Providing optimal condition for more limitation to objective function in water reservoirs

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Abstract: Considering the importance of optimization issue and its effective role in increasing the efficiency of the systems, the recognition of the priority of optimization of various parameters and its effect on the percent of optimized operation in various conditions is of great importance. In this paper, a double-reservoir system was evaluated and in three cases, various components of it was optimized by multi-population genetic algorithm method and in case 1, by fixing the fulfilled demands, the reservoir capacity and in case 2 by fixing the assumed values of reservoir capacity, their demands are optimized then practical rules and the practical rules of two dams were optimized. Finally, after the investigation of each case, the charts and tables were drawn and by case comparison of each of them, the best case was evaluated and in parameter selection conditions, the ideal case was identified. In the investigation of the current paper, the results of the calculations showed that case 2 was with close percent to the optimized objective function.

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Introduction:

The history of genetic algorithm

Genetic algorithm is a model of evolutionary algorithms being modeled by evolutionary mechanisms in the nature such that the people of the society are defined by chromosome. The population of the chromosomes (people of the society) enters a stage similar to evolution. Genetic algorithms are used in various levels. One example of their applications is multi-dimensional optimization issues that its chromosomes are coded by various values. Practically, the calculations of genetic model are done on bit arrays or the operation defining chromosome. The operators of working on a simple bit let the work done by crossover and mutation operators and other operators. Genetic algorithms act by the following periodical method: At first, a population of chromosomes is created randomly and then their qualification is calculated. Later, by crossover and mutation operators, a new population with higher qualification values is produced. The replication of once the hoop creates a generation. In each time of hoop, the previous society is ignored and a new society is evaluated instead. The first generation is selected randomly and then considering the qualification of people and the existing operators, the community goes to the people with higher qualifications [2, 3, 5].

Materials and methods

Based on figure 1, for simulation of the double reservoir system, two assumed dams are used one in the downstream and the other one in the upstream of the river basin.

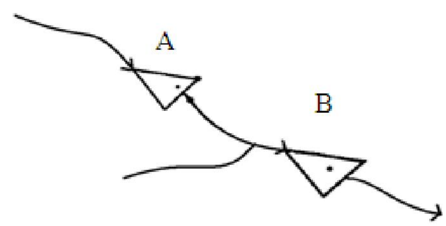


Fig 1: The view of a double reservoir system

Dam A is used in the upstream for water irrigation storage and dam B in the downstream is used for residential and industrial consumption. If the reservoir volume V and the total volume of discharge valves are W, the following changes are considered in two reservoirs.

About the reservoir volume in million cubic meter and the volume of the valves in million m3 per year for dam A A$0<W_a<10$ $0<V_a<60$

The reservoir volume in million m3 and the volume of the valves in million m3 per year for the dam B$0<W_b<15$ $0<V_b<300$

To answer any optimization issue, some constraints are considered to reach the optimized value of objective function. But in genetic method, the constraints are removed from the total form and are appeared as functions called penalty. In the calculations of these functions, some points including the good condition of reservoir and the active supply of two reservoirs and the environmental flow conditions are considered. Here considering economical issues are important.

In Table 1, the penalty values of reservoir defined as the ratio of supply to capacity are estimated for both dams.

Table 1: Penalty of reservoir state (the ratio of supply to capacity (S/C)

The ratio of supply to capacity (S/C)	0.6-0.9	0.3-0.6	0.1-0.3	<0.1
Dam A	0	pen(0.6)=6*C	pen(0.6)+50*C	pen(0.3)+2000*C
Dam B	0	pen(0.6)=6*C	pen(0.6)+50*C	pen(0.3)+2000*C

Considering the values in Table 1, penalty of the cases of reservoirs about both dams are evaluated of the ratio of supply to the capacity of reservoirs. For example if the answer of S/C is 0.5, the penalty of both dams (6*C) is true that is 6 times the real capacity of reservoir. In the most ideal case that the ratio of supply to capacity is near 1, the considered penalty is zero (1).

In tables 2, 3 the penalty values based on the ratio of active supply to the demands of shoal of the reservoirs of the dams are evaluated and as dam B has more active supply, the interval is divided into less intervals. The best limit is the equal ratio of nominator and denominator and by reducing the penalty value, it is increased.

Table 2: The penalty of reservoir supply (The ratio of useful supply to the demands AS/D) about dam A

The ratio of useful supply to the demands AS/D	1	0.8	0.6	0.4	<0.4
Dam A	0	pen(0.8)=5*0.1*D	pen(0.8)+10*0.2*D	pen(0.6)+50*0.2*D	pen(0.4)+100*(0.5-AS/D)*D

Table 3: The penalty of reservoir supply (The ratio of useful supply to the demands AS/D) about dam B

The ratio of useful supply to the demands AS/D	1	0.85	0.8	0.8	<0.8
Dam B	0	pen(0.85)=60*0.05*D	pen(0.85)+250*0.05*D	pen(0.8)+600*0.05*D	pen(0.8)+2000*(0.8-AS/D)*D

Considering the numbers in Tables 2,3. If the result of the fraction SA/D about dam B is 0.85. The considered penalty is (60*0.05D) that D is the demand in shoal of the dam and SA is the active supply in Dam B. The optimized limit is the equal denominator and nominator and by reducing it the penalty is increased.

In Table 4 the penalty of environmental flows of the distance between two dams, based on the ratio of active flow and the expected natural flow after good storage in ballast is investigated, where AF is active flow and NF is natural flow between two dams [1].

Table 4: Penalty of environmental flows (actual flow/natural flow) AF/NF

Actual flow/natural flow AF/NF	0.2-1.2	<0.2
The distance between two dams	0	10*(0.2-AF/NF)*NF)

In optimization issues, finding a good objective function as the best result is achieved of max or min, it has important role in the investigation of the results. In this system, considering the importance active supply of water inside the reservoirs and water loss of environmental flows, the relate penalty values are two times of the penalty of the reservoir and from the sum of them the comprehensive penalty function is estimated.

Optimization of double reservoir system

To simulate the investigated system, a double reservoir system with the assumption of the half filling of the reservoirs is used and as it was mentioned, the capacity values and the supply demands in shoal of each of the dams is involved based on logical assumptions and environmental and hydrology of the region. To compare the effect of optimization each of the components in the result of the system, the results of optimization are evaluated in two cases and numbers of the reservoir capacity, the amount of discharge of valves and the supply in the reservoirs are shown in tables 6, 5.

Table 5: The optimized value of the numbers of reservoir capacity in million meter^3

Parameter	Case 1	Case 2
Reservoir A capacity(Mm^3)	23.45	28.784
Reservoir B capacity (Mm^3)	197.823	210.824

Table 6: The optimized amount of the number relate to useful supply of A, B reservoirs in million m^3 per year

Parameter	Case 1	Case 2
Active supply of Dam A	11.121	0.6
Active supply of Dam B	8.612	8.112

In tables 5, 6 the numbers of case 1 of optimization of the capacity of the reservoir alone and by considering the supply needs in the shoal are used.

The numbers of case 2 of optimization of demands in shoal of reservoir are by knowing the values of the reservoir capacity fixed. The important point in table 5 is considering the changes in cases 1, 2 for both dams A, B. In case 2 the optimization was done on the capacity of reservoirs by fixation of the fulfilling demands. The lack of good water supply and the lack of water supply in the parts leading into the lower parts of the reservoir, can be one of the reasons of this event because by good supply, the demands of shoal in a less capacity. The numbers of optimization of the useful reservoir about both reservoirs are shown in table 7.

Table 7: The optimized amount of the numbers of useful supply of Reservoirs A, B

Parameter	Case 1	Case 2
Active supply of Dam A	11.121	0.6
Active supply of Dam B	8.612	8.112

The trend of two cases is exactly similar to Table 6. Thus, in cases 1, 2 the capacity values and supply demands in shoal are optimized. Regarding the results of useful supply in Dam A, the descending trend of the numbers in two stages is replicated such that in case 2, the number is reduced to 0.6 and this trend proves the result of supply capacity of reservoir A in Table 7.

The important point is the considerable difference of the numbers in cases 1,2. One of the reasons is the high amount of supply in case 1 to case 2 and it shows that by optimization of the capacity of reservoir, by fixed demands, the volume of active supply is increased and this amount is many times more than the time the demands are optimized. Regarding dam B, the process is changed and as this trend is not dropped equally, the difference of the numbers is decreased and this is relate to the environmental conditions around the region and the great amount of surface and volume of the second dam to the first dam and ascending trend of case 1 to case 2 is replicated here.

In Table 8, the percent of supply to demand about two dems is evaluated.

Table 9: The optimized amount of the numbers related to the percent of supply to demand of reservoirs shoal (S/D)

the percent of supply to demand (S/D)	Case 1	Case 2
Dam A	72.64	99.65
Dam B	92.81	98.32

Here the number of supply to the fulfilled demand is considered, the ascending trend of the number is considerable in both dams.

In Table 9, the closeness to objective function in each case is estimated.

Table 9: The proximity to the objective function in each case

Parameter	Case 1	Case 2
Objective function	0.981	0.994

As is shown, in case 2 the highest closeness to the objective function is occurred that has an ideal result.

To investigate the accuracy of the optimized numbers in each case, we investigated the probability of exceeding from the numbers in the above tables about each of two dams and the results are shown in Table 10.

Table 10: The probability of exceeding from the optimized number of the ratio of supply to demand (S/D)

The ratio of supply to demand =1	Case 1	Case 2
Dam A	0.5432	0.0123
Dam B	0.8245	0.3248

As is shown, if the ideal objective, the equal amount of supply capacity and the demand are the basis, in both dams, the exceeding of the optimized number is descending such that in case 2 (namely in dam A), is minimum and a kind of increase of accuracy in case 2 is shown.

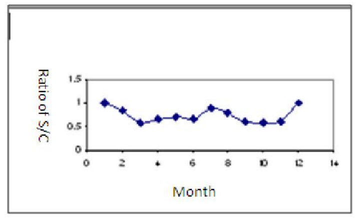
If consider the acceptable ratio of the supply to reservoir capacity as 0.6, the values of probability of exceeding the numbers is shown in Table 11 and here the high accuracy of the observed number in case 2 is shown well.

Table 11: The probability of exceeding from the optimized number of the ratio of supply to capacity(S/C)

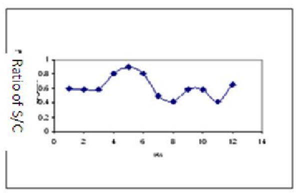
The ratio of supply to capacity =0.6	Case 1	Case 2
Dam A	0.6451	0.012
Dam B	0.815	0.3241

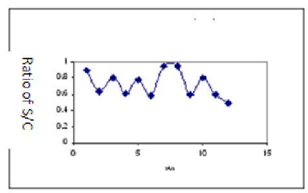
As is shown, the numbers of exceeding the optimized number in accordance with Table11 in dam B is more than dam A and it can be relate to the greatness of Dam B and the relate losses of evaporation and other losses.

More explanation about the comparison of the numbers namely in cases 1, 2 is continued by plotting the charts as drawn in the following.



Case 1



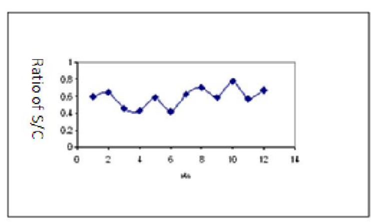


Case 2 case 3

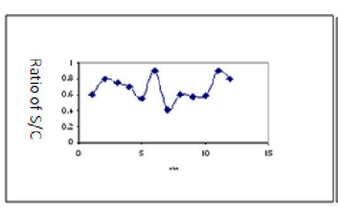
Fig 2: The curve of the changes of reservoir supply during one year for Dam A

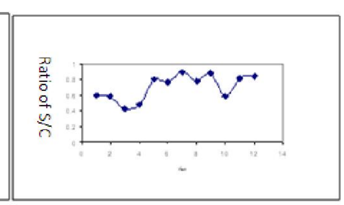
The most important points about the charts is the highness of charts and the high accuracy of the numbers in the table in case 2 compared to case 1 and this shows that in case 2 that demands are optimized, compared to case 1 that optimization of reservoirs capacity was considered about increasing the supply, we observed better results. Based on the charts about dam A, if the ratio of supply to the demand and capacity of reservoir is close to 1, the exceeding from the numbers is less than 0.1 that is an acceptable number.

The above issues about dam B were investigated and are shown in Figure 3.



Case 1





Case 2 case 3

Fig 3: The curve of changes of reservoir supply during one year for dam B

Based on the above charts in comparison of the cases 1,2, case 2 in this dam presented better result.

Results

Generally, by genetic algorithm method, we can optimize the systems consisting of some consecutive reservoirs by presenting the assumptions based on the reality and by selecting the good penalty functions and finally an ideal objective function can be optimized.

In each stage of the stages of this method, it should be considered that the numbers as the result of each generation should have high qualification to the previous generation to be evaluated by consecutive replications; the optimized value of objective function is evaluated.

In the current study, with the comparison done about the optimization of the various parameters of double reservoir system and by investigating the charts and tables, the effective role of optimization of all the constituent elements of the system was defined in achieving the good objective function. It is obvious that in optimization conditions of all the parameters, the highest closeness to the objective function is occurred. But the aim of the study is the investigation of the preference of optimization of parameters in cases of selecting mono-parameter and its influence on optimized operation of the reservoir in multi-reservoir systems. Here in two various cases, at first the capacity and then the amount of shoal requirements are optimized absolutely and in each case, the closeness percent to objective function was calculated by multi-population genetic algorithm. In the comparison between the recent cases, in mono-parameter selection condition, the optimizations of the requirements with 99.4% closeness to the objective function were introduced.

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