A NOVEL INTEGRATION OF LASER ENGRAVER AND 3D PRINTER

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Abstract - *This paper is proposed to design and develop a new integration of 3D printer and laser engraver in a single control system. The 3D printing technology is based on the Fused deposition modeling technique (FDM) which is an additive manufacturing process while Laser engraving (a subset of laser marking) is based on the subtractive manufacturing process. Both these processes are controlled digitally though they utilize different approaches to build their parts. In 3D printing technology, it extrudes plastic filaments from a nozzle and deposits melted plastic on a plane layer by layer. The quality of printing depends upon the height of the nozzle for printing. If the height is too high, the printed part unable to stick to the bed. If the height is too low, the melted plastic stops from the nozzle. For the optimum height, inductive proximity sensor is fitted to develop the auto-bed levelling system. For laser engraving, this auto-bed levelling system is suitable for laser to find optimum height for suitable depth in the product. For making auto-bed levelling Work with optical laser engraving, an investigation of the Laser engraving at different heights are presented. Besides, a calibration to obtain optimal height is also presented in this paper. This paper conferred a detail of developing associate degree integration of 3D printer and optical laser engraving.*

Key Words: Computer Numeric Controlled (CNC), 3D Printer, Laser Cutter, Laser Engraver, 2D Plotter, Arduino, Ramps, Stepper Motors, etc.

1. INTRODUCTION

With the rapid development in science and technology, the conventional means of manufacturing are becoming obsolete due to some unconventional techniques like 3D printers, laser engravers, etc. The use of these unconventional techniques has not only revolutionized the process of manufacturing but it also speeds up the process and increases accuracy too. The 3D printer is a type of additive manufacturing process in which products are built layer by layer. Various techniques have been developed in order to level the heat-bed mechanically. This paper discusses the FDM technique for 3D printing within which the filament is liquified into a molten state and also allowed to solidify once a layer has been shaped. FDM could be a quicker technique than the opposite ones, however lacks in higher resolution if care isn't taken. There are some 3D printers that also use multi extruders to combine completely different colors and to print a colorful object. Equally varied styles of lasers have also been developed that embrace carbonic acid gas optical laser, micro-jet optical laser and

plasma optical laser, etc. optical laser frequency, range of passes, focal length and engraving speed impact on material removal rate by an optical laser diode. Delta techniques for optical laser engraving method are also utilized in order to scale back the moving parts therefore obtaining higher speeds and acceleration whereas reducing the power consumption. Optical laser diodes will be accustomed to cut the material similarly as engrave materials like wood, acrylic and plastic, etc. With the rise in technology a machine is also made to draw pictures, charts, electronic circuits, etc. that uses a pen as a tool to plot varied things that machine is termed 2nd plotter. A 2nd plotter will be created using all the stepper motors or with a servo motor in the coordinate axis along with stepper motors in the x and y-axis. Ordinarily all, these technologies are controlled through the computer numerical control (CNC) system within which silicon chip is employed which is capable of process logical directions interfaced with a computer. The logical directions are provided by employing a computer within the kind of code or text or image that is then transformed into a machine language, sometimes referred to as G -Codes, by silicon chip to be dead by the machine. This paper describes the technique needed to merge these techniques into one machine. Arduino is employed as a microcontroller and also works as a silicon chip which may be simply programmed and one will simply erase the previous program. Ramps 1.4 controller board is additionally utilized in accordance with Arduino to regulate the method.

2. SYSTEM CONFIGURATION

This system is an integrated system of 3D printer and laser engraving machine, as shown on Fig. 1. The developed printer includes an 3D printing system, auto-bed-leveling system and a laser engraving system.
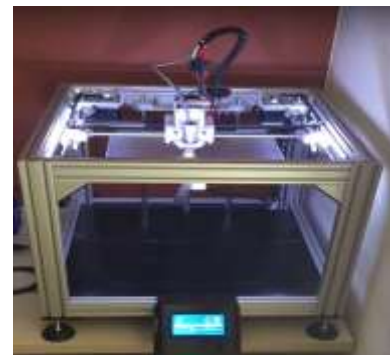

Fig. 1-: An integrated system of Laser Engraver and 3D printer

2.1 3D printer

This machine is a Fused Deposition Modeling (FDM) based printer. It utilizes a hotend to heat filament and deposit melt filament in building zones layer by layer until the part is completed. There are two common hardware structures of FDM machines, 3-Axis and Delta Robot, as shown in Fig. 2[1]. The Delta Robot utilizes six parallel arms to move the hotend platform to depositions. Its advantages include stable and robust moving. This type of machine is widely applied in the packing industry. However, its platform seems not to be able to load heavy components. Because of this disadvantage, a 3-Axis based machine is suitable for this study.

Fig. 2[1]: configuration of a delta robot

An FDM machine always requires critical conditions to obtain a high quality of printed parts. For example, the height of the first layer is an essential factor to affect the printing quality. Thus, many engineers had developed several auto-bed-leveling systems to solve the problem. The task of those auto-bed-leveling systems is to precisely locate their hotends one A4 sheet thickness above the bed. If the thickness is too large, it will cause the printed part trouble to stick on the print bed. If the thickness is too small, it will stop the melted filament out from the nozzle. Currently, there are three common types of auto-bed leveling systems, i.e., touch probe, force-sensing resistors (FSR), an inductive proximity sensor. The height of the touch probe is usually lower than that of the nozzle during the auto bed-leveling Process. It must be pulled up when the printing is started. Otherwise, it will damage the bed. The force-sensing resistors are installed directly beneath the bed, so they may not be suitable for a hotbed. Inductive Proximity sensor does not have the above two problems, but it only works with a metal bed.

Fig. 2[2]: Inductive proximity sensor

The system has three end-stops to assist 3D printers in detecting its home on three axes. The inductive proximity sensor can be treated as the end stop on Z-axis. The sensor has four wires, and Arduino controlled it. Its wiring diagram is shown in Fig. 2[3].
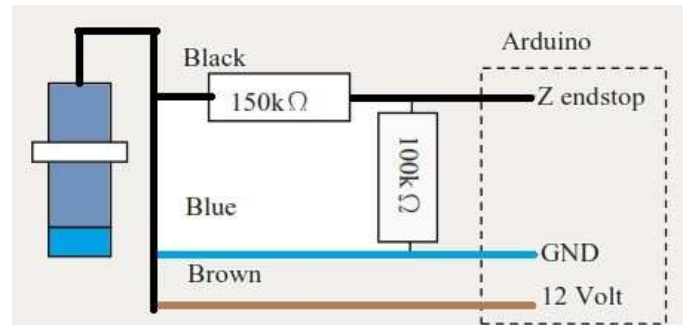

Fig. 2[3]: wiring diagram of Inductive proximity sensor

2.2 Laser engraver

Within this past couple of years, Laser technology was developed very successfully and rapidly. Its applications are widely in various fields, like medicine, science, military, and industry. Here, this study utilized Laser as a tool to execute a engraving task. The Laser used in this study is shown in Fig. 2[4]. It is a 500mw/450nm/12volt Laser. Since Arduino Mega controlled it, a relay is needed. The energy of the Laser is low, so it can only execute an engraving task.

Fig. 2[4]: 500mw/450nm Laser

The relay is an electrically operated switch which is used to control Laser on/off. Arduino, in this study, controls it. Fig 2[5] shows the wiring diagram of relay and laser.
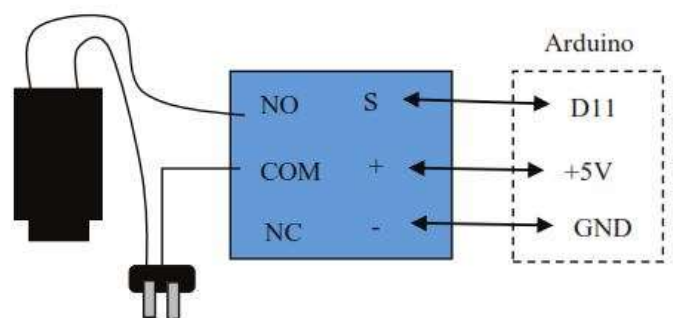

Fig. 2[5]: wiring diagram of relay and laser

2.3 Mechanical Design

The machine is built using Cartesian type 3D printers design. The main difference lies in its tool post. In 3D printers, only the extruder is mounted at the tool post. However, to fulfill the purpose of this machine, the tools required for laser engraving and 2D plotting are also mounted on the same tool post, i.e., laser module and pen, respectively. A possible configuration is shown in Fig 2[6].

Fig -2[6]: CAD model of the frame

2.4 Designed platform for extruder, hotend, and Laser

The machine is built using Cartesian type 3D printers design. The main difference lies in its tool post. In 3D printers, only the extruder is mounted at the tool post. However, to fulfill, the purpose of this machine, the tools required for laser engraving and 2D plotting are also mounted on the same tool post, i.e., laser module and pen, respectively. The first platform was designed to hold a laser module only. It cannot satisfy the need for this study. Therefore, a new holder was designed to hold an extruder, an inductive proximity sensor, and a Laser simultaneously. In order to develop the platform quickly, the SolidWorks was used to create the computer model, and a 3D printer was used to print a robust platform within a short period of time. The printed material used in this study is Polylactic acid (PLA).

We need something to cool the plastic as it comes out of the nozzle. For accurate printing, a cooling fan is more important. So, we have placed the stock piece of a fan. It is the stock piece, but at the bottom, the air is directed towards the nozzle. We have located a fan in parallel to the bed. Pins connect the fan to the ramps.

2.5 Aurdino + Ramps 1.4

The Arduino Mega and RAMPS 1.4 were used to control three motors on three axes, the extruder, three end-stops, a heater of the print bed, temperature sensors, etc. There are many various wiring diagrams of RAMPS 1.4.
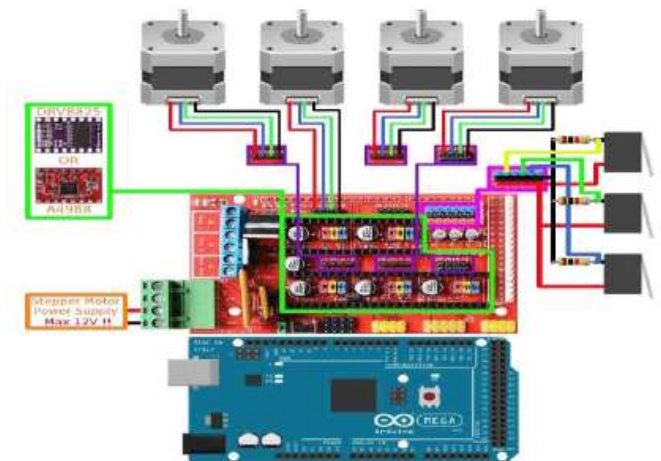

Fig -2[7]: Pin connection of Arduino

This study utilized an inductive proximity sensor instead of a z end stops as well as installed an Arduino relay shield to control a Laser on/off. For a quick development, a famous and free firmware called Marlin is used to control the devices to execute 3D printing and Laser engraving. The Marlin had defined all of the pins of RAMPS 1.4 to specific devices as end stops, extruders, motors, bed heater, hotend heater, temperature sensors, etc., under its sub-header file called pins.h. If users do not severely change the wiring setup, users can redefine the hardware setups under the header file called configuration.h.

The D9 port in ramps board is used to power the part cooling fan. Its power can be varied from 0 to 255 with increments of 1. This port can be switched on and off by using commands 106 and 107, respectively. The optical laser diode can be attached to this port to fulfill the purpose of laser engraving. The on and off G-codes will be replaced by 106 and 107, respectively, and its power could be controlled by using any number from 0 to 255 with 0 zero being minimum and 255 being the maximum power. If the function of the part fan is also required, then a switch can be used at D9 port. Its position can be set in order to achieve the desired process. The rest of the wiring is the same as used for Cartesian 3D printers.

2.6 Software

The developed machine is a digital manufacturing system which usually depends upon software to generate an executable code, i.e. G-code, based on a given computer models. 3D printing and Laser engraving are relied on two opposite manufacturing approaches. Of course, they need different software to accomplish their specific tasks. This study selected the Repetier host associated with Slicr3r for handling 3D printing and the Inkscape for handling Laser engraving.

2.6.1 Repetier host

There are many free softwares for handling 3D printing process, such as Cura, Repetier host and KISSlicer. The Repetier host is a popular open source for handling 3D printing. Before a 3D printing task, it is needed to conFig. the Repetier host based on the given machine first. The printer settings include defining the size of the bed and adding G29 command on the start of the G-code for executing an auto-bed-leveling process.[11]
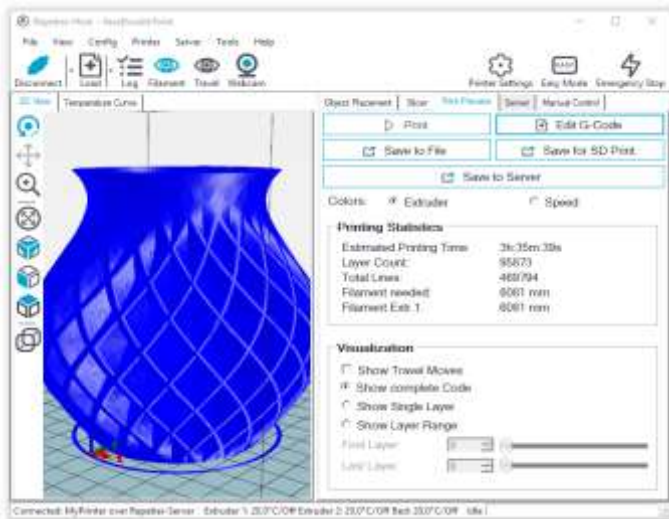

Fig -2[8]: Repetier host is ALL-IN-ONE software solution for 3D FDM machines.

2.6.2 Inkscape

Currently, Laser engraving and Laser cutting are often seen as a 2D manufacturing process. 3D computer models contain 3D geometrical information, so it may not be suitable for Laser engraving and cutting. According to this fact, it clearly illustrates that the Repetier host is not suitable to handle Laser engraving and cutting. Fortunately, free and open software called Inkscape was developed to assist us in handling Laser engraving and cutting. The Inkscape contains functions of converting a 2D image to an executable Laser cutting and engraving codes, i.e., G-code.
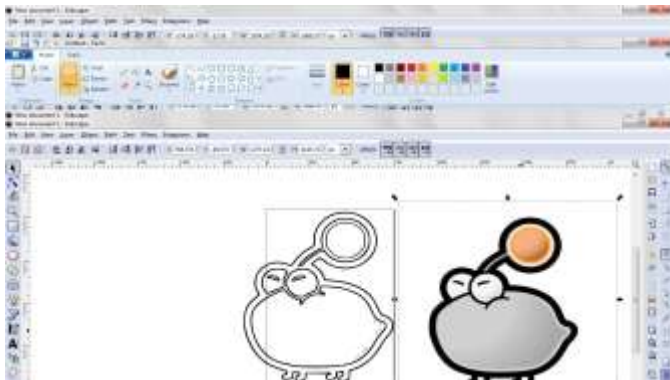

Fig.-2[9]: The Inkscape for tracing bitmap to a single path

Generally, Inkscape is used to obtain Laser paths, and an extension called Generate Laser G-code is introduced to convert generated Laser paths to a G-code. An executable G-code must contain the commands to move Laser at the available working height as well as to turn on and off Laser on planned paths appropriately. The extension has a convenient interface to allow users to add the specific G commands on G-codes efficiently and robustly. In this study, the Laser relay was connected with Pin 10 of the RAMPS 1.4. Therefore, the Laser can be turned on by the command "M42 P10 S255" and turned off by the command "M42 P10 S0". With our settings, the extension automatically adds "turn-on" commands before the starts of cutting paths and "turn-off" command after the ends of cutting paths.

2.6.3 Marlin Firmware

Marlin Firmware runs on the 3D printer's main board, managing all the real-time activities of the machine. It coordinates the heaters, steppers, sensors, lights, LCD display, buttons, and everything else involved in the 3D printing process.

Marlin implements an additive manufacturing process called Fused Deposition Modeling (FDM) Fused Filament Fabrication (FFF). In this process a motor pushes plastic filament through a hot nozzle that melts and extrudes the material while the nozzle is moved under computer control. After several minutes (or many hours) of laying down thin layers of plastic, the result is a physical object.

The control-language for Marlin is a derivative of G-code. G-code commands tell a machine to do simple things like "set heater 1 to 180°," or "move to XY at speed F." [6]

3. Flowchart

As shown in the block diagram, DC power supply is given to Microcontroller for the movement of the Axis as well as the working of Laser. According to controller signal stepper motor will move, and a laser will engrave on that workpiece. Synchronization of axis and laser will create the required design on the workpiece.
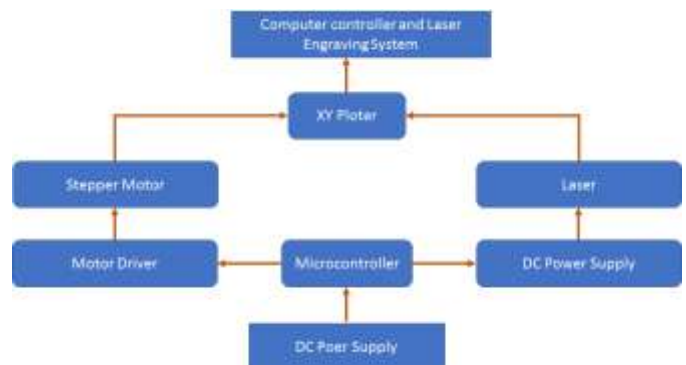

Fig -3[1]: CAD model of the frame

The first step in 3D printing is to design a digital 3D model. It is nothing but a process of developing a mathematical representation of any surface of an object in three dimensions via specialized software. Here we are using CAD (computer-aided design) tool to develop such a model.

Design slicing: design slicing is the process where the 3d model will slicing vertically into many layers so that the printing process will be easier. Printing of these components will be done layer by layer from the bottom. In the case of Laser Engraving, we are creating a 2D image as we are doing Engraving on a flat surface. This 3D model or 2D image will be converted into G Code using software GIMP, which is open-source software. In this model, we have used the Arduino UNO controller. Using GIMP software, we will give Gcode to the Arduino controller. Then we have used GRBL firmware for Arduino Controller that controls stepper motor.

GRBL uses G-Code as input and outputs signals via the Arduino pins, which will give a command to stepper motor driver LM317. That will generate required pulses for the movement of stepper motor. This is how we can control our axis and create a 3D model in case of 3D printer or we can create required image on surface using Laser Engraving.

4. Analysis and Results

4.1 Analysis

By varying the processing parameters of laser such as power, speed and number of passes, different colors can be created on the surface. Various focusing lenses are available according to the needs. Lenses with shorter focal length create a smaller spot diameter and are better suited for engraving applications. Lenses with larger focal length are suited for cutting applications. Table-1 shows some numerical values for these factors for wood.

Focal length	25mm	50mm	75mm
Spot diameter	40μm	70μm	∼100μm

Table- 1: Focal length vs spot diameter

To increase the depth of cut with low power, one can reduce its speed and increase the number of passes required.

4.2 Results

Objects created by our prototype are attached below Fig. 4[1] & 4[2].

Fig.-4[1]: Laser engraving on wooden objects

Fig.-4[2]: 3D printed gears of PLA created from this prototype.

5. Conclusion

The concept was converted into a reality along with all its components. A working prototype was made with the help of different components acquired and purchased. It was found out during the conducted experiments that laser is working properly on a wooden workpiece and engraving wood as per design. Similarly, the 3D printer also working properly and we also made some mechanical objects like gears. The platform here can accommodate only small objects which can be kept in the pocket. The size of a platform or bed can be increased for bigger projects in the future.

Additionally, the calibration for improving the engraving quality is presented and discussed. The engraver is a practical digital system, just like a 3D printer. It is a programmable machine. By sending G-code commands, users can control the machine digitally or manually. The auto-leveling is a typical example to demonstrate the powerful potential of a digital system. The most commercial Laser engravers can only deal with the cut objects laid on a flat surface. Since their cutting tracks are required to keep a specific distance from cut objects, the cuttings cannot be accomplished when the Laser loses its focal length. This paper introduces the auto-leveling applied in a 3D printer to solve this problem.

Advantages:

- Low weight

- Easily transportable

- Low cost

- Easy Setup to understand

- Laser Engraver and 3D printer both technologies available

Disadvantages:

- Available for soft material

- Works only with DC supply.

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