WATER QUALITY ANALYSIS AND ITS RELATION TO THE SCALING AND CORROSION TENDENCY IN AN OPEN WATER COOLING SYSTEM

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Abstract

The problem of scaling and corrosion are common phenomena in a water cooling system especially the open cooling system. This study was carried out in Temenggor dam with an objective to check the water quality at the intake and tailrace of the hydro power plant. In-situ measurement and laboratory analysis on the water samples were carried out. Seven parameters were measured in-situ i.e. temperature, pH, specific conductivity, dissolved oxygen (DO), total dissolved solid (TDS), turbidity, and chlorine concentration. The water samples were collected using water sampler at three locations near the intake area at surface, and at the interval of one meter up to three meter depth. Two locations at the tailrace also were collected in the same pattern. These samples were brought back to the laboratory in UiTM, Shah Alam for further analysis. Laboratory analysis includes alkalinity, Ca^{2+}, Mg^{2+} and Fe^{2+} concentrations, and total suspended solid (TSS). From the results, the LSI, RSI and PSI were calculated to predict the scaling and corrosion tendency. The index shows strong tendency for corrosion to take place in the cooling system as the related factors supported it.

Keywords: scaling, corrosion, water quality, water cooling system.

Introduction

Water cooling system is a method of removing of heat from the component. Water is used as the heat transmitter. Usually water cooling is taken form the river, lake and estuary but, there are problems from the water itself such as water hardness and impurities. Water impurities can be in either gases form (oxygen, carbon dioxide and other) and solid form (suspended and dissolved). Suspended form include any impurities that are not dissolve (sand, silt) while the dissolved solid include any impurities that are dissolved in water supply [1, 2].

Deposition of scale is a chemical precipitation process where dissolved salts in the cooling water "out" surfaces in contact with the water due to their solubility limits being exceeded. Previous studies showed that the factor influences the scale are temperature, water hardness and pH. Corrosion is an electrochemical process by which a metal returns to its natural state i.e. forms oxide when in contact with oxygen. The factors influence the corrosion are chlorine, total dissolved solid (TDS), conductivity and temperature. Chlorine and conductivity can be related with TDS or total suspended solid (TSS) to form the corrosion. This is because, chlorine present in water as gas which is reacted with moisture in the air to produce hydrochloric and hypochlorous acids that corroded the steel. The higher the TDS or TSS values, the higher the conductivity of water and the higher the probability for corrosion to occur [3, 4, 5].

Considering these problems which are happening in Temenggor hydropower plant and other similar plants, this study was conducted to find out the effect of water quality on the cooling system especially the open system like Temenggor power plant which is taking the water into the cooling system directly without any prior treatment. The main objectives of this study are; to measure water hardness and metal content from the water source, to relate the water hardness value with the scaling index, and to suggest the possible treatment for these scaling and corrosion problems.

Method

The study was conducted at Temenggor Dam, Perak where the hydro power plant is located. Measurements were done at 5 locations, 3 points at the intake position and 2 points at the tailrace. Table 1 show the sampling and in-situ measurements locations.

Table 1: Sampling locations and in-situ measurement

LOCATION		DESCRIPTION
Point 1 (P1)	N 05º24.650' E 101º18.032'	The water intake position to the power plant
Point 2 (P2)	N 05º24.627' E 101º18.086'	
Point 3 (P3)	N 05º24.715' E 101º17.933'	
Point 1 (TP1)	N 05º24.212' E 101º18.014'	The tailrace of water from the power plant
Point 2 (TP2)	N 05º24.398' E 101º17.968'	

The in-situ measurements were done using Hydrolab for eight parameters including pH, temperature, dissolve oxygen (DO), conductivity, turbidity, total dissolved solid (TDS), free chlorine and depth in meter. The water samples were collected at the same location up to 3 meters depth using water sampler. The samples were preserved using concentrated HNO_3 at pH 2 and kept in refrigerator at 4°C prior to analysis. The analysis conducted were alkalinity, water hardness and metal content of the water.

Results and discussions

Table 2 show the results of analysis of water samples collected at different locations at Temenggor dam. Figures 1 to 6 shows the plots for pH, temperature, TDS, DO, conductivity, and free chlorine versus depth at the intake and tailrace.

pH of water is decreasing from 7.75 to 6.40 as we go deeper into the water column. pH measured at 12 meters depth is similar to the pH measured at tailrace. Similarly, the water temperature dropped from 28ºC to 24.8ºC. TDS increased from 0.02 to 0.04 ppm after going down to more than 15 meters. Specific conductivity and chlorine content are also increased after a certain depth, from 0.02 to 0.05 ppm and 2 to 8 ppm respectively. Dissolved oxygen dropped from 8 to 0.5 ppm. The trend for all parameters measured is, the measurements at tailrace are similar to the measurement at the depth below 10 meters. This indicates that the water going in to the cooling system is the water at the lower part, at least 10 meter depth.

The water hardness is a measure of concentrations of Ca^{2+} and Mg^{2+} as their carbonate. From the results it shows that the water is soft because the water hardness values are in the range of 8.16-10.11 ppm and 13.64-14.79 ppm for intake and tailrace respectively, which are less than 70 ppm (see Table 2). The factors influencing scaling are high methyl orange alkalinity (ppm as $CaCO_3$), high calcium contents (ppm as $CaCO_3$), high pH and high dissolved solids.

The LSI shows that the samples are free from the scale because based on theory, the value less then zero mean that no scale occurs. Meanwhile the RSI show that the samples have tendency for corrosion. Factors influencing corrosion are high dissolved solid, high temperature of water, high concentrations of chlorides and sulfates, carbon dioxide contents, impurities in water (total dissolved solids), pH and possible presence of free mineral acid, sulfide, SO_2 and others. We can say that, the problem occur in this cooling systems is corrosion but it may be other problems also which can influenced or contributed to cooling system such as scaling, fouling, and microorganism growth.

Table 2: Results of water hardness, alkalinity and metal content analysis done in the lab

SAMPLE	T (°C)	TDS	pH	[Ca]	HARDNESS	ALKALINITY	[Fe]
	(ppm)						
P1 (SURFACE)	27.9	0.0202	7.75	1.75	8.24	0.085	ND
P1 (1 METER)	27.9	0.0203	7.68	2.05	8.81	0.085	ND
P1 (2 METERS)	27.9	0.0203	7.64	1.92	8.66	0.090	ND
P1 (3 METERS)	27.9	0.0203	7.59	1.98	8.64	0.110	ND
P2 (SURFACE)	28.0	0.0202	7.61	1.80	8.16	0.085	ND
P2 (1 METER)	27.9	0.0204	7.59	2.12	9.25	0.080	ND
P2 (2 METERS)	27.9	0.0204	7.58	2.23	9.59	0.080	ND
P2 (3 METERS)	27.8	0.0204	7.38	2.42	10.11	0.085	ND
P3 (SURFACE)	28.6	0.0203	7.66	2.21	9.49	0.085	ND
P3 (1 METER)	28.2	0.0202	7.66	2.27	9.65	0.085	ND
P3 (2 METERS)	28.0	0.0203	7.68	2.26	9.76	0.080	ND
P3 (3 METERS)	27.9	0.0204	7.57	2.22	9.46	0.085	ND
TP1 (SURFACE)	24.8	0.0347	6.58	3.42	13.79	0.12	4.501
TP1(1 METER)	24.8	0.0348	6.44	3.56	14.23	0.105	4.101
TP1(2 METERS)	24.8	0.0348	6.39	3.34	13.64	0.115	4.378
TP1(3 METERS)	24.8	0.0351	6.39	3.42	13.86	0.11	4.356
TP2 (SURFACE)	24.8	0.0338	6.37	3.77	14.79	0.11	0.161

Table 3: Calculated indexes based on the measured values

SAMPLE	INDEX		
	LSI	RSI	PSI
P1 (SURFACE)	-4.5420	16.8340	-6.3488
P1 (1 METER)	-4.5417	16.7634	-6.2786
P1 (2 METERS)	-4.5858	16.8116	-6.2100
P1 (3 METERS)	-4.5361	16.6622	-5.8548
P2 (SURFACE)	-4.6666	16.8340	-6.3334
P2 (1 METER)	-4.6431	16.8762	-6.3671
P2 (2 METERS)	-4.6323	16.8446	-6.3463
P2 (3 METERS)	-4.7727	16.9254	-6.2095
P3 (SURFACE)	-4.5176	16.6952	-6.2344
P3 (1 METER)	-4.5129	16.6858	-6.2297
P3 (2 METERS)	-4.6234	16.7268	-6.3374
P3 (3 METERS)	-4.8609	17.2918	-6.4878
TP1 (SURFACE)	-5.3533	17.2866	-5.5513
TP1(1 METER)	-5.5349	17.5098	-5.7635
TP1(2 METERS)	-5.5726	17.5352	-5.6348
TP1(3 METERS)	-5.8027	17.9953	-5.7000
TP2 (SURFACE)	-5.5570	17.4840	-5.6556

Conclusion

The water cooling system in Temenggor hydro power plant is most likely facing the corrosion problem together with scaling, fouling and bacteria growth since RSI index showing corrosion tendency. The main cause of this problem is due to the untreated water going into the system and the system is not in operation for the whole year around.

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