Archive of SID Shahid Chamran University of Ahvaz Irrigation Sciences and Engineering (JISE) Vol. 42, No. 1, Spring 2019, p. 189-200

EXTENDED ABSTRACT

Determination of Opening Level, Spillway Gate Dimensions and its Control using Linearization of the Outgoing Discharge Equations and the Water Level of the Dam Reservoir

M. A. Lotfollahi Yaghin[1*] and M. Rahim Afshani[2]

1*- Corresponding Author, professor, PhD, Faculty of Civil Engineering, University of Tabriz, Iran. (*a_lotfollahi@tabrizu.ac.ir*).
2- PhD Candidate, MSC, Faculty of Civil Engineering, University of Tabriz, Iran.

Received:29 June 2017 Revised:8 September 2017 Accepted11 September 2017

Keywords: Smart Spillway Gate, Geometric Properties of Spillway Gate, Gated Spillway, Proper Utilization of Dam Reservoir. ***DOI:*** 10.22055/jise.2017.22234.1596.

Introduction

Spillway gates are used to increase water depths on power generating turbines, regulate the flow passing the spillway and augment the safety of the dam and its installations during flooding. Inappropriate performance, inaccuracy in determining the proper dimensions and sudden opening of the spillway gate(s) causes vibration, overtopping, instability in the dam, and also damages to the dam's body, its installations and even downstream areas. Regarding the rainfall reduction, adjusting reservoir level, increasing water pressure on power generating turbines and proper use of water inside the reservoir, determining the accurate dimensions of the gate and making smart spillway gate(s) are required. Using the technique of linearizing the equations of discharge passing spillway and water level inside the reservoir and the point of equilibrium of the incoming and outgoing discharge hydrograph, the dimensions of the spillway gate are carefully designed and constructed in accordance with the environmental conditions and its installation site. By smarting the spillway gate and determining its precise dimensions, it will be possible to control floods remotely, manage water consumption, save manpower and reduce visual error.

Material and Methods

Non-linear equations related to discharge passing the spillway and water level and volume inside the reservoir were first converted to linear equations, and then the equilibrium point of the incoming and outgoing hydrographs and the gate opening parameter were determined. Regarding the water height inside the reservoir or the flood design height, the maximum water height (minimum gate height) was measured. Then, the value of the opening parameter was determined based on the maximum height of the passing water. Because of the wide range of variations in the opening parameter, the geometric location of the equilibrium point of the incoming and outgoing flood hydrograph in the spillway was determined in accordance with environmental and economic condition and also gate's installation site. The geometric dimensions of the gate were determined based on the geometric location of the hydrograph balance point related to the incoming and outgoing flood. The block diagram of Fig. 1 was used for smart automatic control of the spillway gate(s).

www.SID.ir

Archive of SID

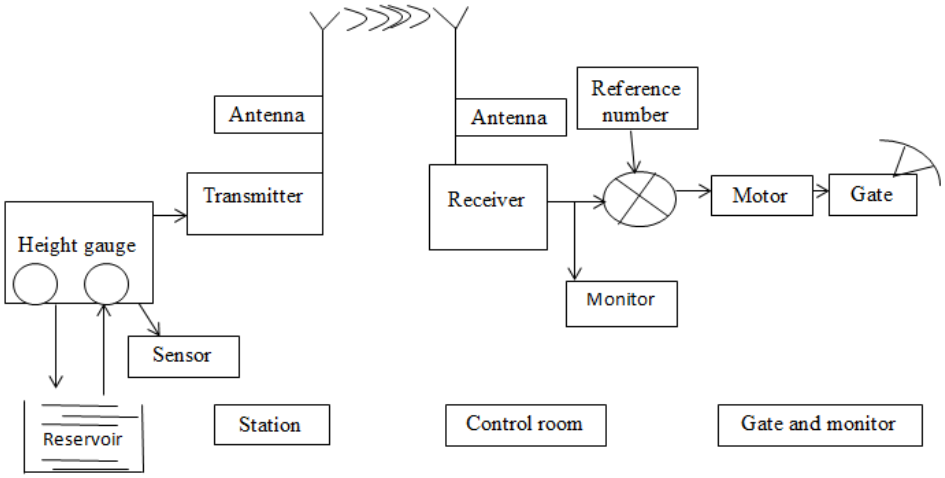

Fig.1- The block diagram of the station and control room

Sampling of superficial water at specified intervals was carried out by transmitting and receiving devices. To sample the superficial water, the system first sends ultrasonic waves to the water surface and then receives waves from it. Considering the waves sending and receiving time as well as the wave velocity in the air, the distance between the system and the water surface was determined then. By deducting this distance from the distance between the system installation site and the bottom of the reservoir, the water height was obtained. The values obtained for the water height were transmitted via the radio and satellite system to the control system in the control room (located in the dam's body). The control system analyzes these values and then compares them with the base values. If the water height is higher, lower or equal to the base value, the control system then sends the necessary control command to the gate actuator (e.g. electric motor, hydraulic device or pneumatic system) and the gate is opened, closed or stays constant based on the received command. This operation is repeated to keep the water level within the desired range. The smart system was made up of electronic elements, microprocessors, ATMEGA8, water height sensor, ultrasonic and radio transmitter and receiver devices, electric motors and other electronic components. In the design of smart systems, C, C^{++} and ARDUINO softwares were used. The designed system was tested repeatedly in the lab to confirm the desirability of its results as well as its accuracy.

Results and Discussion

Following the linearization of the equation of the outgoing discharge and the water height inside the dam's reservoir, there was considerable flexibility in the design of the spillway capacity and the geometric characteristics of the gate(s). The expansion of the variation of the opening parameter increases the scope of the design of the gates dimensions and geometric characteristics, simplicity and adaptability to the environmental conditions and the gate's installation site. The smart system shows the water height, the water volume inside the reservoir, the flow rate and the outgoing water velocity in the gate and the hydrograph of the flood entering the reservoir on the monitor screen. The smart system is equipped with warning units and can detect destructive floods and notify them to the user(s). Thus, the user will be notified instantly of the state of the dam and incoming and outgoing discharge and can make the necessary decisions before the incident.

Conclusion

Using the linearization method, it is possible to accurately design the geometric dimensions of the spillway gate(s). The extension of the variation of the opening parameters extends the scope of the spillway gate(s) design. The installation of the smart gate and gate openings control will increase the

www.SID.ir

safety of the dam as well as valleys and downstream areas and the water pressure on the power generating turbines. By installing smart control systems, the possibility of opening and closing the gate(s) will be provided by radio and satellite systems, which will save on cost and manpower, as well as visual error reduction. Increasing the water height and volume inside the reservoir, preventing water loss, flood control, and optimizing water consumption in the downstream areas are the other benefits of the smart control systems.

© 2019 by the authors. Licensee SCU, Ahvaz, Iran. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution-NonCommercial 4.0 International (CC BY 4.0 license) (https://creativecommons.org/licenses/by/4.0/).

www.SID.ir