Mechanical Engineering Thesis Defense

A Study of Energy Savings Potential of Reflective Roof Coatings in U.S. Climate Zones

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Abstract

This study investigates the energy saving potential of high albedo roof coatings which are designed to reflect a large proportion of solar radiation compared to traditional roofing materials. Using EnergyPlus simulations, the efficacy of silicone, acrylic, and aluminum roof coatings is assessed across two prototype commercial buildings—a standalone retail (2,294 sqm or 24,692 sqft) and a strip-mall (2,090 sqm or 22,500 sqft)—located in four cities: Phoenix, Houston, Los Angeles, and Miami. The performance of reflective coatings was compared with respect to a black roof having a solar reflectance of 5% and a thermal emittance of 90%. A sensitivity analysis was done to assess the impact of solar reflectance and thermal emittance on the ability of roof coatings to reduce surface temperatures, a key factor behind energy savings. This factor plays a crucial role in all three heat transfer mechanisms: conduction, convection, and radiation. The rooftop surface temperature exhibits considerable variation depending on the solar reflectance and thermal emittance attributes of the roof. A contour plot between these properties reveals that high values of both result in reduced cooling needs and a heating penalty which is insignificant when compared with cooling savings for cooling-dominant climates like Phoenix where the cooling demand significantly outweighs the heating demand, yielding significant energy savings. Furthermore, the study also investigates the effects of reflective coatings on buildings that have photovoltaic solar panels installed on them. This includes exploring their impact on building HVAC loads, as well as the performance improvement due to the reduced temperatures beneath them.

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