Regulation of Water Reservoir Resources Using Alternative Sensors

Almaz Aliyeva[1], Nargiz Rasulova[2]
Institute of Information Technology of ANAS, Baku, Azerbaijan
[1]*depart7@iit.ab.az*, [2]*asnarmah@gmail.com*

***Abstract*— Some issues related with development of automatic water volume control system using alternative sensors of data on quantity of water in the reservoir are reviewed in the article. Alternative sensors of data on quantity of water in the reservoirs are depth gauges and reservoir surface area meters. Given the bathyorographical manipulator of reservoir, depth and surface area of the basin allow to determine the volume of water in the basin. Samples of water volume calculations in reservoir depending on depth and surface area of the basin provided.**

***Keywords*— water reservoir; rational control of water resources; water volume automatic manangement system**

I. Introduction

Currently, special attention is given to issues related with automatic water quantity control issues in water reservoirs. This is caused by climate changes, which lead to floods or draughts. Solution of flood and draught problems are relevant for regions of Azerbaijan.

Essence of automatic water quantity control in water reservoirs consists of supporting water volume on a desired level. It must be noted that, data sensors, directly indicating quantity (reserve) of water in the water reservoir does not exist. There are sensors of water level in the water reservoir, also it is possible to obtain information about water reservoir surface area provided by remote sensing satellites of Earth. Issues related to automatic control of water quantity using alternative sensors of data about water quantity in reservoirs applying elements of GIS-technology are reviewed in the report, which is the new scientific approach for solution of the given task.

II. Contour Calculation of Automatic Water Volume Control in the Reservoir

In the article, contour calculation of automatic water volume control in one reservoir is reviewed [1], structural scheme of which can be presented as following (figure. 1):

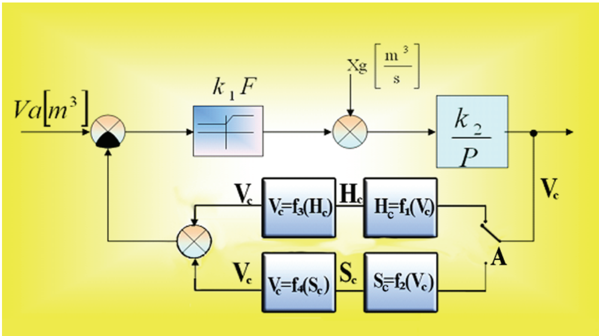

Figure 1. Structural scheme of water volume control system for one water reservoir

Following indications are used in structural scheme (figure 1).

$X_g(p)$ — Volume of water inflow to water reservoir in one second $[m^3/\text{sec}]$;

$V_a(p)$ — desired water volume in the reservoir $[m^3]$;

$V_c(p)$ — Current water volume in the reservoir $[m^3]$;

$$k_3 = \frac{X_g(p)}{V_a(p)};$$

k_1, k_2 — Amplification factors;

F — Nonlinear element, characterizing means of water drainage (empty) from water reservoir;

A — Alternative sensor switch;

H_c — Current value of water level in the water reservoir $[m]$;

S_c — Current value of water reservoir surface area $[m^2]$.

Parameters $H_c = f_1(V_c)$ and $S_c = f_2(V_c)$ on figure 1 are values of water depth and surface areas of water in the water reservoir correspondingly, which are measured using alternative sensors.

Following transfer function corresponds to structure scheme figure 1:

$$W(p)=\frac{V_c(p)}{V_a(p)}=\frac{k_1k_2F+k_2k_3}{p+k_1k_2F} \quad (1)$$

Mathematical modeling for solution of differential equation [2], obtained from correlation (1) was conducted:

$$V_c'(t)=k_1k_2F(V_a(t)-V_c(t))+k_2X_g(t) \quad (2)$$

It is known that, volume of water in water reservoir is measured indirectly, using water reservoir depth measurement:

$$V_c=f_H\,(H_c)\approx\sum_{k=1}^{n}(H_c-P_k)EU \quad (3)$$

Where:

H_c —Current water surface level in water reservoir in relation to world ocean level;

P_k — water reservoir depth height, corresponding to k-th pixel in relation to world ocean level;

E — distance corresponding to pixel width;

U — distance corresponding to pixel length;

n —number of pixels reflecting water reservoir surface;

k — number of pixel.

Depth measurement on water reservoir surface at high waves, commits an unacceptably significant error. In such cases, it is proposed to use satellite images of the water reservoir [3] with acceptable frequency of information retrieval in order to determine the water volume in reservoir (figure 2):

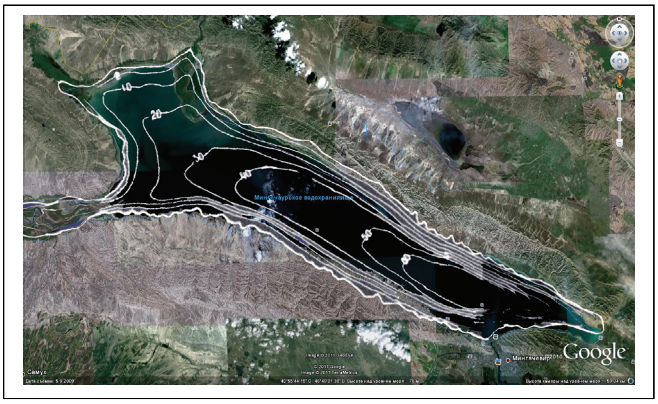

Figure 2. Space image of Mingachevir water reservoir

In such case, water volume in water reservoir can be determined as follows:

$$V_c=f_S\,(S_c)\approx S_c\,\frac{\sum_{k=1}^{n}(H_c-P_k)}{n} \quad (4)$$

Where:

S_c — Current value of water reservoir surface area, calculated using space image;

H_c — level of water in the water reservoir at the moment of remote sensing from satellite image of water reservoir surface;

n —number of pixels in the water reservoir surface image;

k — number of pixel;

P_k — water reservoir bottom height, corresponding to k-th pixel in relation to world ocean level.

Information obtained from correspondence $S_c=f_{sh}(H_c)$ can provide additional knowledge on current condition of surrounding areas and bottom of the water reservoir.

III. Analysis of Modeling Results

Numerical experiment is conducted based on example of Mingachevir water reservoir [4, 5, 6, 7, and 8]. Transition process for initial conditions and limitations is calculated

$$(V_c(t_{\text{initial}})=11\,000\text{ mln }[M^3], V_c(t_{\text{final}})=5\,000\text{ mln }[m^3],$$

limitation of water drainage speed from water reservoir equals to 150 000 $[m^3/day]$).

Modeling results demonstrated that:

- Approximately 21 days are required in order to drain 6000 mln m^3 water from water reservoir without limitation of water drainage speed, which cannot be allowed, as initial water drainage speed from water reservoir is excessive (600 000-500 000 m^3/day);
- Approximately 38 days are required in order to drain 6000 mln m^3 water from water reservoir at discharge capacity no higher than 150 000 m^3/day.
- Proposed automatic control system of water volume in the water reservoir provides tracing desired volume of water, less than 20 days late, which is quite acceptable with consideration of medium-term hydro-meteorological forecast.

IV. Conclusion

- Structural scheme of a model of automatic control system of water volume in the water reservoir is proposed.
- An alternative data sensor on size of water reservoir surface area based on space images is proposed alongside with traditional data sensor on thickness depth of water in water reservoir in order to manage the water volume;
- Numerical experiment on modeling of automatic control system of water volume in the water reservoir through the example of Mingachevir water reservoir.

References

[1] Voronov A.A. Automatic control theory. Part 2, 2nd publication, process. and add., M.: Higher school, 1986, 504 p. (in Russian)

[2] Bakhvalov N.S., Zhidkov N.P.,Kobelkov G.M,, Numerical Methods.M: Binome, 2001, 630 p. (in Russian)

[3] Chandra A.M., Gosh S.K., Remote sensing and geographical data systems. M:Technosphere, 2008, 328 p. (in Russian)

[4] Technical retooling of Mingachevir HEPS, project, volume 1, natural conditions, book 1, Hydrological conditions and climate. Topographic-geodesic substantiation, All-Union planning-surveying scientific-research union "HYDROPROYEKT" named after S.Y. Zhuk, Baku Deparment, 573-T2, Baku: 1983, 146 p. (in Russian)

[5] Sedimentation processes in Mingachevir water reservoir on Kura river, Academy of sciences of Azerbaijann SSR, Institute of Geography, Baku: 1982, 170 p. (in Russian)

[6] Explotation plain of Mingachevir hydroelectric complex on Kura river for the period of 1991-1995 y., Hydrologic characterisrics., All-Union planning-surveying scientific-research union "HYDROPROYEKT" named after S.Y. Zhuk, Baku Deparment, 712-T2, Baku:1991, 113 p. (in Russian)

[7] Explotation plain of Mingachevir hydroelectric complex on Kura river for the period of 1991-1995 y., Water economy. All-Union planning-surveying scientific-research union "HYDROPROYEKT" named after S.Y. Zhuk, Baku Deparment, 712-T1, Baku: 1991, 119 p. (in Russian)

[8] Orujov G.G., Aliyev A.A., Kalbiev N.N., Development of model of automatic control system of water volume in the water reservoir, Southern-Western State University Bulletin, N1, part 1, Kursk: 2012, pp 57-63. (in Russian)