AUTOMATION OF CONSTANT HEAD ORIFICE OFF-TAKE STRUCTURE

By

HAPIDA BT. GHAZALI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

March 2005

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

AUTOMATION OF CONSTANT HEAD ORIFICE OFF-TAKE STRUCTURE

By

HAPIDA BT. GHAZALI

March 2005

Chairman: **Professor Wan Ishak Wan Ismail, PhD**

Faculty: **Engineering**

The efficiency of irrigation for paddy cultivation depends very much on water supply and demand to be provided during the growing season. Due to complexity in operating water intake structure, the Constant Head Orifice (CHO) was developed to overcome the problems which required intensive labour. A CHO off-take structure is an important structure in the irrigation scheme to facilitate measurement and provide constant irrigation water supply.

Presently, all CHO off-take structures in Malaysia are manually operated. Target discharges are seldom met due to upstream water level fluctuations, and the operators are unable to cope with the opening and closing of the many orifice gates and the turnout gates. CHO's are not automated due to the large number of gates involved in an irrigation scheme and there are many water level sensors required for the automation system.

Automation is potentially one piece of the puzzle in trying to modernize and improve overall irrigation project performance.

A CHO automation system was developed in this study in order to make improvement on the operational system of existing CHO structures by automating the gate operation through interfacing with Supervisory Control and Data Acquisition (SCADA) system. A double barrel CHO structure at Block M2 at secondary canal TB (Taliair B) in the Sg. Muda Irrigation Scheme, Seberang Perai Utara, Penang was chosen for the installation and testing of the automation system.

The developed CHO automation system included mechanization of the intake and off-take gates, Programmable Logic Control (PLC), water level sensors, communication media and master control server. The system allowed the operator to automatically route scheduled changes in demand through their canal system utilizing water levels at the main canal and at the CHO stilling chamber, and time delay calculation. The "Kinetic Automation" controller unit can automatically maintain constant differential head at 100 mm. The master controller used the standard personal computer and customized SCADA package. Each gate is operated with Rotork IQ35F16A actuators which are controlled by the "Kinetic Automation" controller unit at site. Control is based on water level from MJK ultrasonic sensors and gate position sensor which was incorporated in the Rotork IQ35F16A actuator. Public Switch Telephone Network (PSTN) was used as a media of

communication between the master controller and “Kinetic Automation” controller unit and MODBUS communication protocol.

The study found that, there is a linear relationship between discharge and the gate opening. At a constant differential head, the discharge increased with increase in orifice and turnout gates opening.

It was observed that there is a general increase in orifice gate opening for manual measurement compared to the automatic control. T-test comparison shows that the mean orifice gate openings for automatic control and manual measurement are not significantly different from one another. There was an overall increase in average discharge values between automation supply and manual gauging. Generally, the manual gauging discharges were higher than automation discharges for most flow settings. T-test comparison indicates that the average difference in discharge values from the automated supply and manual gauging is not significantly different from zero. In another words, the discharges from the two methods are not different from one another.

The time required to open the gate by the automated CHO system increases with increase in orifice gate opening. A similar trend is observed for the manually-operated CHO. For any particular orifice gate opening, the time requirement for the automated CHO is always less than that required by the manually-operated CHO by as much as 1/11 to 1/5 of the time.

There are huge benefits from the automation of the CHO; fast response in water supply, computerized control of water supply, easy and efficient operation, and well regulated irrigation water supplied remotely, easy maintenance and web enabled. The success of the project has eliminated the human problem and simplifies operational procedures. The CHO can be economically operated, with ease of discharge measurement and minimized cost of maintenance. Besides, DID needs to popularize the importance of Information Communication Technology (ICT) and automation of CHO in irrigation to its own staff as well as the general public. However this will require commitment from all those involved among all levels of government and private sectors.

Abstrak tesis kepada yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENGAUTOMATAN UNTUK STRUKTUR ORIFIS TURUS MALAR

Oleh

HAPIDA BT. GHAZALI

Mac 2005

Pengerusi: **Profesor Wan Ishak Wan Ismail, PhD**

Fakulti: **Kejuruteraan**

Kecekapan penanaman padi adalah amat bergantung kepada sistem pengairan dan keperluan air semasa musim tanaman. Lanjutan dari kerumitan untuk menyalurkan air ke bendang, satu struktur Orifis Turus Malar (CHO) telah dibangunkan. Struktur ini memerlukan tenaga kerja yang lebih. Struktur ini merupakan satu struktur yang penting bagi menyalurkan air ke kawasan pengairan dengan kadar ukuran luahan air yang tetap.

Pada masa ini, kesemua struktur CHO di semua kawasan pengairan di Malaysia beroperasi secara manual. Jumlah sukatan luah sukar menepati sasaran disebabkan oleh perubahan aras air di saluran utama dan kerja-kerja membuka dan menutup pintu air yang banyak memakan masa yang panjang dan meletihkan. Struktur CHO tidak diautomasikan memandangkan jumlah penderia aras air yang banyak perlu digunakan dan tidak berekonomi bagi pemasangan sistem automasi.

Pengautomatan untuk CHO yang telah dibangunkan dalam kajian ini adalah untuk penambahbaikan sistem operasi CHO yang sedia ada. Sistem automasi yang dibangunkan ini digabungkan kepada sistem *Supervisory Control and Data Acquisition (SCADA)*. Satu CHO berkembar di Blok M2 , Taliair B (TB) di Skim Pengairan Sungai Muda, Seberang Perai Utara, Pulau Pinang telah dipilih bagi pemasangan dan pengujian sistem automasi yang dibangunkan.

Pengautomatan ini termasuklah menjenterakan pintu air masuk dan pintu air keluar, kawalan *Programmable Logic Control (PLC)*, penderia aras air, kemudahan perhubungan dan server kawalan utama. Sistem ini membenarkan pihak operator membuat pertukaran jadual mengikut keperluan berdasarkan aras air di taliair utama dan aras air di dalam takungan penenang CHO secara automatik dengan selisih kiraan jangka masa. Perisian "Kinetic Automation" yang digunakan boleh menstabilkan selisih turus (*differential head*) di antara sungai utama dan takungan penenang secara automatik sebanyak 100mm. Stesen Kendalian Utama menggunakan komputer dan perisian SCADA yang direka khas bagi projek ini. Setiap pintu air dipasangkan dengan Rotork IQ35F16A *actuator* dan dikawal oleh "Kinetic Automation" controller di tapak. Penderia aras air yang digunakan adalah jenis *MJK Ultrasonic sensor* yang memberi bacaan aras. Talian telefon digunakan bagi menghubungkan di antara stesen kendalian utama dan "Kinetic Automation" controller dengan menggunakan protokol komunikasi MODBUS.

Hasil daripada kajian ini, dapat diperhatikan bahawa hubungan diantara luahan dan bukaan pintu air adalah sekata . Pada keadaan perbezaan aras yang tetap, didapati kadar luahan bertambah dengan pertambahan bukaan pintu masuk dan pintu keluar.

Dapat diperhatikan juga, terdapat peningkatan yang hampir sama pada bukaan pintu masuk yang diukur secara manual berbanding ukuran yang diberikan daripada sistem outomasi. Perbandingan statistik menunjukkan bahawa purata bukaan pintu masuk untuk ukuran manual dan automatik adalah tiada kesan terhadap kedua-duanya. Selain itu, dapat diperhatikan juga, terdapat semua peningkatan pada luahan diantara luahan yang diberikan daripada sistem automasi dan sukat luah secara manual. Secara rambang, sukat luah secara manual memberikan luahan yang lebih tinggi berbanding luahan yang diberikan oleh sistem automasi pada kebanyakan *setting*. Perbandingan statistik menunjukkan bahawa terdapat purata perubahan pada sukat luah secara manual dan luahan automasi adalah tidak memberi kesan terhadap kedua-duanya.

Masa yang diperlukan untuk membuka pintu air secara kawalan automatik adalah bertambah dengan pertambahan kadar bukaan pintu air. Keadaan yang sama juga dapat diperhatikan pada CHO yang dikendalikan secara manual. Dapat dilihat, perbezaan masa bukaan pintu air, manual dan automatik adalah ketara dengan jarak diantara 1/11 hingga 1/5 daripada jumlah masa.

Faedah yang ketara dapat diperolehi daripada sistem automasi CHO ini adalah kepantasan tindakbalas dalam penyaluran air, dengan kawalan komputer, kendalian yang

mudah dan tepat, kawalan air dapat dilakukan daripada jauh. Selenggaraan yang mudah dan ianya juga boleh dipamerkan melalui web. Kejayaan sistem automasi juga dapat mengurangkan tenaga manusia dalam kendalian CHO dan memudahkan kendalian CHO. CHO yang berekonomi dikendali dapat memudahkan sukatan luahan dan kos penyenggaraan dapat dikurangkan. Pihak Jabatan Pengairan dan Saliran Malaysia perlu memupuk kesedaran orang ramai tentang kepentingan sistem otomasi CHO di kawasan pengairan. Ianya memerlukan komitmen di semua peringkat kerajaan, swasta dan orang ramai.

ACKNOWLEDGEMENTS

All Praise be to ALLAH SWT for all the blessings that support me to achieve this study.

I wish to express my warmest, sincerest thanks and deepest gratitude for overall enlightenment, suggestion and ancillary to my supervisor, Professor Dr Ir Wan Ishak Wan Ismail for his guidance and encouragement throughout my studies. Also, I am gratified to my supervisory committee members, Professor Ir Dr Mohd Amin Mohd Soom and Dr. Chan Chee Wan for their support, useful advice, making valuable comments and suggestions. I will always cherish their contributions to my professional growth.

Special thanks to Seberang Perai Utara, DID office personnel, especially En. Khirluddin, Tn Hj Pauzi, En. Sabra, Pn. Rohani, En. Jaafar and all the staff in SPU, DID office for their very good support and co-operation throughout the studies. En Yahya and staff in Hydrology Division in Penang office for their help during the field experimentation. I really appreciate and glad to thank En. Hasim Harun, DID Ampang for his technical assistance, sincere support and encouragement, and not to forget En. Rosazlan Abu Seman, Tn Hj Ismail Ahmad and my Director Tn Hj Mobarak Hussein, of DID Mechanical Division.

I would like to thank my colleague Marvin for his help and technical advice throughout my studies. Jawaher, Aimrun, Hassan, Mustafa, Rowshon and Ahmed for their help and encouragement throughout my studies. Their thoughtfulness and advice have certainly improved the quality of this thesis.

Last, but certainly not least, sincere thanks go to my husband Mohd Noor b. Awang for his understanding, continuous support, encouragement, patience and sacrifices expressed during the period of my studies, and to my beloved children, Syamin and Muhammad Syamir for being an everlasting source of inspiration. I love you all very much.

I certify that an Examination Committee met on ……. to conduct the final examination of Hapida bt. Ghazali on this Master of Science thesis entitled "The automation of Constant Head Orifice (CHO) off-take structure" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Faculty of Engineering
Universiti Putra Malaysia
(Member)

Professor
(Independent Examiner)

_____

GULAM RUSUL RAHMAT ALI, PhD
Professor/ Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirements for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Ir Wan Ishak bin Wan Ismail, PhD
Professor
Institute of Advanced Technology
Universiti Putra Malaysia
(Chairman)

Ir Mohd Amin Bin Mohd Soom, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Chan Chee Wan, PhD
Senior Research Officer
Mechanization and Automation Division
Malaysian Agricultural Research and Development Institute (MARDI)
(Member)

_____
AINI IDERIS, PhD
Professor / Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I hereby declare that this thesis is based on my original work, except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

_____

HAPIDA BT. GHAZALI

Date:

TABLE OF CONTENTS