Report

To: Dr. Trevas

From: Team 23: Connor Gonzalez

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Re: Individual Analysis: Pumps

Introduction:

The In-Vitro Tube model will need to have fluid flowing through the model. The solution for this problem will be a pump. This report will analyze two types of pumps: programmable and student designed piston pump (SDPP). Three programmable pumps have been assessed and the best pump has been selected. If our PI qualifies for a grant, then the programmable pump will be purchased. If there is no grant then the SDPP will be fully designed.

We are choosing to analyze programmable pumps because these pumps are designed specifically for replicated the flows of the human body.

The SDPP is the second pump we are analyzing because this type of pump is relatively simple to design. It is simple because it is just one piston pushing fluid, then sucking fluid in from the reservoir, then pushing the fluid back out again. After research we found that the piston pump would be the best student designed pulsatile pump.

Assumptions:

The pump that is selected for the in-vitro model must have an anatomically correct flowrate and pressure. To solve for the pressures and flow rates, we will assume the fluid to be Newtonian as well as the density and viscosity to be constant.

For the programmable pumps we assume that the most important quality is accuracy.

Equations:

All equations use variables defined in the left column. All the equations in the right column and variables in the left column correlate to Figure 1 below the columns.

The flow rate (Q) of the pump and the frequency for the pump (Fr_P) determine the volume per stroke (V_s). The V_s can then be used to find the bore (B) and the stroke length (L_s).

$$\frac{Q}{Fr_p} = V_s$$

$$\frac{\pi B^2}{4} * L_s = V_s \ with \ B \cong L_s$$

The pressure delivered from the pump (P) is determined by the diameter of the in-vitro model (D), the force of the pump (F_p) and the resistance force from the model (F_R). The F_R is dependent on the D and the pressure drop from the entrance and the exit of the in-vitro model (ΔP).

$$P = \frac{4[F_p + F_R]}{D^2\pi};\ F_R = \Delta P\ \frac{\pi}{4}D^2;$$

$$F_P = \frac{\pi D^2}{4}(P - \Delta P)$$

The power needed for the pump (H) is determined by the P and Q. H can also be descried using voltage (E) and current (I).

$$H = PQ; E = HI$$

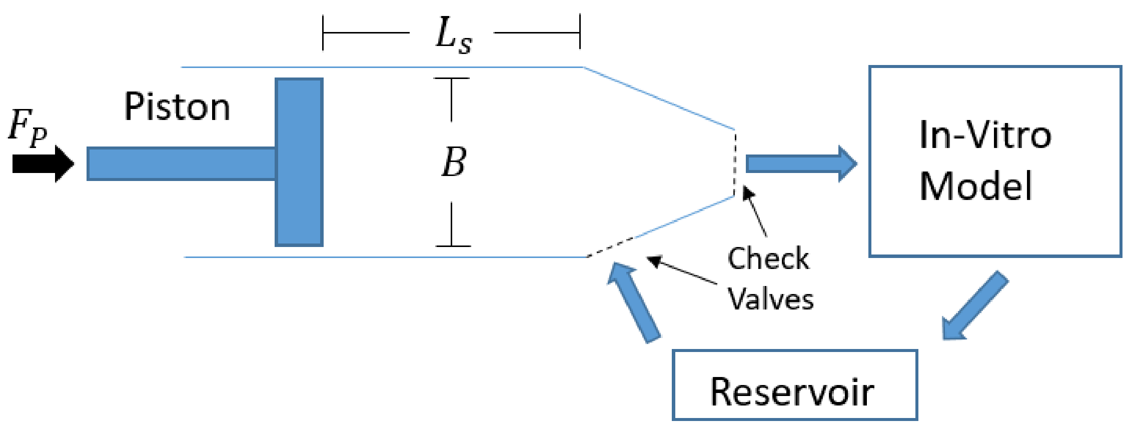

Figure 1 - SDPP Sketch.

If we use Q=750cc/min, Fr_p=60 bpm, ΔP=40 mmHg, D=5mm, blood pressure of 120/60 mmHg, a static pressure of 60 mmHg and an E=10V then by using the equations above we find that V_s=12.5cc, B=2.50 cm , L_s= 2.50 cm, F_p=0.523 N, H=.1 W and I=.02 ohm's. With an Arduino connected to a servo motor, the SDPP designed can be finished to these specifications to allow for pulsatile flowrates.

Programmable Pump:

Out of the three pumps we looked at, pump 2 (PD-1100, BDC Laboratories) has the lowest error, pump 3 (CardioFlow 5000, Shelley Medical) has the second lowest error and pump 1 (Pulsatile Blood Pump 55-3305, Harvard Apparatus) does not have an error published. Because pump 1 has no error published we will consider that the least desirable pump.

Results:

Until we find out if we will be receiving the grant, we will wait to decide on the pump for the in-vitro model. If we receive the grant then we will purchase pump 2 because it has the lowest error. If the grant is not received, then we will finish our designs for the SDPP.