COMBINED REMOVAL OF SEDIMENTS FROM THE CHIRYURT RESERVOIR

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The Chiryurt reservoir on the Sulak River, put into operation in 1961, had an original total storage of 98 and useful of 9 million m³. During the next 7 years it was subjected to considerable silting, as a result of which its storage decreased to 1.5 million m³. After conducting a series of hydraulic flushings [1, 2], it was possible to partially remove the deposited sediments. With the construction of the Chirkey and then the Miatla hydro developments in 1978 and 1988, the Chiryurt reservoir began to receive clarified water, the process of intense siltation stopped. Subsequent observations showed that within the 2-m drawdown storage the regulating storage changes little and presently amounts to 7-8 million m³.

Considerable siltation causes difficulties in operating the reservoir by the water users, including the power industry. For example, the Miatla hydrostation at maximum load releases a 2.5 times greater discharge than the diversion works located below the Chiryurt hydrostation can take in. Owing to the lack of the regulating storage of the reservoir the possibilities of the operation of the cascade are limited in a number of gases, sometimes idle discharges of water occur, which, naturally, leads to losses in the generation of electricity.

Since 1985 the sediments have been being removed by means of a ZGM-1-350-A dredge with a sediment capacity of 145 m³/h along with hydraulic flushing. The operating plan of cleaning, drawn up by the Baku branch of the All-Union Planning, Surveying, and Scientific-Research Institute (Bakgidroproekt), called for excavating the sediments in two stretches: on the left bank near the irrigation intake on an area of 150 × 600 m with a volume of 260,000 m³ and on the right bank near the intake on an area of 150 × 300 m with a volume of 130,000 m³; the estimated cost of the work was 387,000 rubles. The rather high cost of the works limited the use of hydraulic flushing to local zones near the intake works and in comparatively small volumes.

At the same time, hydraulic flushing has the advantage that it is possible to remove the sediments by the dredge to preassigned regions of the reservoir, thereby excavating deposits of the necessary profile and depth. This cannot be achieved by hydraulic flushing. The sediments are removed mainly from the channel part of the reservoir, affecting little or not at all the deposits along the banks and especially where they have become compacted and overgrown by reeds. Furthermore, scouring of sediments can occur at low elevations and thus a part of them will be removed not from the zone of the regulating storage but from the zone below the dead storage level.

To increase the effectiveness of removing sediments, the management of the cascade of Sulak hydroelectric stations and the Industrial Association for the Organization and Improvement of the Technology of Operating Electric Power Stations and Networks (Soyuztekhenergo) developed and tested a method of combined removal — the use of a dredge and hydraulic flushing [3]. In this case, the purpose was to unite the positive qualities of each of the methods, namely, the cheapness and high effectiveness of flushing with the possibility of cleaning in a preassigned region of the reservoir. This is accomplished in the following way.

Pilot channels (cuts) are made in the sediment deposits to be removed by means of a dredge. They are made curvilinear in plan with the concave side facing the deposits to be washed away. The width of the cuts is 10-20 m (based on conditions of performing the work), and the depth should provide passage of the flushing flow with decrease of the pool. The start and end of the cut should extend into the channel part of the reservoir. Under these conditions two factors having a positive effect on removing sediments by flushing occur. First, at the place of the reservoir where the cut (or system of cuts) is located there will be an increase of the cross-sectional area and, consequently, some decrease of the level. This in turn will lead to an increase of the slope of the free surface of the flow on the upstream stretch of the reservoir corresponding to an increase of the flow velocity and, as a consequence, to an increase of the effectiveness of eroding the deposits and their transportation. Second, passing through the cut, the flow will erode the sediment deposits along the length of its concave part.

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Fig. 1. Schematic diagram of the location of the cuts in the Chiryurt reservoir: 1) intake works; 2) pilot channel of the first phase; 3) pilot channel of the second phase; 4) pilot channel of the third phase; 5) zone of cleaning by the dredge; 6) boundary of the reed beds.

and transport them to the main channel with further discharge into the lower pool. The effect from each of these factors can change depending on the local conditions (topography of the reservoir bed and degree of its siltation, composition of the sediments, location and size of the cuts in plan, conditions and regimes of flushing, etc.).

It was suggested to make three or four cuts in the dam part of the reservoir (Fig. 1). The first of them, located in the immediate vicinity of the main channel, is presently completed. Its actual length was 180 m, depth 2.5-3.5 m, and total volume of the excavation 25,000 m$^3$.

However, the cut made substantially differed from the planned: instead of curvilinear, its form in plan had the shape of a trapezoid with a variable width from 20 m at the inlet to 80 m at the outlet. This is related to the fact that the dredge used was originally intended for cleaning a reservoir over the area and by virtue of its technical characteristics it could not excavate a narrow curvilinear cut.

Two experimental hydraulic flushings were carried out after completing the cut: the first with lowering the pool by 1 m below the normal pool level (NPL) lasting 9 days and the second with lowering the pool by 2 m below the NPL lasting 26 days (during the planned shutdown of the hydroelectric station for repairing the diversion canal).

The water levels in the reservoir, discharges, and inlet and outlet sediment concentration of the flow were measured for observation of flushing. In addition to a routine check, a topographic survey of the stretch of the reservoir where the cut was located immediately after its completion and 4 months later was made twice.

During the 26-day flushing the water discharges did not remain constant: during 24 h they changed severalfold in the range from 100 to 500 m$^3$/sec, which is related to the peak-load operating regime of the upstream Miatla hydrostation.

To keep the level constant at 2 m below the NPL, it was necessary to constantly operate the gates on the headworks, regulating the discharge into the lower pool.

On the basis of the observation data, the sediment concentration of the flushing flow was plotted as a function of the discharge. Despite the scatter of individual measurement points (which is related to the unsteady regime of the stream), a clear-cut relation is noted between the sediment concentration and the discharges (Fig. 2). An excessive sediment concentration of the flushing flow occurs at a discharge greater than 150 m$^3$/sec and it markedly increases with increase of discharge. Thus, at a discharge of 200 m$^3$/sec the sediment concentration is 0.03 g/liter and at 300 m$^3$/sec it increases 8 times (0.23 g/liter); at 400 m$^3$/sec it more than doubles in comparison with the preceding (0.52 g/liter). Thereafter at discharges of 500 and 550 m$^3$/sec the sediment concentration continues to increase, although not so intensely and is respectively 0.86 and 1 g/liter.

For the adopted calculated unit weight of the sediment deposits $\gamma = 1.5$ tons/m$^3$, 15, 160, 500, 1000, and 1300 m$^3$ of sediments is flushed per hour from the reservoir at discharges of respectively 200, 300, 400, 500, and 550 m$^3$/sec. Depending on the size of the flushing discharge and regimes of its variation during 24 h on average from 2000 to 5000 m$^3$ of sediments (maximum 12,000 m$^3$) was removed from the reservoir in this period, and in all during the 26 days, 74,000 m$^3$ of sediments was removed.