SRM UNIVERSITY AP
Andhra Pradesh

Multi-disciplinary Design Project Report

Design and Fabrication Of Syringe Pump

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Contents:

Motivation:

A syringe, etymologically defined as a tube used for transferring fluids, has been conventionally used for a variety of scientific and medical purposes since millennia. Syringe pump also known as syringe drivers are metering pumps typically utilized in chemical and biomedical research for controlled administration of small amounts of fluid. This pump is capable of metering a limited volume of fluid through medical syringes at a low level of dosage error. Also, the estimation and characterization of pesticides and pollutants from aquatic samples requires Mass Spectrometric analysis which is carried out using syringe pumps. They are also used for devising a microfluidic channel to perform multiplex protein microarrays. On top of all these applications, we can also use this syringe pump in our UROP project. Where we can also find the laminar length of two different fluids coming at the same flow rate and at proportionate composition. Therefore, as evident from the diversity of syringe pump applications, we can make potential use of syringe pump for many future works.

Objective:

To deliver required flow rate of a given fluid and to mix two fluids at a proportionate rate. Also, this pump has been made open source and it is sold at a very high cost so to generate the same flow rate at low cost is also our objective.

Literature Review

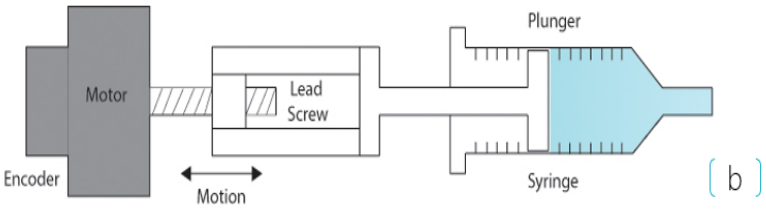
Authors	Topics	Syringe Quantity (ml)	Fluid Used	Flow rate (ml/min)	Remarks
Hiung Yin Yap, Chin Fhong Soon, Kian Sek Tee, Nurfarina Zainal, Mohd Khairul Ahmad (6th March,2016)	Customizing a high flow rate syringe pump for injection of fluid to a microfluidic device based on polyimide film.	5ml	Paraffin oil.	1- 5 ml/min.	Able to produce low percentage of error in dispensing fluid into a microfluidic device from 1- 5 ml/min. At high flow rate, the PDMS(Polydimethylsiloxane) microfluidic device fabricated was able to flow fluid from the syringe pump without leakage of fluid from the channel.
Muhammad Ahmed Khan, Osama Mazhar, Sameed Tehami (October,2015)	Designing of Micro-controller-based Syringe Pump with Variable and Low Delivery Rates for the Administration of Small Volumes.		Water.	Flow rates As small as 0.00166667 ml/min- as large as 16.665 ml/min.	Capable of delivering volumes as small as 0.1ml to as large as 12ml at delivery rates as small as 0.00166667 ml/min- as large as 16.665 ml/min with extra-ordinary accuracy and precision with respect to both flow rate and volume.
Mohsen Jafarzadeh, Fardad Farokhi, (6th December, 2016)	Design and construction of an automatic syringe injection pump.	60ml	Drug.	10.2 ml/min.	Experimental results indicate that for the syringe used in the pump, for every 2000 motor pulses, 1cc of fluid was injected into the patient. The shortest time achieved was approximately 6s for 1cc of drug or fluid. The speed for 1cc of drug injection was approximated as 10.2 ml/min.

A. Andrew Silva, N. Chiranjeevi, V. Kaushikan, R. Vengatesh, (March,2019)	Advanced control system for syringe pump using IOT.	5ml	Water.	0.03ml/min.	The flow rate measured experimentally was found to be 0.07ml/min which is different from theoretical result of 0.01ml/min predicted by Appaji et al [4]. To achieve the difference between theoretical and experimental flow rate of 0.03ml/min the steps was kept at 10 milliseconds and number of steps being 320.

Working Principle of our Prototype:

Working Principle

The Syringe Pump is composed of
a stepping motor and its driver,
a bracket, a nut,
a pusher block,
a reciprocating screw and a Syringe



It converts rotary motion of motor to reciprocating motion of syringe piston.

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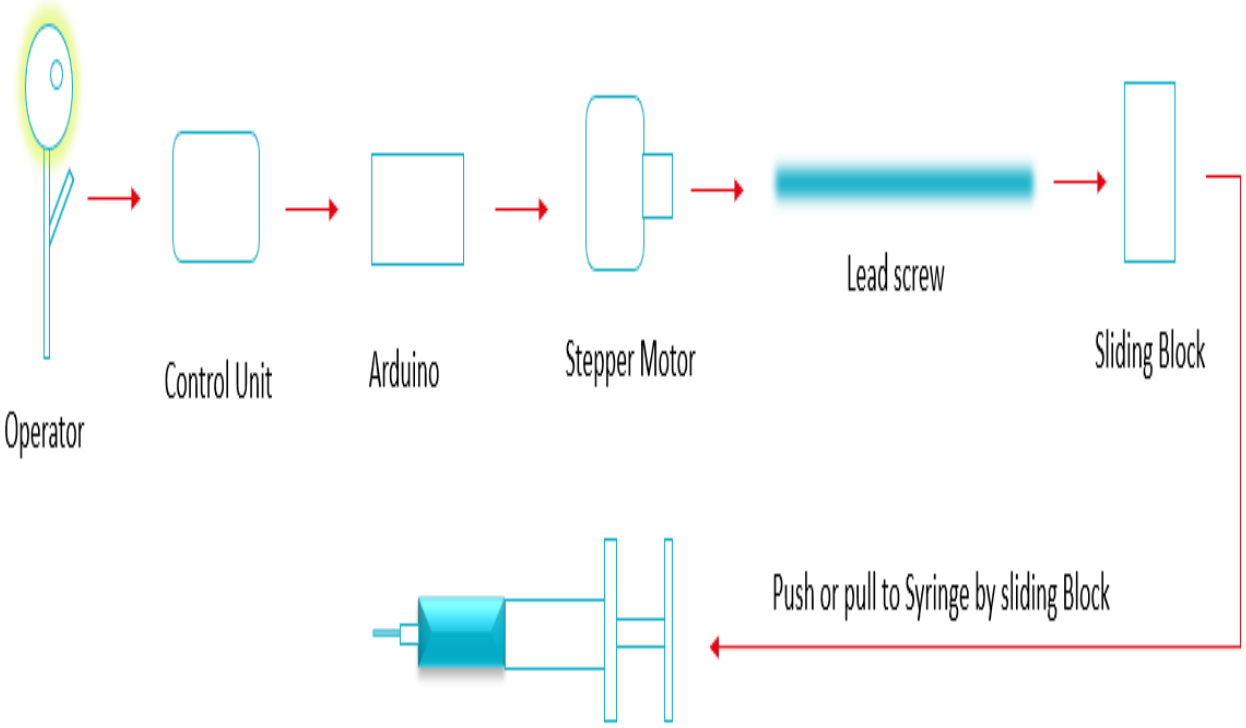


Experiments with relevant figures:

So far, we have been trying to make the prototype of our project and we are in our way to complete it.

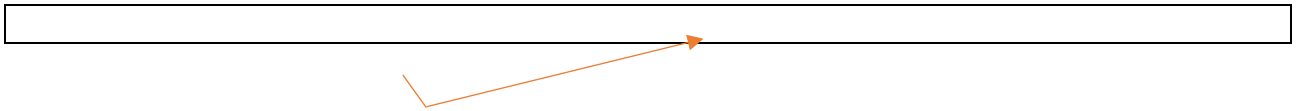
These are the steps involved in our project plan.

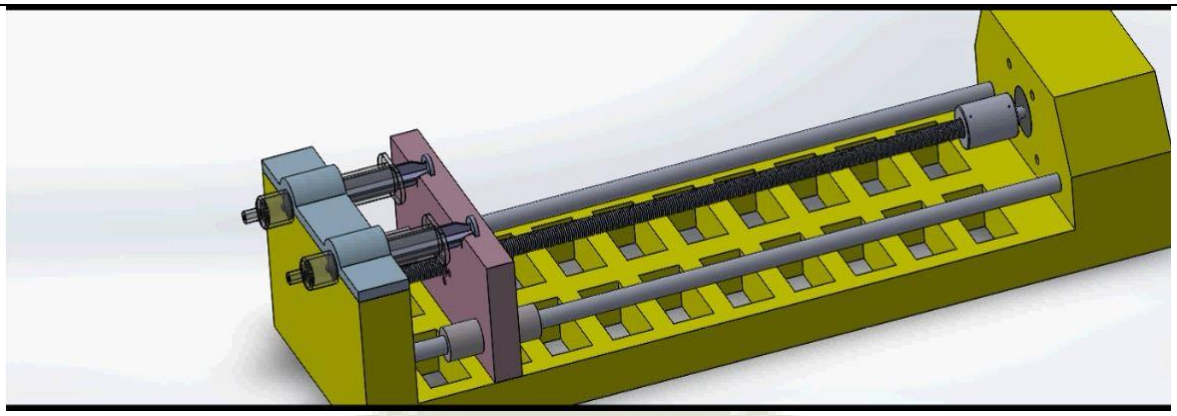
(1) Dimension of the prototype
(2) Identifying and buying the required Components
(3) Lab Work
(4) Calibration (till reaching the expected level)
(5) Finalizing our model.

Dimension of the prototype:

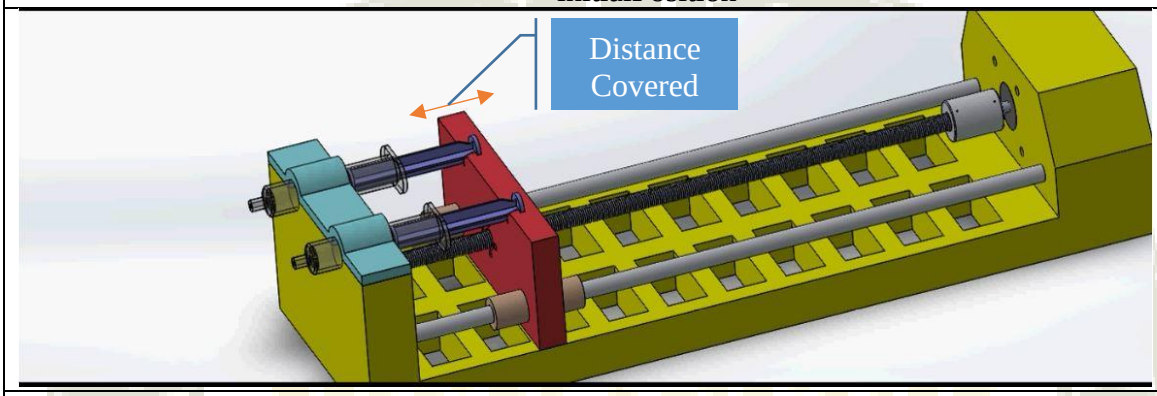
We used SolidWorks for the purpose of designing the CAD model of our Model and we animated for visualizing.

We produced a Drawing Sheet with all the dimensions.





initialPosition



Final Position

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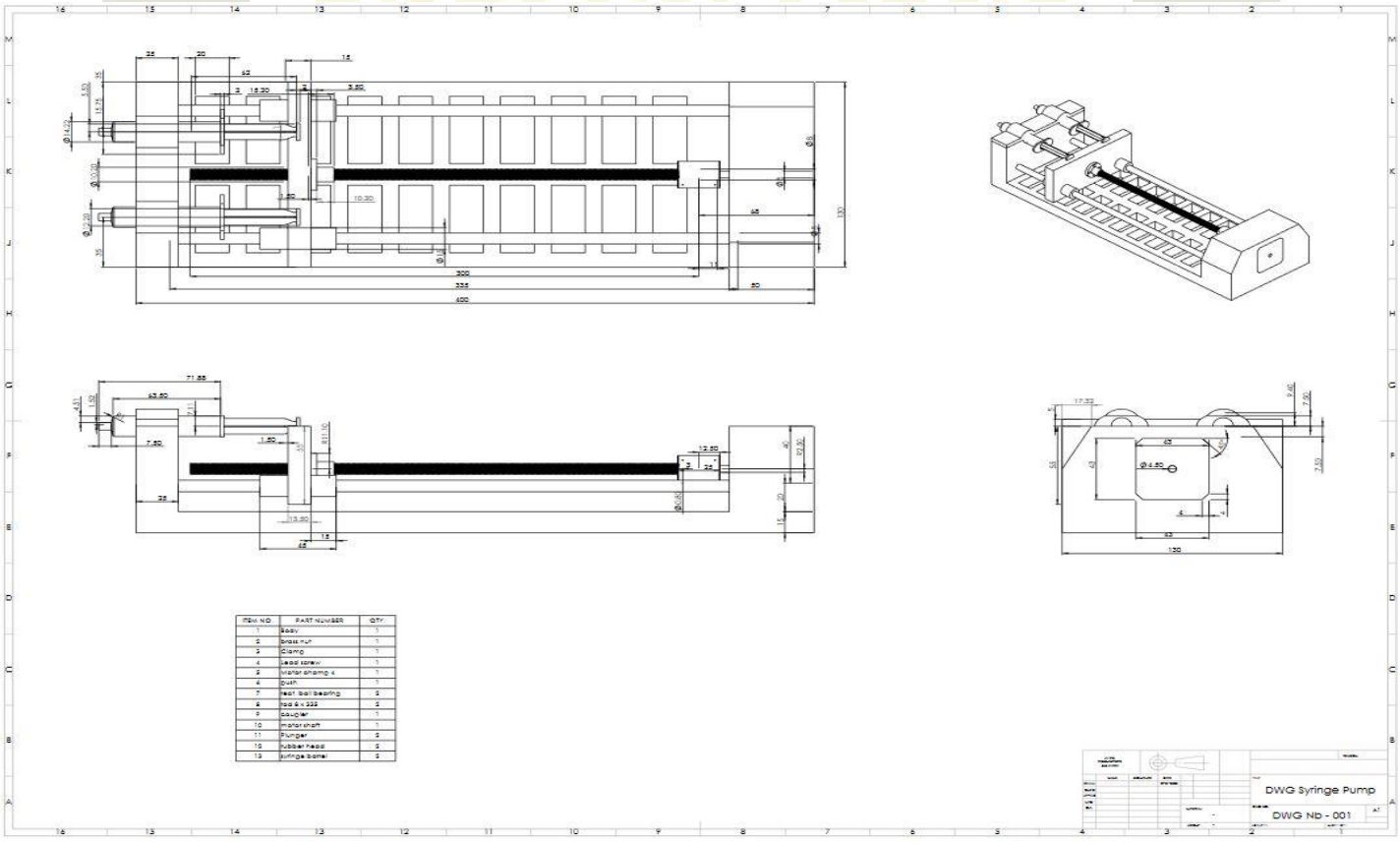

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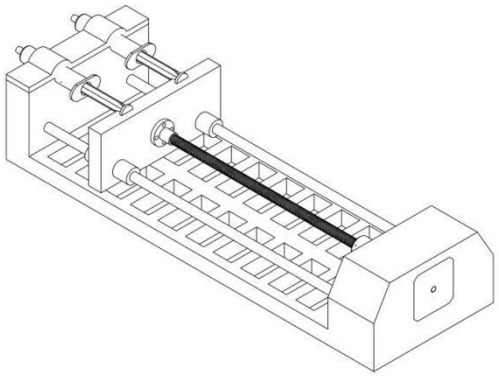
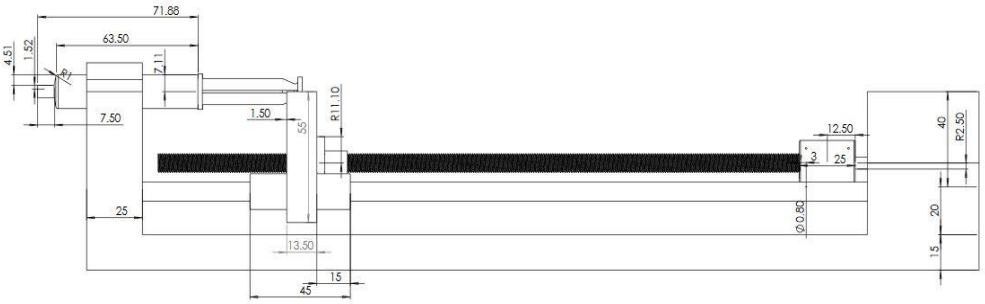
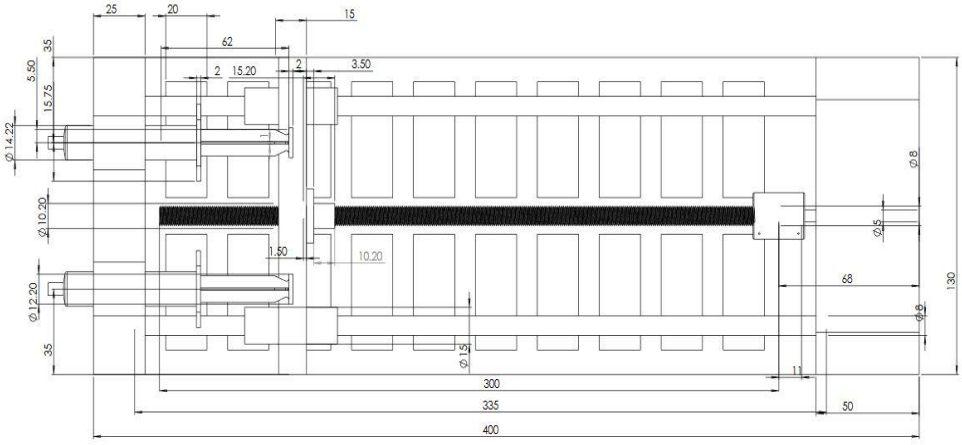


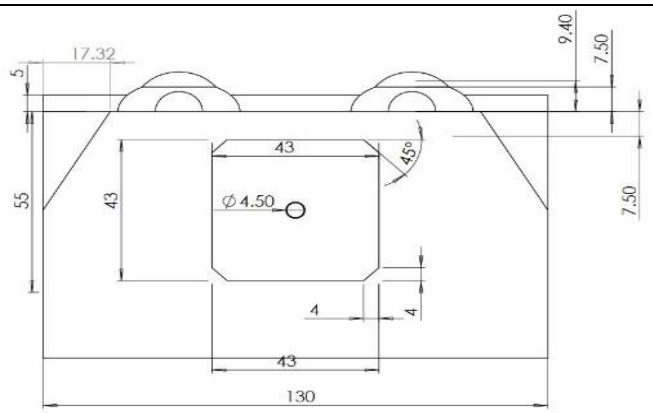
Isotropic View



Right View



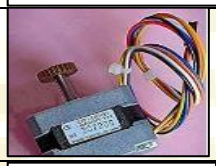
Top View



Back View

Components:

We identified the components needed for the project and we bought them from the available places.

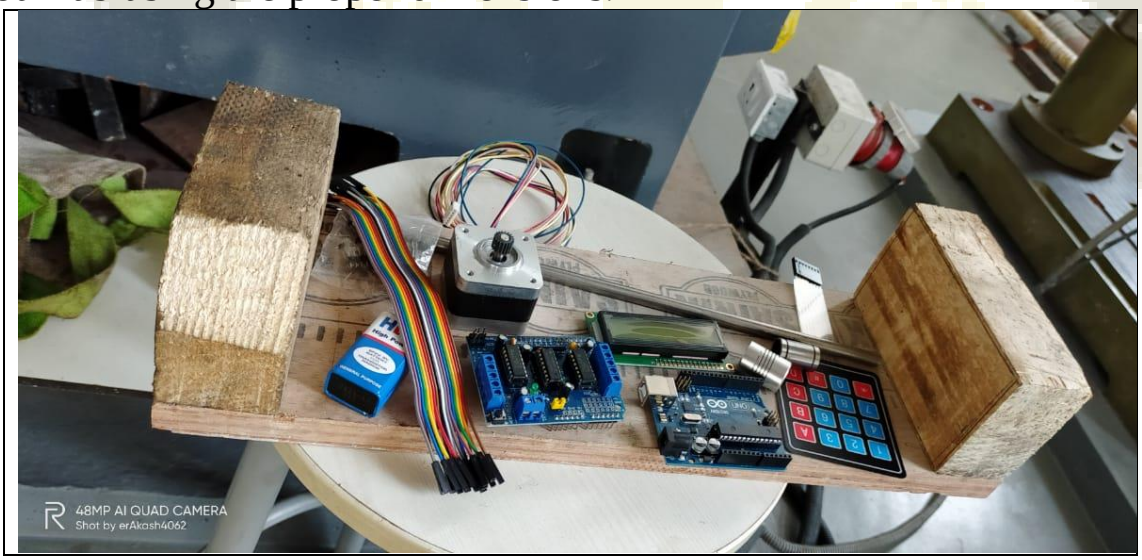
Generic Arduino UNO Kit	
Stepper Motor	
Lead screw with Brass nut	
Smooth rods	
Syringes	
Coupler	
Bearings	

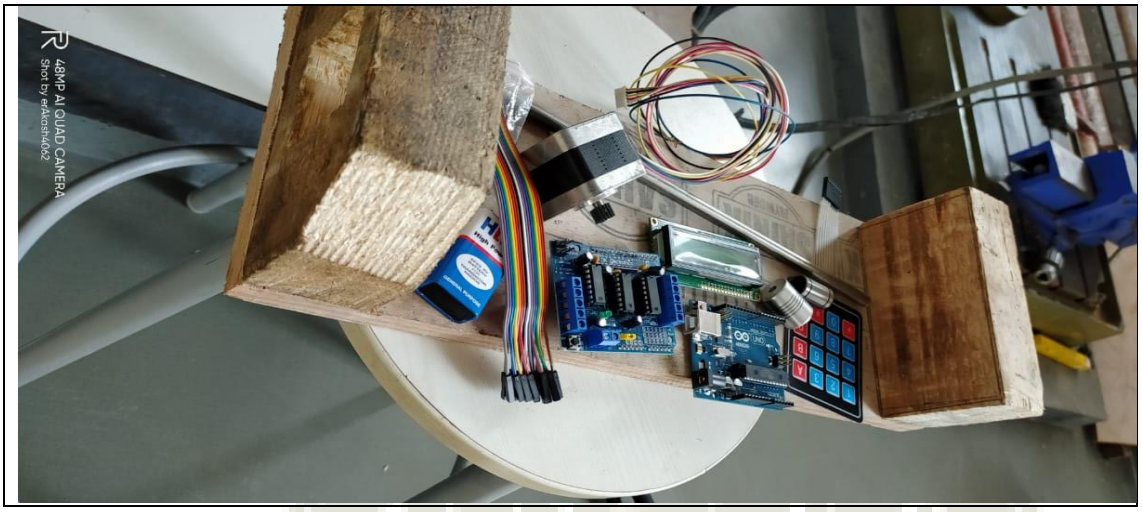
ITEM NO.	PART NUMBER	QTY.
1	Body	1
2	brass nut	1
3	Clamp	1
4	Lead screw	1
5	Motor champ 4	1
6	push	1
7	rect. ball bearing	2
8	rod 8 x 335	2
9	coupler	1
10	motor shaft	1
11	Plunger	2
12	rubber head	2
13	syringe barrel	2

Bill of Material

Lab work:

We started working in the lab in order to produce the prototype.
We built the base and vertical support of our prototype using the machines available in our lab using the proper dimensions.





Some of the pictures of us working in the lab (with proper assistance).

Calibration

We calibrated our stepper motor with different RPM's.

Design and Calculation:

Diameter of Syringe=28.6mm
Pitch of lead screw=1.5mm
Steps of stepper motor=100steps/rev
1.Distance to supply 1ml fluid
1ml=1cm3=1000mm3
Length *area=volume
L=1000*4/(pi*(28.6)^2)
L=1.556603mm
2.Steps to move 1.556603mm
=1.556603*100/(1.5)
=103.7735 steps for 1ml
For 2ml=103.7735×2=207.547 steps
For 3ml=311.3205 steps
For 4ml=415.094 steps
For 5ml= 518.8675 steps
3.Flow rate
Speed of the stepper motor= x
Flow rate = Pitch * speed * Area

A) Q=1ml/min
Q=1000mm/60sec
Speed=$\frac{1000 \times 4}{60 \times 1.5 \times \pi \times (28.6^2)}$ =0.0172955964260rpm/sec
For 1ml/min =1.03773578556 Rpm/min.

B) Q=2ml/min
Speed=$\frac{2000 \times 4}{60 \times 1.5 \times \pi \times (28.6^2)}$=0.034591192852 Rpm/sec
For 2ml/min =2.0754715711202 Rpm/min.
C) Q= 3ml/min
Speed=$\frac{3000 \times 4}{60 \times 1.5 \times \pi \times (28.6^2)}$=0.0518867892780 Rpm/sec
For 3ml/min=3.1132073566804 Rpm/min.
C) Q=4ml/min
Speed=$\frac{4000 \times 4}{60 \times 1.5 \times \pi \times (28.6^2)}$=0.069182385704 Rpm/sec
For 4ml/min=4.1509431422405 Rpm/min.
E) Q=5ml/min

Speed=$\frac{5000 \times 4}{60 \times 1.5 \times \pi \times (28.6^2)}$=0.08647798213 Rpm/sec

For 5ml/min=5.1886789278007 Rpm/min.

Conclusion:

A syringe pump device has been developed to provide an automatic process for flow control of fluid. The flow rate is achieved by the pushing force exerted by a stepper motor connected to the plunger via the rotation of linear slider. This report covers all the procedure of Research and Development of Syringe Pump that started with concepts and comes to end with effective prototyping of a syringe pump. At initial stage, syringe pump was designed in SolidWorks and simulation was performed. Later on, fabrication of syringe pump was done. Once the fabrication was done, proper calibration was done and this device was capable to deliver the fluid having small flow rate ranges from 1 – 5 ml/min with high accuracy and precision for the respective flow rates. This devices resemblance with one of the commercially available syringe pumps.

Future Work:

There are several more ideas that are intended to be made into reality as far as the future perspective is concerned. The first and the foremost is to add an option to select several syringe sizes that is required usually by the users. Another future aspect is to create an interface that allow the engineers to update and customize the code of micro-controller for different size of syringe and flow rates. Later on, we will try to customize the code so that we can give manual input for desired output using LCD and input keypad. If time permits, we will use this syringe pump for study of motions of Water Droplets at different Reynolds number (which can also be a good research work and later on, can be converted into a reputed Journal Paper.

References:

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- Jafarzadeh, M.; Farokhi, F. Design and construction of an automatic syringe injection pump. Pacific Science Review A: Natural Science and Engineering Volume 18, Issue 2, July 2016, Pages 132-137.

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