REPAIR OF THE DAMAGED SHAFT OF THE NO. 4 GENERATOR OF THE UCH-KURGAN HYDROELECTRIC STATION

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The Uch-Kurgan hydroelectric station on the Naryn River (Republic of Kyrgyzstan) was put into operation on November 5, 1962. The hydrostation with a capacity of 180,000 kW at a design head of 25.8 m and discharge through one turbine of 186 m³/sec annually produces 820 million kWh of electricity.

The powerhouse of the hydrostation is combined with eight bottom outlets. In it are installed four units with Kaplan turbines and overhead generators with thrust bearings on a rigid helical support and with elastic metal—plastic segments with a fluoroplastic coating. An experimental two-blade turbine (unit No. 2, turbine of type PL-707-VB-500 with a capacity of 45,500 kW, rotational speed 115.4 rps, generator SV-840/150-52) was put into operation for the first time in the world at the station.

Installation of the first unit began in May 1961. Units Nos. 1, 3, and 4 (turbines of type PL-577-VB-500 with a capacity of 41,750 kW, speed 115.4 rps, generators SV-840/150-52 with a capacity of 45,000 kW, voltage 10.5 kW, speed 265 rpm, allowable load on the journal 1100 tons) were put into operation at the following times: No. 1 on January 2, 1962, No. 2 on June 3, 1962, No. 3 on September 6, 1962, and No. 4 on November 5, 1962.

A 250-ton bridge crane with an auxiliary 30-ton hoist was installed in the machine hall of the powerhouse.

Between June 1, 1993 and June 30, 1993 unit No. 4 was operating under supervision after completion of overhauling with complete dismantling of the unit with removal of the turbine runner. An inspection of the thrust bearing of the generator revealed the presence of oil on the bearing cover. It was not possible to establish the cause of the occurrence of the oil.

In early July 1993 the operating service checked the leather seal of the bearing bushing and seal housing, a chemical analysis of the oil was made, oil was poured into the bearing with the unit stopped, water was fed into the oil coolers with a check of the oil level in the bath, the operation of the oil-level relay was checked, and trial starts of the unit at no-load speeds were carried out with subsequent checking of the enclosure and oil header.

On July 15, 1993 the oil leakage onto the bearing cover increased markedly, and the unit was stopped under emergency conditions. After dismantling the thrust bearing a crack was found in the groove of the generator shaft under the circular key of the bearing bushing around the circumference of the shaft to 50% of the total length of the circumference.

On July 22, 1993 the metals and welding laboratory of the Kyrgyz Power Equipment Repair Plant (Kyrgyzenergoremont) made an ultrasonic inspection of the generator shaft. The inspection was made with a UD-12 flaw detector with a direct finder at 1.8 MHz.

A through crack with a length along the outside diameter of 970 mm and along the inside diameter of 700 mm was detected in the upper part of the circular groove at the place of attaching the bearing shaft (Fig. 1) by a lock ring to the shaft. The distance from the upper end of the generator shaft to the crack was from 412 to 429 mm. Further operation of unit No. 4 was impossible before eliminating the defect (Fig. 2).

Several variants of reconditioning the generator shaft were examined, including two main ones:

1. Without dismantling the generator shaft, the severed part of the shaft is fastened by eight M80 × 6 bolts, for which is was necessary to drill 86-mm-diameter, 480-mm-deep holes in the end of the shaft, to finish drilling the 86-mm-diameter hole to a depth of 670 mm by a 74-mm-diameter drill and cut an M80 × 6 thread to the depth of the tap, to make an undercut with a diameter of 120 mm and depth of 55 mm, to manufacture the bolts. The tightening torque of the bolts is 2.55 tons-m. Then the crack is cut by an air-arc cutter along the inside and outside diameters, the cut is cleaned and
degreased, the shaft is heated in the crack section to 250-300°C, and welding is carried out with electrodes UONI-13/55 or OZL-8 with a diameter of 3-4 mm. Welding is carried out at first along the inside and then outside diameter. After completing welding the temperature of the zone is kept for 5 h at 250-300°C with subsequent checking by dye penetrant inspection after cooling.

This variant was rejected due to difficulties in performing vertical drilling of the generator shaft and subsequent cutting the M80 thread under conditions of the hydrostation.

2. The bearing bushing is removed from the shaft. The crack is checked by dry penetrant inspection; the ends of the crack are drilled by a 15-mm-diameter drill; the defect is completely removed by air-arc gouging starting from the inside diameter. Cleaning, checking of the elimination of the crack by dye penetrant inspection, and heating to 200-300°C are carried out, after which welding is carried out starting from the inside diameter. Then the root of the weld is sampled from the outside by the mechanical method and dye penetrant inspection is carried out. During continuous welding cooling below 250°C is not allowed, and at the end of welding a temperature of 250-300°C is maintained for 5 h; after complete cooling mechanical cleaning is done for dye-penetrant inspection.

In the machine shops the bearing bushing was installed on a vertical boring and turning lathe, adjusted by seating rings, and control bands were machined at the working places of the lower and upper bushing seals. After this the bearing bushing was cut into two parts over the height. Connecting flanges were made and fitted to the cut parts of the bushing.

Machining for a new lock ring was carried out in the upper part of the bearing bushing on the vertical boring and turning lathe. The upper part of the bearing bushing was connected to the lower part by 16 M24 pins.

Measurements along the control bands of the newly connected bushing showed a wobble within 0.03 mm.

The generator rotor was raised on brake jacks in the pit of the unit. The lower part of the bearing bushing was heated, connected to the specular disk, and put on the generator shaft. Eight 50-mm-diameter holes were drilled through the bearing bushing into the generator shaft with a depth of not more than 40 mm, eight 50-mm-diameter pins and segments of