Study on Variable Refrigerant Volume Air-conditioning System

S. K .P. Vitharana

Master of Science

Building Services Engineering

2009 / 2010

University of Moratuwa

Sri Lanka

March 2013

Supervisor:

Prof. R.A. Attalage

Declaration

I hereby declare that this submission is my own work and that, to the best of my knowledge and behalf, it contains no material previously published or written by another person nor material which to substantial extent, has been accepted for the award of any other academic qualification of a university or other institute of higher learning except where acknowledgment is made in the text

S. K. P. Vitharana .....

Name of the Student Signature

Date : .....

Prof. R. A. Attalage .....

Name of the Supervisor Signature

Date : .....

Acknowledgement

This research project was carried out under the supervision of Prof. R. A. Attalage, Deputy Vice Chancellor, University of Moratuwa. His guidance, valuable comments and inputs for the project at different stages were of immense encouragement and support in completing the project at the level of a Master Degree. I sincerely believe that the experience and exposure I gained while working under the guidance of Prof. R. A. Attalage, in various associations and committees greatly helped me to complete this research project successfully. So, I am grateful for his dedication and fullest co-corporation extended to me in this endeavor.

The exposure I attained while working in the Demand Side Management Branch of the Ceylon Electricity Board was immense. Mr. Bandula S. Tilakasena, Deputy General Manager of the former Demand Side Management branch of the Board, who entrusted me with the task of facilitating the implementation of Energy Conservation Projects in the Commercial Sector in Sri Lanka, extended me with various opportunities to gain firsthand experience in the area of Energy Efficiency, Energy Conservation and specially on the Energy Efficiency of different types of Air-conditioner systems. He helped me a lot to develop my self-confidence and to play a leading role in the promotion of Energy Efficiency in the Commercial Sector in Sri Lanka. I am indebted to him for his kind help and for the trust he kept on me.

I am grateful to Mr. K.L.L. Fernando; former Addl. Director of Facilities Management Department of the Central Bank of Sri Lanka, Mr. Raj Fonseka; Asst. Maintenance Engineer of the same organization and Mr. Vidhura Ralapanawa of Mas Holdings for providing me with information and software support required for this research study and sharing their views and experience on the VRV Air-conditioners, Operation and Maintenance aspects and the Energy Efficiency of Air-conditioners available in the local market.

Further, I appreciate all of my friends and colleagues who encouraged and assisted me in different ways towards the completion of this thesis successfully.

Abbreviations

CBSL - Central Bank of Sri Lanka

CLF - Cooling Load Factor

COP - Coefficient of Performance

DEC - Direct Evaporative Cooling

DX - Direct Expansion

EER - Energy Efficiency Ratio

EEV - Electronic Expansion Value

FPFA - Fan-Coil Plus Fresh Air

IGH - Internal Heat Gain

LCC - Life Cycle Cost

OAC - Overall Average Annual Cost

VRF - Variable Refrigerant flow

VRV - Variable Refrigerant Volume

Abstract

During the last two decades, air-conditioning has become a basic requirement in industrial, commercial and residential sectors. With the widened use of air-conditioning in all the sectors, the human community has faced serious environmental and socio economic problems. Prevailing energy crisis and ever increasing energy pieces has made the situation worst. Under the scenario, various novel technologies have been emerged to the air-conditioner market. Variable Refrigerant Volume (VRV) air-conditioning technology is also considered as an advanced technology developed to cater the need of efficient use of energy for air-conditioning.

The major objective of the research study was to analyze the suitability of VRV air-conditioning system, analyze the actual saving potential and cost effectiveness of VRV air-conditioning system compared to the other available types of air-conditioning systems and access the maintainability of VRV air-conditioning system. The study was conducted at a selected representative installation namely at the Sovereign Residences of Central Bank of Sri Lanka. Summary of findings are as follows.

- VRV air-conditioners are suitable for medium scale hotel applications. However, this conclusion cannot be generalized for all the installations and the appropriate air-conditioning system for particular building should be selected only after performing a comprehensive analysis of energy performance of considered options on that particular installation (preferably after a computer simulation and life cycle cost analysis of different options). Therefore, though the demand for VRV air-conditioning system is prevailing due to the higher efficiency rating and the part load performance of the air-conditioning appliances, the desires of the purchases on energy saving potential of VRV air-conditioners could be satisfied only when it is selected for an appropriate application.
- Saving potential of VRV air conditioners could be high as 18 % compared to the energy consumed by split air-conditioning systems when used for appropriate applications. Therefore, the VRV system can be considered as a potential candidate for the installations where the building occupancy and cooling load are regularly varying. Further, Chiller (Central) air-conditioning system can also be considered as a potential candidate as it performs almost efficiently as the VRV system. It consumes around 4 % more energy than VRV system.

- Computer simulation (Equest) shown that VRV air-conditioning system is the most efficient option among the potentially applicable options considered for the building. However, the Life Cycle Cost (LCC) analysis shows that Chiller system is the most economical air-conditioning system for the same building. Therefore, it is vital to perform LCC analysis in addition to performance analysis when selecting the appropriate air-conditioning system for a building.
- Maintainability of the VRV air-conditioning systems is acceptable. It is necessary to select the correct density and thickness of the refrigerant pipe insulation to minimize the possibilities of formation of condensation along the refrigerant pipes. Also, the power quality should be maintained at an acceptable level to ensure the durability and proper functionality of electronics of the VRV air conditioning equipment.

Table of Contents

List of Tables

List of Figures