UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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WATER TREATMENT PLANTS (WTPs) WITH HIGH EFFICIENCY MOTORS (HEMs) AND VARIABLE SPEED DRIVES (VSDs)

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WATER TREATMENT PLANTS (WTPs) WITH HIGH EFFICIENCY MOTORS (HEMs) AND VARIABLE SPEED DRIVES (VSDs)

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DECLARATION

I declare this dissertation entitled "Water Treatment Plants (WTPs) with High Efficiency Motors (HEMs) and Variable Speed Drives (VSDs) is the result of my own research except as cited in the reference. The dissertation has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : ……………..............................

Name : GHASSAN JAWAD KADHIM

Date : ……………………...................

APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion, this dissertation/report is sufficient in terms of scope and quality as a partial fulfillment of Master of Electrical Engineering (Industrial Power).

Signature : ……………...............................

Supervisor Name : Prof. Dr. Mohammad Rom Bin Tamjis

Date : ……………………....................

DEDICATION

Almighty Allah who blessed me with a lot of graces.

I dedicated this dissertation:

To the spirit of my father

To my beloved mother

Tomy wife "Rabab Ikram"

To my Daughter “Laya” and my son “Harith” my sisters and brothers for their love and encouragement.

ABSTRACT

The industrial sector especially (water treatment plant) is the largest consumer of energy in Malaysia with about 70% of the total electricity is consumed by electric motor driven pumps. The industrial sector contributes significantly to the national growth, and this economic growth drives the high growth in energy demand. Therefore, the increase in energy cost recently has created a situation where it has become essential to develop alternative energy technologies as well as improve efficiency. In this case, energy efficiency means reducing environmental degradation and increasing sustainability as well as cost savings. This dissertation proposes a completely new design of drives system in water treatment plant. This dissertation focuses on the economic benefits that can be obtained by replacing mechanical flow control of pumps with variable speed drive and replacing standard motors with new high efficiency motors at water treatment plants in Malaysia. Analyses had been carried out on a water treatment plant in Malaysia. This study explains the economic benefits of variable speed drive and high efficiency motors in water treatment plant industries. Based on the load profile before and after the installations, it has been estimated that there can be a total energy savings of 1862,263MWh, 2793,395MWh and 3724,529MWh by utilizing energy efficient motors for a 50%, 75% and 100% load respectively. and Similarly, it is hypothesized that a significant amount of energy can be saved using VSDs to reduce speed it is found that for 60 % to 10 % speed reduction can be reach to maximum and minimum value of energy savings of 7604,460MWh ,2015,640MWh, respectively. And it has been estimated that amounts of electric bill saving cost RM 234,702 (i.e. RM 2,816. 424) per year, the payback periods is 10 months. Energy savings up to 66.3% can be obtained for overall industry.

ABSTRAK

Sektor perindustrian terutama (loji rawatan air) adalah pengguna terbesar tenaga di Malaysia dengan kira-kira 70% daripada jumlah tenaga elektrik yang digunakan oleh motor elektrik pam didorong. Sektor perindustrian menyumbang dengan ketara kepada pertumbuhan negara, dan pertumbuhan ekonomi ini mendorong pertumbuhan tinggi dalam permintaan tenaga. Oleh itu, kenaikan kos tenaga baru-baru ini telah mewujudkan satu situasi di mana ia telah menjadi penting untuk membangunkan teknologi tenaga alternatif serta meningkatkan kecekapan. Dalam kes ini, kecekapan tenaga bermakna mengurangkan pencemaran alam sekitar dan meningkatkan kelestarian serta penjimatan kos. disertasi ini mencadangkan reka bentuk yang sama sekali baru sistem pemacu dalam loji rawatan air. disertasi ini memberi tumpuan kepada manfaat ekonomi yang boleh diperolehi dengan menggantikan kawalan aliran mekanikal pam dengan memandu laju boleh ubah dan menggantikan motor standard dengan motor kecekapan tinggi baru di loji rawatan air di Malaysia. Analisis telah dijalankan ke atas loji rawatan air di Malaysia. Kajian ini menjelaskan manfaat ekonomi memandu laju boleh ubah dan kecekapan yang tinggi motor dalam industri loji rawatan air. Berdasarkan profil beban sebelum dan selepas pemasangan, ia telah dianggarkan bahawa terdapat boleh menjadi penjimatan tenaga 1862,263MWh, 2793,395MWh dan 3724,529MWh dengan menggunakan motor cekap tenaga untuk 50%, 75% dan 100% memuatkan masing-masing. dan Begitu juga, ia membuat hipotesis bahawa sejumlah besar tenaga boleh disimpan menggunakan VSDs untuk mengurangkan kelajuan didapati bahawa 60% kepada 10% pengurangan kelajuan boleh sampai ke nilai maksimum dan minimum penjimatan tenaga 7604,460MWh, 2015, 640MWh, masing-masing. Dan ia telah dianggarkan bahawa jumlah bil elektrik menjimatkan kos RM 234.702 (iaitu RM 2,816. 424) bagi setiap tahun, tempoh bayaran balik adalah 10 bulan. Penjimatan tenaga sehingga 66.3% boleh diperolehi bagi industri secara keseluruhan.

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LIST OF SYMBOLS AND ABBREVIATIONS

Symbols	Description
% FL	Fraction of Full Load at Motor Runs
%	percent
α	proportional
$	Dollar
Δ	Different of
ɳ	Efficiency
£	pound
=	Equal to
ɳe	Efficiency of High Efficiency Motor
ɳs	Efficiency of Standard Motor

Abbreviations	Description
A	Ampere
AC	Alternating Current
AES	Annual Energy Saving
BCR	Benefits to Cost Ratio
CDM	Clean Development Mechanism

CEMEP	Electrical Machines and power Electronics
CER	Certified Emission Reductions
CO2	Carbon Dioxide Gases
DAF	Dissolve Air Floatation
DC	Direct Current
EC	Electricity Cost
EE	Energy Efficiency
EF	Emission Factor
ESP	Energy Saving Potential
EPACT	Energy policy Act
GDP	Gross Domestic product
GHG	Green House Gases
H, hr	Hour
HEMs	High Efficiency Motors
HP	Horse Power
HZ	Hertz
IGBT	Insulated gate bipolar transistor
Kteo	Kilo tone of Oil Equivalent
L	Load Factor
NEMA	National Electrical Manufactures Association
N	Number of Motors
OMET	Open Market Emissions Trading
PAY	Payback Period
PC	Pump Characteristics
PTM	PusatTenaga Malaysia/Malaysia Energy Center

RM	Ringgit Malaysia
RPM	Rotation per minute
ROI	Return of Investment
SC	System Characteristics
TNB	Tenaga National Berhad
U.K	United Kingdom
U.S	United State
UNFCC	United National Framework Convention on Climate Change
V	Voltage
VSDs	Variable Speed Drives
W	Watt
WTPs	Water Treatment Plants
yr	Year

LIST OF PUPLICATIONS

Ghassan J.K., R.T. Mohamad, M.R., Ab Ghani, 2015. Modeling Water Treatment Plant with High Efficiency Motor (HEMs). *International Journal of Applied Engineering Research, ISSN0973- 4562* ,10, pp.38498-38499.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Electric motors in industrial applications consume about 40% of all the generated electrical energy worldwide. Electric motor systems are by far, the most important type of load in industry, using about70% of the consumed electricity. The industrial sector is the largest energy user around the world. The electrical energy consumption in Malaysia has increased sharply in the past few years. Higher efficiency electric motors can lead to significant reductions in the energy consumption and environmental impact (De Almeida et al., 2011).Electrical energy producers need to constantly expand their generation capacity to supply the growth of private and industrial consumers. Consumers are dependent on the supply availability, but increasing costs is a vital issue. This paves the way for reduced electricity consumption and energy efficiency improvements, benefiting all parties concerned (Greunen, 2014). Energy is vital for sustaining a comfortable modern life. Natural resources such as natural gas, kerosene, diesel and coal have long been used to generate energy. Energy refers to electrical or thermal energy produced by either or both fuel and electricity (Shiyao Wang, 2013). Fuel is burnt to produce thermal energy which then drives engines. Electric energy is converted to mechanical energy by electric motors for moving, stirring, blending or any form of displacement activity. Energy efficiency is a measure of savings of energy, which is used to provide goods and services, while maintaining the desired benefit. Significant scope for improving energy efficiencies exists within the industrial, commercial, domestic, and transport demand sectors. Generally Energy Efficiencies (EE) measures' can be defined as steps that can be taken to reduce energy consumption. The measures include:

i. Encouraging customers on the demand side to invest for capital improvement with attractive return from investment.
ii. Changing energy consumption behavior without disturbing existing comfort.

The term energy conservation seems to be similar to the term energy efficiency and thus interchangeable. Some prefer to use much simpler terms such as energy savings instead of EE. Nevertheless, whichever term one chooses, the idea of EE remains the same as defined above (Abdelaziz et al., 2011). There are those who define EE as a method of reduction in emission of harmful gases to the environment and reduction of the depletion rate of natural resources. None can deny the fact that energy generation process has some side effects in polluting the environment, and eventually contributes to global warming and ozone layer depletion. EE methods is potential as the best method to reduce further emission and damage to environment (Bierbaum and Friedman, 2008). It is a very common perception that a nation's economy and its energy usage will grow at the same pace, with the emissions of pollutants like carbon dioxide following a similar trend. Historical data of many countries proves the close link. Likewise, in Malaysia, CO2 emissions have grown in parallel with Malaysia's economic growth. In addition to the future global environment issues, stubbornness in not implementing EE measures will cause a faster depletion in natural resources. Once again, it has to be stressed that natural resources are vital for sustaining life on earth. This is a serious problem for countries with less natural resources and even a development block for countries without natural resources (Sharifah, 2006).

This is due to the fact that a country's foreign reserve must be utilized for purchasing energy instead of investing fully in the development of the country. Without EE, more natural resource will be used and future generation will end up facing energy crisis. To avoid these problems from occurring in the very near future, 'Energy Efficiency (EE) options' need to be executed in order to increase the energy supply and demand without rapidly depleting the limited natural sources.

i. A large number of energy efficiency policies can be employed but the two major approaches include.
ii. Improvements in the efficiency of the final demand reducing the need for energy supply.
iii. Improvements in the efficiency of the delivery systems for energy reducing losses in the supply systems.

Several measures to increase energy efficiency are from a societal point of view since the procedure can reduce fuel costs and demand. For private decision makers, the situation may be different where there is higher demand for financial return of investment, thus information costs of identifying efficiency options and subsidies of energy prices may lead to a lack in investment. Thus, two common traits necessary in all energy efficiency procedures are loss reductions and decreasing emissions.EE became more prominent after the oil crisis in the 1970s which caused developed countries to start seeking for alternative energy resources and EE options. In Malaysia, renewable energy (RE) and energy efficiency (EE) concepts are only recently brought forward into the mainstream of national economic agenda under the category of developing the energy sector. The Malaysian Government's enforcement of Energy Efficiency Regulations to support implementation of demand side management has changed the energy usage pattern. Also, the appliance labeling stipulated in the third Outline Perspective Plan (OPP3) period further enhances this energy usage pattern. However, the government support on RE and EE activities is limited to only providing relevant infrastructure through legal and financial institutions. Now, it is up to the industry to reciprocate and take the right action. The environmental impact of the VSDs is a potential reduction of greenhouse gasses or other elements that have a negative impact on the environment (Atabani et al,. 2011). Most driven systems account for approximately 70% of the electricity consumed by industries in Malaysia. The motors in the industrial sector in Malaysia consume as much as RM6 billion worth of electrical energy annually. Induction motor is the main driven system in the modern industrial society. In Malaysia, the bulk electricity consumption in the industrial and commercial sectors is by electric motors. Activities and processes in industries are heavily dependent on electric motors for compacting, cutting, grinding, mixing, fans, pumps, materials conveying, air compressors and refrigeration. Motors are also used widely in the commercial sector for air conditioning, ventilation, refrigeration, water pumping, lifts and escalators etc. Energy losses in a large number of industries are prevailing thus potential energy efficiency improvements are imminent. High Efficiency Motors (HEMs) use specific materials to reduce core and copper losses. Therefore, they generate less heat and require smaller space. A motor's function is to convert electrical energy into mechanical energy for performing useful work (Hasanuzzaman et al,. 2010). The usage of energy efficient motor can reduce financial cost of industrial sector such as the cost of motor maintenance and cost of buying a new motor because it has long life span. Therefore, energy efficient motors can save a substantial amount of money in the long run.Using energy efficient motor that has slightly higher efficiency than standard motor can also