IRRIGATION CANALS IN SPAIN: THE INTEGRAL PROCESS OF MODERNIZATION

Prof. José Liria Montañés [1]
Laura Cózar Fernández [2]

ABSTRACT

Efficient use of water is a driving force in Spain, a mostly an arid country, having an adverse hydrological regime and insufficient rain for the practice of irrigation. Water needs increase continuously and there are almost no suitable places for new dams. The irrigation demand is the most important consumption use. Saving water would be the solution.

This paper will focus on the first element of the irrigation net; that is, water transportation / distribution by canals. Many irrigation canals are old and regulated by elemental systems, with frequent water losses. In order to improve them, there are several structural and non-structural responses under way now, fostered by the Spanish Government.

Regulation was introduced in Spain forty years ago with downstream and upstream constant water level gates. Nowadays the use of mixed gates combined with an upstream reservoir , completely centralized from a remote command centre, is becoming very frequent and profitable. The system is complemented with "all or nothing" jump distributors moved by compressed air, which regulate lateral turnouts.

HYDROLOGICAL SITUATION OF THE COUNTRY CONCERNING IRRIGATION

For millennia, Spain, a country featured by its dryness and its extremely irregular hydrological regime, has been practicing irrigation in order to take advantage of its favorable sunshine. Nowadays, irrigable areas demand more than 75% of the total quantity of regulated water within the country. Water necessities grow for human consumption, industry and agriculture and it is very difficult to increase availabilities, because the natural hydraulic regimen is very irregular and there are almost no suitable places for building new dams.

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[1] Engineering Consultant- 34-91-5618871- jliria@ciccp.es

[2] M.Sc. Civil Engineering -GETINSA-Empresa Consultora de Ingeniería-34-91-5542129- lcozar@getinsa.es

Efficient water use is essential and the effort should be directed toward irrigation activity, the main and wasteful consumer. Nowadays in Spain, big efforts are being made to save water, with modern, automatically controlled systems, integrated with SCADA.

Consequently, one way of resolving the problem might be the improvement of water management, focused here now in irrigation canals, most of them very old and regulated by elemental systems, with frequent overspills and other water losses, water theft and unscheduled irrigation.

FAO has defined modernization as "a process of technical and managerial upgrading of irrigation schemes combined with institutional reforms, if required, with the objective to improve resource utilization and water delivery service to farms" (Facon and Renault, 1999).

In this sense, Spanish Public Administration is developing structural responses such as canal lining and others works of upgrading, and at the same time it is fostering non-structural responses related to technical improvement in regulation systems (on one hand canal operation, and on the other the electronic, electrical and mechanical components that direct the regulation).

Efforts of the Ministry of Environment to Ameliorate the Situation:

The Ministry of Environment, in charge of surveying most irrigation canals, has decided to help its own technicians and Irrigation Districts having canals, to improve management by updating their regulation and control systems. Therefore, it has launched a project, called "Upgrading of large infrastructures for transport and distribution of water." Its aim is not to update a specific canal, but to provide some help to technicians in order to upgrade management of most canals in the country.

The firm GETINSA, was selected by the Ministry to develop the project. The first phase is composed of two complementary parts:

Drafting of a Technical Guide for canal instrumentation: The aim is to advise the designer when choosing the equipment of the canal and find the most suitable solution adapted to its specific conditions. As element of scientific divulgation, this document reflects the "state-of-the-art", concerning all the equipment and electronic components: hydraulic gates, valves, automatisms, sensors etc.

Open mathematic model of simulation of unsteady flow in canals: It is an useful computing tool -called RIEGA 1.0 (acronym of Regulation of Water Transport and Distribution Infrastructures, in Spanish)- for the calculation of canal response to gates operation or variations in the functioning regime. It can detect overflow or lack of water in different stretches. It is particularly helpful when planning the flow schedule. The results of the different trials feedback the system and provide the canal manager with valuable knowledge when taking decisions, both during the design phase of a new project and when improving working canals. It is a model based on known techniques, but with the peculiarities of being flexible and at free disposal of the technicians of the Ministry. The source code is open and the algorithms compose an understandable and modular structure, which will allow to be adapted and/or developed depending of the future necessities.

CURRENT STATE OF THE SPANISH IRRIGATION

Traditional Systems

Canal system control methods are slowly improving from local manual systems, passing through local automatic, to supervisory and combined ones, but still with elementary systems. In fact, almost all of the Spanish irrigations that have been improved with automatic gate systems, are regulated by methods of hydromechanics. Canal regulation has traditionally been based on downstream operation in primarily demand-oriented systems, and upstream operation in supply-oriented ones.

Nevertheless, in spite of the said great improvement in some aspects, there are still some regulation problems. In general, canal operation can hardly face the variation of consumption needs in the different turnouts. So, it is useful or even essential, to be able to calculate the canal inflow schedule with an accurate mathematic model, that also represents properly the lamination effect in water level.

New Systems

Since a few years ago, mixed water level control gates are placed more frequently. They regulate downstream levels by assuring, in addition, maximum-minimum safety levels. They are controlled by hydromechanics systems and they work thanks to the effect of weirs and valves housed in chambers connected to the canal. We will not explain here how they work, because this is very well known, however, we will remind that the mixed gate situated in a canal establishes correspondence relations according to predefined laws between these two water levels (upstream and downstream). Downstream level is fixed through the crest height of a small spillway inside the chamber. On older gates, it is constant and fixed from the moment they are implemented. Nowadays it can be modified from the control center, and the regulated level may be changed according to the water schedule. Given the great variety of its functions, the mixed gates are reserved for equipping big channels with sufficient volume and are capable of making separate reserves and also compensate the demand and contribution of the daily water needs .

The functioning curve is as in Figure 1, in which upstream and downstream levels are linked, (Axis YY) and (Axis XX).

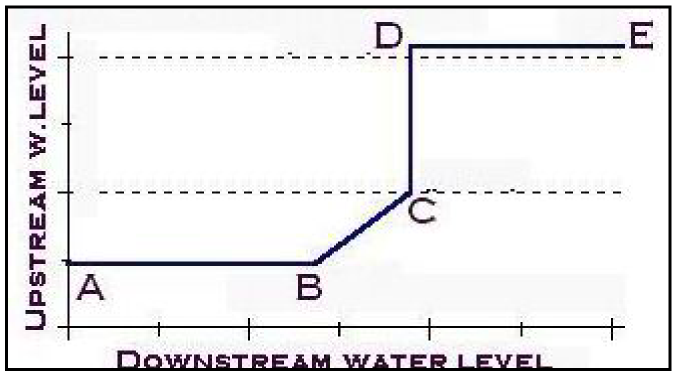

Figure 1. Diagram of a constant upstream/downstream water level gate.

Normal functioning stretch is CD, in which, for any upstream level, the downstream level is constant. Stretch DE is a security stretch, in which independently from the downstream level, upstream level is constant and equal to the maximum permitted, in order to avoid overspills. AB is a security stretch, in which the upstream water discharge is avoided when it is insufficient, by maintaining the minimum level adopted. Stretch BC corresponds to transition situations.

The possibility that the upstream level had important value fluctuations is very useful to combine one of these gates with an upstream reservoir. It stores the excess of inflow water during abundance periods but during shortage periods the stored water is released, always keeping the fixed downstream level. This aspect is very interesting when the canal operation aim is to keep constant levels on certain stretches. It is enough to place a complementary gate at a certain distance downstream of the gate, which only allows flowing planned discharge by taking advantage of the constant level obtained. The mixed gate will open or close according to the target discharge.

The combination of mixed gates and associated reservoirs is very useful to regulate the canal automatically. They were used on several occasions in Spain, such as, in the Paramo Bajo canal (please refer to photograph number 2) supplied by Einar company. This photo shows the storage area as a lateral structure, connected hydraulically with the canal on its side, and the mixed gate connected to the canal. (The photo also displays a safety spillway in the canal that does not affect our explanation.)

Figure 2. Paramo Bajo canal-Constant upstream/downstream water level gate combined with a reservoir.

However, irrigation needs require more sophisticated systems. Water demands are not constant throughout the year. They depend on the season, on the surface irrigated at each moment, on the type of sown culture, etc. which force to find a more flexible operation able to be adapted to changes on water schedule.

Traditional mixed gates such as the ones explained, used to be installed with the selected data of the functioning curve, which were conditioned by the height of the spillway crest and some other additional elements that define the geometry of gates.

The Einar mixed gates used now in Spain, built and placed by said company, show several possibilities. The crest of the spillway is mobile, so it can be elevated or dropped according to orders received from the management center. Therefore, at each moment, the instructions can be changed. We find a sort of SCADA systems, with quite a wide potential value in developing process. Of course, the pure hydro mechanicals regulation systems do not nave the ability of transmitting information to the control centre, a defect that should be solved. In short, it is important to achieve higher flexibility when managing canals, modifying the orders from a centralized command centre.

But regulating water levels and flows is not enough when talking about the necessary upgrading. The system needs to be able to operate the turnout gates of different Irrigation Districts from the managing center, in order to deliver the demanded flows at any time. This item is already successfully solved in many cases, for instance, in San Sebastián distributor and in Aragón and Cataluña Canal.

From our point of view, the sort of lateral turnouts which works the best, regarding to the accuracy on responding to planned levels and flow rates, is the one called jump distributor or baffled weir. When water level is between the maximum and minimum limits of fixed range, baffled weirs can maintain an accurate flow rate. They work by an “all or nothing” system (totally open or closed) and with the possibility of supplying some fractions of the maximum derivable flow rate. It is because they are sub divided into several minor gates. A right canal operation guarantees the desired water levels and flows.

There are many irrigating areas in Spain equipped with this sort of lateral gates, but up to now all of them were managed by hand, with substantial staff expenses. The San Sebastian Distributor is monitored from a centralized command. Each group of gates is provided with a hut in which there is an air compressor moved by a small engine, of approximately .2 horsepower. Compressed air keeps stored at five atmospheres in a 50 litres (thirteen gallons) tank.

Figure 3 shows the interior of the hut with the tank, engine, battery, compressor and the wardrobe where there are placed some air filters and electro valves.

Electro valves are activated when a gate operation is required, allowing compressed air to act over some pneumatic cylinders. So they react opening or closing the gate with a strong instantaneous effort. The energy is obtained thanks to a small surface external solar panel, linked to storing electric batteries (the number of daily movements of the gate is very small so the amount of energy obtained like this is quite enough). Among the batteries and the energy stored in the pressurized air, there is no difficulty in the storage of the energy produced by the small power of the engine.

Figure 3- Interior of the hut. Motor, compressor, tank, batteries, etc.

Figure 4 displays the whole hut and the distributors set. There are two types of distributors or modules:

- Sector type shape.
- Smaller plain board shape

Figure 4. Whole hut and modules.

The detail of the moving cylinders is different according to the size of the module. Photograph number 5 shows small modules of plain board.

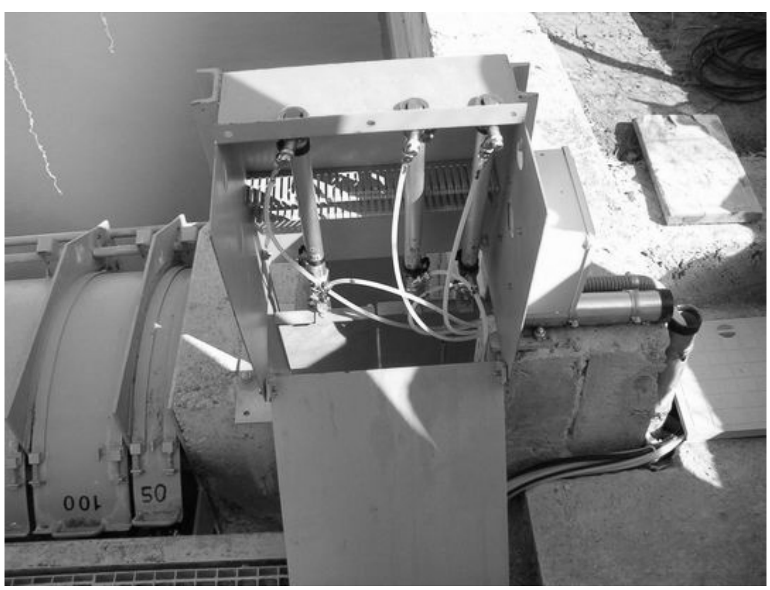

Figure 5. Detail of pneumatic cylinders of the plain modules.

On the other hand, in the bigger sector gates, cylinders are horizontally placed, fact that favors its rotation, as can be seen on photograph number 6.

Figure 6. Sector modules, with horizontal pneumatic cylinders.

New Irrigation Networks Control solution, integrates cutting edge technologies such as Supervisory Control And Data Acquisition (SCADA) systems, remote terminal units (RTUs), network operational control centers and irrigation management applications interconnected via wireless communications and the Internet.

Central-control automation in San Sebastian irrigation area allows the information to be communicated from the different RTUs (placed in check structures) to the central control unit, that processes the multi-site data and sends control signals back to the individual RTUs. Data transmission is through GPRS system, so for this reason, the huts are fitted with suitable aerials that act over a programmable automatic device (PLC). The orders are given from the central PC with rather a simple software. As a safety device, there is a rod submerged into the canal that sends an alarm signal in case of water shortage and, consequently, cuts the power.

Nowadays, the San Sebastián Distributary is working like that, irrigating around 7500 acres (3.000 Has). It forms part of the Aragón and Cataluña Canal, that waters more than 375.000 acres (150.000 Has). This Canal is divided into various Irrigation Districts. They find the system very profitable because of several reasons: water saving, guarantee of a good service rendered and saving of staff expenses, etc. There is a very promising tendency to move to the new system, taking great advantage of it.

FUTURE PERSPECTIVES

Our main purpose has been to show an overview of the way initiated in a traditionally irrigated country as Spain. A country accustomed to water scarcity, that is trying to solve its problem through an integral process of modernization, focused now on reducing the water losses rate in canals.

As a conclusion, our opinion is that future can be contemplated with optimism:

On one hand, the Spanish government, worried about saving water, is fostering the hydraulic engineering research and is also helping to improve techniques related to regulation systems of irrigation canals and water delivery.

On the other hand, there are some Irrigation Districts just understanding the economic advantages of innovative solutions, as well as the practical benefits of implementing SCADA systems. In fact, they willingly accept it and they are promoting themselves the improvement, because modernization is pursuing efficiency in the use of water but also reducing energy and operating costs in general. Our personal experience makes us strongly believe in this way: the easy and quick transmission of the new techniques from farmer to farmer, and from an Irrigation District to another, based on successful experience and trials.

We conclude that, step by step and thanks to all the parties involved (Ministry of Environment, Irrigation Districts, farmers, technicians, etc.), the forenamed process of modernization will be able to become real and profitable.