Left Ventricular Assist Device
Test Loop Project #
P09021

The construction of the test loop is integral to the development of magnetically levitated axial low LVAD because the machine is able to characterize the pressures and flows associated with the device and determine the pumps impact on blood.

The final product is modular, biocompatible, has quick connects and a single tank that uses test specific tank lids. (See labeled diagram on the left). It is all controlled by a single LabView program.

This Project builds off of the work of previous Senior Design Projects. Past projects have created a durability test for LVAD, a centering magnet device and a hemodynamic flow simulation systems. The findings of University of Virginia Article, “Design Initial Testing of a Mock Human Circulatory Loop to Test LVAD Performance” has also been integral to our design choices.

To complete this project, our project team identified the customers needs and specifications, conceptualized development and selection of materials, created a systems design, and built and tested the model.

**Design Conceptions** differed by the number of loops and orientation. The Final Design was chosen using Push charts. Subsystems include:

- Blood Sub-System elements of materials and blood extraction.
- Dynamic Sub-System elements of compliance chambers.
- Static Sub-System Elements include air removal and automated resistance.
- Electrical elements of flow, pressure and temperature sensors as well as the DAQ.

**Fluid calculations** were performed to test if there is an adequate flow of pressure within the system. Results concluded that there is adequate flow of pressure within the system to allow adjustments to be made through testing to compensate for the non-steady characteristics.

**Fluids Analysis Results (Q=6L/min)**

<table>
<thead>
<tr>
<th>Fluids Analysis Results (Q=6L/min)</th>
<th>Physical Loop</th>
<th>Blood Loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>h_L</td>
<td>12893.8 in²/s²</td>
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</tr>
<tr>
<td>P_VAD_In</td>
<td>65.88 mmHg</td>
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</tr>
<tr>
<td>P_VAD_Out</td>
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**Bubble Dissipation Calculations** were performed to determine the reservoir size needed for air to escape. The test concluded that bubbles of significant size(5mm) will have enough time to rise in our reservoir.

**Accomplishments**
- Successfully built a modular loop, does not leak!
- Water bath successfully reaches temperature.
- Stepper motor adjusts pressure.

**Next Steps**
- Still waiting to perform tests with LVAD and PVS
- Still waiting to perform blood tests
- Still waiting to confirm sensors

The Electric Model was used to determine what loop design was needed in order to model the human circulatory system.

The main finding was that the loop only requires an Arterial Compliance Tank.

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Heat Transfer Calculations were performed to determine the heat transfer that occurs within the loop. The Heat Transfer of Compliance tank results concluded that the time for the blood loop to heat is less than two hours. A slow temperature rise will be less likely to damage the blood. Lastly, it was determined that no significant heat life occurs in the tubing.

**Bubble Dissipation Calculations and Analysis**

The bubble will reach its maximum velocity when the acceleration is zero:

\[
\frac{\Delta P VAD}{\Delta V} = \frac{2}{9} \sqrt{\frac{\rho \Delta P VAD}{\rho VAD}} \sqrt{\frac{\rho VAD}{\rho A}}
\]

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**Heat Loss in Tube**

\[
\text{Heat Loss in Tube} = \frac{Q^2}{C_p} \times \Delta t
\]

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Project Customer and Sponsor: Steven Day


The team would like to express its appreciation and gratitude to those who contributed to this project. Special thanks to Dr. Steven Day for his guidance and support, and Ivan Farber from Oetiker Inc., for his generous donation of components and installation tools. Additionally, the team would like to thank Dr. Doolittle, Dr. Daniel Phillips, Mr. John Wells, Mr. David Hathaway, Mr. Robert Kraynik, Mr. Steven Kociol, and the entire VAD research team for their assistance, patience, cooperation and constructive criticism.

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**Customer Needs**

<table>
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<tr>
<th>Specifications</th>
<th>Units</th>
<th>Ideal Value</th>
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<tr>
<td>Test device needs to be self contained and portable, minimize volume of fluids, and be easy to fill and drain</td>
<td>System Leakage</td>
<td># leak locations</td>
</tr>
<tr>
<td>Automatically generate pressure and flow curves to help characterize pump</td>
<td>System LxWxH</td>
<td>inches</td>
</tr>
<tr>
<td>Pressure</td>
<td>mm Hg</td>
<td>100</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>liters/minute</td>
<td>6</td>
</tr>
<tr>
<td>Temperature</td>
<td>degrees C (F)</td>
<td>37 (98.6)</td>
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**Specifications**

- System Leakage: # leak locations
- System LxWxH: 48x36x30 inches
- Pressure: mm Hg
- Flow Rate: liters/minute
- Temperature: degrees C (F)

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**Requirements**

- LVAD with QuickConnect connections
- Pressure sensor to measure compliance in head Blood
- Water tank with heat and air gage to simulate Blood
- Automated Compliance chamber with interchangeable lids
- Died in blood extraction needs.
- Second has head and air gage to simulate compliance is achieved.

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**Location of Flow sensor to characterize pump performance**

- Thermal sensor for temperature of fluid
- Differential pressure sensor to characterize pump performance