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Research Article

# Steam System Optimization at Palm Oil Mill: Case Study in Sabah, Malaysia

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**Abstract**

In this paper, a preliminary study of industrial steam system reveals that most of the industrial steam user especially the palm oil mill did not bother to save energy as long as the mill meets their productions target and is getting profits for the company. The management is not aware that a huge amount of energy is being wasted during the processes of extracting oil from the fresh fruit bunch (FFB). To embark this study, Steam System Scoping Tool (SSST), Steam System Assessment Tool (SSAT) and 3E Plus: Insulation Program Software, provided by the United Nations Industrial Development Organization (UNIDO) are used to assess the efficiency of steam system operations. The tools also assist in preliminary assessments of how efficiently the steam system is operating. After analyses are conducted, the proposed improvement project is recommended to modify the system back to its initial designed best efficiency. The results also show that there were various losses that are contributing to the energy waste and its cost impact to the mill. Meanwhile, the boiler efficiency was only about 68.6%. The findings proposed steam system optimization (SSO) opportunities by installing the feedwater economizer and reducing the blowdown rate of the boiler. The efficiency of the boiler was increased to 77% from its current operating condition. This also improved the steam quality and production output of the mill. Through these SSO, the annual demand saving is around 4.9 MW, with an energy saving of 75,276 GJ/yr., capable of reducing 13,002 metric tons of carbon dioxide emissions per annum and save 598.3 Tph/yr of biomass fuel. Thus, through this steam system optimization the estimated annual net cost savings are around USD 100,000.00. This paper aims at promoting similar system optimization projects at other plants throughout Malaysia, as it benefits to all industrial steam user especially the palm oil mill industries in Malaysia.

***Keywords*: Palm Oil Mill; Energy Saving Opportunities; Steam System Optimization; Steam System Tool Suite

## 1. Introduction

Energy is the main driver for the organization of the mill to keeps its operation moving. System optimization is the method to identify the amount of savings achievable and to ensure the equipment throughout the mill is operated in an optimum condition. It is common for palm oil mills that has been operated for decades to stray out from their initial ideal control parameters settings. Due to that, system will be operated inefficiently, where losses will occur. In order to understand the efficiency of the whole system of the mill, each of the major components of the industrial steam system need to be isolated and evaluated based on each major area of the systems. Any generic steam system either in industrial, commercial or institutional will have four major areas which are generation, distribution, end-use and condensate recovery as can be seen in Figure 1. Each of these areas have their numerous component which may or may not exist in medium or small steam user. The proficiency of each component may affect the overall system efficiency (Chowdhury et al., 2018).

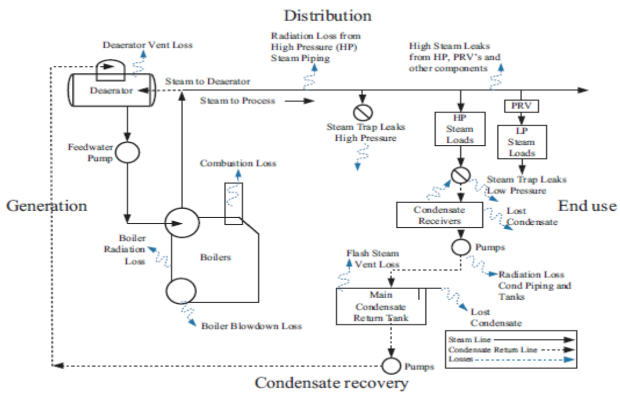


Fig. 1. Generic Steam System Schematic (adapted from (Chowdhury et al., 2018))

The data from industry states that the average steam energy usage could be as much as 35-40% of the onsite energy usage. Thus, implementing the optimization and minimizing their operating costs is crucial (Industrial

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Steam System Optimization Expert Training, 2012). In fact, steam system improvements can save an average of 8-10% in fuel costs at a typical industrial facility (Tool to Boost Steam System Efficiency, 2008). In 2011, the largest energy consumer in Malaysia was the industrial sector, 35% of the 62.7 Millions of tonnes of oil equivalent (Mtoe) of energy as shown in Figure 2. Moreover, as shown in Figure 3, the premier fuels consumed in the generation of power plants in Malaysia was the fossil fuel which is coal and natural gas, 43% of each input structure (Chong et al., 2015). There are various industrial system in the country, but since most of it has major steam system in common, it makes it beneficial to target these systems for energy efficiency measures (Worrell & Price, 2015).

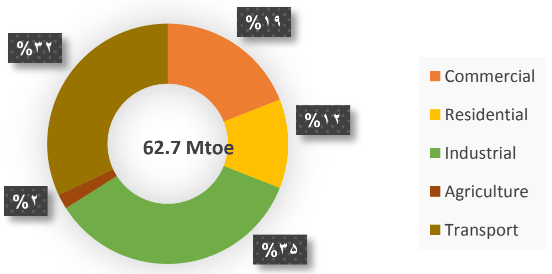



Fig. 2. Energy consumption by sector in Malaysia 2011

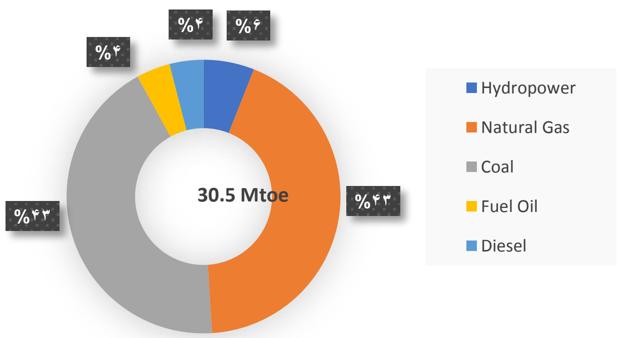



Fig. 3. Fuels input of power plants in Malaysian in 2011

In this study, the fuel used to generate the steam is coal (Fibre and Shell). The fuel is mainly produced from the milling process of the FFB line 13 and 19 as shown in Figure 4.

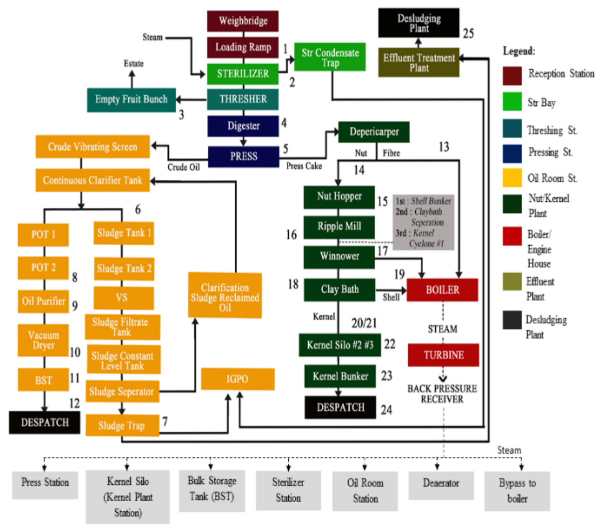



Fig. 4. Overview flow chart of the milling process at the case study's plant

In 2001, the steam system tool had been used by the United States of America, Department of Environment (DOE) Industrial Assessment Centre to assess steam system at eighteen small and medium-sized facilities. The assessments successfully found 89 steam system opportunities with an average payback of seven months and an average fuel bill savings of 12.5%. It yielded a total of USD 2.8 million of the annual saving (Tool to Boost Steam System Efficiency, 2008 pp. 2). These tools were used in 2014 at an oleochemical industry in Malaysia to seek potential saving opportunities in the steam system. The implemented efficiency measures showed a significant annual savings result total of USD 210,896.00 with simple payback of two years (IOI Pan Century Oleochemical Sdn.Bhd, 2014). The contribution towards the profitability for every plant will be significant by enhancing the efficiency of the steam system.

An article reviewed about the system debottlenecking was been conducted at food industrial plant in the USA. The steam system optimization that being conducted had proposed eight recommended opportunities. Table 1 shows the SSO opportunities that being proposed in the industry plant in USA. All the recommendations demand no major process modificaation and can be installed either through the periodic maintenance or during the plant turn-around. This industry had an opportunity to save USD 270,000 annually and can help in reducing carbon emission around 1284 metric tons per annum (Nevena et al., 2000).

Table 1
Steam Systems Saving Opportunities (Nevena et al., 2000)

| Recommended Opportunities | ESTIMATED ANNUAL SAVING | | | |
|---|---|---|---|---|
| | Cost Saving (USD) | CO2 (Metrics tons) | Investment (USD) | Payback Period |
| Installation of Economizer | 72,000 | 442 | < 182,000 | 2.5 years |
| Installation of Vent Condenser to the Deaerator | 10,400 | 53 | < 18,000 | < 2 years |
| Quenching of Flash Steam in Central Condensate Receiver | 10,900 | 59 | < 3,000 | < 4 months |

| | | | | |
|---|---|---|---|---|
| Recover Heat from Cooling in Air Compressor | 57,300 | 346 | < 62,000 | 1.1 year |
| Optimize Condensate Return System | 74,300 | 207 | 137,000 | < 2 years |
| Prevention of Thermal Shock in Aquachem & Nitrogen Area | 4,300 | 4 | 15,000 | < 3.5 years |
| Flash Steam Recovery using Heat Exchanger | 28,700 | 173 | 51,000 | 1.8 years |
| Recover Pressure (Energy) Instead of Reducing Steam Pressure through PRV | 10,800 | - | - | - |
| **TOTAL** | **270,000** | **1,284** | | |

Another study also mentioned the improvement measures have been arranged into two methodologies. A good maintenance and enhancing the operating conditions with no/low cost of investment and enhancing the significant energy user with major improvement. This article also studies the steam system of the major petroleum refinery. The study discovered annual saving total up to USD 1,115,300 through the optimization of the steam system (Ven, 1999).

In this case study, the mill faced several challenges throughout processing the FFB. Firstly, the temperature of the feedwater boiler is low, which was 65℃. Lower temperature of feedwater boiler will lead more time heating up the water to produce steam, higher fuel consumption and diminish the overall efficiency to 68.8%. Yoon, Y.K. stated that by maintaining the feed water within the feed cistern at higher temperature also can helps prevent corrosion within the boiler system. The quantity of oxygen absorbed by the water is proportional to the temperature and pressure of the water. The lower the water temperature, the more oxygen the water can absorb. At feedwater temperatures above 100 ℃., there is minimal to no oxygen absorbed by the water. The solution for the steam system optimization through heat recovery can maintain the feedwater temperature as high as 97℃. The typical temperature of the feedwater in the boiler system is 65℃ (Yoon, 2020). The other problem that needs to be encountered was occasionally the temperature of the steam used to sterilize the FFB at sterilizer station was low. This will affect the quality of the production of crude palm oil (CPO) and the palm kernel (PK). Sterilizer station is the first station that processes the FFB. This station utilizes 90 to 120 minutes of high temperature steam of 145℃ in order to sterilize the palm bunches (Palmoilmills.org, 2018). Hence, the current condition of the system needs to be monitored in order to adjust the system back to its initial best efficiency. Through optimization of the system, the mill will reduce its baseline consumption, thus increases the productivity and the production quality of the mill.

### 1.1. Significance of Works

In this study, the problem where the lower temperature of the feedwater boiler and the lower steam temperature to sterilize the palm bunces is due to the inefficient of the steam system in the mill. This paper provides an example of a significant improvement on steam system of palm oil industry, especially at the case study's site. When the mill conducts system optimization, wastage will be eliminated. Each amount of money that the mill save is the amount of money that the mill will earn, because it is not being consumed towards wastages. This is the principle behind the implementation of energy savings measures. Other significances of this case study are reducing carbon dioxide emissions, enhancing energy efficiency and increase the production quality through energy saving opportunities through saving of input consumptions. Saving input consumptions provides opportunities for the plant to give way for more production. The amount of wastages is the amount of production that can be produced if the plant conduct the operation properly. This work is a newly implemented project in Malaysia specifically in palm oil mill, and to date, there are no case study implemented in Sabah, Malaysia for the steam system optimization. The methodology for this study will be a novelty and guidance to the rest of the industry using steam as their system of process production, in particularly those that are implemented in Malaysia.

## 2. Methodology

### 2.1. Office Data Collection and On-Site Measurement

In this study, the targeted mill went through assessment through piping and instrumentation diagram of the system and milling process of the FFB with the help of the organization personnel. During this office data collection, all the baseline data were collected (operating cost, electrical consumption and production output). The main generation of steam in palm oil mill is the water-tube boiler, which contributes as the significant energy user for its fuel consumption. The numerical analysis and the software that is used to boost the system efficiency is the Steam System Suite Tool. This Steam System Tool Suite is used to evaluate and identify the steam system improvements. The tools consist of three software which are Steam System Scoping Tool (SSST), 3E Plus® Software and Steam System Assessment Tool (SSAT).

#### 2.1.1. Steam System Scoping Tool (SSST)

This SSST is a software-based questionnaire and is used to identify the potential improvement opportunity areas in the mill's steam system. It consists of 26 qualitative questions divided into Steam System Profile, Steam System Operating Practices, Boiler Plant Operating Practices and four generic areas of the steam system practices (Steam Distribution, Generation, End-Use, and

Recovery). Based on the result of the SSST, it delivers a score representing opportunities for improvement.

### *2.1.2. 3E Plus® Software Tool*

3E Plus is an insulation program software used to calculate the heat losses based on the data collected during the field measurement. It also helps the user to determine the optimal insulation thickness. Before using this software, an assessment was conducted by identifying the potential heat losses sources using a thermal imaging camera. Tables 1 and 2 shows that the thermal images which were taken on site, focusing on three stations, which are sterilizer, oil room and boiler house station. These three stations are the significant energy usage (SEU) at the palm oil mill investigated in this study.

The huge loses of heat to the surrounding were on the main stop valve (MSV) pipeline at the boiler house station, followed by the steam header pipeline at the oil room station and on the steam inlet pipe at sterilizer station. The thermal images reading showed 183℃, 120℃ and 113℃ respectively. The losses of heat on these pipelines will affect the quality of steam distribution, the extraction of palm oil and quality of the sterilized FFB during the plant processes. The further results will be discussed on section 3.2.1.

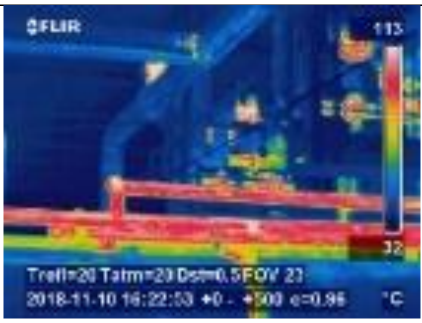
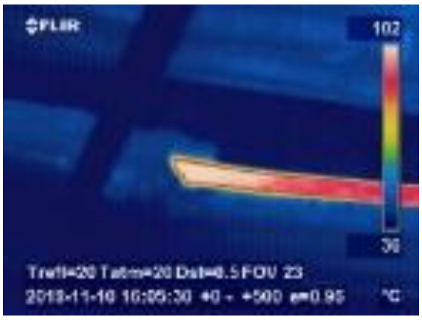
During the preliminary assessment conducted using this thermal imaging camera, there were seven traps observed which shows the ineffective steam strap management. Figures 13~19 show the several steam straps captured using the equipment. The figures indicated that the yellowish and reddish line after the trap showing high temperature leakages from the steam, which also suggesting the steam traps are faulty and needs replacement. The evaluations of the insulation are based on the data collected on-site. The equations below were used to calculate the heat losses and fuel wasted along the three significant energy user areas identified in this study. The equation of the heat losses and the fuel wasted can be expresses as Eq. (1) and (2), respectively (Cengel and Boles, 2015);

$$\dot{Q}_{total} = q_{per\ length}\ L_{total}\ (kW) \tag{1}$$

$$Fuel_{Wasted} = \dot{Q}_{total}\ x\ \frac{3\ 600s}{1\ hr}\ x\ Operating\ \frac{hour}{yr}\ x\ \frac{1}{Boiler\ efficiency}\ \left(\frac{mt}{yr}\right) \tag{2}$$

where $q_{per\ length}$ is the heat losses per specific length, and $L_{total}$ is the length of the targeted pipe measured in the system.

Table 2
Tabulated Data on Heat Losses Parameter Measurement

| Stations | Thermal Images | Parameters Measurement | | | |
|---|---|---|---|---|---|
| | | Process Temp., ℃ | Ambient Temp., ℃ | Maximum Surface Temp., ℃ | Nominal Pipe Size, mm |
| Sterilizer |   Fig. 5. Steam Inlet Pipe | 118 | 32 | 113 | 150 |
| Oil Room |   Fig. 6. Steam Header 2-Piping Line 4 (Horizontal) | 120 | 36 | 102 | 50 |

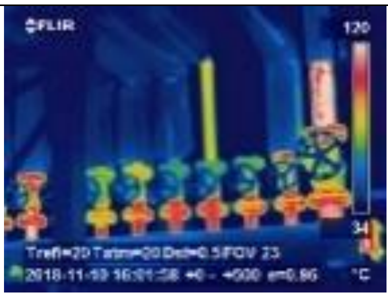
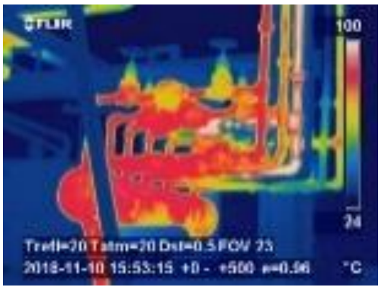
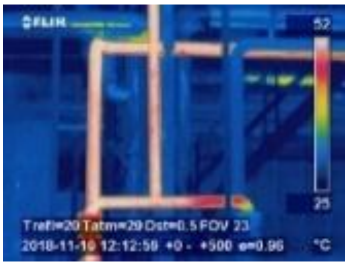
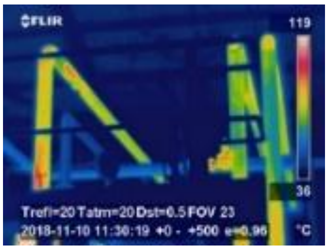
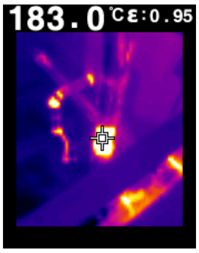
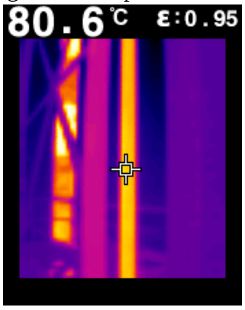
| | | | | | |
|---|---|---|---|---|---|
| | <br>Fig. 7. Steam Header 2<br>(Piping Line 4)<br>(Piping Line 1) | 120 | 34 | 79 | 50 |
| | | 120 | 34 | 120 | 100 |
| | <br>Fig. 8. Steam Header 1<br>(Vertical Line)<br>(Horizontal Line) | 120 | 24 | 100 | 50 |
| | | 120 | 24 | 100 | 50 |
| | | 120 | 24 | 98 | - |

Table 3.
Tabulated Data on Heat Losses Parameter Measurement

| Stations | Thermal Image | Parameters Measurement | | | |
|---|---|---|---|---|---|
| | | Process Temp., ℃ | Ambient Temp., ℃ | Maximum Surface Temp., ℃ | Nominal Pipe Size, mm |
| Boiler House | <br>Fig. 9. Feed Water Pipe<br>(Vertical Line)<br>(Horizontal Line) | 65 | 25 | 52 | 100 |
| | | 65 | 25 | 52 | 100 |
| | <br>Fig. 10. Superheater Pipe<br>(Vertical Line) | 135 | 36 | 80 | 100 |

| | | | | |
|---|---|---|---|---|
| <br>Fig. 11. SV Pipe to Turbine | 135 | 36 | 183 | 115 |
| <br>Fig. 12. Deaerator Pipe towards Feedwater | 65 | 26 | 80.6 | 100 |

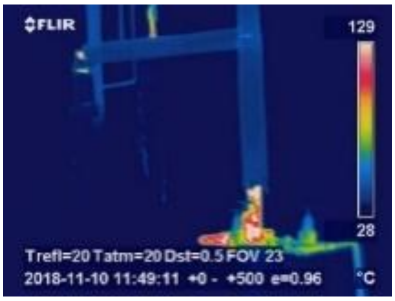


Fig. 13. Steam Trap 1 at Main Line Area (Boiler Station)

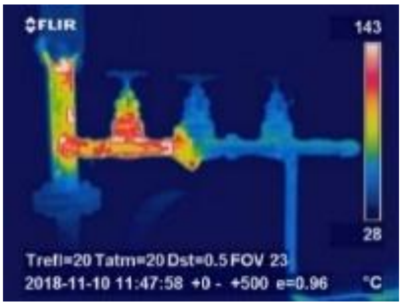


Fig. 14. Steam Trap 2 at Steam Pump Area (Boiler Station)

Fig. 15. Steam Trap 3 (Boiler Station)

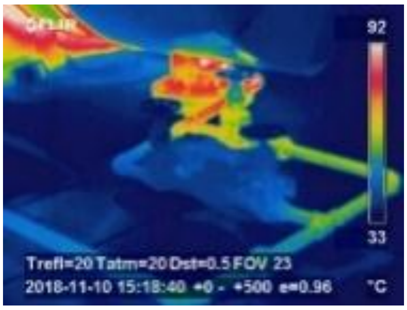


Fig. 16. Steam Trap BPR (Back Pressure Receiver)

Fig. 17. Steam Trap for Steam Header 3 at Oil Room Station

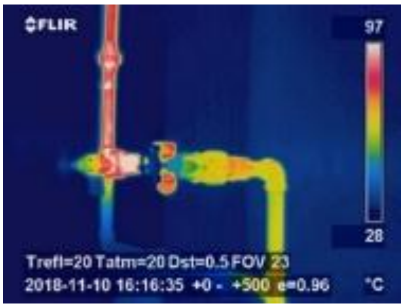


Fig. 18. Steam Trap Near POT (Pure Oil Tank area)

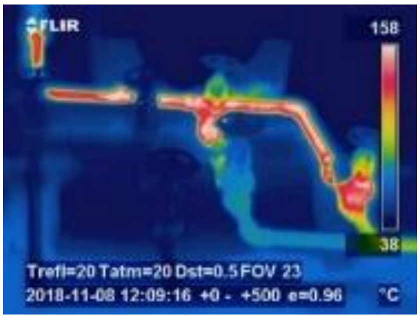


Fig. 19. Steam Trap at Crude Oil Tank Area

### *2.1.3. Steam System Assessment Tool (SSAT)*

The SSAT is used to model the current operating system and consist of thirteen improvement scenarios as shown in the Figure 20 and it also contains the stack losses calculator. The SSAT is organized with three pre-defined steam system templates which are 1-header, 2-header and 3-header. All the site details are very crucial to obtain a trusted steam system model which represents the on-site steam system.

The stack gas measurement conducted in this study was conducted at a height of 21 $m$ from its stack boiler. Figure 21 shows the thermal images of the stack gas temperature obtained in three measurements.

The temperature of the stack gas is used in the SSAT stack gas calculator. It will estimate the stack losses, which in our finding, was 26.4% with 11% of oxygen content. Thus, the boiler efficiency at the mill was a mere 68.6%. This efficiency also had been cross checked using direct method for boiler efficiency.

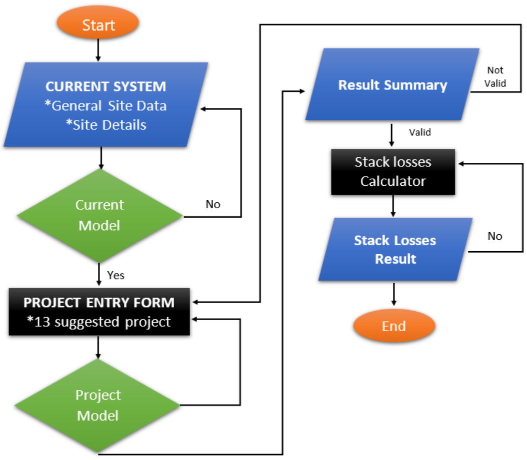



Fig. 20. Flow chart of using SSAT

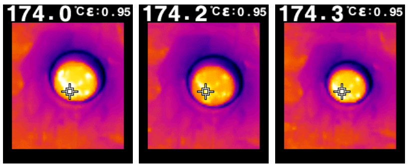



Fig. 21. Thermal Images of the stack gas temperature

## 3. Results and Discussions

### *3.1. Preliminary findings*

Figure 22 shows the energy consumption against the production output of the mill (CPO and PK), which shows that both are dependant to each other. The baseload energy consumption within these three consecutive years is 32,933 kWh. The $R^2$ values for this energy regression analysis is 0.51 (51.0%). The graph shows that the $R^2$ values for this energy regression analysis is only 0.51 (51.0%). It shows the total of energy being consumed converted and represented in electricity bill based on Malaysian tariff. It increased together with the production output at positive side of the graph, except at the red point. The red point shows that the plant consumed higher energy but having lower production on that time and the quality production is also lower (Kernel Extraction Rate (KER)-18.73; Oil Extraction Rate (OER)-3.79).

Meanwhile, the green point at the negative side of the graph indicates that the energy consumption is lower, but it produces higher production during that time. However, the production does not achieved the targeted quality extraction rate (OER-19.23; KER-5.10). This case occurred due to the lower steam quality and the steam system is inefficiently operated due to many heat losses during the production process as shown in Tables 1 and 2. These cases also affected by the raining weather during FFB process, lower FFB quality received to the mill and uncontrollable losses during process.

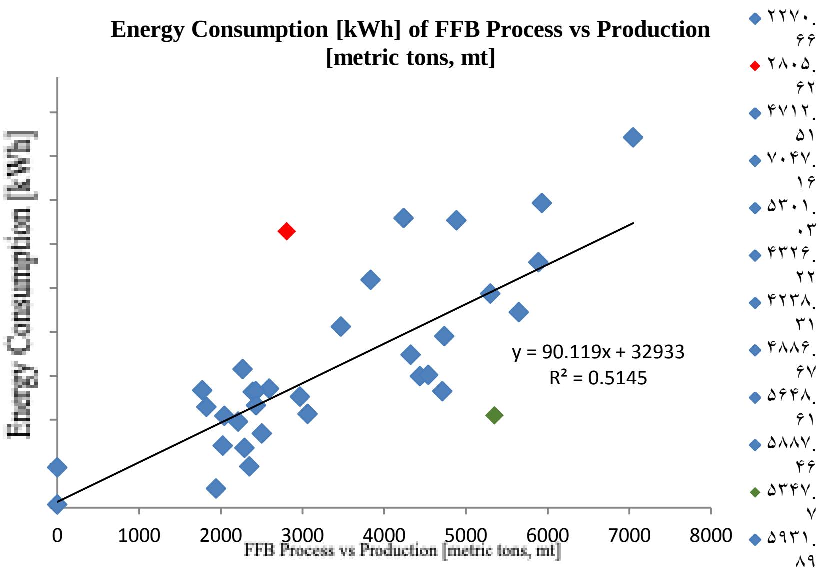



Fig. 22. Linear Regression Analysis: Energy Consumption of FFB Process against Production

It is important for the mill to be observe its energy consumption trend to reduce its baseline and knowing how good the mill is operating. This baseline can be used as a reference point that allows the mill operator to compare its energy performance after any modifications are made.

### *3.2. On-Site Data Measurement*

Upon conducting the SSST by interviewing the mill personnel, 62.1% of scoping tool assessment score were obtained. This suggests that the mill can improve its energy intensity usage by doing some improvements to its current operating conditions. It can be concluded that currently, the mill that is being studied is not managing its energy usage efficiently.

### *3.2.1. Analysis of Heat Losses*

The heat losses measurement only focusses in three stations. As stated earlier, all of these stations are the significant energy uses (SEU) in palm oil mill and the quality of steam that received to this area give impact to the quality of the productions during milling process. The evaluation of heat losses due to improper insulation was conducted. The total heat losses based on the measurement taken is 95.0l W/s during the process of FFB. Based on these heat losses, the amount of wastage during milling operations was estimated to be 234 metric tonne per year and that is equivalent to around USD 3,115.63 annually.

### *3.3.2. Analysis of Steam System Blowdown Energy Losses*

There is an average of ten cycles of concentration in the water-tube boiler. The boiler blowdown is in manually practices where the impurities blown out within five times in an hour. Based on the boiler efficiency evaluation, the amount of the blowdown thermal energy content and blowdown losses is 484.0 kW/s and 4.9% of feedwater boiler respectively. The estimated cost impact for this energy blowdown losses is around USD 110,245.44.

3.2.2 Modelling of Current Operating and Proposed Improved Conditions of Steam System

Prior to doing measurements, the analysis of current operating condition for the mill's steam system is being modeled using SSAT. The generated model for mill's steam system is shown in Figure 23. From the figure, it can be observed that the current operating condition costs USD 2,253,560.60 annually, and this data is also cross checked with the actual operating cost for the mill.

This current model is then used to compare with the proposed projects to save energy. The first proposed project is to reduce the blowdown rate to 1.5% of feed water flow. Currently, the blowdown is being conducted at a pace of five times per hour, eight hour per shift or 80 times per day. There are two shifts in a day. This proposed project can be done by installing an automatic blowdown system. Next, installing the economizer can help to increase the feedwater boiler and optimizing the steam demand. These two proposed projects can automatically increase the boiler efficiency from 68.6% to 77%. Thus, the proposed project model is shown in Figure 24.

The summary of the results of the SSAT after modelling the project input is shown in Table 3. The mill can obtain the annual saving through the utility balance of the steam system optimization. The table shows that there is 10.9% and 5.9% reduction of the boiler duty and the consumption respectively, if the boiler efficiency is increased and the blowdown rate of the feedwater boiler is reduced. Reducing the stack temperature can also save an estimated of around 576 kW and one tonne per hour of the biomass fuel, annually.

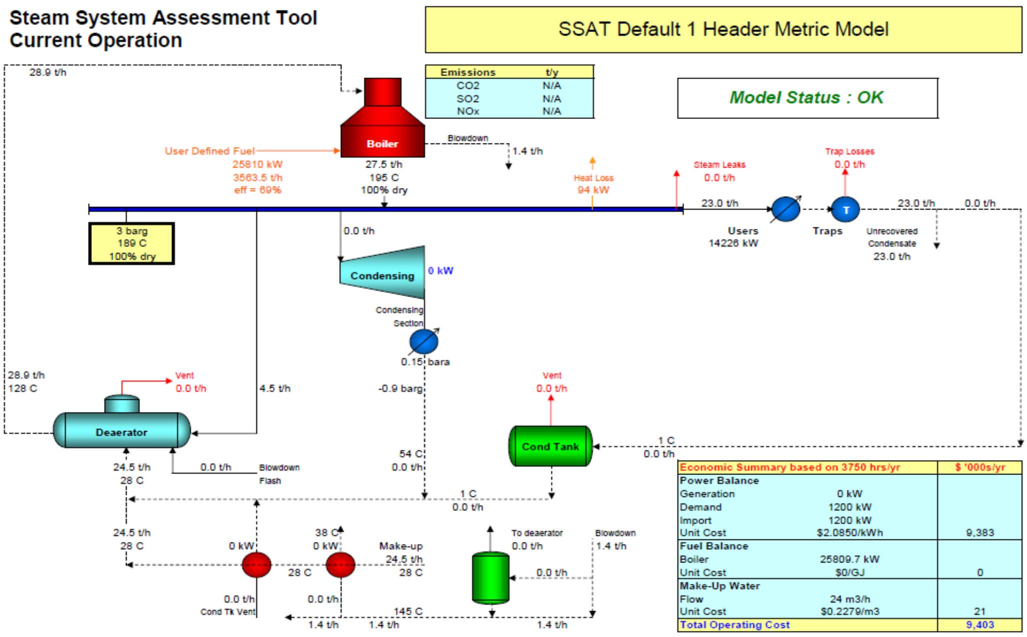



Fig. 23 Current Operating Model

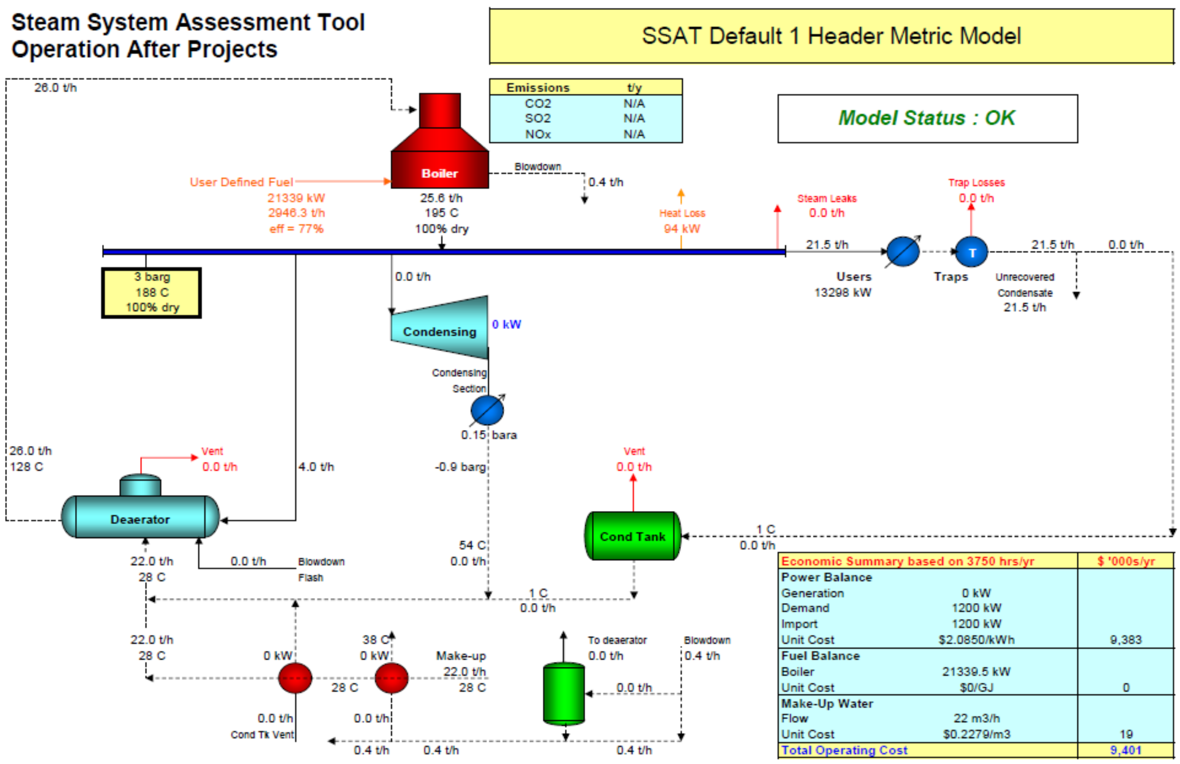



Fig. 24 Project Model

Table 4.
Summary of SSAT Results (Source: Database results of SSAT)

| | | Total Cost (in USD '000s/yr.) | Boiler Duty (kW) | Fuel Consumption (Tph) | Boiler Steam Flow (TPh) |
|---|---|---|---|---|---|
| **Current Operating** | | 2,203 | 25 810 | 3 563.5 | 27.5 |
| **Increase Boiler Efficiency** | After Project | 2,203 | 22 994 | 3174.8 | 27.5 |
| | **Reduction** | **0** | **2816**<br>**10.9%** | **388.7**<br>**10.9%** | **0** |
| **Reduce Blowdown Rate** | After Project | 2,203 | 24 299 | 3354.9 | 27.3 |
| | **Reduction** | **234** | **1511**<br>**5.9%** | **208.6**<br>**5.9%** | **0.2**<br>**0.7%** |
| **Reduce Stack Temp.** | **Reduction** | - | **576** | **1.0** | |

## *3.3. Estimated savings*

From the measurements, the temperature and the oxygen contents still can be reduced. Improvements by reducing the temperature and its $O_2$ contents will result in a lesser stack loss, as can be seen in Table 4.

Using the stack losses table provided in the software, the current boiler efficiency is 68.6%. The water-tube shell losses for the mill and blowdown losses is 0.1% and 4.9% respectively, and it is not a value that is negligible. Thus, by implementing the feedwater economizer, the efficiency of the boiler can be increased to 72.3%. The amount of energy transferred to the feedwater by installing economizer can provide savings of energy on its heat recovery.

Table 5
Stack losses Values on SSAT Stack Loss Calculator

| Boiler Capacity (Tph) | | Stack Temperature (°C) | Oxygen Content (%) | Stack loss (%) | Boiler Efficiency (%) |
|---|---|---|---|---|---|
| 28 | Current | 174 | 11 | 26.4 | **68.6** |
| | New | 140 | 7 | 22.7 | **72.3** |

*Assumption based on SSAT of the current oxygen content by cross checking using direct and indirect method of the boiler efficiency at 68.6%.

The amount of energy transferred to the steam in the boiler is 27.80GJ/Hr. The current fuel usage is 5.1 Tph. The new fuel usage if the economizer is implemented will be 4.9 Tph. Thus, the estimated annual energy saving for the mill is 7,700 GJ per year with annual cost saving approximately USD 15,000.00/yr.

Reducing the blowdown rate substantially reduce energy losses, as the blowdown liquid temperature is coming from the same steam generated in the boiler. The other effects are that the makeup water and the chemical treatment cost will also be reduced.

As stated earlier, current mill practice is manual blowdown. The mill personnel do not know whether it is insufficient blowdown or excessive blowdown. The blowdown is performed just by blowing the impurities to lower down the total dissolved solid (TDS), neglecting the fact that a huge amount of energy, water and chemical used are wasted. The factors that are affecting the optimum blowdown rate are including the boiler type, operating pressure, water treatment and the quality of make-up water (Minimize Boiler Blowdown, 2012).

The installation of automatic blowdown control system and reducing the blowdown rate from 4.9% to 1.5% is proposed to improve the steam system. The operating pressure boiler is 18 barg and 27.5 Tph steam boiler.

Based on the analysis that is being conducted on implementing the automatic blowdown control system, the thermal energy saving was approximately 251.0 kJ/kg per year. The estimated amount of water and chemical saving is USD 73,000.00 per annum, meanwhile the estimated annual fuel saving is around USD 7,000.00. Hence, the estimated of the annual cost saving by installing the automatic blowdown system is USD 80,000.00. The summary of energy optimization opportunities in Table 5 shows the implications of the estimated annual saving for the mill. The estimated annual saving for the electrical demand, energy saving demand and the biomass fuel is 4,903 kW, 75276 GJ and 598.3 Tph respectively. The table also shows the implication on carbon dioxide emission, where if the recommended opportunities are conducted, the mill will be able to reduce an estimation of around 13,002 mt of carbon dioxide from being exhausted to the environment. The total estimated annual saving is around USD 95,000.00.

Table 6
Summary of Energy Saving Opportunities

| Recommended Opportunities | ESTIMATED ANNUAL SAVING | | | | |
|---|---|---|---|---|---|
| | **Electrical Demand (kW)** | **Energy Demand (GJ)** | **CO2 (Metrics tons)** | **Biomass (Tph)** | **Cost Savings (USD)** |
| Reduce Blowdown Rate | 1,511 | 27,000 | 4,007 | 208.6 | 80,000.00 |
| Increase Boiler Efficiency | 2816 | 40500 | 7468 | 388.7 | 15,000.00 |
| Reducing Stack Gas Temperature | 576 | 7,776 | 1,527 | 1.0 | |
| **TOTAL** | **4,903** | **75,276** | **13,002** | **598.3** | **95,000.00** |

*1 kWh being saved is equivalent to reduced 0.0007mt of carbon dioxide emissions

## 4. Conclusion

The purpose of this work was to investigate the relationship between the production output of the mill and its energy baseline, identify the heat losses and cost impact to the mill, evaluate the current steam system and propose SSO opportunities for the improvement of the steam system in Sabah, Malaysia. For these purposes, assessments of the steam system of the mill were performed by doing on-site measurement, modelling steam system using software provided by UNIDO and making analysis for the current and optimized condition. All findings and results of this research may contribute to the estimated annual saving of the mill. The estimated annual electrical demand, energy demand and the biomass of fuel are around 4903kW, 75 276 GJ and 598.3 Tph of fuel respectively. The total annual net cost savings that can be obtained are estimated to be USD 100,000.00 through this system optimization. Industrial steam user needs to be aware of their energy consumption in order to generate more productions which have contributed to good quality of production and gain outmost savings. This paper also proved the significance of work the mill can obtain through this system optimization. The paper also shows that the the carbon dioxide emission can be reduced, enhancing the energy efficiency and increasing the production quality. These savings eventually can be used to increase production.

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