THE HYDROUNIT OF THE KRASNOYARSK HYDROELECTRIC STATION

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At the Krasnoyarsk Hydroelectric Station* (Fig. 1) hydrounits (Fig. 2) with a capacity of 500 MW are being installed, which are unequalled either in Soviet or foreign hydro-power construction. Radial-axial hydraulic turbines† (Francis turbines) produced by the CPSU XXII Congress, Leningrad Metal Plant (LMP), have PO 697-VM-750 rotors with a diameter \(D_1 = 7.5\) m. Starting with a design head of 93 m the turbine develops 508 MW. The discharge capacity of the turbine is 615 m\(^3\)/sec; its efficiency in the optimum zone reaches 94%. The speed of rotation \(n_{\text{nom}} = 93.8\) rpm. The operation of the hydro-turbine equipment is fully automated.

The turbine rotors are one-piece. They were delivered to the construction site by water transport on a specially reequipped seagoing lighter. A pier equipped with a 260-ton bridge crane was constructed for unloading the lighter. A special trailer was made up for moving the rotor to the assembly crane of the station. The use of one-piece rotors of simplified design and smaller weight considerably expedited the work of assembling.

The turbine cover has a conical belt and an open inner part which makes it possible to repair the turbine bearing without lifting it. The turbine's bearing was designed with rubberized inserts, water lubricated. The bearing space has an end-type packing, with rubber rings. At the contact with the bearing the shaft has a removable stainless steel jacket. A packing is provided in the lower part of the bearing which separates the bearing from the rotor and permits repairs without emptying the turbine draft tube.

One of the most serious problems in the planning of the hydrounit was the development of the volute chamber. Investigations resulted in an increase of the coefficient of the incoming velocity to 1.04 which determined the intake diameter of 8.7 m by means of some changes in the outlines of the volute chamber it was possible to achieve good power characteristics in the first section. The volute chamber is assembled on location and is welded from individual plates up to 35 mm in thickness which were rolled and fitted beforehand in the plant. At points of highest load alloy steel was used. To reduce the stresses in the metal where the volute chamber joins the stator, part of the load is transferred from the hull to the concrete which in this area adjoins the metal without an elastic gasket. To arrive at a more precise distribution of the loading and of the reinforcement diagram of the concrete part of the structure a special investigation was carried out on a large model (scale 1:10).

The welded-cast stator of the turbine consists of two belts connected by 12 cast streamlined columns. The lower belt rests on a foundation and is attached with anchor bolts. To meet transport conditions the stator was made in 6 parts. The guide apparatus of the turbine consists of 24 veins supported at three points with a reduced eccentricity which precludes the possibility of self opening under water pressure even with the loss of oil pressure in the governor system. The drive of the control apparatus is accomplished by two straight-axle, paired, dual servomotors, affixed on the support of the step-bearing. Such a placement of the servomotors simplifies the construction of the turbine pit. A swinging beam with an electrical three-ton telpher is installed in the pit.

The tapered portion and torus of the draft tube is metal lined to a height \(2.6D_1\).

The turbine is equipped with an electrical hydraulic governor which insures automatic operation of the unit under no load, during isolated operations for a selected user, and when operating in the system with group regulation. The oil pressure installation (OPI) has a working pressure of 40 atm which makes possible a reduction in the sizes of the servomotors, the D-valves and the pipelines of the regulating system.

† See paper by M. I. Gal'perin published in this issue.

Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 8, pp. 3-9, August, 1967.
The principal weight data of the "PO 697-VM-750" turbine are as follows:

- Volute chamber: 250 tons
- Stator: 180 tons
- Foundation part and lining of the cone: 60 tons
- Rotor: 240 tons
- Shaft of the unit: 100 tons
- Control apparatus: 385 tons
- Servomotors: 15 tons
- Guide bearing: 18 tons
- Governor: 17.9 tons
- OPI (oil pressure installation): 17.9 tons

Total weight of one generator: 1,365 tons

The "SV 1690-64" type generators manufactured for the Krasnoyarsk station by the S. M. Kirov Leningrad "Elektrosila" association have a number of distinguishing characteristics: the generators are umbrella-type with the step-bearing support on the cover of the turbine. A system of forced air cooling of the rotor and of direct water cooling of the stator winding was adopted for the first time for large hydrogenerators. The generator has no special shaft. Its function is performed by the massive central part of the rotor in which the shaft of the turbine and the rotating part of the bearing are attached. The hydrogenerator is designed for 155 rpm (1.65 \text{~n}_{\text{nom}}); however, when the runaway speed of 180 rpm is reached the stresses in the rotor will not exceed the proportional limit and its deformation will be smaller than the air clearance between the rotors and the stator.

The rotor has 8 removable spokes bolted to the central part. The rim is assembled of stamped segments 3 mm thick. The stator consists of six sectors which, unlike the previously used method of bolted connections, are assembled into a ring by welding. The step-bearing is one-row with self-setting segments. The unit load is about 38 kg/cm². Two rows of oil-pipe coolers are built into the oil bath. The coils for circulation of the cooling water are built directly into each segment. The bath of the step-bearing, with an external diameter of 6.2 m and a weight of 20 tons, was made in one unit and delivered by water transport together with the turbine rotors. The generator has a babbitt bearing with self-setting segments and is built into the upper radial type cross-piece. The bearing oil bath has a tubular oil cooler.

The generator brakes with retinaks linings are pneumatic, but are used hydraulically in lifting the rotor for repairs. Compressed air for braking will be supplied from an OPI tank with a pressure reduction down to 7 atm. Screw jacks are also provided.

The generator has circular sprinkler pipe lines for fire extinguishing in the regions of upper and lower frontal parts of the stator winding and above the stator of the auxiliary generator with an automatic control of the water supply from a special fire sensor. The water in the circular water line will come through a main fed from the volute chambers of several of the turbines and as a reserve, directly from the upstream pool. To avoid damage to the frontal parts of the winding by an excessively strong water stream its pressure will be reduced to 3.5 atm.

The principal weight data of the "SV 1690-64" generator are as follows:

- Upper crosspiece: 116 tons
- Step-bearing with bath: 70 tons
- Rotor: 884 tons
- Stator: 410 tons
- Auxiliary generator: 55 tons
- Exciter: 25 tons
- Regulating generator: 5 tons

Total weight of one generator: 1,640 tons