Faculty of Mechanical Engineering

OPTIMIZATION OF CENTRALISED AIR CONDITIONING SYSTEM PERFORMANCE FOR UNIVERSITY OFFICE BUILDING

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Doctor of Engineering

2023

OPTIMIZATION OF CENTRALISED AIR CONDITIONING SYSTEM PERFORMANCE FOR UNIVERSITY OFFICE BUILDING

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A thesis submitted
In fulfilment of the requirements for the degree of Doctor of Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this thesis entitle “Optimization Of Centralised Air Conditioning System Performance For University Office Building” is the results of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : Imanurezeki Mohamad

Date : 15 October 2022

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Doctor of Engineering.

Signature : 

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Date : 12 October 2023

DEDICATION

To my family.

ABSTRACT

The centralised air-conditioning (CAC) system is the most common cooling system for medium-to-large office buildings that accounts for a large amount of annual building energy consumption and leads to high electrical energy costs. Since CAC system performance is encountered with a significant level of uncertainty due to integrating cooling process parameters and several mechanical equipment, there is no systematic approach to evaluating the performance of a CAC system to result in an optimal configuration and system operation. Therefore, this study developed a systematic framework for optimising the performance of CAC systems based on various evaluation method, known as The Performance- Based Evaluation Indicator, or (PBEI) method. The method was used as a decision-support tools for CAC system's building, cost, risk and technical performance, which also known as the performance score indicator. The study's results indicated that by improving the configuration and operational parameters of the CAC system, total system efficiency can be enhanced by 20% and the equipment's operational life extended by five years. A humidity level of 65% to 75% and 20% electrical energy savings can be achieved by optimising the CAC system's control loops of cooling process parameters. The study's findings contributed to a better knowledge of the CAC system management and resulted in the development of a decision-making strategy for either equipment replacement or upgrade in order to achieve an optimised performance level.

PENGOPTIMUMAN PRESTASI SISTEM PENYAMAN UDARA BERPUSAT UNTUK BANGUNAN PEJABAT UNIVERSITI

ABSTRAK

Sistem Penyaman Udara Berpusat (CAC) adalah sistem penyejukan yang paling biasa digunakan untuk bangunan pejabat sederhana sehingga besar yang menyumbang kepada sebahagian besar dari penggunaan tenaga tahunan bangunan dan membawa kepada kos tenaga elektrik yang tinggi. Oleh kerana, prestasi sistem CAC dihadapi dengan tahap ketidakpastian yang ketara kerana melibatkan integrasi parameter-parameter proses penyejukan dan pelbagai peralatan mekanikal, tiada pendekatan sistematik untuk menilai prestasi sistem CAC untuk menghasilkan konfigurasi dan operasi sistem yang optimum. Oleh itu, kajian ini membangunkan rangka kerja sistematik untuk mengoptimumkan prestasi sistem CAC menggunakan kaedah Penunjuk Penilaian Berasaskan Prestasi, atau kaedah (PBEI). Kaedah ini digunakan sebagai instrumen pendukung keputusan untuk prestasi bangunan, kos, risiko, dan teknikal sistem CAC, yang juga dikenali sebagai Penunjuk Skor Prestasi. Keputusan kajian menunjukkan dengan meningkatkan tatarajah dan parameter-parameter operasi sistem CAC, keseluruhan kecekapan sistem dapat dipertingkatkan sebanyak 20% dan hayat operasi peralatan dipanjangkan dengan lima tahun. Paras kelembapan 65% ke 75% dan 20% penjimatan tenaga elektrik mampu dicapai dengan mengoptimumkan kawal kitaran proses penyejukan sistem CAC. Hasil kajian ini menyumbang kepada pengetahuan pengurusan sistem CAC yang lebih baik dan menghasilkan dalam pembangunan strategi membuat keputusan sama ada untuk penggantian atan menaik taraf peralatan dalam usaha untuk mencapai paras prestasi optimum.

ACKNOWLEDGEMENTS

My outmost gratitude goes to Allah, Almighty for His kindness in blessing me with strength and wisdom for this piece of work made possible according to his plan.

The financial assistance from Yayasan Biasiswa Tunku Abdul Rahman is grateful and acknowledged.

I would like to express my deepest appreciation to my advisor, Assoc. Prof. Dr. Ahmad Anas Yusof and Assoc. Prof. Dr. Ir. Hayati Abdullah for their expertise, encouragement, thoughtful guidance and ultimate support throughout this study.

I owe my deepest gratitude to Prof. Ir. Dr. Mohammad Yusri Hassan and Assoc. Prof. Ir. Dr. Md Pauzi Abdullah for their willingness to impart their time and professional expertise in electrical energy systems. Additional thanks to my friends and staff in the Office of Asset and Development, UTM and Faculty of Mechanical Engineering, UTeM for their technical support and camaraderie.

It is an honor for me to Prof. Ts. Dr. Mohd Zamri Ibrahim, Prof. Madya Dr. Musthafah Mohd Tahir and Ir. Al-Khairi Mohd Daud as a committee member. Their passionate support, and constructive criticisms to refine this research which contributed much to improving this thesis.

I am especially thankful to my mom, who always encouraged and supported my dreams. May Allah reward her with the highest degrees in *Jannah*. I also express my gratitude to my family for their endless support and love. To my wife and kids who have always beside me provided unconditional love, and displayed unwavering faith in my abilities, inspired all my past, present, and future achievements, and for their consistent support and encouragement.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

BCSI	-	Bangunan Canselori Sultan Ibrahim
CAC	-	Central / Centralised Air Conditioning
AEMAS	-	ASEAN Energy Management Scheme
AHU	-	Air Handling Unit
UTM	-	Universiti Teknologi Malaysia
AC	-	Air-Conditioning
kWh	-	Kilowatt - Hour
BEM	-	Building Energy Management
SAS	-	Statistical Analysis System
SPSS	-	Statistical Package for the Social Sciences
NEMS	-	National Energy Modelling System
ANN	-	Artificial Neural Network
HVAC	-	Heat Ventilation Air Conditioning
SRM	-	Simple Regression Model
MLR	-	Multiple Linear Regression
DT	-	Decision Trees
SVM	-	Support Vector Machine
ASHRAE	-	American Society of Heating, Refrigerating, and Air Conditioning Engineers
BMS	-	Building Management System
BEA	-	Building Energy Audit
PAC	-	Packaged Air-Conditioning
ACMV	-	Centralised Air Conditioning and Mechanical Ventilation
VAV	-	Variable Air Volume
CAV	-	Constant Air Volume

NPLV	-	Non-Standard Part Load Valve
COP	-	Coefficient of Performance
EER	-	Energy Efficiency Ratio
SEF	-	Supply Exhaust Fan
EF	-	Exhaust Fan
NV	-	Natural Ventilation
VFD	-	Variable Frequency Drives
ST	-	Steel
PVC	-	Polyvinyl Chloride
HDPE	-	High-Density Polyethylene
CI	-	Cast Iron
AC	-	Asbestos Cement
CPP	-	Concrete Pressure Pipe
cfm	-	Cubic Feet per Minute
FDD	-	Fault Detection and Diagnosis
SBS	-	Sick Building Syndrome
DDS	-	Daily Discomfort Score
DR	-	Demand Response
M&V	-	Measurement and Verification
IPM & VP	-	International Performance Measurement and Verification Protocol
IEA	-	International Energy Agency
ECBCS	-	Energy Conservation in Buildings and Community Systems
EPI	-	Energy Performance Indices
SCOP	-	Seasonal Coefficient of Performance
SEER	-	Seasonal Energy Efficiency Ratio
BEA	-	Building Energy Audit
DBT	-	Dry Bulb Temperature
WBT	-	Wet Bulb Temperature
RH	-	Relative Humidity
RTD	-	Resistance Temperature Detectors
VAV	-	Variable Air Volume
EUI	-	Energy Utilization Index