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Design of coolers for use in an existing cooling water network

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ABSTRACT

This paper presents a procedure for the specification of design conditions for the incorporation of new coolers into existing cooling water networks. In practical terms, the location for the placing of a new cooler into an existing network will depend among other things on the plant layout; once this is decided upon, there are various ways in which the new unit can be incorporated, namely: (a) in a totally new parallel branch; (b) in series with other units in an existing branch and, (c) in parallel with an existing exchanger. This paper looks at the thermo–hydraulic effects that result when each of these options is considered. On the one hand, it is shown that the placing of a new unit in series with existing branches leads to reduced thermo–hydraulic disturbances upon the other units and, on the other, the installation of new exchangers in new branches results in increased disturbances which may prove less economical. The procedure involves the thermo-hydraulic simulation of the cooling water network which includes consideration of pump performance and cooling tower performance. An approximate sizing approach for new coolers based on the flow resistance factor (K) is introduced and incorporated into the analysis. Another important element considered in this work is fouling due to crystallization of inverse solubility dissolved salts. Results confirm the findings of other researchers that arbitrarily installing new coolers on new parallel branches is not a good practice. It is shown that the design of new coolers needs to be carried out in the context of the subsequent performance of the cooling network.

1. Introduction

Good engineering requires many factors be considered when a plant is to be modified. These include effects on the performance of existing equipment, plant control and plant flexibility. However, this can only be achieved when the engineer has procedures that permit such analyses to be undertaken. In the context of cooling water networks Tavares et al. [1] have recently shown the importance of considering the hydraulic effects when evaluating plant modifications. Anozie and Odejobi [2] demonstrated the importance of finding the optimum water flow rate in single condensers and its downstream effect in the case of a power plant. In this work, partially financed by an oil company, a case is examined where a new cooler is to be installed in a network that appears to have sufficient spare water capacity. It is found that in some situations a new unit does not provide the desired performance even though it appears to be over designed. This indicates that this type of problem should not be addressed solely through the evaluation of the design data of the new exchanger separately or through the utilization of conventional heat exchanger network simulation. It requires combined analysis of both hydraulic and thermal behavior.

Studies on the thermal operation of cooling networks have been carried out by Hyungtak et al. [3]. Their work looks at the optimal distribution of water flows through the cooling network using a mathematical approach. Kim et al. [4] appreciated that the interconnected nature of a cooling systems causes that any flow rate manipulation affects the thermal performance of other units. They used a non linear programming approach to determine the most effective strategy for flow rate manipulation by means of a set of control valves. Majozi and Moodley [5], studied the design of cooling systems for the case of multiple water supplies and multiple cooling towers using a mathematical approach. This study looks at the thermal aspect of the design. Gololo and Majozi [6] further look at the grassroot design of cooling water system for wastewater minimization. The network of coolers are first designed using non linear programming where a superstructure is proposed to find the best opportunity for cooling water reuse; the case of multiple cooling water sources or cooling towers is also analysed along with their thermal performance. Söderman and Ahtila [7] also appreciate the importance of a thermal and hydraulic analysis of heating and cooling systems in large processing plants. They propose a mathematical optimisation to find

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