Experimental Open Channel with Automated Structures

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Abstract: - In Mexico, practically all conveyance systems for water irrigation are composed by a network of channels with control structures operated manually. The lack of automation often results in low irrigation efficiency. To improve water management in these systems, the government has modernized some irrigation districts with automatic structures. However, problems have emerged with the operation of these structures, causing the users to show their inconformity about the new gates. In order to solve this problem, an experimental channel was built where prototypes of hydromechanical structures were installed. This paper presents the results of the experimental channel in terms of capacity building and research on the adaptation of the automated gates to the characteristics of Mexican canals.

Key-Words: - Open channel; automated; floodgates; operation efficiencies.

1 Introduction

Water application for agricultural purposes in adequate time and amount plays a fundamental role in crop yield. On the other hand, water availability for irrigation has been reduced in the past years due to severe and extended droughts [1]. About 70% of the current worldwide water withdrawal is used for irrigation [2], and the global efficiency Mexican irrigation districts are lower than 50% [3]. As a result, a considerable amount of irrigation water is lost in conduction, distribution or on-farm application.

In Mexico, practically all water conveyance systems for irrigation are composed by a network of channels with control structures operated manually by empirically trained technicians. As a consequence, in many occasions the on-farm water allocation is fit to the agricultural needs. In fact, water allocation depends on the individual criteria and skills of the ditch rider at the delivery time. This problem has resulted in low water distribution efficiency, and attracted the interest of researches interested on identifying alternative water management options [4].

One of such alternatives has been used since 1935 in some European countries such as France, Spain and Italy to improve distribution efficiency in the operation of irrigation canals. This alternative focuses on automation using hydromechanical floodgates [5]. Due to their operation characteristics and because they do not require manual intervention, water distribution can become more efficient and equitable. In the American continent, the application and development of such technology has exclusively occurred in the United States.

In Mexico, the government has modernized some irrigation districts installing this technology in Reynosa, Apatzingan, Valle de Mezquital and Santiago, among others. In certain cases results have shown that this equipment's implementation has not fulfilled the expectations, due to lack of experience in floodgate operation. Therefore, it is necessary to acquire a better knowledge about this technology in order to determine the benefits and limitations of these automated structures in the Mexican conditions.

2 Fluidic Automation

The increasing technological development in all fields of science has contributed to the solution of some of the problems limiting the manual operation of irrigation channels. New criteria have been developed allowing the establishment of better conditions for hydraulic channel operation. New equipments and automatic devices have been developed to regulate water levels, flow and service. These devices are based on telemetry systems and motorized equipment attended by computers implementing control algorithms. As an alternative the hydraulic energy of the channel can be used to control the physical variables of the system [6].

The fluidic automation concept has been used in some fields of hydraulics for some time now, and it

has been gaining importance in practically all scopes related to water management. The fundamental principle in fluidic automation is related to a system that takes advantage of the gravity force and available energy in water to obtain a proper control and distribution of water in time and amount, therefore satisfying the needs of the users. To establish a system with these characteristics, it is necessary to design and develop equipment that works independently of any other type of energy. Therefore, to obtain automatic movement in the structure, floaters and/or counterweights must be used to allow an adequate calibration of the equipment and to obtain a direct command on the control variable (i.e., the design flow). This must be achieved without external energy sources which could fail and disturb the normal operation of the equipment [6].

The introduction of this concept in channel operation has generated a great interest among designers and operators of hydraulic structures. Consequently, the hydraulic criteria for channel design have been modified to accommodate the new type of structures and the new ways of operation.

In Mexico, the adoption of fluidic automation for irrigation canals is promising. It is expected that the new techniques will lead to an improvement in channel response capacity. This will in turn result in a better satisfaction of the users' water demands. Nevertheless it is important to bear in mind that additional investments will be required. This seems completely justified by the expected benefits derived from better performance, as well as by the cost-benefit relationship associated with system operation. In this sense, García-Villanueva [4] reported some of the advantages derived from channel operation with fluidic automation:

- Better water distribution and transport efficiency,
- Lower labor requirements,
- Better water control, more efficient water distribution,
- A greater control on allocated volumes permitting adequate supply in amount and time,
- Transparency and equity leading user satisfaction, and
- Opportunity at delivery, meaning that in some automated systems it is possible to anticipate the needs of users and consequently attend them promptly.

However, the same author reported some disadvantages:

- The physical vulnerability of some automation equipments, such as in relation to vandalism, wrong operation or physical alterations that can affect the operation of control structures.
- One of the basic characteristics in automatic control is that it limits discharge to the minimum that satisfies the users' demands. This type of operation can increase the risk of channel.

All the irrigation districts in which the Mexican Government has installed automated floodgates have reported fatal problems. These were mainly due to the lack of qualification and experience in this type of structures. In some cases the structures deteriorated because of the lack of a proper maintenance. As a consequence, the users have reported water delivery deteriorating, and crop production decreasing.

In order to address this problem, and with a view to increase the districts' capacities to manage these structures, the *Universidad Autónoma de Zacatecas* (UAZ), through the Water Resources Planning Program, built an experimental channel in the year 2000. The technical and economic support of the *Instituto Mexicano de Tecnología del Agua* (IMTA) and the *Agencia Española de Cooperación Internacional* (AECI) is acknowledged. This channel is 70 m long with a 1.00 by 1.20 m cross-section. Prototypes of hydromechanical structures were installed to regulate upstream or downstream depths. The floodgates for the regulation of downstream depth were of the AVIS and AVIO types, while for the regulation of upstream depth the AMIL type was used.

The UAZ experimental channel is unique in Latin America and was constructed for demonstrative, capacity building and research purposes. Experimentation on this channel made possible to establish local criteria for the installation, calibration and operation of the floodgates. Relevant experience to face and solve problems related with the operation of these structures has been achieved.

3 Experimental Channel with Automated Structures

The experimental channel is equipped with the following control structures: an AVIS 56/106 installed to regulate the downstream depth; an AMIL D90, located in the middle of the canal with the purpose of regulating upstream depth, and finally, at the downstream end, two AMIL D80 and one AVIO 28/6 placed laterally. In addition, the

channel has constant flow modules XXI-120, XXI-60 and XXI-30 to derive flows to different points in the channel. It also has a siphon with a capacity of 60 L/s in the first channel segment to derive excess water. Fig. 1 presents a complete channel perspective, while Fig. 3 shows the experimental channel plant.

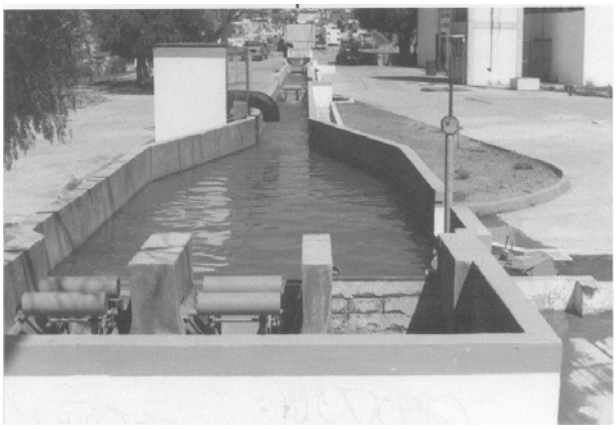

Fig. 1 Channel perspective view from the downstream end

3.1 Capacity building

The experimental channel has allowed IMTA, *Comisión Nacional del Agua* (CNA) and UAZ specialists (among others) to acquire experience in the calibration and, operation of AMIL, AVIS and AVIO floodgates (Fig. 2) This experience that has been put to practice in the solution of operational problems reported in recently automated Mexican channels. This was the case of the Santiago Irrigation System (SIS). In addition, the channel has been used as part of the practice curriculum of students of civil engineering, agronomy and the Water Resources Planning Program.

Fig. 2 Students training in the operation of AVIS 56/106 floodgate

3.2 Channel modernization in The Santiago Irrigation System (SIS)

A pilot project was executed in 1997 in the main channel network of the SIS in Miguel Auza, Zacatecas. This project was part of a Government program aiming at improving water management standards. The manually operated slide gates were replaced by automatic AVIS and AVIO floodgates that allow water delivery to users with a better efficiency than the traditional systems. The results were not absolutely satisfactory, with unrest among water users severe structure deterioration after just three years of operation. It was observed that the mere replacement of the structures did not result in benefits to water management. A series of additional actions are required to promote adequate structure operation. These actions should be continuously revised to ensure that the objectives regarding costs, service quality, and equity are attained.

Renault [7] pointed out the difficulties of reaching success in this process. In fact, modernization of irrigation projects has been defined as a process of administrative and technical improvements combined with an institutional reform to improve the use of all involved resources (labor, water, financial and environmental, among others) and the water delivery service to users [8].

A year was devoted to developing solutions for the complicated situation in the SIS. Considering that modernization is totally different from rehabilitation since the latter simply returns a "deteriorated" project to its original state [8], for the SIS rehabilitation was no longer useful since it would generate a "rehabilitation-deterioration-rehabilitation" vicious circle which would not benefit water management at all.

3.3 Research

The original design criteria of the automated floodgates is based on local regulation of water depth with the help of lateral extraction devices (constant flow modules) operating at the same hydraulic head as the floodgates. However, in Mexico due to the local characteristics of the conveyance networks it is necessary to change the target water levels over time. A specific device was designed to enable the automated floodgates (particularly the AMIL type) to regulate not only the operation level for which they were designed but also other levels within a certain range. This device is based on a variable counterweight in which the force that must overcome the water energy could be modified and consequently generates different operational target levels.

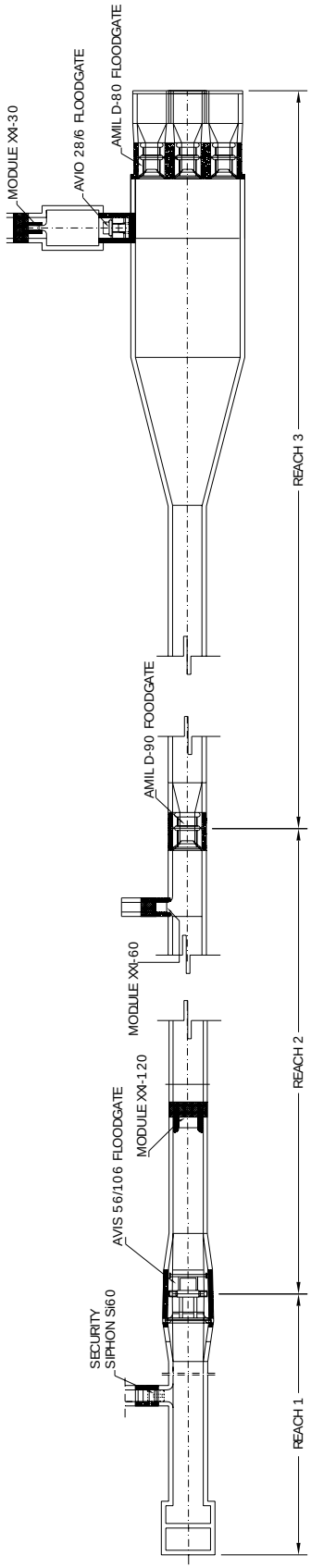

Fig. 3 Experimental channel plant (adapted from [9])

4 Conclusion

Automated floodgates are an alternative contributing to improve canal operation for agricultural irrigation, decreasing the water losses generated by this practice. By other hand, the experimental channel has fulfilled the theoretical and practical expectations. The necessary expertise has been generated as far as calibration, installation and operation of automated floodgates. This expertise was applied to problem solving, such as in the case of the Santiago Irrigation System. Finally, an auxiliary device was designed to regulate several upstream water levels.

References:

[1] Rosano-Méndez L., Rendón, P. L., Pacheco, H. P., Etchevers, B. J. D., Chávez, M. J. and Vaquera, H. H., Calibración de un Modelo Hidrológico Aplicado en el Riego Tecnificado por Gravedad, *Agrociencia*, Vol. 35, 2001, pp. 577-588.

[2] Postel, S., Water: Rethinking Management in Age of Scarcity. *Worldwatch Paper 62*, 1984.

[3] Iñiguez, C. M., *Análisis de la Flexibilidad en la Distribución del Agua en los Distritos de Riego*. Colegio de Posgraduados, México, 1994.

[4] García-Villanueva N. H., *Estructuras Fluídicas para la Automatización de Canales*, Colección Manuales, Instituto Mexicano de Tecnología del Agua. México, 1998.

[5] Guillén, G. J. A., Lomelí, V. R. J., Palacios, V. E., Espinosa, M. R. and Ramírez, L. J., *Operación, Conservación y Administración de Módulos de Riego*, Comisión Nacional del Agua and Instituto Mexicano de Tecnología del Agua, México, 2000.

[6] Barrios-Domínguez J. N. and García-Villanueva N. H., *Automatización de Canales de Riego*. Universidad Autónoma de Zacatecas, México, 2000.

[7] Renault, D., Re-engineering Irrigation Management and System Operations, *Agricultural Water Management* Vol. 47, April 2000, pp 211-226.

[8] Burt, C. M. "Current Canal Modernization from an International Perspective, Irrigation Training and Research Center, California Polytechnic State University, USA, 1999.

[9] Bautista-Capetillo C. F., *Canal Experimental con Estructuras Auto-Operantes*, Universidad Autónoma de Zacatecas, México, 2002.