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The Characterization of Cooling Waters by Using Stability Indexes

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Abstract

The primary objectives of cooling water treatment are to maintain the operating efficiency of the cooling water system and to protect the equipment that contacts the cooling water.

These objectives are accomplished by controlling or minimizing deposition, corrosion and microbiological growth on the cooling water system equipment.

In this paper, cooling waters are characterized considering the tendency of scale formation or corrosion phenomena apparition, based on stability indexes: Langelier saturation index (LSI) and Ryznar stability index (RSI).

Key words: *Langelir index, Ryznar index, cooling water*

Introduction

Deposits that occur in cooling water systems are usually divided into two categories: scale and fooling. The presence of either type of deposit in the heat exchangers can interfere with heat transfer there by reducing the efficiency of operation. Deposits can also promote under deposits corrosion phenomena [1-2].

To predict if scale would form in the hotter section, researchers have developed several scaling indices: Langelier Saturation Index (LSI) and Ryznar Stability Index (RSI). Langelier Saturation Index is used to predict the calcium carbonate scale – forming and scale dissolving tendencies of water. The method is based on determining the saturation pH (pH_s) at which calcium carbonate scale will start to precipitate out of solution. If the measured pH of the water is greater than its pH_s, (LSI > 0), there is a scale – forming tendency. If the measured pH of the water is less than is pH_s (LSI < 0), the water will have a scale – dissolving tendency [3-4].

Formula for RSI is: $RSI = 2pH_s - pH$

A value of 6 indicates “stable” water, a value less than 6 indicates a scale forming tendency, and a value greater than 6 indicates a scale – dissolving tendency.

Experimental Details

The composition and the characteristics of feed water and waters from different areas of heat exchange are presented in table 1.

Table 1. Characterization of the studied cooling waters

Corrosive medium	pH	HCO_3^- mg/l	Hardness mval Ca^{2+}/l	Conduct. µS/cm	Resistivity Ohm	TDS ppm	Salinity ppm
1 A	7.46	274.5	8.40	1300	756.6	792.7	675
2 A	7.97	274.5	9.04	1286	766.3	781.0	663
3 A	6.84	201.3	11.36	1643	598.6	1003.0	861
1 R	8.04	433.1	15.20	2174	445.5	1351.0	1176
2 R	8.12	445.3	16.40	2264	433.4	1385.0	1205
3 R	7.90	262.3	20.00	2859	344.8	1741.0	1400
1 E	7.41	280.6	8.96	1456	676.0	887.4	757
2 E	6.90	396.5	9.92	1283	768.6	780.5	664
3 E	6.90	372.1	9.84	1253	784.4	763.3	648

where: 1 A, 2 A, 3 A – feed water; 1 R, 2 R, 3 R - water from the cooler; 1 E, 2 E, - wastewater; 3 E - wastewater from downstream

To identify factors that determine the formation of scale, the sample from the cooler pipes was analyzed by X-ray diffraction (fig.1).

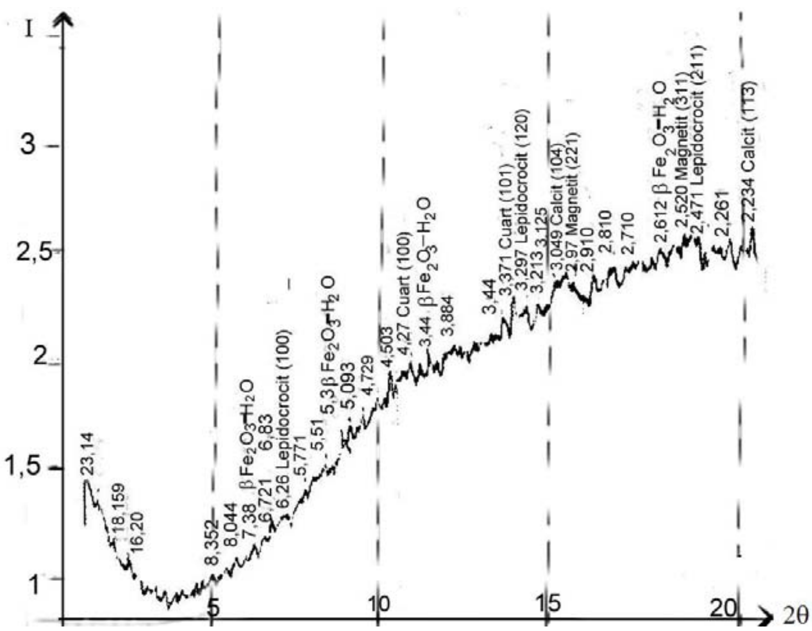

Fig. 1. X-ray diffraction spectrum of the crust (radiation Cu K_α, I = 1.54 Å)

Langelier saturation index was calculated by using the relation:

$$LSI = pH - pH_s$$

where: pH is pH – of the studied water, pH_s is pH – of water saturated in $CaCO_3$.

Usually, pH_s is calculated after the relation:

$$pH_s = 9.3 + S + t - D - A$$

where: $S = 0.1[\lg(TDS, mg/l) - 1]$

$t = -13.12 \lg(^{o}C + 273) + 34.55$

$D = \lg(Ca^{2+}, mg\ CaCO_3/l) - 0.4$

$A = \lg(T_{Alkalinity,}\ mg\ CaCO_3/l)$

Ryznar index is defined by the relation:

$$RSI = 2pH_S - pH$$

The values obtained for the stability indexes are given in table 2.

Table 2. The stability indexes of the studied waters

Sample	pH	Hardness mval Ca^{2+}/l	TDS mg/l	Alcalinity T mval/l	S	D	A	pH_S	LSI	RSI
1 A	7.46	8.40	792.7	4.5	0.2	2.22	2.35	6.93	0.53	6.40
2 A	7.97	9.04	781.0	4.5	0.2	2.26	2.35	6.89	1.08	5.81
3 A	6.84	11.36	1003.0	3.3	0.2	2.35	2.22	6.93	-0.09	7.02
1 R	8.04	15.20	1351.0	7.1	0.2	2.48	2.55	6.47	1.57	4.90
2 R	8.12	16.40	1385.0	7.3	0.2	2.51	2.56	6.43	1.69	4.74
3 R	7.90	20.00	1741.0	4.3	0.2	2.60	2.33	6.57	1.33	5.24
1 E	7.41	8.96	887.4	4.6	0.2	2.25	2.36	6.89	0.52	6.37
2 E	6.90	9.92	780.5	6.5	0.2	2.30	2.51	6.69	0.21	6.48
3 E	6.90	9.84	763.3	6.1	0.2	2.29	2.48	6.73	0.17	6.56

Results and Discussion

There is observed that waters of the cooling system (open recirculating) system have a relatively high content of salts. In the recirculation process there is a salts concentration which determines an increase of hardness from about 8 - 10 mval Ca^{2+}/l in feed water, to 15 - 20 mval Ca^{2+}/l in waters from coolers.

The presence of calcium and magnesium salts, especially of bicarbonates, dissolved in cooling waters, determines the apparition of scale by the precipitation of calcium carbonate at temperatures over 90°C.

Under the deposited layer, corrosion processes appear; these waters are in a permanent contact to air and contain dissolved oxygen which accelerates the corrosion process. The apparition of the corrosion processes is confirmed by the scale composition (iron oxides). In the same time, by waters treatment against scale formation (by acidulation), there are accentuated these corrosion processes, phenomena which are accelerated also by the increasing temperature in the system.

Conclusions

- Feed water of the cooling system has a high hardness. In the recirculation process, salts concentration appears, which determines the increase of hardness from 8 mval Ca^{2+}/l to 20 mval Ca^{2+}/l.
- Solid deposits from condensers have a complex structure and contain calcium carbonate, iron oxides, silica and amorphous substances, evidenced by the X-ray diffraction analysis.
- Ryznar index greater than 6 for cooling water of the installation indicates an intensification of the corrosion phenomena and a tendency of scale dissolution.
- Water from coolers presents an accentuated tendency of crusts formation (RSI < 6). This behavior can be explained by the fact that in the recirculation process of waters there is an increase in salts content, because of the evaporation phenomenon.

- Based on the analyses, it can be concluded that for waters used in the open recirculation cooling system from the gas compression station, corrosion processes have an important contribution to scales formation, these being determined by the salts content of waters, by the present oxygen- the system being in direct contact to the atmosphere- with the modification of waters composition in different treatment processes.

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Caracterizarea apelor de răcire cu ajutorul indicilor de stabilitate

Rezumat

Obiectivele primare în tratarea apei de răcire sunt de menţinere a eficienţei operaţiilor sistemului apei de răcire şi de a proteja echipamentul aflat în contact cu apa de răcire.

Aceste obiective sunt realizate prin controlul sau reducerea depunerilor, a coroziunii şi creşterii microbiologice de pe echipamentul sistemului de răcire cu apă.

În lucrare sunt caracterizate ape utilizate în sistemele de răcire, din punct de vedere al tendinţei de formare a crustelor sau de apariţie a fenomenelor de coroziune, pe baza indicilor de stabilitate: indicele de saturaţie Langelier (LSI) şi a indicelui de stabilitate Ryznar (RSI).