

## Research Article

# Semiconductor Polymer Carbon Composite Coated Fabric for Warm Beds in Hospital

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Patients suffering from diseases that occur due to spreading of virus like fever and cold will have decrease in body temperature. They feel cold in the normal body and room temperature conditions. For the comfort of these patients, an electric under blanket is designed which warms up the patient to maintain the normal body temperature. The heated under body supports include a heater assembly and a layer of compressible support material. The heater assembly includes a flexible heating element, multiplex polyester, and a temperature sensor. The flexible heater element may include a fabric, which coated with a conductive or semiconductive polymer. The heated under body support may also include a water resistant shell, whereas it may encase the heater assembly and the compressible support material. The material used for outer shell and inner heating element has simulated in COMSOL tool for analyzing the heat transfer between them. The proto type model has simulated in PROTEUS software, which includes Arduino UNO and thermistor. This analysis will give the result whether the material can be used as the under garment for warming the patient.

## 1. Introduction

Center inner warmth degree usually managed in a decent reach, on the equal time, when under massive sedation or neuraxial sedation, and the frame's potential to govern temperature is weakened. This final effect in a center to fringe rearrangement of skeleton is get heated and a decrease in center temperature. This drop has increased through openness to a groovy careful weather, employer of unwarmed intravenous liquids, and dissipation from careful access factors [1]. Truth be advised, center to fringe reallocation of

internal heat diploma information for 89% of warmth misfortune at some stage in the primary hour of clinical manner and 60% within the time later, this warm temperature misfortune from the body for the duration of a medical way is because of different warmth misfortune systems. Hence, a patient can get hypothermic throughout a cautious interest, called perioperative hypothermia, which takes vicinity in 50% to 90% of sufferers going thru a scientific method [2].

Perioperative hypothermia can bring about detrimental outcomes, along with cardiac complications, infection of the surgical website, impaired blood clotting, more common

blood transfusions, terrible nitrogen stability, not on time wound recuperation, behind schedule healing from anesthesia, prolonged hospitalization, shivering, and affect person soreness. In truth, a 20 degree Celsius drop in middle frame temperature in surgical treatment triples the incidence of wound infection and prolongs hospitalization through around 20 percentage, or roughly 2 extra days of hospitalization [3].

The normal body temperature ranges from 27 to 37 degree Celsius. Therefore, as per the body temperature. The above specifications are taken. The following one is calculated through watts/voltage equal to amperes.

Current range is 5 amperes. (body range).

Maximum voltage is 24 volts.

Wattage per inch square is 5 watts.

Therefore, for nylon, the current rating is 2.5 amperes.

For Kapton, it is 2.08 amperes. So, both of these give to 4.58 approx. equal to 5 amperes.

So, for maintaining the current rating, we designed the mattress of 5 × 5 inch×inch mattress.

5 inch × 5 inch × 5 watt/inch × inch = 125 watts/24 volts gives to 5.2 amperes.

Tables 1 and 2 list out the properties and specifications for the materials that include density, thermal conductivity, and power based on the temperature. When found a main quest for examination and modern-day improvements are licenses, greater capability. One patent endeavors to research how adaptable a restrained air framework can be.

The device that proposed here would incorporate probably efficiently delivered depending on the medical system place. This customization brings about the limit to buy numerous covers of differing length and plan. Another patent builds up a close circle input framework that mechanically kills the gadget if an excessive temperature has supported for a hard and fast degree of time. This safety encompass limits the opportunity for copies and uneasiness. Warmed dozing pads can be made greater successful by using analyzing various materials to divert and send warmth in a coordinated manner. Infrared warming lighting fixtures may additionally likewise emerge as greater powerful as bulb configuration focuses greater warm temperature over a bit quarter. These developments should be considered an endeavor to expand the usefulness of our item past current capacity. There are not many novel arrangements or upgrades that have showed up in this industry permitting us to think little while hoping to have a gigantic effect.

Dynamic and indifferent warming techniques are utilized to treat and avoid perioperative hypothermia aloof techniques that comprise the utilization of material or aluminum covers and head covers, while dynamic heating techniques contain the usage of confined air warming gadgets and liquid heaters.

It is a demand for a functioning warming strategy for less asset settings to stop according to operative hypothermia careful sufferers that experience awkward scenes of shuddering in line with operatively and postoperatively, showing instances of hypothermia during medical procedure. So, careful results can drag out hospitalization and increment cost.

## 2. Literature Survey

The KOALA Warming Framework by NOVAMED is a way of behaving, underbody-warming system intended for salvage. The item promoted for its capacity to adjust to various beds and warm patients substantially more proficiently than constrained air- or water-based warmers. The X-beam and radio semitransparent sleeping pad lashes straight around the bed and uses an outside control framework. The sleeping pad advances total patient access with quiet activity to limit sway on current careful procedures. The framework requires 75 watts for activity [5].

This framework mirrors large numbers of similar highlights we had recently distinguished for our item. The temperature settings are 99F, 100F, 102F, and 104F, a thermal resistor to ceaselessly evaluate the temperature of the resting cushion [6]. The resting pad covered in polyurethane covered synthetic fiber with welded wrinkles for defilement control. The more sweltering contains three inside layers, the base layer is a strain mitigation versatile cushioning that changes with the patient's body and appropriates weight and warmth, the middle layer is an ensured carbon polymer sheet that gives unsurprising warming, and the top layer is cotton for further developed comfort and pressure help [7]. We are hoping to join a significant number of these elements in our gadget, and this new benchmark approves a considerable lot of the plan choices we had recently made. Albeit this gadget satisfies our prerequisite for reuse, the gadget actually needs outside contribution to work (no criticism circle), does not fulfill the tasteful or connection modes wanted by or partners, and does not satisfy our minimal expense objective.

Electrically warmed covers are decided to be protected from dangers of electric shock and over temperature if they finish standard assessments for flow spillage, dielectric strength, and ordinary and unusual overheating. Plan contemplations which influence execution on these tests incorporate the development of the sweeping wired design, the power rating of the cover, the sort of over temperature insurmountable utilized, and the safeguard qualities of that security [8].

Correlations of the 60 Hz electric field openings related with high voltage transmission lines to those related with normal family sources can give a significant contribution to administrative choices that include transmission line fields. Electric covers are of interest in this setting because the openings they produce are among the most extraordinary and delayed of any of the family wellsprings of sixty Hertz electric field openness. The author presented his paper a hypothetical investigation of the body surface fields actuated by electric covers. Its openness forces are contrasted with those related with transmission lines [9].

Fuzzy hypothesis was first distributed in 1965 by an educator at the College of California, Chad (LA Zadeh). He set forward the idea of a fuzzy set, focusing on that the degree of fuzzy rationale portrays the idea of things, in actuality, and works on the weaknesses of the parallel rationale. He narrated in his article the framework of fuzzy [10].

We have tried different things with a few electric covers under various conditions. The microcontrol unit with the

TABLE 1: Properties of the material.

| Type of material used                | Composition material                   | Material property   |
|--------------------------------------|--|---------------------|
| Carbon tape                          | Carbon-boron alloy                     | 29.5 watts per inch |
| Kapton K and HN                      | Polyimide insulated film               | 10 watts per inch   |
| Ultra heating fabric                 | Metal polymer fiber composite          | 89 ohms per metre   |
| Thick film of polymer heating sheets | Conductive polyester substrate         | 1.25 watts per inch |
| Heatflex                             | Fiber glass reinforced silicone rubber | 12 watts per inch   |

TABLE 2: Specification of the material [4].

| Material | Density (g/cm <sup>3</sup> ) | Thermal conductivity (w/mk) | Power per inch×inch |
|----------|------------------------------|-----------------------------|---------------------|
| Nylon    | 1.15                         | 0.25                        | 60                  |
| Kapton   | 1.4                          | 0.1                         | 56                  |
| Bakelite | 1.3                          | 0.2                         | 50                  |

fluffy control framework recognizes the situation with operate and gives the reasonable potential warming state. The functioning cycle is half of the phase, and the entire control process is separated into two phases. An obligation pattern of the electrically warmed wire's work time is set to be hundred percentages at the underlying autochange stage. If the MCU distinguishes that the electric cover is utilized perilously, it changes the warming power [11].

Nanotechnology-based totally textile coating is a combined method to fabric engineering, which is particular based on the usage of nanoscale substances and novel methods to produce clever completing. Nanofiber coating of various steel and nonmetallic substrates has been intensively considered for sensory and infrastructure purposes [12].

Carbon nanotubes have been stabilized on a cotton floor the use of 1,2,3,4 butane tetracarboxylic acid as a crosslinking agent and sodium hypophosphite as a catalyst. The stabilized carbon nanotubes modify the surface of the fibers and growth and the capability and thermal balance of the substrate [13].

### 3. Existing Methodology

There are different strategies for dynamic, overbody warming come as fluid (easy warm) or resistive warming covers. These covers can both be set beneath the affected person or be correctly being formed to the shapes of the frame. A shut circle input framework conduction of heat moves from the gadgets to the patients. Underbody warming is likewise a widely known method to manipulate inner warmth level. Warming mats, similar to the Gelli-Roll, adequately give tolerant solace and warming totally through conduction on the posterior of the affected person.

A few clinical beds provide comparative resistive warming innovation to distinctive covers available even as coordinating the warming additives into the mattress pads. This arrangement gives a close circle framework that has encased in the mattress and disposes of the requirement for added cleaning past contemporary practices. Other novel arrange-

ments exist beyond warmed covers and cushions. Intravenous gadgets work to warm beverages prior to entering the frame and focused lighting may be applied to supply infrared warming across the affected person.

### 4. Proposed Methodology

*4.1. Design Drivers.* The gadget has to manage the temperature of patient during medical procedure to forestall perioperative hypothermia. The plan will become pointless, if it neglects to successfully move the patient warmth to look after the normothermia. Depends upon the body and atmospheric situation, there may be a variation in radiation between 50 and 70% of body warm, convection around 15 to 25%, dissipation in the range of 5 to 20%, and conduction around 3 to 5%. So, temperature will manage moderately heat fringe internal warmth level and generally cool center internal warmth stage, this will look at the constant state movement of warmth whilst the gadget has moved warmth to the affected person, and it takes the time to attain at that constant kingdom, to realize the warming device plan adequacy. Notwithstanding shifting warm temperature to the patient, the device needs to maintain great and conductive warmth misfortune from the chest location of patient via the protective or warming the affected person (or each). This plan driver needs to be assessed at the basics of heat pass, making use of overseeing conditions of conduction and radiation and PC fashions just as exact testing.

*4.2. Nylon Thermal Testing.* Conductive heat transfer is governed by heat transition equation as mentioned in equations (1) and (2) and temperatures taken with thermocouple for different materials shown in Figure 1 and Table 3.

$$X = \frac{cA\delta T}{t}, \quad (1)$$

where  $A$  is the cross-sectional territory,  $c$  is the conductivity of warm,  $X$  is the heat transition,  $\delta T$  is the cold and hot sides of the material between the variation in temperature, and  $t$  is the material density. To obtain the thermal conductivity of polyurethane coated nylon experimental value, the heat flux value has substituted in the original equation.

$$X_2 = X_1 \times \frac{d_2\delta T_1}{d_1\delta T_2}. \quad (2)$$

We might utilize this as an incentive and then play out a

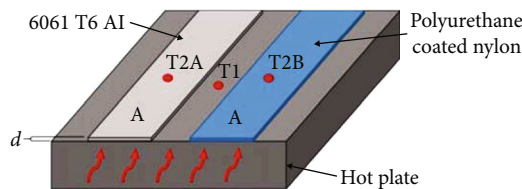


FIGURE 1: Experimental setup of aluminum and nylon (reference [4]).

TABLE 3: Temperatures taken with thermocouple for different material (reference [4]).

| Material | Hot plate temp | Material interface temp | Thermal conductivity |
|----------|----------------|-------------------------|----------------------|
| Aluminum | 82             | 78                      | 205                  |
| Nylon    | 82             | 60                      | 61.5                 |

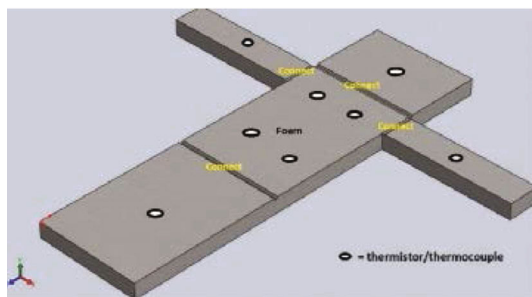


FIGURE 2: Picture of thermocouples implanted just underneath the furthest layer (reference [4]).

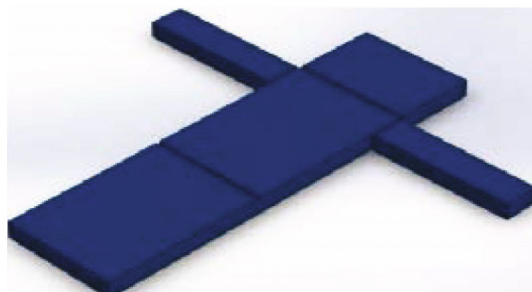


FIGURE 3: Picture of gadget shrouded in polyurethane-covered nylon by means of a hotness sealer (reference [4]).

warmth transition exam and electricity equilibrium to assess the degree of heat conveyed to the affected person at unique temperatures. We set our machine to at some stage in pastime, and it ensures that the affected person in the forestalling dissected with the aid of locating massive amounts; as an instance, warmth transition and separator cloth thickness do not enter into a hypothermic condition.

The hypothermic patient's temperature has monitored in the nasopharynx. Usually, it has measured underneath the tongue by inserting a probe that causes discomfort to the neuraxial anesthesia for the affected person. The mea-

sured temperature has compared with the pulmonary artery temperature, as the temperature of blood near the cardiac is the absolute temperature in the middle frame.

Because of the flexible and capable characteristics of the carbon tape, that laying on the top surface will not induce pain to the patient. In addition, the carbon tape will not dissipate heat. The warm mattress has tested without current limiter and with current limiter to measure the resistance of the blanket. It has observed that the temperature ranges from 22°C to 34°C using the modern current limiter after 10 minutes of testing, whereas with current limiters, the temperature ranges from 22°C to 42°C within 3 minutes. Here, the wires in without current limiter act as a sandwiched layer between the foam and nylon.

## 5. Design Description

*5.1. Resistive Warm Mattress.* In this due to radiation and conduction, the mattress heats up the patient without any surgical treatment; it confronts the tearing, puncturing, and fluids in the body. The bottom layer will encompass light blue minimobile luxurious company foam, on the way to act as a sturdy base for the tool. The subsequent layer will encompass our deflector, to save the patient from the loss of heat through the lowest level in the equipment that is a part of fabric reflective mendacity upon the foam. The deflector in the warm mattress secures the foam with a twig adhesive, and the resistive heating machine has placed above the deflector. Hence, inside the bill of materials and embedded in porous material, it contains a particular-gauge insulated twine proven. The diffuser that is pinnacle resistive heating gadget equally spreads the heat throughout the mattress surface. In our system, the diffuser is made of hunk of cotton with loosely wounded. To prevent the device from tearing and puncturing, the device is completely surrounded using polyurethane covered nylon fabric and the tool sewn together with Kevlar string.

The silicon rubber that molded at room temperature with vulcanized fabric is used to make the ear bud. Acrylonitrile butadiene styrene plastic is used to make the reusable clip. This modern gadget fulfills the reusability requirement at the same time as appropriately measures the temperature in center frame.

*5.2. Temperature Sensor Conversion.* In our system, three temperature sensors were used: one is to sense the heating wire, the second sensor measures the temperature on surface of the bed, and the third sensor placed in the patient ear that represents the temperature of the middle body. As the temperature varies, the resistance of the thermistor also varies, and the Arduino board monitors the 400 series thermistor that placed at the heating twine. Even the temperature of wire exceeds the limit, the system is going to be off automatically until the temperature reaches the safer level. Thus, the temperature in the surface of the mattress will not exceed beyond 40°C so that the moist pores and the epidermis can be at for an indefinite quantity of period scheduled with independent of flaring.



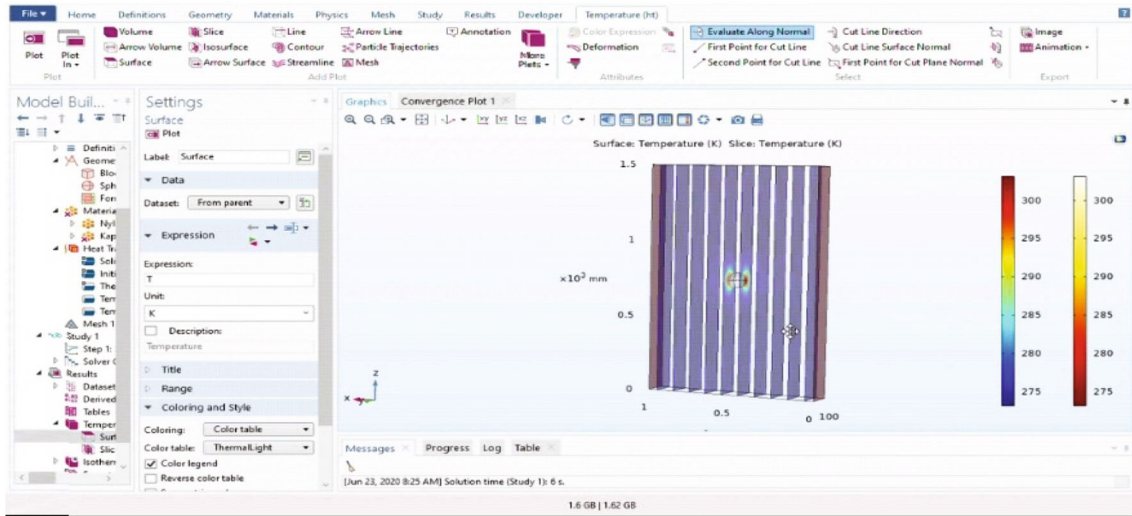


FIGURE 4: Heat transfer from Kapton to nylon.

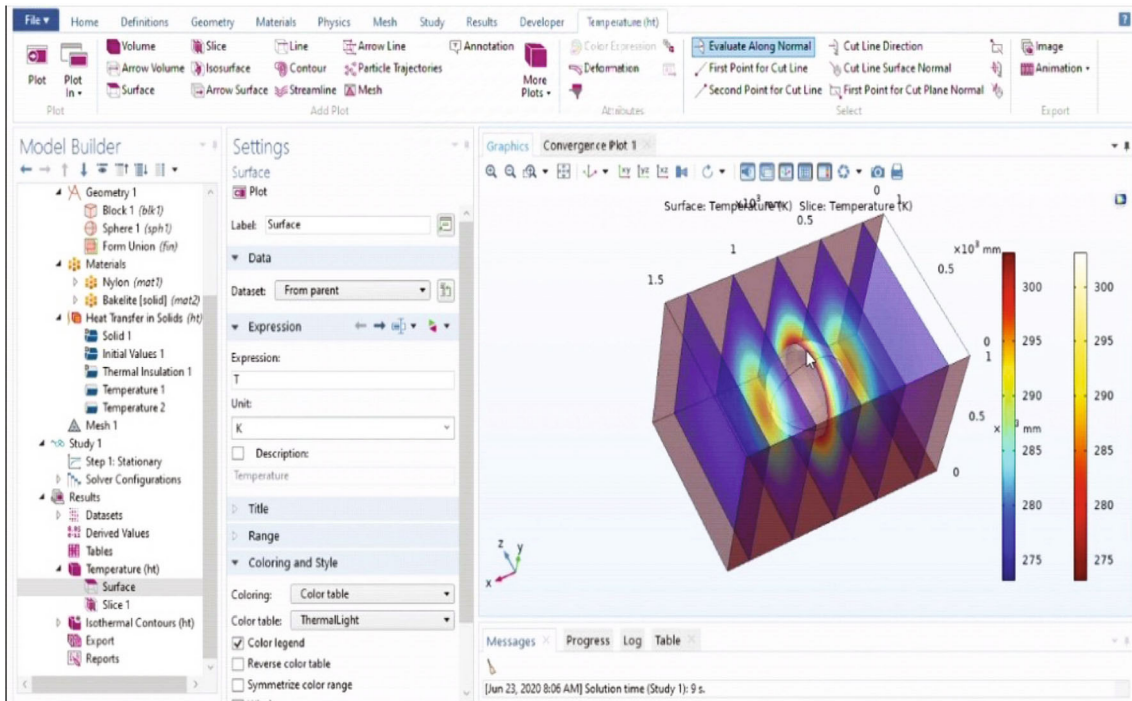


FIGURE 5: Heat transfer from Bakelite to nylon.

Three switch and three buttons provided in the control gadget to set the mode of the temperature. At the point when the switches on the machine will go into the essential circle in the event that any one button has squeezed, the sleeping cushion surface temperature is prepared to the relating temperature.

5.3. *Screen Output.* The Arduino board sends three different data to an LCD screen such as which mode the gadget is in auto and guide, affected person middle body temperature, and mattress floor temperature.

Framing the absolute scale base, form numerous bed segments to length of the OR sleeping cushion. Line all things considered the body areas, and afterward, sew the two arm parts to the edge stage. Eight thermocouples sewed into the zenith floor of the reflector, just beneath the thermoplastic fixed microfiber texture with fire safe string (conductive string or yarn) as shown in Figures 2 and 3.

These are a bigger number of than one segment at some stage in the total scale froth bed with the goal to be related in corresponding with the resistive wires. As it will essentially allow us to close of specific portion of the gadget, it will

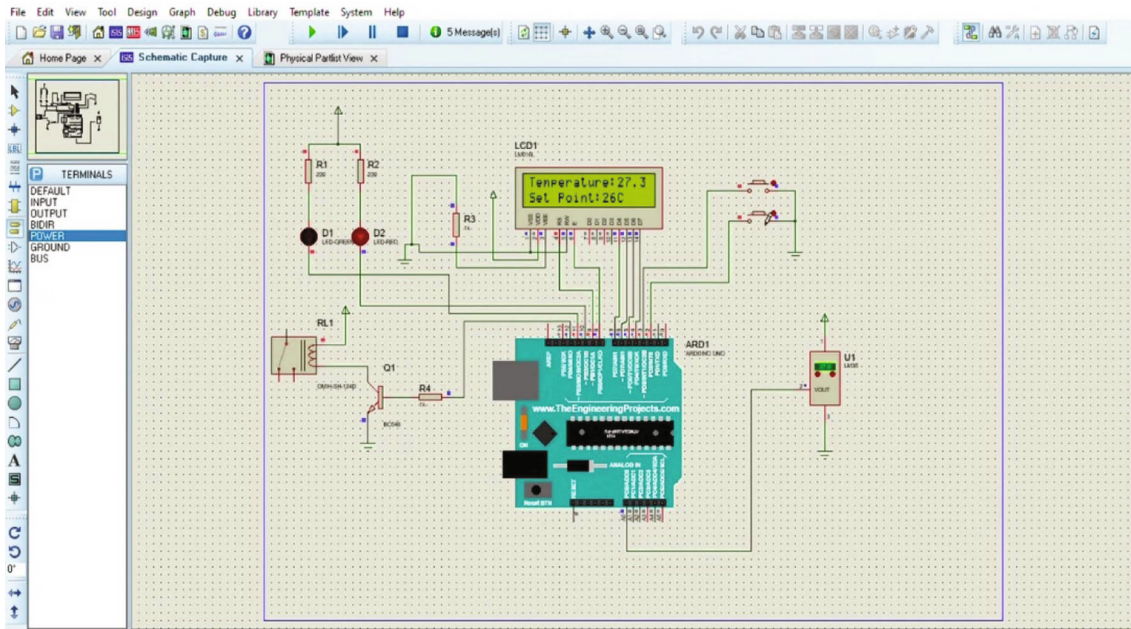


FIGURE 6: Heater is in offstate as the temperature exceeds the set point.

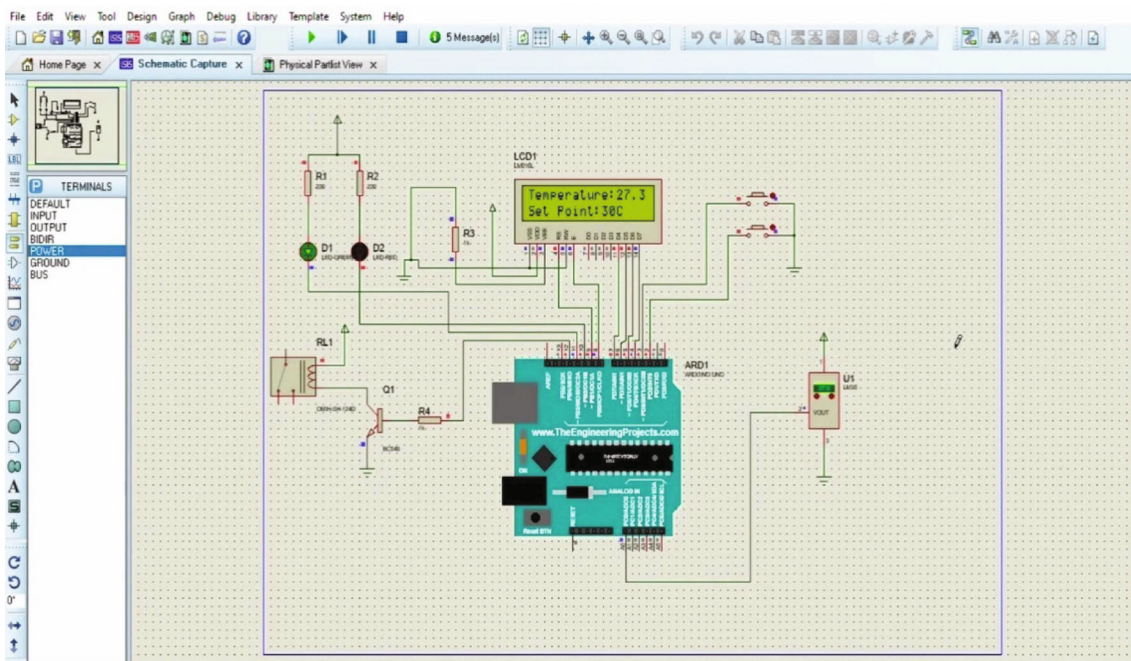


FIGURE 7: Heater is in onstate, as the temperature did not exceed the set point.

likewise verify that the total gadget does not quit working if one of the areas breaks, taking into consideration more straightforward upkeep.

## 6. Results and Discussion

To approve the capacity of gadget to warm the patient viably and to lead preclinical investigations with creature models, trailed by patients, under neuraxial sedation to reproduce

the surgery in working room condition, everyone must gauge the center inner warmth stage constantly, which could be predicted with our nonevident just as with a rectal thermometer to examine an intrusive system in opposition to our tympanic layer estimations. To create a plot of center internal warmth degree in the course of the hour of the methodology, ensuring that the middle inner heat degree stayed inside the 36°C–38°C normothermic variety, this test could likewise create information to determine the mistake



of tympanic layer thermometer in estimating center inner warmth stage.

The model is simulated using the COMSOL model to reproduce warmth flow of the stepped forward association of the experimental setup mattress, undersurface dozing cushion, and patient. The goal of the form is to peer how warm temperature may go through the sound-sleeping pad and warming the hospitalized person as is shown in the temperatures of the middle framework, floor of the sheet material, and warming thing. This arrangement would permit to parent the wattage needed from the warming thing to the impacted person's middle inner warmth stage in the normothermic assortment (near 37°C) inside the underlying 10 minutes of movement and show screen the machine's ability to keep up ordinary temperature. With the following assumptions, the simulated model was done:

- (i) All substances, other than the affected person, start at room temperature (22°C)
- (ii) The center inner heat stage of the affected person starts at 36°C, and fringe internal warmth degree starts off evolved at 34°C
- (iii) The affected person may be verified as an arrangement of concentric rectangular form, and the outside of that is obliged to the additives of anthropometric estimations via COMSOL and the inward of which fills 42% of the bigger square shape's quantity
- (iv) Convective warmth movement from the encircling air is 10 Watts/meter square with a less power of oscillating air over a floor, and the outside exhibits outside of the person who affected
- (v) The middle frame's cardiorespiratory warmth advent is 50-kilo calorie per hour, and coetaneous warm temperature misfortune is 80-kilo energy
- (vi) The thicknesses of the warming thing and diverter are 0.01 and 0.02, individually

The proposed model used to decide the power of the hotness source imperative to heat the center edge transposition into the state of being assortment. The variant moreover shows a glow guide of the temperature dispersions at some stage in the patient, sleeping pad, and working bed as shown in Figures 4 and 5.

The proposed framework checks the component temperature and texture surface that are associated with the thermocouples, and the silicone temperature is calculated at two spots.

The first is with a four hundred arrangement thermal resistor installed into the focal point of the piece and rest one at the top surface of the section. The variances in temperature over the long haul as the gadget work assess the item's viability in warming the silicone chunk from a frostbite state.

Hardware simulation for properties is like automatic shutoff done by using Proteus software. It uses Arduino Uno, LM35, and relay to design the hardware system. A set point is set which changed manually by using push but-

tons. If the temperature exceeds the set point, the heater shut down automatically and if the temperature does not exceed, then heater is on as shown in Figures 6 and 7.

## 7. Conclusion

With the comparison of two heating elements, the device is developed, and the results are obtained. The objectives in pushing ahead with this undertaking are enhancing materials, decreasing expense, and assembling the full-scale model. The proposed plan work will complete on consolidate, further developing the materials property, decreasing material expenses, and scaling the warming part to the overall scale model and then filtering the plan of the glowing tympanic layer instrument, fostering the affiliation instrument which ties down the sheet material to the working bed, moving the control circuit to a microchip, and orchestrating the dashboard lodging to be safe and secure. Never-ending store of this course of action changes and updates will make the full-scale model (standard size, heat-fixed napping cushion with affiliation part, tympanic film thermometer, control unit, and power supply).

## Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Conflicts of Interest

There is no conflict of interest.

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