Stenosis Model for a Mock Circulatory Loop

Overview
An arterial stenosis is the narrowing of a blood vessel as a result of blockage that drastically alters the fluid mechanics compared to healthy vessels. Specifically, the blood velocity and pressure changes are significant and have been linked to thrombosis formation and embolization. The sponsor, Dr. Keefe Manning, is instructing a new biomechanics laboratory course where students will study flow through a stenosis, but the current models have certain shortcomings that must be addressed by a new design. A new stenosis model is needed that will allow for flow visualization and pressure measurements to be carried out simultaneously.

Objectives
The PSU Department of Biomedical Engineering is offering a new biomechanics laboratory course where students use a stenosis model to study the flow and pressure dynamics of a partially blocked blood vessel. A re-designed stenosis model is needed that allows for simultaneous pressure and flow measurements.

Approach
- Discussed goals for the stenosis model with Dr. Manning
- Determined the major customer needs were ability to perform flow visualization, ability to perform pressure measurements, and modularity
- Analyzed the previous models that were used in the lab
- Developed CAD drawings of the final model
- Researched machining options and determined a CNC lathe is the best way to machine the curved spline geometry
- Machined an alpha prototype for testing the acrylic to determine if flow visualization was possible
- Submitted a CAD model to Engineering Services for machining of final prototype
- Tested the final prototype using particle image velocimetry to visualize the flow and a pressure transducer to obtain pressure measurements
- Validated the testing results with a COMSOL model
- Developed a complete manufacturing plan for duplication of the prototype and a user’s guide to be used by future students.

Outcomes
- This project allows for the use of one model instead of two to simultaneously perform flow visualization and to measure the flow
- The modularity allows for multiple degrees of stenosis to be studied