DYNAMIC COOLING LOAD ANALYSIS ON INDOOR THERMAL COMFORT STATE IN PASSENGER TRAINS

Thusantha Palangasinghe Kodituwakku

(158284G)

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DECLARATION

Declaration by the candidate

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Name of the candidate: T.P.Kodituwakku
Reg.No : 158284G

Declaration of the supervisors

The above candidate has carried out research for the Master of Engineering in Energy Technology and the Dissertation under my supervision.

Signature of the supervisor: …… Date: ……...

Dr. M. M. I. D. Manthilake,
Senior Lecturer,
Department of Mechanical Engineering,
University of Moratuwa

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ABSTRACT

Increasing passenger density makes indoor state of train compartments not thermally comfortable. Air conditioned train compartments have been introduced to provide comfortable pleasant interior environment to the passengers. However the trains consume in a high share of electricity for thermal comfort purposes thereby reducing their fuel economy and increasing emissions. Before adopting more air conditioned train compartments to the railway system, it is necessary to understand indoor thermal comfort state expected by passengers and the energy saving potential. This study discusses the acceptable indoor thermal comfort conditions and the variation in cooling load due to fluctuation of outdoor ambient conditions in moving train compartments. It was based on the Fangers thermal comfort model and a mathematical model was built to simulate this dynamic cooling load. Indoor thermal comfort parameters were examined by surveying of passengers travelled in air conditioned trains. The survey was conducted in trains run through the Colombo-Badulla main line and the northern line in Sri Lanka by interviewing 186 numbers of passengers using standard questionnaire. As independent variables, it was considered three main indoor thermal comfort parameters: temperature, relative humidity and air velocity. Analyzing the survey data using descriptive method, a comfort zone on psychometric chart was defined and accordingly indoor temperature and relative humidity of 26˚C & 55%RH were obtained as appropriate indoor thermal comfort parameters for railway passengers in Sri Lanka. On the other hand, energy saving potential was estimated through simulating dynamic cooling load values for the selected stations in both railway lines considered. Significant differences in dynamic cooling loads of train compartment were found between different stations and between different periods of time. The steady cooling load calculated according to the usual standard method was comparatively higher than the dynamic cooling load. Application of actual maximum dynamic cooling loads of a moving train compartment has been shown 10.9 kW & 5.9 kW of power reduction in train air condition system for mainline & northern line respectively. Thus the application of dynamic cooling load with reference to the time and space can lead to a significant energy saving in passenger trains.

Keywords: Air-conditioned trains**,** Passenger thermal comfort**,** Dynamic cooling load**,** Energy saving

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STRUCTURE OF THE THESIS

The main body of the study reviews the analyzing of the indoor thermal comfort parameters and variation of dynamic cooling load in moving passenger train compartments. Mainly most effective indoor thermal comfort parameters in passenger trains were investigated and factors influencing the variation of dynamic cooling load in moving train compartments were discussed in deep. This thesis began with an abstract which briefs the total story of the research study. The chapter one is the introduction of the thesis. It reviews the background of the research area of focus, overview and current status of the situation, motives for the study, research problem, aim & objectives, research significance. This chapter describes the conceptual framework of the research and the structure of the model. Chapter two consists with theoretical foundations & empirical results abstract from existing literatures which were mainly based on journal research papers. It presents the research approach and methodology used. All the referred literatures were relevant to the subject area of research focus. The literature review illustrated the expecting research gap which was to be filled.

Chapter three, it also discusses methods of data collection, questionnaire used for the survey of railway passengers, formulation of mathematical model, preparation of collected data for calculation and estimations, and analytical methods to be used. Collection of all the primary and secondary data prepared and presented in this chapter. Chapter four which reviews data analysis & the results is the most important part of this thesis. Thermal comfort zone was defined according to the estimated neutral temperature value and it was extended & validated by the questionnaire survey data. Then the indoor thermal comfort parameters were analyzed and acceptable indoor conditions were determined accordingly. Dynamic cooling load values of the selected stations were estimated using finalized indoor conditions and tabulated outdoor ambient conditions which varied with time and space. Data and calculated values have been examined in logically to obtain the required results. Static steady cooling load values were calculated by using usual standard method with reference to the existing standard data and the hourly

maximum outdoor ambient conditions obtained relevant to Colombo area. Data were analyzed using descriptive method and results were statistically analyzed to observe the effect of ambient conditions on train cooling load by application of linear multiple regression method using MS Excel software. Also the trends of conduction cooling load, when using standard steady and dynamic unsteady methods respectively were analyzed and highlighted in plotted graphs.

The chapter five discusses the results and comparatively analyzes the results obtained in previous chapter using tables and plotted graphs. It explains deeply the required thermal comfort conditions and the energy saving potential of air conditioned passenger train compartments. Finally, chapter six covers the summery of key findings, conclusions, recommendations and the policy implications. This chapter summarized the main results of the study. Important findings have been briefed as key findings and conclusions presented the outcomes which achieved the objectives. Several numbers of limitations met during the study mentioned in this chapter. Also three important future works related with the results of this study have been proposed and a summery included at the end of the chapter six. Under the References, all sources of literature used have been listed with descriptions written according to the IEEE standard. At the end of the thesis, the format of the questionnaire used in this study included as an appendix.