
Figure 12: MHI 3D printer frame showing various hotend assembly for automatic tool changing mechanism 13
Figure 13: Nozzle 14
Figure 14: Hotend 15
Figure 15: Heating Block 15
Figure 16: Fan 16
Figure 17: Motor 16
Figure 18: Arm plate 17
Figure 19: Lever 17
Figure 20 MK8 drive gear 18
Figure:21: SmCo magnets 18
Figure 22: Coupling plates 19
Figure 23: Hotend hanger 20
Figure 24: Heat Break 20
Figure 25: Assembly of extruder, arm plate and motor 21
Figure 26: Material Properties 22

LIST OF TABLES

Table 1 Design Specifications 7
Table 2 Comparison of solution 1 and solution 2 12
Table 3 Filament Properties 23
Table 4 Manufacturing time process and material 24
Table 5 Cost Analysis 25

LIST OF APPENDICES

Appendix 1: Technical data of NEMA stepper motor 29
Appendix 2: Technical data of fan 30
Appendix 3: Technical data of volcano nozzle 31
Appendix 4: Technical data of MHI 3D printer 32
Appendix 5: Technical data of gear 33
Appendix 6: Technical data of heat break 34
Appendix 7: Technical data of hotend assembly 35
Appendix 8: Technical data of hotend housing 36

LIST OF ABBREVIATIONS

HAMK = Hämeen Ammattikorkeakoulu

UAS = University of Applied Sciences

MHI =Mehta Heino Industries

CNC = Computerized Numerical Control

mm = millimetres

PTC = Parametric Technology Corporation

3D = 3 (Three) Dimensional

2D = 2 (Two) Dimensional

FDM = Fused Deposition Modelling

FFF = Fused Filament Fabrication

DFMA = Design for Manufacturing and Assembly

PLA = Polylactic Acid

ABS = Acrylonitrile Butadiene Styrene

JST = Japan Solderless Terminal

SmCo = Somarium Cobalt

1 INTRODUCTION

1.1 Basics of 3D Filament Printing

There are several methods to print plastics in three dimensions; however, in this thesis only Fused Filament Fabrication (FFF) will be explored, and, though it is only a matter of preference, this printer currently uses Ø 1.75 filament.

“With 3D printing, complexity is free. The printer doesn’t care if it makes the most rudimentary shape or the most complex shape, and that is completely turning design and manufacturing on its head as we know it” (Reichental ,2019)

Basically, the printing procedure is as follows. The filament is fed from a reel into an extruder, heated to the plastic’s melting temperature (e.g., PLA 190- 220 °C) and then the fluid plastic is extruded from the extruder’s nozzle and deposited on to first the printer bed, and then it is built up layer by layer on the developing 3D print. The point at which it is deposited, is determined by the position of the extruder, which, in turn, is controlled by the mechanical positioning equipment (e.g., sliding bearings and rods). The position of the extruder is determined by the g-code, which is uploaded into the printer’s control system before the printing starts.

Though the filament reel has a filament size of Ø 1.75, the diameter of the extruded plastic can be set to a range of sizes with nozzles of a specific size, as the print designer requires. It is this nozzle changing procedure that is the main point of this thesis, which is to discover a way to change the nozzle to one of a different size automatically, rather removing the nozzle and then replacing it with another, by hand (i.e., unscrewing the nozzle with tools and similarly replacing the second nozzle).

Inventing such a nozzle- changing mechanism would greatly improve the performance of the printing procedure, as the pause time for changing the nozzle would be very quick, and no pause marks (Note: marks caused by the extruded plastic being removed from the print surface, and then later the nozzle returning to the print continuing to deposit the hot plastic, where it can start with a small but noticeable blob) or temperature change marks (Note: marks caused by the print cooling, while the nozzle is being changed) would show on the print. Practically speaking, the operator would not have to deal with removing a nozzle that has been heated to 200+ °C and also the heating block and nozzle thread would not be worn with continually being unscrewed and screwed. This damage is increased by the temperature difference of the two components when the nozzle is tightened, locking it tighter as the nozzle expands from the heat from the heating block.

1.2 Mehta Heino Industries Oy – Background

Mehta Heino Industries Oy (MHI) is a 3D printing (start-up) company located in Espoo, which is developing cost-effective 3D Printer technology based on FFF, also known under the trademark term as FDM. This printer is controlled with a very user-friendly interface. In the coming days, this company is planning to launch their product throughout Finland and later into the European market. They are selling their prototype 3D Printers to selected pilot customers and are currently receiving presale orders from their growing customer base.

The MHI3D printer is designed to use FFF and FDM technology and production grade thermoplastic filaments to create strong, durable and dimensionally stable parts with high accuracy. This FDM (Fused Deposition Modelling) is a well-known method of printing, which builds up the printed parts layer by layer from the bottom up by heating and extruding thermoplastic filaments through a nozzle, giving the products of FDM 3D printers this high dimensional retaining tolerance and creating exceptionally resilient products with well selected filaments.

Figure 1: MHI3D Printer (Mehta Heino Industries Oy,2019)

The company's vision is to give everyone access to a 3D Printer that is used as a tool to materialize each designer's own creative ideas, for limited production of specialized parts and explore the possibilities of this modern technology along with extending the frontiers of design and modelling. 3D Printing is a means of fabrication that will be used everywhere, in the schools, workshops, offices, and factories in the foreseeable future.

With this company's fast-growing business, they are actively engaged in working on the next level of technology, and with these improvements they are essentially giving their customers a feel of what to expect in the coming years. The current MHI3D printer, which is a fully CNC printer, is built with a machined aluminium body, giving it an extremely rigid structure. Besides this, it has the best industrial components available on the market today, allowing it to print very reliably and with high print quality. A patent for the unique design has been filed.

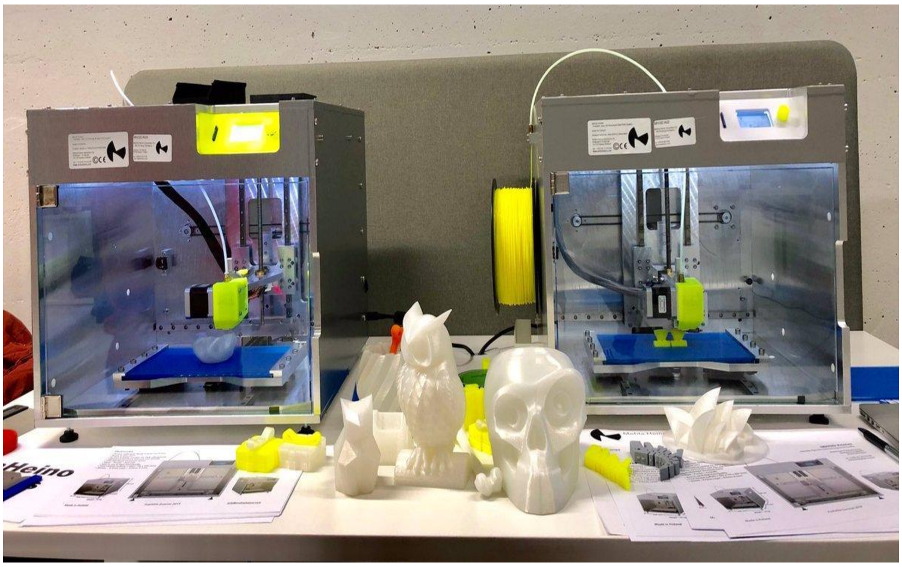


Figure 2: MHI 3D Printers without automatic tool changing system
(Mehta Heino Industries Oy,2019)

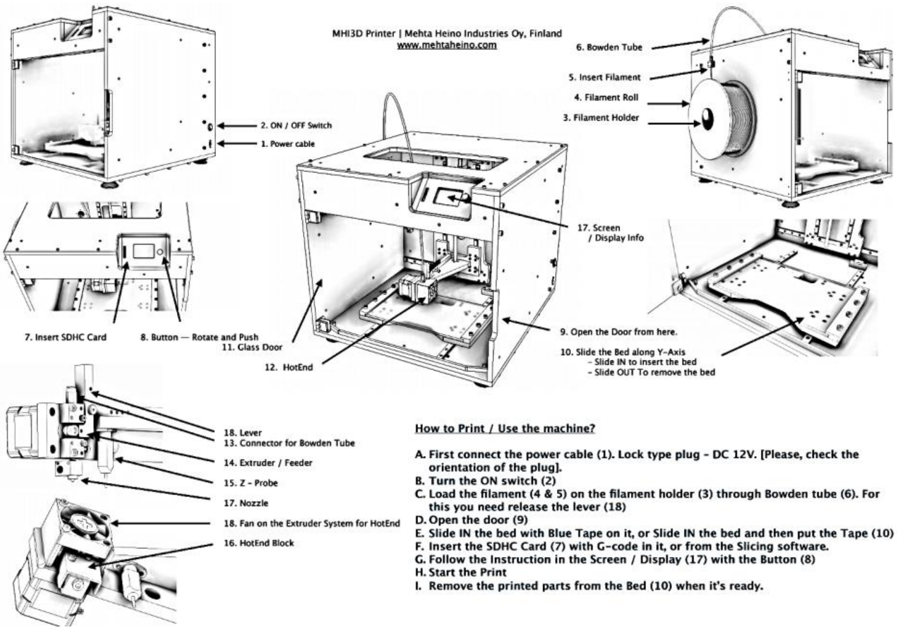


Figure 3: Detailed information on the MHI3D printer, showing it
with manual tool changing system
(Mehta Heino Industries Oy,2019)

Further to these essential on-going developments, the following pages describe a needed time saving automated manual tool changing enhancement.

1.3 Objective

The principle objective of this thesis is to develop the automatic tool changing system for the MHI3D printer, which entails changing and replacing the filament extruder nozzle, so that it can be quickly and easily replaced at any time.

This system's housing is to be located on the printing machine's cabinet inner side wall with a specific number of hot end units ready to be selected as required.

These units have nozzles of different size diameters, for example, 0.4 mm, 0.35 mm (but not exclusively these sizes), which can be selected if and when required before or during each operation.

Operating automatic tool changing system requires the g-code to be programmed, which is outside the scope of this thesis; however, it is obviously included in the considerations when designing the mechanical movements of the system.

With a manual nozzle-changing printer, to replace the hotend of the nozzle, the user needs tools to disassemble the hotend unit (the hotend unit includes a nozzle, a heater, a thermistor heat sensor and a heater block, as shown in the detail drawing in figure 3). Disassembling the unit in this way is very time consuming as the operator must follow each step in the printer's maintenance manual. Therefore, to make progress in the design of the printer, this process must be automated and the nozzle-changing or hotend procedure has to be very easy and this is done by developing an automated tool changer for this 3D Printer.

In this MHI3D Printer, to change the nozzle the user has to change the whole hotend package and only changing the nozzle part is not recommended by the manufacturer (MHI) because there are special calibration procedures to manufacture the hotend package and the whole machine is factory calibrated. Therefore, users are not recommended to change individual parts themselves but to use ready replacement units to make sure the factory calibrations work.

To change the hotend package, first the hotend has to heat up to approximately 200 degree Celsius, after that filament has to be removed from it by doing retraction from the MHI3D's screen and by pulling the filament from the hotend. Also, the heater wire has to be disconnected. Behind the motors (Arm of MHI3D Printer), there is an electronic connector that has to be removed in order to remove the hotend package and then a screw has to be opened from the hotend. Finally, the hotend is ready for removing and the users can change the hotend package to new one from MHI3D or they can put back the same hotend into the machine by following the reverse order of removal.

Here, this process has to be improved by developing a process for automatic replacement and an automatic mechanism to change the nozzle so that the user does not have to spend time on it. For example, on the inner side wall of the machine, several ready hotend packages with different nozzles of different sizes like 0.4, 0.35 (mm) and so on can be placed for automatic replacement. This idea is to develop the automatic process for the next version of MHI3D Printer. Possibly the machine can drive towards the nozzles nearby side wall, and it will replace according to the g - code or according to the command made by users from the software just like the tool change in the CNC machine.

From this thesis, the company will be developing the next model 3D Printer which will be highly advanced compared to their competitor 3D Printer and help them to develop their business.

For me, I will be learning the more about 3D printer like how it works in more detail and about machine design. Also, I will be developing the skills like designing the nozzle package, planning the production process and overall increase my knowledge in mechanical engineering field.

2 MECHANICAL DESIGN PROCESS

Mechanical design is the process of creating a system, component, or process to meet desired needs in the machinery field. It is a decision-making process, in which the engineering sciences and mathematics are applied to convert resources optimally to meet a specified purpose.

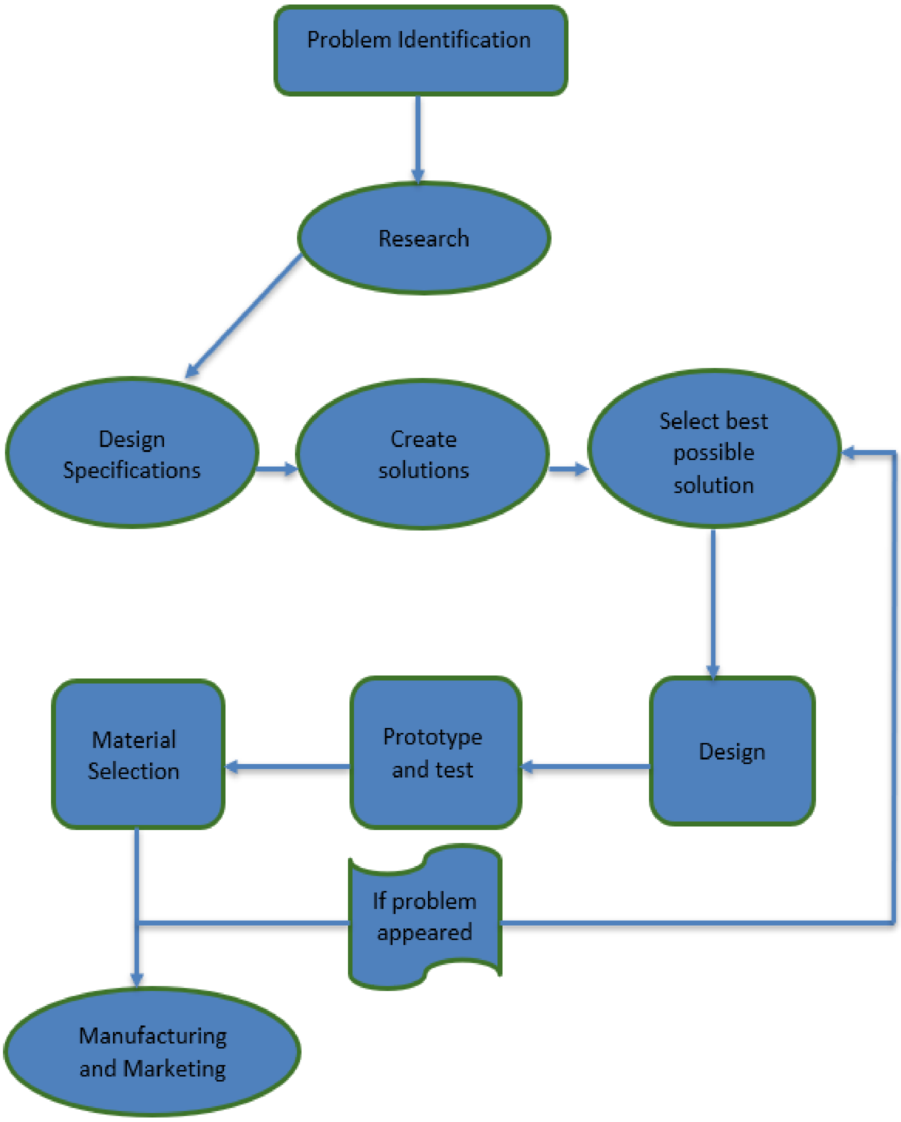


Figure 4: Mechanical design process

2.1 Problem identification and research

Manual tool changing system in MHI 3D Printer was time consuming so Mehta Heino Industries Oy decided to modify manual tool changing system to automatic tool changing system to develop the next model 3D Printer which will be highly advanced compared to their competitor 3D Printer.

Research on product design was done and following things were considered:

- Reuse of previous parts
- Safety
- Problems during Manufacturing and Assembly
- Low cost
- Portable size
- Quality

2.2 Design Specifications

The first thing is to create general ideas on modification. To make the automatic tool changing system, the whole hotend should be made automatically changing because automatic nozzle changing system is not efficient as the parameters are changed after changing the nozzle. In this process, the requirements of the commissioning party are analysed. The necessary aspects of design such as functions, technical features, cost analysis and timings are evaluated during this process. While designing the automatic tool changing system, various specifications were analysed as per the requirements set by Mehta Heino Industries Oy and as illustrated in Table 1.

Table 1 Design Specifications

ASPECTS	SPECIFICATIONS
Functions	The basic function requirement is extruder should work automatically according to the given program.
Size	Heatsink with outer diameter around 40mm was specified by the commissioning party.
Cost	As cheap as possible with good performance.
Safety	Sharp edges in the design have to be prevented for the safety.
DFMA	The manufacturing and assembly of the designed extruder have to be simple, easy and effective.

2.3 Possible Solutions

As this automatic tool changing system for the MHI 3D printer has not been designed before, the method of creating a changing mechanism has had to be devised from scratch, and finding the ideal solution is not immediately obvious and the solutions needed to be tested for suitability, bringing about more than one approach to the problem starting with the following “Solution 1”.

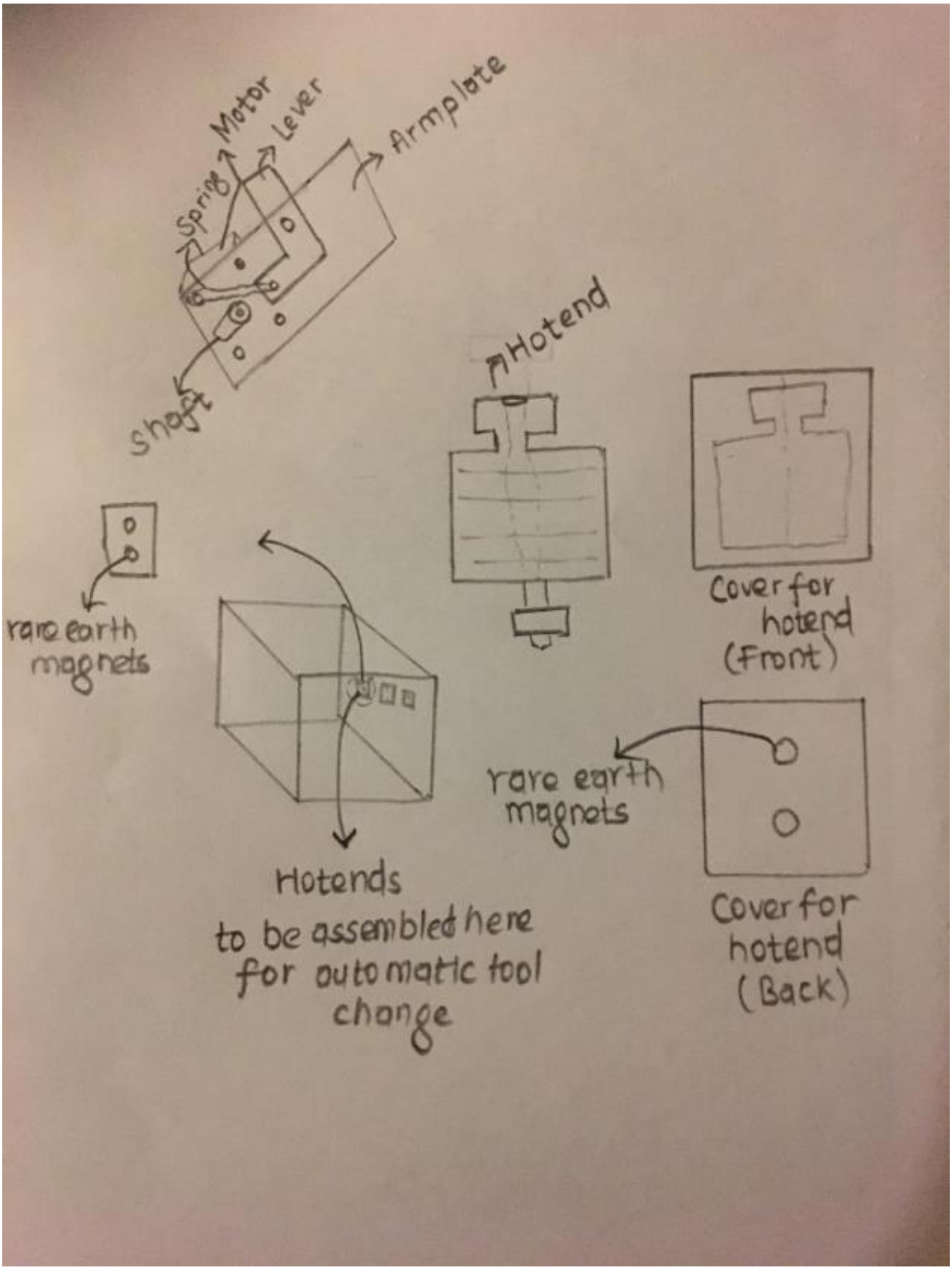


Figure 5: Sketch of solution 1

2.3.1 Solution 1

The first solution that was devised, to use magnets to hold the automatic tool changing system mechanism, i.e., the nozzle-changing unit. The magnets were attached to the nozzle-changing unit, which comprised of the extruder assembly, the hotend (Note: with the nozzle in the hotend), a cooling fan and cables supplying power. The whole nozzle-changing unit is enclosed in a protective box.

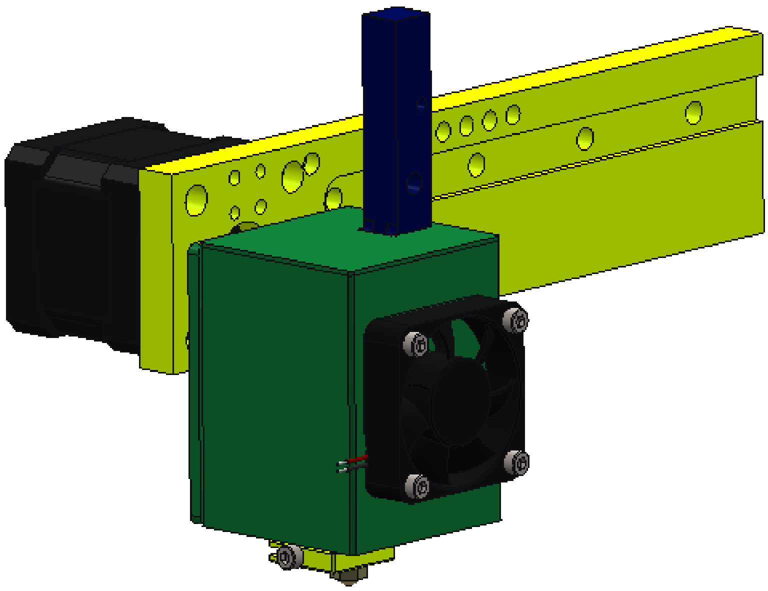


Figure 6: Hotend assembly of solution 1

Similarly, the printer cabinet have magnets installed on the arm plate attached to the side wall of the inside of 3D printer cabinet. In the same way, the extruder housing come up with magnets (i.e., two pairs of powerful SmCo permanent magnets with a maximum operating temperature of 360 °C), to hold the nozzle-changing unit with interlocking grooves to position the unit exactly.

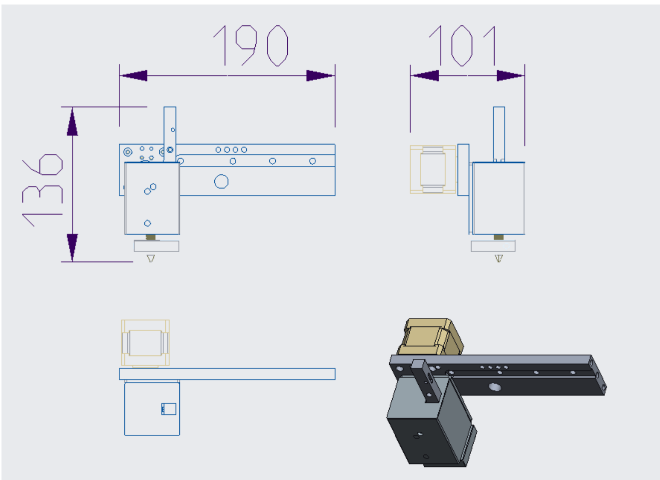


Figure 7: 2D drawing of solution 1

Similarly, the two pairs of magnets on the nozzle change unit and the arm plate were designed to precisely interlock together as the nozzle-changing unit and the arm plate moved into close vicinity to each other, when the nozzle-changing unit was transferred by the extruder housing to arm plate.

The exact pressure with which the nozzle-changing unit is pressed on to the arm plate and the extruder housing, depends on the G-code programming.

After extensively testing Solution 1, it was decided to create Solution 2 and it was found that the first solution required too many parts, and it was becoming evident a simpler design could be implemented.

2.3.2 Solution 2

The second solution is designed, using a mechanical coupling with magnets. It is similar to the first solution, but few changes are made in the second solution. The covers of hotend were replaced by a small cover whereas the coupling plates were made as the different parts. The same SmCo magnets are used in solution 2 as in solution 1. The number of magnets used in solution 1 were 4 whereas 6 number of magnets are used in solution 2. The hotend hanger is a new design in this solution that hangs several hotends on the inner wall of the MHI3D printer.

In assumption, reducing the number of parts reduces the cost and increasing number of magnets and adding hanger design results in better functionality.

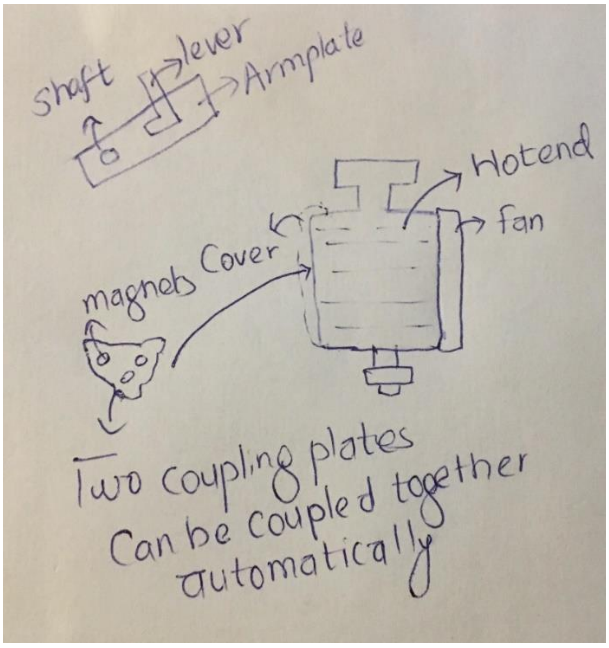
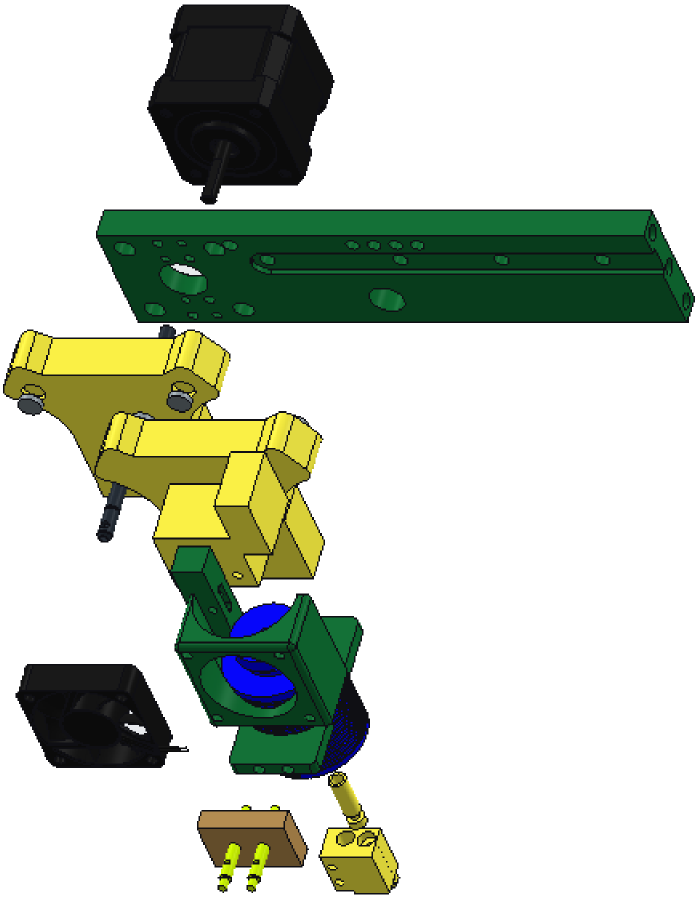


Figure 8: Sketch of solution 2



(Exploded view)

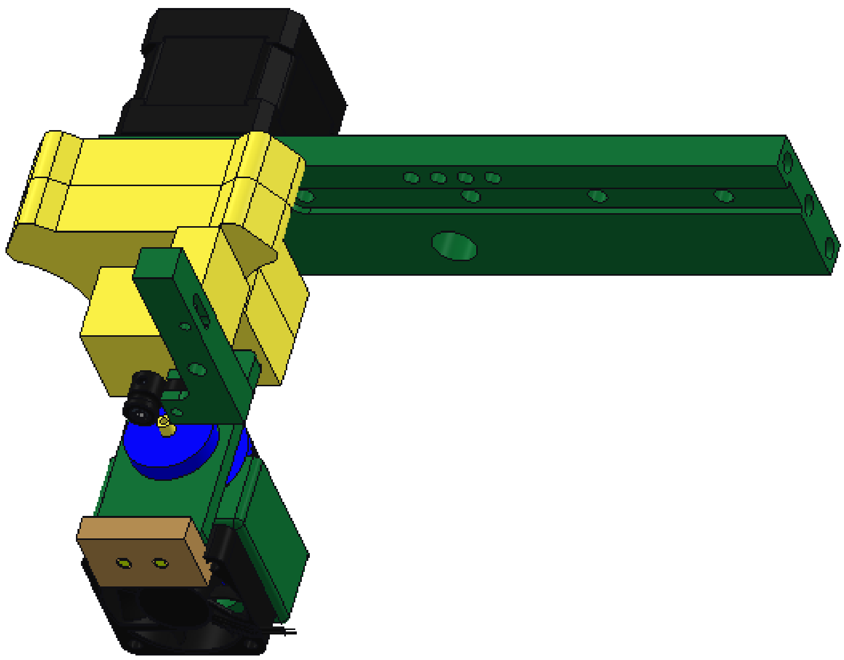


Figure 9: Coupled hotend assembly and its housing
(assembled view)

2.4 Select the best possible solution

Solution 1 and solution 2 are compared. Solution 2 was finalised based on the following things:

- Effective function
- Portable size
- Low cost
- Problems during Manufacturing and Assembly

Table 2 Comparison of solution 1 and solution 2

Solution	**Advantages**	**Disadvantages**
Solution 1	• Good functionality	• Expensive • Problems during manufacturing and assembly
Solution 2	• Easier to assemble • Better functionality • More compact • Cheaper to manufacture • Cheaper to assemble	

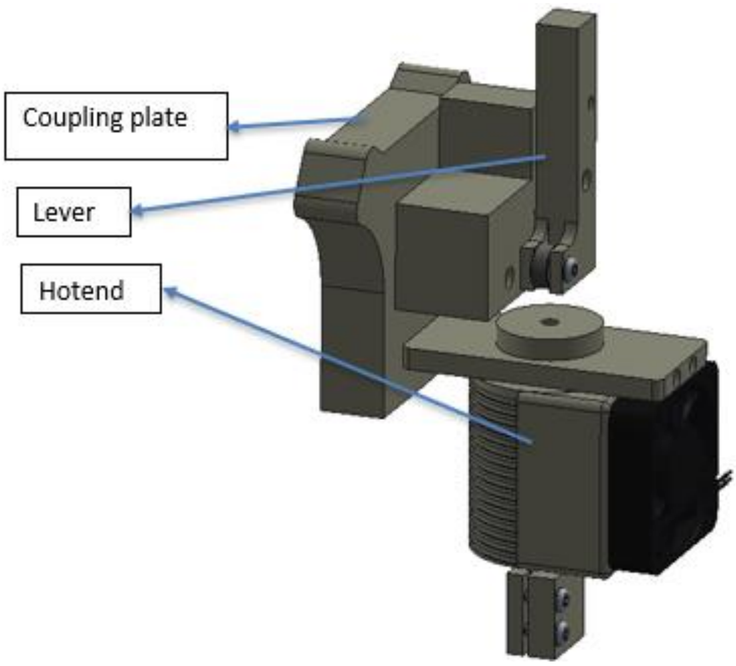


Figure 10: Hotend Assembly with coupling and lever

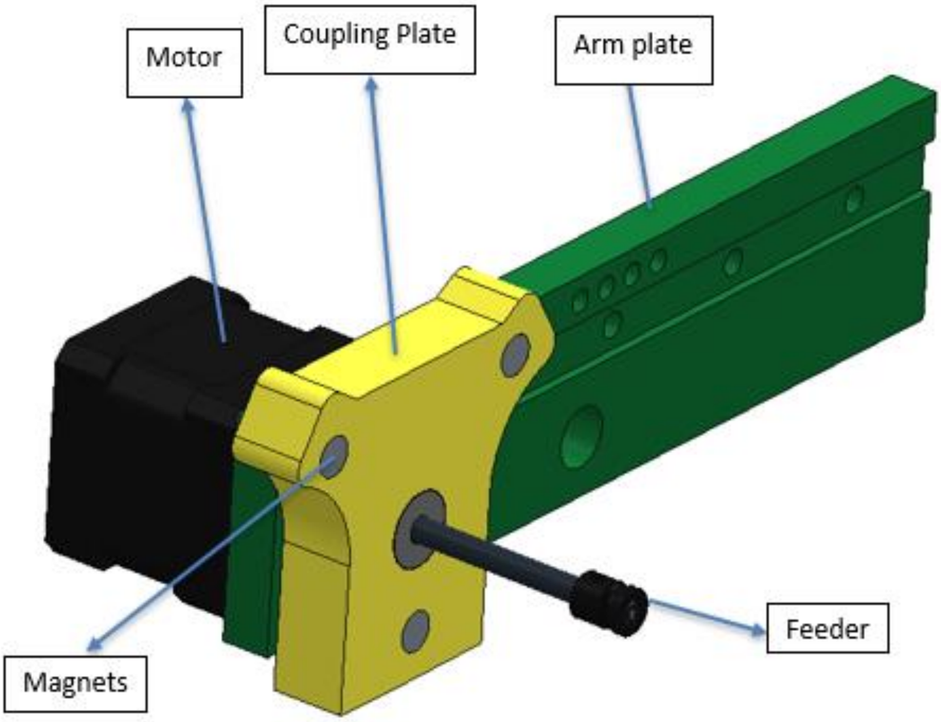


Figure 11: Hotend Housing (Another half)

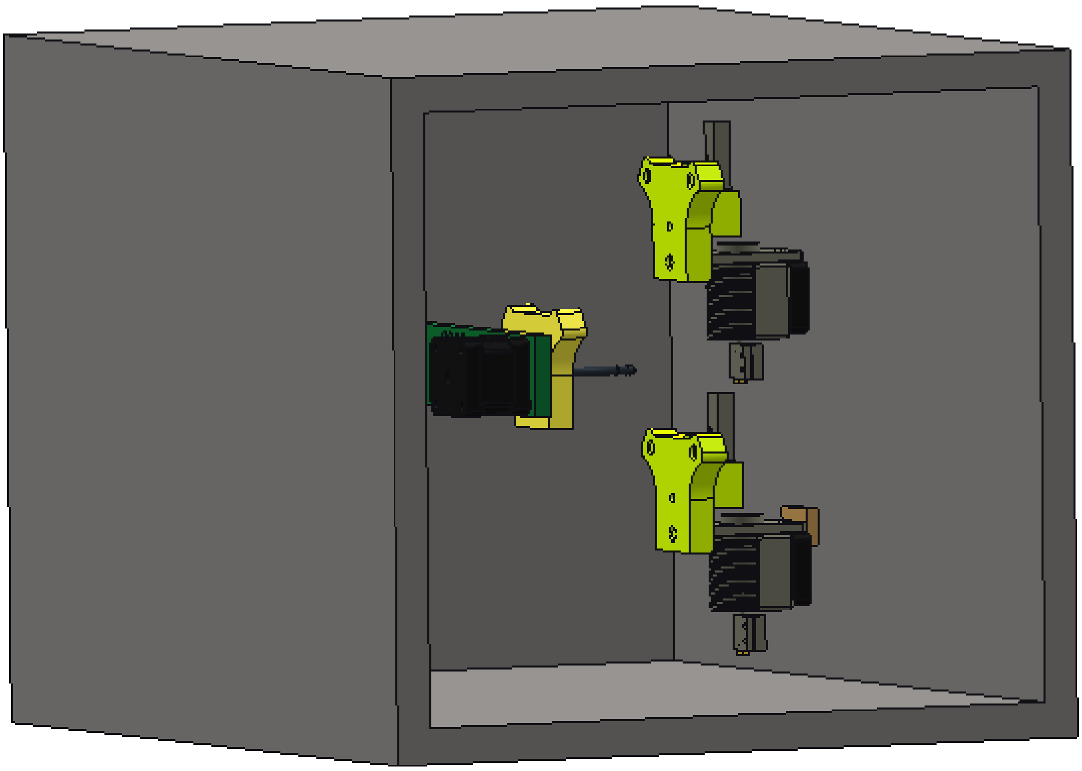


Figure 12: MHI 3D printer frame showing various hotend assembly for automatic tool changing mechanism

3 DESIGN PROCESS

The third step is to design 3D model, create 2D drawings, figure out automatic mechanism and finalise materials. The hotend and other necessary components were designed.

3.1 3D Modelling

3D modelling is the process of creating three-dimensional model of an object. Using 3D, it is possible to capture size, shape and texture of a real or imaginary object. The 3D models were designed by using PTC Creo Parametric version 4 CAD software.

3.1.1 Nozzle

This is one of the purchase components to develop automatic tool changing system. It is a part of the 3D printer that extrudes the filament to build the printing component. It has a large impact on how long the printing component takes time to print as well as the quality of the final printed component. The 3D printer nozzle size and material are the key characteristics to look at.

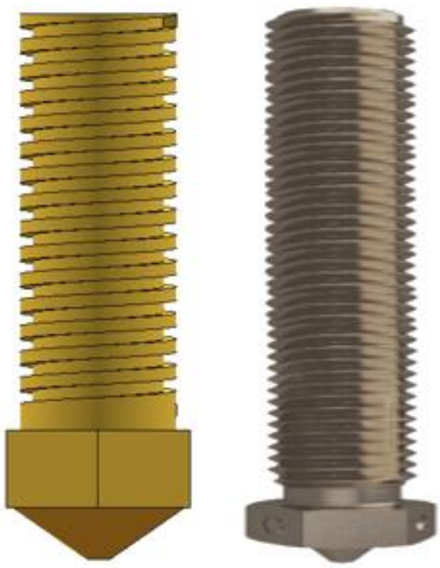


Figure 13: Nozzle (E3D online,2019)

3.1.2 Heatsink

The heatsink is a component of the 3D printer that melts the filament for extrusion and helps to maintain a consistent and accurate temperature for successful prints. The heatsink is the region where the heated filament comes out and moves across the print bed to create 3D objects. Since this is where the filament heats up & partially liquifies, it gets quite hot (250 degrees Celsius) and is insulated from the rest of the printer. Different materials may print best at different temperatures and its temperature can be set with slicing program for example Ultimaker Cura.

Figure 14: Heatsink

3.1.3 Heating Block

The heat block in the 3D printer is the part of the extruder where the nozzle meets the thermal barrier tube. The heater cartridge that heats and thermistor that measures temperature are contained inside the heat block. Typically made of aluminium, the part functions literally as a block of heat, melting the filament as it passes through the thermal tube to be extruded out of the nozzle.

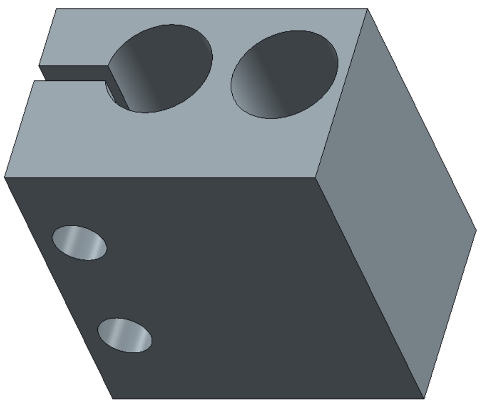


Figure 15: Heating Block

3.1.4 Cooling Fan

Cooling fan is one of the purchase components in this project and it is contained in all kinds of 3D printers. These special fans used in this project are called as brushless fan. It contains two pin JST connector which uses Direct current. These fans run quietly and have long lifespan. These are portable and are ideal for cooling 3D printer hotends and cooling print itself. The size of fan is 40x40x10mm.

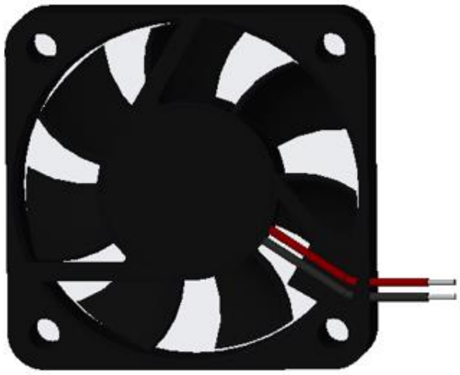


Figure 16: Fan (Aus3D,2019)

3.1.5 Motor

It is the NEMA 17 stepper motor with 1.7x1.7inch faceplate. These are brushless DC motor used to pull the filament into the extruder appearing in this project. They operate by generating torque through magnetic field from electromagnets.

Figure 17: Motor (Ebay,2019)

3.1.6 Arm plate

The motor and hotend assembly are attached in the arm plate in MHI3D printer. The arm plate can move top bottom. It changes the hotend assembly according to the code command.

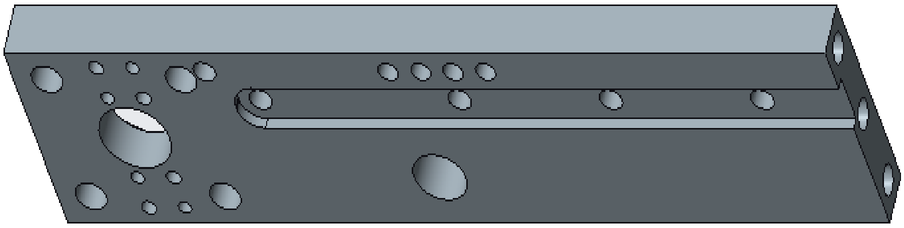


Figure 18: Arm plate

3.1.7 Lever

The lever in the 3D printer is a part of the MHI3D printer that adjusts filament into the hotend. It is attached by using a spring on it which makes the lever flexible to slide. The bearing is assembled in the lever which rotates continuously to push the filament into the hotend. The coupling plate and lever are assembled by using several screws.

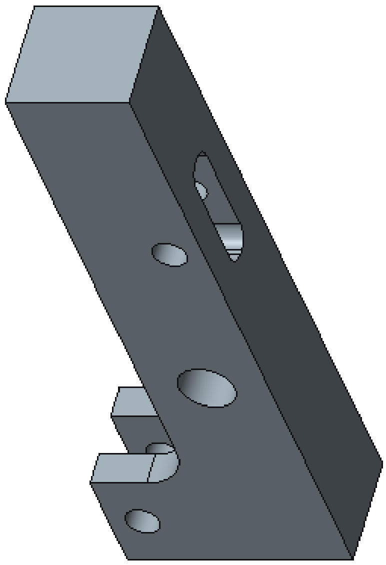


Figure 19: Lever

3.1.8 MK8 drive gear

These are stainless steel gear and are suitable for 1.75mm and 3mm filament. These have very sharp 26 number of teeth to dig into the plastic filament. The shaft of the stepper motor passes through the feeder rotating it constantly. This rotational moment feeds filament into the extruder.

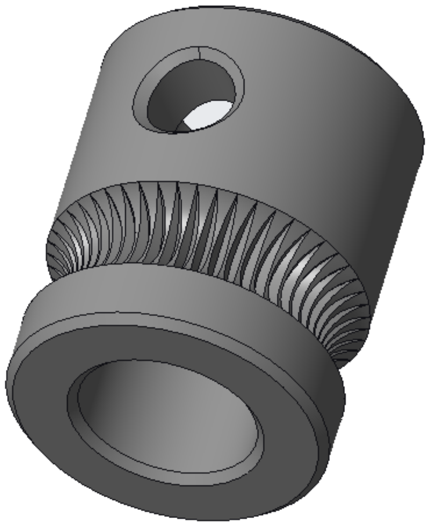


Figure 20 MK8 drive gear

3.1.9 SmCo magnets

These are very strong rare earth magnets that can operate in maximum temperature of 360°C .These are corrosion resistance magnets, composed of samarium and cobalt elements.

Figure:21: SmCo magnets (First 4 magnets,2019)

3.1.10 Coupling plates

Two similar coupling plates are designed, both coupling plates are assembled with magnets and the stepper motor´s shaft that passes through the central hole. The magnets work as the locking mechanism. One of the coupling plates is assembled to the hotend housing whereas another coupling plate is assembled to the hotend. The hotend and its housing are assembled automatically by using G-code.

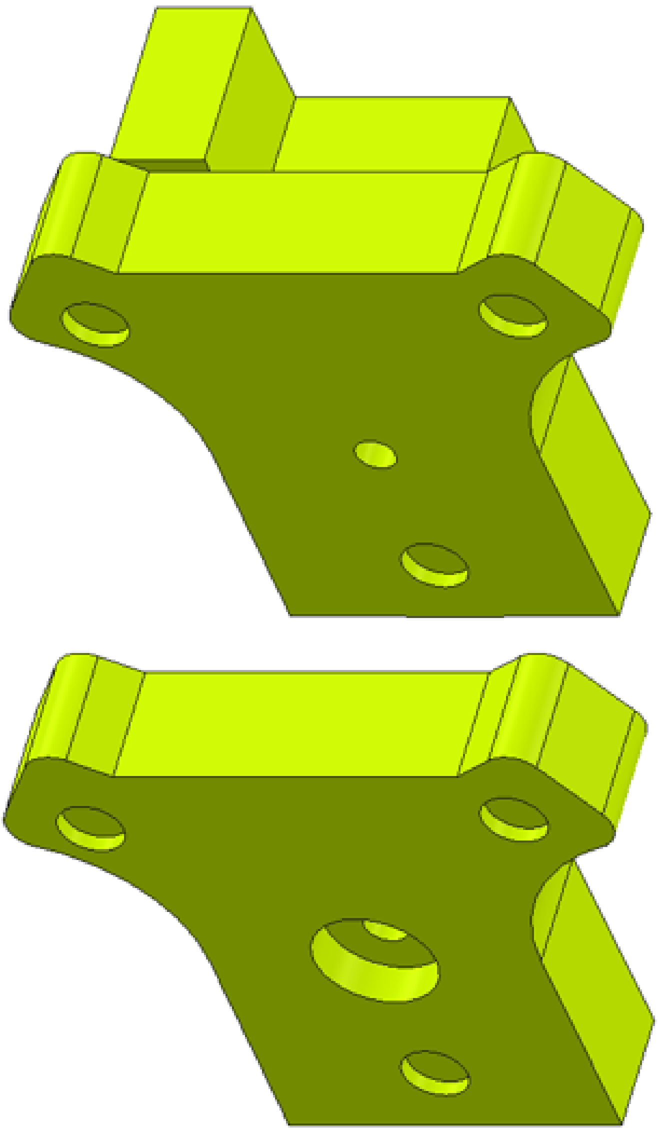


Figure 22: Coupling plates

3.1.11 Hotend Hanger

The hangers are welded to the inner right wall of the MHI3D printer frame. These contains spring loaded pins (Pogo pins) on it, which assembles to the holes in the hotend assembly. The hotend is taken to the hotend hanger from the extruder during automatic tool changing and new hotend assembly is taken from another hotend hanger. It can be called as the parking place for the hotends.

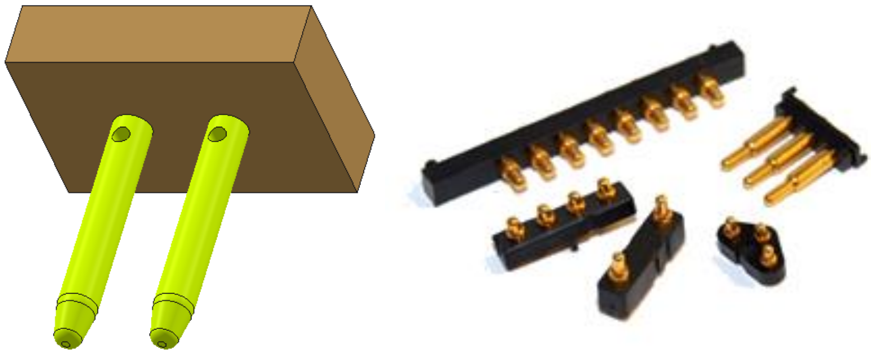


Figure 23: Hotend hanger (N and H Technology,2019)

3.1.12 Heat Break

The heat break is connected to heat sink and heat block, which confine most of the heat near the nozzle, creating a as small transition area as possible.

Figure 24: Heat Break (Amazon,2019)

3.2 2D Drawing

2D drawing is the process of creating two-dimensional drawing of the object. These drawings were created directly from the 3D model in this project. The 2D drawings were designed by using PTC Creo Parametric version 4 CAD software.

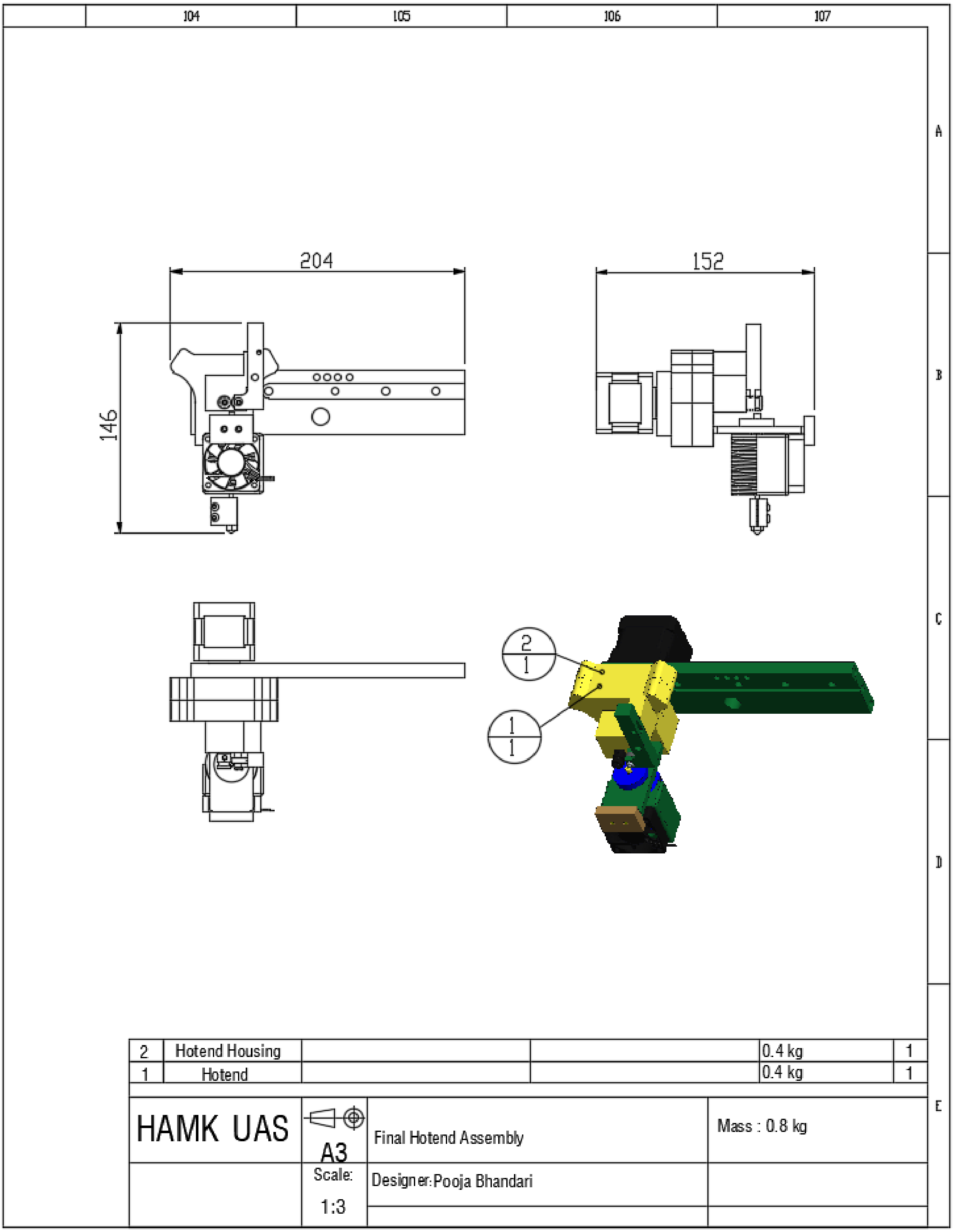


Figure 25: Assembly of extruder, arm plate and motor

4 AUTOMATIC MECHANISM

The manual tool changing system was modified to automatic tool changing system. The extruder assembly was newly designed with coupling mechanism on it. The attaching mechanism is made by using the magnets. Several extruder assemblies are arranged accordingly in the inner wall of the MHI3D printer. The system needs to be programmed for the automatic tool changing system.

5 MATERIAL SELECTION

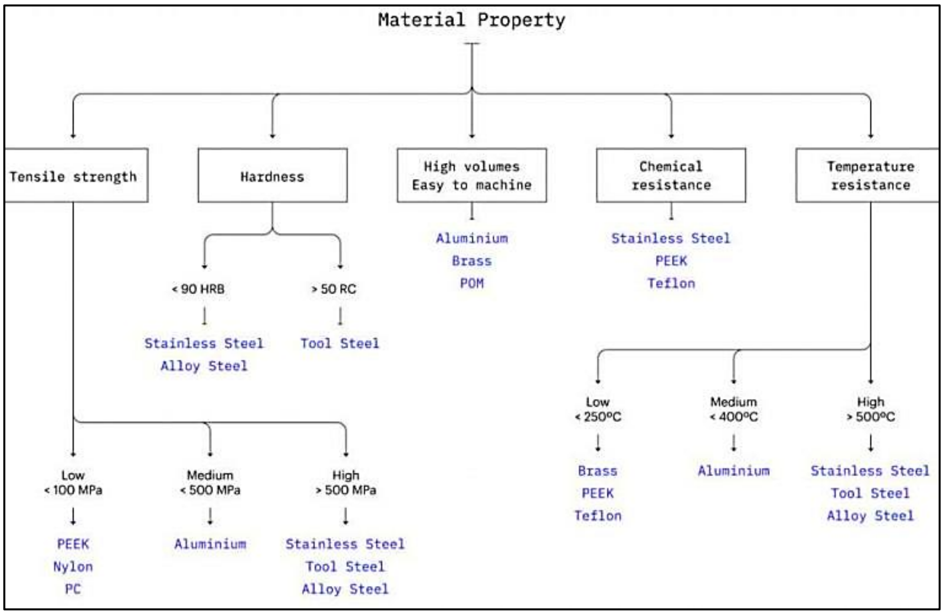


Figure 26: Material Properties (CNC cutting shops,2019)

Material selection is one of the most important part in product design. It determines the lifespan and quality of work done by the product. Following things are considered in material selection of purchase components and remaining components needed to be manufactured by MHI Oy:

- High yield strength
- High tensile strength
- No/low corrosion
- Cheap
- Temperature resistance
- Chemical resistance
- Easy to assemble
- High fatigue strength
- Toughness
- Hardness
- Brittleness

Table 3 Filament Properties (Research gate,2019)

Filament	Based on	Advantages	Used In	Print Temp. (C)	Heated Bed – Temp (C)	Print Difficulty
PLA	Polylactic Acid	User Friendly	Consumer Products	180 -230	No	Easy
ABS	Acrylonitrile Butadiene Styrene	High Strength	Moving Parts	210-250	50-100	Moderate
PETG	PET+Glycerol	Hight Strength	Moving Parts	220-235	No	Moderate
Flexible TPE/TPU	Thermoplastic Elastomer	Elastic	Wearable's	225-235	No	High
HIPS	High Impact Polystyrene	Dual extrusion with ABS	Support Structure	210-250	50-100	Moderate
PVA	Polyvinyl alcohol	Dual extrusion with ABS	Support Structure	180-230	No	Easy
Nylon	Polyamide	High Strength	Moving Parts	220-260	50-100	Moderate
PET (CEP)	PolyEthylene Terephthalate	High Strength	Moving Parts	220-250	No	Moderate
Carbon Fiber	PLA+Carbon Fiber	High Strength	Moving Parts	195-220	No	Moderate
PC	Polycarbonate	High Strength	Temperature Resistance	270-310	90-105	Moderate
Conductive	PLA+Carbon	Conductive	Electronics	215-230	No	Easy
ASA	Acrylonitrile Styrene Acrylate	High Strength	Weather Resistance	240-260	100-120	Moderate
PP	Polypropylene	High Strength	Flexible Components	210-230	120-150	High

6 DESIGN FOR MANUFACTURABILITY AND ASSEMBLY (DFMA)

Design for manufacture means design of a product with ease of manufacturing and Design for Assembly means design of a product with ease of assembly. DFMA is one of the principles of concurrent engineering and has various benefits in developing the product with low cost, high quality and low production time.

In the design of the automatic tool changing system, hotend, coupling plates and hotend hanger needs to be manufactured and assembled so design for manufacturability and assembly requires to be considered.

6.1 Manufacturing

Manufacturing is process of production of the machineries by using several processes. Some of the components in the automatic tool changing system are needed to be manufactured by MHI Oy whereas some of the components are commercially available.

Following table shows the information on origin of the materials, manufacturing process and estimated time to manufacture:

Table 4 Manufacturing time process and material

Part	Material	Manufacturing Process/ Commercially available	Estimated Time
Heatsink, Cover	Aluminium	Turning	1 hour
Nozzle	Brass	Commercially available	
Coupling plates	S235	Milling	30 minutes
Feeder, Heat Break	Stainless steel	Commercially available	
Tube	S235	Turning	20 minutes
Heat box, Hotend hanger	Stainless steel	Turning	60 minutes

6.2 Assembly

Various components like Extruder, nozzle, coupling plates, magnets, feeder and tube are needed to be assembled to develop automatic tool changing system for MHI3D printer. The main theme is to assemble the product easily in short time.

Screw is used in the assembly of lever and coupling plate and also used to assemble motor and armplate whereas, the hotend cover can be assembled to hotend either by welding or by gluing. The coupling plate and arm plate can be welded together by using fillet weld of the fillet size 3mm also the hotend assembly can be assembled by using fillet weld of fillet size 3mm to the coupling plate and magnets can be glued to the coupling plates.

7 COST ANALYSIS

Cost analysis is another important phase in the design of the product. Reducing the cost of the product without reducing the quality and function of the product is one of the main aims in product design.

Rough cost amount is estimated after the product design. Cost analysis includes material, manufacturing and assembly cost.

Table 5 Cost Analysis

Component	Quantity	Price/Unit (€)	Total
Nozzle	1	10	10
Heatsink and cover	1	50	50
Coupling plates	2	25	50
Heat break	1	10	10
Feeder	1	10	10
Tube	1	10	10
Heat box	1	50	50
Fan	1	10	10
Motor	1	15	15
Assembly + Others			50
Total			265€

8 CONCLUSION

This thesis topic was commissioned by MHI Oy. The main aim of this thesis work was to design automatic tool changing system for next version of MHI3D printer.

With a manual nozzle-changing printer, to replace the hotend, the user needs tools to disassemble the hotend unit. Disassembling the unit in this way is very inefficient as the operator must follow each step in the printer's maintenance manual. Hence, for the improvement of the design of the printer, this process was automated, and the nozzle-changing procedure is expected to be effortless and this was done by developing an automated tool changer for this 3D Printer.

To change the hotend package, first the hotend has to heat up to approx. 200 degree Celsius, after that filament has to be removed from it by doing retraction from the MHI3D's screen or by pulling the filament from the hotend. Also, the heater wire has to be disconnected. Behind the motors (Arm of MHI3D Printer), there is an electronic connector that has to be removed in order to remove the hotend package and then a screw has to be opened from the hotend. Finally, the hotend is ready for removing and the users can change the hotend package to new one or they can put back the same hotend into the machine by following the reverse order of removal.

Here, this process was improved by developing a process for automatic replacement and an automatic mechanism to change the nozzle so that the system is more convenient. On the inner side wall of the machine, two ready hotend packages with different nozzles of different sizes like 0.4, 0.35 (mm) were placed for automatic replacement.

At the end of the project, automatic tool changing system for MHI3D printer was designed which fulfilled the requirements of the commissioning party. The research was made, and ideas were created followed by the continuous improvement, solution 2 was finalised.

It is expected that the hotend packages will be automatically replaced according to the command made by the MHI Oy in the upcoming days.

Overall, it was great experience doing this thesis as I got more information about 3D printer and machine design. Also, I developed the skills like designing the extruder parts and planning the production process.

Thank you to all the parties involved in this thesis project.

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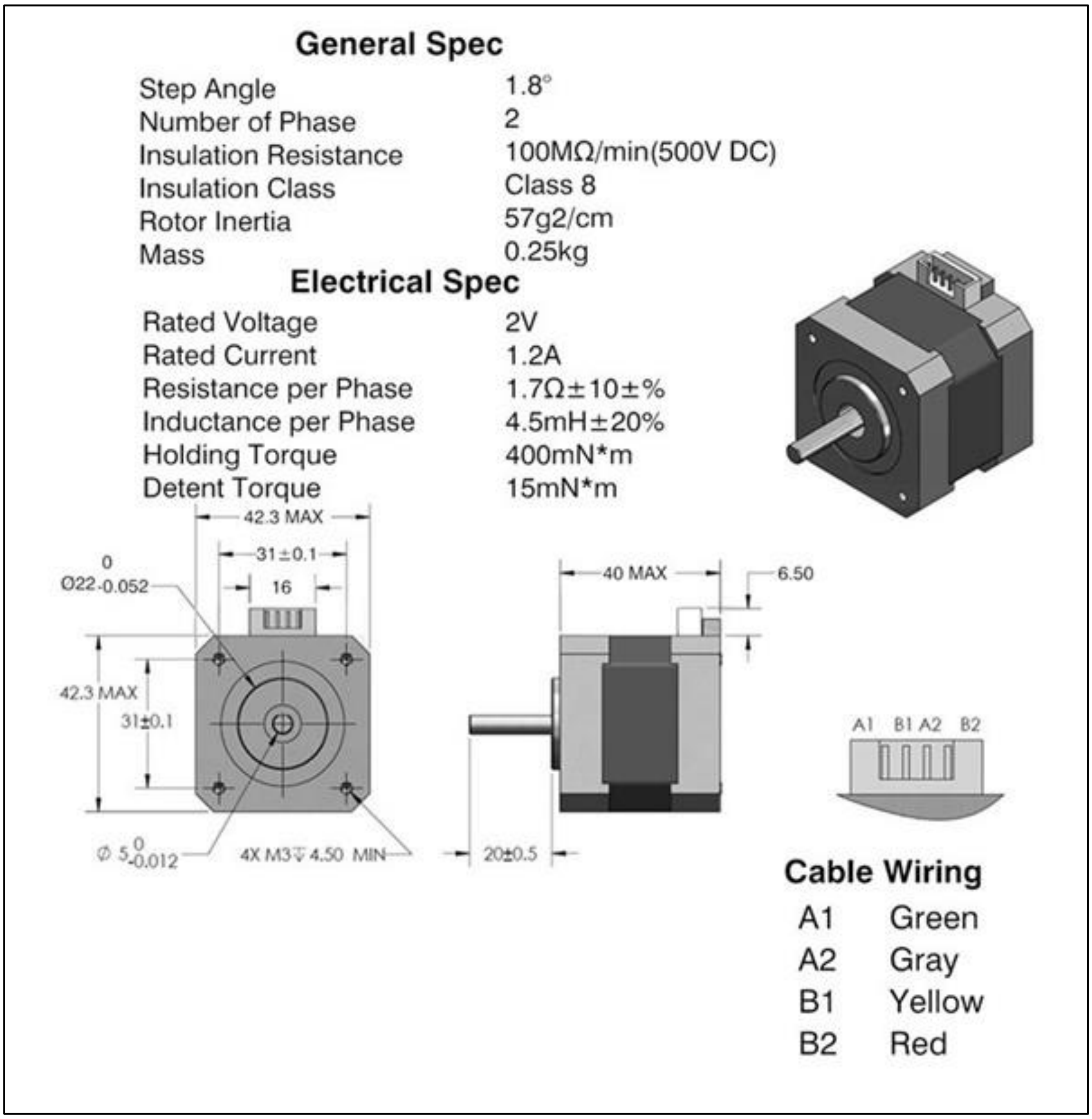
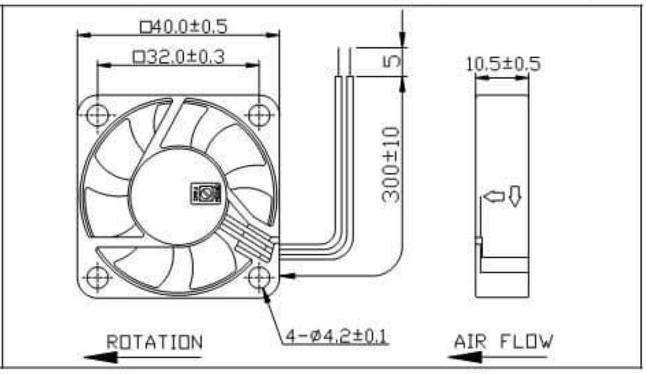
Appendix 1: Technical data of NEMA stepper motor (Ebay,2019)



Appendix 2: Technical data of fan (Mouser Electronics,2019)

OD4010 Series

DC Fan - 5, 12, 24V
40 x 10mm (1.58" x 0.39")

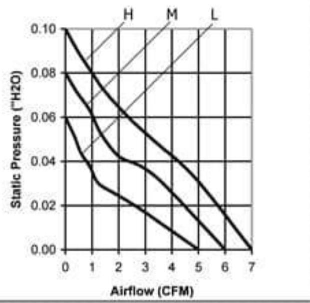


Frame & Impeller	PBT, UL94V-0 plastic
Connection	2x Lead wires 26AWG
Motor	Brushless DC, auto restart, impedance and polarity protected
Bearing System	Ball bearing
Insulation Resistance	10M ohm between leadwire and frame (500VDC)
Dielectric Strength	1 minute at 500 VAC, max leakage < 500 MicroAmp
Storage Temperature	-40C ~ +80C

Available Options:
Tachometer
Alarm
PWM
Sleeve bearing
Life Expectancy (L10)
Ball - 60,000 hrs (45C)
Sleeve - 30,000 hrs (45C)6
Operating Temperature
Ball: -10C ~ 70C

Weight: ~ 0.04 lbs

m1



Model Number	Speed (RPM)	Airflow (CFM)	Noise (dB)	Volts DC	Voltage Range (VDC)	Amps	Max. Static Pressure ("H_2O)
OD4010-05H*	6000	7	25	5	4 ~ 5.5	0.19	0.10
OD4010-05M*	4800	6	20	5	4 ~ 5.5	0.11	0.08
OD4010-05L*	4200	5	14	5	4 ~ 5.5	0.08	0.06
OD4010-12H*	6000	7	25	12	10.8 ~ 13.2	0.10	0.10
OD4010-12M*	4800	6	20	12	10.8 ~ 13.2	0.08	0.08
OD4010-12L*	4200	5	14	12	10.8 ~ 13.2	0.07	0.06
OD4010-24H*	6000	7	25	24	21.6 ~ 26.4	0.09	0.10
OD4010-24M*	4800	6	20	24	21.6 ~ 26.4	0.08	0.08
OD4010-24L*	4200	5	14	24	21.6 ~ 26.4	0.07	0.06

To indicate sleeve bearing replace "B" suffix with "S" in part number (30,000 hTrs life expectancy)
To indicate sealed sleeve bearing replace "B" with "SS" in part number (50,000 hTrs life expectancy)

Knight Electronics, Inc.
10557 Metric Drive
Dallas, Texas 75243
214-340-0265

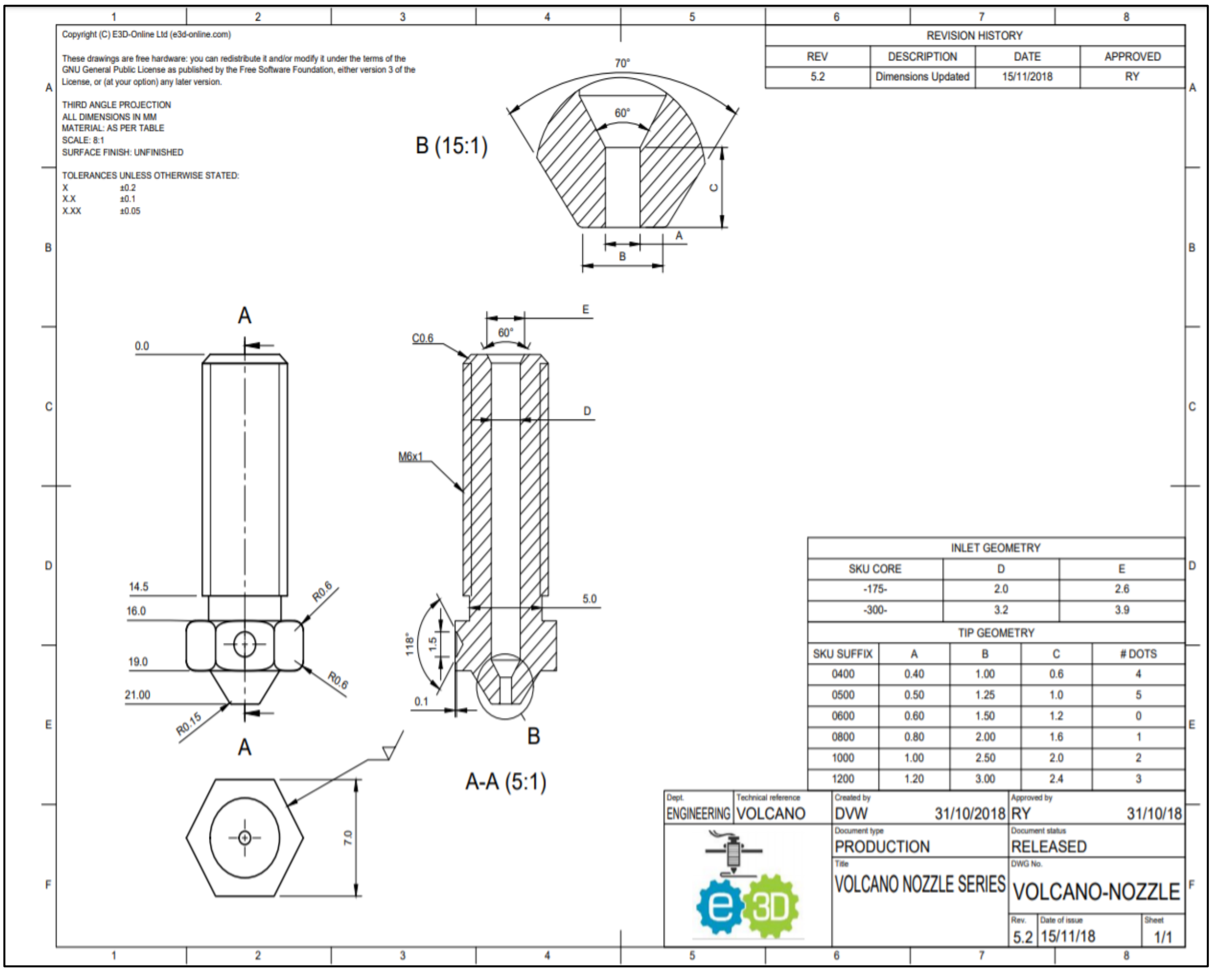
RoHS Compliant

1

TÜV

Orion Fans
Information and data is subject to change without prior notification.

Appendix 3: Technical data of volcano nozzle (Ebay,2019)



REVISION HISTORY

REV	DESCRIPTION	DATE	APPROVED
5.2	Dimensions Updated	15/11/2018	RY

INLET GEOMETRY

SKU CORE	D	E
-175-	2.0	2.6
-300-	3.2	3.9

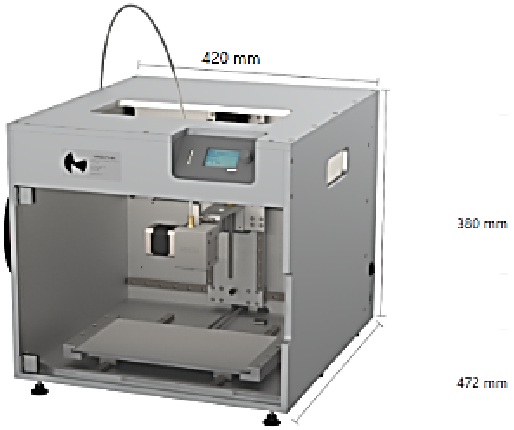
TIP GEOMETRY

SKU SUFFIX	A	B	C	# DOTS
0400	0.40	1.00	0.6	4
0500	0.50	1.25	1.0	5
0600	0.60	1.50	1.2	0
0800	0.80	2.00	1.6	1
1000	1.00	2.50	2.0	2
1200	1.20	3.00	2.4	3

Appendix 4: Technical data of MHI 3D printer (Mehta Heino,2019)

Size & Weight

Dimensions (W x D x H)	420 x 472 x 380 (mm)
Weight	32 kg (approx).
Build Volume (W x D x H)	250 x 150 x 200 (mm)
Weight	32 kg (approx).



Printer & Printing Properties

Assembly Type	Full assembled & Factory calibrated
Layer Resolution	Standard 0.2 mm or 0.1mm
Build plate levelling	No more adjustments. Just slide the printing plate in. *[2 pieces of Build plate included with the purchase of MHI3D Printer]*
Printing Technology	Fused Filament Fabrication (FFF) *[Also known as Fused Deposition Modeling (FDM) – TradeMark of Stratasys]*
Feeder Type	Direct gear feeder System *[Re-engineered feeder system for accurate and precise feeder of the materials]*
Print Head	Single Nozzle *0.4 mm* (standard) *[Easy to change the hot-end package and free of adjustments]*
Nozzle temperature	Up to 280 °C *[< 2min – Nozzle heat up time]*

Materials

System	Open Filament System
Filament diameter	1.75 mm
Supported filament	PLA, ABS, UPM Formi, Polypropylene (PP), TPU 95 (Flexible Materials)

Support for more materials are coming soon. Materials like Nylon, CPE are under testing and the simplify3D profiles will be available for everyone. Stay tuned.

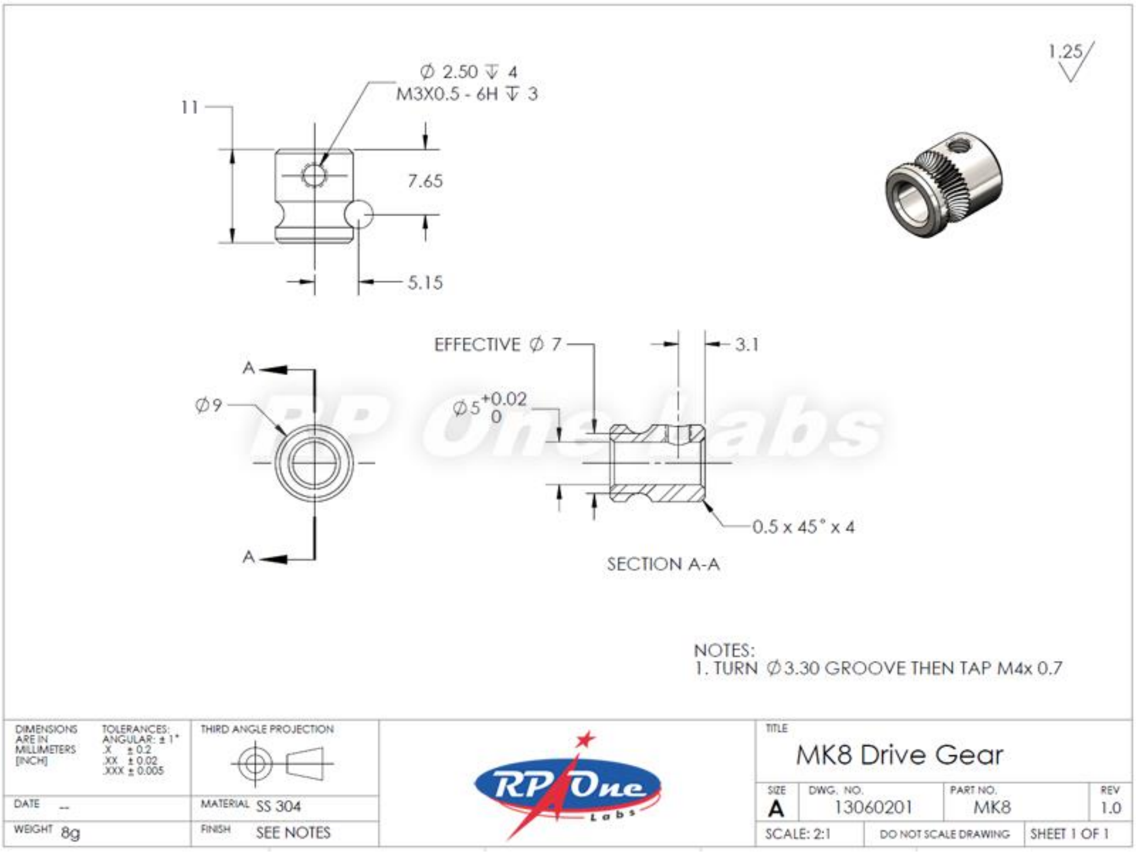
Requirements

Software	Simplify3D [License is included with the purchase of MHI3D Printer] * *MHI3D Slicing Software under development*
Supported operating system	MacOs, Windows & Linux
Support file types	STL, OBJ, X3D, 3MF
File transfer	SD card (security features optional) *[2 pieces of SD card is included with the purchase of MHI3D Printer]*
Operating environment	

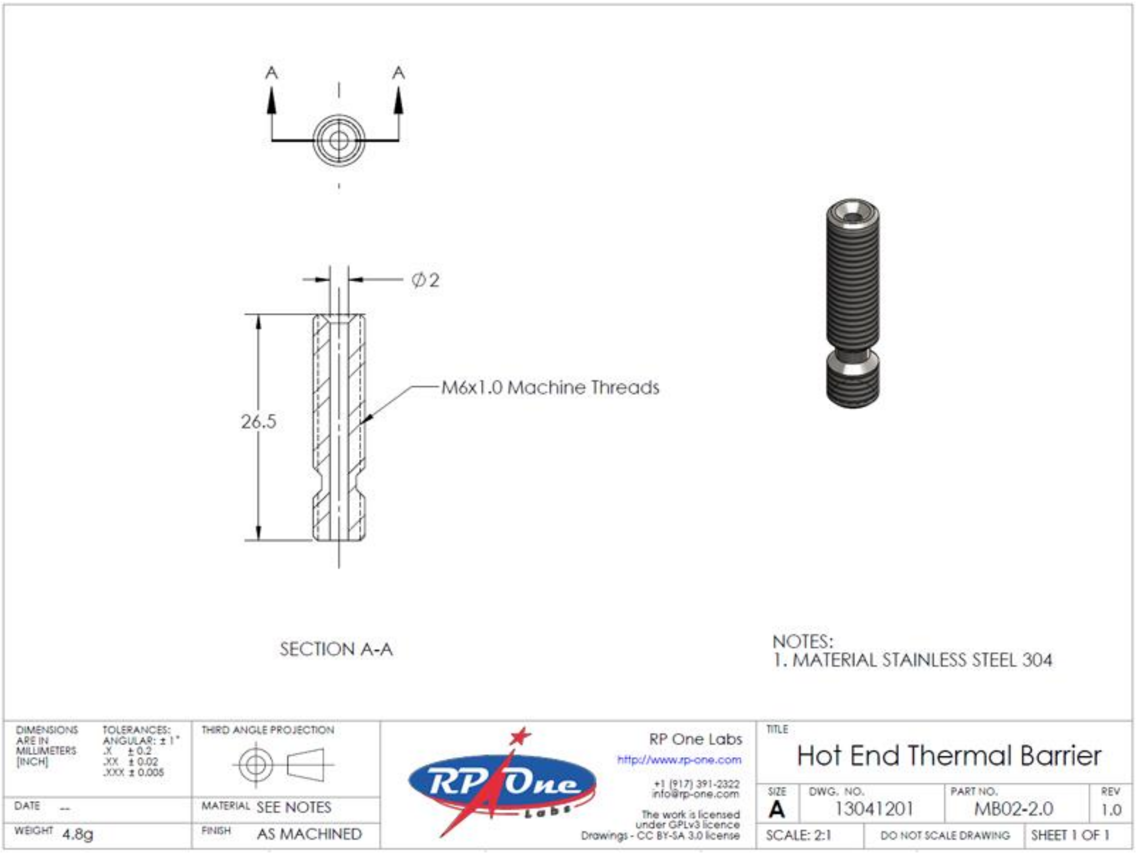
Input & Output

Input	100 – 240 v *4A, 50 – 60hz, 221 W max.*
Output	12 V (DC) *15A*

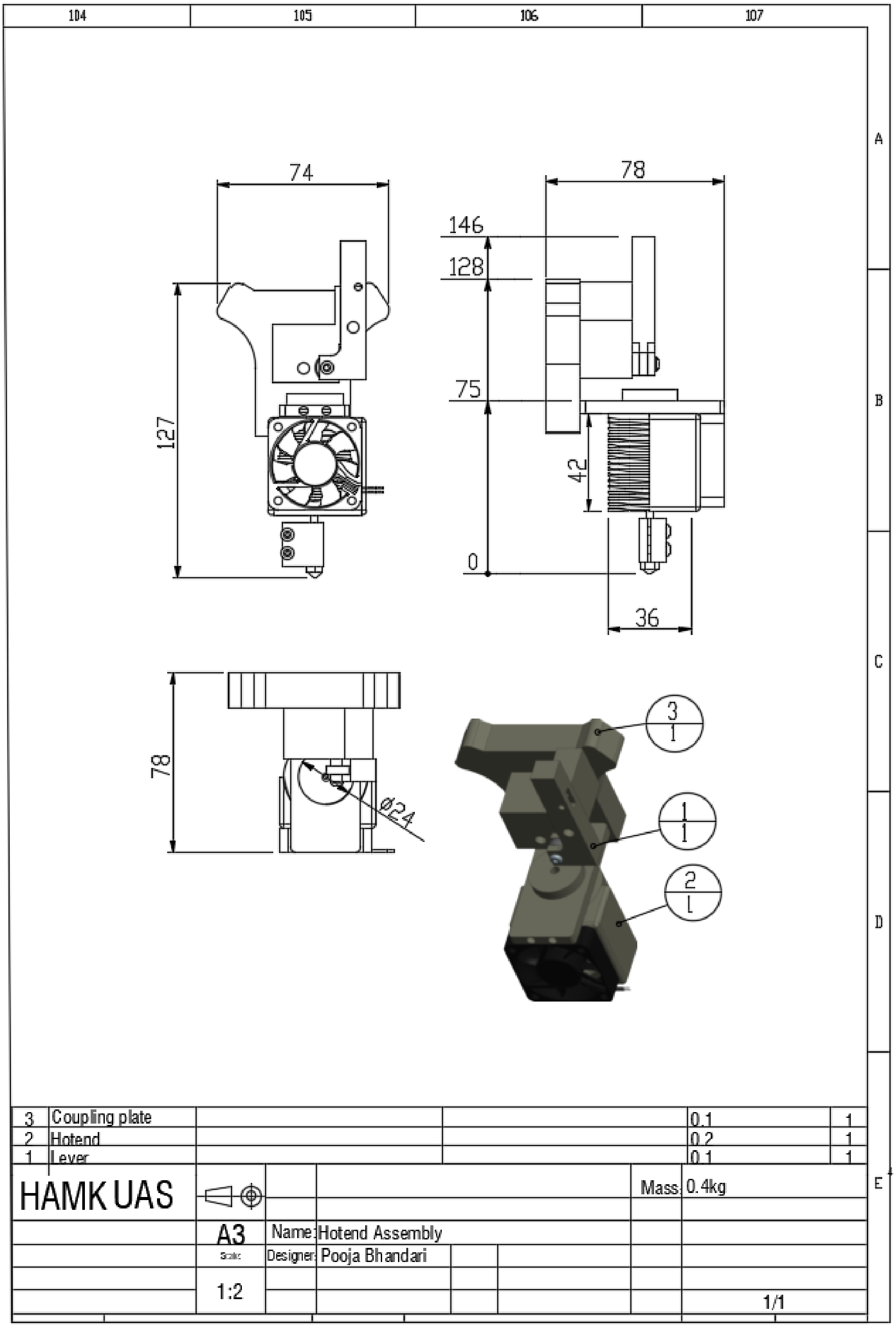
Appendix 5: Technical data of gear (Domoticx,2019)



Appendix 6: Technical data of heat break (Domoticx,2019)



Appendix 7: Technical data of hotend assembly



Appendix 8: Technical data of hotend housing