Proceedings of the Canadian Society for Mechanical Engineering International Congress 2020
CSME Congress 2020
June 21-24, 2020, Charlottetown, PEI, Canada

Development of a Novel Radiant Floor System: Energy Simulation and Comparison with Traditional Radiant Systems

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Abstract

Radiant floor systems have the potential to reduce energy consumption and the carbon footprint of buildings. They exhibit quiet operation, minimal airborne dust production, and furniture space savings. Traditional radiant floor heating systems consist of a heat source—hot water pipes or electrical heating wires, embedded in concrete and other building materials. However, traditional radiant floor heating systems are more expensive than conventional forced-air systems, and there is still potential for improved heat transfer efficiency with novel design improvements. Also, they cannot be easily retrofitted and the tendency of concrete to hold heat makes them less responsive to fluctuations in thermal loads. This study analyzed a novel radiant panel configuration comprising a metal plate with small spikes that can be pressed into cement board or wood. The spikes can serve two purposes; they can bind materials together reducing manufacturing costs and improve heat transfer. The proposed radiant panel is easy to retrofit as it is relatively thin (approximately two inches) and the top layer utilizes hardwood. This top layer is structurally sufficient to take the impact from building occupants. The bottom most layer of the proposed radiant configuration is subfloor plywood which acts as insulation for minimizing the heat transmitted into the ground.

A simulation model for annual energy use, using TRNSYS software, compared the radiant panel configuration with a traditional concrete-based system. Simulations were run under heating dominant, cooling dominant, and neutral conditions; significant cost savings and greenhouse gas emission reduction were seen across all scenarios. There are two main reasons behind the observation of energy savings with the use of the novel radiant panel configuration. The metal spikes are engineered with a shape and material that is particularly effective at directing heat upward, towards the conditioned space. As a result, a smaller portion of the heat is conducted downward, and a smaller portion of the heat gets absorbed by the other materials. Also, since the panel is using high thermal conductivity material with spikes, it responds quickly to fluctuations in thermal demands. The magnitude of these savings are expected to change with varying utility rates, methods of upstream power generation as well as government incentives for reduced energy consumption and Greenhouse Gas (GHG) emission reduction.