Paper 250

CFD-Based Analysis of the Impact of Roof Structures on Solar Collector Efficiency

With the rapid development of renewable energy technologies, solar energy has been increasingly applied in building heating and hot water supply systems. The efficiency of solar collectors is influenced not only by the collector's intrinsic performance but also significantly by the building's roof structure and configuration. Different roof shapes, slopes, materials, and ventilation conditions can alter the heat transfer and airflow distribution on the collector surface, affecting the absorption and utilization of solar energy. Therefore, it is essential to analyze the relationship between roof structures and solar collector efficiency during the building design stage to optimize solar energy utilization.

Computational Fluid Dynamics (CFD) is an effective numerical simulation tool for analyzing airflow, heat transfer, and temperature distribution on collector surfaces. By modeling various roof structures and simulating the thermal and flow fields under changing solar irradiation and wind conditions, CFD can reveal the mechanisms by which roof structures influence solar collector efficiency. CFD simulations can identify local heat flow non-uniformity, evaluate collector performance under natural or forced convection, and provide scientific guidance for energy-efficient building design.

In practical applications, factors such as roof geometry, tilt angle, thermal conductivity of roofing materials, and collector placement must be considered comprehensively. By comparing temperature distribution and thermal efficiency indicators under different designs, optimal roof structures and layouts can be determined to maximize solar energy utilization. This approach provides reliable data to support architects and energy engineers in designing low-energy and renewable energy buildings.

This study aims to use CFD simulations to analyze the impact of different roof structures on solar collector efficiency. The research includes roof geometry modeling, airflow and heat transfer simulation, collector efficiency calculation, and comparative analysis of various design schemes. The results are expected to provide theoretical guidance and practical reference for optimizing building solar energy systems, enhancing energy utilization efficiency, and promoting the widespread application of renewable energy in buildings.