Temperature-Controlled Prosthetic Skin for Medical Manikins

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DUKE ENGINEERING POD DESIGN

Design Problem & Motivation

Currently in healthcare training settings, most manikin simulators do not exhibit realistic feverish symptoms such as changes in body temperature or changes in appearance. Other than the lack of warmth in these manikins, they are also made from plastic—this cold, rigid material does not aid in the imitation of human skin.

By addressing these issues, we can provide medical practitioners a more comprehensive simulation for diagnosing health conditions.

Design Criteria	Description
Temperature Range	5 preset temperature ranges: 35 - 36°C, 36 - 37°C, 37 - 38°C, 38 - 39°C, 39 - 40°C Reach selected temperature within 10 minutes
Aesthetics	Mimics the texture and elasticity of human skin
Charging	Lasts for ≥ 4 hours
Durability	Lasts for ≥ 1 year
Dimensions	Thickness: 3 mm Area: ~30 x 30 cm^2
Cost	≤ $200

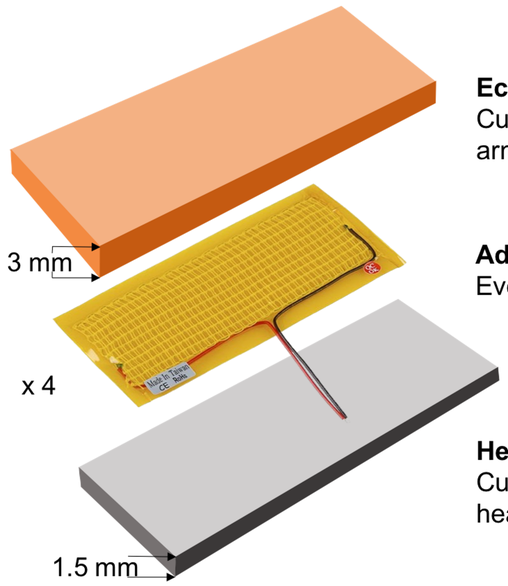
Table 1. Design Criteria Chart

Design Solution

We addressed the problem by designing a device that can be attached to the forearm of a medical manikin. It has the capability of heating up to five temperature levels. The material used for the surface of the device was chosen to mimic the texture and elasticity of human skin (Figure 1).

Our final solution consists of four 14 cm x 5 cm heating pads sandwiched between a skin-like silicone material and a heat-resistant foam casing (Figure 2). Users can set and transition between preset temperatures using a remote (Figure 4). The remote communicates with the skin via bluetooth (Figure 3).

Figure 1. Final Device to be Attached to Manikin, Connects to Circuitry in Figure 3



Ecoflex Skin
Cut out to surface of manikin arm

Adafruit Heating Pad (x4)
Evenly spaced under the skin

Heat Resistant Foam
Cushions and separates the heat from the electronics

Figure 2. Exploded View of Temperature-Controlled Prosthetic Skin

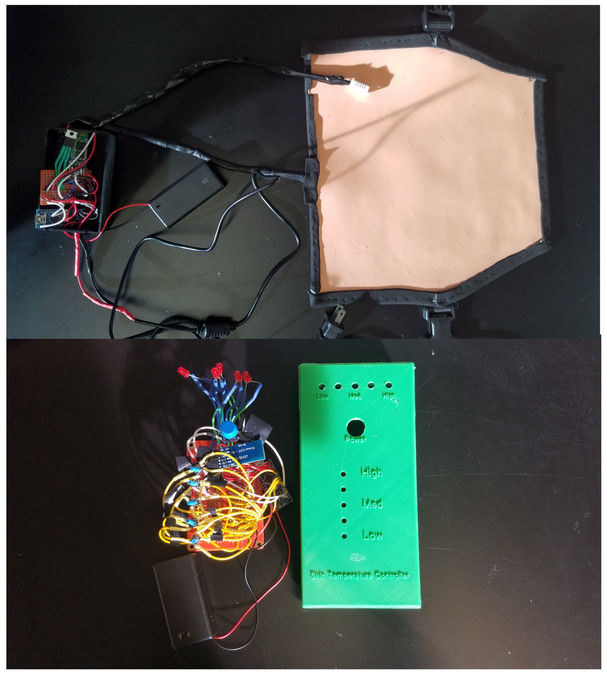


Figure 3. Final Composition of Internal Circuits and Remote

Testing

Design Criteria	Test Description
Temperature	1. Heating the device to each of the 5 preset temperatures (specific temperatures were calculated based on external human skin temperatures)[1] 2. Ensuring the device can maintain a temperature for 10 minutes 3. Ensuring the device can transition between the preset temperatures
Aesthetics	User-defined scale based on the realistic feel of the skin
Charging	Measuring the time it takes for the battery to run out at each temperature
Durability	Wrapping, buckling, unbuckling, and unwrapping the skin around an arm 100 times
Dimensions	Fitting on actual mannikins in Nursing School and measuring fit with Likert Scale
Cost	Calculating final cost and ensuring it is less than $200

Table 2. Test Descriptions

Results

- Skin can reach all 5 necessary temperature ranges within 5 minutes
- Device charging uses wall outlet
- The skin was buckled and unbuckled for 100 times each, which is the presumed user frequency of the device per year.
- Skin patch fits securely around medical manikin, shaped from an initial skin patch of 30 x 30 cm^2
- Final design cost $173, which is under our budget of $200.

Conclusion

We successfully made a realistic skin patch that has the elasticity of human skin. The hexagonal shape of the skin patch, when wrapped around the arm of a manikin, snugly encloses the forearm with only a minimal amounts of the skin case showing. Our skin patch can be remote-controlled to heat up to 5 specific temperatures between 34°C and 40°C within 10 minutes, simulating feverish symptoms. All in all, we managed to complete or project in only $173, leaving us under budget and allowing us to create an affordable product.

Next Steps

- Increase precision of selected temperatures
- Generate a color change to mimic a feverish appearance
- Imitate perspiration by incorporating fluids into the design
- Scaling the device up to cover a greater surface area
- Optimize durability of materials and attachment points

References

1. Cooney, D. O. (1976). *Biomedical Engineering Principles*. New York, NY: Marcel Dekker, Inc.

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