CoolPac: Cooling Device for Firefighters

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Outline

- Background
- Current Products
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Createc Consulting LLC

- Sponsor Advisor: Hans Almqvist
- Focused on designing personal safety equipment for firefighters, industrial workers, etc.
- Main customers are local and federal government
- Successful designs include S.C.U.B.A breathing apparatus, hazmat suits, SCBA faceplates
Heat Stress

- Buildup of body heat generated internally or externally
- Hastens muscular fatigue
- Increases cardiovascular strain
- Compromises cognitive function
- Firefighters especially at risk due to high internal and external heat
Heat Stress

Firefighting → Heat Stress → Fatigue → Overexertion/Strain → Biomechanical Changes → Slips, Trips, Falls

Heat Stress → Overexertion/Strain → Cardiovascular Changes → Sudden Cardiac Events

Fatigue → Biomechanical Changes → Cardiovascular Changes
CoolPac Prototype

- Designed as a sleeve to be worn under the suit
- Consists of the sleeve, phase-change material (PCM), and fastening device
- Human thermoregulation involves increased blood flow to extremities under stress
- Temp. of the sleeve < temperature of the body
- Heat can be absorbed by the PCM due to the shallow blood vessels
CoolPac Prototype

Thermoregulation of the Human Body

Normal Blood Flow

Blood Flow Under Heat Stress

4% of Blood Flows to the Skin for Heat Loss

48% of Blood Flows to the Skin for Heat Loss
Current Market

- **KoreKooler Rehab Chair**
- Similar heat transfer concept
- Limited by lack of mobility
- **PECS Cooling Vest**
- Not as physiologically efficient
- Adds considerable weight
Patents

- Patent US 2006/0064147 by Hans Almqvist
- “Cooling Garment Having Phase Change Material in Extremity Portions”
Objectives

- PCM Optimization
- Mechanical Redesign
- Validation testing for arms and legs
Requirements

- PCM Optimization:
  - Attempt to meet sponsor’s PCM needs:
    - Latent Heat of Fusion: 70-75 Wh/kg
    - Melting Temperature: 25-32°C
  - Research Alternative PCM for CoolPac Device:
    - PCM Energy Ltd: Melting Point (24 – 26°C)
    - PCP Australia: Melting Point (29°C)
Requirements

■ Validation Testing:

■ Testing needs to be carried out in a scientific environment with the proper tools and equipment

■ Cycling Bike, Thermal Sensors, Heart Rate Monitor, Full Body Suit and/or Firefighter Suit, CoolPac Prototypes (2-4)

■ The use of the BME departments Bio-Pac testing equipment to measure both vital signs and body temperature.

■ Farmington Health Center laboratory and/or Gampel testing facility
Requirements

- Provided constraints need to be met.
  - Work generated by test subject:
    - 300 Watts
  - Test Cycle:
    - Measure initial heart rate and core body temperatures.
    - Donning of equipment
    - Repeating cycles of work and rest
    - Make final measurements.
- Age/Gender/Weight:
  - The age group should be focused in the range of 20-30 years old
Requirements

- Mechanical Re-Design:
  - Alteration to the prototype:
    - Comfort/Durability
    - PCM Alignment: Maximize Surface Area
      - Current design entails 3x4” blocks of PCM oriented around the sleeve.
      - Possible re-designs involve changing the block shaped PCM’s to either longer rectangular shapes and/or circular shaped ones.
    - Fastening: Easy to put on and take off
Budget

- **Price per Phase Change Material pad**
  - $3.75 each
  - Need up to 50 pads (to test on arms & legs)
  - $3.75*50 = $187.50

- **Sleeve materials**
  - approx. $50 for cloth/sewing materials
  - approx. $50 for fastening materials

- **Exercise Bike:** approx. $500

- **Biopac sensors**

- **Thermoregulation suit**
  - Free, provided by Createc Consulting for validation testing

- **Total proposed budget:** ≈ $1000
  - Unknown/extra costs factored in
Project Flow

1. Background research
2. Consult Sponsor & Ask Questions
3. Research PCM
4. Test PCM Material Properties
5. Select PCM
6. File for IRB Compliance
Validation Testing of current prototype

Analyze Results

Discuss design options (to make better)

Design new prototype

Finalize new design

Create new prototype

Presentation
Conclusion

- Project involves testing and design optimization
- CoolPac has great potential to increase firefighter safety
- Great potential for financial success
References

Questions?