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Design and Development of Dual Extruder 3D Printer

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Abstract: *3D printing is a desktop fabrication. It is really innovative and unending process idea along with the cost of this project is less, it is used to create ideas into reality. 3D printer machine assembly is done by using equipment in workshop or home, parts of the 3D printer which are available in the market. 3D printing or additive manufacturing is a process of making three-dimensional solid object of any shape from a digital model. Successive layers of materials laid down to build an object. Each of the layers can be seen as thinly sliced cross-section of the object. 3D printing enables the production of complex shapes using less material than traditional additive manufacturing method. In particular, we integrated a heated dual nozzle extrusion system and a cooling platform in the new system. In addition, we altered the software of the 3D printer to ensure fully automized procedures are delivered by 3D printing device. As for the software, the firmware of the conventional 3D printer was changed and modified to allow for the flow of the filament, thus eliminating overflows in sections of the printing path where the speed changes sharply*

Keywords: 3D printer, Additive manufacturing, Dual extruder.

I. INTRODUCTION

The ability to print a 3D object from a digital file is a breakthrough technology. 3D printing technology has shown rapid growth in the last few years. The principle of 3D printing is to bond materials in layers to form a three-dimensional object. There are several 3D printing methodologies such as stereo lithography apparatus (SLA), selective laser sintering (SLS), fused filament fabrication (FFF), and laminated object manufacturing (LOM).

Fused filament fabrication (FFF) is one of the most popular technologies due to its simplicity. In FFF, a plastic filament from a coil is driven to the extrusion nozzle and then passes through the heater with the required melting temperature. The object is printed layer by layer with the flow of that melted material. After flowing through the extrusion nozzle, the material and material limitations for fine and accurate 3D printing. The solution is to implement several extrusion solidifies immediately. The application of pressure in the nozzle pushes the semisolid material out of the nozzle. The stable pressure and constant moving speed of the nozzle result in a uniform extrusion and, therefore, in a more accurate product. First, the printing speed is relatively low compared to other printing methods. More time is needed to Fused filament fabrication (FFF) is one of the most popular technologies due to its simplicity. In FFF, a plastic filament from a coil is driven to the extrusion nozzle and then passes through the heater with the required melting temperature. The object is printed layer by layer with the flow of that melted material.

After flowing through the extrusion nozzle, the material solidifies immediately. The application of pressure in the nozzle pushes the semisolid material out of the nozzle. The stable pressure and constant moving speed of the nozzle result in a uniform extrusion and, therefore, in a more accurate product. First, the printing speed is relatively low compared to other printing methods. More time is needed to obtain thinner layers to build an object with more accurate and precise dimensional control. Second, the process has been limited to print only one type or colored material at a time.

This paper provides a novel solution to the issues of time consumption, color, nozzles that operate simultaneously, which could save printing time and allow the utilization of varieties of color or material filament.

II. CONFIGURATION OVERVIEW

This section provides information on the mechanics and limitations of the conventional single nozzle extruders and the possible improvements by the proposed multi-nozzle extruders.

A. Working Principles of Extruder and its Limitations

The fundamental working principles of an extruder have been described in the introduction section. The extruder is composed of cold-end and hot-end. The function of cold-end is to drive the filament into the hot-end. The cold end generally consists of a stepper motor which rotates a toothed gear against a bearing. The filament (usually 1.75 mm and 3 mm in diameter) located between bearings is driven towards the hot end when the motor is activated. Some of the cold-end parts can be 3D printed with plastic filaments. The cold-end cannot be heated as it may be close to the hot-end location. Therefore, heat sinks, fans, water cooling, or Peltier effect cooling are normally used to address this issue.

There is a thermal insulator or break between the cold-end and hot-end, which joins these two ends and prevents heat conduction between the two ends. The thermal insulator is normally made of PEEK (Polyether ether keton) plastic with PTFE (Polytetra fluoro ethylene) liners. Groove mounts are also used to connect the cold-end to the hot-end.

The function of the hot end is to melt the filament. It is normally made of brass, but in some cases, aluminum and glass are used to reduce the weight of the hot end. The hot end consists of a heating chamber with two holes, one hole for filament feed in, and the other hole for the extrusion of molten plastic. The diameter of the extrusion (tip) hole of the nozzle varies from 0.3 mm to 1 mm. The typical working temperature for the hot end ranged from 150 ºC to 250 ºC, which includes the melting temperature of the most popular filaments like ABS and PLA.

Thermistors are normally used in the feedback loop to measure and monitor the temperature. The extruder is mounted to the frame of 3D printer by different means and standards. The material inside the chamber should be in its molten state, but the temperature must be kept as low as possible, because the quality of some polymers will deteriorate at high temperatures. Furthermore, the application of high temperatures inside a nozzle requires cooling after extrusion. The stability of constant pressure for extrusion is dependent on the constant supply of material from the cold end fed into the chamber.

The use of only one extruder limits the 3D printing capabilities. Only one single filament can be set into an extruder at a time and therefore only one color/material filament can be used. Changing of filament would require a noticeable time break as the printing process is paused. The procedures include pulling out the used filament, cleaning the extruder chamber, and feeding in the next filament.

B. Multi-Nozzle Extruder Challenges

It is possible to feed several filaments in one goal with the implementation of extruders with several nozzles. It can facilitate printing with multi-colors and/or multi-materials. Dual extruder is one of the successful implementations of the concept. There are two nozzles on the dual extruder head and the extrusion principle is the same as single nozzle extruder. One of the primary reasons for using a multiple extruder is to increase the speed of printing process.

The printing time canbe reduced by continuous operation of extruders as it is no need to spend extra time on changing filaments. In most cases, the second extruder of the dual extruders is used to print supporting material to hold the object's suspended volume part for complex 3D structural. In addition, some of the models use more than two nozzles at the same time.

III. LITERATURE SURVEY

Vedant Daramwar et al. worked on Design and Development of Multi-Material Extrusion in FDM 3D Printers this research highlights the design, development and choice of the most rugged, accurate, reliable and effective approach towards use of multiple filaments and concluded that the method of printing by using 'Multiple Printing Heads', being a more efficient and accurate technique, has been explained, along with the design of the entire mechanism.

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Krisztian Kun worked on Reconstruction and development of a 3D printer using FDM technology to outline the milestones of the reconstruction of the printer, the restoration of the technical documentations (Reverse Engineering), and then the calibrations and the measurement result and concluded that the designed printing unit is a compact, user-friendly jog unit and a head-holder console. And a structure is created, where the extrusion head unit does the X-Y movement at the same time, and to be able to print support material [1].

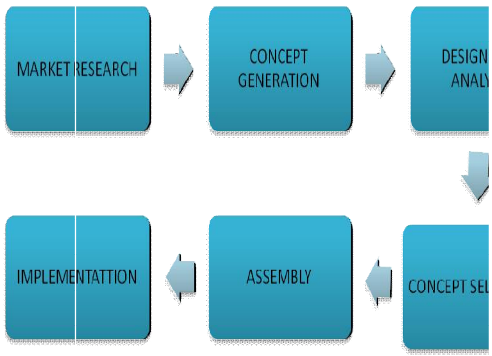
Andi Dine, Edward Bentley et al. worked on A Dual Nozzle 3D Printing System for Super Soft Composite Hydrogels to design and integrate new subsystems into a conventional extrusion-based 3D printer, to obtain a hardware that encompasses a range of new capabilities and concluded that this printing technique utilizes a liquid to solid phase change of the printing solution to ensure structural stability for large scaffold volumes [2].

Roman Polak et al. worked on Determination of FDM Printer Settings with Regard to Geometrical Accuracy stating that material extrusion is one of the most used additive technologies. The most common application of this technology is in the production of prototypes and preparations.and small serial parts. This article deals with the relationship between different model geometries and parameters such as temperature, speed of printing and height of layer.

Typical features of this technology are ease of printing, but it depends on the type of material used and the device. Printers with Fused Deposition Modeling (FDM) technology have no feedback about printed material, such as printing accuracy. This paper aims to easily find ideal parameters for FDM printing technology using Polylactic Acid (PLA) material and concluded that it is hard to find these settings during real production; therefore, this experimental analysis was carried out. The collected data shows the dependence of the geometry on the print properties. The main tested parameters were speed, temperature and layer height. The results show the accuracy mainly depends on the temperature and layer height. The best results were obtained using lower temperature and thinner layers. Many articles deal with dimensional accuracy and model post processing regarding the surface finish. The information contained in this article can be used for verification of these properties and finding the ideal parameters on other FDM devices. This test has many possibilities for continuing and expanding the testing information for ideal FDM printer settings. Further research will continue with testing other print parameters, such as different nozzle sizes, other materials (ABS, Nylon, PETG etc.) and combining them with the parameters tested in this article [3].

Xiuxia Zhang et al. worked on Design and Simulation of Multi-nozzle FDM 3D printer for fabricated Solar thin-film cells to widely realize the personalized use of solar thin-film cells in every family, save costs and generate clean energy, our team wants to fabricate a 3D printer of solar thin- film cells. The solar film cells were 3D printed fabrication by FDM3D printer would improve their performance as battery. In this paper, for fabricating P nano-diamond/ZnO solar film cells the hot bed and nozzle of 3D printer were designed to achieve 3D printing of solar cells. A printer for fabricated

IV. METHODOLOGY



The first step is to identify the need for an emerging market for portable, low-cost, standard-purpose, dual extrusion 3D printers. The problem with the existing FDM 3D printers on the market is that they are very expensive and not cheap for many interested parties. Then a market survey is done to find out who the potential customers are. And how much are they willing to pay for the new FDM 3d printer if available for purchase.

Then the design and operation is visualized with a 3D printer available in IEM department and mechanical department and research is done on various MSME's Bangalore using 3D printers to make parts and fastprototyping. Observations

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and studies are also done with web resources and magazine papers published on FDM 3D printers. The feature considerations and targeted specifications that need to be achieved in the final product are done. The next step was to amend the Bill of All Materials, Electronics and other materials needed to build a FDM 3d printer and to conduct market research when available on the market at a low price. Thereafter assembling and inspecting various electrical and electrical equipment such as control boards, circuits, power supply unit drivers, actuators etc. Eventually it combines electronic components with various mechanical and structural elements and is tested and finally begins to use the machine to make the necessary materials.

V. CONCEPT GENERATION

Concept generation is the process of creating ideas for designing a product based on the target specifications and requirements. These ideas describe the design and working principles of the product, along with how it can meet the customer requirements. The concept generation phase starts with analyzing the customer requirements from different angles and results in developing a final design for the product. You may illustrate the proposed design as a 3D model, blueprint, or rough drawing. Creativity and problem-solving skills are vital for this process.
The four concepts which are generated are as follows:

i) CONCEPT -1

In this hand feed mechanism 3D printer has become an unchallenged method for the manufacturing of complex shape objects. We must give hand feeding of filler material.

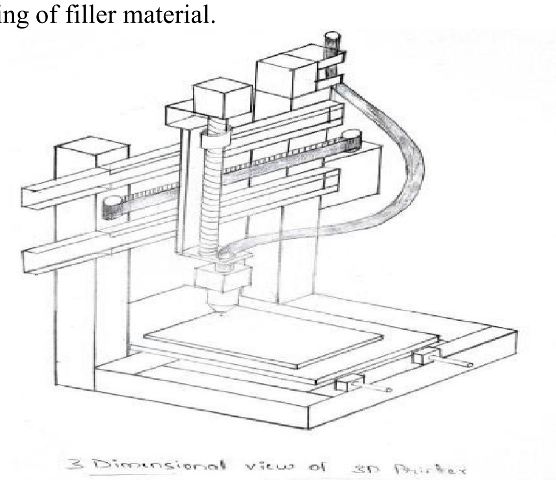

Fig.1. 3D Model of Concept One.

ii) CONCEPT-2

One of the best reasons for a dual extrusion process is to use different filler materials simultaneously with different colours.

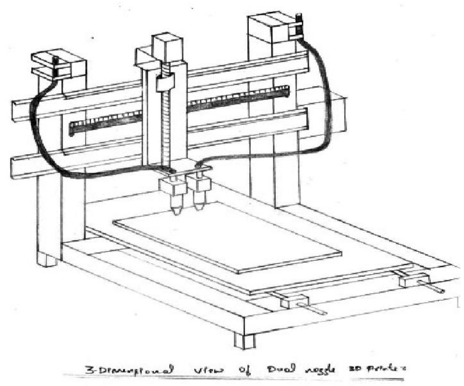

Fig.2. 3D Model of Concept Two.

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VI.CONCEPT SELECTION

We generated four concepts based on the 3D printer. After comparing the advantages and limitations of these mechanisms.

- Hand feed mechanism
- Dual extrusion mechanism
- Single extruder mechanism
- Roller feeding mechanism.

Among these given above mechanisms we have selected dual extrusion mechanism with less limitations and maximum benefits.

Advantages

1) Each material has a unique nozzle that is specifically designed for it, and it may even have a distinct extruder (direct or Bowden).
2) Because the printing heads are attached to the main body, there is no additional weight on the carriage (except from the servo motor).
3) The printing nozzle is not impacted by other nozzles, preventing interference, and leaking.
4) It is simple to replace an extruder and hot end component that isn't working.
5) The only restriction on the number of filaments (extruders) is the printer's size. Numerous printing heads can fit within large printers.
6) This mechanism has a broad range of applications since it may be utilized with various heads, such laser heads, without requiring significant modifications.

Disadvantages

1) The machine as a whole now weighs more.
2) Repair and maintenance may be a bit laborious.
3) The machine's initial cost would be fairly costly owing to the several printing heads, but it would be well worth it.

VII. CONCLUSION

One of the most significant advancements in the field of FDM 3D printing is multi-material extrusion, which has made 3D printing possible in new ways. Multi-material extrusion has several advantages; thus, it must be used properly and efficiently. We've also covered a variety of possibilities for multi-material extrusion in this paper, along with the difficulties they provide.

The outcome of the project is, as per the literature survey we found that many of the researchers have done lot of research on this topic but, there is a shortage of data on dual filament extruder approach. From the literature review we found that we can action the research on dual filament extruder approach for the purpose of adding multiple colors in the 3D printing technology. With this we have set the objectives to execute the same with the narrating methodology. After the planning stage we have generated different concepts connected from the literature survey. After generating four different concepts comparing together, we felt of selecting concept four of the limitations are less compared to the previous three concepts.

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