An Analysis of Temperature Changes of Devices Produced using 3D Printers with the Help of Abacus Software

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Abstract

3D printers are tools utilized to create real 3D samples using the 3D files within your computer. The first feasibility and idea of such tools dates back to 1950. The very first sketch of 3D printers was presented in 1980s called "Rapid Prototyping" and the first sample was developed by Charles Hall and it was recorded with the name of the same scientist. But the current 3D printers were first made in 1986 using SLA method and entered the market two years later.

Keywords: Temperature equilibrium, 3D Printer, ARDUINO program, SLA method

1. Introduction

Ghanbarpour and Seyyed Afghahi (2016) carried out a research entitled "3D printers, characteristics of different methods and materials used", to investigate about different materials as the raw materials for 3D printers. But this research is not valued as an engineering research and solely can be considered as a general knowledge about such devices. Hashemzadeh-e-Bashari and et al (2016) explained the construction of 3D printers in a study entitled: "designing and manufacturing linear delta robot functioning as a 3D printer". They principally could only introduce the different pars of such a machine and it rather seems like a work report.

All things date back to the year 1980. It was when the first appropriate materials and equipments were prepared for 3D printing for the first time. It is clear that at that time nothing seemed so easy as it seems now and in addition to very high expenses required for the instruments and raw materials, a great deal of professional understanding was necessary to model and produce a very simple object. At that time, Mr. Chalk Hall could successfully make a type of machine resembling to 3D terminals which was then known as accelerating machines or AM and it utilized a new process called stereo-lithography. In this method, through reflection of ultraviolet (UV) lasers onto photopolymer materials (a type of huge molecule which changes in nature as affected by light beams or ultraviolet rays), their forms changed and complex geometric figures could be created.

All 3D printers are differentiated regarding the technology and the materials used to produce them. For example, some 3D printers are made with powders (nylon, plastic, ceramics, metals) and are melted through a light heat source (laser) and then made solid and are turned into the form of the intended sample and then do printing. In some others polymer plastics are strengthened and made into solid form using layered lasers (these layers are too thin). The spread of tiny particles from the materials onto the platform surface representing the jet-print technology in 2D printing is known as paste spread technology in 3D printing. The most common technology in the field is known as FDM through which the raw materials of ABS plastic or PLA go through the machine nuzzle in string model and do layering after being heated. Since 3D printing can make it possible to make devices directly and concisely, we can produce complex objects with high qualities without any need to assembly and within the least time period using this technology.

In 1980, 3D printers were used to construct certain products or small peripheral devices, visualizing the data, and the rapid construction of industrial test samples. Today, this technology has developed tremendously and in addition to those mentioned above, the role of 3D printers in architecture, home construction, industrial designing, construction of automobiles, toys, vehicles, aircraft industry, military functions, engineering, medicine and drug production, biotechnology, fashion and modeling, shoe production, ornaments, glasses, and food industry could be easily touched.

Currently it is thought that in future the problems arising through the construction of fraudulent devices by these printers and selling them in the market would lead to great problems. If such printers become commonly used, it would no more be difficult to produce other products exactly similar to the original ones and we would observe a rush of fraud products into the market and consequently there would be great losses incurred by big companies and if they encounter bankruptcy, in addition to great economical losses we would observe a great mass of workers becoming jobless. Of course, it is also possible to use dangerous raw materials that harm human being safety in the manufacturing of fraudulent products. For example, suppose that you think you are buying high quality glasses, but in fact they are copies of the original glasses created by 3D printers through which instead of using standard raw materials they have used dangerous and harmful materials. It would be a catastrophe and the result will harm all. Therefore, big companies are still reluctant to generalize such technology. But whether they like it or not, the world is moving forwards to use such technology publicly. Thus, to control the problems mentioned above, the governments should devise certain rules to minimize such problems.

2. 3D printer Software's

Connection with ARDUINO program: The software core of 3D printer is comprised of an open-text program under the control of AVR microcontroller mode of ATMEGA2560 written in Arduino programming context and is open publicly. The program utilized in this printer called Marlin Framware could be downloaded through Github website (http://github.com) or Reprap website (http://reprap.org) and they are open to all.

To make it possible to program Arduino boards, one should install Arduino IDE software. It not only prepares the programming environment and the written code compilers directly and after the installation of Arduino boards' drivers, but also it proposes the upload capability of the written program on board for the user freely.

Analysis using abacus: In analyzing temperature changes using abacus we should define certain amounts in the form of the data for the software. To do so, defining and observing the items below would be obligatory:

- for the material Pla we should consider characteristics below:
  - ➢ Density = 0.13 Kg/m^3
  - ➢ Thermal Conductivity: 0.13 W/m-k
  - ➢ Specific Thermal Capacity: 1800 J/kg-K
- System type: transient
- Our intended material has characteristics between white plastic and polypropen. Thus, for reflection coefficient we should choose an amount in between two materials' coefficient and 0.95 would be a reasonable selection (0.84<X<0.97).

- All temperature amounts should be identified based on Kelvin.
- The fixed amount of Stephan-Bultzmann is equal to $5.67*10^{-8}$.
- The environment temperature should be adjusted at 293.15 Kelvin.
- The thermal bed temperature of the machine should be set at 360.15 Kelvin.
- The homomorphous thermal transfer coefficient for the underneath surface of the object is 6.51715 and it is 13.5152 considering other layers.
- The device temperature in production time (nuzzle exit) is 473.15.

3. Results of Numerical Simulations

Results' measurement: Results of the analysis could be compared with real state. To do so, we utilize a thermometer and in fact it is a machine with a linear resistor and the more temperature enforced, it would present more resistance. The thermometer is attached to an ohmmeter machine and it is gauged with a certain range and the number calculated would be multiplied by the machine coefficient. For room temperature we devise 0.21 and for the device temperature we represent the number 0.71 at first. It can be observed that the amount of resistance shown changes from 0.71 into 0.21 rapidly (within about 0.3 second) and it accords with results of the analysis.

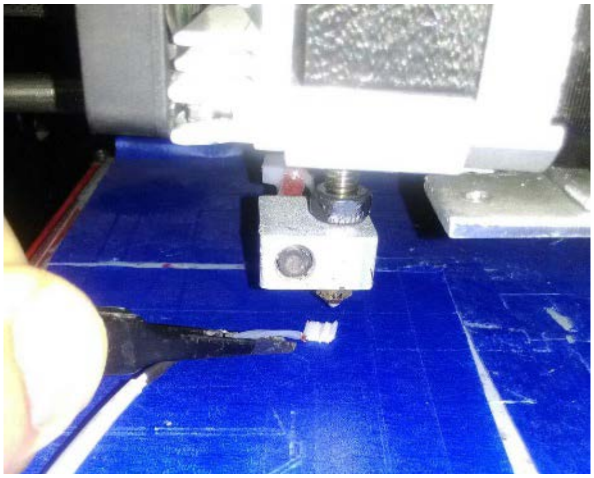

Fig. 1. Object resistance when it gets out of the nuzzle

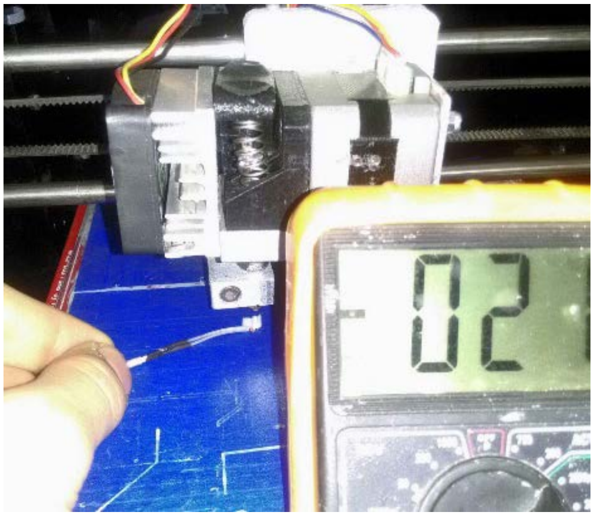

Fig. 2. Object resistance after temperature equilibrium

Results of simulations with abacus: Results gained for the temperature contour are represented through the following figures:

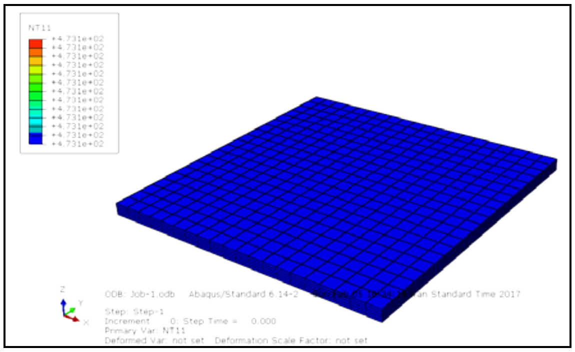

Fig. 3. Temperature contour in time t=0^s

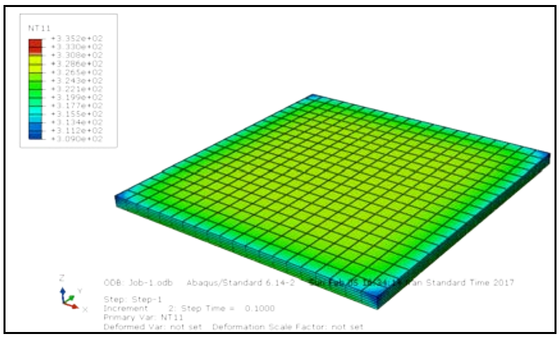

Fig. 4. Temperature contour in time t=0.1 s

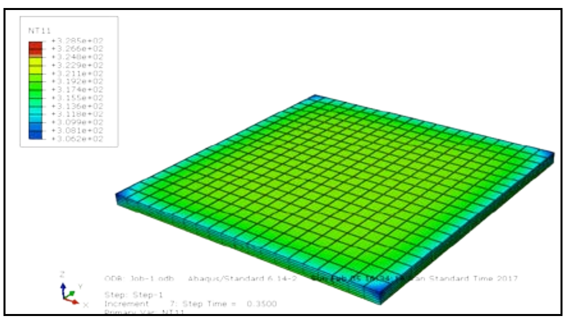

Fig. 5. Temperature contour in steady (t=0.35s)

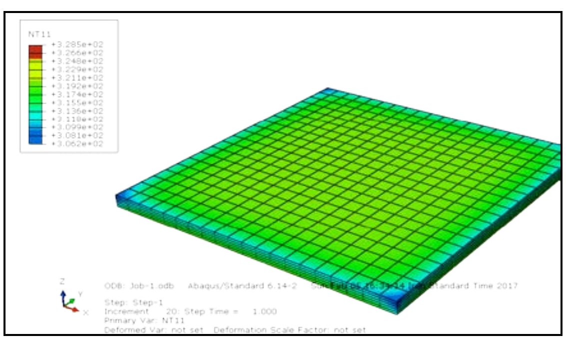

Fig. 6. Temperature contour after one second

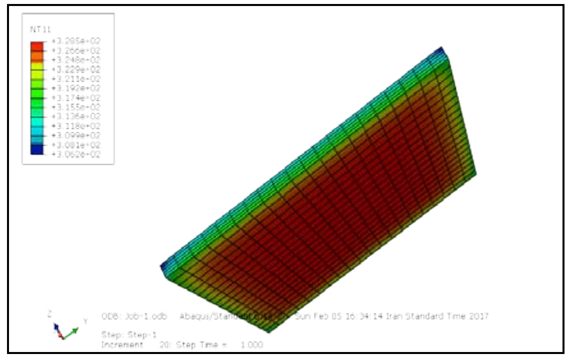

Fig. 7. Temperature contour after one second (under the object)

The graph of temperature changes for specified points:

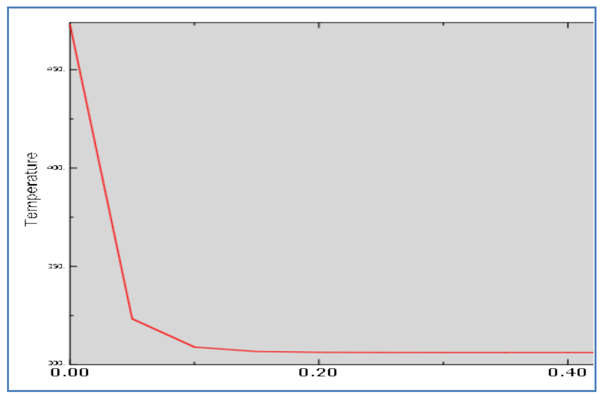

Fig. 8. The graph of temperature changes based on time for corner node of upper plate

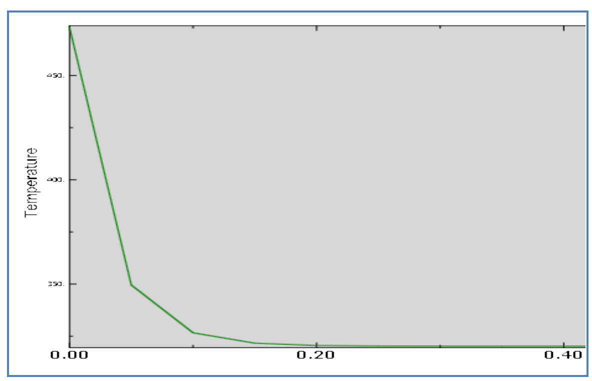

Fig. 9. The graph of temperature changes based on time for central node of upper plate

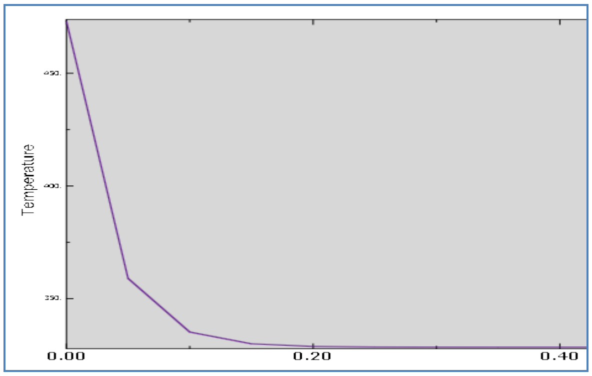

Fig. 10. The graph of temperature changes based on time for central node of lower plate

4. Conclusion

Results of numerical simulations showed that: It would take a very short time to create the same temperature for the intended instrument. In fact, this is a basic characteristic specified for the raw materials of this type of 3D printers because we need materials that can rapidly lose fluid state and become solid. This means that the basic principle for these materials is to carry out the processes of melting down and solidification rapidly. Thus, PlA material can be utilized as an appropriate raw material. The required time span for steady heat transferring process is 0.35 second and it accords with the results gained from measuring through other machines (mentioned above).

If we adjust nuzzle movement speed appropriately, there is no need to use fan to cool the vertical instruments with small plates and this activity (omission of fan from production circuit) due to melting process not being sudden and thus the reduction of the probability of cracks increases the strength of devices produced.

5. Suggestions for Future Research

Through a more precise study of printers we can refer to the following items in future works in the field: If the extruder moves along with x and y axes instead of x and z, the print would have a better quality and the time will be shorter. The cause of better quality is also due to lack of movement of the device along with y because the device movement may cause an unwanted heat transfer. Finding a set of aggregate materials (composites) for enhancing the production using 3D printing methods is preferable.

References

[1] Bergman, Theodor L, Fundamentals of heat and mass transfer, Seventh edition. John Wiley and Sons Pub. (2011)

[2] Ghanbarpour, Mahdi; Seyyed Salman Seyyed Afghahi (2016). 3D printers, characteristics of different methods and materials used. 3rd. National Conference and 1st. International Conference of Applied Researches in chemistry sciences and chemistry engineering, and 3rd. National Conference and 1st. International

Conference of applied researches in biology, Tehran, Malek Ashtar Industrial University.

[3] Hashemzadeh-e-Bashari, Sasan; Khorasani, Milad; Adeleh Karimzadeh-e-Abdoljabbar (2016). Designing and construction of linear robot delta with 3D printer functions. The 1st. International Conference on novel research accomplishments in mechanics, mecatronics and biomechanics, Tehran, International Federation of Inventors' Association (IFIA), Applied Science University.

[4] www.infrared-thermography.com

[5] www.makeitfrom.com

[6] www.thermal-wizard.com/tmwiz/convect/natural/hup-isot/hup-isot.htm