IMPROVING THE ENERGY EFFICIENCY OF A BOILER SYSTEM FOR USING LAUNDRY STEAM OF 5 STAR BANGKOK HOTEL

Somkiat Pornsaroj[1], Sakchai Rakkarn[1], Samroeng Netpu[1], Jeerawat Plongmai[2] and Jomphop La-or[2]

[1]Master of Engineer Program in Engineering Management, Graduate School, KasemBundit University, 1761 Pattanakarn Road., Saunlaung, Bangkok 10250,Thailand

[2] Industrial Engineering Technology, Faculty of Engineering, Kasem Bundit University, 1761 Pattanakarn Road., Saunlaung, Bangkok 10250,Thailand

ABSTRACT

This paper is to identify the using of energy in efficiency way and to reduce using LPG to produce thermal energy and electricity, also using the thermal energy to produce hot water together with planning and developing system in future. Because of the high energy of steam system has consumed about 6 million baht per year and lost highest approximately at 18.17%. This research is conducted by surveying and measuring of the loss in steam production system, steam distribution system, and the equipment of using steam in the production process. In order to improve the system to become more efficiency and also define the measures in practical continuously. The record of the information has been used to compare with standard score in theory to improve high efficiency and develop on steam system. This study also use the engineering management conceptual to rectify the working schedule relevant with the working of boiler for reducing cost to 7 % without investment. In addition, using the results is compared with investment by considering on investment and pay-back period, which can be additionally reduced by 6.14% of production process. Therefore, the results in a total cost reduction of at least 13 percents for applying in manufacturing process followed on theoretical, the calculation.

KEYWORDS: Engineering Management, Energy Reduction, Cost Reduction, Heat Boiler

1. Introduction

Since many modern buildings today are equipped with many requirements, the fresh air, cooling and hot tend to become more necessity with the design management in building.

The Heat Ventilating Air Condition system (HVAC) is the system that be utilized to meets the requirements of tenant and the people who come to use services in building which makes the expenses of energy management is getting highly cost. According to this, the Sustainable Development system is being used in designing of complexity heat system, cold system, and cooling system in order to reduce energy consumption together with maintaining the good services. Sustainable building services ensure a comfortable internal climate suitable for living. The important criteria goal of HVAC is maintaining air quality together with improving energy consumption effectively [1]. Nowadays, the effective *energy management becomes* more important than ever. Especially the oil energy is the main fuel of productions; for example, using in transportation or automobile and producing electricity. Oil is a natural substance that getting scarce and it is going to be finished soon. Therefore the world is looking for alternative energy sources to replace oil such as the using of solar energy to produce electricity [2] or the using of heat in *sterilization process in industry by applying the heat conduction method, heat convection method and radiation method in each technologies* [3] which have the same ultimate goal to reduce using oil and cost, also reducing of carbon dioxide emissions which are the main cause of global warming. For Thailand, the main country's income is from tourism industry which is now considered as the high rank statistic as showed that tourists travel to Thailand about 30 million people in 2015 and about 32 million people in 2016 [4]. According to this continuously increasing ratio, the energy consumptions and energy costs in residential or hotel buildings are also getting high in order to facilitate and service tourists. In particular, the HVAC system in hotels make a huge use of 65% of all energy using in building. Thus, the researchers aim to study in the improvement of boiler systems in laundry which is part of buildings energy management under Building Control Act, B.E. 2535 (1992). Also, we investigated the improvement and applying system with the same work activities which aims to reduce cost and carbon dioxide emissions at 7% target. The research is conducted at the five star hotel featured a large laundry and use stream as main energy to process laundry. The laundry process used Boiler fire tube 4 pass dry backs heavy fuel oil A, but it is modify burner to dual type can used fuel 2 type by Heavy oil and LPG gas right now used LPG gas The capacity of Boiler 3000 kg/hour They have 2 Boiler open 6am-7pm working daily one boiler alternative working (13 hours/day, 365 day/year) . This Boiler are used 14 years and installed at the basement of building, so it is difficult to change the new machine. Therefore, we have studied to improve and increase

performance of boiler systems by improving of stream generator, stream distribution system and machines. We also studied on how to improve on stream generator's working, blow down system, improve combustion efficiency using standard values from the development team, Bureau of Energy Human Resource Development, Ministry of Energy [5] and improve energy consumption efficiency analysis by using various calculation programs [6]. The main principle of reducing and saving are include reducing the excess air from the combustion, reducing the uses time and improving the stream distribution system related to the research of Flue Gas Loss and retrieved back to make utilize with small size of boiler [7] by using heat exchanger and waste heat recovery [8] or blow down. One of the case study from Ampol food Company, they use the drainage water from boiler and can reduce the fuel oil grade C to 1.6 liters per hour which cost 163,800 THB per year and can pay back within 0.3 month. In this study, the researcher aim to focus on the improvement of energy efficiency in boiler system as it is a potential system in energy conservation compared with of capacity equipment in producing and distribution of stream [9]. In the laundry process, we can find the most effective heat measure by studying the whole process of producing and distribution to machine include analyzing all the possible irregularities in the system [10], so that to apply with the heat energy and electricity conservation measure and adjust the work process to match within each related parts without disturbing any processes in order to get the most effectiveness with engineering management [11] with aim to the result of reducing energy and cost as target.

As mentioned above, this research aims to study at 5 stars hotel with boiler system in laundry which having huge fuel consumption and losses in many aspects. Many theories, measurements and data collections are applied to data analysis and improvement together with implementation in working process in order to increase efficiency get the most effective as reducing fuel consumption to 7% and LPG consumption less than 0.39 kg per clothes 1 kg.

2. Materials and Method

The experiment studies on the behavior of using boiler by investigating the boiler system, distribution stream system, stream device, interview the users, parameter measurement and checking the data record compared with the standard values of Department of Alternative Energy Development and Efficiency [12] in order to improve the

saving LPG and electricity measure and applying engineering management with working schedule and process to get the most efficiency at last.

2.1 Resource

The five star hotel located in Bangkok facilitated with laundry system. The study investigates on boiler system, stream distribution system, and related working machine in production process. The main factors of research include:

- Type of boiler including the efficiency of machine, fuel and working hours.
- The total number of machine and the systems using in boiler, the distribution system and device system.
- Fuel consumption data, water consumption data and laundry data from last years.
- Working schedule of boiler and stream consumption of laundry.
- Standard values and other calculation programs.

2.2 Tools and Instrument

In order to achieve the result, the researchers have to measure boiler capability and heat loss in order to analyze and improve boiler and systems.

- Measuring of fuel consumption.
- Measuring of Oxygen, Carbon dioxide released from chimney.
- Measuring of TDS (Total Dissolved Solids) and pH of water in boiler system.
- Measuring of water temperature, boiler's wall and heat released from chimney.
- Measuring of stream pressure.

Figure 1 The measurement of boiler operations

2.3 Data Collections

The data collected from 14 years-old boiler located at basement of hotel building which it is very difficult to change the new machine with grade a fuel oil. At the present, the boiler is adapted to use into two system which are LPG gas (main power) and fuel oil. There are two boilers switch working by turn on at 06:00-19:00 Hrs. (13 hours per day/ 365 days per year). The stream consumption average at 6-7 bars mostly gained from washing machine, clothes dryers and ironing machines which have high stream consumption. Based on the data analysis, there is energy consumption indicator data as follows:

- Heat consumption and energy consumption indicator in boiler system

Fuel consumption (LPG)	125,202	Nm^3/Y
Fuel cost per unit	22.69	THB / kg
Heat energy in boiler system	947,311.60	MJ
Cost	5,937,326.11	THB / year

- The losses of two boilers from measurement

Table 1 The number of losing energy in boilers

Main steam Loss	Thermal Power MJ/Year			
	Boiler No1		Boiler No.2	
	MJ/Y	Percentage	MJ/Y	Percentage
1.Strack	674,600.92	14.25	746,309.15	15.75
2.Frame	52,383.43	1.11	97,920.78	2.07
3.Blowdown	15,686.92	0.33	16,611.74	0.35
Total	**742,370.87**	**15.69**	**860,841.67**	**18.17**

2.4. Method

This research applies the four measures for improving of energy efficiency in boiler system and stream distribution. And also improving with investment in equipment and apply with stream devices to be increased energy efficiency of systems.

2.4.1) Measures to reduce excess air from combustion

2.4.2) Rescheduling Operation Boiler Measure

2.4.3) Reduce Blow down Measure from TDS Value

2.4.4) Measure of Switching Boiler Working (switched from every two days to one time per week)

2.4.5) Improvement of efficiency distribution stream system

2.4.6) Apply with stream device by The Waste Heat Recovery system replacement Heat pump

3. Results and Discussion

The data collection and parameter measurement, the boiler no.1 efficiency is at 79.5% and boiler no.2 is at 81.6% (the standard must be 85%) below 5%. and combustion efficiency of 2 Boiler 85.4% The boilers are having too much blow down and the temperature of chimney is at 182°C. The boiler insulation is in good condition and insulation frame 48°C (the standard value must not over than 60°C). There is a condensation retrieve to boiler and the temperature is at 85-87°C. The researchers considered each data and define the increasing efficiency measure in three aspects.

3.1 Improvement of efficiency in boiler system and stream distribution

The data collected can be proceed to improvement efficiency measures as follow:

1) Measures to reduce excess air from combustion

The 3.0 tons/hour boiler was measured to find the efficiency combustion and exhaust gas and found that the value of O_2 is higher than standard values in both set. Actually, the O_2 standard value should not over than 2- 4% for gas in normal conditions [13]. If the O_2 is higher than standard value, the heat loss will be increased. As the results, the fuel consumption is getting high. We do adjust boiler no.1 from 5.9% down to 3.6% with the same effective rate at 86% and boiler no.2 from 5.6% down to 3.3% with gain more effective from 86.2% to 86.5%. The adjustment is needed time to complete combustion as connected with other factors such as burner and air in order to gain the best values and without any effects to other devices. After the improvement, the heat energy consumption reduce to 211683.70 MJ/Y, save energy cost at 130,019.30 THB per year and reduce *carbon dioxide* emissions at 16.44Ton/Y without any expenses.

2) Rescheduling for Operation Boiler Measurement

As from the on-off boiler data recorded before improvement, the boiler is started the machine at 06:00 hrs. and then shutdown at 19:00 hrs. The researchers did adjust the time in order to reduce fuel consumption. In order to do this, we ask cooperation from laundry department to set up their working hour from 06:00-19:00 hrs. We found that the high volume of stream consumption occurred at 10:00-17:00, so we have changed the starting machine time from 06:00 to 06:30 and turn off the machine before time 15 minutes in order to clear the stream in the system. The results show that the heat energy consumption reduce to 269,267MJ/Y, energy cost reduce to 152,097.42 THB per year and reduce *carbon dioxide* emissions at 20.91 Ton/Y.

3) Reduce Blow Down Measure from TDS values of Blow down Boiler No. 1 and Boiler No.2 (the standard value of controlled TDS must not over than 3500 ppm) [14]

Table 2 TDS water blow down values

Time	6 am	Noon	6 pm
Boiler No.1	2415 ppm	2419 ppm	2407 ppm
Boiler No.2	1970 ppm	1998 ppm	1992 ppm

The TDS values from both boilers showed that the numbers are lower than standard values. [15] The Blow down process is conducted 2 hours/15 second per time which makes loss of heat energy and water at 4 hours /10 second per time and can reduce heat energy consumption to 9,104.96 MJ/Y, reduce energy cost to 6,028.03 THB per year, and reduce *carbon dioxide* emissions at 0.71Ton/Y.

4) Measure of Switching Boiler Working (switched from every two days to one time per week)

The working time of boilers were switched from every two days to one time per week by recording parameter number such as the previous heat up before and after improvement. The results found that the heat energy consumption is reduced to 182,539.83 MJ/Y, energy cost is reduced to 84,103.13 THB per year and *carbon dioxide* emissions reduce to 14.17Ton/Y after improvement.

Table 3 The fuel measurement before and after switching working time from every two days to one time per week

Before	**Boiler No.**	**1**		**2**		**1**		**2**
	Day	1	2	3	4	5	6	7
	Fuel	47.6	26.59	47.6	26.59	47.6	26.59	47.6
	Heat up	Nm^3	Nm^3	Nm^3	Nm^3	Nm^3	Nm^3	Nm^3
After	**Boiler No.**	**1**						**2**
	Day	1	2	3	4	5	6	7
	Fuel	26.59	26.59	26.59	26.59	26.59	26.59	47.6
	Heat up	Nm^3	Nm^3	Nm^3	Nm^3	Nm^3	Nm^3	Nm^3

According to the survey and proceed followed by the four measures above, we can implement with operation process without any investments and can reduce the consumption as show in the table 4.

Table 4 The result summary after improvement efficiency of boiler system followed by the measures

No.	Improvement Details	Energy Reduce (MJ/Y)	Cost Reduce (THB/Year)
1	Reduce excess air from combustion	211,683.70	130,019
2	Changing of boiler working time	269,217.63	152,057.42
3	Switching boiler working time from every two days to one time per week	182,539.73	84,102.75
4	Reducing of Blow down	9,104.96	6,028.03
Total Thermal energy power and Cost saving		**672,546.02**	**372,207.20**

In this study, the researchers improve the boiler supply system to make utilize energy with the most effectively. (16) As from the used boiler, the improvement can be implemented immediately without any investments needed and can reduce energy consumption more than the target (the target is at 7%) with the high efficiency and productivity by compared as the usage of gas for 1 kilogram which the new improvement is used lower than 0.39 kg. The graph shows comparison of gas usage within three years and target

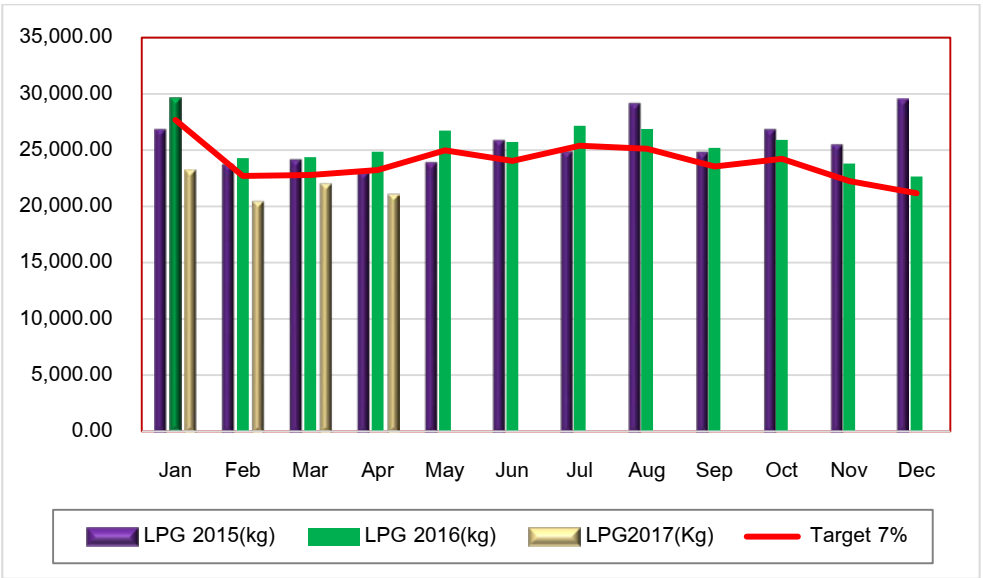

Figure 2 Comparison of usage LPG gas of year 2015-2017

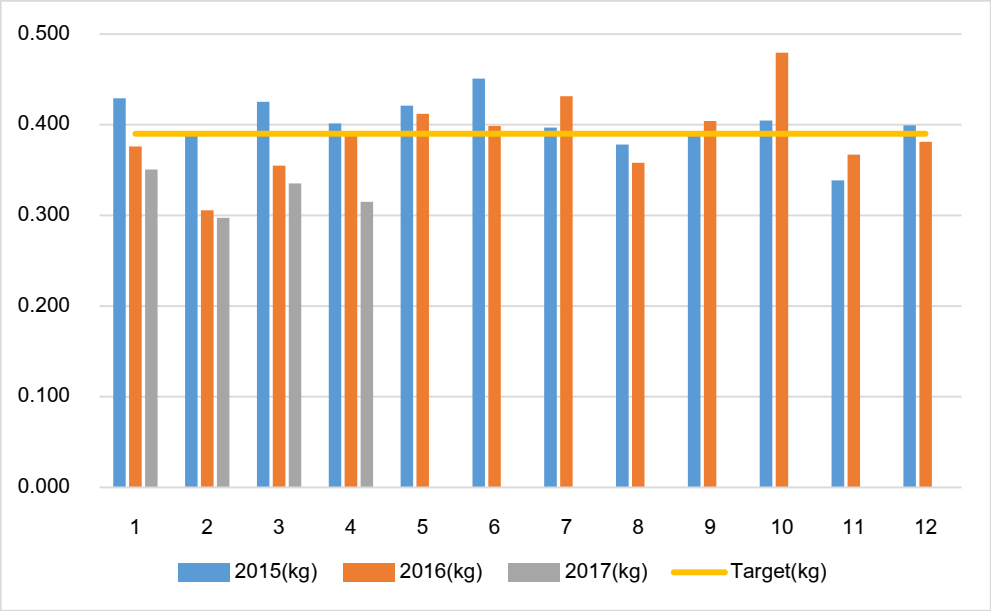

Figure 3 Comparison of usage gas 1 Kg with clothes 1 Kg within three years

3.2 Improvement of efficiency distribution stream system

The distribution stream system have been maintained very good but need to repair insulation steam supply pipe, flange, valve and some parts of joint. If the insulation is repaired, we expect that the heat energy consumption will reduce to 121,375.82 MJ/Y with the investment of 22,000 THB and can save cost at 31,540.36 THB per year with the payback period at 0.7 year.

Figure 4 Show of damage insulation and need repair

Table 5 The results of replacement with insulation of pipe, valve, flange damage

Period	Year 2017
Investment	22,000 Baht
Thermal energy reduce	121,375.82 MJ
Cost reduce	31,540.36 Baht
Payback period	0.7 Month

3.3 Applying with Stream Devices by the waste heat recovery system

The temperature measurement of chimney rates at 180-200ºC which can make use of the remaining heat by using it to produce hot water at 50ºC. The process can be done by applying Economizer system to produce hot water instead of using heat pump at the time boiler is working. The calculation shows that if we do the investment at 400,000 THB, the heat energy can be reduced to 373,887.36 MJ/Y and reduced energy cost to 107,471.27 THB per year with the payback period at 3.7 year. Comparison with the heat pump saving, the record of electricity used in 7 days at the time boiler is working, the heat pump uses electricity at 141,6249 Kw per year, heat energy at 509,846.4 MJ/Y and heat energy reduces to 515,511.36 MJ/Y which is saving cost to 622,983.63 THB per year and the payback period at 0.64 year.

Figure 5 Electricity measurement of heat pump when producing hot water

Table 6 The results of energy saving by replacement heat pump hot water production 12 hrs.

Table	Unit	Data
Electricity power	Kwh/Y	141,624
Thermal energy loosed	MJ/Y	509,846.4
Cost saving	Baht/Y	515,511.26
Total save cost	Baht/Y	622,982.63
Investment	Baht	400,000
Payback period	Year	0.64

3.4 Future work

- The return of condensate water is not completed yet and all condensate water can be improved to increase the water temperature make up water of boiler, which results in higher boiler system efficiency and more energy saving.
- Capacity of boiler 3 ton per hour, in practical use 1 ton per hour about 65% of boiler. To be adjusted for operating machine in suit operation of boiler will reduce operation time or change the size of burner to smaller size for reduce LPG consumption economy based-on investment and payback period.

4. Conclusion

By researching and implementing measures to improve boiler efficiency, it is part of the improvement of large machines in the production process which can reduce the heat energy consumption, energy cost, and *carbon dioxide* emissions without any investments. The process need only changing in working systems and processes. For investment, we have to consider at Break Even Point and other effects. This is to make consider for the next research and continually improvement. In order to do research and improvement, we have to investigate the operations and all processes must not disturb other services. We have set the target to reduce at 7% from year 2016 and get the high effective production in laundry system by using LPG gas 0.39 KG to wash 1 KG of clothes. At the results, we can improve the efficiency as follows:

- Improvement efficiency of process measures which can reduce energy consumption to 7.14%.
- The measures that ongoing process can reduce energy consumption to 6.14%.
- Overall result of improving energy efficiency in boiler system reduced to 13.28%.
- Overall effectiveness in laundry process is at LPG 0.37 KG per clothes1 KG as targeted.

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Authors's Profile

Somkiat Pornsaroj, Chief Engineer at Dusit Thani Bangkok Hotel (Mobile number: (+66) 081-3468183). He has graduated in Bachelor of Engineering in Industrial Technology and Master of Engineering in Engineering Management from Kasem Bundit University.

Sakchai Rakkarn, Ph.D. Director of Master of Engineering in Engineering Management Program. (Mobile: (+66) 094-9459988, Email: sakchai.rak@kbu.ac.th). He has graduated in Bachelor of Engineering (First Class Honor) in Industrial Engineering at Kasem Bundit University, Master of Engineering in Industrial Engineering at Kasetsart University and Philosophy of Doctoral in Systems and Control Engineering at Case Western Reserve University.

Samroeng Netpu, Ph.D. Lecturer of Master of Engineering in Engineering Management Program. (Mobile: (+66) 089-9946598, Email: netpu007@gmail.com). He has graduated in Bachelor of Engineering in Machanical Engineering at King Mongkut's University of Technology Thunburi, Master of Engineering in Engineering Management at Kasem Bundit University University and Doctor of Engineerng in Integrated Product Design and Manufacturing at King Mongkut's University of Technology Thunburi.

Jeerawat Plongmai, Director of Department of Industrial Engineering Technology. (Mobile: (+66) 081-3491799, Email: jeerawat.plo@kbu.ac.th) He has graduated in Bachelor of Industrial Technology in Industrial Engineering and Master of Business Administration Management at Kasem Bundit University. He also holds Master of Engineering in Industrial Management Engineering at King Mongkut's University of Technology North Bangkok.

Jomphop La-or, Lecturer Department of Industrial Engineering Technology (IET.), Faculty of Engineering, Kasem Bundit University. Contact Tel. 02-320-2777 Ext. 1216, Fax 02-321-4444, Mobile phone 090-135-4077, E-mail: jomphopl@gmail.com, Bachelor degree Graduated from Production technology and Master degree Production Engineering KMUTNB. Bangkok Thailand