

Heated Seat Simulation Study for Thermal Seat Comfort Improvement

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ABSTRACT

Optimizing climate seat systems requires increased complexity in seat design which in turn is driving a need for more detailed thermal simulation methods. This paper presents the model development considerations and results of a thermal simulation study aimed at improving the thermal seat comfort experience of Hyundai-Kia's heated seating systems.

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INTRODUCTION

The automotive HVAC system is the primary system responsible for controlling and maintaining thermal comfort of vehicle occupants. Heat transfer with vehicle seats, however, plays a significant role in the thermal experience due to its proximity and large contact area with the seated occupant [1,2,3] This contact not only exposes the occupant to the current thermal conditions of the seat but also tends to isolate affected body regions from the climate controlled air provided by the HVAC System. [3]

To increase customer satisfaction and improve thermal comfort, climate control components are often added to seats such as heating elements or ventilation ducts to complement the HVAC system, in effect, turning the seat into a secondary thermal control system. This design approach has the potential benefit of improving the fuel efficiency of the vehicle by better directing thermal energy to/from the occupants and reducing the energy requirements of the HVAC [3]

Optimizing climate seat systems to fully benefit from this secondary thermal system requires increased complexity in seat design which in turn is driving a need for more detailed thermal simulation methods. This paper presents the model development considerations and results of a thermal simulation aimed at improving the thermal seat comfort experience and energy usage of heated seat systems. Specific Goals of the simulation were:

- To identify opportunities for improvement in thermal exchange and sensation between the body and seat
- To compare thermal trends between different design conditions.

BACKGROUND

The thermal comfort problem at its core is a function of heat exchange between the environment and the human body. This exchange primarily occurs through convection with the ambient air, conduction with contact surfaces, evaporation of sweat from the body, and radiant heat loss to or gain from nearby materials.

When considered in these terms the seat is just a part of the environment. The difference between seated contact area versus other parts of the thermal environment is vehicle seats tend to have larger contact surface areas with the human body. These contact surfaces increase localized conduction and reduce convection producing localized microclimates. See [Figure 1](#).

These microclimates and the ambient environment are experienced by the occupant through neurons that sense the thermal changes in the surrounding tissues. The body uses this information to regulate heat exchange by constricting or increasing blood flow to extremities, shivering to produce heat in tissues, and producing sweat to increase cooling through evaporation.

The most important aspect of thermal sensation is it varies across the body and localized thermal regulation changes as the body adapts to the environment. Consequently, the perception of microclimates produced from sitting will be perceived differently across the body and change as the body adapts.

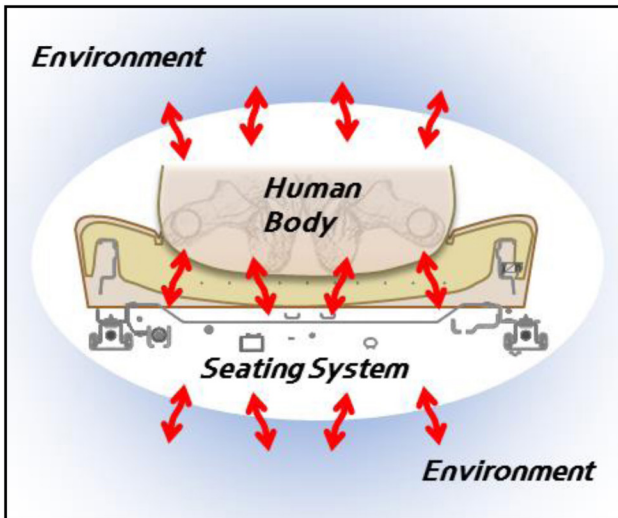


Figure 1. Example Seated thermal exchange.

METHOD

Simulations of this highly complex system were used to identify opportunities to improve the thermal comfort of the occupant and optimize energy expenditure. The simulation was based on ThermoAnalytics' RadTherm Model, RadTherm's Human Thermal Model and UC Berkeley's Thermal Comfort model.

RadTherm is a general purpose thermal analysis tool that was used to model conduction, convection, and radiation between the seat, occupant, and environment. RadTherm's human thermal module was used to predict physiological effects including metabolic heat, thermoregulation, etc. The Berkeley thermal comfort model was used to predict local and overall perceived thermal sensation and comfort.

The Berkeley model distinguishes 16 local body regions in static, transient, and localized heating/ cooling scenarios. The output relates to subjective ratings of 2 concepts: Thermal Sensation and Thermal Comfort for the local body parts as well as the overall body. (See Figure 2) In this model, sensation is related to "How hot or cold a body part is perceived to feel" and comfort is related to "Whether the sensation makes the person feel good or bad." [4]

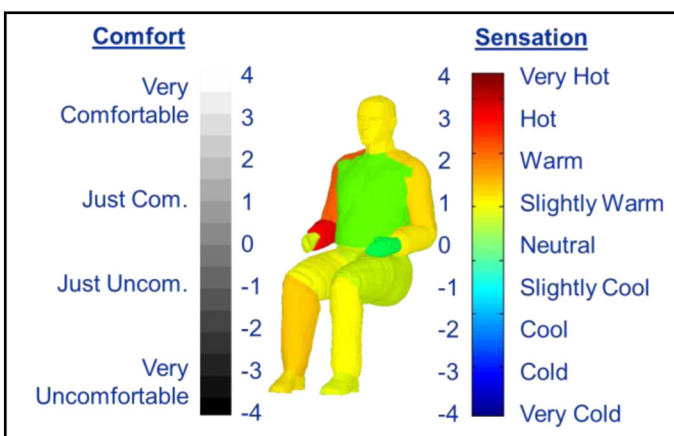


Figure 2. Berkeley Thermal Model.

The challenge was how to setup and apply these models used for general simulation of thermal transfer and full body thermal comfort to be more directed at seated thermal comfort.

Seat - Compressed Shape

The seat selected for this simulation was the Hyundai Sonata. For this simulation, only the Seat A-Surface (top seating surface), the foam pad, and portions of the frame were required for the model. The seat frame is not included in the simulation and is only used to define a backstop for seat deformation. Small fasteners, cables, and other parts not relevant to thermal analysis were removed in CAD. The final data seat was meshed and exported into ANSA.

The next step was to modify the 3D geometry to represent the shape of the components under a loaded, compressed condition. For the purposes of this simulation it was determined that the Sonata design penetration from the SAE H-point manikin would be acceptable as a repeatable, meaningful metric for comparison. Although the H-point design device does not represent any individual occupant, it has the benefit of providing a repeatable contact shape and posture that is meaningful to the targeted deflected performance.

This was accomplished by importing the H-point Surface geometry located at design coordinates into ANSA. The de-penetration tool in ANSA was then used to deform the seat cover to match the H-point surface geometry. (See Figure 3 and 4) ANSA direct morphing was then used to de-penetrate the foam pads to fit deformed seat cover.

The next step was to add the heating element between the Trim cover and foam pad. The element path was traced and projected onto a surface in ANSA. Direct morphing was then used to fit the element to the seat cover. The final element path is completed using the diameter of the wire.

This compressed shape is critical to the simulation because it determines the contact points for heat conduction with the body and it also identifies changes in component density from an uncompressed state to the actual loaded condition.

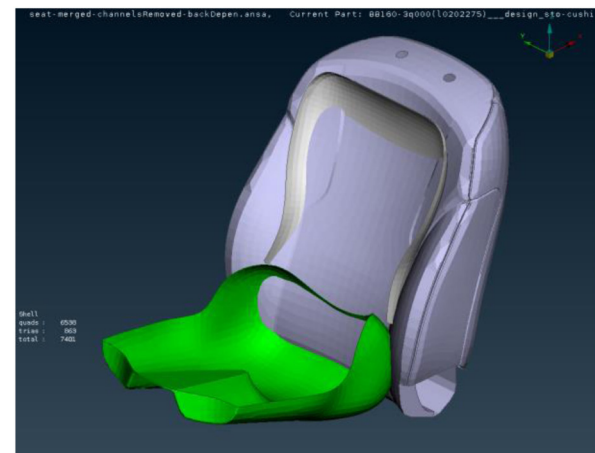


Figure 3. Seat back and H-point shell merge.