Development and Evaluation of a Smart Water-Cooled Cushion for Adaptive Temperature Regulation

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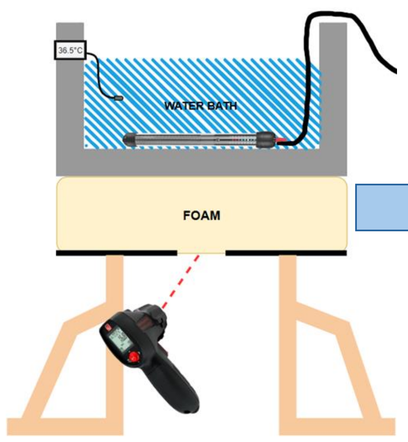
Introduction

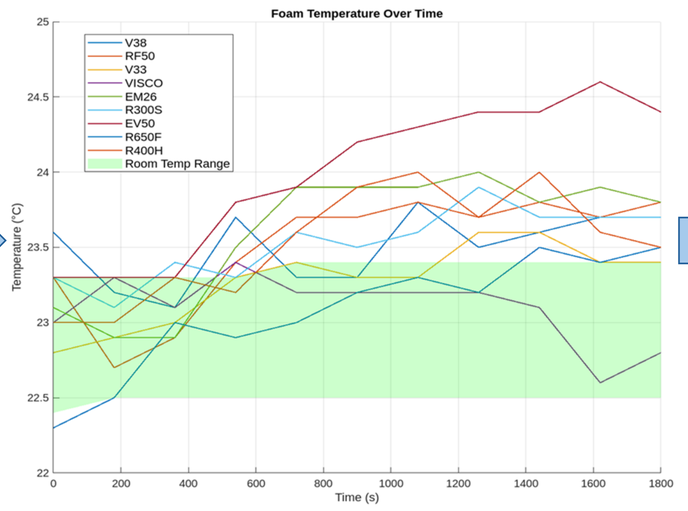
Prolonged seating, particularly among individuals with reduced mobility or neurological conditions, can lead to serious health risks. Inability to frequently reposition results in sustained loading at the body-support interface (BSI), causing increased pressure, heat build-up, and a higher likelihood of developing pressure ulcers. Excessive heat and moisture further compromise skin integrity, contributing to discomfort and long-term tissue damage. Traditional foam cushions focus on pressure relief but lack effective thermal regulation. This project responds to the need for a solution by exploring a smart cushion design that actively manages temperature. Controlling the temperature at the BSI and subsequently reducing the health risks associated.

Stages of development

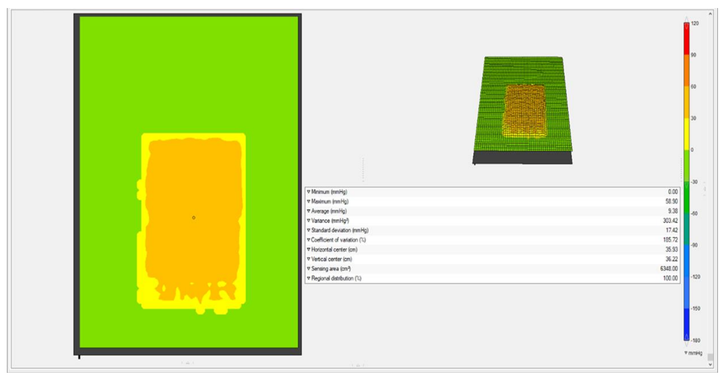
1. Material selection

Thermal testing on 9 different foams for best conduction whilst incorporating pressure testing





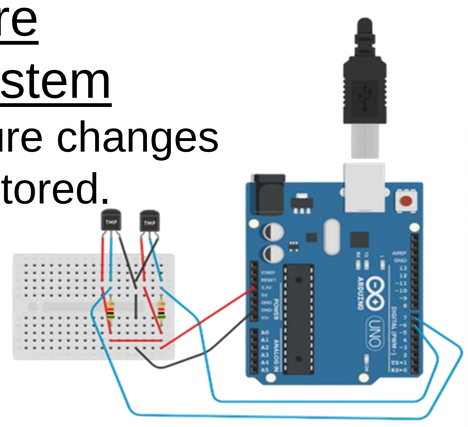
3 best thermally performing foam pressure mapped



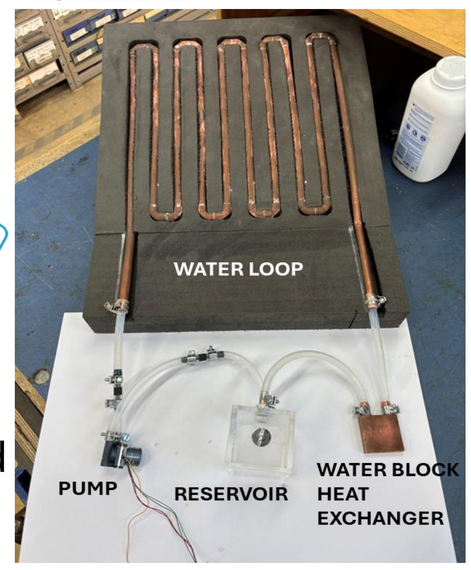
15mm R400H foam best thermal and pressure performance

2. Temperature monitoring system

Small temperature changes need to be monitored. Arduino system using DS18B20 temperature sensors created



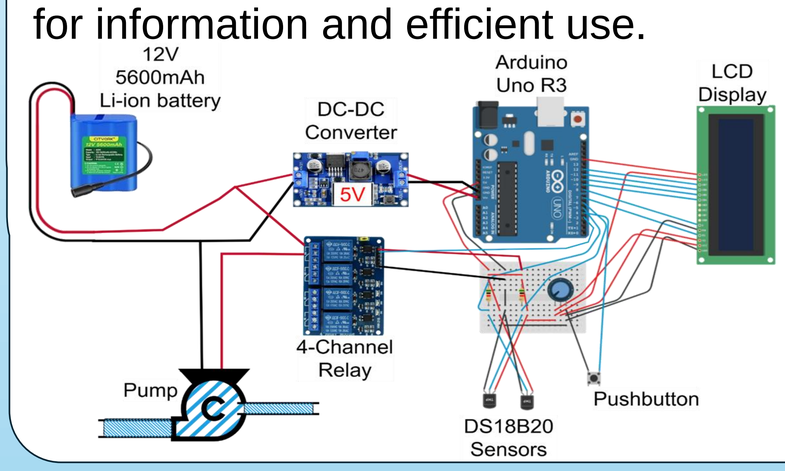
3. Water-cooling system



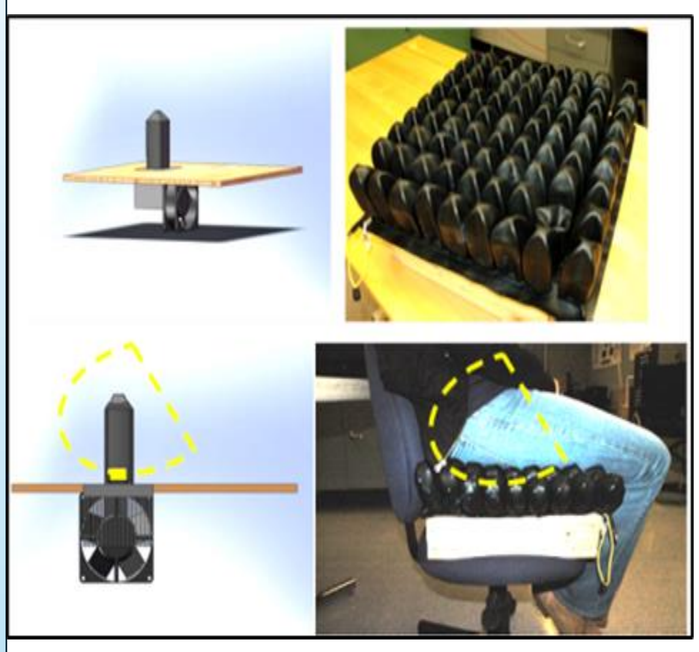
Simulation showed circular copper pipes most suitable. Combined with water pump, reservoir, heat exchange block to form system

4. Assembly

3 stages brought together, and occupancy detector and LCD introduced for information and efficient use.

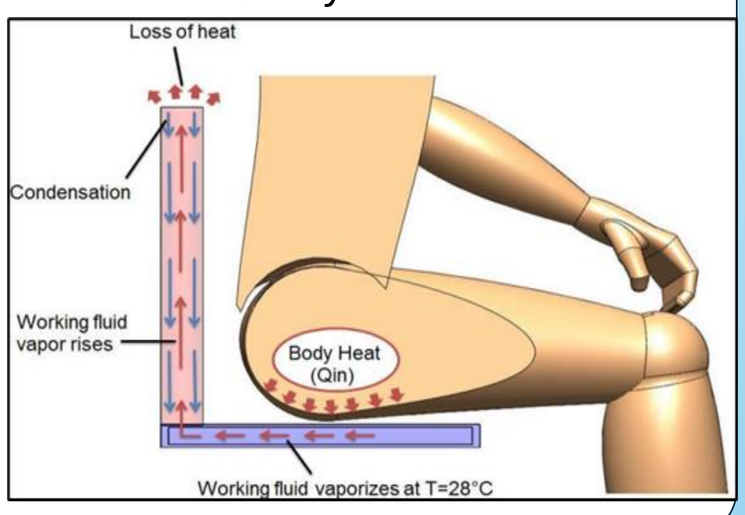


Current Research



Wheelchair cushion integrating Peltier semiconductor modules for site-specific cooling at high-risk pressure areas. The system actively reduced skin temperatures without affecting pressure redistribution, demonstrating the feasibility of targeted thermal management to prevent pressure ulcers in individuals with limited mobility.

Cushion using ammonium hydroxide sealed in heat pipes under partial vacuum (evaporates at ~28°C), heat from the user causes the fluid to evaporate, vapor rises to condenser section in backrest, cycles down through gravity to evaporator section



Final Prototype

Housing for electronics and water-cooling system. With temperature sensors, water tube and occupancy detector threaded through. 15mm R400H Velcro-secured down.

Results