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Project Graduation
For Obtaining the Master's Degree In
Mechanical and Production Manufacturing

Conception and Realization of 3D Printer

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Acknowledgment

We would love to take these few lines,

to thank our parents for their unconditional support and encouragements throughout our entire academic and professional life.

For all the care and the supervision they raised us with. None of this would have been possible if it wasn't for their great efforts.

As well as our promoters and teachers for this year and our previous years, for their unlimited help and guidance.

Our friends also deserve a share of our gratitude for the joy they offered in the hard times and all the aid they provided along with the wise advices.

Abstract:

3D printing is known as an advanced process that is increasingly used in modern industry. In reality, the 3D printer has a significant impact on the industry. This master's thesis describes the flexibility of this machine by evoking these parts and the materials used, and by predicting the errors of Software and Hardware from the theories of the elements. Then design and build the machine.

Résumé:

L’impression 3D est connue en tant qu’un processus avancé de plus en plus utilisé dans l'industrie moderne. En réalité, L’imprimante 3D a un impact important sur l’industrie. Ce mémoire de master décrit la flexibilité de cette machine en évoquant ces pièces et les matériaux utilisés, et en prévoyant les erreurs du Softwares et du Hardware à partir des théories des éléments. Puis faire la conception et la réalisation de la machine.

مقدمة :

تُعرف الطباعة ثلاثية الأبعاد بأنها عملية متقدمة تستخدم بشكل متزايد في الصناعة الحديثة. في الواقع، الطابعة ثلاثية الأبعاد لها تأثير كبير على الصناعة. تصف أطروحة الماستر هذه مرونة هذا الجهاز من خلال استحضار هذه الأجزاء والمواد المستخدمة، ومن خلال التنبؤ بأخطاء البرامج والأجهزة من النظريات . ثم تصميم وبناء الجهاز

List of abbreviations and symbols

Pt	Number of steps per turn
Ap	Angle of step
De	Distance of the filament pushed before the extrusion head
Ve	Volume of the filament pushed before the extrusion head
Df	Distance of filament pushed from the extrusion head
Vf	Volume of the filament pushed after the extrusion head
3D	3 Dimensions.
ABS	Acrylonitrile Butadiene Styrene
ACIS	Standard ACIS Text (.file format)
CAD	Computer Aided Design
CNRS	National Center for Scientific Research
DIY	Do It Yourself
DLP	Digital Light Processing
DTM	Desk Top Manufacturing
DWG	Device Working Group (.file format)
FDM	Fused deposition modeling
FFF	Fused filament fabrication
HIPS	High Impact Polystyrene
IDE	Integrated development environment
KT	Torque constant
LCD	Liquid crystal display
MIT	Massachusetts Institute of Technology
OBJ	Geometry definition file format (.file format)
PDF	Portable document format (.file format)
PET	Polyethylene terephthalate
PLA	Polylactic Acid
PM	Permanent Magnet

PPSF	Polyphenylsulfone
RISC	Reduced Instruction Set Computer
SLA	Stereolithography
SLS	Selective Laser Sintering
STEP	Standard for the Exchange of Product model data (.file format)
STL	Stereolithography (.file format)
TH	Holding Torque
UV	Ultra violet
VR	Variable Reluctance

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General Introduction:

Three dimensional (3D) printing has evolved dramatically through the past years. 3D printers has became plentiful and affordable enough that anyone can own one it can be an attractive choice in businesses, researchers, educators, and even hobbyists alike. it can be used to create prototypes for manufacturing engineering models, or fix thing around your place.

Every 3D Printer needs a specific material in order to draw the 3D objects as a final product, this phase requires the plastic material, its devided to different types.

3D printers must be properly assembled, adjusted, maintained and repaired when they break. Many of the problems encountered when printing are related directly to some mechanical adjustment or software settings. We will be covering how 3D printer works , softwares (3D Softwares that supports this operation, Files Formats, Arduino Program…) and hardware (Electronics and Mechanical Material) required, types of plastic supplies. Along with the theory of its elements and the 3D conception, we will do the building and calibrating process.

Chapter I

Introduction to 3D Printer

I.1) Introduction:

in this first chapter , we will take notes about the 3d printer as its definiton, the history and its evolution and the types of 3d modeling that exist in this industry, and what can be done with it.

I.2) What is a 3D Printer :

To understand what's a 3D printer, we have to dissociate theses words ''3D'' and "Printer". Let's start with the word Printer, as simple it seems to be it refers to printing as our traditional printer who will print in a paper of different sizes and to make words appear the printer needs some inks . The technologies for theses printers are two types : Inkjet and Laser. The ink jet sprays a bit of ink (black or color) on the paper, and after a few seconds, spits out the latest chapter of your novel, the report your boss wanted ten minutes ago, or directions to the nearest computer repair shop. Laser printers use a different, more complicated method of applying an electric charge to a round drum that picks up toner
(a laser printer's "ink") and then applies that toner to a page.
Inkjet and laser printers print on flat paper**[1]**. And Here we have our hard copy of our digital file but as the ink's thickness is negligible, we'll say that is print in a plan of (X,Y) otherwise two-dimensional plan. But can we print with these inks and give them a proper thickness and consider that as a three-dimensional plan? sorry for you, but we can't!
that's why the 3D printer was created for this purpose, to get your last 3D model that you have created, with Solidworks or blender and other application of designs to come from codes and virtuality to reality. to create our 3D model, we will need some plastics filament,

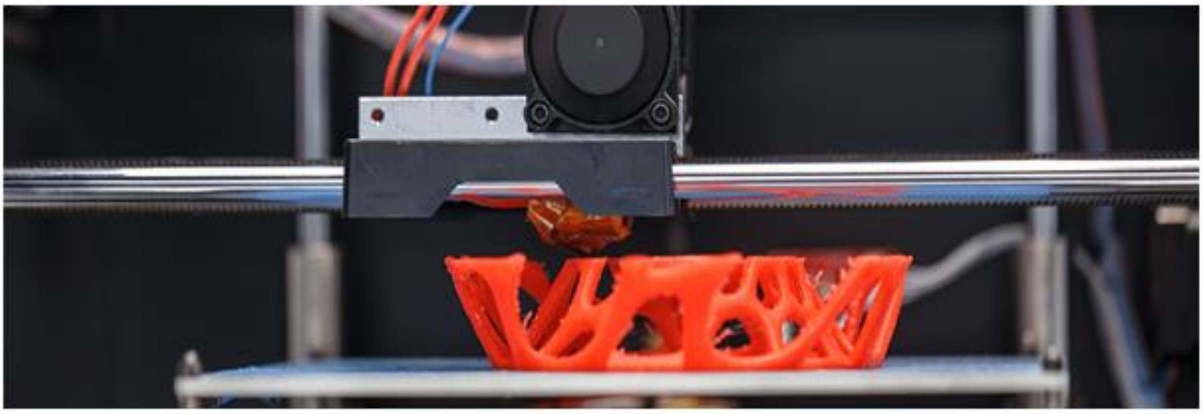


Figure I.1: process of 3D impression

that's the "ink" for our machine, such as ABS, PLA, HIPS and other type of plastics. as obvious it seems to be our 3D printer works in a three-dimensional plan (X,Y,Z), so the extruder will move in three directions with three axes, X and Y to print the length and width and for the third one will move in a Z axe to give to our model his thickness and this operation is called "Additive manufacturing" who has several forms or types that refer to the material used and the process used to take the material and form the object. However, they all use the same basic steps (called a workflow) to create the object.
Let's start from a raw idea and see how the idea is transformed into a physical object using additive manufacturing. An object is formed using computer-aided design (CAD) software. The object is exported in a file format that contains the standard tessellation language for defining a 3D object with triangulated surfaces and vertices.**[2]**
So one in for all, the 3D Printer is a machine allowing the creation of a physical object from a three-dimensional digital model, typically by laying down many thin layers of a material in succession.

I.3) History of 3D Printer:

The history of 3D printing begins in 1981 with Dr. Hideo Kodama's patent application for a rapid prototyping device. As far as we're aware, Dr. Kodama is the first person ever to apply for a patent in which laser beam resin curing system is described. Unfortunately, the Japanese doctor's application never went through. Due to issues with funding, he was unable to complete the process before the one-year deadline.

Nevertheless, the idea of "rapid prototyping devices" continued to develop, and the next people we know about who had an impact on the idea were Jean-Claude André, Olivier de Witte, and Alain le Méhauté. Back in the 80s, le Méhauté was working at Alcatel researching fractal geometry parts. He argued with his colleagues because they thought his thinking was "off the path". Still, he was determined to prove himself, and so started thinking about how to produce such complex parts.

Le Méhauté shared his problem with de Witte, who was working for a subsidiary of Alcatel. Having worked with lasers, de Witte knew about liquid monomers that could be cured to solids with a laser. This opened the way to building a rapid prototyping device.

The two brought the new idea to André, who was working at the French National Center for Scientific Research (CNRS). Although he was interested in the idea, the CNRS ultimately didn't approve of it. Apart from a lack of equations, they claimed it simply didn't have enough areas of application…

The trio filed for a patent in 1984, but without proper funding, they were forced to abandon the project.**[3]**

Charles W. (Chuck) Hull is generally credited with developing the first working robotic 3D printer in 1984, which was commercialized by 3D Systems in 1989. These machines were systems that used a laser to harden liquid resin, and many machines still use this technology. Other early work was taking place at the Massachusetts Institute of Technology (MIT) and the University of Texas. Meanwhile, S. Scott Crump and Lisa Crump patented fused deposition modeling (FDM) in 1989 and co founded printer manufacturer Stratasys, Ltd. This technology (more generically called FFF, for (fused filament fabrication) feeds a plastic filament into a heated extruder and then precisely lays down the material. When key patents expired in 2005, this technology became the basis of the RepRap movement.**[4]** This thesis mostly focuses on this type of printer.

I.4) Evolution of 3D printer:

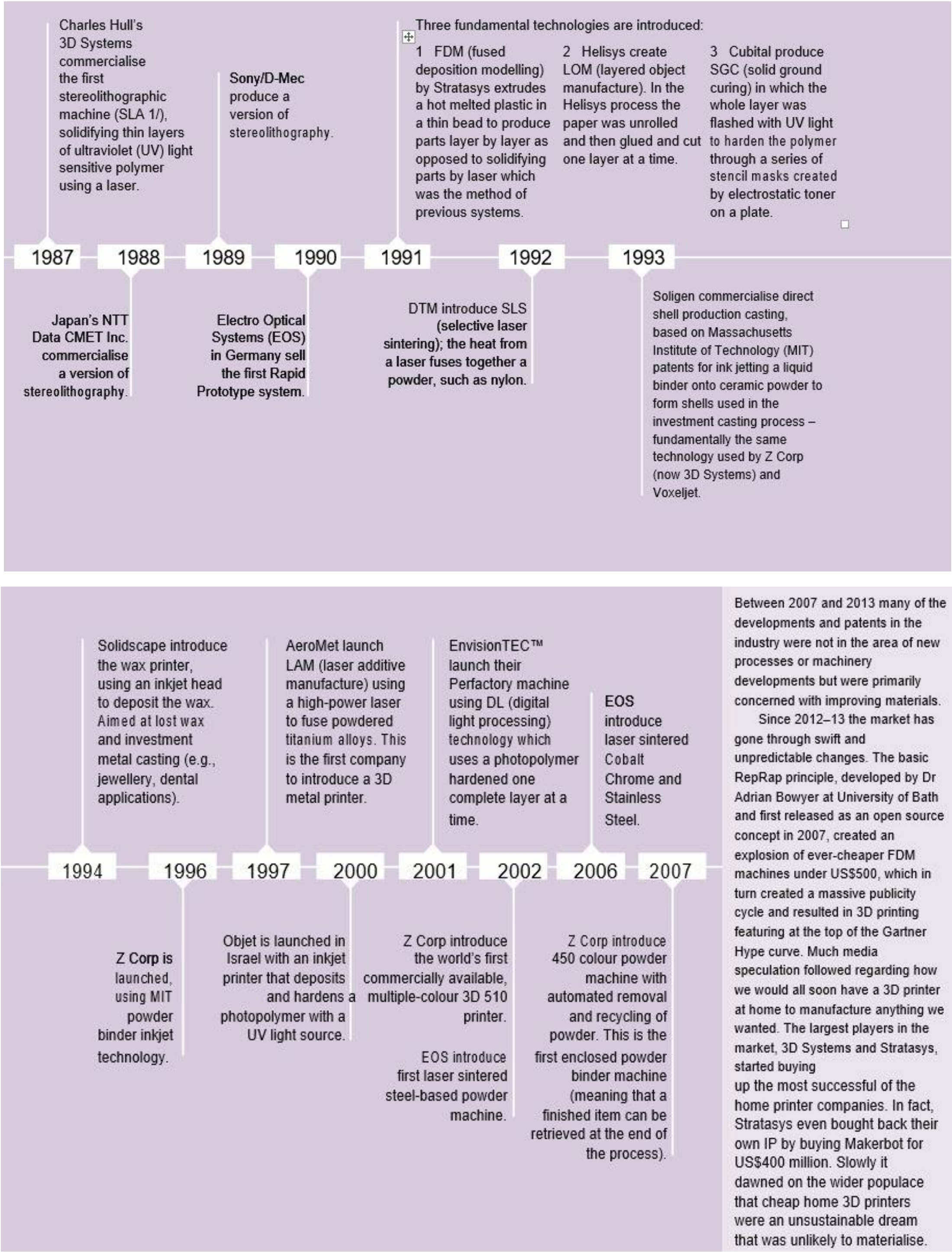


Figure I.2 : Timeline of 3D machine Development. [5]

I.5) Type of 3D printers:

I.5.1) Fused deposition modeling (FDM):

Figure I.3: Fused deposition modeling Material

FDM technology is currently the most popular 3D printing technology and used in both affordable 3D printers and even 3D pens, which we happen to specialize in. This technology was originally developed and implemented by Scott Crump from Stratasys, founded, in the 1980s. Other 3D printing companies have embraced similar technology but under different names. A well-known manufacturer MakerBot coined a virtually identical technology, calling it Fused Filament Fabrication (FFF). With the assistance of FDM, you can print not just operational prototypes, but also ready-for-use products such as lego, plastic gears and much more. What's great about this technology that all components printed with FDM can go in high performance and engineering-grade thermoplastic, which is quite beneficial for mechanic engineers and manufacturers.

FDM is the only 3D printing technology which uses production-grade thermoplastics, so items printed have excellent mechanical, thermal and chemical attributes.

3D printers which use FDM Technology construct objects layer by layer from the very bottom up by heating and extruding thermoplastic filament. The whole process is somewhat similar to stereolithography. Specialized programs or Slicers "cut" CAD models into layers and computes the manner printer's extruder would assemble each layer. In addition to thermoplastic, a printer may extrude support materials too. Then the printer heats thermoplastic until its melting point and extrudes it throughout nozzle on a printing bed, which you may know as a build platform or a desk, on a predetermined pattern determined by the 3D model and Slicer software. The Slicer software running on the computer connected to the 3D printer translates the measurements of an object into X, Y, and Z coordinates and controls the nozzle and the foundation follow calculated route during printing.

When the thin layer of plastic binds to the layer beneath it, it melts and hardens. When the layer is completed, the base is lowered (as shown in step 5) to accommodate the printing of the next layer, this is shown in steps 1 to 5 in the diagram below.

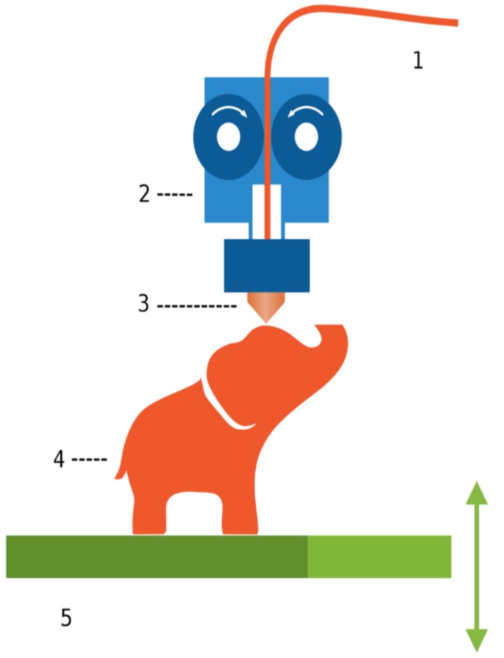


Figure I.4 : The full FDM process in 5 steps

Printing time depends upon size and complexity of your model. Small objects can be completed relatively quickly, while larger, more intricate parts need more time. When compared to SLA, FDM has a slower printing speed. Overall printing time depends upon size and complexity of your model. Small objects can be completed relatively quickly, while larger, more intricate parts need more time. When the printing is finished supporting materials can readily be removed either by putting an object into a detergent and water solution or snapping the support material off by hand. Nylon is typically used as a support material and can be dissolved in acetone. Read more about this process in our article about the various types of 3D printer filaments.

Then objects may also be painted, plated or even hammered afterward. FDM technology is widely spread today, and used in industries such as automobile manufacturers, food producers, and toy manufacturers. FDM is used for new product development, prototyping and even in end-product manufacturing. This technology is considered simple-to-use and environment-friendly. Through the use of this 3d printing method, it became possible to construct objects with complex geometries and cavities. We can use many different types of thermoplastics with FDM printers. The most common of these are ABS (Acrylonitrile Butadiene Styrene) and PLA(Polylactic Acid) plastic You can read more about these 3D printer filaments here. Additionally, there are several kinds of support materials such as water-soluble wax or PPSF (polyphenylsulfone). Pieces printed with this technology have excellent mechanical strength and heat resistance, allowing you to use printed models as functional prototypes. FDM is widely for the production end-user goods. We are specifically referring to small, detailed components and technical manufacturing tools. Some thermoplastics (such as PLA, which is non-toxic) may even be utilized in food and drug packaging, making FDM a favorite 3D printing method within the medical sector.

I.5.2) Stereolithography (SLA) :

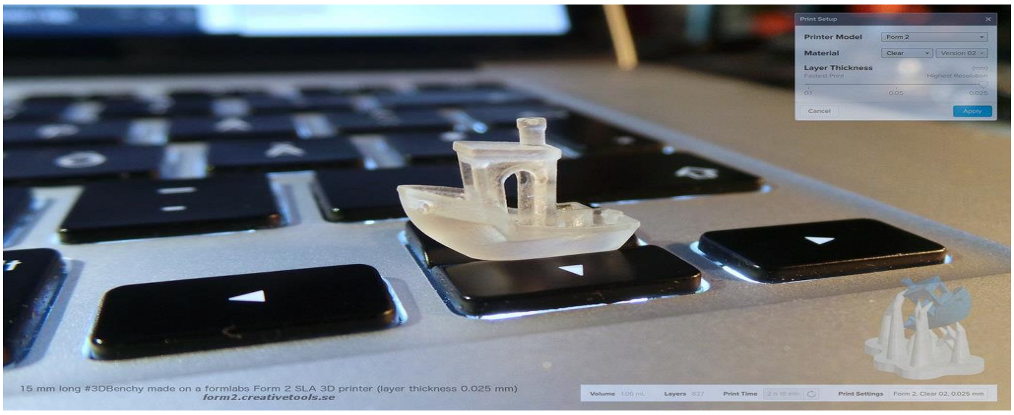


Figure I.5 : Stereolithography 3d model

SLA is a 3d printing method which could be used to execute your projects that involve the 3D printing of items. Although this process is the earliest one in the history of 3D printing, it is still in use today. The idea and application of this method are amazing. Whether you're a mechanical engineer, who wants to confirm whether the part can fit your design or creative individual who wishes to print a plastic prototype for a fresh upcoming project, Stereolithography can truly bring your 3D models to life. SLA printing machines do not function like normal desktop printers that extrude some quantity of ink to the surface. SLA 3D printers operate with an excess of liquid plastic that after a while hardens and forms to a solid object. Parts printed by stereolithography 3D printers usually have smooth surfaces, but its quality depends on the quality of SLA printer used. After the plastic hardens a stage of the printer drops down in the tank a fraction of a millimeter and laser forms another layer until printing is finished. After all, layers are printed, the item has to be rinsed using a solvent and then put in an ultraviolet oven to complete processing.

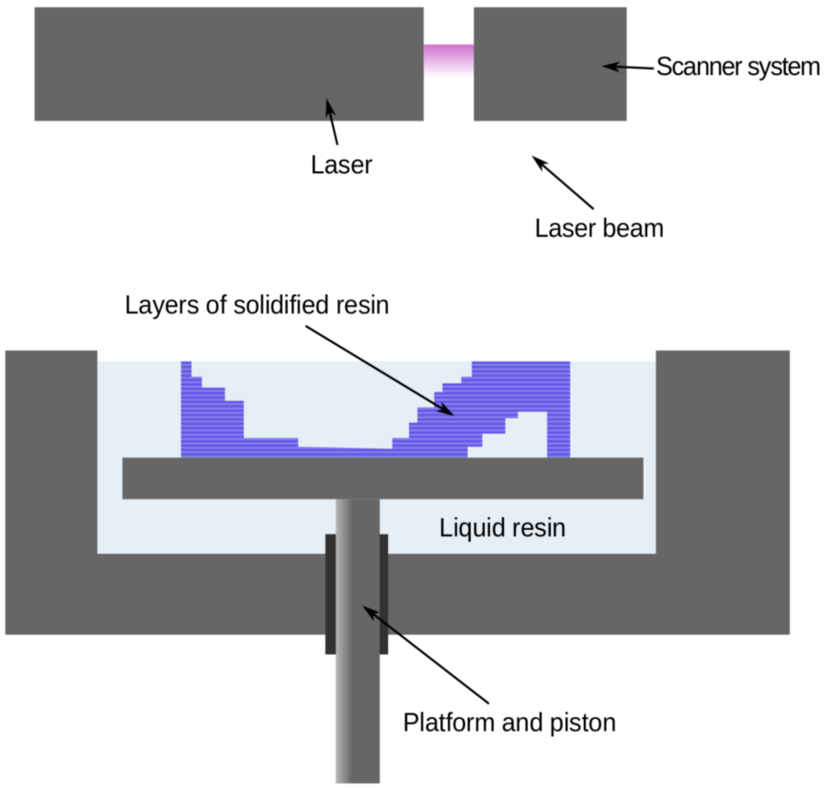


Figure I.6 : SLA printing process explained

The time required to print an object depends upon the size of the SLA 3d printer utilized. Small items can be printed within 6-8 hours using a basic kid's 3D printer, while large 3d prints can be several meters in 3 dimensions and printing time could be up to several days long.

<u>I.5.3) Digital Light Processing (DLP):</u>

DLP is another 3D Printing process quite much like stereolithography. The DLP technology was made in 1987 by Larry Hornbeck of Texas Instruments and became well known for its use in the production of projectors. It utilizes digital micromirrors laid out on a semiconductor chip. The technology is found in mobile phones, film projectors, and, of course, in 3D printing. For

3D printing, both DLP and SLA functions with photopolymers. However, the difference between SLA and DLP technology is that DLA requires an additional source of lighting. 3D printing amateurs frequently use more traditional sources of lights like arc lamps for DLP printing. The other important piece of the DLP puzzle is an LCD (liquid crystal display) panel, which gets applied to the entire surface of the 3D printed layer during a single run of the DLP procedure. The substance used for printing is a liquid plastic resin that's set in a transparent resin container. The resin hardens quickly when exposed to a lot of photons, or more simply put, bright light. The printing speed for DLP is the kicker. A layer of hardened material can be produced with this kind of printer in few seconds. After the layer is completed, it is transferred, and printing of the next layer is started.

I.5.4) Selective Laser Sintering (SLS):

SLS is a technique that uses a laser as power supply to form strong 3D printed objects. This technique was developed by Carl Deckard, a pupil of Texas University, and his professor Joe Beaman in the late 1980s. Later on they participate in base of Desk Top Manufacturing (DTM) Corp., that was sold to its large competitor 3D Systems in 2001. As was mentioned previously, 3D systems Inc. developed Stereolithography (SLA), which per chance happened to be extremely similar to Selective Laser Sintering (SLS). The most notable difference between SLS and SLA is that it uses powdered material in the vat rather than liquid resin in a cube, like SLS does.

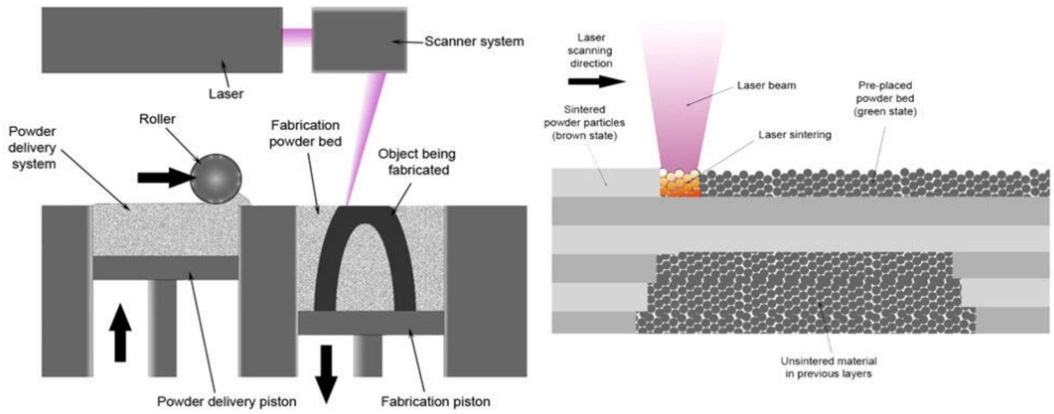


Figure I.7 : Schematic showing how SLS works

Unlike some other additive production processes, such as FDM and SLA, SLS does not have to use some other support structures as the object being printed is surrounded by unsintered powder.

Like the rest of the methods listed above the method begins with the creation of a computer-aided design (CAD) file, which then has to be converted into .stl format with special applications. The material used for printing can range from nylon, glass and ceramics to some metals such as aluminum, silver or steel. Due to large selection of materials which may be used with this sort of 3d printer that the technology is quite popular for 3D printing customized goods. SLS is more dispersed among manufactures instead of 3D amateurs at home as this technology requires using high-powered lasers, resulting in these printers being rather expensive. That being said, there are quite a few startups working on cheap SLS printing machines. For example, recently Andreas Bastian has shared details about his SLS printer (in development) which uses wax and carbon for printing. Another fantastic example is the Focus SLS printer which can be easily used at home requirements and originally was presented at Thingiverse.**[6]**

I.6) Conclusion:

in this chapter we had known the states of this ‘’art’’ what was going on , like his history and evolution through the ages. and all the types of 3d printer or 3d print to use , like SLS ,SLA ,FFF(or FDM). That helped us to choose our model to base on, which is the FDM (Fused deposition modeling).

Chapter II

Necessary equipments

II.1) Introduction:

In the purpose of creation of any types of machines we need some requirements or equipments ,to create our project.
In this chapter we will talk about the requirements needed to create our 3D model such as materials to print it ,and the equipments we need to build our 3D printer.

II.2) Materials:

II.2.1) PLA (Acide polylactique):

PLA is the easiest polymer to print and provides good visual quality. It is very rigid and actually quite strong, but is very brittle.

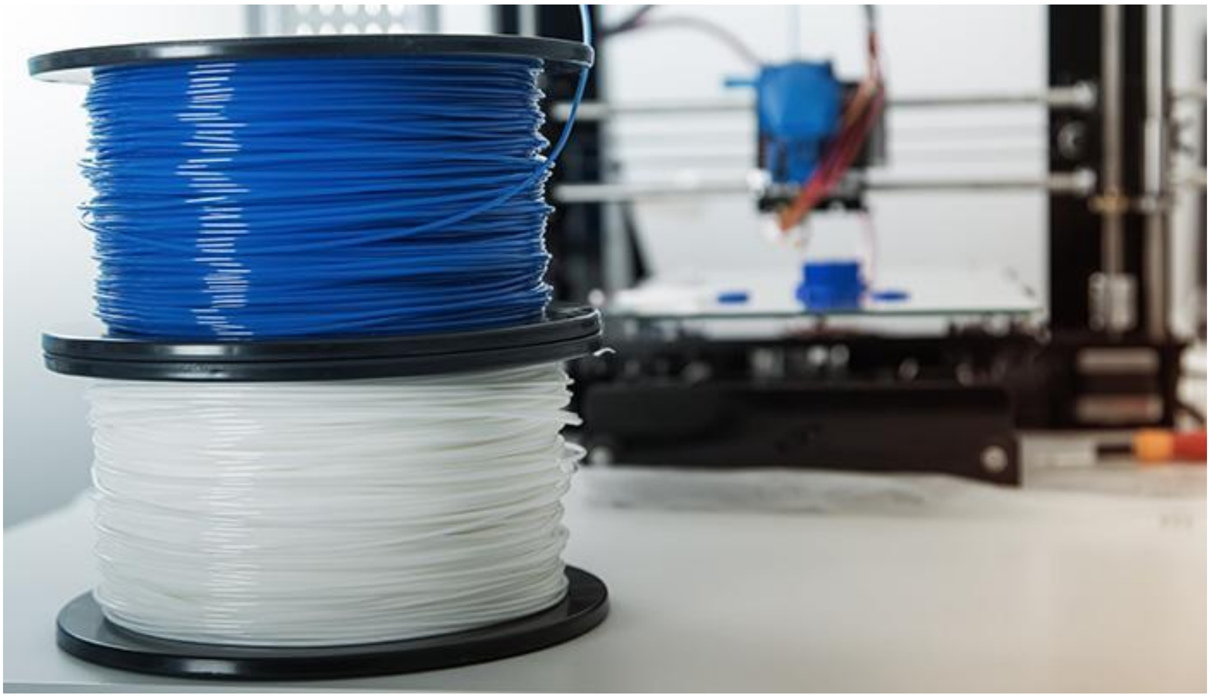


Figure II.1: Coil of PLA filament

Melt temperature : 190°C-220°C

Bed temperature : 45°C-60°C

Pros:

- Biosourced, biodegradable
- Odorless
- Can be post-processed with sanding paper and painted with acrylics
- Good UV resistance

Cons:

- low humidity resistance
- Can’t be glued easily. **[7]**

II.2.2) ABS (Acrylinitrile Butadiene Styrene) :

ABS is usually picked over PLA when higher temperature resistance and higher toughness is required.

Figure II.2: Coil of ABS Filament

Melt temperature: 220°C-250°C
Bed temperature: 95°C-110°C

Pros:

- Can be post-processed with acetone vapors for a glossy finish
- can be post-processed with sanding paper and painted with acrylics
- acetone can also be used as strong glue
- Good abrasion resistance

Cons:

- UV sensitive
- odor when printing
- potentially high fume emissions **[8]**

II.2.3) PET (polyethylene terephthalate) :

PET is a slightly softer polymer that is well rounded and possesses interesting additional properties with few major drawbacks.

Figure II.3: Coil of PET Filament

Melt temperature: 240°C and 260°C

Bed temperature: 100°C

Pros:

- Can come in contact with foods
- High humidity resistance
- High chemical resistance
- Recyclable
- Good abrasion resistance
- Can be post-processes with sanding paper and painted with acrylics

Cons:

- Heavier than PLA and ABS **[9]**

II.2.4) HIPS (High Impact Polystyrene):

HIPS (High Impact Polystyrene) is a dissolvable filament that is commonly used as a support material for ABS prints. It is a lot similar to ABS, except that HIPS is slightly lighter and more dimensionally stable than the former. This makes it a great substitute for ABS when you need lightweight prints for heavy applications, such as cosplay and wearable items and protective casing.

Figure II.4: Coil of HIPS filament

It needs to be dissolved in a substance called D-Limonene in order to be removed from prints. It leaves no marks on the prints upon removal.

Melt temperature: 230°C-245°C

Bed temperature: 100°C -115°C

Pros:

- Lightweight
- Dissolvable by d-limonene
- Affordable
- Impact and water-resistant

Cons:

- High printing temperature
- Requires ventilation
- Needs a heated bed and heated chamber **[10]**

Application part:

in order to create our object with the 3D printer we are going to use PLA filament. It only needs a melt temperature of 190°C to 220°C.

II.3) Necessary Equipments:

II.3.1) Stepper motor:

Figure II.5: Stepper motors

A) Definition:

A stepper motor is an electromechanical device it converts electrical power into mechanical power. Also, it is a brushless, synchronous electric motor that can divide a full rotation into an expansive number of steps. The motor’s position can be controlled accurately without any feedback mechanism, as long as the motor is carefully sized to the application.Stepper motors are similar to switched reluctance motors.

The stepper motor uses the theory of operation for magnets to make the motor shaft turn a precise distance when a pulse of electricity is provided. The stator has eight poles, and the rotor has six poles. The rotor will require 24 pulses of electricity to move the 24 steps to make one complete revolution. Another way to say this is that the rotor will move precisely 15° for each pulse of electricity that the motor receives.

A stepper motor, as its name suggests, moves one step at a time, unlike those conventional motors, which spin continuously. If we command a stepper motor to move some specific number of steps, it rotates incrementally that many number of steps and stops. Because of this basic nature of a stepper motor, it is widely used in low cost, open loop position control systems. Open loop control means no feedback information about the position is needed. This eliminates the need for expensive sensing and feedback devices, such as optical encoders. Motor position is known simply by keeping track of the number of input step pulses.

B) Characteristics of a stepper motor:

Stepper motor characteristics are divided into two groups

-Static characteristics

-Dynamic characteristics

1. Static characteristics:

Holding Torque (TH): It is the maximum load torque which the energized stepper motor can withstand without slipping from equilibrium position. If the holding torque is exceeded, the motor suddenly slips from the present equilibrium position and goes to the static equilibrium position.

Detent torque (TD): It is the maximum load torque which the un-energized stepper motor can withstand slipping. Detent torque is due to magnetism, and is therefore available only in permanent magnet and hybrid stepper motor. It is about 5-10 % of holding torque.

Torque constant (Kt): Torque constant of the stepper is defined as the initial slope of the torque-current (T-I) curve of the stepper motor. It is also known as torque sensitivity. Its units N-mA, kg-cm/A or OZ-in/A

2. Dynamic characteristics:

A stepper motor is said to be operated in synchronism when there exist strictly one to one correspondence between number of pulses applied and the number of steps through which the motor has actually moved. There are two modes of operation.

Start-Stop mode: Also called as pull in curve or single stepping mode.

Slewing mode : In start –stop mode the stepper motor always operate in synchronism and the motor can be started and stopped without using synchronism. In slewing mode the motor will be in synchronism, but it cannot be started or stopped without losing synchronism. To operate the motor in slewing mode first the motor is to be started in start stop mode and then to slewing mode. Similarly to stop the motor operating in slewing mode, first the motor is to be brought to the start stop mode and then stop.

Start Stop mode: In this second pulse is given to the stepper motor only after the rotor attained a steady or rest position due to first pulse. The region of start-stop mode of operation depends on the torque developed and the stepping rate or stepping frequency of stepper motor.

pulse is given to the stepper motor only after the rotor attained a steady or rest position due to first pulse. The region of start-stop mode of operation depends on the operation depends on the torque developed and the stepping rate or stepping frequency of stepper motor.**[11]**

C)Types of stepper motor:

There are three main types of stepper motors, they are:

1. Permanent magnet stepper
2. Hybrid synchronous stepper
3. Variable reluctance stepper

Permanent Magnet Stepper Motor: Permanent magnet motors use a permanent magnet (PM) in the rotor and operate on the attraction or repulsion between the rotor PM and the stator electromagnets.

Variable Reluctance Stepper Motor: Variable reluctance (VR) motors have a plain iron rotor and operate based on the principle that minimum reluctance occurs with minimum gap, hence the rotor points are attracted toward the stator magnet poles.

Hybrid Synchronous Stepper Motor: Hybrid stepper motors are named because they use a combination of permanent magnet (PM) and variable reluctance (VR) techniques to achieve maximum power in a small package size. **[12]**

D) NEMA 17 1.7A:

in our project , we are going to take this NEMA 17-size hybrid bipolar stepping motor has a 1.8° step angle (200 steps/revolution). Each phase draws 1.7 A at 2.8 V, allowing for a holding torque of 3.7 kg-cm (51 oz-in). **[13]**

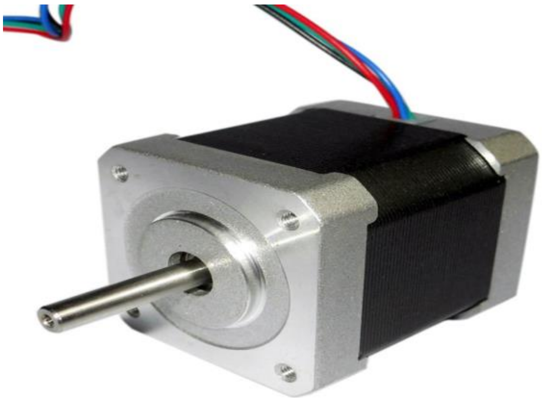


Figure II.6: Stepper motor NEMA 17

II.3.2 Arduino Board:

A) Definition:

Arduino is an open source programmable circuit board that can be integrated into a wide variety of makers projects both simple and complex. This board contains microcontroller, which is able to be programmed to sense and control objects in the physical world. By responding to sensors and inputs, the Arduino is able to interact with a large array of outputs such as LEDs, motors and displays. Because of its flexibility and low cost, Arduino has become a very popular choice for makers and makerspaces looking to create interactive

hardware projects. Arduino was introduced back in 2005 in Italy by “Massimo Banzi” as a way
for non-engineers to have access to a low cost, simple tool for creating hardware projects. **[14]**

B) Types of Arduino Boards:

• Arduino Mega
• Arduino Uno
• Arduino Leonardo
• Arduino Red board
• Arduino lily pad.**[15]**

There is more and more open source Arduino Boards but we will not name them all, we chose Arduino Mega 2560 R3.

C) Arduino Mega 2560 R3:

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 . It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. **[16]**

- The brain ATmega2560 microcontroller chip :

You can think of the microcontroller chip itself as the “brains” of the board. The chip used in the Arduino Mega is the ATmega2560. It’s the large, black component in the center of the board. This chip is known as an integrated circuit, or IC. It’s actually not alone but rather sits in a socket. If you were to remove it.**[17]**

The **ATmega2560** is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the **ATmega2560** achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed. John Nussey: 'Arduino for dummies', Published by John Wiley & Sons, Ltd, 2013.**[18]**

-Board Details :

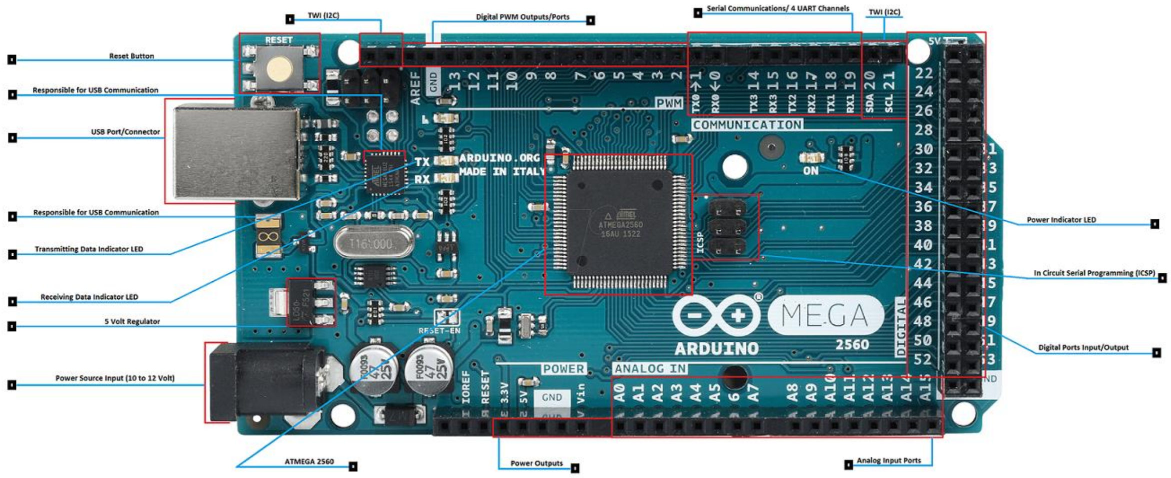


Figure II.7: Arduino Board Components

II.3.3 Ramps 1.4 Arduino mega 2560 Shield:

RepRap Arduino Mega Polulu Shield, or RAMPS, is a board that serves as the interface between the Arduino Mega — the controller computer — and the electronic devices on a RepRap 3D printer. The computer extracts information from files containing data about the object you want to print and translates it into digital events, like supplying a voltage to a specific pin.

It takes many, many such pins turning on and off to tell a printer what to do. Unfortunately, the Mega doesn't have enough power to actually operate the printer's hardware. **[19]**

II.3.4 Endstop (motion sensors):

The 3D printer axes all need a datum (also known as home position or end-stop) to reference their movements. At the start of each build each axis needs to back up until the datum point is reached. The switches also help protect the machine from moving past its intended range and damaging itself.

Mechanical Endstop:

Precision/repeatability depends on the switch quality, length of lever arm attached (longer increases contact distance but is worse for precision), and impact speed of the carriage with the switch. It is possible to have a good mechanical switch or a bad mechanical switch. This is typically a reasonable default choice because it is simple and cheap.

A small mechanical switch with a short lever arm (or the lever arm removed) will generally achieve the required +/-0.01mm switching precision. Very cheap switches, high contact speeds, and long lever arms may provide inadequate resolution for Z homing or probing, but will still be adequate for low-precision X and Y homing purposes.

Where mechanical switches tend to cause issues is in noise rejection. Different controller boards use different ways of wiring the switch: some use two wires and only send a signal when triggered. When not triggered, the signal wire is left floating or weakly pulled up by the microcontroller, while attached to a long wire that acts as an antenna to pick up EM noise. It is very common for heater or stepper wiring to emit nasty EMR due to the PWM current control.

Two-wire end-stop cables should always be run away from stepper and heater wiring. Shielding and twisting the conductors is a good idea too.

A more robust approach is to use three-wire switches that actively pull the signal line high or low depending on the switch position. These will tend to reject noise better.

Very cheap mechanical switches may fail within the life of the printer. However, most limit switches are rated for millions of cycles, which is unlikely to occur over any normal printer's lifespan.Mechanical switches are easy to align and easy to trigger by hand during troubleshooting. **[20]**

Figure II.8 : Mechanical Endstop

<u>Optical Endstop:</u>

The Opto Endstop, which is very accurate and easy to use . When the light is blocked, Opto Endstop will immediately output the digital control, and the LED will be on. Opto Endstop adopted standard electronic brick interface, therefore, it is easy and convenient to plug and play. **[21]**

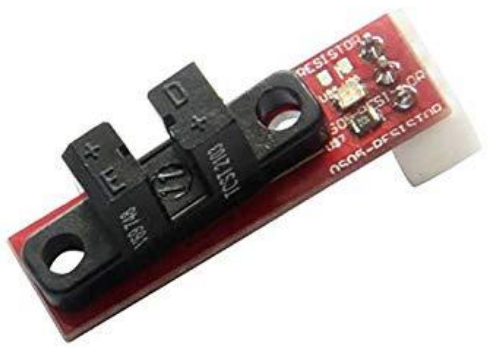


Figure II.9 : Optical Endstop

Magnetic Endstop:

This sensor is a double-ended type and may be actuated with an electromagnet, a permanent magnet or a combination of both. The magnetic switch is a wonderful tool for designers who would like to turn a circuit on and off based on proximity.

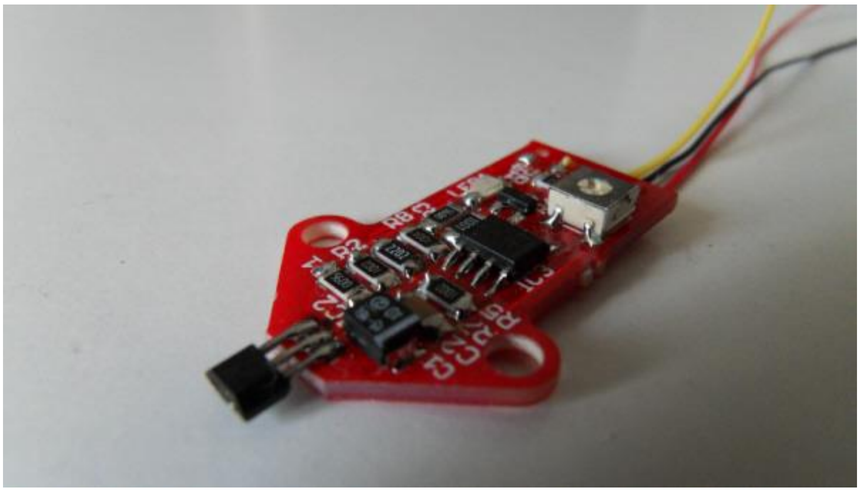


Figure II.10 : Magnetic Endstop

These endstops; Hall effect sensors is a transducer that varies its output voltage in response to a magnetic field. Hall effect sensors are used for proximity switching, positioning, speed detection, and current sensing applications. **[22]**

2.3.5 Power supply 12V:

Figure II.11: Power Supply 12V

12V power supplies (or 12VDC power supplies) are one of the most common power supplies in use today. In general, a 12VDC output is obtained from a 120VAC or 240VAC input using a combination of transformers, diodes and transistors.**[23]**

II.3.6 Print Bed:

A print bed is the surface of a 3D printer where a print head lays down the materials that make up a 3D print. A 3D printer requires the print bed to be level and flat in order to successfully produce layers of media in filament form that make up a 3D-printed object.

Standard original equipment print beds may be made of plastic, aluminum or glass. For better results, a print bed is sometimes lined with an adhesive, which can be a commercial product or a homemade treatment like a glue stick or blue painter’s tape. **[24]**

Types of Bed :

Yellow Painter's Tape:

Yellow painter’s tape is the fallback solution for many 3D materials, especially PLA filament. It is simple, cheap and effective. Just cover the bed with strips of the tape. This tape can even be bought in very large rolls, making it easy to cover your whole bed.. You may also want to apply some glue to stick the first time for extra adhesion. Using this technique, no bed heating is required.

Heated Glass Print Bed:

Many people like printing directly on glass because it is easy to remove your print when done and leaves a nice glossy finish on the bottom of the 3D part. 3D Printing on glass should be done with moderate heating (60 C). You should also make sure the glass is clean. Use some Window cleaner on it if necessary. Prints with very thin sections may be pulled off easily. To prevent this, you might try adding a brim.

Kapton Tape + Hair Spray:

Kapton tape is a high temperature adhesive tape with a translucent gold tint that works great for ABS filament. It is famously used on spacecraft, but also makes a good protective surface for 3D printing. Apply Kapton tape to the bed, then spray on hair spray as if you were spraying cooking oil onto a baking sheet. Generic hair spray is fine.**[25]**

II.3.7 Hotend:

The filament extruder on a FDM printer is the part that extrudes the plastic filament in a liquid form and deposits it on a printing platform by adding successive layers. The printing head is made of many distinct parts including a motor to drive the plastic filament and a nozzle (or extruder) to extrude the plastic.

Some 3D FDM / FFF printers are now equipped with two extruders. This enables you, in particular, to print two materials simultaneously in order to obtain 3D prints in two colors. The presence of two extruders also allows support material to be extruded, which can be removed afterward using a solvent.

To regulate the plastic cooling process, some printers are enclosed. This helps maintain a uniform temperature in the manufacturing chamber, ensuring greater consistency in the print result.**[26]**

II.4) Conclusion:

The materials and equipments above were the most necessary requirements in order to build an ordinary 3D printer, there are a lot more equipments that will be an upgrade to the machine for better features and different uses. we used this DIY method for an easier process and it has less economic cost.

Chapter III

Mechanical study & configuration

III.1) INTRODUCTION:

in this chapter we are going to take a look at some properties of the materials used, some analysis and mechanicals studies about the main parts of the machine as the hotend, filaments, and there sizing. Then we will check the effects of the temperatures on the Hotend.

III.2) Properties of materials for each defined domain:

Material	Domains	Properties		
		Heat capacity at constant Pressure CP (j/kg.k)	Density ρ (kg/m³)	Thermal Conductivity (W/m.k)
Aluminum AW-3003-H18	Heat sink/ heat block	893	2730	155
Stainless steel 14306	Heat break	502	7960	14
Grass EN CW614N	Nozzle	377	8470	123

Material for printing	Properties		
	Heat capacity at constant Pressure CP (j/kg.k)	Density ρ (kg/m³)	Thermal Conductivity (W/m.k)
ABS	1080-1400	1040	0.17
PLA	1800	1240	0.1849

Board III.1: Properties of materials

III.3) Sizing:

III.3.1) Bolt A2-70 M6x8:

Diameter: 6mm
Length: 8mm
Pitch: 1.0mm
Type: Socket head cap screw
Specification: Din 912 / ISO 4762

Material: Stainless Steel

III.3.2) Screw A2-70 M6x20:

Diameter: 6mm
Length: 20mm
Pitch: 1.0mm
Material: Stainless Steel
Specification: Din 933 / ISO 4017

III.3.3) U-grooved pulley bearing:

Inner Diameter: 4mm
Outer Diameter: 13mm
Width: 4mm
U-slot radius: 1mm
Notch width: 2.1mm
U-groove bottom diameter: 11mm

III.4) Nozzle sizing:

Material: Brass.
Input Filament Diameter: 1.75mm.
Weight: 3g.
Nozzle diameter: 0.4mm.

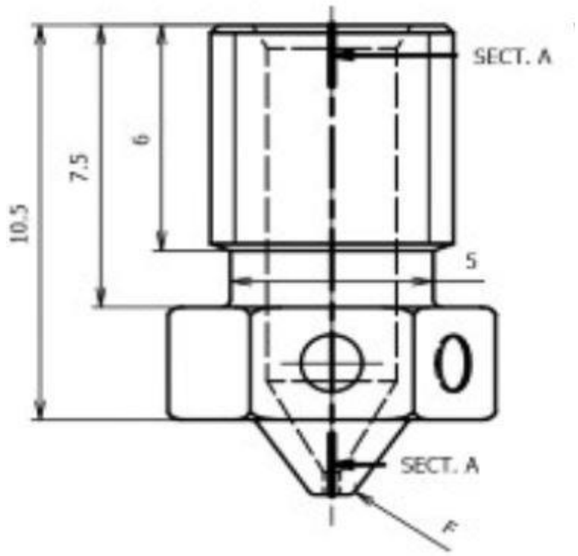


Figure III. 1: Blue Print of the nozzle used

III.5) Nozzle wear:

To apply this method, we will need the technical drawing of the nozzles of the 3D printer we use, a document that most manufacturers can download from their website. In this case, we will use:
Technical drawing Nozzle E3D v6. and our nozzle is the V6-NOZZLE-300-400.

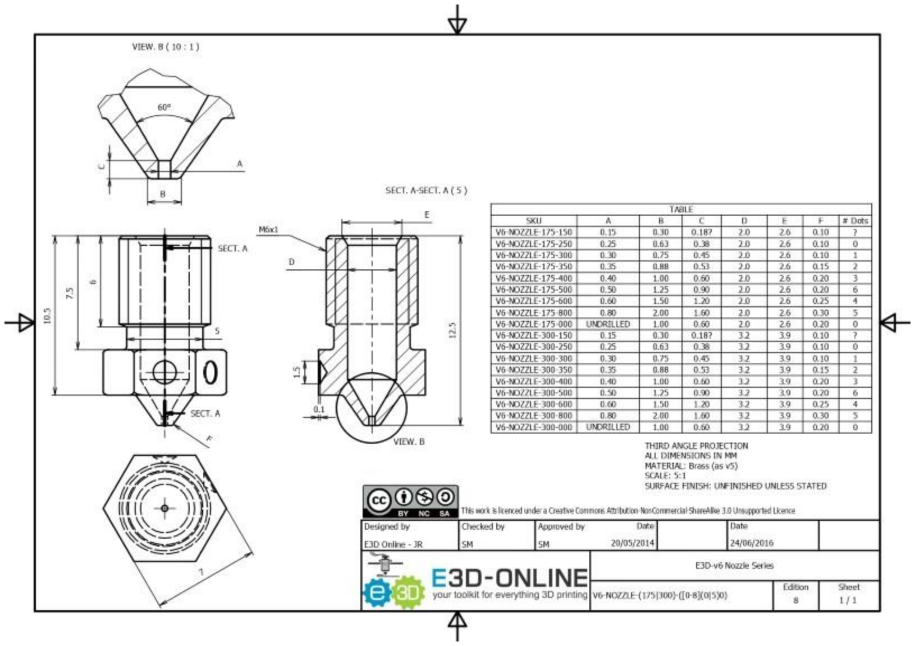


Figure III.2: Technical drawing nozzle V6

The measurement that interests us is the "C" which represents the length of the filament exit perforation after the extrusion cone. The wear should never exceed 80% of the total length of "C", because if the wear is closer to the inner cone, the 3D prints will be of poor quality, even impossible to achieve. To check this value, we need to remove the nozzle from the HotEnd, measure the total length and apply the following formula:

$$\frac{\text{total original length - total real length}}{\text{C}} \times 100 =$$

this rule is applied in some imaginative nozzle to see the result:

$$\frac{12.5\,mm - 12\,mm}{0.60\,mm} \times 100 = 83.33\%$$

Nozzle wear is 88.33%. [27]

III.6) Volume of filament:

The parameters taken for the dimensioning of the extrusion nozzle system:

a.Number of steps per turn *Pt* is given by:

$Pt = 360 / Ap$

With: *Ap*: Angle of step

we choose: $Ap = 1{,}8°$, we will have: $Pt = 200$.

b.Distance of the filament pushed before the extrusion head is given by:

$$De = \frac{P * Ps}{Pt}$$

With: *P*: Perimeter of the pulley.

Ps: Number of steps desired.

c.Volume of the filament pushed before the extrusion head is given by:

$Ve = De * \pi * rf^2$

with: *rf:* filament radius

.

d.Volume of the filament pushed after the extrusion head is given by:

$Vf = Df * \pi * rb^2$

with *rb:* Nozzle radius.

Df: Distance of filament pushed from the extrusion head.

e.Distance of filament pushed from the extrusion head:

The volumes of the filament pushed before and after the extrusion nozzle are equal $Ve = Vf$ *so*:

$$De * \pi * rf^2 = Df * \pi * rb^2$$

$$Df = \frac{De * \pi * rf^2}{rb^2 * \pi}$$

We choose: $D = 10mm$, $P = 31.4\ mm$, $rb = 0.4mm$ we can have:

$$\boxed{Df = Ps * rf^2 * 0{,}98125} mm$$

$$\boxed{Vf = Ps * rf^2 * 0{,}49298} mm^3$$

In the case of the 1.75mm filament:

We have $rf = 0{,}875mm$ so:

$$\boxed{Df = Ps * 3{,}005078125} mm$$

$$\boxed{Vf = Ps * 1{,}50975125} mm^3$$ **[28]**

3.7) Cloud diagrams:

3.7.1) Hotend without a fan:

Running the simulation on the entire design took a relatively short time (regarding computer capacities). I could have split the model in half but as it is not entirely symmetrical, I preferred to keep it this way and have the full information.

This type of hot end is not supposed to be heated without a fan, but it seemed interesting to see how the hot end and the PLA would behave under such circumstances. It could also help us understand how we could improve or create a cooling system.

We can observe on the picture on the left that the temperature rises up to 120-130°C on the skin of the heat sink. PLA starts to melt at around 140-150°C and is already very flexible when higher than 100°C, thus, as the filament is pushed through the hot end, it could result in a PLA build up transmitting heat by conduction up in the heat sink and potentially blocking the heat sink when the hot end cools down.

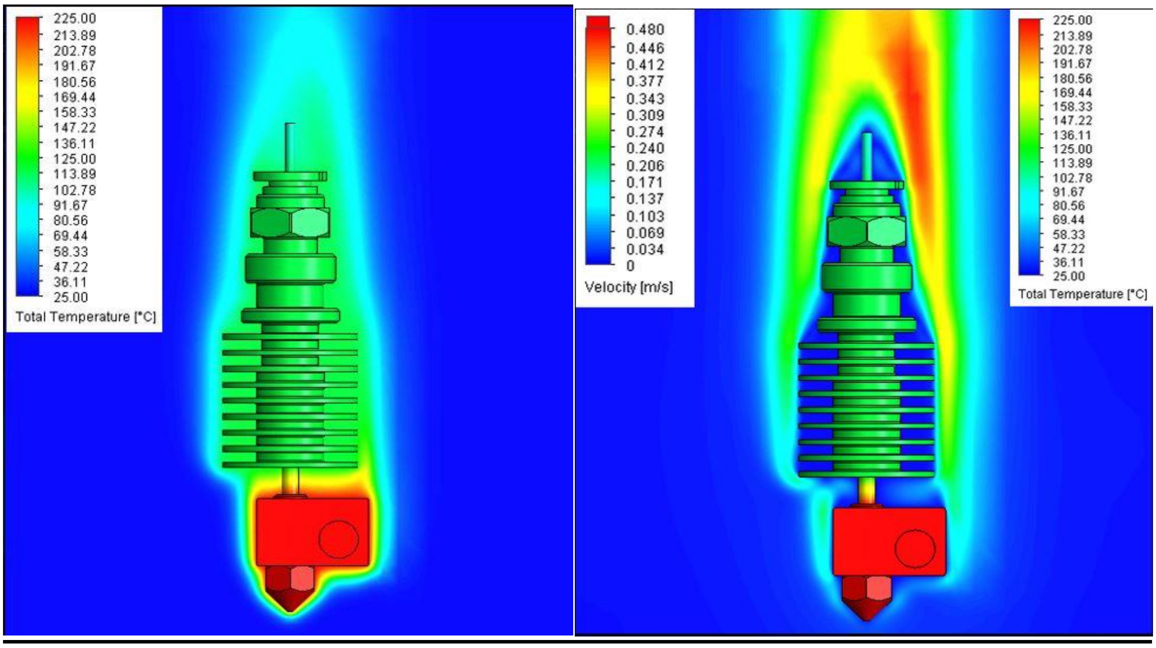


Figure III.3: diagram of total temperature of the hotend
And the air velocity

The two pictures show that hot air is going up through the heat sink and thus warming it by convection. The second picture tells us that the hot air is creating a barrier preventing the good circulation of fluid between the fins, indeed the the movement of the air associated to the vertical geometry of the hot end makes the velocity of the air between fins close to zero preventing a good cooling.

We can see that the heat break works pretty well as the temperature drop between the closest surfaces of the heat block and the heat sink (around 6mm distant) is almost 110°C. As the heat break forms a thin bridge between the heat block and the heat sink and stainless steel has a relatively low thermal conductivity, heat is mostly transferred through air natural convection.

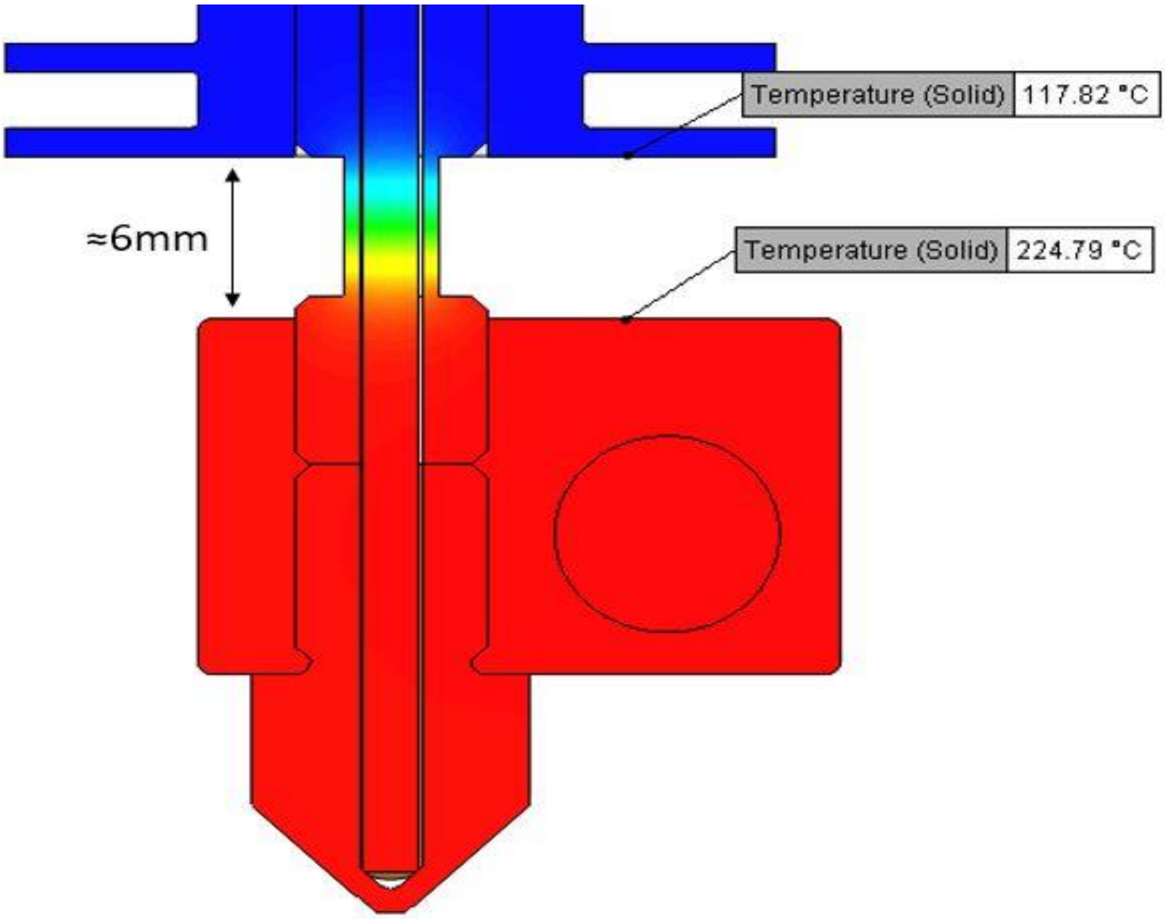


Figure III.4: Heat break and Heat block comparison

Regarding PLA, which is really the aim of the simulation, we see that it mostly follows the temperature pattern of the hot end. The PLA filament reaches 140°C at the bottom of the heat sink, theoretically below the melting the temperature, and so allows to behave properly as it only melts in the expected area.

However, Solidworks Flow Simulation does not support melting materials, meaning that is does not predict how the material is going to melt and how it is going to impact its properties regarding its new mechanical specifications. Additionally, PLA is already soft at this temperature and can lead to blocking the tube just by piling up even without being completely melted.

It is safe to say that the hot end would perform correctly under these exacts specification and input. The behavior would quickly change as air temperature changes or heating temperature is increased.

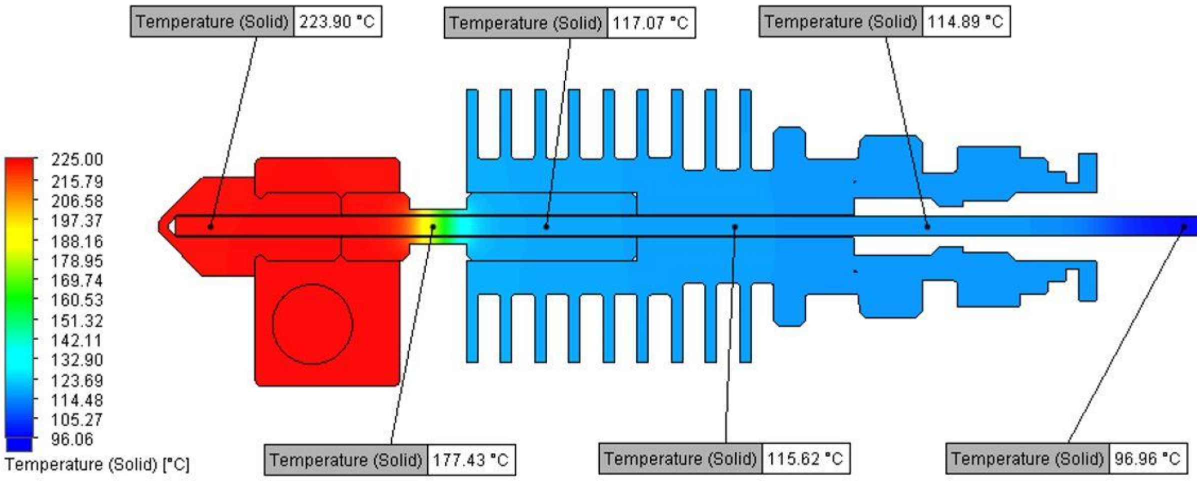


Figure III.5: The temperature of the PLA through all the Hotend

It has to be noted that this geometry is not designed to be utilized without a fan and so it is not optimized for a passive cooling solution

III.7.2) Hotend with a fan:

This configuration features a fan blowing air towards the heat sink, this helps taking the calories off by forcing air convection through the fins. This is how the actual design of the E3D is supposed to operate and, before looking at the results, we can think that the efficiency of the heat sink will be much higher.

Indeed, we see on the left picture that the temperature on the heat sink is much lower than on the previous configuration. As the temperature does not exceed 40°C on the heat sink skin, we can safely say that the filament will not be melted inside the heat sink (this will be verified further in this article). The high temperatures are kept on the lower parts of the hot end, the heat break, the heat block and the nozzle. As the air is stopped from going up by the horizontal air flow of the fan, it cannot heat up the heat sink by convection, limiting the propagation of heat to only conduction through the materials.

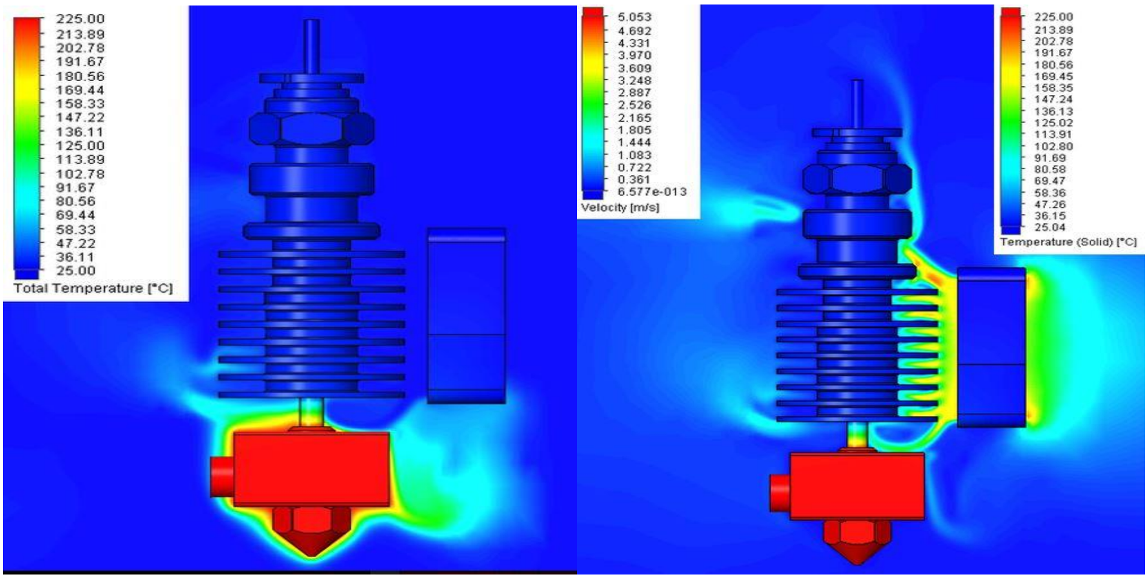


Figure III.6: Total Temperature and the velocity of the air With a fan

The two pictures above show that the fan is very efficient in our application, indeed air temperature is high only really close to the heat block, above that part, the fresh air flow sweeps the ascending hot air just around the top of the heat break keeping the heat sink cool.

On the side picture, the temperatures of the two facing surfaces of the heat sink and heat block depict well the efficiency of the fan. There is almost a 200°C gradient between the two surfaces, clearly creating a known area where the phase changing of the PLA happens: the heat break.

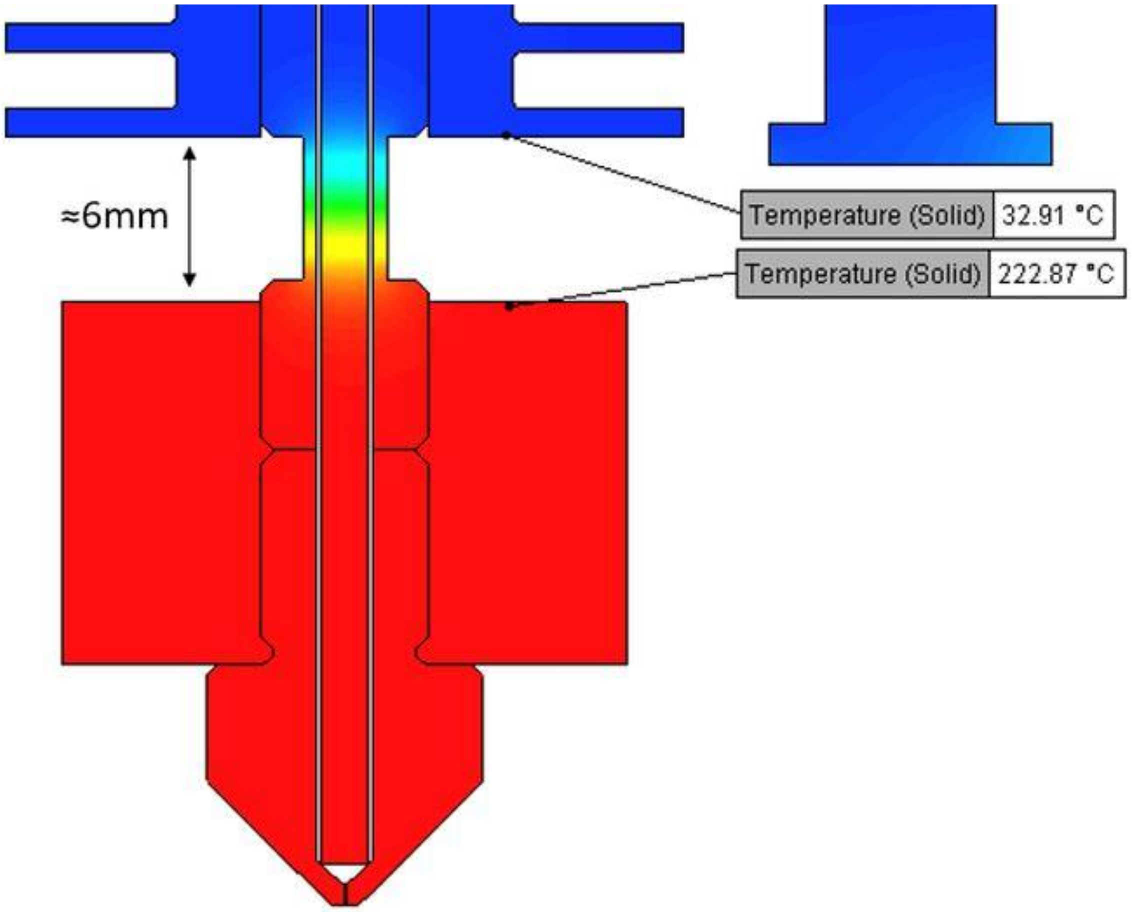


Figure III.7: Comparison between the Heat sink and the Heat Break with a fan

Looking at the cut plot of the entire hot end, we can see that the PLA behaves a lot better with the fan activated. At the bottom of the heat sink, the PLA entering the heat break is at around 60°C and starts melting in the lower part of the heat break as expected. This way, when it is cooled down after a print job, the filament will not solidify in the heat sink preventing clogging when reheating.

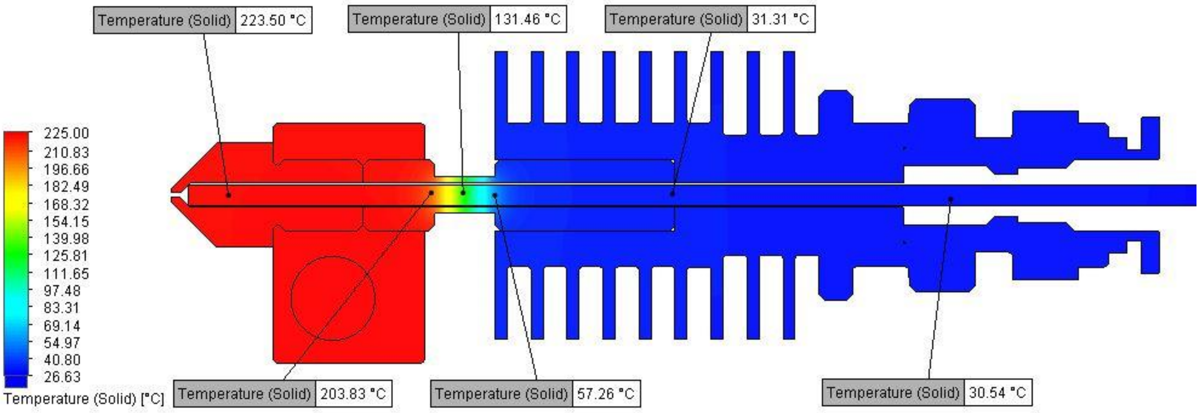


Figure III.8: PLA through all the hotend

We see that a fan is efficient enough for this application and at this kind of temperatures. A further study should be made to validate a worst-case scenario behavior (250°C at heat block and 60°C air temp).

III.7.3) Hotend with fan and air duct:

The final configuration features a fan and an air duct (which is often 3D Printed). We directly see, as expected, that the air flow is better channeled through the heat sink fins. However, the enhancement compared to the fan alone is not obvious at first sight. Indeed, the heat sink temperature seems very close to the previous configuration, and the overall temperature profile looks also similar.

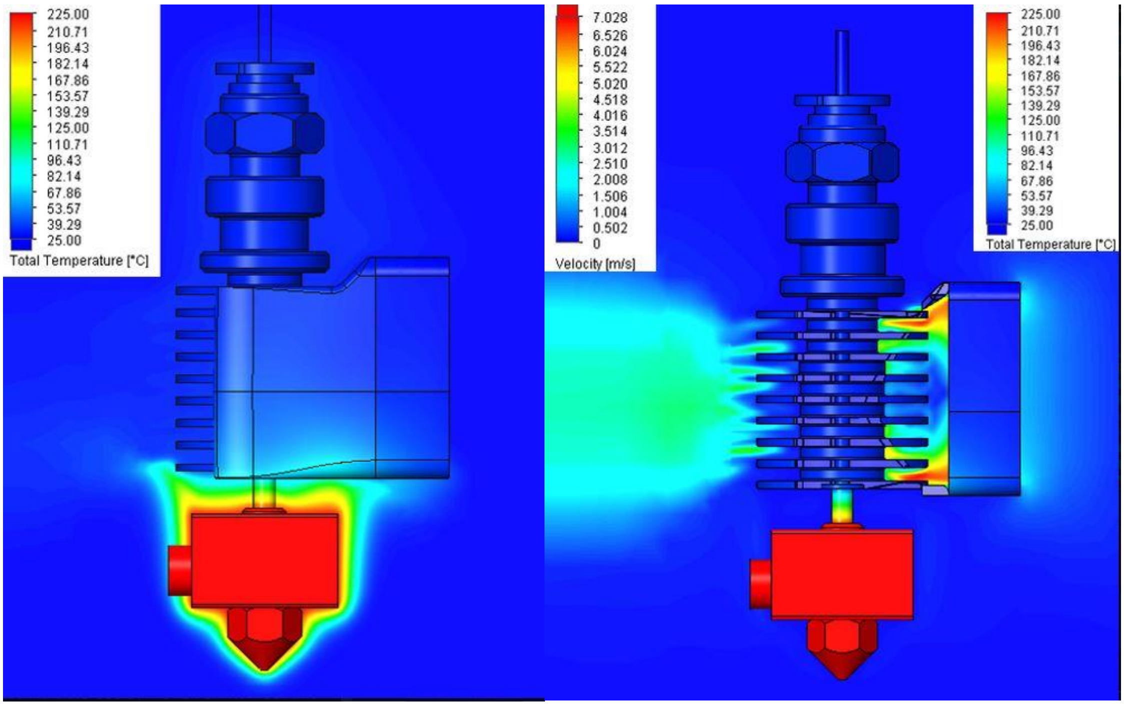


Figure III.9: The total temperature and air velocity with a fan and an air duct

The final configuration features a fan and an air duct (which is often 3D Printed). We directly see, as expected, that the air flow is better channeled through the heat sink fins. However, the enhancement compared to the fan alone is not obvious at first sight. Indeed, the heat sink temperature seems very close to the previous configuration, and the overall temperature profile looks also similar.

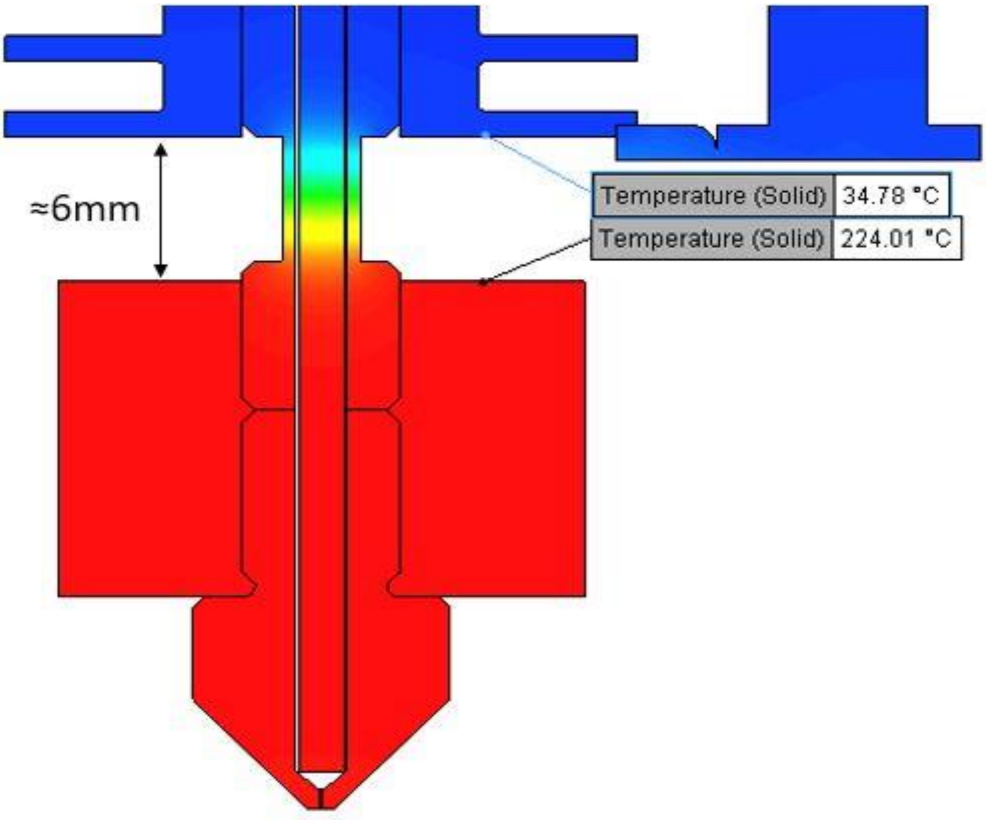


Figure III.10: Comparison between the heat sink and heat break with an air duct and a fan

Air around the heat block is disturbed by the fan air flow but this does not improve the efficiency of the system as the heat block does not really lose heat due to the fan air flow in the configuration without a duct.

Looking at the two facing surfaces of the heat block and the heat sink, we see that the temperature difference is again about the same as the previous configuration, with even a bit higher number for the lower heat sink surface as the air flow does not go through it directly.

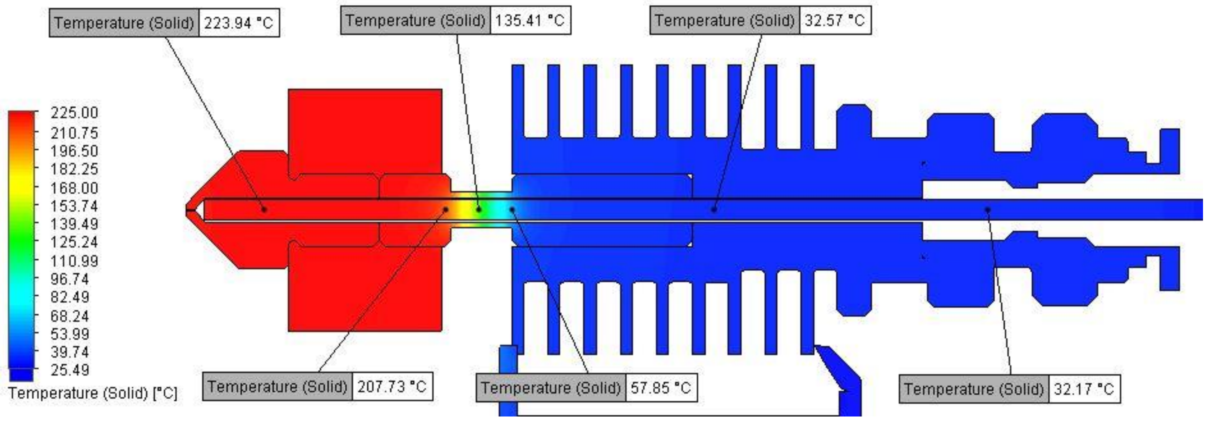


Figure III.11: PLA through the hotend with a fan and an air duct

The cut plot shows no real improvement compared to the second configuration, the PLA temperatures are about the same and even a bit higher. Again, there seems to be no gain from using a duct under these conditions. **[29]**

III.8) Conclusion:

In this chapter, we checked what sizing we needed for our hotend and the nozzle that should come with it. And the materials which they are made of, we compared if the Heat block, heat sink and nozzle could resist to a high level of temperature (in our case its 220°C). We determined the equation to use, should our nozzle be used excessively, to see if we should exchange it. We confirmed the efficiency of a fan in a hotend and the behavior of the PLA in the hotend with and without a fan. However, as air ducts are widely used in the 3D printing world, it seems that their utility is not really proven, at least for this exact configuration. Further investigation will be made to assess the utility of the air ducts in different configurations.

Chapter IV

Conception & realisation

IV.1) INTRODUCTION:

After designing the Machine on the SOLIDWORKS software, we needed some other softwares to help us in the process: Arduino IDE, Pronterface.

We used other materials like aluminum, glass, wood ... etc., for the production.

The assembly does not generally require any tool. The main thing comes down to:

-a set of Allen key.

-a set of flat keys.

-a necessary to solder the electronics (iron, Pewter Finish Solder, third hand) in case of electronics self-built.

-a caliper for different measurements.

-a multimeter.

-Screwdriver.

IV.2) Software used:

IV.2.1) SolidWorks: Solidworks is computer-aided design software belonging to the company Dassault Systèmes. It uses the parametric design principle and generates three types of linked files: the part, the assembly, and the drawing. Thus any modification on one of these three files will be reflected on the other two.

SolidWorks supported native or neutral formats are DWG, STEP, ACIS, STL, Parasolid, PDF; OBJ..etc **[30]**

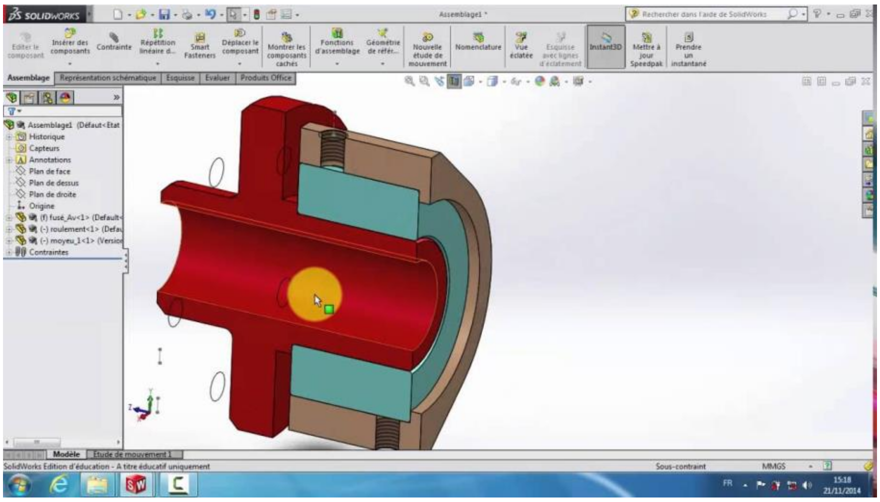


Figure IV.1: SolidWorks Interface

IV.2.2) Arduino IDE: Arduino IDE is an open source software that is mainly used for writing and compiling the code into the Arduino Module. It is an official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process.

The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given arduino module, This environment supports both C and C++ languages.

The IDE environment is mainly distributed into three sections: Menu Bar; Text Editor; Output Pane. **[31]**

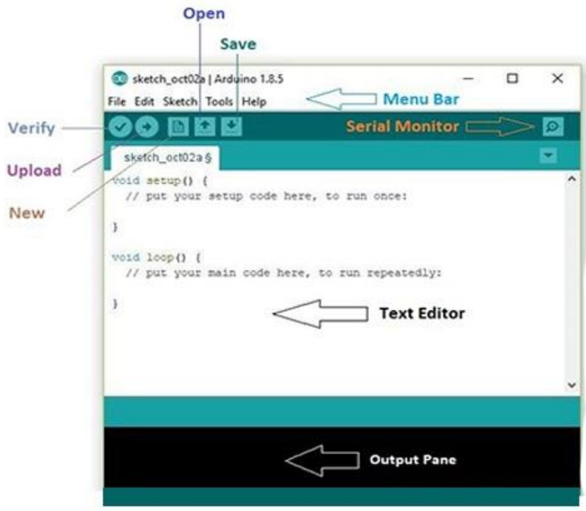


Figure IV.2: **Arduino IDE Interface**

Every Arduino sketch has two main functions to the program: **Void setup ()** – Sets things up that have
to be done once and then do not happen again. **Void loop ()** – Contains the instructions that are repeated over and over until the board is turned off.

As you go to the Tools section, you will find a bootloader at the end. It is very helpful to burn the code directly into the controller, setting you free from buying the external burner to burn the required code. We used **XLoader** in our experience.

IV.2.3) Pronterface:

Printrun is a powerful software toolchain for reading and modifying STL files, slicing them and preparing the resulting g-code, and sending the g-code to your printer. There are three different tools:

- **Pronterface** is a GUI host that manages your printer as well as prepares, slices, and prints your STL files.
- **Pronsole** is a command-line interface with the same capabilities as Pronterface.
- **Printcore** is a g-code host with no user input.

Printrun was written by Kliment Yancev and is currently maintained by him and Guillaume “iXce” Sequin. It has been an important tool for 3D printer users since at least 2011. It’s free, open-source software and is licensed under the GNU General Public License, version 3. **[32]**

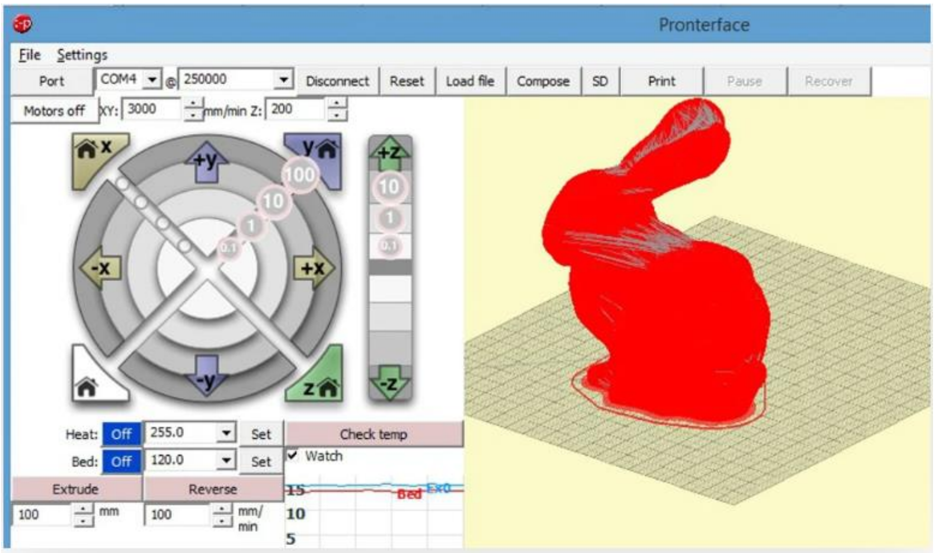


Figure IV.3: Pronterface Interface

IV.3) Conception:

- Bed dimensions 100mm x 100 mm.

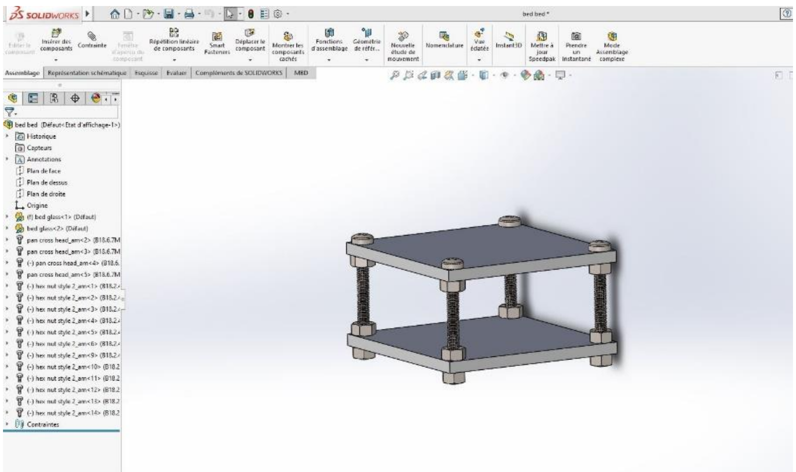


Figure IV.4: 3D model of the Bed

- Plane surface dimensions 75mm x 45mm x 2mm

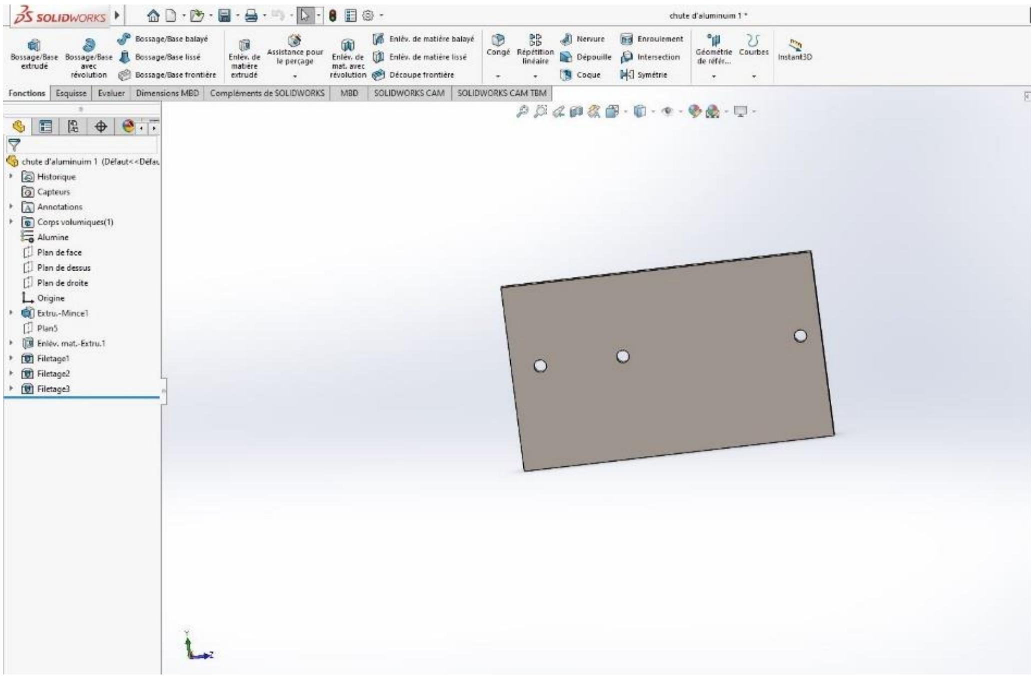


Figure IV.5: 3D model of the Plane Surface

- Aluminium angles dimensions 200mm x 50mm

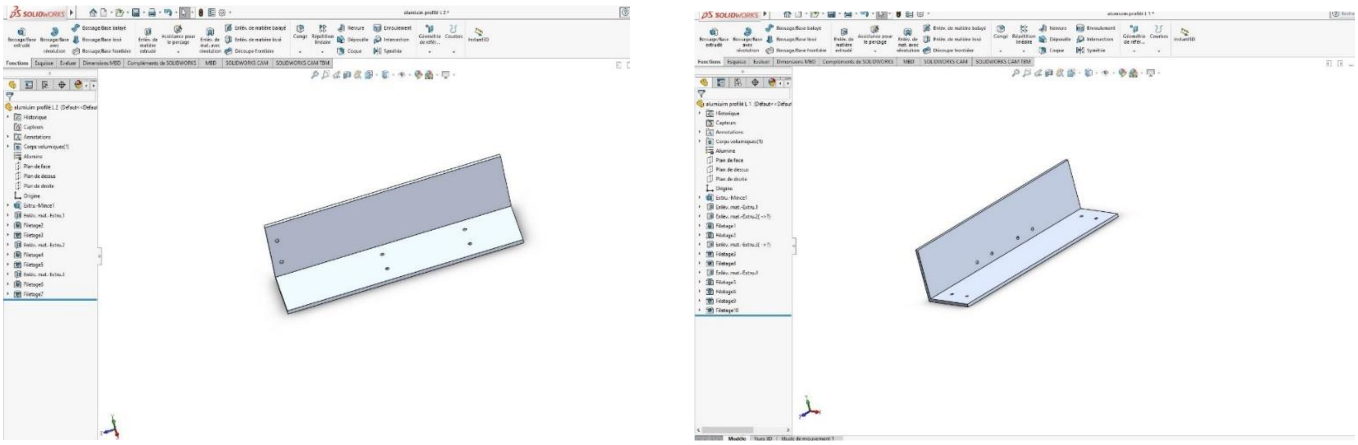


Figure IV.6: 3D model of the Aluminium angles

- e3D V6 1.75mm Hotend. Length 64,5mm (from the head until the nozzle head).

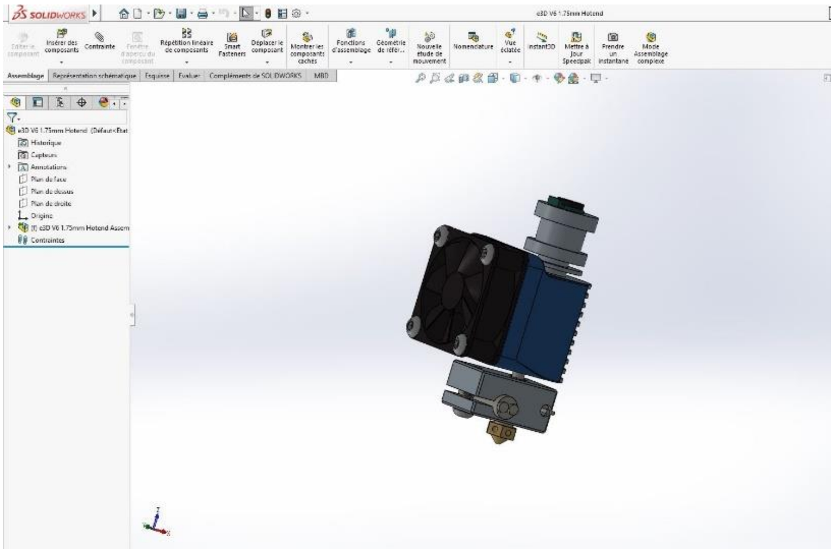


Figure IV.7: 3D model of the Hotend

- Extruder kit

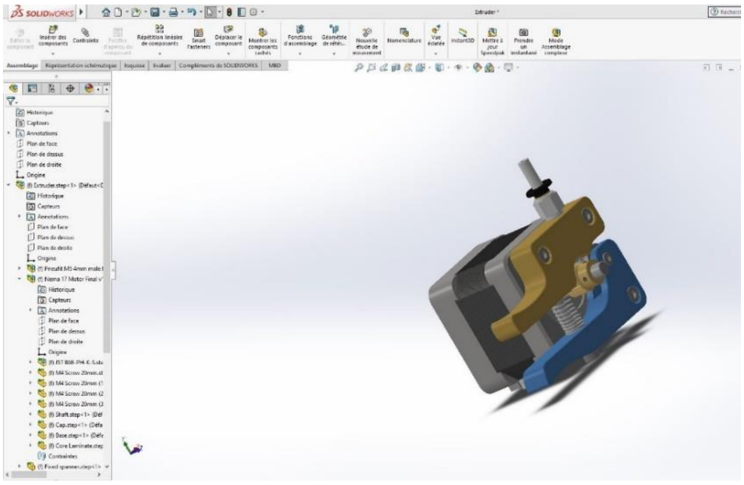


Figure IV.8: 3D model of the extruder kit

IV.4) Realization:

IV.4.1) Connection of electronic parts :

The photo below shows the RAMPS 1.4 shield mounted on the Arduino Mega board.

Also sees the 4 pololus drivers intended to drive the 4 motors necessary for printer operation.

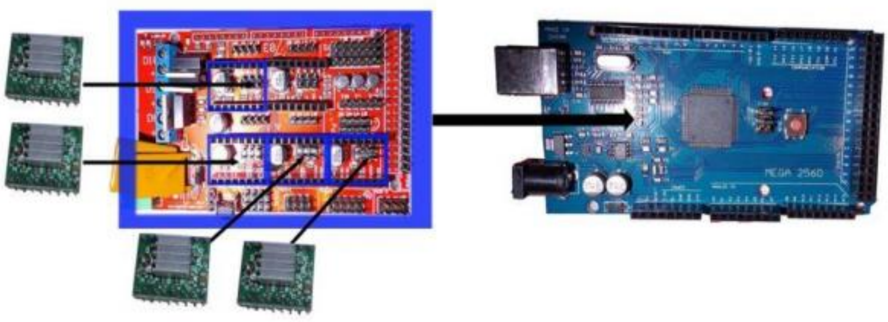
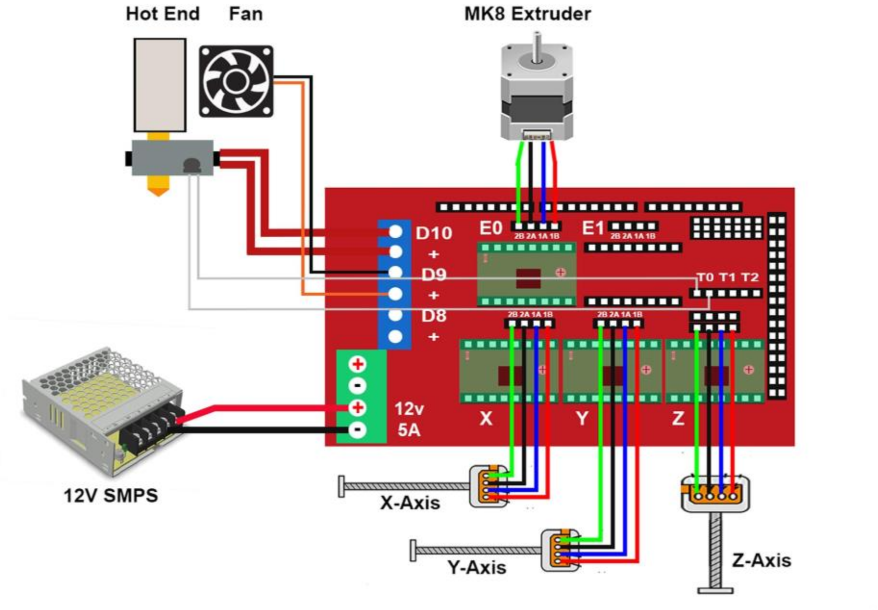


Figure IV.9: Arduino + Ramp + stepstick mounting

IV.4.2) Wiring:

All the electronic components of the printer will have to be connected to the card control electronics.

The following diagram will help you to tidy up all these cables, to choose in which sense to connect them, in an orderly and understandable way.



<u>X-Axis:</u> Drive disk 1.

<u>Y-Axis:</u> Drive disk 2.

<u>Z-Axis:</u> Floppy disk drive.

Figure IV.10:Circuit Diagram

IV.4.3) Parts manufacturing:

-We used the aluminum profile to make angles as pillars and holders

Figure IV.11: Aluminium angles

-We used a wooden Plane as a surface, and fixed the floppy discs (one on the pillar, one on the surface).

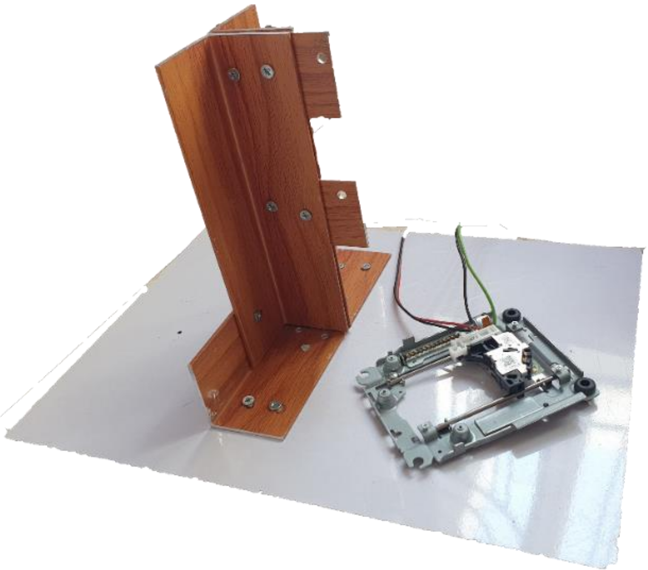


Figure IV.12: Wooden plane + drive disk

IV.4.4)-Assembly:

After having the shape of the printer, we started to assemble the hotend, electronic parts, stepper motor, power supply, bed.

The figure bellow represents the finale shape of the machine.

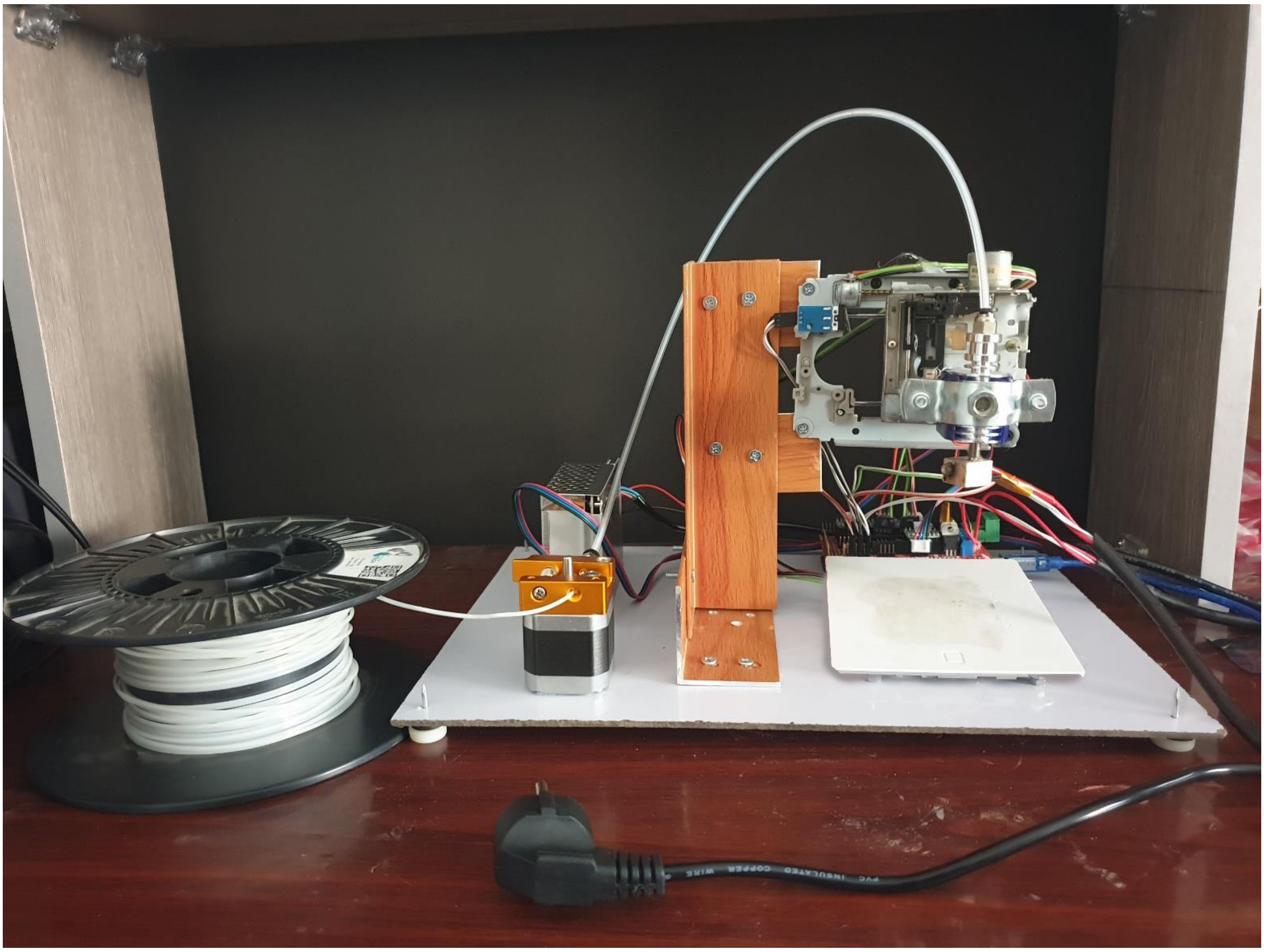


Figure IV.13: Final Form

IV.5) Conclusion:

In this chapter, we carried out the complete assembly of the new 3d printer with mechanical and electrical assembly .For this we encountered several difficulties in the axis calibrations, temperature correctors calibration.

Chapter V

3D Animation

V.1) INTRODUCTION:

In this chapter, we simulate our machine into a 3D animation that represents how the machine works.

V.2) Blender:

Blender is the free and open source 3D creation suite. It supports the entirety of the 3D pipeline—modeling, rigging, animation, simulation, rendering, compositing and motion tracking, even video editing and game creation. **[33]**

We used our previous 3D models from Solidworks by converting them to STL files that blender supports and then we started the animation phase.

The figures bellow will represents the steps:

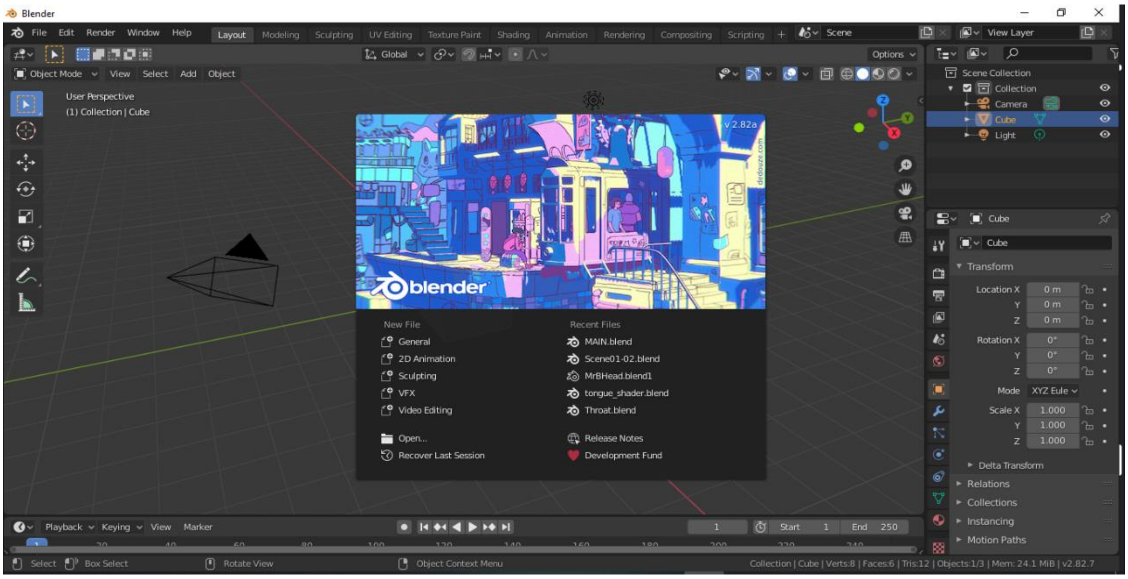


Figure V.1: Blender interface

We created the scene by importing the STL files and assemble them then we created our environment and light system along with the camera movements:

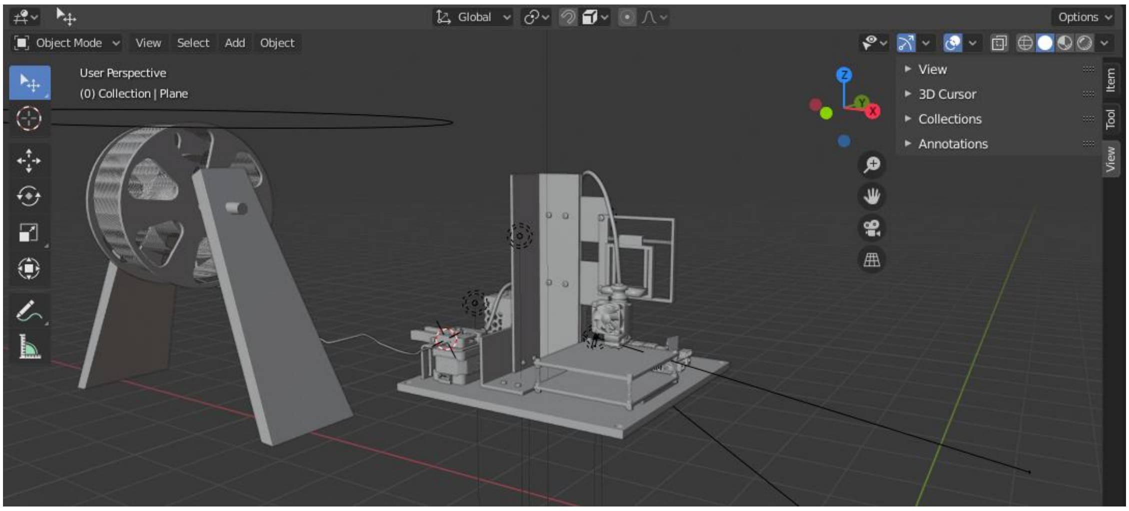


Figure V.2: Assembling the 3D models

Figure V.3: Texturing and lightning

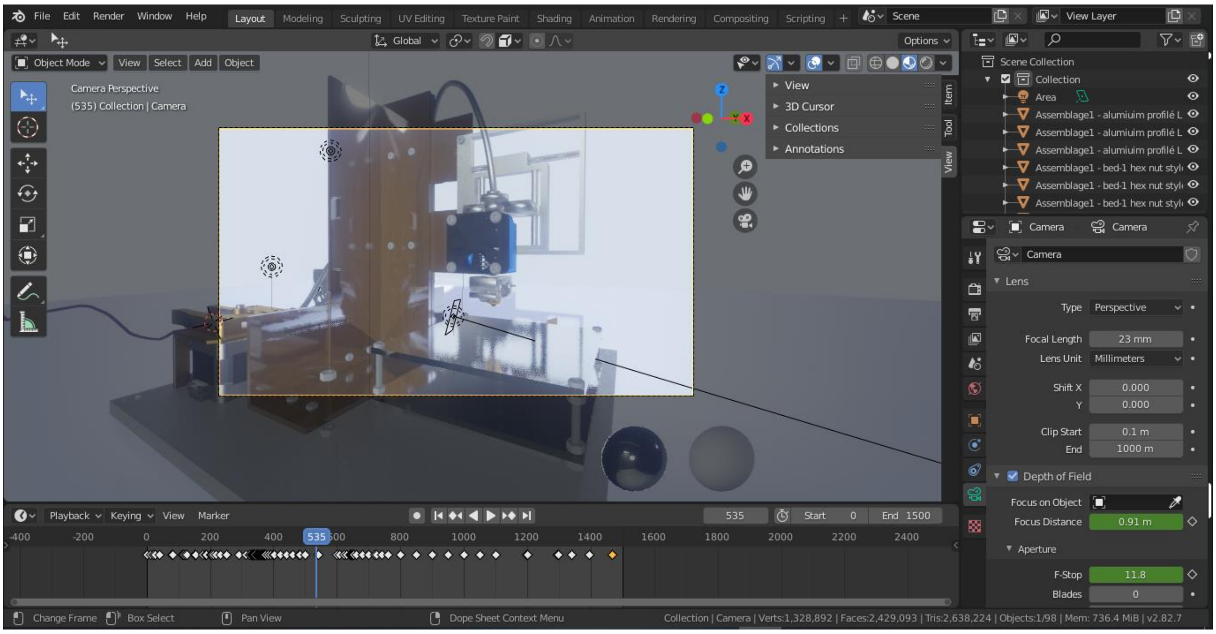


Figure V.4: Setting the camera movements

After finishing all these steps we had to render the scene as a video

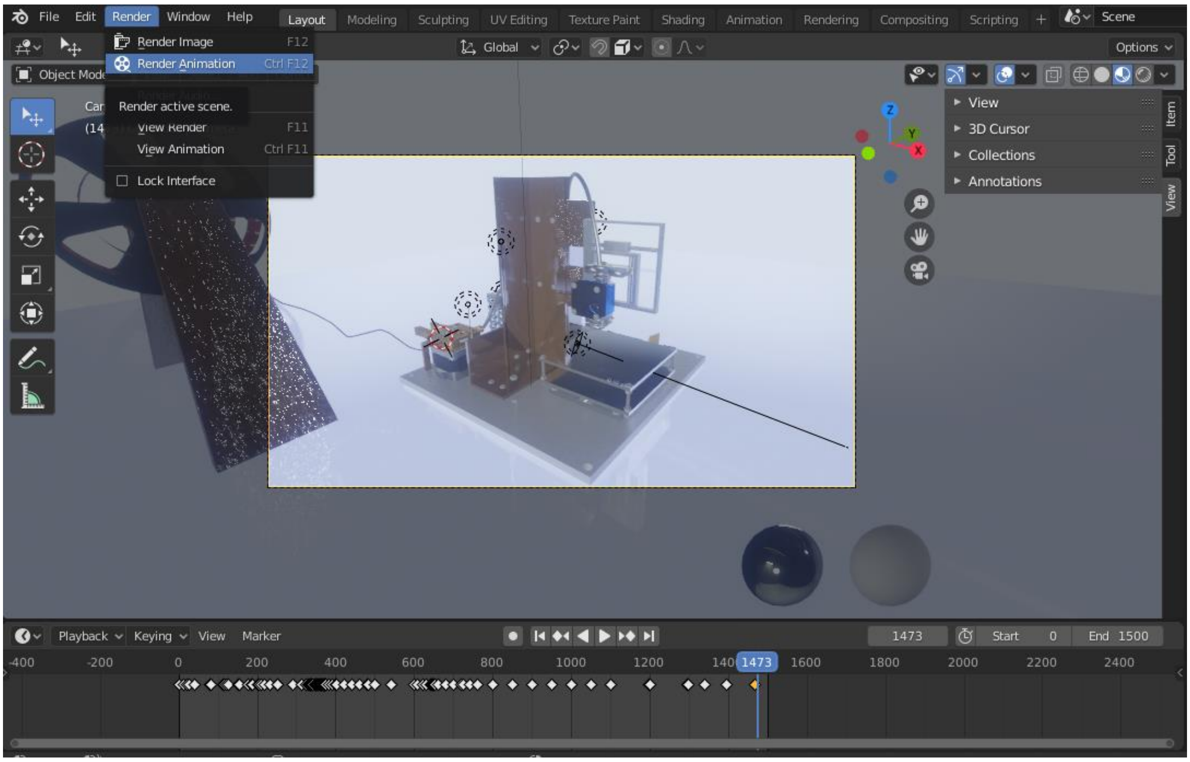


Figure V.5: Rendering the scene

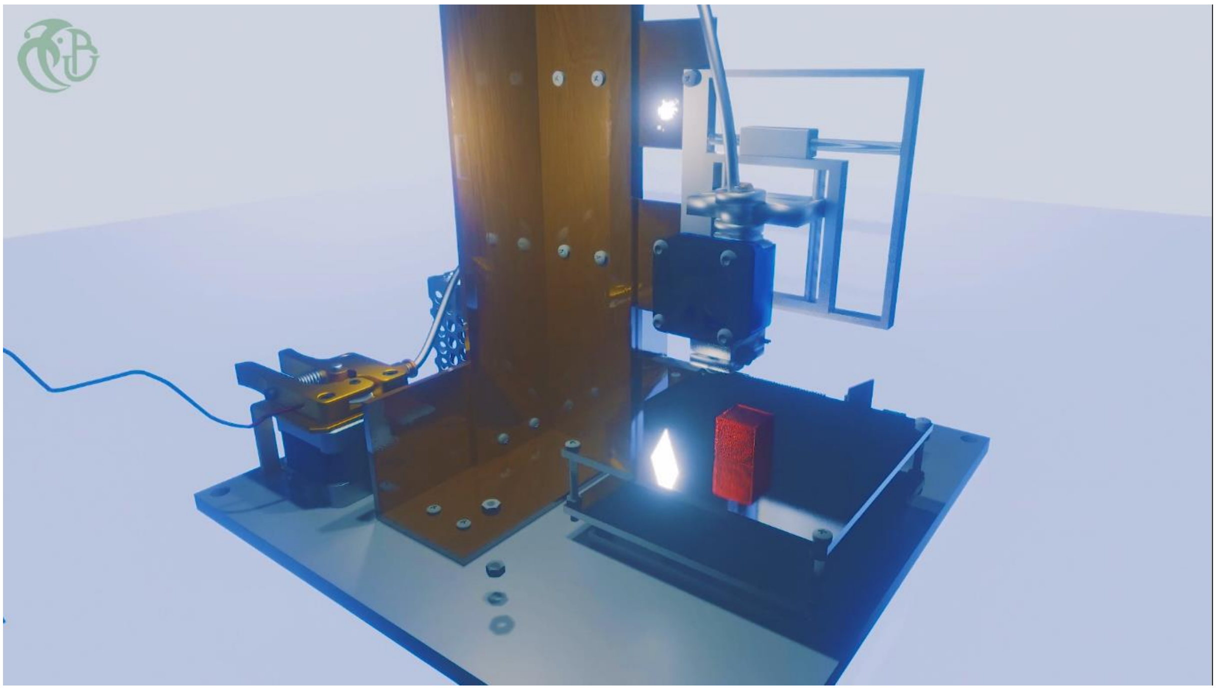


Figure V.6: Final Result

V.3) Conclusion:

Using the Blender software is helpful when it comes to animate your 3D models by creating the dynamic environment and camera movements to make things looks much expressive and smooth.

General conclusion

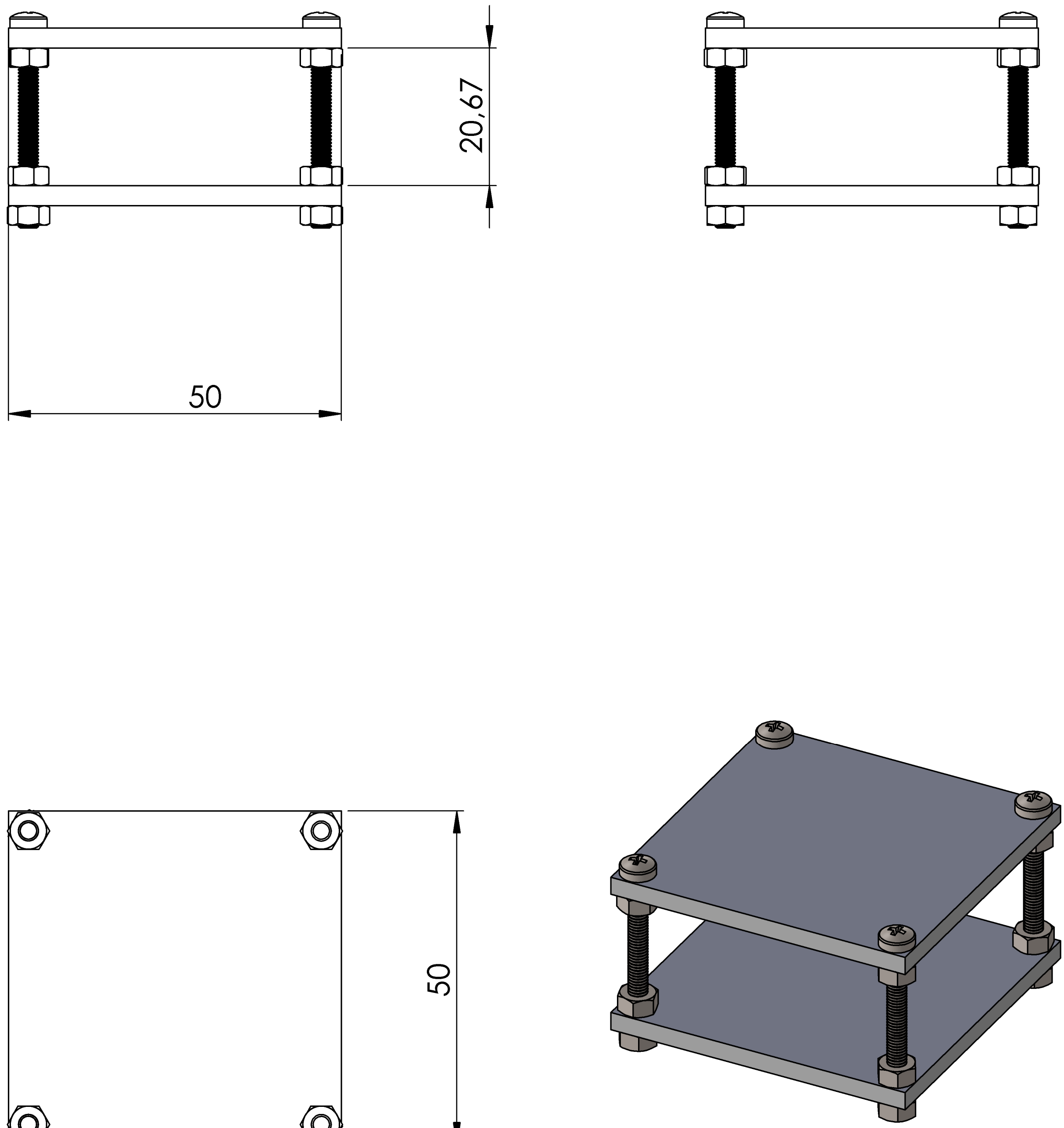
Since the world of 3d printer become so popular and important in almost all industrial fields it, it created a lot of ways and tools to make the building process easier and it helped us through the communities that gives a lot of solutions for the trouble shootings and some other hardware and software issues, along with the open source codes and softwares that improved the printing phase and even gave it other features.

Our main goal from this project is that we want to prove that building this machine is not that complicated, and can be done with simple and handy tools that anyone can afford, besides we wanted to create a special way of building the 3d printer which exclude the big surface, using 4 stepper motors which can be expensive by replacing it with hard and floppy drives that serves the same mechanism
this 3d printer can be used to create a lot of helpful solutions such as additional pieces or even a full piece that can be assembled.

For future works, we can suggest adding more features to the printer in order to increase the printing speed in parallel a feature to decrease the degree for the hotend aswell.

Annex

In the following annex, we are going to show the drawing part



SAUF INDICATION CONTRAIRE:
LES COTES SONT EN MILLIMETRES
ETAT DE SURFACE:
TOLERANCES:
LINEAIRES:
ANGULAIRES:

FINITION:

CASSER LES ANGLES VIFS

NE PAS CHANGER L'ECHELLE

REVISION

	NOM	SIGNATURE	DATE
AUTEUR			
VERIF.			
APPR.			
FAB.			
QUAL.			

TITRE:

MATERIAU:

No. DE PLAN

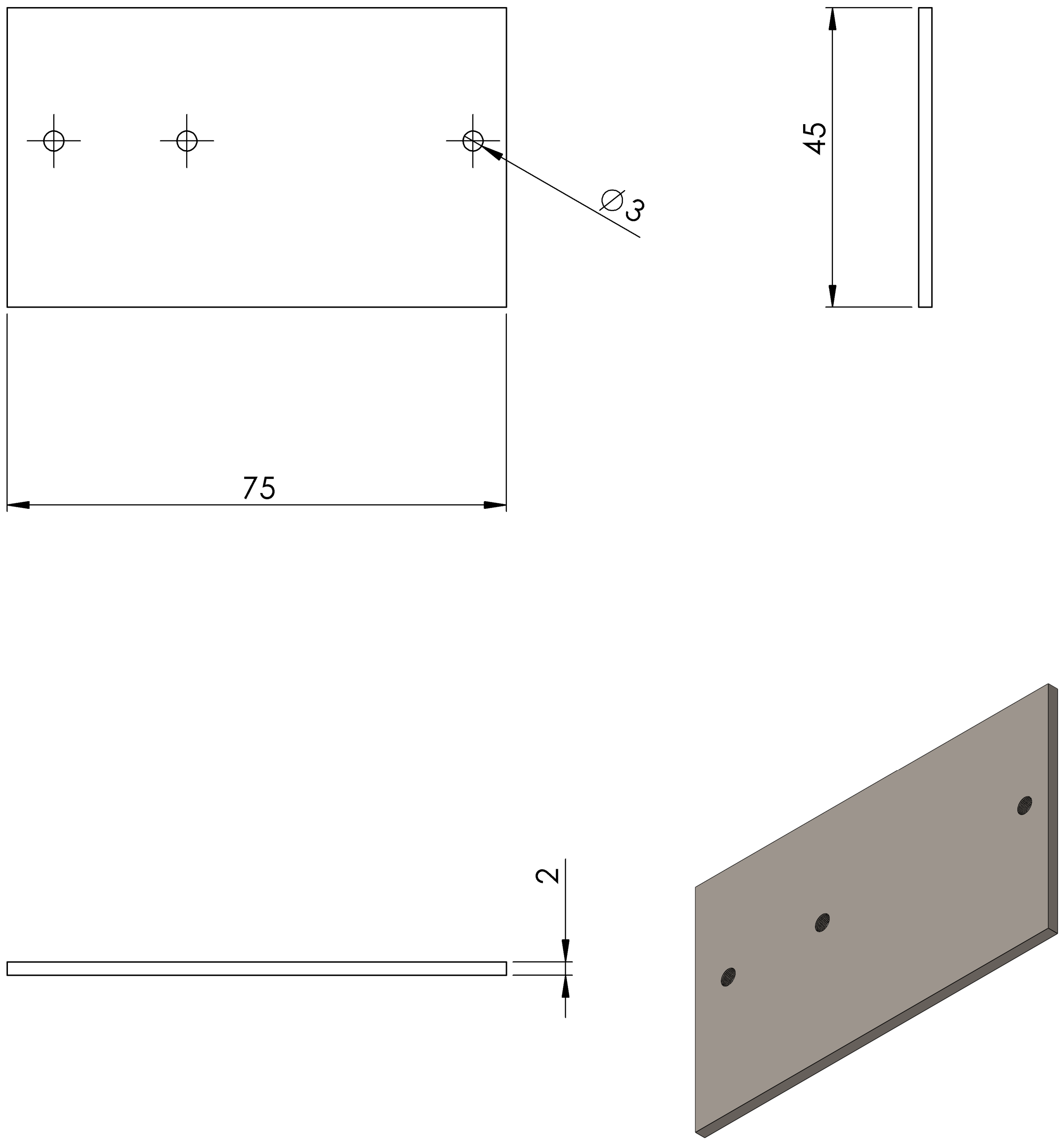
bed

A4

MASSE:

ECHELLE:1:1

FEUILLE 1 SUR 1



SAUF INDICATION CONTRAIRE:
LES COTES SONT EN MILLIMETRES
ETAT DE SURFACE:
TOLERANCES:
LINEAIRES:
ANGULAIRES:

FINITION:

CASSER LES ANGLES VIFS

NE PAS CHANGER L'ECHELLE

REVISION

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AUTEUR			
VERIF.			
APPR.			
FAB.			
QUAL.			

TITRE:

MATERIAU:

No. DE PLAN

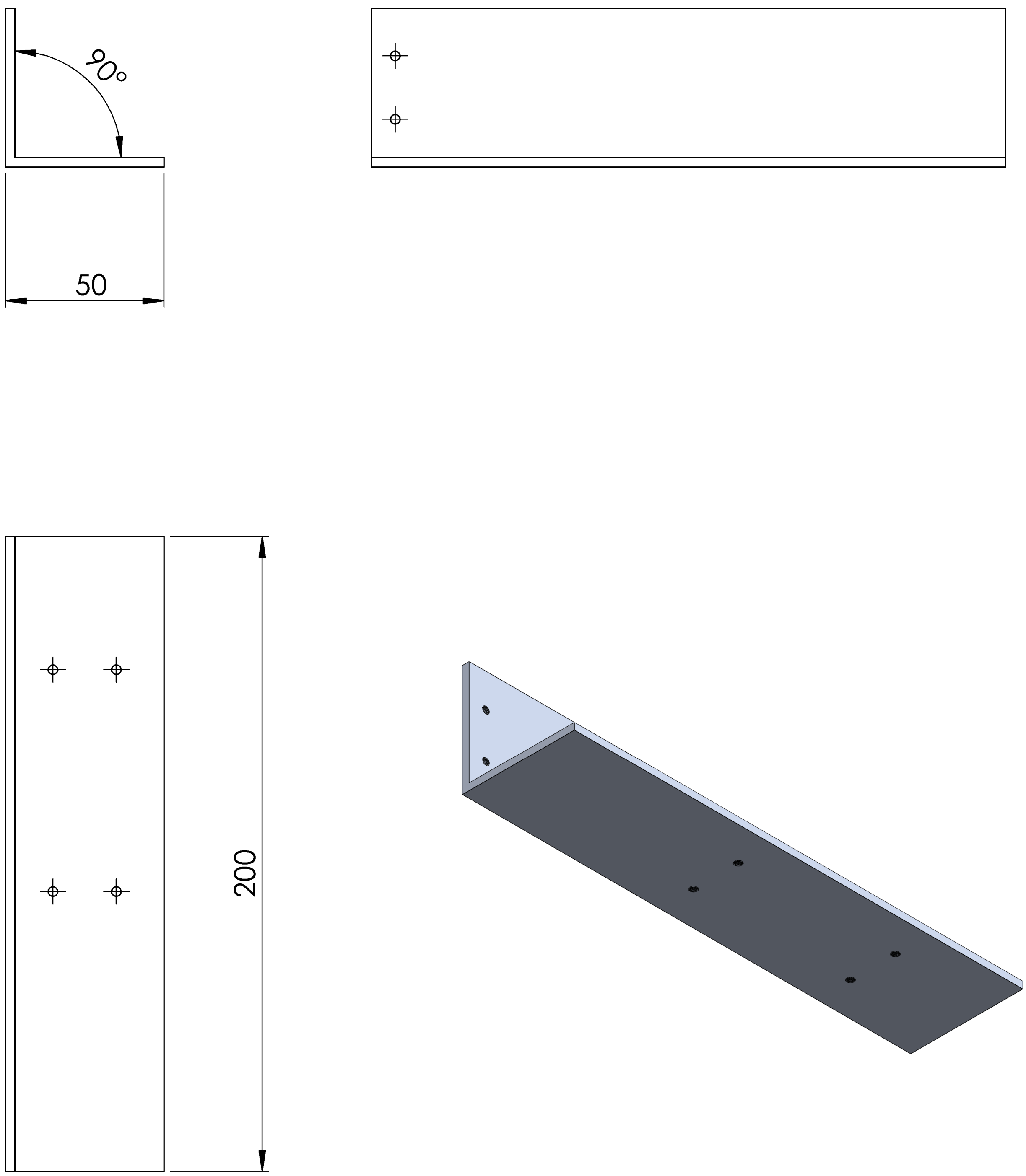
aluminuim part

A4

MASSE:

ECHELLE:1:1

FEUILLE 1 SUR 1



SAUF INDICATION CONTRAIRE:
LES COTES SONT EN MILLIMETRES
ETAT DE SURFACE:
TOLERANCES:
LINEAIRES:
ANGULAIRES:

FINITION:

CASSER LES ANGLES VIFS

NE PAS CHANGER L'ECHELLE

REVISION

	NOM	SIGNATURE	DATE
AUTEUR			
VERIF.			
APPR.			
FAB.			
QUAL.			

TITRE:

MATERIAU:

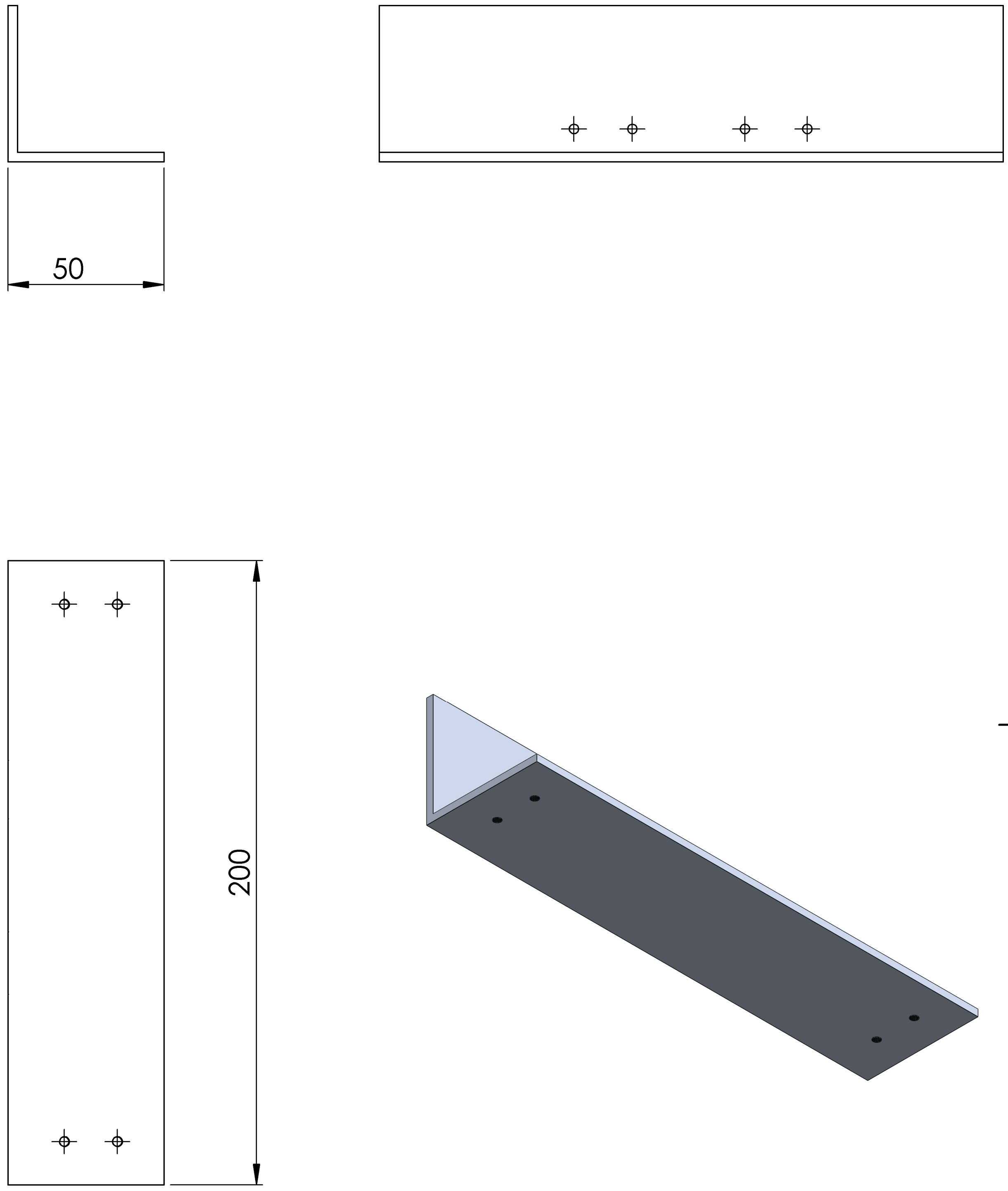
No. DE PLAN
aluminuim angle

A4

MASSE:

ECHELLE:1:5

FEUILLE 1 SUR 1



SAUF INDICATION CONTRAIRE:
LES COTES SONT EN MILLIMETRES
ETAT DE SURFACE:
TOLERANCES:
LINEAIRES:
ANGULAIRES:

FINITION:

CASSER LES ANGLES VIFS

NE PAS CHANGER L'ECHELLE

REVISION

	NOM	SIGNATURE	DATE
AUTEUR			
VERIF.			
APPR.			
FAB.			
QUAL.			

TITRE:

MATERIAU:

No. DE PLAN

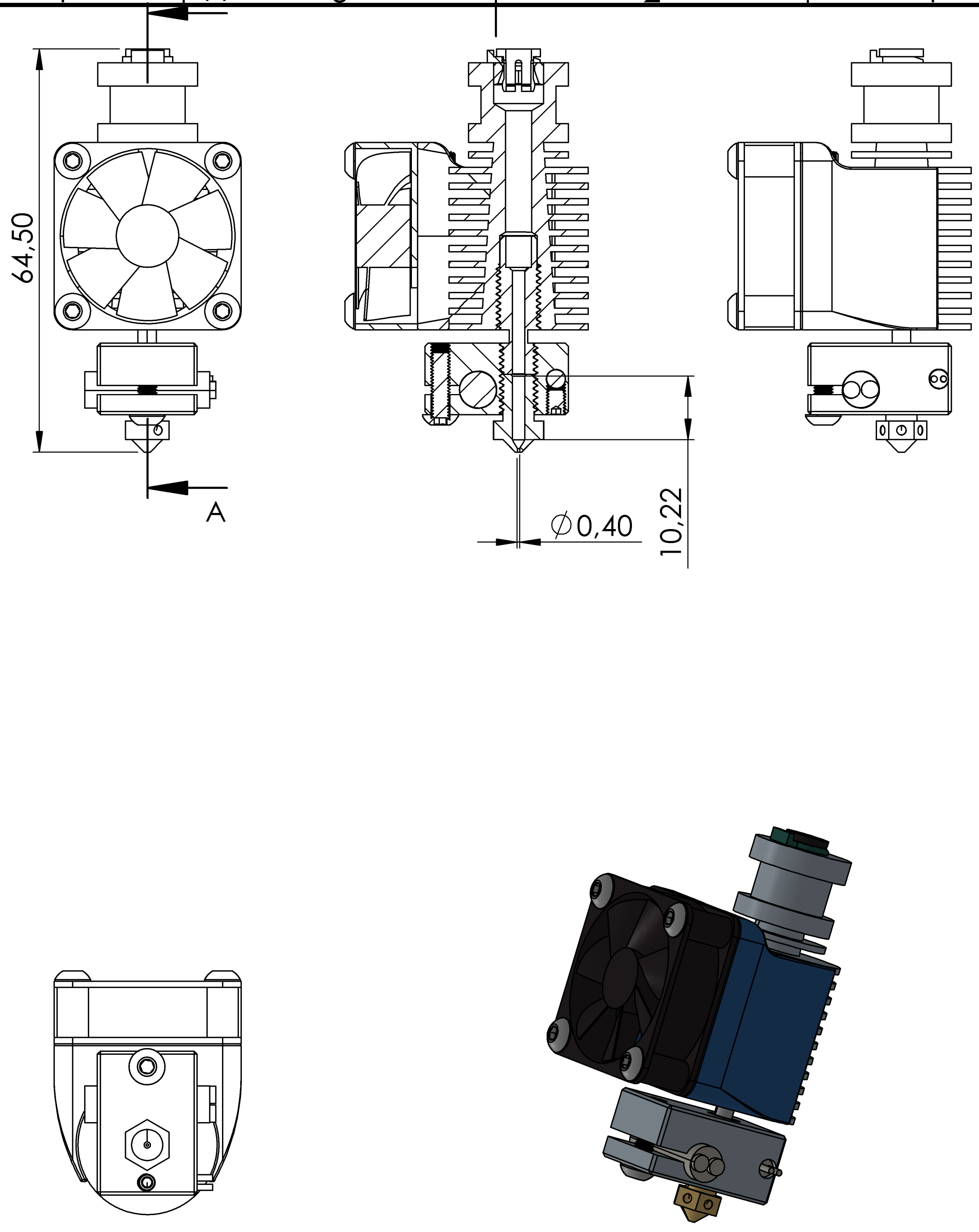
aluminuim angle base

A4

MASSE:

ECHELLE:1:5

FEUILLE 1 SUR 1



SAUF INDICATION CONTRAIRE:
LES COTES SONT EN MILLIMETRES
ETAT DE SURFACE:
TOLERANCES:
LINEAIRES:
ANGULAIRES:

FINITION:

CASSER LES ANGLES VIFS

NE PAS CHANGER L'ECHELLE

REVISION

	NOM	SIGNATURE	DATE
AUTEUR			
VERIF.			
APPR.			
FAB.			
QUAL.			

TITRE:

MATERIAU:

No. DE PLAN

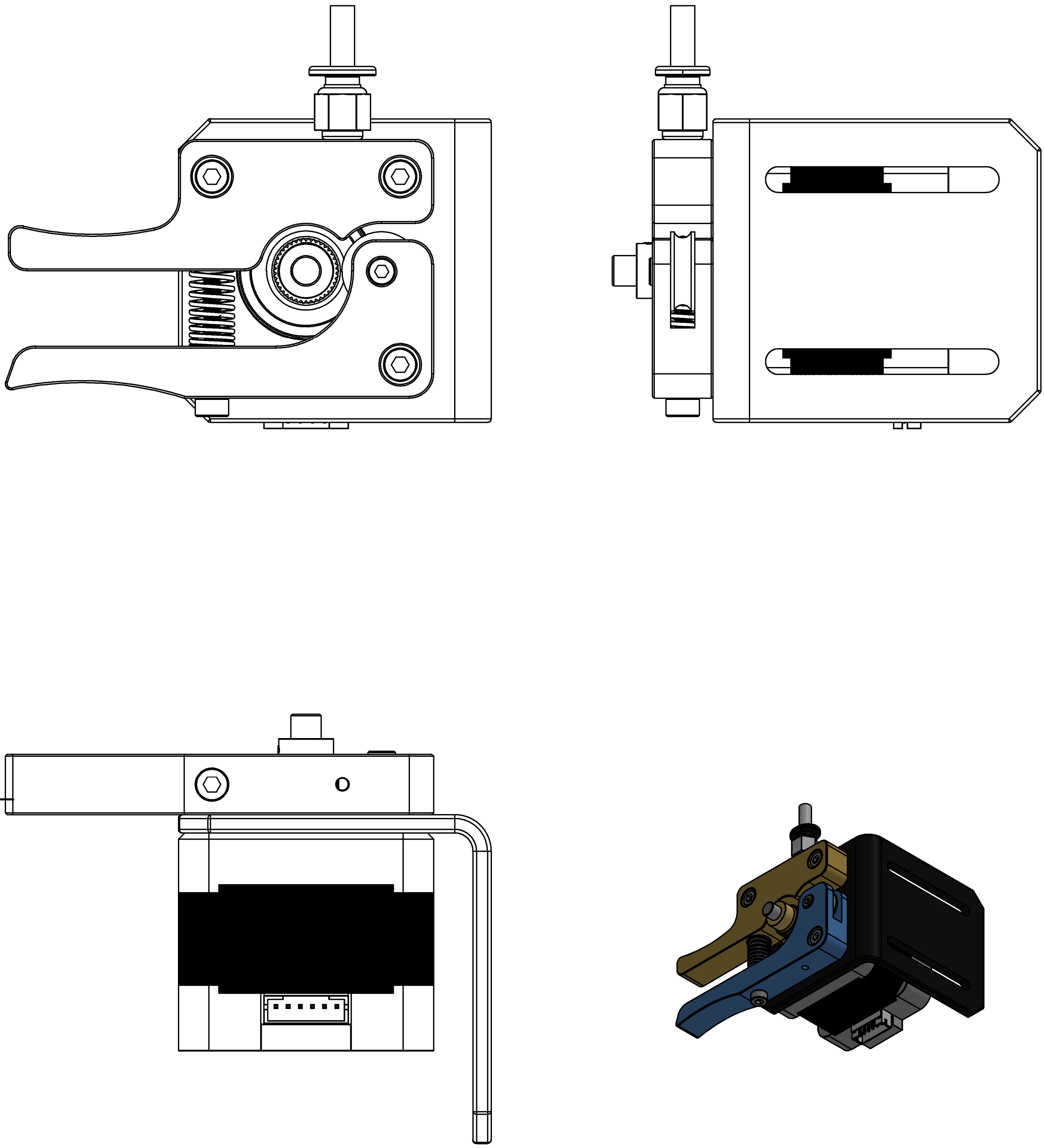
e3D V6 1.75mm Hotend

A4

MASSE:

ECHELLE:1:1

FEUILLE 1 SUR 1



SAUF INDICATION CONTRAIRE:
LES COTES SONT EN MILLIMETRES
ETAT DE SURFACE:
TOLERANCES:
LINEAIRES:
ANGULAIRES:

FINITION:

CASSER LES ANGLES VIFS

NE PAS CHANGER L'ECHELLE

REVISION

	NOM	SIGNATURE	DATE
AUTEUR			
VERIF.			
APPR.			
FAB.			
QUAL.			

TITRE:

MATERIAU:

No. DE PLAN

Extruder

A4

MASSE:

ECHELLE:1:2

FEUILLE 1 SUR 1

References

[1] Printing in Plastic Build Your Own 3D Printer - James Floyd Kelly and Patrick Hood-Daniel- Chapitre 1 Before you begin Page 1

[2] [Charles_Bell_(auth.)]_Maintaining_and_Troubleshooting your 3D Printer Page 4

[3] https://all3dp.com/2/history-of-3d-printing-when-was-3d-printing-invented

[4] [Joan_Horvath__Rich_Cameron]_Mastering_3D_Printing

[5] 3D Printing for Artists Designers and Makers 2nd Edition - Timeline of 3D machine DevelopmenT

[6] https://penandplastic.com/3d-printer-types

[7] https://www.simplify3d.com/support/materials-guide/pla/

[8] https://www.simplify3d.com/support/materials-guide/abs/

[9] https://omnexus.specialchem.com/selection-guide/polyethylene-terephthalate-pet-plastic

[10] https://www.simplify3d.com/support/materials-guide/hips/

[11] https://www.elprocus.com/stepper-motor-types-advantages-applications/

//.Stepper Motor Microstepping with PIC18C452 Padmaraja Yedamale Sandip Chattopadhyay Microchip Technology Inc (z-lib.org)

[12] https://www.brainkart.com/article/Characteristics-of-Stepper-Motor_11752/

[13] https://www.pololu.com/product/2267

[14] https://www.makerspaces.com/arduino-uno-tutorial-beginners/

[15] https://www.elprocus.com/different-types-of-arduino-boards/

[16] https://docs.rs-online.com/9ab3/0900766b80e8ba22.pdf

[17] arduino for dummies, page 19, John Nussey, edition 1, année 2013

[18] https://www.rhydolabz.com/components-microcontrollers-c-172_192/atmega256016au-microcontroller-p-1900.html

[19] https://all3dp.com/2/ramps-1-4-review-the-specs-of-this-controller-board/

[20] https://3dprinting.stackexchange.com/questions/1109/which-endstops-are-most-precise

[21] https://store.fut-electronics.com/products/opto-endstop

[22] https://store.fut-electronics.com/collections/magnetic-encoder/products/magnetic-sensor-switch

[23] https://www.acopian.com/12v-power-supplies.html

[24] https://whatis.techtarget.com/definition/print-bed

[25] https://www.matterhackers.com/news/choosing-the-right-3d-print-bed-surface

[26] https://www.sculpteo.com/en/glossary/extruder-definition/

[27] https://filament2print.com/fr/blog/57_guide-nozzles-quand-changer.html

[28] mémoire d'université boumerdas **(automatics)-**Étude, conception et réalisation d'une imprimante 3D-

[29] https://thomasannet.wixsite.com/portfolio/thermal-analysis-hotend

[30] https://www.sculpteo.com/fr/glossaire/solidworks-definition-fr/

[31] https://www.theengineeringprojects.com/2018/10/introduction-to-arduino-ide.html

[32] https://all3dp.com/2/printrun-a-beginner-s-tutorial/

[33] https://www.blender.org/about/