ABSTRACT

An increase in water usage for industrial demand has led the increase in wastewater effluents. On the other hand, the availability of raw water resources is becoming so scarce and deteriorated in terms of both quantity and quality. It results in more complex treatment processes to yield in industrial water and consequently, high production costs. Besides, with the more stringent regulation for wastewater effluent standard in Indonesia, the industry has to comply it by improving the performance of its wastewater treatment plant. Therefore it is necessary to investigate the possibility to save water and energy in order to sustain the industrial development.

In this research, stepwise optimization for steam, cooling water network and wastewater treatment capacity was conducted by the water pinch method. The optimization development of superstructure method by using mathematical model was used to overcome the limitation of water pinch method. The steam minimization was carried out by letting high pressurized steams to flow down the medium and low pressurized steams. While optimization of cooling water network was conducted by altering parallel network system to the combination of serial and parallel network systems. Recycling of Heat Exchanger (HE) effluent to another HE was run continuously as long as it meets the quality requirement. To minimize the cooling water demand, it was carried out by increasing the returned temperature to the cooling tower. The difference of outlet cold stream temperature to inlet hot stream temperature was limited at ΔTmin of 5^oC. In this study, the value of heat duty Q was fixed, so that HE specification will not change. The superstructure optimization was analysed by considering all alternatives of the cooling water network configuration, and then it was solved by using Lingo 11.0.

Optimization of wastewater treatment capacity was carried out by analyzing the wastewater flow distribution, differentiating between the flow to be processed or to be discharged directly into water bodies. Prior to the optimization, the main pollutant should be specified first which was NH_3 in this study. The effluent concentration must comply with the effluent standard. The mathematical model was developed to distribute the wastewater, in order to obtain the minimum wastewater treatment capacity. The superstructure optimization was carried out by considering all alternatives of wastewater distribution configurations, and then solved by using Lingo 11.0.

Further method development was conducted to determine the minimum steam product, cooling water demand and wastewater treatment capacity, simultaneously. The optimization method was developed using mathematical models created by Lingo 11.0. The purpose of the development of simultaneous optimization method was to integrate the water networks of steam, cooling water and wastewater distribution in order to maximize reuse, regeneration and recycling water. The integration of the water network in the ammonia plant was able to reduce both raw water demand and wastewater treatment capacity.

The result shows that the minimization of steam demand was able to reduce steam demand by 35.5 tons/hour or by 18.2% of the total steam consumption, 194.79 tons/hour. The optimization of the cooling water network by the water pinch method reduced cooling water demand by 14.2% from the existing condition with the returned temperature to the cooling tower increased from 41,11 ^oC to 42.9 ^oC. While the superstructure optimization method reduced the cooling water demand by 14.18% from existing conditions with the returned temperature to the cooling tower increased from 41,11 ^oC to 50.9 ^oC.

The optimization of wastewater distribution by the water pinch method reduced the wastewater treatment capacity by 60.8% from 217 tons/hour. The influent concentration of the wastewater treatment plant was 391.2 ppm and the effluent concentration was 88.5 ppm. The optimization of wastewater distribution by the superstructure method could reduce the wastewater treatment capacity by 62.76%. This result was greater 5% than the result obtained by the water pinch method. The results using both water pinch and the superstructure methods showed that the effluents were still above the effluent standard. The superstructure optimization method with the target effluent concentration of 70 ppm as required by the effluent standard was carried out. The result showed that the wastewater treatment capacity could be reduced by 22.9% from the total flow of 217 tons/hour. The influent concentration of the wastewater treatment plant was 233 ppm and the effluent concentration was 70 ppm. It shows that the effluent of the wastewater treatment is able to be recycled into the cooling water when all of wastewater flows are treated through the wastewater treatment plant.

Results of the simultaneous optimization showed that the steam demand, cooling water demand, and the total wastewater treatment capacity could be reduced by 18.2%, 14.18% and 22.9% respectively. The reduction of the raw water demand was 1,909.2 tons/hour or 14.24% from the existing condition of 13,408.79 tons/hour. Superstructure method with the developed mathematical model is practical to use and is able to be applied for other industries.

Key words: cooling water, optimization, reduction, simultaneous, *steam*, wastewater