SREPOK 4A HYDRO POWER PROJECT - LOT NO.11

CALCULATION OF COOLING WATER SUPPLY SYSTEM

HCZN-SP4A-03050-101

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Examined:

Checked:

Calculated:

CONTENTS

1. General

The main consumers of cooling water system in this power station: the air coolers and the bearing cooler of turbine-generator unit and main shaft seal. Determine the diameter of each water pipe according to corresponding water consumption of each consumer which are provided by the manufacturers.

2 . Water Consumption of Consumers

The water consumption of the consumers will be mostly included as following:

Water consumption of main shaft seal: 50L/min=3.0m^3/h

Water consumption of the air-coolers: 210m^3/h

Cooling Water consumption of unit bearing:

769L/min = 46.14m^3/h

Working pressure of the coolers: 0.2MPa

total water consumption of units:

$$3+210+46.14=259.14(m^3/h)$$

According to the specification, the discharge of the cooling pump is 300m^3/h, 300m^3/h$\geqslant$259.14m^3/h, meet requirements. The discharge of the cooling pump 300m^3/h is selected.

3. The Manner Of Cooling Water Supply of Units

The scope of water head is 13.84m~18.78m in the power station.

Cooling water for each unit will be taken by water cooling pumps from its own tailrace separately. Then the taken water shall be delivered to the automatic strainer, then to main cooling water supply pipe of units. Then the cooling water will be supplied to the consumers of the unit by the main pipe.

4. Selection For Cooling Water Pipes And Main Equipments of Units

4.1 Calculation For Diameter Of Cooling Water Supply Pipe of Units

$$d_{JZ} = \sqrt{\frac{4\times Q}{\pi\times v}} = \sqrt{\frac{4\times 0.072}{3.14\times 2.5}} = 0.1915\ (m)$$

where：

Q ——cooling water consumption of the unit

$Q = 259.14\ (m^3/h) = 0.072\ (m^3/s)$

v——flow velocity of water in pipe.

d_{JZ}——the diameter of the unit cooling water supply and drainage pipe

We will select d_{jz}=200mm the diameter of cooling water supply and drainage pipe. So the velocity of flow should be calculated according to the following formula:

$$v=\frac{4\times Q}{3.14\times d_{jz}} = \frac{4\times 0.072}{3.14\times 0.2^2} = 2.29(m/s)$$

The velocity of flow doesn't greater than 2.5m/s according to the specifications. The velocity of water v=2.29m/s will be selected here. Meet requirements.

So the diameter d_{JZ} = 200mm of cooling water pipe of units will be selected.

4.2 Selection For Diameter Of Water Supply And Drainage Pipes Of The Generator Air-Coolers

The diameter of water supply pipe of the generator air-coolers should be calculated according to the following formula:

$$d_K = \sqrt{\frac{4\times Q}{\pi\times v}} = \sqrt{\frac{4\times 0.05833}{3.14\times 2.5}} = 0.1724(\mathrm{m})$$

where：

Q——Water consumption of the generator air-coolers（m^3/s）.

$$Q = Q_K = 210m^3/h = 0.05833\ m^3/s。$$

v——flow velocity of water in pipe.

d_k——the diameter of cooling water supply and drainage pipe for the generator air-coolers.

We will select d_k=200mm the diameter of cooling water supply and drainage pipe. So the velocity of flow should be calculated according to the following formula:

$$v=\frac{4\times Q}{3.14\times d_k}=\frac{4\times 0.05833}{3.14\times 0.2^2}=1.86(m/s)$$

The velocity of flow doesn’t greater than 2.5m/s according to the specifications. The velocity of water v=1.86m/s will be selected here. Meet requirements.

The diameter d_k =200mm of water supply and drainage pipes for the generator air-coolers is selected .

4.3 Selection For The Diameter Of Water Supply And Drainage Pipes Of Bearing of the unit .

The diameter of water supply pipe of bearing of the unit should be calculated according to the following formula:

$$d_B = \sqrt{\frac{4\times Q_B}{\pi\times v}} = \sqrt{\frac{4\times 0.0128167}{3.14\times 2.5}} = 0.0808\ (m)$$

where:

Q_B——Water consumption of thrust bearing of generator(m^3/s).

Q_B =769L/min =0.0128167m^3/s。

v——Flow velocity of water in pipe(m/s).

d_B——the diameter of cooling water supply and drainage pipe for the unit bearing.

We will select d_B=100mm the diameter of cooling water supply and drainage pipe. So the velocity of flow should be calculated according to the following formula:

$$v=\frac{4\times Q_B}{3.14\times d_B}=\frac{4\times 0.0128167}{3.14\times 0.1^2}=1.633(m/s)$$

The velocity of flow doesn’t greater than 2.5m/s according to the specifications. The velocity of water v=1.633m/s will be selected here. Meet requirements.

The diameter d_B =100mm of water supply and drainage pipes for the unit bearing is selected .

4.4 Selection For Diameter Of Water Supply for the main shaft seal

The diameter of water supply pipe for the turbine main shaft seal should be calculated according to the following formula:

$$d_B = \sqrt{\frac{4\times Q_m}{\pi\times v}} = \sqrt{\frac{4\times 8.3333\times 10^{-4}}{3.14\times 2.5}} = 0.0206(m)$$

where:

Q_m——Water consumption of the turbine main shaft seal (m^3/s).

Q_m =50L/min =$8.3333\times 10^{-4} m^3/s$。

v——Flow velocity of water in pipe(m/s).

d_m——the diameter of cooling water supply for the turbine main shaft seal.

We will select d_m=32mm the diameter of the turbine main shaft seal supply water pipe. So the velocity of flow should be calculated according to the following formula:

$$v=\frac{4\times Q_m}{3.14\times d_m} = \frac{4\times 8.3333\times 10^{-4}}{3.14\times 0.032^2} = 1.04(m/s)$$

The velocity of flow doesn't greater than 2.5m/s according to the specifications. The velocity of water v=1.04m/s will be selected here. Meet requirements.

The diameter d_m =100mm of water supply pipes for turbine main shaft seal is selected .

4.5 Selection for Automatic Strainer

The selection of automatic strainers should meet the requirement of the discharge. The automatic strainers shall be installed on intake pipe of cooling water supply pipe of units, so the discharge shouldn't less than the maximum discharge 259.14m^3/h of this pipe. According to specifications, one automatic water strainer shall be set for each intake pipe, whose type is **ZLSG-200 GⅡ,** that having the function of automatic self cleaning backwash . The parameters of selected automatic strainer as follows:

Parameter List Of Automatic Strainer **ZLSG-200 G**Ⅱ

type	Design discharge	diameter of intake and outlet	diameter of self cleaning backwash pipe	the rated power	precision of filtration
ZLSG-200 GⅡ	339m^3/h	200mm	80mm	0.75kw	2mm

5. Calculation for Pressure of Cooling Water

The manner of cooling water supply for this power station is taken water by cooling pumps from the downstream. The pressure calculation is divided into two parts. The first part is from intake of downstream to the inlet of the cooling pumps, the second part is from outlet of the cooling pumps to user of cooling water.

5.1 Checking for Suction Lift of the cooling Pump

Checking for suction lift of the cooling pump have to meet the requirement of the following formula

$$H_S \geqslant H_g + h_w$$

Where：

H_S—— practical allowed suction lift of the cooling pump

H_g—— the elevation difference from the center of the pump to the lowest water suction surface (m)

h_w—— total loss in oil inlet line (m)

5.1.1 Calculation for route loss along the suction water pipe

The cooling pumps directly taking water from downstream, the pipe is 200mm, its length should be calculated as the estimated length of 12m, assume the discharge of single pump is Q,

§e=0.025l/d,

$$h_{e1}=\S e\times V^2/2g=0.025\times(12/0.2)\times\frac{\left(\frac{4Q}{\pi\times0.2^2}\right)^2}{2g}$$

$$=77.54Q^2$$

5.1.2 Calculation for local head loss

The local head loss coefficient of DN200 pump suction pipe should be calculated according to the following table, the discharge of one pump is calculated as Q:

item	local loss coefficient	QTY
trash rack	§e＝3.8	1

transition pipe	§e＝0.21	1
90 º elbow	§e＝0.52	3
gate valve	§e＝0.07	1
tee joint T	§e＝0.6	1

Σ §e=3.8×1+0.21×1+0.52×3+0.07×1+0.6×1=6.24

$$h_{m1}=\S e\times V^2/2g=6.24\times\frac{(\frac{4Q}{\pi\times 0.2^2})^2}{2g}=322.57Q^2$$

5.1.3 Calculation for total head loss

$\Sigma h_w=\Sigma h_{e1}+\Sigma h_{m1}=(77.54+322.57)Q^2=400.11Q^2$

So, $H_S \geqslant H_g+h_w$

$H_S \geqslant (\triangledown 1-\triangledown min)+hw$

▽1—— the cooling pump elevation, ▽1=164.70m;

▽min —— the minimum downstream water level,

▽min=166.50

$H_S \geqslant (\triangledown 1-\triangledown min)+hw$

$H_S \geqslant (164.70-166.5)+400.11Q^2$

Q—— the cooling pump discharge , Q=300m^3/h=0.08333 m^3/s

$H_S \geqslant -1.8+400.11\times0.08333^2$

$H_S \geqslant 0.98(m)$

5.2 The calculation for the cooling pump lift H_J

5.2.1 Calculation for head loss

① The first segment of the suction pipe

The cooling pumps directly will take water from downstream. The first segment of the suction pipe is from intake to the cooling pump.

According to above calculation (part 5.1), the total head loss of the first segment is $400.11Q^2$=2.78m.

② The second segment of supply water pipe

The second segment is from the cooling pump to the all consumers.

In all consumers of cooling water, required pressure by the cooler of guide bearing is the maximum. Pressure design according to required hydraulic pressure by cooler of bearing can meet the requirement of pressure of all cooling water consumers.

a) Calculation For Head Loss Along The Route

From the cooling pump to cooler of bearing, diameter of water supply pipe is divided into four parts, ① pipe diameter DN200mm, length is 12m; Q ＝ 259.14m^3/h ＝ 0.072m^3/s; ② pipe diameter

DN100mm, length is 60m; Q＝769L/min=46.14m^3/h=0.01282m^3/s; then

§ e=0.025l/d,

$$h_{e2}=\text{§ e}\times V^2/2g=0.025\times(12/0.2)\times\frac{\left(\frac{4\times0.072}{\pi\times0.2^2}\right)^2}{2g}$$

$$+0.025\times(60/0.1)\times\frac{\left(\frac{4\times0.01282}{\pi\times0.1^2}\right)^2}{2g}$$

=0.4+2.04=2.44m

b) Calculation for Local Head Loss

Local water head loss coefficient from outlet of the cooling pump to the cooler of bearing should be calculated according to the following formula, h_m= § e×V^2/2g

item	local loss coefficient	QTY	pipe diameter（m）	velocity of flow（m/s）	water head loss（m）
gate valve	§ e＝0.08	2	DN200	2.29	0.043
90^o elbow	§ e＝0.72	2	DN200	2.29	0.385
Check valve	§ e＝5.5	1	DN200	2.29	1.47
strainer	§ e＝8	1	DN200	2.29	2.14
straight tee	§ e＝1	1	DN200	2.29	0.267
reduced tee	§ e＝0.88	2	DN200/DN100/DN200	2.29	0.47

gate valve	§ e＝0.2	2	DN100	1.633	0.11
90^{o} elbow	§ e＝0.63	8	DN100	1.633	0.35
Total					5.235

c) Total Head Loss for the second segment

$\Sigma h_2 = \Sigma h_{e2} + \Sigma h_{m2}$

$=2.44+5.235$

$=7.675m$

③Total Head Lo7.675ss

$\Sigma h=2.78+7.675$

$\Sigma h=10.455m$

5.2.2 The calculation for the cooling pump lift H_J

The elevation of the cooler for bearing is 183.0m, the minimum operation level in front of reservoir is 166.50m. The cooling pump elevation is 164.70m. According the Specification (SECTION 03050 PART 1.6) , the net head is 0.2MPa at inlet of cooler). So the required the cooling pump lift H_J is 20+10.455+(183-164.70)=48.755mH_2O.

5.3 Selection for the Cooling Pump

According to above calculation, the cooling pump must meet the following requirements:

the discharge of the cooling pump: $Q=300m^3/h$

the suction of the cooling pump: $H_S \geqslant 0.98m$

the lift of the cooling pump: $H_J \geqslant 48.755m$

The parameters of selected the cooling pump as follows:

Main Parameter List of the Cooling Pump

Design discharge	diameter of intake and outlet	Rated suction head	Rated pump head	the rated power
300m^3/h	200mm	4m	54m	110kw