Design and fabrication of a prototype micro pump

Swastik Pradhan
Assistant Professor, School of Mechanical Engineering, Lovely Professional University, Phagwara, Punjab-144411, India

Keywords: **3D** modelling, Micropump, Double acting cylinder, electromagnet**,** solidwork

Abstract

Now a day's demand of the micro pump is quite high in the field of medical and bio-technology. The micropump will supply the micro fluid. The micropump develop should posses some of the peculiar characteristics, such as flexibility, operates at low voltage, safety factor should be considered, reduced the chances of infection since it will fit inside the body. The reflexes should be good and precise. In this paper, a new approach is made to make a prototype model. Actually, it has to be made using shape memory alloy coil actuator. This actuator will act as a servo actuator for the micropump. The actual micropump consist of two inlet valves, casing to hold the pump and a pump chamber. The fabrication of the micro pump resembles the actual micropump which is able to make a flow of the suitable fluid. That will helpful or useful towards the medical application and in the field of biotechnology.

Introduction

There are many challenges faced in the field of biomedical and bio-technology related to the microfluid flow using a microfluidic device. Some of the microfluidic device are micropump and micro needles. Most of the challenging factors are the design issue, fabrication of such device, packaging of the device and mostly the application of such device inside the body creates a problem. Most of the times the design and fabrication create a problem due to the small shape of the device. During fabrication of the device the specific flow rate, the pressure exerted during reverse pumping, the amount of dose to be filled, the selection of the materials to avoid the presence of moisture in the drug. The energy consumes and supply of the power for activation of the micropump and also durability, biocompatibility and sustainability of the micropump are some of the major concern. [1]. For this suitable fabrication model has to be designed. With a suitable fabrication technique. It will reduce the cost of the device and also helpful for the packaging. The packaging of the micropump should be design and fabricate by keeping in mind the robustness, infection prevention, unintentional discharge and leak proof. Most of the literature have been vitrified the and fabricate the micropump as stand alone devices.

Nguyen et al. [2] studied the microfluidic part or micropump develop follows the pump principles and their realization with MEMS technology. The pump size, flow rate and back pressure are considered for proper design of the micropump.

Jeong et al [3] also said the PDMS is also actuate by a thermo-pneumatic force. Three peristaltic type actuator additionally micro heater attached to the glass substrate. The microchannel connects the chamber along with that it connects to inlet and outlet port. Fabrication is done by using spin-coating process, molding is done by negative photoresist along with the two-curing method. Thickness of the actuator is 30 micron and the diameter of the diaphragm is 2.5 mm. Where the maximum flow rate of the water is found to be about 0.36 microlitre when it is running at a 2 Hz with a three-phase voltage supply of 20V.

Jeang et al. [4] studied P+ silicon diaphragm material to fabricate the micro heater combined with a nozzle diffuser is taken to manufacture the thermo-pneumatic micro pump. In this the diaphragm is made just like a corrugated sheet which will be more flexible than the flat one. A cavity pressure is maintained to cause the ohmic heating and natural cooling. The fluid flow will take place in a single direction passing through the nozzle diffuser when the micropump vibrates. Result obtained revealed that the corrugated diaphragm gives three times better result than flat one. Maximum rate of flow was about 14 micro-liter per minute when operated at a frequency of 4Hz with an applied voltage of 8V.

Mizoguchi et al [5] developed a micro-mechanical pump driven by laser light. It consists of microcell connected with the help of membranes. Light heated fluid actuates the pump. Flow occurred through the cell which are covered by a thin layer of glass plate with an 18 micron of gap. The operating light input required is 11mW per each cell where a 3Hz operating frequency is achieved. It is observed that this device operated a very low temperature range.

Lee et al. [6] used micro-electro-mechanical system technologies to develop a micropump to control the bio samples and also the reagent fluid. Etching with silicon and silicon glass anodic bonding techniques is used. It consists of piezoelectric disks, glass and silicon. Diaphragms are excited due to application of pulse signal to the lead zirconate titanate. The micropump size is of 30 X 20 X 1 mm3. It is able to control bi directional flow of the sample at 12 microlitre per stroke with 10 Hz frequency.

Research methodology

The project design and development of double acting electromagnetic actuators would lead to the development of new type of electromagnetic actuators which are mostly used by bio-medical industries. These types of actuators are controlled very easily and precisely, and losses are less as compared to pneumatic and hydraulic actuators. As these actuators are going to be in Micro scale the work efficiency of system increases with respect to applications. After developing this kind of actuators it will be more precise and accurately control the drug delivery in bio-medical applications. In this type of actuators, the movement of piston can be controlled easily as compared to pneumatic and hydraulic systems as well as the energy is conserved because there is no need of intermediate instruments like in pneumatic and hydraulic actuators.

Advantage of the micropump made up of magnetic actuator

- The actuation stroke will increase i.e. displacement per length will increase.
- The transduction movement will be linear.
- The flow of the fluid will be discharge in both the direction i.e. bi-directional actuation will occurred.
- The actuation will be contact less.
- The voltage required to activate the actuation will be low.
- The energy density will be high since it is operated using magnetic acuation.

Design of Components

Figure:1 Electro Magnet

The electromagnet will create a magnetic field by using the electric current. The wire is wounded into a coiled shape to form the electromagnets. The wire turn are made of ferromagnetic materials in this study it is iron. The number of turns increases the magnetic flux and makes a powerful magnet The three dimensional model of the electromagnet is made using the solidworks software as shown in Figure 1 and 2.

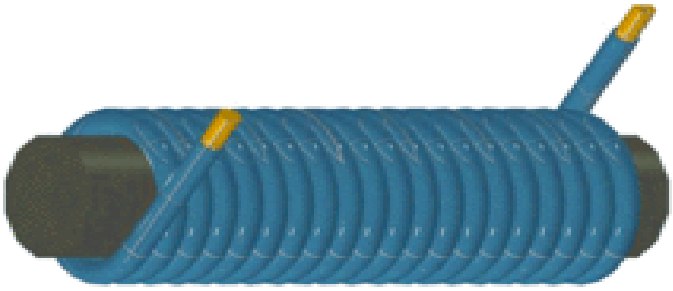


Figure:2 Electro Magnet winding

piston

The piston is use to generates the flow of the fluid. In this study two ways piston is made as shown in Figure 3. In this the forward motion of the piston will compressed and make the fluid flow in one

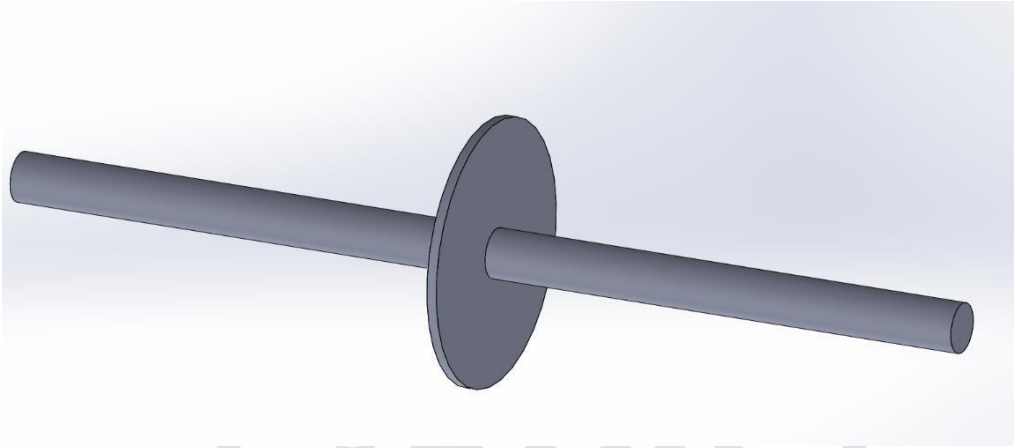


Figure: 3 Movable piston

end whereas in other end the fluid will enter inside the chamber. 3D model of the piston id created as shown in the Figure.

Cylinder

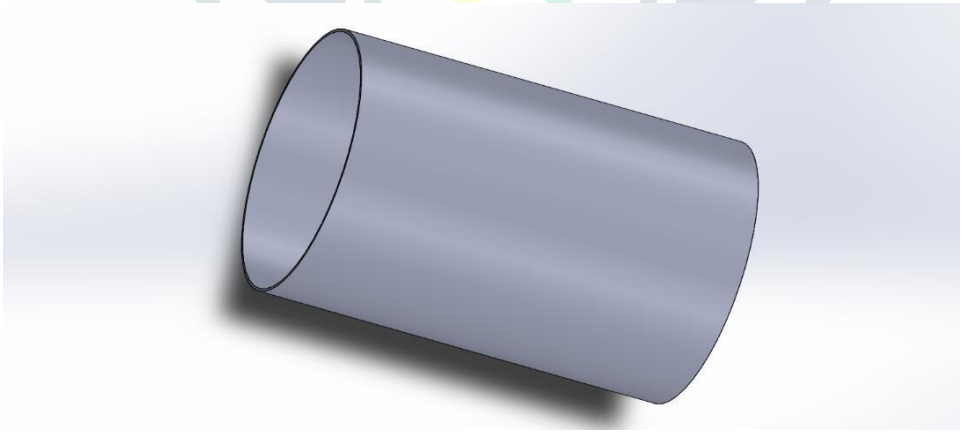


Figure: 4 Outer Case

Cylinders may be sleeved or sleeveless A sleeveless engine may also be referred to as a "parent-bore engine". Cylinder is the main unit of the pump. It is the space inside which a piston travel. The 3D model of the cylinder is shown in Figure 4

Cylinder Plate

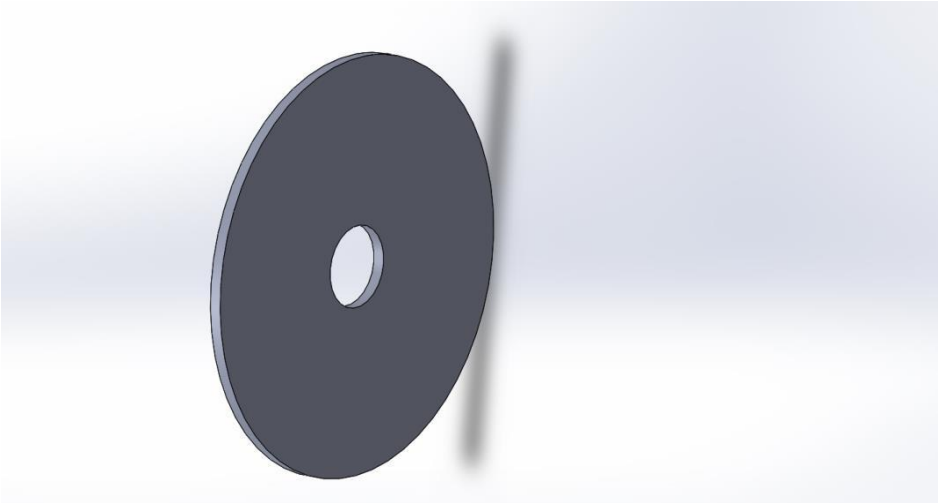


Figure:5 Casing plate

Cylinder plates are made in order to restrict the over flow or movement of the piston from its working area. This also helps in preventing the external factors which can influence the piston action. As shown in Figure 5

Assembly of Electromagnetic Actuator

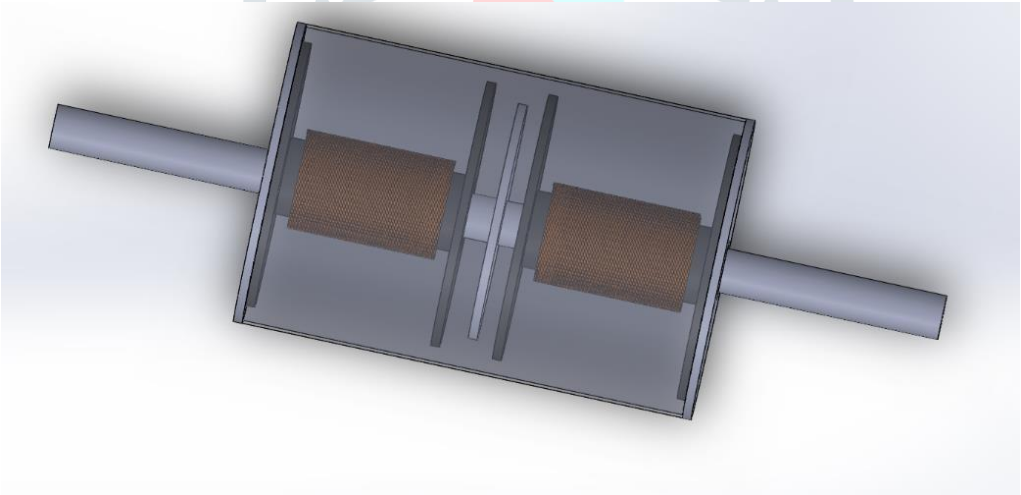


Figure: 6 Electromagnetic Actuator

Working. principle

Electro-Magnetic Double Acting Cylinder

In electro-magnetic double acting cylinder forward stroke as well as return stroke both can be control. Two electro magnets are placed inside the case so that for attraction one is activated so the piston moves forward for obtaining reverse stroke second electro magnet is activated by deactivating the first one so that it can attract the piston

Due to change in amplitude of the current, strength of the electro-magnet can be changed easily. And reversing the polarity of the current generated poles can also be reversed. By using this electro-magnet principle movement of the piston can control more accurately and precisely

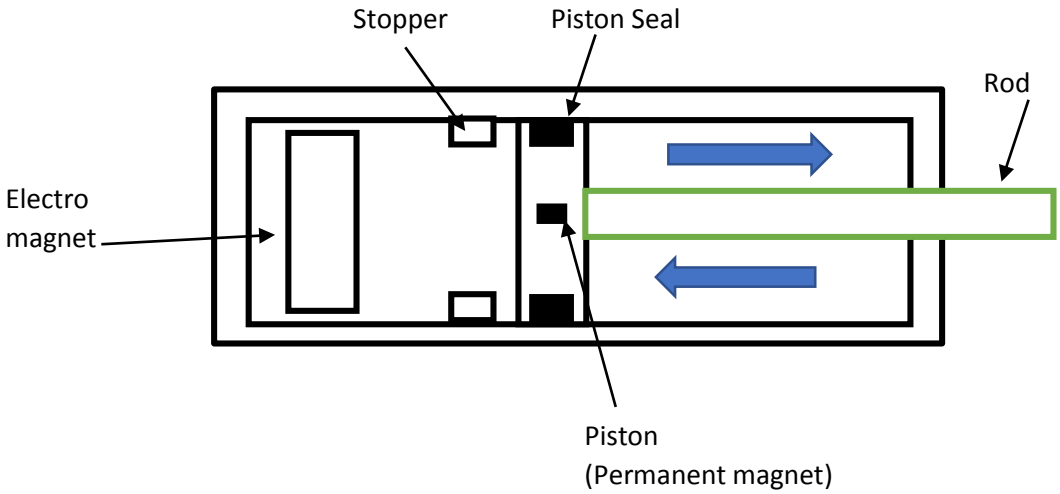
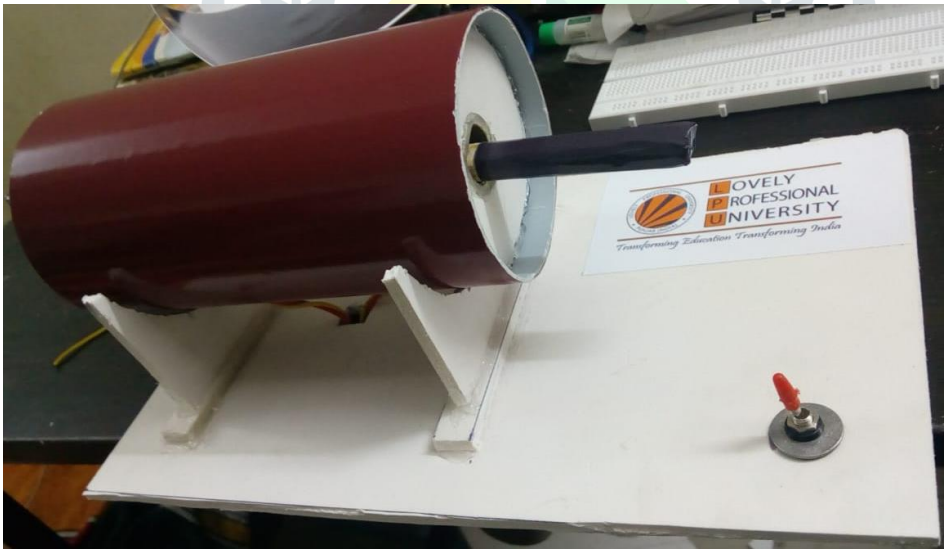


Figure:7 Double acting cylinder

Inside the cylinder the piston is made for double acting where the piston movement is more controllable and operate in both directions. Double acting cylinder is classified in two type, single rod double acting cylinder and double rod double acting cylinder, both operate on same principle only the difference is in number of rods. In single rod single acting cylinder only one side is piston is there and in double rod double acting cylinder, two rods are available. Thus, the movement of the piston can be control more accurately and precisely as shown in Figure 7.



=

Figure 8 Prototype of micropump

Conclusion

In the year 1975 the setup for the micropumps initiated. The research and development was made in the field of design and fabrication. MEMS technique is mostly applied so as to maintain the criteria and precaution

required the micropump to use in the biomedical areas [7]. In this study a prototype of the micropump is made and the three dimensional model of the prototype is made using solidworks software to check the feasibility of the model.

References

[1] Woias, P. (2005). Micropumps—past, progress and future prospects. *Sensors and Actuators B: Chemical*, *105*(1), 28-38.

[2] Nguyen, N. T., Huang, X., & Chuan, T. K. (2002). MEMS-micropumps: a review. J. Fluids Eng., 124(2), 384-392.

[3] Jeong, O. C., Park, S. W., Yang, S. S., & Pak, J. J. (2005). Fabrication of a peristaltic PDMS micropump. Sensors and Actuators A: Physical, 123, 453-458.

[4] Jeong, O. C., & Yang, S. S. (2000). Fabrication and test of a thermopneumatic micropump with a corrugated p+ diaphragm. Sensors and Actuators A: Physical, 83(1-3), 249-255.

[5] Mizoguchi, H., Ando, M., Mizuno, T., Takagi, T., & Nakajima, N. (1992, February). Design and fabrication of light driven micropump. In [1992] Proceedings IEEE Micro Electro Mechanical Systems (pp. 31-36). IEEE.

[6] Lee, D. S., Ko, J. S., & Kim, Y. T. (2004). Bidirectional pumping properties of a peristaltic piezoelectric micropump with simple design and chemical resistance. Thin Solid Films, 468(1-2), 285-290.

[7] Laser, D. J., & Santiago, J. G. (2004). A review of micropumps. Journal of micromechanics and microengineering, 14(6), R35.