**Introduction**

The primary focus of the project was to design an MRI-compatible system that circulates cool water over a treatment area, providing increased convection allowing for a quicker, more effective procedure. Key considerations for this project included:

- Cooling system could not interfere with the heat inducing ultrasonic waves emitted by an ultrasound transducer or Magnetic Resonance guided High Intensity Focused Ultrasound (MRgHIFU). MRI-compatible.
- System needed to easily attach to the existing MRgHIFU system and maintain constant contact with the skin.
- All cooling system parts needed to be MRI-compatible.

**Prototype design**

After many design attempts including primitive construction using Tupperware and plastic wrap, and a more refined ABS 3D printed cooling pad with 9 ports, the final cooling pad is ABS 3D printed with a curved surface and 11 ports.

**Fluid Flow Simulation**

Evenly distributed, turbulent flow is desired to maximize cooling.

**Test Methods**

Experiment – Transient cooling of Test Phantom

- Thermocouples at water inlet & outlet
- Thermocouples at phantom surface & depths at 5 - 20mm
- Test phantom at refrigerated temperature, approx. 6°C before experiment
- Water supply at ambient temperature, 22°C
- Flow rates = 3, 6, 9, 12 ml/sec
- Temps recorded at 1 sec intervals - 1000 sec

**Data Reduction**

Method 1 - Determine heat transfer coefficient through steady state equations:

\[ Q = h \cdot \Delta T \]

\[ Q = h(T_s - T_{inf}) \]

Method 2 – Finite difference analysis using Matlab

Interior node equation:

\[ T_n^{i+1} = Fo(T_n^{i+1} + T_{n+1}^{i+1}) + (1-2Fo)T_n^{i+1} \]

Boundary node equation:

\[ T_0^{i+1} = 2Fo(T_1^{i} + Bi \cdot T_1^{i}) + (1-2Fo-2BiFo)T_1^{i} \]

**Focused Ultrasound Procedure (MRgHIFU)**

Currently the Utah Center for Advanced Imaging Research (UCAIR) uses a focused ultrasound procedure to concentrate acoustic energy beneath the skin’s Surface. A fraction of ultrasonic waves are absorbed at the skin’s surface creating unwanted heating and discomfort to the patient. This project is aimed at reducing procedure time by keeping the patient comfortable through a forced convection cooling process.