INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Evaluation of Thermal Comfort Status and Design Intervention Inside the Kitchen of Indian Railway Pantry Car

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SHORT ABSTRACT

Thermal comfort refers to the thermal balance between the "human body" and the "environment" and also the appropriate balance between "body heat production and heat dissipation," which have a significant impact on the human body. Numerous research is available on thermal comfort under different environments like buildings, transports, manufacturing industries and allied work sectors in both developed and developing nations. Although fewer studies have also been conducted under different kitchen environment such as rural households, restaurants, and hotels; but research work associated with the kitchen environment of the railway pantry car is almost negligible. Pantry car represents a significant contribution to the catering system in Indian Railways, which provides meals to every onboard passenger. It is an integral part of every long and short distance train. This study presents a field survey and simulation investigation of thermal comfort conditions inside the kitchen of railway pantry car during different cooking periods. Present study aims to evaluate and improve the thermal comfort conditions inside the kitchen of the Indian Railway Pantry Car (IRCTC).

During the field survey, a standard checklist on subjective perception of thermal comfort was carried among 69 chefs working in 14 pantry car kitchens of Indian Railways. The data was collected during two seasons (summer and winter) and in two climatic zones (humid and subtropical climate zone and tropical wet and dry climate zone). Environmental parameters (air temperature, globe temperature, relative humidity, air velocity) of thermal comfort were also measured. Based on the survey outcomes and measured data, this study analyzed the chefs' neutral temperature and comfort temperature range inside the existing kitchen environment of pantry car; with the aid of indices like predicted mean vote (PMV) and predicted percentage dissatisfied (PPD). The results show that the measured indoor thermal parameters do not comply with the international standard. The maximum limit for thermal parameters was observed during lunch and snacks period, while minimum for the breakfast period. The outdoor thermal parameters affect the indoor thermal parameters during the seasonal and climatic variations when cooking inside the pantry car. Between all cooking periods like breakfast, lunch, snacks, and dinner; there was no significant

difference found for all parameters (air temperature, globe temperature, relative humidity, air velocity) in the summer season, however significant difference was observed among monitored parameters during the winter season except humidity and air velocity. The PMV-PPD index predicted a very high thermal dissatisfaction rate during cooking inside the pantry car. Simultaneously, the analysis also revealed that this index was not appropriate to evaluate the pantry car kitchen environment's thermal comfort due to high temperature, high metabolic rate, and less air movement. Subjective responses indicated that the chefs were dissatisfied with the current conditions of the pantry car as most of the cooks reported a high dissatisfaction rate. The chef neutral temperature of the pantry car was determined as 23°C and 21.62°C during the summer and winter season, respectively. Simultaneously, the comfort temperature range was determined for summer (18.50-27.80ºC) and winter (17.80-25.50ºC) season, respectively. These findings help to improve the indoor working environment of the pantry cars kitchen of Indian railways.

During the simulation investigation, a computational fluid dynamics (CFD) approach was incorporated using the standard effective temperature (SET) index to determine thermal comfort status. A baseline CFD model of the pantry car kitchen was validated by comparing it with the measured value of air temperature and air velocity, which found acceptable limits for validation according to the ASHRAE-55 standard.

While performing CFD analysis of non-air-conditioned pantry cars, four different modified case models were considered. The analysis results designate that the existing case model did not follow the recommended range of the SET index. Further, results indicated that *"Case I"* significantly improved the air velocity and reduced indoor temperature; which helps to enhance thermal comfort. Simultaneously, a value of SET was found with a comfortable thermal sensation within all cooking periods, which is better for the pantry car workers. This study suggested a sustainable improvement in the thermal comfort of the non-air-conditioned pantry car kitchen in the Indian Railways, which can be implemented immediately.

Similarly, while performing CFD analysis of air-conditioned pantry cars, three modified cases of pantry cars were executed. The analysis results indicate that the pantry car's existing case model did not follow the recommended range of the SET index. Comparing the existing case model with all the modified cases, it was observed that the indoor temperature dropped in the modified cases. Whereas in all modified pantry case models, the *"Case III"* model showed a better concept where the air velocity increased substantially as the temperature decreased. Simultaneously, the SET was found to have a comfortable thermal sensation between the temperature (26.5–28.6°C) ranges during the entire cooking period. However, in *Case I* and *Case II*, the SET limit's value was comfortable, except for the lunch period. It may be concluded that the supply air from the upper edges of the kitchen's front and back walls would increase thermal comfort and energy savings.