NAU NORTHERN ARIZONA UNIVERSITY

Bioengineering Devices Laboratory

BDL Compact Vessel Cleaner (CVC): Final Proposal

Team 2

Our Team

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Project Description

- Goal: To develop a pump system capable of cleaning 3D support material from vasculature models and improve flow model conditions.
- The flow model is used to simulate physiological conditions of the circle of willis for in-vitro (“within lab”) medical device deployment.

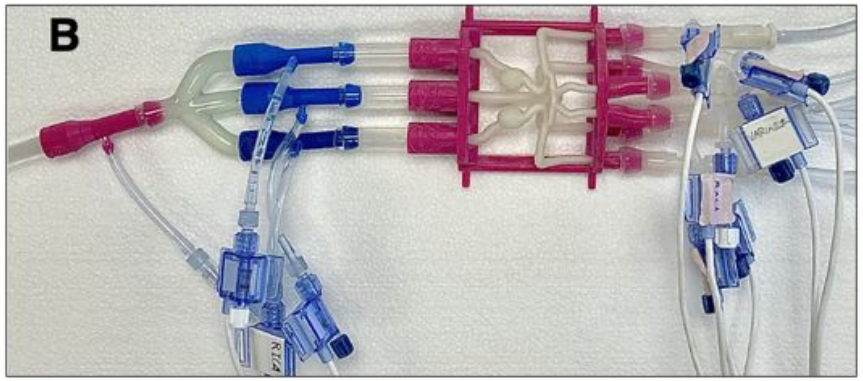

Figure 1: Circle of Willis Model with Pressure Transducers

- The Bioengineering Devices Lab (BDL) is an NAU research lab that focuses on biomaterials and medical device testing for aneurysm treatment.

Design State

- Cleaning process of model:
  - Clear exterior support with gloves
  - Pre-clear interior support of introducers using electric screwdriver
  - Inject 0.5 mol NaOH into interior and let support soak for over ten minutes
  - Use pump system to push out interior support with water.
- Completion of design validation and further physical prototyping before construction phase is complete

Prototype Image

- Preliminary Design created by Mentor with filter added by Capstone team.

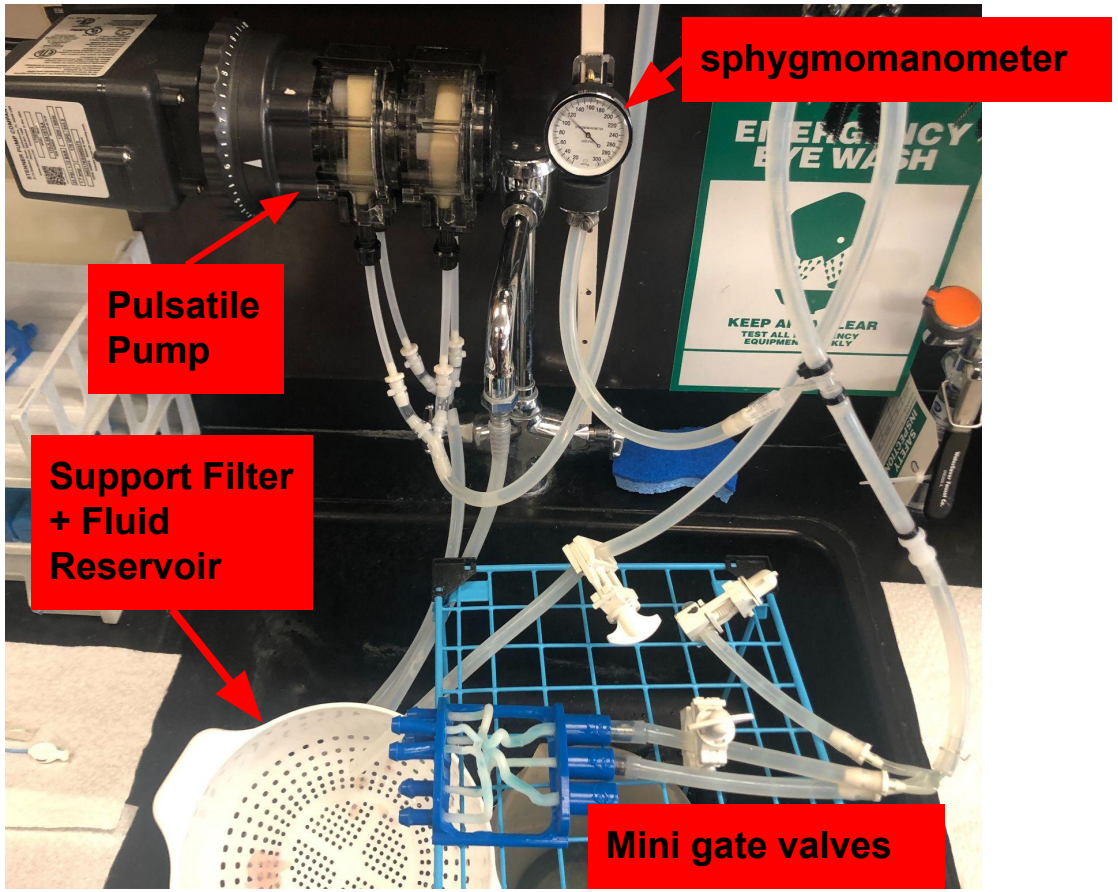

Figure 2. Preliminary CVC

System Demonstration

- Model Video: https://www.youtube.com/watch?v=E9E_IJSB6IU

Prototype Image

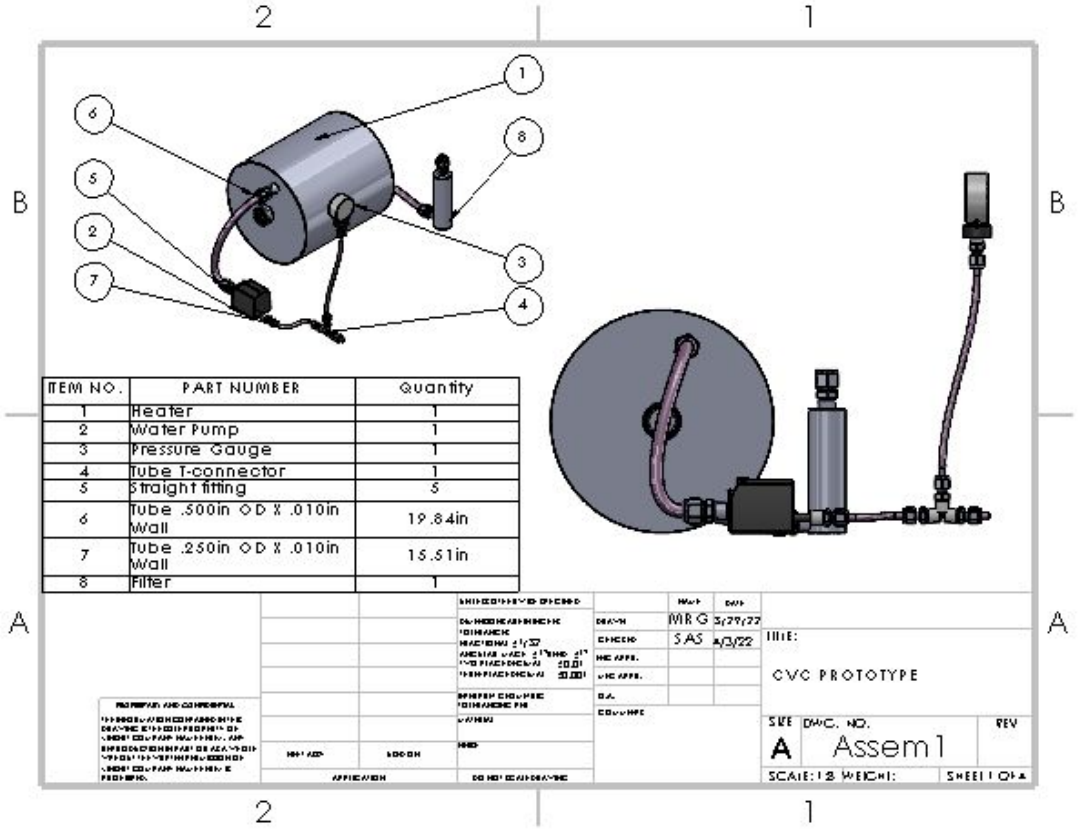

Figure 3. Prototype Assembly

Customer Requirements

- Fulfilled Customer Requirements:
  - Filter keeps support material from flowstream (minimized pump damage)
  - Heating element, fluid reservoir, and pump are included (needs design validation)
  - Within budget

Engineering Requirements

- Fulfilled Requirements:
  - Sphygmomanometer measures 100-200 mmHg during demonstration.
  - Power input no larger than standard wall outlet, 120V.
  - Mesh size for support material filter, <4mm.

- To be met
  - Maximum temperature of 80ºC.
  - Flow rate (TBD).

Bill of Materials

Table 1: Prototype BOM

Item #	Part Number	Quantity	Cost	Sum
1	Reservoir + Heater	1	$70	$70
2	Water Pump	1	$30	$30
3	Pressure Gauge	1	$30	$30
4	Tube T-connector	1	$0.25	$0
5	Straight fitting	1	$1.00	$1
6	Tube 0.5 in. OD w/ 0.10 wall	1.65333333	$1.50	$2.48
7	Tube 0.5 in. OD w/ 0.10 wall	1.2925	$1.50	$1.94
8	Filter	1	$50	$50
				$186

Design Validation - FMEA

Table 2: FMEA 1 BDL CVC

Product Name	Compact vessel cleaner	Development Team				Page No 1 of 1			
System Name	N/A	BDL CVC Spring 2022 Capstone				FMEA Number	1		
Subsystem Name	N/A					Date	3/27/2022		
Component Name	N/A								
Part # and Functions	Potential Failure Mode	Potential Effect(s) of Failure	Severity (S)	Potential Causes and Mechanisms of Failure	Occurance (O)	Current Design Controls Test	Detection (D)	RPN	Recommended Action
1-Reads pressure			1		1	Visual	1	1	
2-moves the fluid through system	High Cycle Fatigue	System failure	8	Poor maintenance,	4	Visual	3	96	Testing
3-Holds the fluid for the system	Thermal Fatigue	Leaking, Human injury, Incomplete operation	5	Surpass maximum teperature	3	Visual	3	45	Material Specification
4-Takes out impurities in the fluid	Corosive wear	Impure fluid, Dammage the pump or heating system	5	Poor maintenance	2	Visual	6	60	Regular maintenance
5-Removes support material from fluid	Corosive wear	Impure fluid, Dammage the pump or heating system	5	Poor maintenance	1	Visual	2	10	
6-Collects support material			3		1	Visual	1	3	
7-Connects componets and allows fluid to travel between components	Thermal Fatigue	Leaking, Incomplete operation	6	Poor maintenance, Assembly errors, Surpass maximum teperature	2	Visual, Pressure reading	2	24	Material Specification
8-Heats fluid	Thermal Fatigue	Support material wont be removed	8	Electrical current too high	4	Visual, Tempertaur reading	3	96	Testing
9-Controls system	Electrical Overstress	Automation failure	3	Poor maintenance, overstressing	2	Visual	1	6	
10-Reads temperature for the system			1		1	Visual	1	1	

Design Validation : Component Testing

Heating Component (ME 495)

- Testing- Voltage required to reach maximum temperature ER.
- Testing- Measuring output temperature from heating system.
  - The temperature as a function of time: $T(t)=T_{\infty}+(T_0-T_{\infty})e^{-t\tau}$

Pump Component (ME 495)

- Testing- Minimum flow rate required to reach maximum pressure ER, with respect to tubing type.Poiseuille equation $\Delta P=QR$, $R=(128\mu L)/(\pi (ID)^4)$
- Testing- Measuring output pressure from exit plane of tubing at vessel connection.

Design Validation: Model Testing

Full system testing:

- Procedure 0 - Functionality of all system components
- Procedure 1- Clean a control model (consistent geometry)
- Procedure 2 - Clean restriction model (area reduction)
- Procedure 3 - Clean Circle of Willis model (irregular geometry)

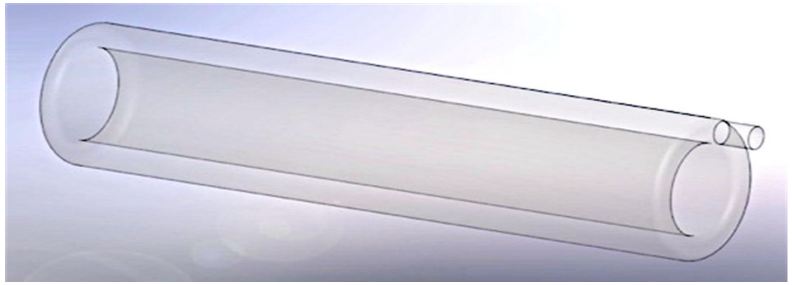

Figure 3: Control Model

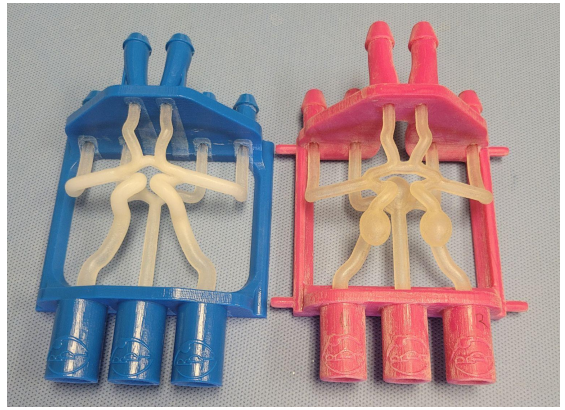

Figure 4: Circle of Willis Model

Left: No Aneurysms, Right: With Aneurysms

Design Validation - Resources

Equipment

- Tubing
- Arduinos
- Fountain pump
- Thermocouple
- Pitot tube
- Pressure Transducers
- Data Acquisition (DAQ) Module
- Engineering Computers (BDL & 495 Lab)
- Machine Shop Equipment

Spaces

- ME 495 Lab
- BDL Lab (Bldg. 210)
- Machine Shop (Bld. 98C)

Resources

- ME 495 Lab TA's and instructors
- Mana Alyami
- LabVIEW 2020 (BDL & 495 Lab)
- Solidworks 2020

Schedule (Remaining)

- https://docs.google.com/spreadsheets/d/1FVUyg-aU-zs20mbjo1faa_6WLSn-YZ80FPxUktBRjFs/edit?usp=sharing

Figure 5: Gantt Chart

Schedule (Fall term)

- Currently behind schedule for design validation.
- Will be on schedule after validating design.

Budget

Total Budget: $1500

- Items Purchased:
  - Fountain Pump: $30
- Anticipated Expenses: $500
  - Breakdown on next page

Remaining Budget: $1470

Budget (Continued)

Remaining Budget: $1,470

- Anticipated Expenses: $500
  - Medical Tubing: $0.75-2/foot, 10-25 feet
  - Vessel Prints: $0.40/gram
  - Heating Element: $30-$50
  - Frame Manufacturing (will vary, low priority)
- Contingency Budget: $970
  - Fountain/Pulsating Pumps Replacement
  - Other Replacements

Thank You