การประยุกต์ใช้เทคโนโลยีสะอาดเพื่อการประหยัดพลังงานในโรงงานอุตสาหกรรมเคมีขนาดย่อม [*]

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บทคัดย่อ

บทความนี้ เป็นการศึกษาศักยภาพของการประหยัดพลังงานในโรงงานอุตสาหกรรมขนาดย่อมในประเทศไทย   ซึ่งปัจจุบันโรงงานอุตสาหกรรมขนาดย่อมยังไม่ถูกจัดอยู่ในขอบข่ายของกฎหมายการอนุรักษ์พลังงาน   โดยทั่วไปแล้วกลุ่มอุตสาหกรรมเคมี   เป็นกลุ่มที่ใช้พลังงานมากถึงแม้ว่าจะเป็นอุตสาหกรรมขนาดย่อม   ดังนั้นหนึ่งในโรงงานในกลุ่มอุตสาหกรรมเคมีได้ถูกเลือกมาเพื่อเป็นกรณีศึกษาในโครงการเทคโนโลยีสะอาด จากการศึกษาพบว่า ค่าของพลังงานที่ใช้ในกระบวนการผลิต สามารถประเมินค่าเป็นเชิงตัวเลขได้   นอกจากนี้ การศึกษาเทคโนโลยีสะอาดนี้ยังสามารถแนะนำวิธีเพิ่มการประหยัดพลังงาน ซึ่งสามารถคำนวณประสิทธิผลของการประหยัดพลังงานได้โดยใช้หลักการของเวลาคืนทุนเป็นบรรทัดฐาน   เพื่อให้ผู้ประกอบการ   หรือผู้ที่เกี่ยวข้องในโรงงานอุตสาหกรรมขนาดย่อมใช้ในการพิจารณาและการตัดสินใจ

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Energy saving as the application of cleaner technology: A case study of one of the Thai SME's in chemical segment *

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Abstract

The potential of energy saving in the Small and Medium Enterprises (SME) in Thailand which according to the Energy Conservation Promotion Act (ECPA) are classified as the non-designated facilities was investigated. One of the Thai SMEs in the chemical segment which is an energy intensive segment was selected for the study. The study showed how the energy used and manufacturing processes in a typical energy intensive SME in Thailand can be evaluated in a quantitative way, and to provide a specific recommendation which would be cost-effective for the reduction of energy used. The effectiveness of the implementation of the energy saving methods recommended is estimated in terms of a pay back period.

Keywords: clean technology, energy saving, SME, cost effective.

Introduction

Current concerns about global warming, the alleged increasing greenhouse effect, environmental instability and sustainable development, especially after the June 1992 Earth Summit in Rio de Janeiro, Brazil have prompted many governments to introduce both direct and indirect legislations to motivate and enforce the industries to work at greater energy efficiency. In fact the Thai government had introduced the Energy Conservation Promotion Act (ECPA), just before the Rio summit, in April 1992 to promote the use of energy efficient and energy saving technologies (NEPO, 2000). According to the ECPA the industrial and business enterprises in Thailand can be categorized into two classes. The first class is known as the designated facilities which are the ones that installed transformer capacity of at least 1,175 kVA or have electricity demand of at least 1,000 kW or have total consumption commercial energy including electricity and steam of at least 20 millions MJ/year. The enterprises which are not included in the first class are classified as the second class and usually be referred to as the non-designated facilities. Unfortunately the compulsory program specified by the ECPA to implement the energy conservation activities is only applied to the designated facilities and does not extend to the non-designated facilities which included most of the Small and Medium Enterprises (SMEs) in Thailand. Such requirements for SME would have been very important since the 97.9% (Sevilla

and Soonthornthada, 2000) of the Enterprises in Thailand are SMEs Therefore it is necessary to investigate a saving potential of energy used in a typical SME. In addition the production processes can be analyzed in order to find the method to minimize the generation of wastes and emissions according to the Cleaner Production (CP) concept to reduce risk to humans and the environment. The potential to apply CP is much greater in the SMEs where the lower of production costs will make the SME more competitive and profitable.

The aims of this paper is to show how the energy used and manufacturing processes in a typical SME in Thailand can be evaluated in a quantitative way, and to provide a specific recommendation which would be cost-effective for the reduction of energy used.

The assessments of potential energy savings

Generally the assessments of potential energy savings are based on two main technical and economic parameters. When considering the potential for increased energy efficiency, it is essential to distinguish between four types of potentials which are (APERC, 2002).
1. The theoretical potential represents achievable energy savings under theoretical considerations of thermodynamics. This usually has shown in the forms of the first-law efficiency and/or the second-law efficiency (Ho and Chandratilleke, 1987).
2. The technical potential represents achievable energy savings that results from implementing the most energy-efficient technology available regardless of the cost.
3. The economic potential is the energy saving that would result if during each year of period in question. All improvements are shifted to the most cost-effective at given energy market prices. The economic potential assumes the perfect market conditions, that is, it assumes that everyone can and has reliable information about the cost-effectiveness and technical performance of existing and emerging options for energy efficiency.
4. The market potential or expected potential is the efficiency improvement that can be expected to be realized under market imperfections that keep efficiency potential from being fully realized. In practice the market potential is the most meaningful, however the accuracy of the market potential estimation is very much depending upon how market imperfections are handle.

The Study

For this study, the KM Interlab Co.,Ltd. which produces and distributes the cosmetic products was chosen as a representative of the SME in the chemical segment. In general, manufacture of cosmetic is basically an energy intensive process in that the chemical and physical process reactions take place at relatively high temperatures in comparison with most of the processes in other segments of the SMEs. This will provide a greater opportunity for improving the effectiveness of energy used. The KM Interlab Co.,Ltd. , manufactures 3 main products which are skincare, make-up and lipstick. The majority of products are skincare with the average output rate of about 280 kg/day corresponding to 91% of total output mass. Consequently most of the energy consumed is in the manufacturing of skincare products. Due to the time constrain of this study only the processes which consumed most of the energy were selected to be evaluated. From the preliminary study it was found that most of the energy lost was in the forms of used steam which was released directly into the atmosphere and/or condensate water which was drained into the sewage system after it was used to heat various raw materials and to maintain the internal temperature of all 4 reactors used in the skincare manufacturing processes to be at 85°C. Schematic sketch of the production processes and steam used for skincare products manufacturing is shown in Figure 1. In order to generate steam, fresh water at room temperature (about 28 ^{o}C) was fed into the boiler which has been heated by burning diesel fuel. The boiler is required to generate steam at the average rate of 0.74 ton/hr continuously for 9 hrs per working day, of which

86 % of steam generated is used for the skincare manufacturing processes. However if the used steam can be reused large amount of energy associated with high energy steam can be saved.
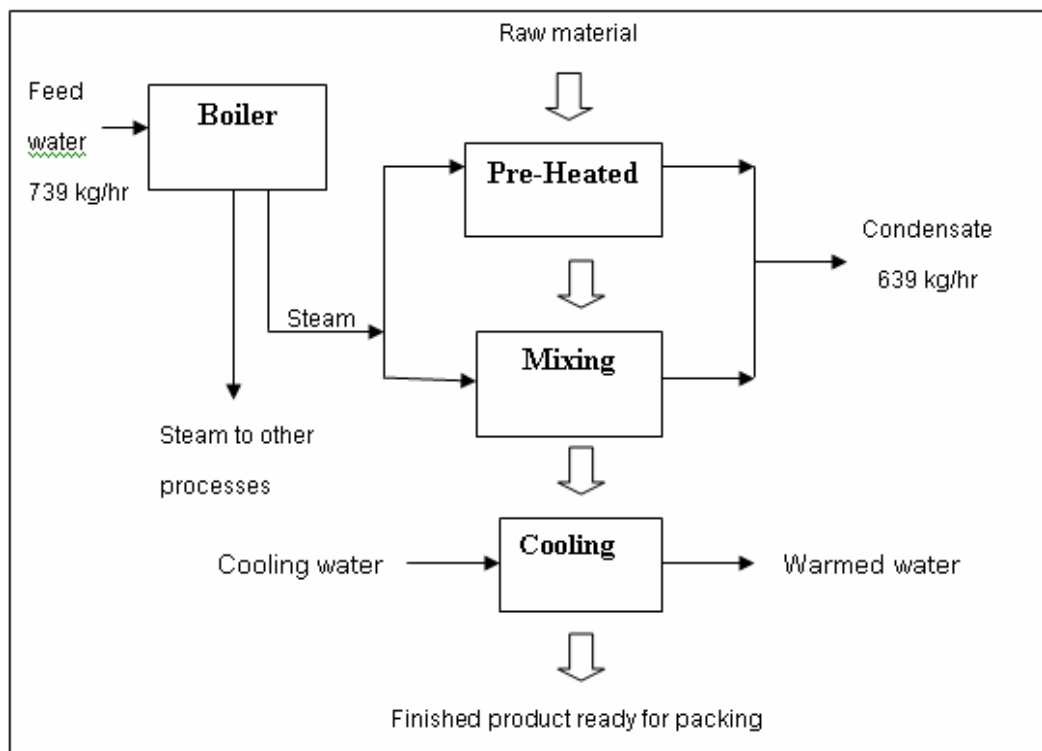
Figure 1 *Manufacturing process for skin care*

Generally most of saving potentials of steam generation are in the forms of condensate return and flash steam recovery. Returning of high-purity condensate reduces boiler blow-down energy losses and make-up water requirements (Harrell, 2002). This save fuel/energy used for heating cold make-up water, water chemical treatment cost, and by eliminating the discharge of condensate into the sewer system the sewage treatment cost is reduced. Since condensate is relatively pure, returning condensate to feedwater will improve feedwater quality which means less corrosion problems and more reliable boiler operation. When the pressure of saturated condensate is reduced, a portion of the liquid flashes to steam at a lower pressure. This can be done intentionally to regenerate low-pressure steam to meet process requirement. In addition insulation of steam lines can help to ensure proper steam pressure for production and can reduce heat loss from surface by 90% results in typical saving ranging from 3% to as high as 13% (U.S. Dept. of Energy, 1995) of total energy used for steam generation.

Data collections

The overall steam consumption and condensate produced in the skincare manufacturing were based upon steady-state measurements under normal production conditions for the period of one month. The input rate of feedwater supplied to the main boiler (with a nominal steam rate of 1000 l/hr) which supplied steam to all four reactors was monitoring, while the volume of condensate produced in each of the four reactors was measured hourly during the nine working

hours. The total volume of feedwater used per day and the total condensate produced per day were recorded. The average values of the measurements during the one month period are shown in Table 1. These values were used as the basis for the extrapolation of the quantity of the condensate produced in one year in the conjunction with one year feedwater consumption data which has been routinely collected by the factory. Three randomly selected samples of condensate per working day were tested for hardness, iron and pH. Table 2 shows the results of the tests.

Condensate return

During steady-state and under normal skincare production conditions, the steam after being used to preheat raw materials and to heat reactors will convert to the 85 ^{o}C condensate at the average rate of 639 kg/hr. At the present the normal practice at the plant is to drain this condensate into the sewage system. Form Table 1, it can be seen that there is the discrepancy between the volume of feedwater and the condensate produced of about 100 l/hr or 100kg/hr, this extra 100kg/hr is required of other processes. The quality of condensate as shown in Table 2 is relatively high, this high quality and high energy condensate if retuned to the boiler will reduce the heat energy required. The 639 kg/hr condensate at 85°C if mixed with 100 kg/hr fresh water at an average room temperature of 28°C will result the mixing temperature of 77.3^{o}C for the 739 kg/hr of feedwater to be boiled to generate steam. The rate of fuel which can be saved by heating up the 77.3^{o}C water instead of the 28°C water to produce the steam can be calculated from

$$Z = \frac{Q(T_1 - T_2)}{q\eta}$$

when Z =   Fuel used in litre/hr

T_1 =   Temperature of mixing feedwater (^{o}C)

T_2 =   Room temperature (^{o}C)

Q =   Flow rate of feedwater litre/hr

q =   Heat capacity of diesel fuel = 9,220 kcal/litre

η =   Efficiency of boiler = 0.7

which upon substituted the relevant values yields; $Z = \frac{739(77.3 - 28)}{9220 \times 0.7} = 5.645$ therefore

the amount of diesel fuel saved per working hour is 5.645 litres, for the working of 9 hour per day and 22 days per month, this saving is about 1,117.71 litres per month. If the price of diesel fuel is estimated to be 15 baht per litre then this corresponding to the saving of 16,766 baht per month or 201,192 baht per year. At the same time the volume of fresh water used for feedwater will be reduced by 126.5 m^3 per month or 1,518 m^3 per year which equivalent to the saving cost of water and its treatment of about 633 baht per month or 7,596 baht per year. The total saving cost of using condensate return is 208,788 baht per year.

Since the investment required for the installation at the condensate return is estimated to be 25,000 baht then the cost can be recovered within 1.5 months assuming the discount rate of 10% per year.

Steam line insulation

Large amount of heat is lost due to poor steam line insulation. By insulating all of the steam lines using the insulator of 1 inch (25.4 mm) thickness the amount of wasted energy was estimated to be the equivalent of 99 litres of diesel fuel per month or the saving cost of 1,495 baht per month or 17,940 baht per year. The cost of insulating all of the steam lines is 14,000 baht. This investment will be recovered within 10 months if the discount rate of 10% is assumed.

Water used		m^3	Kg/hr
Feed water		6.65	739
Condensate	Reactor 1	1.26	
	Reactor 2	1.35	
	Reactor 3	1.69	
	Reactor 4	1.46	
	Total Condensate	5.75	639

Table 1a *Daily feeder rate and the daily average rate of condensate produced during the one month period of April 2003 in the skin care manufacturing process*

Month	Year	Mass flow rate (kg/hr)
May	2002	667
June	2002	420
July	2002	487
August	2002	797
September	2002	686
October	2002	675
November	2002	664
December	2002	642
January	2003	575
February	2003	697
March	2003	719
April	2003	639
Average		639

Table 1b *Daily average rate of feed water*

Water quality	Values
pH	7-9
Hardness	<1 mg/l
Iron	0.05-0.1 mg/l

Table 2 *Characteristics of condensate water*

Discussion

The potential of saving by employing the condensate return is very substantial, the break even point of this investment is only 1.5 months which is very short. The saving due to steam line insulation is about 11.6 times lower than the saving due to employing the condensate return. But this small amount of saving can become a key factor in the industry which is highly competitive. By varying the discount rate from 5% to 15% the overall sensitivity of energy saving cost estimation can be assessed. In the present study the discount rate of 10% is treated as the most realistic given the market condition in Thailand at the present

Conclusion

An energy audit can provide an understanding of how energy is used and should identify from quantitative evidence those areas where significant wastages occur and where financially viable options for improvement exist. In the present study, opportunities for improving the energy efficiencies are identified. By using the condensate return and by insulating the steam lines the energy efficiencies of steam generation and used can be improved. The implementation of the condensate return will save the fuel cost by 208,788 baht per year after the pay back period of 1.5 months, while the implementation of steam line insulating will save the fuel cost by 7,596 baht per year with the longer pay back period of 10 months.

Boiler efficiency can be improved further by optimization the amount of excess combustion air while ensuring complete fuel combustion and minimizing stack heat loss. Installation of auxiliary equipments such as economizers, combustion air pre-heaters and blowdown heat-recovery systems can improve boiler efficiency, but this may not be economically justified at the present market situation. Optimization of insulation thickness for reactors and for any steam and condensate return piping, together with steam trap maintenance will reduce the energy used and will make the work environment safer. However the long-term benefits of system efficiency require continuous improvement through proper operating and maintenance practices. This prevents a system from degrading into a mode of poor performance.

Acknowledgement

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