Design and Fabrication of Cartridge of Binder Jetting Module

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ABSTRACT. Binder jet additive manufacturing enables the production of complex components for numerous applications. Binder jetting is the only powder bed additive manufacturing process that is not fusion-based, thus manufactured parts have no residual stresses as opposed to laser-based additive manufacturing processes. Binder jet technologycan be adopted for the production of various small and large metallic parts for specific applications, including in the biomedical and energy sectors, at a lower cost and shorter lead time. One of the most well-known types of stainless steels which has been extensivelymanufactured using binder jet technology. Binder jet manufactured parts have obtained near full density and, in some cases, similar mechanical properties compared to conventionally manufactured parts.

Keywords: Additive manufacturing, Binder jetting technology, Powder printing, three- dimensional printing.

1. Introduction:

Additive Manufacturing is a layer-by-layer fabrication approach has enabled key opportunities for high performance structure and material design. Among all Additive Manufacturing technologies, binder jetting is a suitable platform to realize material innovations for its wide range material capability and highmanufacturing throughput. For example, binder jetting has been used for fabricating high purity copper, a material that is challenging to process using laser-based powder bed fusion technologies due to high thermalconductivity and optical reflectivity.

The binder jetting Additive Manufacturing process can be used to fabricate metal parts by selectively inkjet printing a liquid binding agent into a powder bed followed by post-process sintering of the printed green part.

The jetted binder droplets interact with the powder particles to form primitives that stitch together to form a cross-sectional layer. Once a layer is printed and thermally dried/cured, a new layer of powder is recoated on top of the previous layer, which is then printed and stitched to the previous layer by the jetted binder. The layer-by-layer process is repeated to create the complete green part.

The unbound loose powder in the bed that surrounds the part supports overhanging structures during the build, and can be removed after printing via compressed air. Once depowered, the green part is placed in a furnace to burn off the binder and to sinter the powder particles together to obtain final density and strength.

2. Methodology

Binder Jetting Technology is an additive manufacturing processes in which a liquid bondingagent is selectively deposited to join powder materials. The significant segments of a Binder Jetting machine involve powder levelling roller, powder feed platform, build platform, a motorized syringe extrusion head.

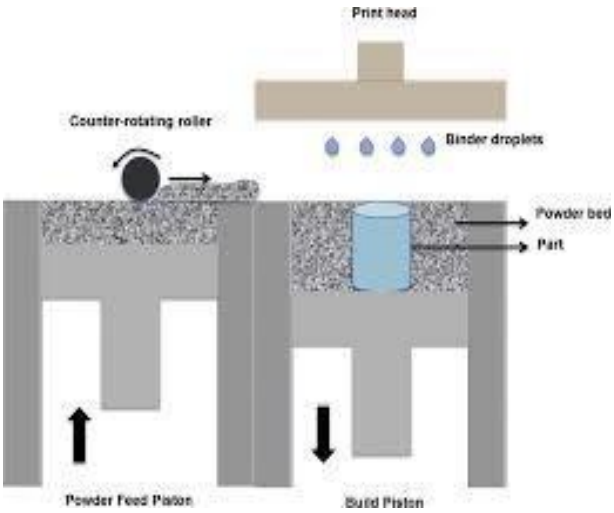

Figure 2.1 Binder Jetting technology

The working process are, at first, the powder roller extends a far layer of powder from the powder feed platform onto the build platform and structures a slender layer of powder bed. Next the syringe extrusion head streams the fluid over the powdered layer as per the characterized layer profile of the 3D CAD model.The powder particles in the chosen zones are protected with neighboring lower layer of powder particles. After completing one layer, the build platform is brought down by a defined characterized height and afterward another powder layer is spread over the previous layer.

These will be repeated until the entire part is done. The completed part is taken out and then expelled from the free powder and followed by post- preparing steps.

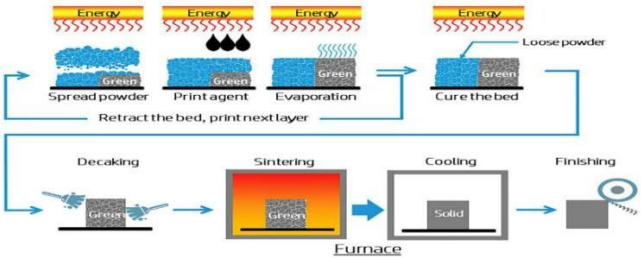

Figure 2.2 Steps involved in Binder Jetting process

3. Key components:

3.1 Mechanical cad design

The design phase is one among the important phases in the construction, in which through many modifications are made to produce an efficient design and it is chosen as a model. The CAD designs are made using Solid works software.

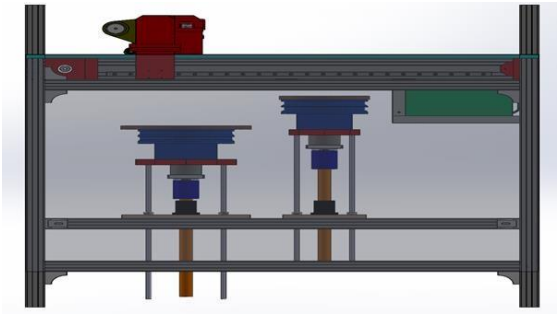

Figure 3.1 Feed and build platforms

3.2 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 working voltage ranges from 7V to 12V.The Input voltage varies from6V to 20V. It has 40mA DC current per I/O pin. It has 256kb flash memory of which 8kb used by bootloader. It has 8kbSRAM and 4kb EEPROM. The shows the image of Arduino Mega.

Figure 3.2 Arduino Mega

3.3 HP C6602 inkjet cartridge

In order to use the HPC6602 inkjet cartridge a certain shield called Ink shield can be used which make to connect Arduino. It is designed to support both the Arduino Uno and Arduino mega. It consists of 5 pins with a 9-12V input. Its speed is 60mm/sec, by using a better firmware this speed can easily be increased.

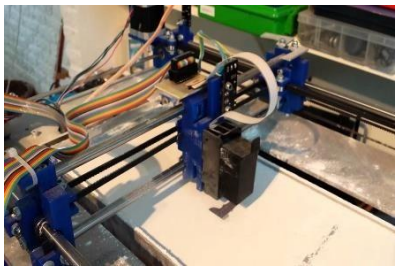

Figure 3.3 6602 inkjet cartridge

3.4 Metal powder

In Metal binder jetting uses only a minute spherical powder with a particle size of approximately 5 - 45 microns. Binder jetting are compactable for any materials that can be sintered but most of the binder jetting machine prints only a few grades of stainless steel like 317L etc. Even though metal binder jetting is also done with metal powders like tungsten carbide cobalt, copper, cobalt chromium.

Figure 3.4 Metal powder

3.5 Binder solution

The liquid polymer binders used in the metal binder jetting which can be act as glue or a solvent based component. It can bind metal powder and effective evaporation of the solvent based component in low temperature. Everything from wax to latex is used as a binder component. The water-based binder is able to flow through the print nozzle and penetrate into the powder

Figure 3.5 Binding of powder

3.6 Ink shield

In the customize the ink shield is to boost circuit. It has two functions. First it boosts 12V from the printer to 20V the cartridges need. Secondly it converts the 4 input lines the Megatronics has to spare to the 12 lines needed for the cartridge.

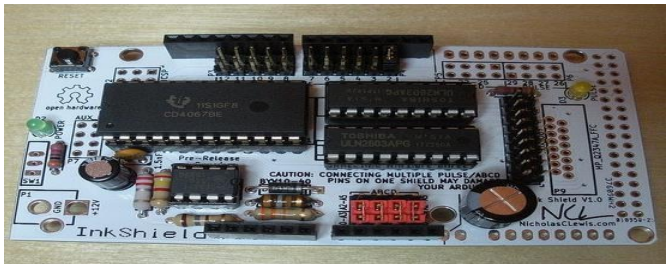

Figure 3.6 Ink shield PCB

5. Flowchart

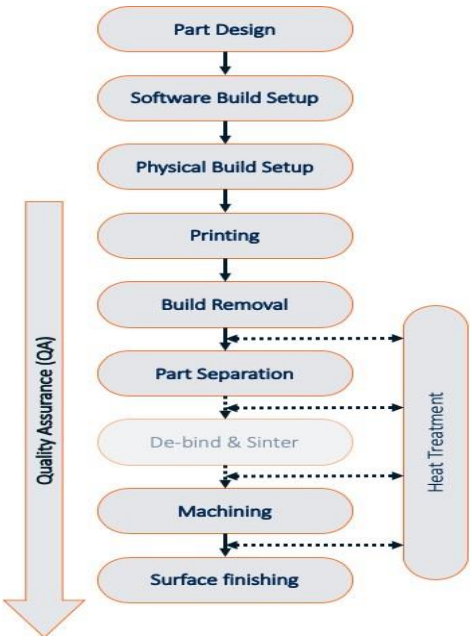

Figure 5.1 Flowchart of Binder jetting machine

6. Working Principle:

The major working steps of the low-cost metal additive manufacturing machine figure 6.1. The steps are described as follows.

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

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

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

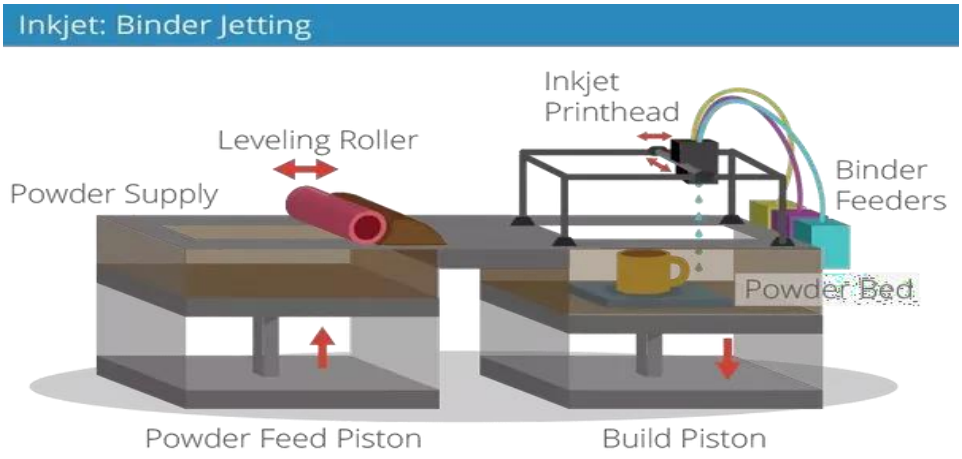

Figure 6.1 Working of the Binder Jetting Machine

7. Conclusions

This Binder Jetting 3D printer has a potential to develop and make numerous components with the availability of metal powder as the build material and sodium silicate as the chemical binder for the development of desired CAD design. For each material, its corresponding binding material must be used, mismatch of materials leads to develop high porous parts with low part strength.

Considering its advantages over other prototyping techniques like Selective Laser Sintering (SLS) and Fusion Deposition Modelling (FDM), in the future, certain modifications can be introduced for developing new prototypes utilizing different materials such as sand, sugar, metal powder and ceramics.

8. References

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