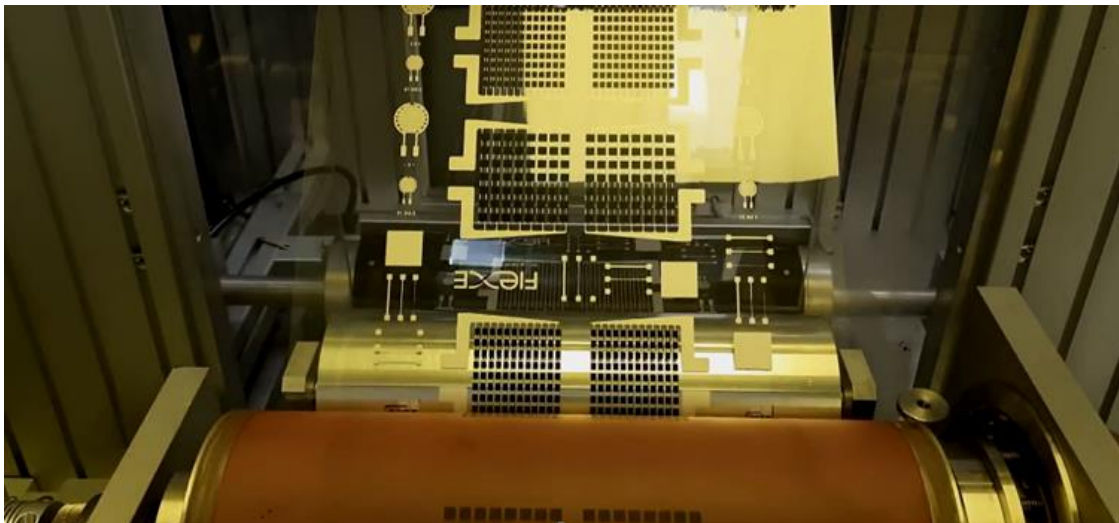


Call for Expression of Interest (EOI)

Self-Regulating Printed Heater Technology

Applications in Smart Wearable Solutions

The **National Centre for Flexible Electronics (NCFlexE)** at **IIT Kanpur** invites expressions of interest (EOI) for collaboration on the development and commercialization of innovative smart wearable technologies utilizing **Self-Regulating Printed Heater (PTC)**. These technologies offer advanced, customizable heating solutions for a variety of use cases, including **Warm Hug**, an engineered heated apparel system that can be retrofitted into jackets, heated belts for pain relief, and other wearables for cold outdoor applications.



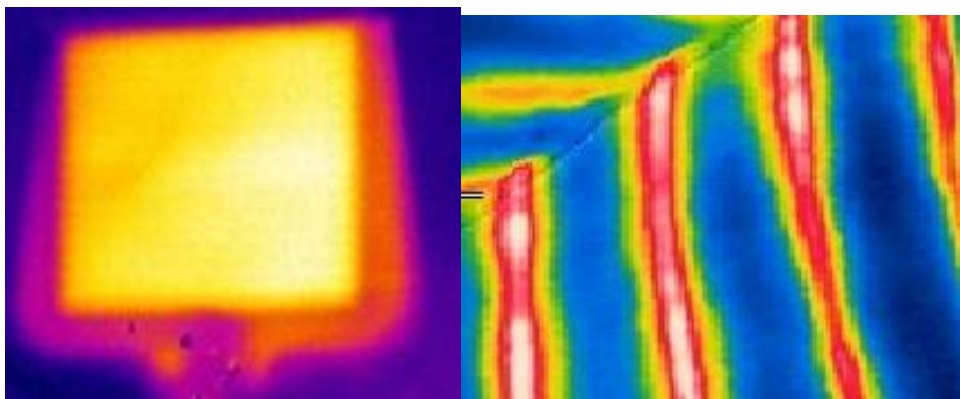
Here is a snapshot of a demo run showcasing R2R printing of PTC heaters. This demonstration highlights the efficient and precise printing process through the Roll-to-Roll line.

Novelty of the solution:

The self-regulated heating pads are fabricated employing PTC functional ink. The traditional heating methods for apparel involve sewing wires into the fabric, typically made of carbon fibre or a metal composite, nickel-chromium or carbon filaments. These methods often utilize NTC (Negative Temperature Coefficient) heating elements, the inclusion of additional temperature

sensors becomes necessary to ensure proper monitoring and prevent any potential risks. However, this approach lacks self-regulation, and a single temperature sensor cannot effectively monitor the entire heated surface. This limitation poses challenges and potential risks. The use of temperature sensors adds complexity and cost to the system, and in environments with extremely low temperatures, the risk of electronic failures and fire hazards increases. Therefore, careful consideration must be given to the design and implementation of temperature monitoring systems to maintain safety and reliability in such demanding conditions.

Moreover, traditional heating methods often result in non-uniform heating across the garment, leading to discomfort and inefficiency.

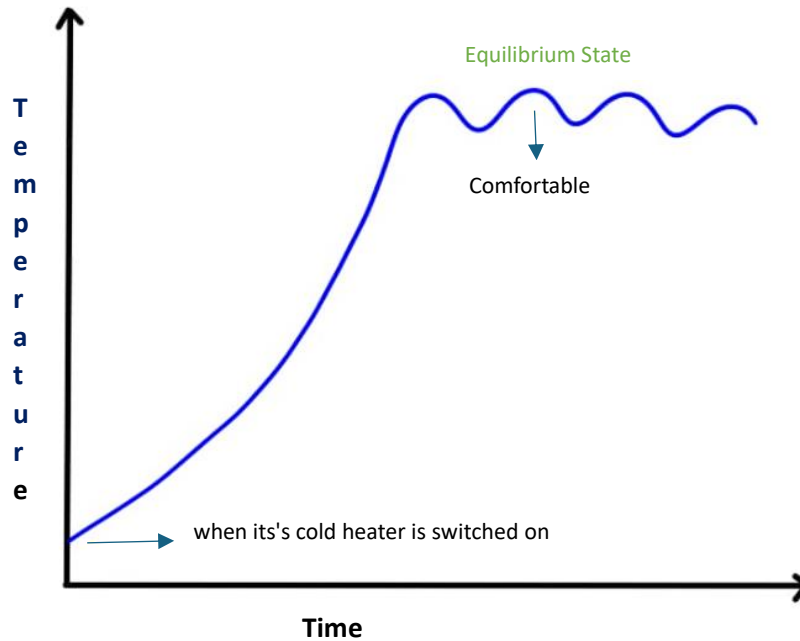


PTC heaters, printed at NCFlexE IITK, provide a more distributed heat compared to commercially available sewn wire heaters.

In contrast, printed PTC heaters offer significant advantages. These heaters are self-regulating, meaning they automatically adjust their resistance as the temperature changes. This inherent self-regulation mechanism ensures a safe and controlled heating experience without the need for external monitoring or temperature sensors. Additionally, printed PTC heaters provide uniform heating across the entire surface, delivering consistent warmth and comfort. Their efficient design and positive temperature coefficient of resistance (PTC) effect allow for a longer battery life and reduced power consumption, making them highly suitable for heating apparel applications.

By utilizing printed PTC heaters, the risks associated with traditional heating methods can be mitigated. The self-regulating nature of printed PTC heaters enhances safety, eliminates the need for temperature sensors, and minimizes the chances of electronic failures or fire hazards. Moreover, the uniform heating distribution offered by printed PTC heaters ensures optimal warmth and comfort for the wearer. Overall, the adoption of printed PTC heaters represents a significant advancement in heating technology for apparel, providing a reliable, efficient, and safer solution compared to traditional heating methods.

Currently, there are limited options available for keeping the body warm safely, and most of them are bulky and not convenient to carry, using traditional heating method.



At certain temperature, its heating power decreases to point where it simply balances the energy loss of the system, showing a self-regulating behavior.

Advantages Over Traditional Heating Solution

Design Freedom	Easily customizable, printed/tailored to any shape and sizes while maintaining the conformability.
Energy Saving	Printed PTC heaters rapidly reduce their power consumption when they reach their target temperature, thus reducing energy consumption and costs.

Cool Start	It heats up rapidly when it is cold, which provides an instant heat for warming up at extreme cold environment. They self-regulate to a specific threshold temperature.
Safety	No risk of hot spots and fire. For example: if a certain area was covered, heat diffusion would be limited; the film under this covered area would automatically reduce its heating power. No potential risk when sensor or temperature control unit fails. (Normal heaters could be a burn or fire hazard if it did not incorporate closed-loop control.)
Healthy and Comfortable	It releases heating mainly in infra-red radiation in a in a very homogeneous manner, without hot spots causing discomfort and hazards, friendly to the human body. It is an area heating source, so it radiates heat uniformly throughout the space around the human body comfortably.

Product Overview and Commercial Readiness

1. Warm Hug – A Smart Engineered Heating Apparel

The **Warm Hug** system seamlessly integrates into any jacket, transforming it into a smart, battery-operated heating system. Powered by printed PTC ink technology, it offers multiple heating modes and can operate for extended periods using a power bank. This versatile solution can be retrofitted into existing jackets, providing flexibility and ease of use.



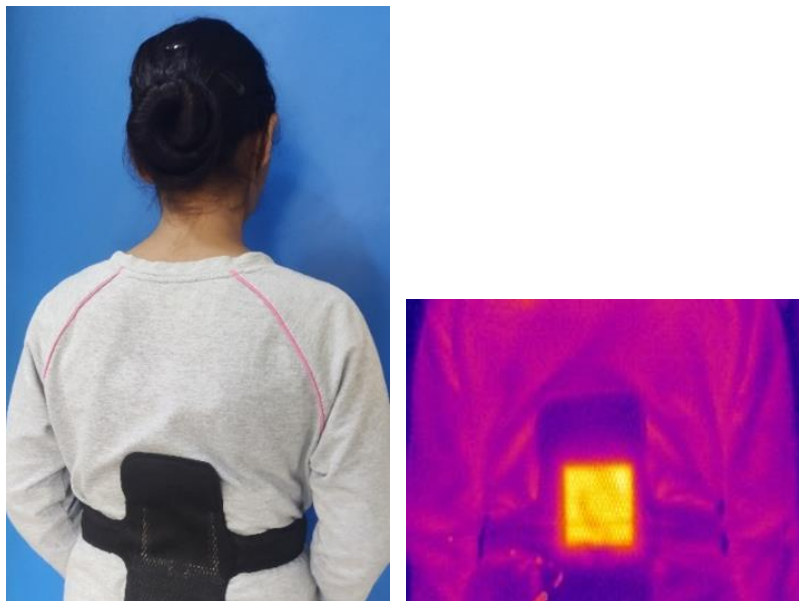
Warm Hug: Retrofitted with a Jacket

Key Features:

- **Multizone Heating:** Heating zones can be customized to target different parts of the body.
 - **Power Bank Operated:** Compatible with a range of power banks, ensuring long-lasting performance.
 - **Safe and Reliable:** Self-regulating printed PTC ink prevents overheating and eliminates hot spots.
 - **User-Friendly Controls:** Simple silicone push-button controls allow for easy adjustment of heating modes.
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2. Customized Printed Heating Wearable for Pain Relief

This wearable device is designed to provide targeted infrared heating for pain relief in specific areas such as the lower back, neck, and shoulders. Utilizing printed PTC ink technology, it ensures safe, uniform heating with no hot spots. Existing wearable vibration therapy wraps can also be integrated with this flexible printed heater solution to provide additional heat therapy.



Key Features:

- **Customizable Shape and Sizes:** Personalized heating configurations for various needs, including lower back and abdominal pain relief, period cramps, waist and knee wraps for arthritis, and joint pain relief.

- **Self-Regulating PTC Ink:** Ensures safe and reliable temperature regulation without the risk of overheating or hotspots.
 - **Portable Power:** Powered by a rechargeable power bank, offering convenient and long-lasting use.
 - **Temperature Control:** Easy-to-use buttons for setting and adjusting the heating level according to user preference.
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3. SWEAT – Smart Warming Electronic Apparel Technology

Developed at **NCFlexE, IIT Kanpur, Smart Warming Electronic Apparel Technology (SWEAT)** offers customizable warmth for users in extreme cold environments. Ideal for military personnel, outdoor enthusiasts, and emergency responders, **SWEAT** ensures comfort, safety, and superior performance in demanding conditions.



Key Features:

- **Printed PTC Heater Integration:** Self-regulating printed heaters, available in various shapes and sizes, provide even heat distribution, removing the need for multi-temperature sensor integration.
- **Power Delivery Compatibility:** Operates with high-wattage power banks, enabling extended operation and supporting multiple heating zones.

- **Multi-Zone Heating Control:** Independent control of heating zones for personalized comfort. Unlike conventional heated jackets, the number of heating zones is not restricted.
 - **Smart Features:** Smartphone-enabled advanced monitoring, safety control, and AI-driven adjustments. An emergency SOS function can be integrated.
 - **Battery Management:** Innovative battery management technology for cold environments can be implemented, if required, to ensure optimal battery performance in extreme cold conditions.
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Partnership Opportunity:

We invite companies, startups, and research institutions to collaborate with **NCFlexE** on the development and scaling of **Printed PTC Heater Technology**. Our center is actively seeking partners to enhance the manufacturability and commercial viability of these cutting-edge solutions. Early partners may receive preferential terms.

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