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DIFFICULTIES IMPOSED BY ICE CONDITIONS DURING HEP CASCADE CONSTRUCTION ON KOLYMA RIVER

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The construction of high dams and making of great reservoirs has change the hydrological condition of rivers. According to many years investigation on great numbers of Hydroelectric object it is revealed considerable changes of ice, thermal and winter water stage regimes downstream both near the dam and in substantial distance from it.

At HEP cascade construction the observations and ice thermal characteristics used for prognosis of ice conditions for regulation of water discharges during winter period take paramount importance.

At present Ust-Srednekanskaya HEP is being constructed on Kolyma R., 217 km downstream operating Kolyma HEP Kolyma R. flows in the territory with the severe climate are distinguished with complicated ice conditions: ice jam freezing, great thickness of ice, breaking up of ice gorge.

By putting into full capacity operation in 1989 year are occur substantial changes of ice thermal conditions downstream. Mean monthly discharges into November – April period during temporary operation of Kolyma project (1983 – 88 years) is increased 2–6 times, during permanent operation from 1983 year into 5–50, the least – 100 times. Augmented during winter period thermal discharges intensified the frazil ice formation downstream of Kolyma HEP thereby increased the danger of ice jam origin.

In the end of October (1998 year) on the constructed site of Ust-Srednekansk HEP during freezing period arose ice jam danger situation. Formed ice jam at Ust-Srednekan settlement (12 km downstream down site) is provoked rising of water level on construction site. To the worth of ice conditions side by side with consolidation of ice jam and long standing of high ice jam levels was furthered by the sharpening change of Kolyma HEP discharge.

By experience of HEP operation in areas with the severe climate conditions the exceeding of day discharge fluctuation more than 30% from mean daily rate during the period of intensive ice formation and ice cover leads to consolidation of ice jam at the edge of the ice and complicated ice conditions.

Annual pre-freezing rising of water level at Ust-Srednekan dam site are 2–3 m and limitations, bringing into daily operating amplitude of above situated HEP diminish complications during construction period.

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During spring period at Ust-Srednekan dam site occur infrequent ice gorges owing to on the whole simultaneous breaking up of tributaries downstream Kolyma R. So in May of 2002 year massive ice gorge upstream constructed Ust-Srednekan HEP formed when tributaries were broken up at steady ice cover in the area of constructed dam. The shift of ice gorge to foundation pit caused it flooding. As foundation pit location in geomorphology is favourable for ice gorge formation the danger of repeat of extraordinary situation would demanded the searching of effective means to decrease ice gorge levels.

The principal problems were to prevent outstripping breaking of Kolyma tributaries relatively to main river bed at dam site.

Those can be achieved by man-made retardation of tributaries or intensive speeding-up of main bed ice-break near dam site or simultaneously efforts in both directions.

Prevention of breaking up of 4 great tributaries is very difficult, needed much costs and risky. An accessible means is additional freezing of ice cover in the tributary offings by means of log-pas watered during the construction over ice surface. For all this is uncertainty about ice-breaking detention time and if debacle in tributaries occurred nevertheless early then in Kolyma River such arrangements have increase the possibility of hanging dam formation. The speeding-up of Kolyma R. breaking up in the area of Ust-Srednekan HEP in the spring of 2003 year by traditional methods such as snow clearing, blacking, explosion were undertaken. However in North-East Siberia where snow thickness on the rivers is 1-2 m and those methods could not make essential influence on breaking time and hardly possible to realize. To take down snow cover make sense only with positive day air temperature because ice do not demolished but on the contrary increase additionally. For reason time of snow clearing has move to breakup time and it effect brings to nothing.

In the absence on the River of openings downstream of constructing dam ice cover was not blasted as being not affective. And at last for ice cover blacking was not founded necessary substance.

In those circumstances the more effective appeared the preliminary estimated gradual increasing of Kolyma HEP discharge for acceleration of passing of edge of the air hole in the ice cover downstream past Ust-Srednekan HEP.

Position of ice limit and it down-upstream drifting was calculated used in Hydroproject Rossinsky 's method corrected by computation and observation on operating Krasnojarskaya, Ust-Ilimskaya, Zejskaya, Vilujskaya 1-2, Sajano-Shushenskaya and Majnskaya HEPs.

Rossinsky 's method is based on solution of heat balance equation of water flow at it interaction with atmosphere, bottom and ice cover.

From heat balance elements are considered such as:

1. Heat enter with water discharge from reservoir;
2. Heat return by flow's bottom;
3. Transformation into heat hydraulic resistance energy;
4. Heat return of open water surface (or ice cover) into atmosphere.

The calculation of lead length (L_{fin}) includes in it determination of zero temperature line (L_0) position i.e. line position according HEP where water is cooled zero temperature and where begins process of frazilizaishon.

Principal calculate dependences for determination position profile of beginning ice formation (L_0) and position profile of brine (L_{fin}) are consciously simplified for purpose of engineering calculations comfort.

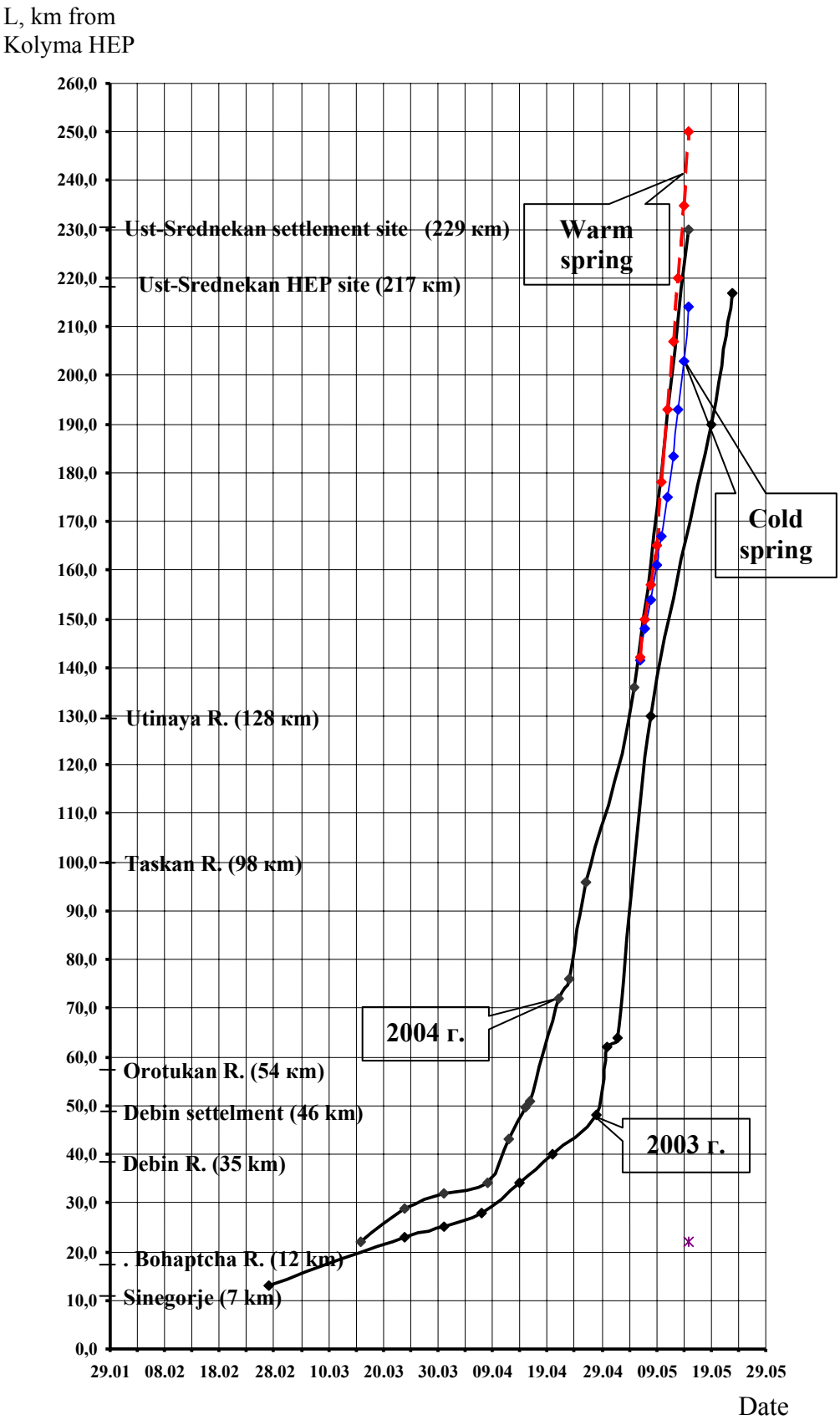

Fig.2. Observated and calculated lengthes of openings in Kolyma HEP downstream

In the spring of 2003 and 2004 year this mode had success. Kolyma HEP discharge was gradually during some days increased from 300 to 925 m^3/sec. That gave the possibility to gullies formation and weakening of ice cover of Kolyma River upstream the Ust-Srednekan and stepping back of the edge of the ice on 2 days early in 2003 and 10-12 days in 2004 year. Ice drift occur without complexes (tabl).

Dates of the beginning of the debacle, water levels, maximum discharges, ice thickness inUst-Srednekan site during spring period

Year	Date of the beginning of the debacle in Ust-Srednekan site	Date of the beginning of the debacle in tributaries	Water levels H_{vax} in Ust-Srednekan site, m	Ice thickness h_{ice} max, cm	Maximum discharges through Kolyma HEP site, m^3/sec	Note
2002	14.05	13-14.05	238,0	200	–	Foundation pit of 1st stage flooded
2003	23.05	25-27.05	234,30	120	988	Debacle without complecation
2004	13.05	25-27.05	233,64	130	848	-«-

The proposed graph of Kolyma HEP discharges and calculated within it passing of the edge of the ice are possible at sufficient water equivalent of reservoir and snow pack able to securing idle discharge.