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Technical-Economic Justification of Replacing Clarifier Processes with Chemical Injections to Improve Cooling Tower Performance in a Selected Thermal Power Plant

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1. ABSTRACT

In this study, a thermal power plant is studied from the point of view of performance and costs of clarifier-related processes on the corrosion and fouling rate of the condenser. This power plant has four cooling towers that are responsible for cooling the condensate water returned from the condenser. Examination of the results of raw water and soft water after the clarifier (injection of FeCl_3 and CaOH) in recent years shows that the alkalinity and hardness levels before and after the clarifier have not decreased significantly. In the current situation, chemical control with the previous chemical regime leads to an increase in the corrosion and sedimentation rate due to the increase in the conductivity of the clarifier supply water. To tackle this issue, a new chemical regime based on the elimination of clarifier processes and the use of corrosion and sedimentation inhibitor compounds are proposed here. In order to investigate the effect of the new chemical regime on the condenser performance, investigation is conducted through coupon monitoring and chemical factor monitoring. The results of the condenser coupon monitoring indicate that the condenser corrosion rate is reduced by six times by applying the new chemical regime. Moreover, the rate of destruction of the wooden structure of the cooling tower in the control unit is 1.5 times higher than in the test unit. On the other hand, based on coupon monitoring results, the rate of sedimentation in the control tower is 1.7 times higher than that of the test cooling tower. Overall results indicate that the corrosion and sedimentation rates are much more effective with the elimination of clarifier processes and the application of the new chemical regime than with the previous regime. Therefore, it is recommended to eliminate the clarifier processes and use antiscalant and anti-corrosion for other thermal power plants whose supply water has been facing a decline in quality and increased conductivity in recent years.

Keywords: Thermal Power Plant, Clarifier, Anti-Corrosion, Antiscalant, Technical-Economic Justification.

2. INTRODUCTION

In this research, the main aim is to study the corrosion and fouling rate for the condenser of a thermal power plant. In the condensers of a power plant, a various range of corrosion including abrasion, galvanic, pitting, stress, microbial and crevice corrosion generally occur. In the subjected power plant, the cooling tower water is supplied from underground sources (well water). In order to reduce hardness of well water, adding coagulants such as CaOH and FeCl_3 in the clarifier is carried out with adjusting pH by using sulfuric acid. In the next step after coagulation and flocculation process, the water hardness is reduced and the soft water transferred to the cooling tower. It should be noted that adding coagulants leads to an increase in the pH of the cooling tower water which is optimized and controlled by adding sulfuric acid [1, 2].

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The results of water analysis of raw water and soft water in recent years show that the alkalinity and hardness levels before and after the clarifier have not decreased significantly. In the current situation, chemical control of cooling tower with the previous chemical regimen leads to an increase in the corrosion and sedimentation rate due to the increase in the conductivity of the clarifier supply water. On the other hand, adding a coagulant to in the clarifier process leads to consume high volume of chemical reagents. Moreover, clarifier process produces a huge amount of sediment which needs to be disposed. Therefore, the high costs of purchasing chemical reagents and disposing of sediments led this power plant to change the chemical regimen and eliminate the clarifier processes [3, 4].

3. MATERIALS AND METHODS

The material including EN262 and EN5677+ supplied by Energy Chemical Company Semnan of Iran. The EN262 contains organic biocide and the EN5677+ contains anticorrosion and antiscalant. These two substances are patented and the formulation license is held by Energy Chemical Company Semnan. A HANA brand conductivity meter and pH meter equipped are applied here. All chemical reagents are supplied by Merck company in analytical grade. Corrosion coupon including carbon steel, copper, admiralty and scale are supplied from Ab Sanjesh Abzar Pasargad Company. Moreover, the wooden coupon is provided by cutting the appropriate dimensions of wood obtained from the structure of cooling tower.

To perform water analysis experiments, three similar samples are taken from the condenser outlet for analysis of microbial factors and chemical parameters. Chemical analysis such as pH and conductivity are performed on site with portable devices. Moreover, the samples are transferred to the laboratory for anion and cation analysis. In order to examine the effect of the novel and previous chemical regimens on the cooling tower equipment (condenser, wooden splash bar, pump, pipes and other equipment) corrosion coupons is placed in a rack. Finally, the effect of the new and previous chemical regimens on these coupons is examined [5].

4. RESULTS AND DISCUSSION

In the subjected thermal power plant, corrosion monitoring is evaluated to understand the effect of reducing water quality on equipment corrosion. In the main cooling tower, a new chemical regimen is applied by removing the clarifier process and injecting biocides, anticorrosion and antiscalant. While in the control cooling tower, cooling tower water is supplied from a clarifier which is based on anticoagulant compound injection. To conduct the proposed research, corrosion is specifically evaluated on a corrosion coupon of condenser type (admiralty material) and a cooling tower coupon (wooden material). Moreover, a scale coupon is applied to monitor sedimentation rate.

To evaluate the coupon analysis, the admiralty coupon made of condenser and the wooden coupon made of cooling tower are used as representatives of specific corrosion coupons. The scale coupon made of stainless steel is selected as a representative of specific sedimentation coupon. The weight loss of admiralty coupon indicates the amount of condenser corrosion caused by the cooling tower water quality. The weight loss of the admiralty coupon for the main cooling tower is approximately 0.21 mg/day. The weight loss for the admiralty coupon in the control cooling tower is approximately 1.28 mg/day. These results indicate that the condenser corrosion rate is reduced by a factor of six with the application of the new regimen.

On the other hand, the weight loss in the wooden coupons shows the rate of degradation of the wooden material of the cooling tower. The weight loss of the wooden coupon in the control unit is 6.07 mg/day and for the main unit is 3.57 mg/day. The rate of degradation of the wooden structure in the cooling tower coupons of the control unit is 1.5 times higher than main unit. These results confirm that the removal of chromic acid and copper sulfate in the wooden material of the control cooling tower occurs over time under the conditions of the previous chemical regimen. This phenomenon leads to a decrease in durability, resistance and rapid degradation of the cooling tower of the control unit.

The results of the weight increase of scale coupon in the control and main cooling towers indicate the rate of sedimentation for the previous and new chemical regimen. The increase in weight of the scale coupon for the control and main cooling towers is 6.07 mg/day and 3.57 mg/day, respectively. The sedimentation rate in the control tower is 1.7 times higher than the main unit. The problems of the increase in sedimentation rate of cooling towers are including reduced heat transfer in the condenser tubes, increased thermal stress, the heaviness of the wooden structure of the cooling tower and its V-shaped fracture, clogging water flow, drop in the condenser vacuum, clogging of the pumps (CW Pump) and clogging of the condenser inlet and outlet filters.

5. CONCLUSION

In this study, a new chemical regime is implemented in a thermal power plant due to decreasing the quality of supplied water and the inefficiency of the clarifier process. In order to implement the new chemical regimen, a continuous injection of anticorrosion and antiscalant is carried out by applying organic biocide. During the period of changing the chemical regimen, the cooling tower of the main and control unit is examined daily from the point of view of corrosion (admiralty and wooden coupon examination), sedimentation rate (scale coupon), physicochemical parameters related to hardness, alkalinity, anion and cation concentration, free chlorine and active substance. The results of the coupon examination of the condenser indicate that the corrosion rate of the condenser is reduced by six times with applying the new chemical regimen. Moreover, the rate of destruction of the wooden structure of the cooling tower in the control unit is 1.5 times higher than in the main unit. On the other hand, the sedimentation rate in the control tower is 1.7 times higher than in the main cooling tower. Applying a new chemical regimen possess a long-term benefit including decrease in the corrosion rates, reduce in the waste work to compensate for losses caused by corrosion, reduce in costs and waste work of



maintaining the clarifier and system automation. Therefore, the elimination of clarifier processes and using anticorrosion, antiscalant and organic biocides is recommended for other thermal power plants whose supply water has been facing a decline in quality and increased conductivity in recent years.

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