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Research Article

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Low-Cost 3D-Printing Device Production for Miniature Energy Storage Systems

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Abstract It is seen that the production costs of 3D-printers have decreased significantly due to the fast development of 3- printer technology. Today's printers are generally based on the principle of melting of filament materials such as ABS and PLA which are made from plastic materials and they are widely used in the development of prototypes in engineering applications. In addition to this, the 3D-printers which use laser beam are used for lower-dimensional objects with higher precision and they use gel-ink for printing materials. One of the basic requirements for the energy storage systems which need high surface area is the adoption of the 3D-printing technologies for obtaining of the higher capacity of the energy storage devices. In this study, we developed a 3D-printing device for miniature energy storage systems which is cheaper than that of the commercial systems and it is promising for future technologies.

Keywords 3D-printing device, energy storage, printer design

1. Introduction

In recent years, 3D-printers take part in every stage of life and it has become used even in simple applications in daily life besides scientific studies. They work the principle of the layer by layer writing and the filaments such as PLA and ABS are heated at the melting temperature. In the printing process, 3-axis free-moving stepper motors are controlled by motor driver board and microprocessors [1,2]. The printers can be obtained as a commercial products and all parts pf the printer device can be bought from market and there are a lot of information about the homemade production of the printer device in web. Furthermore, the printing processes generally use single-flament systems as well as double-color filament printing systems [3,4]. In addition to this, the development of printer technologies gives new products such as resin type printers which have been developed and can produce prototypes at higher resolution than PLA / ABS type printers. Resin type printers have different working principle than that of PLA / ABS type printers. In this type of printers, the ink which is in the form of gel work with the principle of solidification by changing the bond structure by laser beam. Furthermore, the resin material has a polymer based structure and it can easily change with the bond structure by the laser applications.

In last decade, the 3D-printing technology has been adopted to metal filaments which produce metal prototypes or parts. They work with the melting of the metal powders at high temperatures and it is possible to produce large prototypes or parts with this device. This technology is not very common because it requires high temperatures and the production cost is expensive [5,6].

There are many studies on the development of biocompatible materials production in 3D-printer technology. Artificial organs are produced by using cell cultures and their integration into the living body is a challenge for future technologies. Although 3D-printer technology in the energy studies has not common, in last decade, the printed supercapacitors or batteries take an attraction of the scientists and technology firms due to higher energy storage capacities. So there are no commercial 3D-printing systems for energy studies and they are still under development and the scientists generally prefer liquid inks by using graphen or carbon related materials.

In this study, the developed printing system which has two parts and one is 3-axis stage parts and the second is the ink part which is constant and the pad is moving in the system. The developed system is cheaper than that of the similar commercial systems

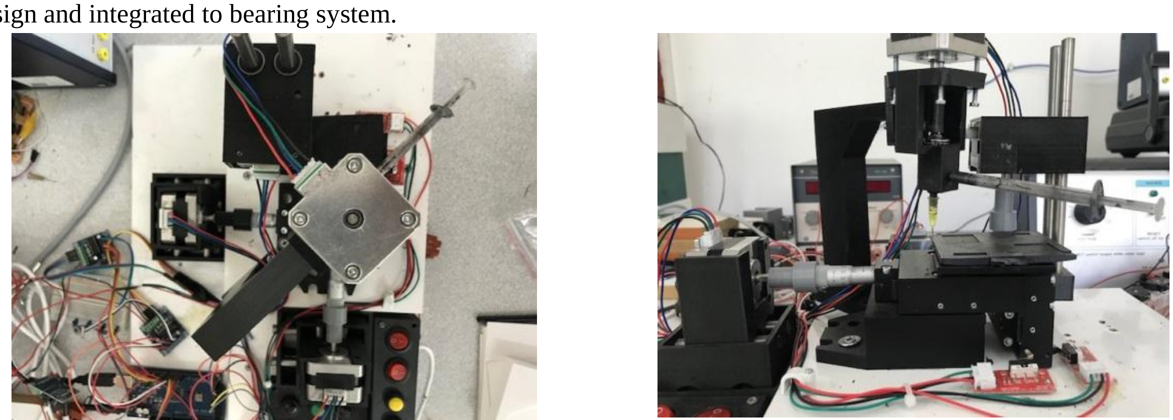
2. **Design and production of 3D-printing hardware**

In the 3D-printer technology, the most basic requirement is a transport system that provides 3-axis motion with stepper motor controller. We used Thorlab 3-Axis RollerBlock Long-Travel Bearing system with manual axis controller as seen in figure 1.a and the bearing system has 13 mm moving properties for each axis. It has the bearing capacity of 4.4 kg and a resolution of 0.5 µm.

(a) (b)

Figure 1: (a) Thorlab 3-boyutlu taşımasistemive (b) Nema-17 motor

For the automation of the system, Nema-17 type stepper motors are used. Thorlab transport system integrated with 3 stepper motors for each moving directions. Therefore, the interconnecting elements between stepper motor and the axis of bearing stage require two components to work in harmony with each other. In this context, interconnection elements between step motor and manual axis controller of bearing system have been developed by using resin type 3D-printer in our laboratories. Furthermore, it should be noted that the one axial movement causes to movement of the other axis components so step motors should move with other axis movements. We developed this part as seen in figure 2a and b. After design and production of the hardware of bearing system, the ink controlling part should design and integrated to bearing system.



(a) **(b)**

Figure 2: Top and side view of the system produced

For this purpose, the ink system is designed using thinkercat open sources program and printed on the resin type 3D printer and integrated into the system as given in figure 3. The ink reservoir includes a step screw which controlled by another step motor (Nema-17) and the turning velocity of the ink control the printing rate and it is a challenged issue for each ink components. The viscosity is directly affect the printing rate of the system.

The control units of the step motors for each axis and ink provider are integrated Arduino mega and step motor controller as seen in figure 4. So, the hardware design, production and electronic components were integrated and optimized and now it needs to develop the software part as seen in the following part.

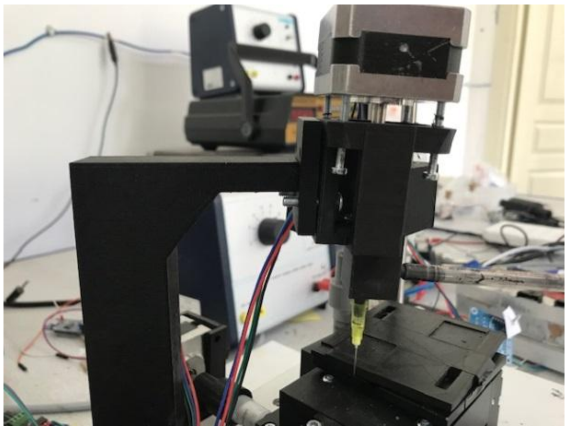


Figure 3: Injection reservoir and ink system integrated the bearing system

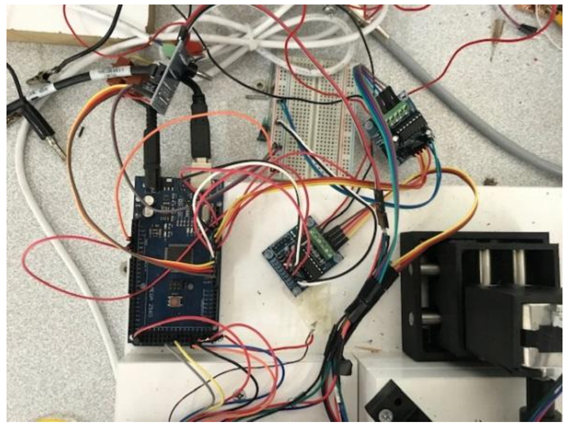


Figure 4: A view of the step motor controllers and Arduino mega integrated the system

3. The software of the system

One of the most important elements of electronic devices is the development of software that provides expectations with reliable and stable system. The flow diagram of the software developed in this context is given in the figure 5. Before the operation of the system, it is necessary to specify the path and maximum working distance of the stepper motors for 3-axis in the system. The stepper motors that move from the starting point are carried out by the command that is entered in the program for corresponding rotation numbers in each direction. After writing of the axis control in the program, the program of the injector system should be developed.

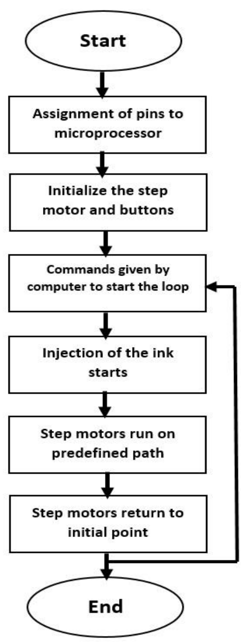


Figure 5: Flow diagram of the software

4. Cost analysis

When the costs of similar 3D printing systems are compared, it is seen that the cost of this production much lower prices than the commercial devices. The most expensive part in this study is the 3-axis bearing system which it has a cost of 1600$. Since we want to develop a high-resolution system, we use Thorlab bearing system, but the lower-resolution 3-dimensional transport systems can be obtained and it costs 200 $. It should be noted that we didn't take into account the price of ABS/PLA type 3D printer since it is not system part and it is used for the printing of the interconnector part of the system developed. When we consider the production cost of the other parts of the system developed in this study, it is around 200$. So total production cost of the system is obtained between 400 and 1800 $ which is much lower than that of the commercial systems

5. Conclusion

In this study, low-cost 3D-printer system for use in energy storage has been developed. The interconnection of the equipment used in the study is designed and produced by a classic ABS / PLA type 3D-printer. Although the printer is supplied with 13 mm movement on each axis, its 3-dimensional carrier system can be improved in desired dimensions and its mobility can be improved. Particularly the ink part was developed by using the step screw which delivers the ink at constant rate on the bearing stage. As a result, a 3D printer system for energy storage applications is produced at low costs when compared with the commercial devices.

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References

[1]. N. Mahmood, Y. Yao, J. Zhang, L. Pan, X. Zhang, J. Zou, Adv. Sci., 5 (2018) 1700464-1700487.
[2]. F. Ganci, S. Lombardo, C. Sunseri, R. Inguanta, Renewable Energy, 123 (2018) 117-124.
[3]. J. He, A. Chen, M. Chang, L. Ma, C. Li, J. Ind. Eng. Chem., 19 (2013) 1112–1116.
[4]. H. He, A. Chen, H.Lv, H. Dong, M. Chang, C. Li, Appl. Surf. Sci., 266 (2013) 126– 131.
[5]. A. Gomez Vidales, K. Choi, S. Omanovic, J. Int. Hydrogen Energy, 43 (2018) 12917-12928.
[6]. M.E. Mert, B. DoğuMert, G. Kardaş, B. Yazıcı, Appl. Surf. Sci., 423 (2017) 704-715.