PROGRAMMING AND CONTROLLING OF BINDER JETTING 3D PRINTER

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ABSTRACT : Binder jet 3D printing is an emerging technology in the field of rapid prototyping which has a capability of processing a wide range of materials, including metals and ceramics. The main aim is to design and fabricate gypsum prototypes based on binder jetting technology. These materials are low cost, easily available materials and are utilized for developing the gypsum prototypes and hence it reduces the cost of building of binder jetting machine. This project presents design modifications from the existing open source binder jetting machine to make it efficient in terms of cost, build and performance. With the new design introduction in the powder 3D printing machine, we can develop intricate, complex shaped gypsum prototypes and yield high green part strength. These modifications also unlock the full potential of the binder jetting technology and allow us to vision more in utilizing different types of powder materials like sugar, metallic powder, gypsum and ceramics with suitable corresponding binder.

1. INTRODUCTION

Rapid prototyping is also acknowledged as Additive manufacturing (AM) or 3D printing is a group of techniques used to quickly fabricate a small-scale model of a physical part or an assembly using 3-dimensional Computer Aided Data (CAD). The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the object is created. Each of these layers can be seen as a thinly sliced cross-section of the object. 3D printing is the opposite of subtractive manufacturing which is cutting out / hollowing out a piece of metal or plastic with for instance a milling machine. 3D printing enables you to produce complex shapes using less material than traditional manufacturing methods.

Unlike conventional techniques of manufacturing methods like machining and forging, which are used to fabricate products through subtractive machining with CNC subtractive methods like machining and forging, the CAD-CAM (Computer Aided Machining) workflow in the traditional rapid prototyping process starts with the creation of geometric data. For RP this data must represent a valid geometric model namely, one whose boundary surfaces enclose a finite volume, contains no holes exposing the interior, and do not fold back on themselves To design the mechanical, electrical components and control program for Binder Jetting machine.

LITERATURE REVIEW:

Xinyuan L et al (2016) stated that, his paper reviews there search progress in the field of binder jetting of ceramics in recent years from the perspective of technology and mechanism. The status development of fabricating ceramic parts (which includes bio ceramics, structural and functional ceramics) using binder jetting was summarized. He specifies that more attention should be given to improve the lower limit of the overall properties of ceramic powders. It was also found that the binder infiltration kinetics behaviors directly affect the strength and accuracy of the green body, which in turn affects the properties of ceramic parts. Finally, several suggestions have been made to further develop binder jetting printing ceramics.

Han Chen et al (2017) stated that, a detailed research and experimental work are conducted based on Taguchi design of experiments method in order to optimize the four key process parameters of Binder jetting process, such as layer thickness, printing saturation, heater power ratio and drying time, for better surface quality and manufacturing dimensional accuracy. This research work also recommends 5 optimal process parameters groups for the practical production to use. It is not only useful for the people involved in the manufacturing department to improve the manufacturing quality, but also useful for the people involved in the design department to revise and improve their design work. Further study could consider more factors in research and try to establish in a depth theoretical physical model of binder jetting process.

3. OBJECTIVES

The main objective is to design and fabricate gypsum prototypes based on Binder Jetting technology.

- To design the mechanical, electrical components and control program for Binder Jetting machine.
- To analyze and testing the required components.

- To fabricate and optimize the material and process parameters of this Binder Jetting machine.
- To check the feasibility analysis of design.

4. METHODOLOGY:

In the proposed methodology, a motorized syringe has been utilized for jetting the binder onto the surface of the gypsum powder in the build platform. It is the part which holds the binder inside the tube with a plunger to push the binder in a determined rate.

The recharging time is very low and less complicated process in-comparison to refilling the inkjet cartridge. The motorized syringe has a plunger type mechanism it can be utilized for both high and low viscous fluid binders. In case of inkjet cartridge, only low viscous liquid binders can be utilized and also due to the solidification of binder at the end of the nozzle, which may cause improper function of the inkjet head and may result in poor build of green part and lead to dimensional inaccuracies.

5. MECHANICAL DESIGN

The design phase is one among the important phases in the construction of a prototype, in which through many modifications are made to produce an efficient design and it is chosen for the build of prototype. Figure 4 represents the outer frame structure of the Binder Jetting machine. The CAD designs are made using Solid works. After the outer frame design the linear guide way are designed along with that the support for the motor is designed as shown in figure 5, for the movement of the support gantry parallel along the linear guide way path.

The figure 6 shows the full assembly of the essential components and incorporates the major mechanisms including the XY plotter mechanism, Z-axis platforms (feed and build platforms), collecting bin, powder leveling roller, binder extrusion head.

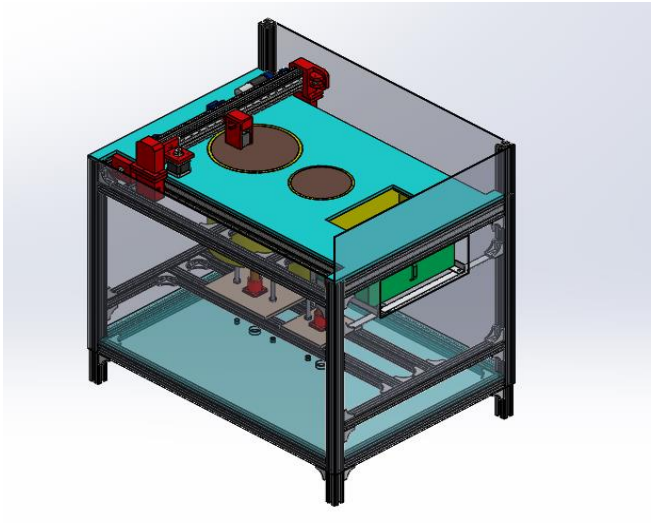

Figure 2 Completed Assembly CAD design

6. HARDWARE REQUIREMENTS

6.1.1 NEMA Stepper Motors

The stepper motors used in this project are NEMA 17 (4.2 Kg-cm torque) and NEMA 23 (180 Kg-cm torque) stepper motors respectively. The planetary geared NEMA 23 stepper motor have a step angle of 1.8 degree and 50 poles. The holding torque of this stepper motor is 4.2 Kg-cm. The total weight of this stepper motor is 300 grams. The length without shaft is 40 mm. The length of the shaft is 24 mm. The Width of the motor is 42.3 mm.

6.1.2 Arduino Mega

In this project, we have used Arduino Mega, as the main control board. ATmega16U2 instead 8U2 as USB to serial converter. The operating voltage is 5V. The input voltage (recommended) range from 7V to 12V.The Input voltage (limit) ranges from 6V to 20V.It has 40mA DC current per I/O pin. It has 256KB flash memory of which 8KB used by bootloader.

6.1.3 Binder Extrusion Head

The binder extrusion head is a motorized syringe setup shown in figure 3. It is the one of the main essential components of the Binder Jetting 3D printer. The binder liquid is filled inside the syringe tube and the plunger pumps.

Figure 3 Binder Extrusion Head

down the liquid hence the binder is forced through a very finite nozzle to let out and it deposits onto the thin layer of gypsum powder present in the build bin. Hence upon stacking individual layers, a compact Green part is formed.

6.1.4 Gypsum Powder

The Gypsum powder (chemical name: Hydrous calcium sulfate) is a white smooth powder, which is created by heating the gypsum stone. The gypsum that is mined is heated, dried, crushed and processed to become the gypsum powder shown in figure 4. It is a nontoxic powder. it is mainly used for the purpose of molding, sculpturing, etc.

Figure 4 Gypsum powder.

Software: It is a part of a control system that consists of data or computer instructions, in contrast to the physical hardware from which the system is built. In computer science and software engineering, computer software is all information processed by computer systems, programs and data. control software includes computer programs, libraries and related non-executable data, such as online documentation or digital media. Computer hardware and software require each other and neither can be realistically used on its own.

There are two types of software used on this project that is

- Repitier host
- Adruino IDE 1.8.2

7. WORKING PRINCIPLE

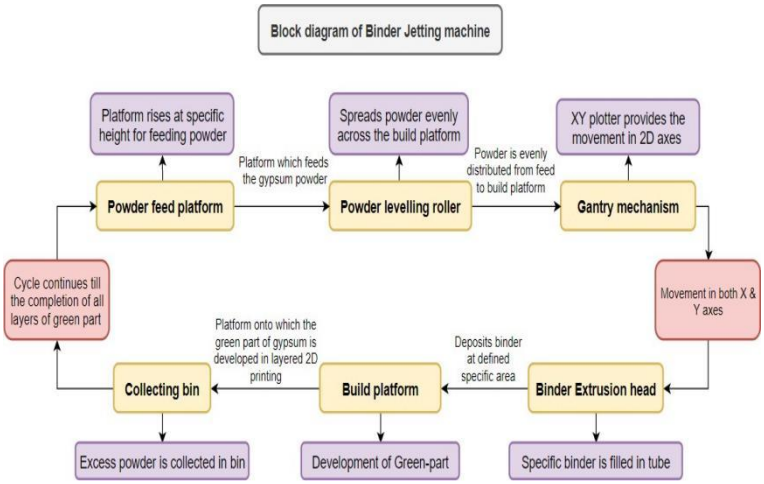

Figure 5 Block diagram of BJM

The major working steps of the binder jetting machine is shown in figure. The steps are described as follows.

Step 1: Deposition of binder across the build bin onto the gypsum powder as per the sliced layer of the CAD model.

Step 2: Rise the Feed platform for deposition of gypsum powder onto the build bin

Step 3: Lower the build bin and evenly spread the powder from feed bin with the help of powder leveling roller.

Step 4: After the even spreading of powder deposit the binder and repeat from step 1 to step 4 till the completion of all layers of the sliced 3D CAD model.

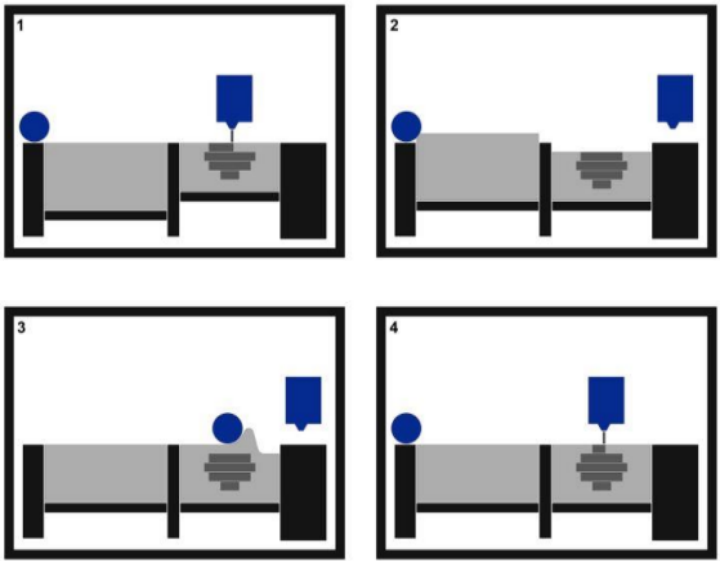

Figure 6 Working of the BJM..

8. RESULT AND CONCLUSION

This Binder Jetting 3D printer has a potential to develop and make numerous prototypes with the availability of gypsum powder as the build material and sodium silicate as the chemical binder for the development of desired Green part. Considering its advantages from traditional systems like Selective Laser Sintering (SLS) and Fusion Deposition Modeling (FDM), this Binder Jetting technology has a huge potential and still has a long way to go for the development of powder-based 3D printing.

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