Australian Journal of Basic and Applied Sciences, 8(4) Special 2014, Pages: 511-515

AENSI Journals

Australian Journal of Basic and Applied Sciences

ISSN:1991-8178

Journal home page: www.ajbasweb.com

Development of gate opening decision support for Arau Canal water level control

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ARTICLE INFO

Article history:
Received 20 November 2013
Received in revised form 24 January 2014
Accepted 29 January 2014
Available online 2 April 2014

Key words:
Control; Irrigation; Water Level

ABSTRACT

Northern Malaysia is known as rice bowl of the nation, therefore irrigation water is becoming more scarce with the continuously increasing demand for agriculture, domestic and industrial purposes. In order to face the irrigation demand, the available water need to monitor and control of its distribution. This paper introduces a control automation system for Arau canal to control flow of water along the canal and its distribution to paddy field. This automatic control system is able to process data of water level and computes the required control actions for water distribution along the canal.

To Cite This Article: M.M. Khalil, SHAHRIMAN A.B, Khairunizam WAN, ZURADZMAN M.R, MOHD AFENDI, E.M. CHENG, SHAFRIZA N.B, S.K. ZAABA., Development of gate opening decision support for Arau Canal water level control. ***Aust. J. Basic & Appl. Sci.,*** *8(4): 511-515, 2014*

INTRODUCTION

Water management for water supply system is particularly important at the present time where water resources become increasingly scarce with the change of season and the climax. For the supply of open channel, has been identified that there is a partial loss of water supplied by the water that cannot be controlled. there has been research done to address this problem as can be seen in and are therefore an active research area, see eg (Cantoni, M. *et al*., 2005; Dulhoste, J.-F. *et al*., 2004; Gomez, M *et al*., 2002; Litrico, X., 2002; Litrico, X., *et al*. 2005; Schuurmans, J., *et al*. 1999; Weyer, E. 2002; Weyer, E. 2003; Weyer, E. 2005; Euren, K and Weyer, E. 2006). Water supply management is based on the requirements required by the user based on the quantity. There are many possible way to control the quantity of using monitoring devices, control gates and other operational devices (Donia, N.S., 2012). This study focuses on introducing Arau Canal control system that currently consist mainly of a monitoring system and the development of automatic control represented by a computer control model based on data driven model.

Study Area Description:

Arau Canal is located in the North of Malaysia where it supplies water for paddy field in the south of Perlis. This canal was under the management of Muda Agriculture and Development Authority. The canal intake from north canal sources from three major dam that is Muda dam, Pedu dam, and Ahning dam. This canal supply for an area of 20,304 hectares of paddy field in district 1, Kangar, Perlis. Besides supplying water for irrigation, this canal also being a source of water for domestic and industrial used for Perlis and also including Langkawi Island. This canal also plays an important role as flood routing in preventing flood event in Perlis. Total length of the Arau canal is about 16 Km, it started from Arau regulator in Arau till the Kuala Sungai Baru.

Monitoring and Control System Development:

In order solve the problem of excess or shortage supply of water to the downstream side, an automatic gate control is required to be implemented to the gate operation. Thus, without the need for operator to be always at the gate, the operation of water supply can be done efficiently. With the current monitoring system that has been installed at gate at Arau canal such as water level sensor and gate opening meter, additional function to be installed is remote control gate. Remote monitoring and control system allows the operator to monitor and operates the gate remotely through the website established.

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Fig. 1. Map of Arau Canal

The basic control mode for irrigation is to control the flow rate and water level control. The control mode can be set by either the controller automatically and semi-automatically. Manual monitoring also done by the gate operators to make sure the automatic monitoring data match with the canal reading of the water level upstream and downstream of the gate. Generally, the monitoring will always give the current status of each river gate and displays the status of water level and gate opening. If there are any sudden changes in water levels or exceeding the limits of danger or warning, the system will continue to inform the controller in an email to the operators.

Fig. 2: Monitoring and control web server

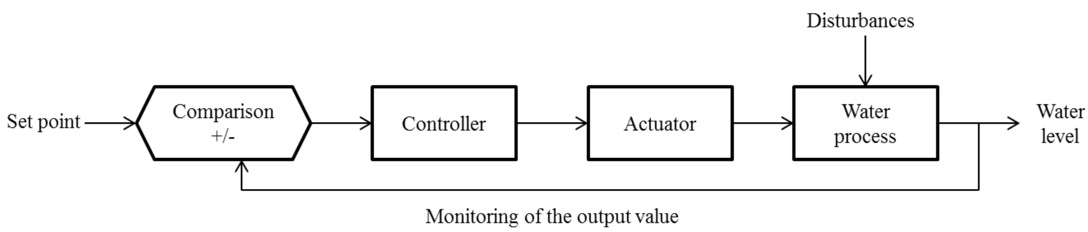

Fig. 3: Process of automatic water level control

For automatic control, the setting will be determined by the operator to set the requirement of that time. It depends either in the season paddy rice planting season or not. Automatic flow rate control will continuously calculate the flow flows over the gates and reports the value to the monitoring system and make adjustments to the gate opening to achieve the flow rate required. As an upstream water level rise or fall, the system will adjust the gate until it reaches the desired flow rate. With this setting, the gate operation needs a minimum of intervention operators along the operation.

Operators can override the automatic gate control and switch into a semi-automatic control anytime whenever needed. With a semi-automatic monitoring and control method, the operators still receive data from water level sensor and the alert if any, but with this mode, the operators can operate the gate position to any desired opening and the flow will be shown in the system.

Model structure used in the development of Arau canal water level automatic control was the same approach as in (Euren, K & Weyer, E., 2006) and volume balance of pool was consider

$$V(t) = Q_{in}(t) - Q_{out}(t) \tag{1}$$

Where V is the volume in pool, Q_{in} is the flow at gate Arau regulator and $Q_{out}$is the flow under gates at Control A.

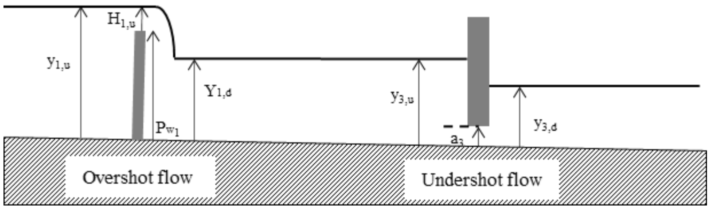

Fig. 4: Overshoot and undershoot flow of gate

From Bernoulli equation (Yunus A. Cengel & John M. Cimbala, 2006), the following flow-gate Equation is derived for overflow gates

$$\dot{V}_{rec} = C_d \frac{2}{3} b\sqrt{2g}H^{3/2} \tag{2}$$

With

$$C_d = 0.598 + 0.0897 \frac{H}{P_w} \tag{3}$$

Where;

$\dot{V}_{rec}$ = Flow of overshot gate (m^3/s)
C_d = discharge coefficient
b = width of the gate(m)
g =gravity acceleration (m/s^2)
H =overshot head
P_w =gate opening

For flow of undershot gates is derived as

$$\dot{V} = C_d ba\sqrt{2gy_1} \tag{4}$$

Where:

$\dot{V}_{rec}$ = Flow of overshot gate (m^3/s)
C_d = discharge coefficient
b = width of the gate(m)
a = height of the gate opening
g =gravity acceleration (m/s^2)
y_1 =upstream water level of gate

RESULT AND DISCUSSION

The work done is to develop automatic water level control in Arau canal which the irrigation canal at Arau canal system was equipped with both overshot and undershot gate.

Results obtained from the study found that the develop systems able to accurately simulate the water levels of the pool based on operation at the canal as can be seen in Fig.5. We can see that the result shows when the gate opening change, there have slightly difference where it have some disturbance which the flow through the gate changes.

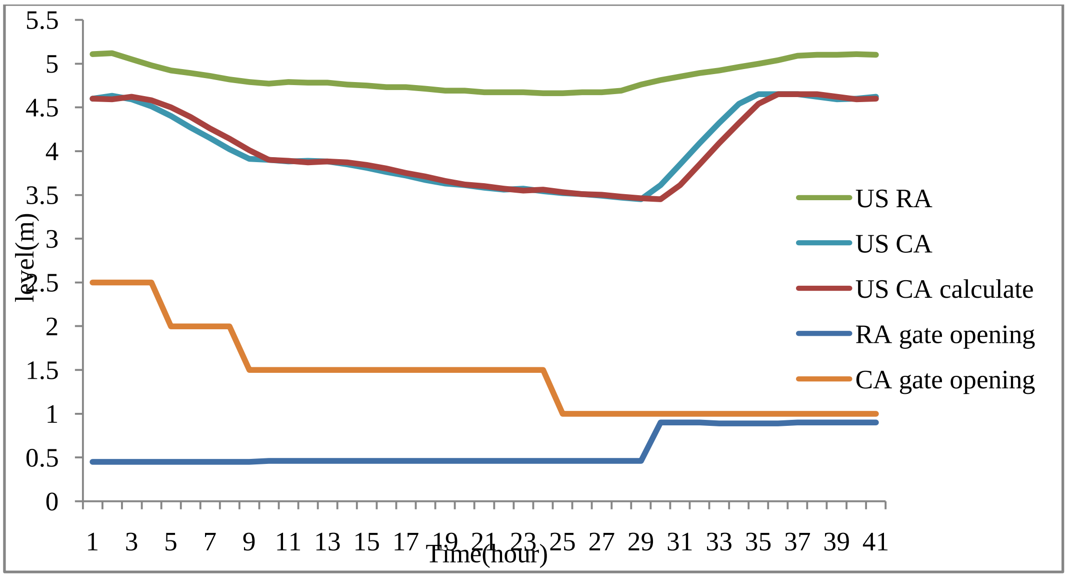

Fig. 5: Simulation of the models against the validation set

Where:
US RA=upstream regulator Arau
US CA= upstream controlArau
US CA Calculate = calculated upstream control Arau
RA gate opening=Regulator Arau gate opening
CA gate opening= control Arau gate opening

Water level response for the the difference of gate opening for pool 1. But it comes together afterwards, primarily since the change that occur to both upstream and downstream of the gates.

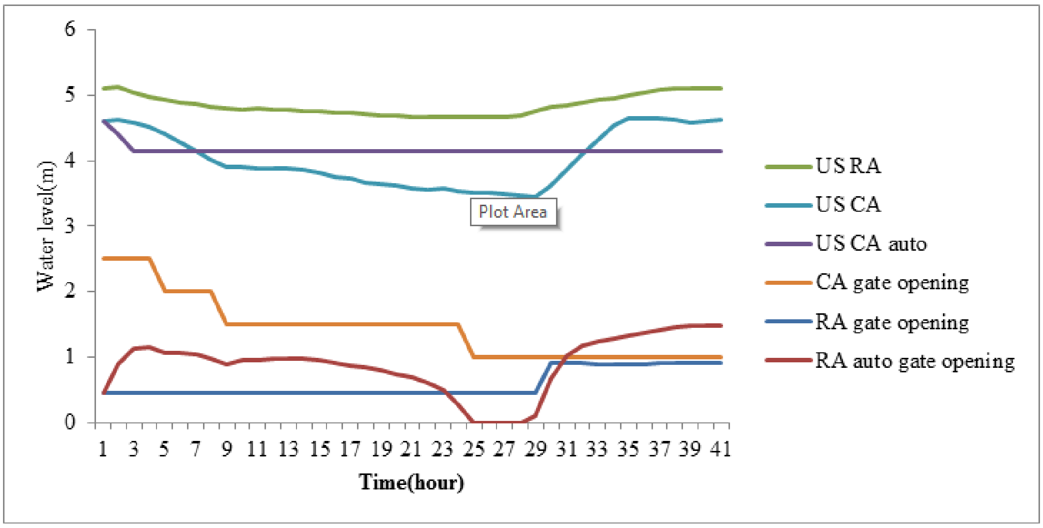

Fig. 6: Automatic water level control for Arau canal
Where:
US RA=upstream regulator Arau
US CA= upstream controlArau
US CA Auto = upstream controlArau with automatic control
CA gate opening= control Arau gate opening
RA gate opening=Regulator Arau gate opening
RA gate opening=Regulator Arau Automatic gate opening

Fig. 6 shows the result of the automatic control in order to maintain water level at pool 1 of Arau canal. From the result can be seen that to maintain water level to the desired level for full supply level of the canal, the gate opening of regulator Arau need to operate rapidly but with a small difference. The differences may vary due to changes of water level at the upstream of regulator Arau. Thus the flow rate of the water supply to the pool may be higher or lower to the required flow rate.

Conclusion:

Key benefits from the system are that it allows the operator to control and maintain continuously desired water supply flow rate through the gate. For the convenience of the rice planting season, the water level at each level at each pool can be maintain at all time to ensure enough supply to the farmer. This is important when the off takes to the paddy fields relying on gravity and no pumping available.

In conclusion, the project for the development of remote monitoring and control seen to be another requirement for the canal and river management. The system able to alert the canal manager of any error occur at their canal and take immediate corrective action if needed before the local operator arrive at the respective gate controller.

ACKNOWLEDGEMENT

The authors express their profound gratitude to Universiti Malaysia Perlis (UniMAP) and all members of Advanced Intelligent Computing and Sustainability (AICoS) Research Group for providing internal foundation and acknowledge to conduct research. This work is supported by research grant scheme (9009-00010) from the Ministry of Higher Education

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