

Key Tech Services Publication, India

<http://www.ktjme.com>

<https://doi.org/10.64188/3048956325027>

Vol.: 2, No. 4, 2025, Pages: 33-38

COOLING LOAD ESTIMATION OF A RESTAURANT DINING HALL USING HEAT BALANCE METHOD

Adil Majeed¹, Gopal Sushir², Shital Tanpure³, Gayatri Pesode⁴, Sagar Mushan⁵

¹⁻⁵ School of Mechanical Engineering, MIT Academy of Engineering, Alandi, Pune

Abstract

Accurate estimation of cooling load is a critical step in the design of air-conditioning systems, particularly for restaurants where occupancy density, ventilation requirements, and internal heat gains are high. This paper presents a calculation-based study for estimating the cooling load of a restaurant dining hall using the Heat Balance (Component Heat Gain) Method. All design parameters, such as occupant sensible and latent heat, ventilation rate, lighting load, solar heat gain through glazing, and overall heat-transfer coefficients, are taken strictly from standard tables provided in Refrigeration and Air-Conditioning by C. P. Arora. No numerical example-specific assumptions are used. The study considers heat gains due to building envelope transmission, solar radiation through windows, occupants, lighting, ventilation, and infiltration. The total room sensible heat, latent heat, and grand total cooling load are calculated and expressed in kilowatts and refrigeration tons. The results demonstrate the suitability of the heat balance method for manual cooling load estimation and provide a clear, standard-based framework for HVAC system sizing in restaurant applications.

1. Introduction

Cooling load calculation forms the foundation of air-conditioning system design. An undersized system leads to thermal discomfort, while oversizing results in higher initial and operating costs. Restaurants present a challenging environment for HVAC designers due to high occupant density, continuous door opening, significant ventilation requirements, and internal heat gains from occupants and lighting. Therefore, an accurate and standard-based cooling load estimation is essential. Various methods are available for cooling load estimation, including software-based simulation, CLTD/CLF method, and heat balance method. Among these, the heat balance or component heat gain method provides transparency and is well suited

Received: 12.11.2025

Revised: 21.11.2025

Accepted: 23.12.2025

Published Online: 10.01.2026

Keywords: Passenger-Passenger-adaptive HVAC, Bus air conditioning, Cooling load, HVAC design, Restaurant air-conditioning, Heat balance method,

*Corresponding author name and email: Sagar G. Mushan, sgmushan@mitaoe.ac.in

How to cite this article: Adil Majeed, Gopal Sushir, Shital Tanpure, Gayatri Pesode, Sagar G. Mushan, Cooling Load Estimation of a Restaurant Dining Hall Using Heat Balance Method, KT Journal of Mechanical Engineering, 2 (4) 2025, 33-38. <https://doi.org/10.64188/3048956325027>

for academic and design calculations. This paper applies the heat balance method, following the procedures and standard tables given by C. P. Arora, to estimate the cooling load of a restaurant dining hall.

2. Literature Review

Several studies have addressed cooling load estimation for commercial and public buildings using both manual and simulation-based approaches. Chairani et al. [2] presented a cooling load estimation methodology based on internal and external heat sources, including occupancy, lighting, and building envelope effects, highlighting the importance of systematic heat balance consideration in building cooling load analysis. A practical application of cooling load calculation for commercial buildings was reported in a study available in the Zenodo repository, which demonstrated standard procedures for estimating cooling load in a commercial complex and emphasized the relevance of conventional HVAC design methods [3]. Mao [4] analyzed and compared various peak cooling load calculation methods and discussed their influence on HVAC system sizing and design accuracy. The study concluded that the selection of an appropriate cooling load estimation method has a significant impact on the final cooling capacity. These works confirm that heat balance-based approaches remain reliable for preliminary and academic cooling load estimation, particularly when standard tabulated data are employed, as adopted in the present study.

3. Methodology

3.1 Method Used

The cooling load is calculated using the Heat Balance (Component Heat Gain) Method as described in Chapter 19 of Refrigeration and Air-Conditioning by C. P. Arora. In this method, the total cooling load is obtained by summing individual heat gains from various sources.

A. Design Data

- Room dimensions: 20 m × 15 m × 3.5 m
- Floor area: 300 m²
- Volume: 1050 m³
- Occupancy: 60 persons
- Windows: 4 windows (each 3.9 m²), 2 facing north and 2 facing south
- Door: 1 door (4.5 m²) on west wall

1) C. Standard Data Sources: All standard values are taken from C. P. Arora:

- Occupant sensible and latent heat: Table 19.1
- Overall heat-transfer coefficients (U-values): Chapter 18
- Solar heat gain factor (SHGF): Table 19.11

- Shading coefficient (SC): Table 19.12
- Ventilation rate: Section 16.4.1
- Lighting load factor: Section 19.2.2

B. Cooling Load Calculations

1) Transmission Heat Gain: Heat gain through walls, roof, floor, windows, and door is calculated using: $Q = U \times A \times T$. Standard U-values and equivalent temperature differences are applied as per the book tables. The total transmission heat gain is obtained by summing the contributions from all building elements.

2) Solar Heat Gain Through Windows: Solar heat gain through glazing is calculated using: $Q_{\text{solar}} = A \times \text{SHGF}_{\text{max}} \times \text{SC}$. Separate calculations are carried out for north and south-facing windows using maximum solar heat gain factors from Table 19.11 and shading coefficient from Table 19.12.

3) Internal Heat Gains:

- Occupants: Sensible and latent heat gains are calculated using standard per-person values for restaurants.
- Lighting: Sensible heat gain due to lighting is calculated using total lamp wattage multiplied by the lighting correction factor.

4) Ventilation and Infiltration Load: Ventilation air requirement is calculated based on occupancy. Sensible and latent heat gains due to outside air are determined using standard heat balance equations provided by C. P. Arora.

5) Total Cooling Load: The individual sensible and latent heat gains from transmission, solar radiation, occupants, lighting, ventilation, and infiltration are summed to obtain the room cooling load. Based on the calculations: • Total Room Sensible Heat (including safety and fan/duct allowance) = 55.34 kW • Total Room Latent Heat (including safety factor) = 3.81kW
The Grand Total Cooling Load (GTH) is therefore: $GTH = 55.34 + 3.81 = 59.15 \text{ kW}$. The required refrigeration capacity is obtained as: $\text{Cooling Capacity} = 59.15 / 3.5167 = 16.82 \text{ TR}$
The total room sensible heat (RSH) and room latent heat (RLH) are calculated. A safety factor is added, and the grand total cooling load (GTH) is obtained. The final cooling capacity is expressed in refrigeration tons (TR).

4. Results and Discussion

The final calculated cooling load for the restaurant dining hall is 59.15 kW (approximately 16.8 TR). Analysis of individual components shows that envelope heat gain through the roof and walls, along with ventilation sensible load, constitute the major portion of the total sensible heat gain. Occupant load is the dominant contributor to latent heat due to high occupancy density typical of restaurant spaces. Solar heat gain through south-facing windows adds a noticeable but smaller fraction to the total load. The results indicate that accurate consideration of ventilation and infiltration is essential for restaurant HVAC design. The calculated cooling capacity provides a reliable basis for selecting an appropriately sized air-conditioning system without oversizing, thereby improving energy efficiency and thermal comfort. The calculated results show that transmission heat gain through the roof and ventilation sensible load are major

contributors to the total cooling load. Solar heat gain through windows also contributes significantly, particularly for south-facing glazing. Internal heat gains from occupants dominate the latent load component. The heat balance method provides a clear understanding of the contribution of each component to the total cooling requirement.

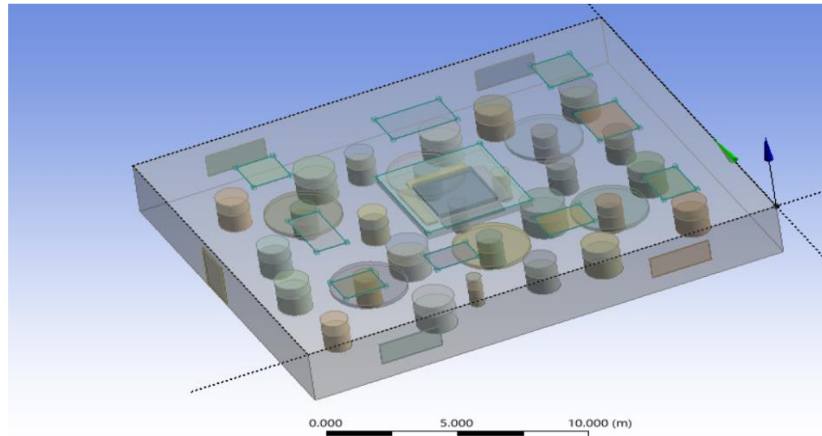


Fig. 1. CAD model

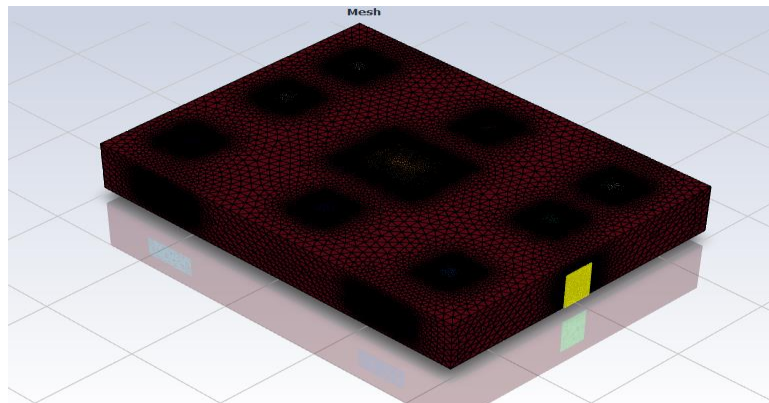


Fig. 2. Meshing

1. Conclusion

This paper presents a standard-based cooling load estimation of a restaurant dining hall using the heat balance method. All parameters are obtained from established tables in C. P. Arora's textbook, ensuring transparency and reproducibility. The calculated cooling load provides a reliable basis for HVAC system sizing. The study demonstrates that the heat balance method is well suited for calculation-based academic projects and preliminary HVAC design.

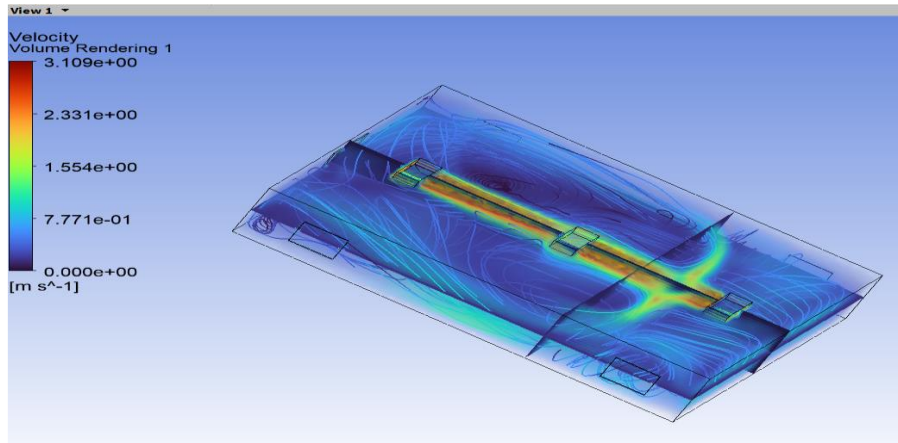


Fig. 3. Results

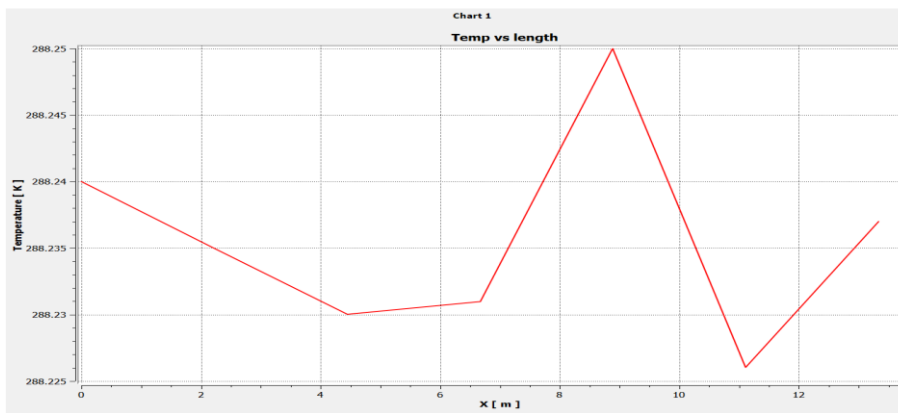


Fig. 4. Temperature Vs length

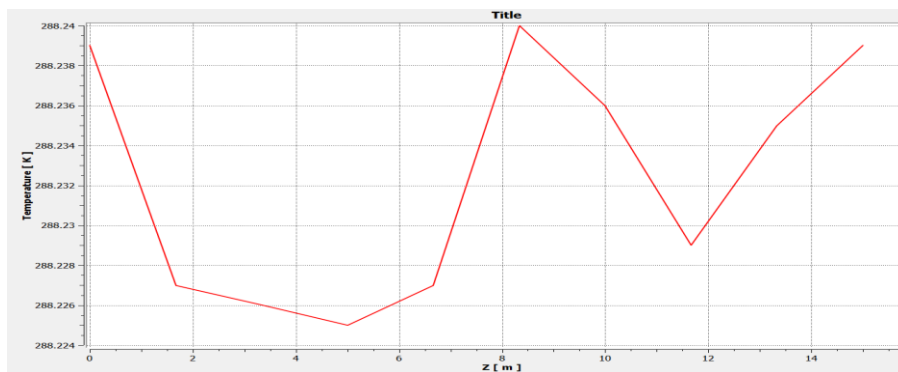


Fig. 5. Temperature Vs width

Acknowledgment

The authors acknowledge Department of Mechanical Engineering, MIT Academy of Engineering, Pune, for their technical support and laboratory access.

References

1. P. Arora, Refrigeration and Air-Conditioning, New Delhi, India: McGraw-Hill Education, 2011
2. S. Chairani, Sulisty, and Widyawan, "Cooling load estimation in the building based on heat sources," IOP Conference Series: Earth and Environmental Science, vol. 63, no. 1, Art. no. 012052, 2017, doi: 10.1088/1755-1315/63/1/012052. <https://iopscience.iop.org/article/10.1088/1755-1315/63/1/012052>
3. Estimation of cooling load calculations for a commercial complex, Zenodo, 2019. [Online]. Available: <https://zenodo.org/record/3586180>
4. C. Mao, "Analysis of building peak cooling load calculation methods," M.S. thesis, Dept. of Mech. Eng., Texas A&M Univ., College Station, TX, USA, 2016. <https://oaktrust.library.tamu.edu/handle/1969.1/158681>
5. Bhatkar V. W, Experimental study of multistage indirect evaporative coolers, Journal of Heat and Mass Transfer, Vol. 24, No.1, pp. 69–77, Dec. 2021. <http://dx.doi.org/10.17654/HM024010069>
6. Bhatkar V.W., Anirban Sur, A. Roy, Exergy analysis of a refrigeration system with a minichannel condenser using R134a refrigerant, Frontiers in Heat and Mass Transfer, 19 (15) (2022) 1- 7. DOI: 10.5098/hmt.19.15
7. Bhatkar V. W. Kriplani V. M., Awari G. K., International Journal of Environmental Science and Technology, 10 (4) (2013) 871-880. Doi 10.1007/s13762-013-0202-7
8. Bhatkar V.W., A. Sur, An experimental analysis of liquid air jet pump, Frontiers in Heat and Mass Transfer, 17 (12) (2021) 1- 7. DOI: 10.5098/hmt.19.15