KKU ENGINEERING JOURNAL 2016;43(S1):180-182 Research Article

KKU Engineering Journal

https://www.tci-thaijo.org/index.php/kkuenj/index

50 Ton tubular ice factory production optimization

Nattadon Pannucharoenwong[1,2], Chatchai Benjapiyaporn*[2], Somnuk Theerakulpisut[2], Sittikorn Saeng-Uthai[2], Julaporn Benjapiyaporn[2] and Polkit Promteerawong[1]

[1]Faculty of Engineering, Thammasat University, Pathumthani 12120, Thailand.
[2]Faculty of Engineering, Khon Kaen University, Khon Kaen 40002, Thailand.

Received April 2016
Accepted June 2016

Abstract

The consumable ice industry is one of the most important consumable industry in Thailand due to the hot climate. There are two types of consumable ice in Thailand which are the tubular ice and the block ice. As there are over 1,500 ice production facility in Thailand according to the Ministry of Energy, large amount of power consumption had been made towards producing the product. Most of the factories are still not considerate about optimizing the production scheme or the machines they used. This leads to the considerations about determining a method to optimize the production process in terms of energy conservation and production efficiency. This research would be a piloted experiment towards an actual 50 ton capacity factory optimization process which the results proved that the five methods used had proved to reduce production time as well as lowering power consumption. The methods included machine maintenance, installation of insulating materials in lower tank, installation of VSD pump, and roof shielding for storage tank. Economically, the process would reached the payback point within two years and this could become a guideline for other production facilities that are interested towards operation research and optimization.

Keywords: Industrial, Optimization, Research, Ice, Consumable, Insulation

1. Introduction

Energy had become an important aspect in human life as there are more demand in each year. More energy source must be supplied to the increasing demands. Currently there had been no considerate solution towards the selection of components such as compressors, condenser, evaporator, or flow rate controller. There had been no study towards designing an energy efficient tubular ice production machine. Efficient energy management will help ice making industry as it will decrease the amount of imported energy and contribute to public knowledge. Ice making industry will benefit from lowered production cost that will lead to increase in profit.

According to the power conservation policy of the Department of Industrial Works Thailand, there are power conservation campaign made towards factories and enterprises in Thailand [1]. From the statistics of Department of Industrial Works (TSIC (Rev 3) No. 15494) it is found that there had been an increasing trend of ice production factories since 1970 [2]. The analysis of the current situation shows that ice making industry had suffered from high energy cost in all sectors. Investigation shows high energy loss in factories which will require urgent improvement. This components include the cooling system, water systems, and compressor. Smaller facilities will suffer more compared to larger facilities and as well as consumable ice sector will suffer more than non-consuming sector. It is found that companies do not use any evaluation index or having a practical system of accounting.

There are several approaches by various researchers towards ice production such as Poramate M., Puwanart K., and Montri P. had made feasibility evaluation, production optimization, and fan blade angle analysis respectively [3-5]. Other numerical and theoretical studies that are related to ice production contributed by researchers [6-9].

The following chapters would be the optimization process of a 50 ton tubular ice factory which would be piloted using five policies toward energy optimization. First, the inlet water temperature would be reduced using a heat exchanger. Second, the lower water reservoir would be insulated. Third, a maintenance of the cooling and ventilation system would be completed. Forth, a VSD pump would be used at the cooling pump. Fifth, the inlet water tank would be shielded with a roof.

2. Materials and Methods

2.1 Materials and schematics of ice production process

*Corresponding author. Tel.: +6697 247 3423
Email address: chaben@kku.ac.th
doi: 10.14456/kkuenj.2016.54

Figure 1 The 50 ton tubular ice maker

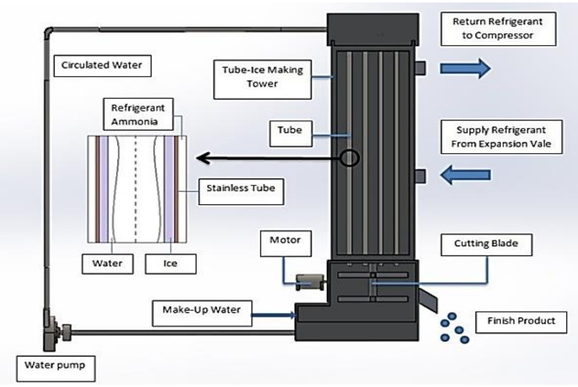

Figure 2 The ice production system schematic

Figure 3 Electrical Measuring Instruments

Figure 1 had shown the whole ice production machine including the cooling system. The system would be run according to the schematic diagram as usual and the electrical measuring instruments would compare the results before and after the optimization of the system. In Figure 2, the schematic diagram of the freezing tower had been shown. The VSD pump would be installed at near the makeup water tubing. Other optimization would be related to regular maintenance and water storage which is excluded from the schematic. Figure 3 shows the electrical measurement device that had been installed at the power terminal. The electrical measurement device is a Chauvin Model C.A. 8334 power analyzer that would collect the required measurements.

The heat exchanger is installed within the system in order to lower the inlet water temperature as shown in Figure 4. This would lead to better performance of the system as well as lowered production time as the inlet water temperature would be decreased.

Figure 4 Heat Exchanger

3. Results and discussion

Table 1 Investment and Savings Data

Item	Investment Per Machine (THB)	Payback Time (Years)	Savings Per Year (THB)
I. Heat Exchanger Installation	30,000	0.22	137,004
II. Tower Maintenance	21,250	0.33	63,804
III. VSD Pump	54,500	1.20	45,422
IV. Inlet Water Tank Roof	20,000	1.54	13,023
VI. Lower Tank Insulation	25,000	1.35	18,316

From the five methods of production optimization, it had proved to save up to 84,154 kWh per year per machine. The data of the investments and payback period had been shown above in Table 1. Figure 5 shows the percentage of savings divided into each approach showing the heat exchanger installation as the most effective approach since it is to reduce the inlet water temperature. It is followed by the tower maintenance, VSD pump installation, water tank roof installation, and lower tank insulation respectively.

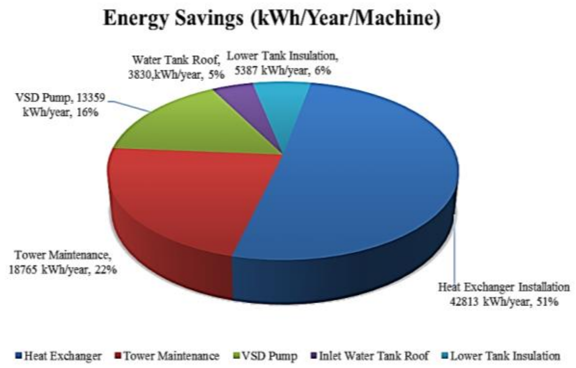

Figure 5 Energy savings from each power conservation policy

The methods made to the factory still have some further area for improvement still. The research still did not alter any physical features of the factory such as altering the building ventilation or optimizing the specification of the system. In the case that there are further improvements with these components, the system should achieve more performance.

4. Conclusions

The results showed that the five methods made toward power conservation resulted over 84,000 kWh per year per machine and the investment made would be repaid within two year. The most effective method found were the heat exchanger installation that was responsible for half of the savings made in the system optimization. Other modifications would assist in maximizing the total system's performance. This industrial research could be a guideline for other factories or industries toward energy conservation and optimization.

5. Acknowledgements

The researchers would like to express our gratitude to the Department of Mechanical Engineering at the Faculty of Engineering of Thammasat University for funding our research and the Automotive Engineering Program of Thammasat University for all supporting the venue of research. KKU-EMCO for your kind support towards our work.

6. References

[1] Diw.go.th [Internet]. Department of Industrial Works Thailand, Inc.; 2013. [Cited 2014 March 9] Avaliable from: www.diw.go.th/hawk/news/ประหยัดพลังงาน.pdf . [InThai].

[2] Sme.go.th [Internet] Office of Small and Medium Enterprises Promotion, Inc.; 2010. [Cited 2013 December 16] Avaliable from: www.sme.go.th/SiteCollectionDocument/วิจัย SMEs/สภาพแวดล้อมทางธุรกิจ/รายงานบทวิเคราะห์ธุรกิจ%20ภาคการผลิตและบริการ/บทวิเคราะห์ธุรกิจ-ผู้ผลิตน้ำแข็ง%20ปี%202553.pdf. [InThai].

[3] Poramate M. The Study of Possibility an Ice Factory in Pathum thani. Proceedings of the 1st UTCC Graduate Research Conference 2006: "Multi-disciplinary Research Paper"; 2006 May 26-28; Bangkok, Thailand; 2006.

[4] Ghabkham P. Study to improve the tubular ice production efficiency [Thesis]. Bangkok: Chulalongkorn University; 2004. [In Thai].

[5] Pirunkaset M, Laksitanonta S. Study on the Effect of Blade Angle on the Performance of a Small Cooling Tower. Kasetsart Journal of Natural Science 2008;42:378-384.

[6] Lamberg P, Lehtiniemi R, Henell AM. Numerical and Experimental Investigation of Melting and Freezing Process in Phase Change Material. International Journal of Thermal Science 2004;43(3):277-287.

[7] Swaminathan CR, Voller VR. A General Enthalpy Method for Modelling Solidifcation Processes. Metallurgical Transactions B 1992;23(5):651-664.

[8] Pekeris CL, Slichter LB. Problem of Ice Formation. Journal of Applied Physics. 1939;10(2):135-137.

[9] Salcudean M, Abdullah Z. On the Numerical Modelling of Heat Transfer During Solidification Processes. International for Numerical Methods in Engineering 1988;25(2):445-473.