



Energy conservation in a local textile finishing processes factory

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Abstract

With great concern over efficient energy usage and thermal pollution in Hong Kong, it is essential for energy intensive industries to hearken to such concern through actual reductions in energy consumption and thermal pollution. This leads to an essential study on the ways of limiting energy wastage and thermal pollution in a local textile finishing processes factory. The main activity of this factory involves singeing, desizing, scouring, hot washing, bleaching, mercerizing, dyeing, printing, soaping, drying and finishing of cotton fabric. In this paper, engineering measures to limit heat energy wastage discharged from continuous bleaching machine, drying chamber, boiler stack exhaust and blowdown are discussed. The cost-benefit analysis for the proposed energy conservation measures are performed in line with the hot effluents discharged standards published by the Environmental Protection Department (EPD) of Hong Kong Government [1]. It is intended that through this study, a better understanding on cost effective energy efficiency in textile finishing processes factories can be achieved.

1 Introduction

Textile finishing processes is one of the energy intensive industries in Hong Kong. Tremendous energy waste is found in the textile finishing processes as shown in Figure 1. With the heat recovery of discharged hot effluent and exhaust gases, not only the cost of production is reduced, but also the thermal pollution problems are solved without additional cost. Details of thermal and water pollution control in this local textile finishing processes factory can be found in Chan et al. [2].



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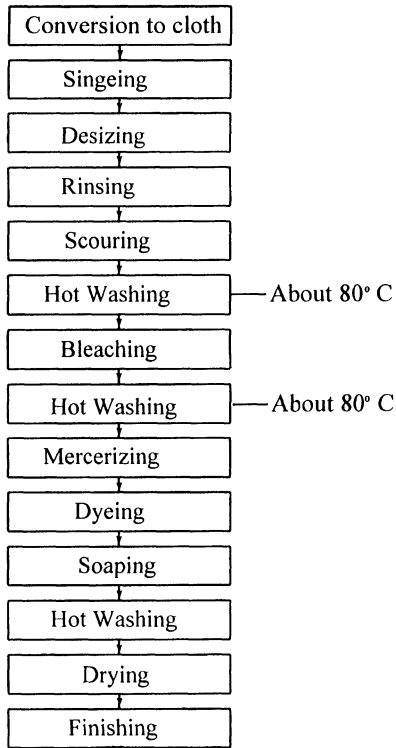


Figure 1.

2 Identification of heat energy wastage in the factory

After carrying out a detailed energy auditing on the production and non-production facilities, the cost-benefit analysis for the hot effluent from continuous bleaching machine, exhaust gas vapour from drying chamber and finishing processes, heat recovery from boiler stack and blowdown are performed. Many books and papers have discussed these topics; e.g. Urbani [3], Nicoll [4], Copper [5], Sarkari [6], Schaffer [7] and Eastop & Croft [8].

2.1 Hot effluent discharged from the bleaching machine

In the factory, the scouring and bleaching processes are integrated by a continuous bleaching machine. The two processes have a unique effluent. The temperature of hot drain wastewater and the flow rate of hot effluent for each machine are measured to 65 °C and 7.3 m³/hr respectively. It is estimated that each continuous bleaching machine is in operation for 7000 hours per year. In order to achieve heat recovery from the hot effluent, there are two possible adaptable ways on the site.

One is to install individual heat exchanger for each of the three continuous bleaching machines. The hot effluent is directly fed into the heat exchanger, thus heating up the cold fresh water, which is then fed back to the continuous bleaching machine as shown in Figure 2.

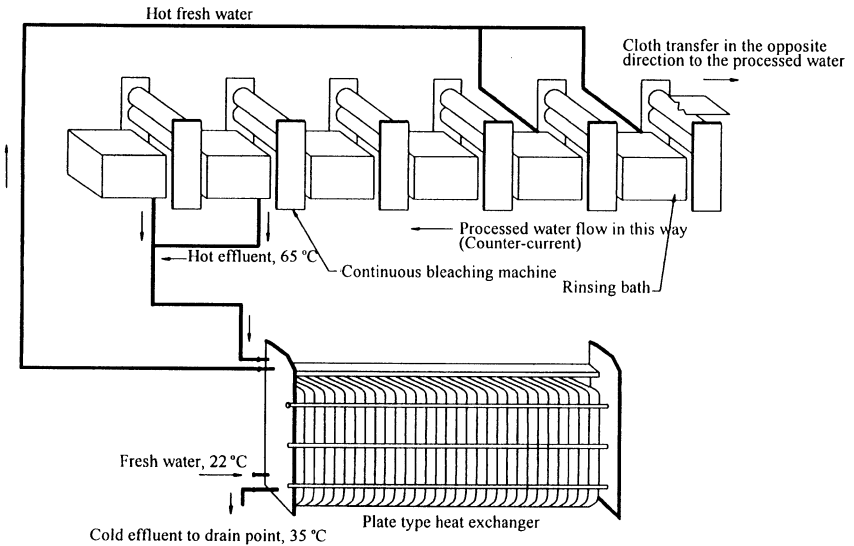


Figure 2: A heat recovery system for individual bleaching machine

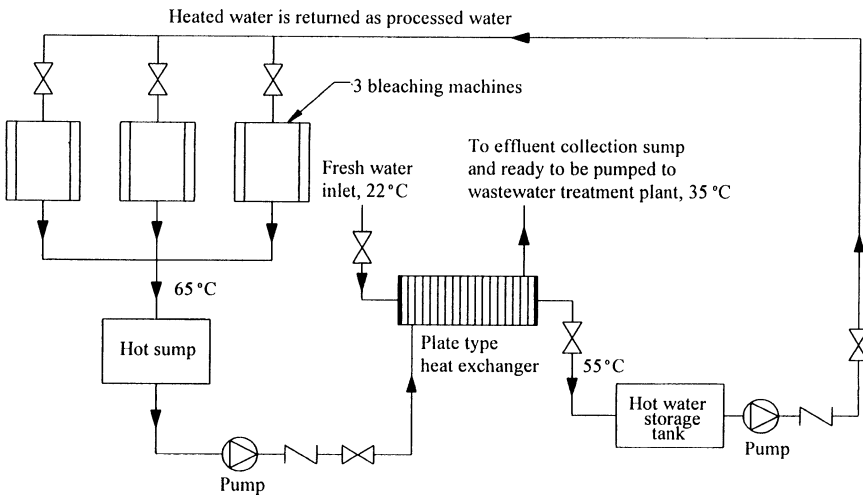


Figure 3: A centralised heat recovery system



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The second method is to collect all hot effluent from different machines into a collection sump. Then the waste heat can be recovered through a centralized system as shown in Figure 3. After passing through the heat exchanger, the heated fresh water is pumped into a hot water storage tank. It is because sometimes not all the continuous bleaching machines are in operation simultaneously. The hot water is then distributed from the storage tank to the bleaching machines for use during production processes.

To decide on the best heat recovery method, several points should be considered according to the factory environment:

1. There are only three continuous bleaching machines in the factory. The number of the machines is too small to justify the extra cost raised by the centralised system. For the centralized heat recovery system, the costs of heat exchanger and pumping equipment, pipe works and control system are higher than installing three separate heat exchangers to three individual machines.
2. There is a large amount of heat loss in the collection sump tank and hot water storage tank for centralised system.
3. For individual heat recovery system, the heat exchanger operates only when the machine is in operation. This means that once it is in operation, the heated up fresh water can be used as processed water and fed back to the machine directly. The control is very simple and independent.
4. No pumping cost is required for the individual heat recovery because the hot effluent flow can be achieved by static head difference and the fresh water can be pumped by the water pressure inside the pipework.

It is found that the installation of a centralised heat recovery system is feasible and economically justified in this factory if the number of continuous bleaching machine exceeds 10 and the total flow rate of hot effluent for heat recovery is more than 800 m³/day. Hence an individual plate type heat exchanger for each of the three continuous bleaching machines are proposed.

In order to meet the effluent temperature requirement [1], the outlet temperature of hot drain water after passing through the heat exchanger is set to 35°C. The flow rate of specified fresh water, 22 °C is taken as 6.6 m³/hr. The temperature of hot drain wastewater and the flow rate of hot effluent for each machine are measured to 65 °C and 7.3 m³/hr respectively. Hence the annual industrial fuel oil savings is estimated to 42,500 gallons (or 7,200 x 10⁶ kJ) for each plate type heat exchanger. This means an annual fuel cost savings of about HK\$ 130,000.

2.2 Heat recovery from drying chamber

For the drying process, the cloth enters a drying chamber after rinsing. Then it is rolled through a drying drum which is heated up by steam from boiler as shown in Fig. 4.

Steam is drawn into the drying drum to heat up the drum surface and then the cloth rolling through the surface is heated up and the water content will be evaporated, making the cloth dry. The condensation inside the drum will then

be discharged through a pipe by the pressure built up in the drum from the steam. This is different from the other drying method in which the water vapour is drawn by keeping a low humidity in the drying chamber.

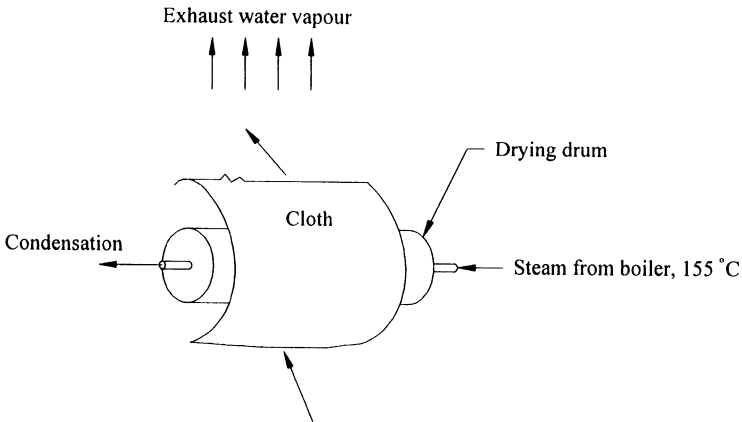


Figure 4: An inside view of a drying chamber

In considering the design of a heat recovery system for the drying chamber, there is a choice between using the water vapour to heat up water or to heat up air. From the prescribed drying principle in the factory, there is only one possible way by which the heat recovered can be used to heat up the water and then to recycle this heated water to the rinsing batch as processed water. It is not suitable to heat up the air because there is difficulty in utilising this hot air in most Hong Kong's factories. However, in places with cold weather, the hot air can be utilised as space heating for buildings.

The temperature and total flow rate of exhaust water vapour are measured to 52 °C and 70,000 m³/hr respectively. The heat recovery from the dryer exhaust is feasible theoretically. Hence the annual industrial fuel oil savings is estimated to 40,500 gallons (or 6,850 × 10⁶ kJ). This means an annual fuel cost savings of about HK\$ 124,000. However, having reviewed the potential energy savings from installing a water-heating economizer under the condition of 52 °C exhaust steam, the energy savings is too low to justify the cost of an economizer.

2.3 Heat recovery from boiler stack exhaust and blowdown

Boiler exhaust gas rejected from the stack is normally of 40-50 °C higher than the temperature of generated steam. By recovering this heat, the consumption of fuel oil and also the thermal pollution to the environment can be reduced. Heat can be recovered by either the economizer to heat feed water or by air preheater for combustion. However the factory has already been incorporated with air preheaters, and the performance of the boilers are shown in Table 1.



Boiler	Volume flow rate, m ³ /s	Temperature of exhaust gas, °C
No. 1	5.25	152
No. 2	4.32	153
No. 3	5.60	250
No. 4	7.70	255

Table 1. Information on the boilers used in the factory

It is worth noted that the exhaust gas temperature can be reduced only above the dew point of flue gas, otherwise corrosion problem may occur due to the formation of sulfuric acid. The supplier of carbon steel economizer recommends that the temperature of the feedwater has to be near 104 °C if the dew point is about 128 °C for a sulfur content of 0.5 % in order to prevent corrosion. Thus, a preheat skid is developed for heat economizer feedwater by using boiler steam as shown in Figure 5. Because the steam energy used in the preheat skid is recycled back into the boiler, there is no significant net energy used to preheat the feedwater. Then, economizers can be installed as shown in Figure 6 on the site to suit boilers by connecting a lower transition.

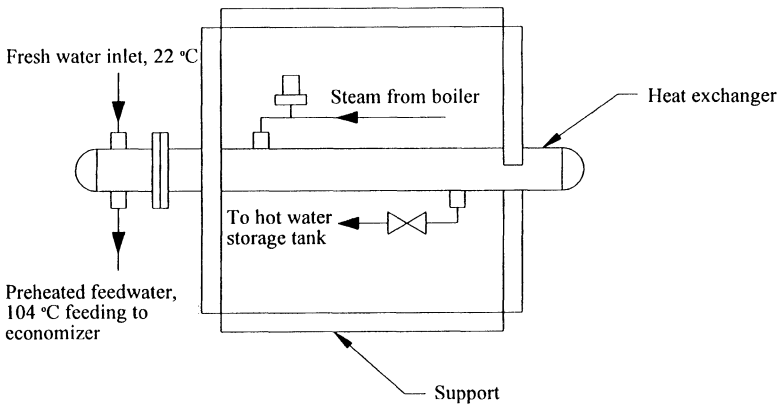


Figure 5: A schematic diagram of a feedwater preheated skid

The exhaust from boilers No. 1 & No. 2 obviously has no economical benefit in the recovery of heat. The No. 3 and No. 4 boilers are identical in fact. The discrepancy flow rate between these two boilers is due to the different operating conditions of the boilers. According to the information provided by the economizer supplier, the outlet temperature of the flue gas is 157 °C and the inlet temperature of feedwater from the preheated skid is 104 °C. The boiler is in operation for about 7,800 hours per year. Hence the annual industrial fuel oil savings is estimated to 107,000 gallons (or 18,000 x 10⁶ kJ) for installing the economizer. This means an annual fuel cost savings of about HK\$ 330,000.

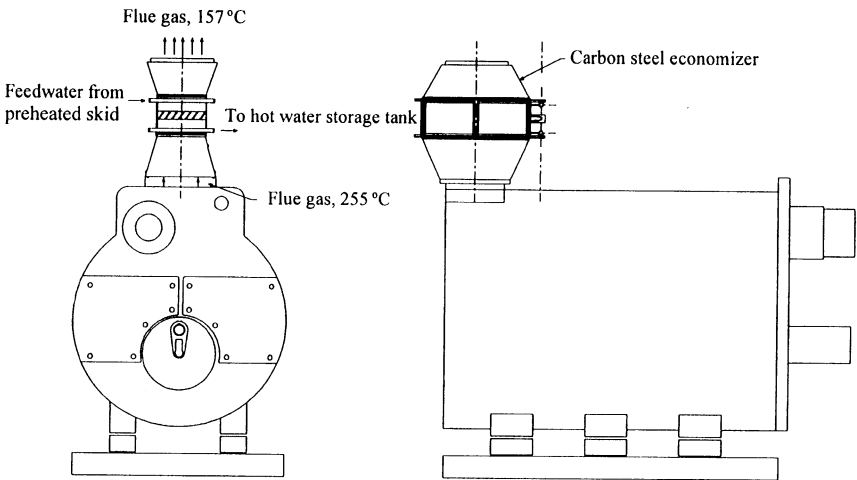


Figure 6: A schematic diagram of an economizer in a boiler

2.4 Heat recovery from boiler stack blowdown

The process of boiler blowdown is to maintain a low concentration of dissolved and suspended solids in the boiler water and to remove sludge in the boiler in order to avoid priming and carryover.

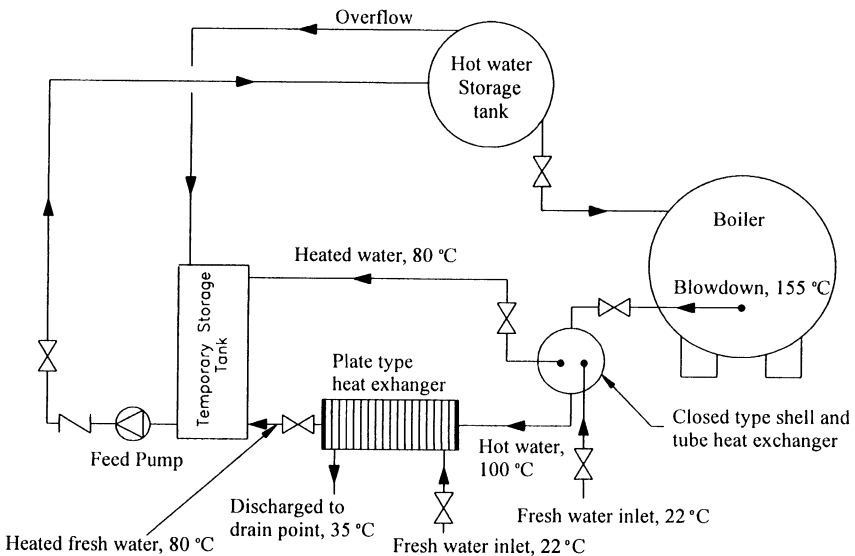


Figure 7: A schematic diagram of a blowdown heat recovery system



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The blowdown recovery system is designed to recover both the latent heat of the 156 °C steam in the first closed type shell and tube heat exchanger and sensible heat of the 100 °C water in the second plate heat exchanger as shown in Figure 7. The blowdown is forced to pass through the first heat exchanger by the high pressure inside the boiler drum and then effluent contained suspended solids will be discharged at the second plate type heat exchanger at a temperature of 40 °C. Afterwards, the hot feed water is pumped into the hot water storage tank and ready to feed back to boiler. In fact, all heated effluents including those from the economizer and steam condensation in the plant will also return to the hot water storage tank. If overflow occurs, the feedwater will flow to a temporary storage tank.

With the existing boiler capacity of 4.4 kg/s at 5.5 bar pressure and the blowdown flow of about 4 %, hence the annual industrial fuel oil savings is estimated to 17,900 gallons (or $3,000 \times 10^6$ kJ) from boiler blowdown. This means an annual fuel cost savings of about HK\$ 55,000.

3 Conclusions

The energy wastage discharged from this local textile finishing processes factory has been identified. It is found that heat recovery from the hot effluent discharged from the continuous bleaching machine, boiler stack exhaust and blowdown are feasible and economically justified in this factory. With the aid of a central computer system, the various processes and heat recovery systems can be better monitored and controlled, and more cost effective energy efficiency in this local textile factory processes can be achieved.

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