Embroidery-Enabled Smart Textiles for Energy-Efficient Automotive Interiors

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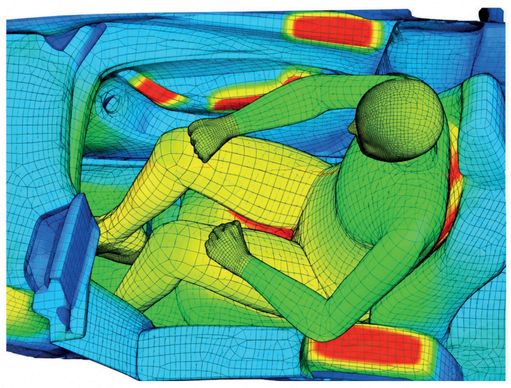


Thermal management has become a key challenge in automotive interior design, driven by the increasing demand for passenger comfort, energy efficiency and sustainable mobility. In electric vehicles, conventional cabin heating systems significantly increase energy consumption, reducing driving range.

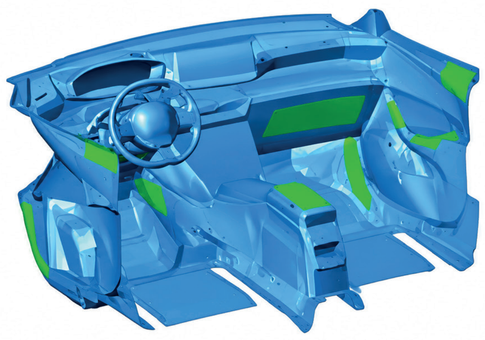
Up to 15% energy savings in cabin comfort with the optimized radiant panel setup – in comparison with reference setup (21 °C).

// MAIN GOAL

The main objective of this work is to develop and validate **embroidery-enabled smart textile heating systems** for automotive interior applications, based on the **thermal bubble concept**, to provide localized **thermal comfort** while reducing **energy consumption** and improving the energy efficiency of electric vehicles.



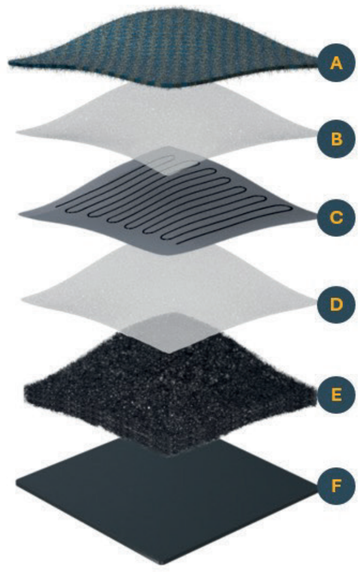
Passengers configuration



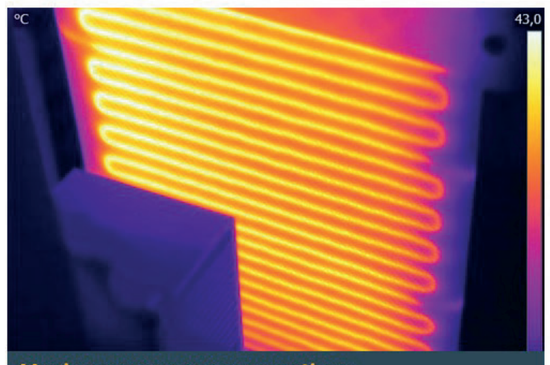
Heated areas in vehicle cabin



1 **Schematic representation of multilayer heating system.**



2 **Thermal image and electrical data of heating system.**



Maximum power consumption:
1.6 A @ 12 Vdc → 20 W
Sample dimension: 150 mm x 200 mm
Power density:
600 W/m^2

NOTE: Heating System dimensioned for 45 ºC in the surface of the stack with a selected multilayer.

A **Decorative layer** B **Adhesive layer** C **Heating layer** D **Adhesive layer** E **Foam insulate layer** F **Plastic component**

// RESULTS

- Sustainability potential through recycled materials and mono-material design.
- Performance validated in a climatic chamber under representative conditions.
- Localized, uniform heating tailored to complex automotive interiors, enhancing thermal comfort and reducing energy consumption.
- Successful integration of conductive yarns into flexible, multilayer textiles using embroidery technology, preserving aesthetics and comfort.