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Chapter 16
Optimization of Tilt Angles for Solar Devices to Gain Maximum Solar Energy in Indian Climate

Digvijay Singh, A. K. Singh, S. P. Singh, and Surendra Poonia

Abstract Availability of maximum solar radiation can be ensured by optimizing the tilt angles for a given location. Most of the optimization techniques are based on the available theoretical models. Keeping this in view, tilt angles were optimized for composite climate (Nagpur and Delhi) and hot and dry climate (Jodhpur), India, using actual solar radiation data of India Meteorological Department (IMD). The optimization of tilt angle is done by establishing a polynomial relation between tilt angle and solar radiation data for annual, bi-annual, seasonal, bi-monthly, and monthly tilts. The optimum tilt angles for New Delhi and Nagpur were found as $\Phi - 5°$ and $\Phi + 4°$, respectively, while for Jodhpur it was $\Phi + 4°$ for south facing. The highest solar radiation was predicted for monthly tilt. However, total solar radiation for bi-annual tilt was also found very close to that of monthly optimum. According to the analysis carried out, it is recommended to have bi-annual tilt (zero tilt from April to September and 42°–49° degree tilt from October to March).

Keywords Latitude (Φ) · Solar radiation · South facing · Optimum tilt angles · Composite · Hot and dry climate

16.1 Introduction

The energy demand is going up with the time in agriculture, domestic, rural, and industrial sectors. It is also well known that increased use of conventional energy sources is leading to the release of a high amount of pollutants. In such a situation, solar energy can be used as an optional energy source. India has abundant solar radiation due to being located near the equator. It is a prerequisite for researchers to estimate the exact values of solar radiation on the surface with different tilt angles and also the Optimum Tilt Angle (OPTA) for a particular location. During summer,

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Chapter 24
Effect of the Cool Roof on the Indoor Temperature in a Non-conditioned Building of Hot–Dry Climate

Mohan Rawat, R. N. Singh, and S. P. Singh

Abstract The solar reflectance and absorbance of the roof surface are two significant factors affecting the thermal performance of non-conditioning buildings. Based on the qualitative analysis, the cool roof (color paint) effect analyzed in terms of indoor temperature. The maximum heat gain entered in the buildings during summer leads to higher energy consumption throughout the summer. Eight composite roof structures with cool paints layer and one without cool paint layer as the base case analyzed for the summer months of April–July. Fourier admittance method used to evaluate hourly floating temperature for roofs treated with cool paints. A simulation study carried out to obtain optimal roof structure for hot–dry climate, Jodhpur and roof structure (RS-6) with concrete, mortar, and cool coating paint combinations found most suitable in terms of minimum variation of indoor temperature. The simulation result indicates that all roof structures with cool roof performed better than roofs without cool roof.

Keywords Cool roof · Fourier admittance method · Heat gain · Thermal comfort · Hot–dry climate

24.1 Introduction

The primary consumer of energy is building sectors in recent times due to the rapid urbanization and population in the metropolitan cities. About 60%, energy consumed in the buildings for heating, cooling, and ventilation increased to 1.8% over the last forty years [1]. In buildings, thermal performance is influenced by the solar absorptance and reflectance of the roof, particularly for non-conditioned buildings. During clear sky conditions, about 20–95% of the radiation is typically absorbed by the building roofs [2]. In all the Asia Pacific Partnership (APP) countries, India ranking is highest for energy consumption in residential buildings. About 45% of the energy is consumed by residential buildings for providing indoor thermal comfort

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Chapter 28
Estimation of Energy Generation and Daylight Availability for Optimum Solar Cell Packing Factor of Building Integrated Semitransparent Photovoltaic Skylight

Digvijay Singh and S. P. Singh

Abstract The semitransparent PV (STPV) module apart from energy generation is also beneficial in providing daylight inside the building. In this paper, mathematical expressions were used for estimating the daylight illuminance (lx) and electricity generation (kWh) through the STPV skylight for the composite climate of New Delhi (28.7041° N, 77.1025° E) at various packing factor (β) (0.4 to 0.9) of the solar cells. Further seasonal optimum (β_{opt}) is predicted for appropriate daylight and electricity generation, which found in the range from 0.57 to 0.62. The appropriate illuminance of above 300 lx and maximum hourly generation of 40–65 W for 5–7 h are obtained for the β of 0.62.

Keywords Daylight illuminance (lx) · Energy generation (E_g) · Packing factor (β) · Skylight Roof Ratio (SRR)

28.1 Introduction

Semitransparent photovoltaic (STPV), one of the emerging technologies in the building sector, is used as a building envelope in an integrated or attached manner. It fulfills the energy requirement as well as daylight in the built environment, partially reducing the needs of artificial lighting and cooling loads of buildings [1]. STPV is glass-to-glass technology, having composites of opaque crystalline silicon cells and transparent glass, which allows the property of visual transmittance in the picture. Figure 28.1 presents a schematic of a STPV module [2]. The transparency of STPV can be increased by increasing the distance between the solar cells [3]. Skandalos et al. [4] investigated the effect of STPV modules (a-si and c-si) individually and also their combined integration as a window. It was observed that both technologies were able to reduce the glare and heat gain up to 30%. For maintaining visual comfort, combined integration of a-si and c-si were found suitable. Karthik et al. [5] observed that the STPV window at cell packing factor (β) of 0.69 and 0.77 was

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Chapter 70
Dehydration of Vegetables Through Waste Heat of Vapour Compression Refrigeration System

Ankur Nagori, Rubina Chaudhary, and S. P. Singh

Abstract Reduction in post-harvest losses of fresh vegetables is a major objective of most of the cold chain programs. Drying is also an effective tool for reducing post-harvest loss. However, the existing industrial drying techniques are energy intensive in operation results emission of high green-house gases. Low-grade waste heat recovered from condenser of refrigeration system could be utilized for drying applications. The process consists an effective utilization of heat, obtained by the condensing unit of a refrigeration system in an intermittent manner with no external energy requirement. An experimental approach of vapour-compression based-refrigeration system has been performed for drying of onion sample. The drying was performed at average temperature of 43 °C. Moisture content was reduced to 12% (wb) after 24 h of drying. Average values of drying rate and SMER were found as 0.013 kg/h and 0.196 kg/kWh, respectively, at the mass flow rate of 0.268 kg/s. The overall drying process is energy efficient. This could be a promising future replacement of current industrial drying systems which are relatively more energy intensive.

Keywords Vapour compression refrigeration system · Refrigeration waste heat · Drying of vegetable · Drying rate

Nomenclature

mm	Millimetre
m	Metre
kg	Kilogram
kW	Kilowatt
h	Hour
s	Second
wb	Wet basis

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Lecture Notes in Mechanical Engineering

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Impact of Roof Colour Paints on the Indoor Temperature in a Non-conditioned Building of Composite Climate

S. P. Singh and Mohan Rawat

1 Introduction

Climate change creates discomfort levels in buildings due to rapid urbanization. Green areas replaced by roads, roofs and facades in cities and all of these components absorb heat from the Sun and cause the warming of these spaces to produce urban heat island effect [1]. About 45% population of the world lived in urban areas, and 60% population will shift till 2025. The temperature of the metropolitan regions is always higher than the rural areas, so the requirement of thermal comfort is an essential concern in urban areas for human health quality [2]. In buildings, thermal performance is influenced by the solar absorptance and reflectance of the roof, particularly for non-conditioned buildings. High albedo paints are a passive building strategy to reduce the energy demand in building [3]. Different strategies have adopted for energy-saving measures for buildings worldwide. An increase in solar reflectance of the outer surface of roof layers is a cost-effective technique to resolve the problem of high cooling load in buildings [4].

The peak electricity demand increased by 1.5–2.0% for every 0.5 °C increase in temperature due to the urban heat island effect in urban areas. It reduced the coefficient of performance of air-conditioning systems. An urban surface with high albedo paints is a verifiable and measurable urban heat island (UHI) mitigation strategy to cool the cities [5]. In composite climate, summer characterized by substantial solar isolation therefore, the outdoor temperature is higher with low relative humidity (10–25%) in India. Major parts of India are located in a composite climate where heat gains through the roof create indoor discomfort. Mostly construction materials used in the buildings are reinforced concrete cement (RCC) followed by concrete, brick, tiles and mud. So the requirement of thermal comfort is an essential need due to

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Economic Feasibility of Refrigeration Waste Heat-Assisted Solar Hybrid Drying System

S. P. Singh and Ankur Nagori

Nomenclatures

VCRS	Vapor compression refrigeation System
RH	Relative humidity
DBT	Dry-bulb temperature
IMC	Initial moisture content
FMC	Final moisture content
ORC	Organic Rankine cycle
SMER	Specific moisture evaporation rate
COP	Coefficient of performance
NPV	Net present value
IRR	Internal rate of return
SR	Sizing ratio
IR	Investment ratio
TR	Tons of refrigeration
ERR	Energy efficiency ratio
PUF	Polyurethane foam
wb	wet basis
m^2	Square meter
m^3	Cubic meter
kg	kilo gram
KJ	Kilo Joule
MJ	Mega Joule
H	hour

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