Department of Mechanical and Materials Engineering

SENIOR DESIGN ORGANIZATION SYNOPSIS – SPRING 2013

SIMULATION AND MODELING OF THE HUMAN HEART FOR CRYOGENIC PERFUSION

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With current technology, human hearts fit for transplant are only viable for approximately four hours. However, an improved cooling method would increase the lifespan of the heart, which would give medical personnel a better opportunity to transport the heart in time to save lives. Research shows that there is an optimal cooling rate for each type of tissue that maximizes cell survival, but external cooling alone is not sufficient to cool all tissue optimally. With external cooling alone, inner tissues are not cooled as quickly, causing thermal stresses and quicker decay. Therefore, we propose a system to cool the heart both externally and internally by pumping fluid in and around the heart at an optimized flow rate and temperature in order to minimize thermal stresses and prevent decay. Our primary goals are as follows:

- Construct an approximate geometric model of the human heart from a material which emulates its physical properties accurately.
- Develop a double-chambered container within the heart that models the internal blood flow and feed cooling liquid into it at a controlled flow rate and temperature in order to test the effectiveness of internal cooling.
- Create an exact ANSYS (CAD) copy of the model heart and run thermal-fluid simulations to compare with physical model and find optimum values.
- Experiment with both the physical and computer models of the heart to find the best possible method of cooling.
- Design a responsive, controlled system using a mechatronic flow rate controller connected a computer and to thermistors and cooling valves within the model.
- Construct a shatterproof, transparent and safe box for heart transport.
- Incorporate a test fluid that changes color depending on temperature for the final presentation.

Ultimately, we expect our system to increase the lifespan of the heart from four hours to approximately eight hours. The final product is intended to be used internationally in an effort to enhance modern heart preservation procedures which can potentially aid individuals with life threatening cardiovascular diseases.