## Cardiac Axial Blood PUmp Analysis and Performance Prediction

**D. H. Hussein,** H. Gitano-Briggs, and M. Z. Addullah
*School of Mechanical Engineering, Universiti Sains Malaysia*

Computational fluid dynamics (CFD) has been used for developing and evaluating the performance of a novel design of the cardiac axial blood pump (CABP). This device could be used as an implantable pump for boosting blood circulation in patients whose hearts are not providing sufficient output. Based on the Berlin Heart configuration the blood pump has been designed for a flow rate of 5 L/mine and 100 mmHg of head pressure. Finite element analysis method has been performed to predict the shear stress, pressure, velocity, pressure drop on the fluid through the pump and the shear stress on the pump impeller. Also, flow streamlines has been discussed in detail in this study to predict the flow streamlines behavior and the stagnation points. The goal of this work is to design an efficient blood pump to support the blood circulatory system and reduce the shear stress and blood hemolysis during transport through the pump. Our design simulated at several rotational speeds (5000 to 7000) rpm to investigate the relationship between the rotational speeds and shear stress. Results indicate that the rotational speed has a direct correlation with shear stress and pressure drop and at 6500 rpm the pump gives its optimal pressure drop.

*Keywords: high shear stress, blood hemolysis, bio-compatibility, axial blood pump, biofluid engineering, flow streamlines*

## A Cardiac Sound Reproduction Apparatus for Improved Stethoscope Testing

**G. Nordehn**
*University of Minnesota Medical School Duluth*

R. Ulseth, T. Bartek, B. McDonald, A. McNally, M. Menart, S. Eames, M. Flynn, B. Blaire, and A. Drewek
*Itasca Community College, Engineering Department*

E. Branson and S. Burns
*University of Minnesota Duluth, Department of Electrical and Computer Engineering*

Valvular heart disease is a significant problem. The primary case physician initially does assessment through auscultation. Accuracy in classification of sounds is suboptimal (20 to 40%). Lower frequencies of heart sounds are important in classification of murmurs associated with valvular heart disease. We find stethoscope sound intensity capture falls significantly at the 1500 Hz range and lower. Strategies to improve auscultation accuracy include improving stethoscope features or developing a device that, when used with the stethoscope, augments sound capturing abilities at lower frequencies. Testing necessitated development of a reliable (without significant intra-sound variation) cardiac sound reproduction device. A sound permeable contracting polymer when used with a stethoscope signficantly increases sound intensity captured in the 625 Hz to 1500 Hz range, when tested with a reliable cardiac sound reproduction device. We prepared an air-sealed device with an amplifier, four internal speakers capable of emitting high quality, low frequency sounds, and a listening pad. An existing electronic stethoscope with, and then without, a sound permeable contracting polymer captured three sounds (normal, innocent systolic murmur, pathological systolic murmur) five times per sound. The sounds were placed in computer files. FFTs were constructed. Sound intensity within the 625 Hz to 1400 Hz range, when the sound permeable contracting polymer is used with the electronic stethoscope, relatively improves, on average, approximately 11 dB, compared to sound captured with the same electronic stethoscope without the sound permeable contracting polymer. This difference is numerically statistically significant ($p < 0.001$). Intra-sound variability testing (standard deviation) of FFTs was not significant. A sound permeable contracting polymer used with an electronic recording stethoscope significantly improves sound intensity in an important auscultation frequency range. Intra-sound testing variation was insignificant. A study is underway to demonstrate impact using an absolute reference point. However, as amplification within existing electronic stethoscopes is commercially available, potential variation in relative reference points may be overcome with existing amplification features on electronic stethoscopes, allowing improved capture of heart sounds within the 625 Hz to 1400 Hz range. Limitations include the need for human subject study. Further testing, including human subjects testing is needed prior to application for FDA approval. FDA approval is needed before any use on humans. The methodology should not be utilized clinically without FDA approval.