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Application of an Energy Management System to Develop an Energy Planning in a Pickling Line

Yulineth Cárdenas Escorcia, Guillermo Valencia Ochoa and Lourdes Meriño Stand

Energy Eficiency Research Group - kaí, Engineering Faculty
Universidad del Atlántico, km 7 ancient vía Puerto, 081008
Barranquilla, Colombia

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Abstract

This paper presents the methodology and results of the application of an energy management system for energy planning in a pickling line in the metal-mechanic sector, so that to identify the energy saving potentials. The fundamentals equations used to estimate the energy performance indicators, a brief description of the pickling line and the results of the energetic and productive characterization are presented. The equivalent production method was conducted to estimate the energy performance indicators of the plant based on a year data operation. In addition, the indicator allowed to identify energetic and economic saving potentials, to look for 19.7 % of saving potentials without technological changes, which represents 565.69 kWh, while the savings potential associated with production were 1722.72 kWh, considering that the line has a critical production of 100000 m^2/day and an average production of 59200 m^2/day. Finally, it can be concluded that the application of an energy management system is powerful method to develop an energy planning in a pickling line, helping the energy culture in the company.

Keywords: Energy management system, energy planning, pickling line, energy performance indicator

1 Introduction

In the different sectors of the economy, the concept of efficiency has been changed from the conception of the conservation to the Efficient Use of Energy [1], [2] Now day, the efficiency is recognized as a strategic component in sustainable development and challenges relating to climate change, energy security and economic development at the lowest cost to society [3].With this concept, the company has identified a representative to productive level and a financial savings [4], these efforts are widely known as technical efficiency and efficiency of resource allocation, where efficiency is related to the use of less energy inputs, while maintaining a constant productive outputs [5]. Different studies show the relationship between the variables, the indexes of energy efficiency and the external and internal variables of the different production processes, for example in China in the coal industry is considered to be energy variables related with the policies of coal price relate to the internal and external variables, where it is stressed that these have a positive impact on energy management strategies and the subjective perception and self-motivation, and a negative impact on the price of energy [6]. Korea for his part and measures the activities of industrial energy savings (ESA) in the Republic of Korea by identifying its determinants through a survey of energy-intensive, which showed that more than 90% of the samples have practiced those institutional and managerial, requiring significant costs [7] [6]. In the same way, United States evaluates decisions on investments in energy efficiency for small and medium-sized manufacturing companies, who have received the evaluation of the Department of Energy (DoE), where it is stressed the importance of the return time and investment costs as the main determinants of savings [8] In addition, based on the results of research in characterization and evaluation of wind and solar potential [9], the industrial sector has fostered over the years the use of renewable energies in productive processes, by means of regulations that governed in each country, allowing a reduction of approximately 37 % of the consumption of energy [10]. Based on the foregoing, the implementation of these systems has become strategic axes and missionary for companies [11], and promote continuous improvement in the processes.

On the other hand, the action of the European Community to develop the agenda of the l Framework for Action on climate and energy up to the year 2030 and the adoption of the Standard of energy management systems ISO 50001 by the International Organization for Standardization, has made it possible to extend the implementation of plans for continuous improvement in the efficient use of energy in the industrial sector, given that this rule suggests a set of technical and management requirements that companies must meet and maintain over time [12], with procedures and techniques for many organizations that require the preparation of professional and technical staff in charge of the Processes [13], [14] [12] Within the relevant aspects in energy efficiency, is the performance of the equipment, this being the main factor of competitiveness in the industrial sector, and bearing in mind that the process of energy efficiency starts with the measurement of the equipment, to obtain inputs for the calculation of the energy performance indicators that show the energy characteristics in the production process.

2. Methodology

2.1. Energy Management System

The efficient energy management tools used in this study are based on the steps and procedures of quality management, supporting on the continuous improvement of the energy performance for industrial processes [15]. Since the approval of ISO 50001, a new stage of implementation of comprehensive management systems has been started at the global level, allowing, for different companies, the establishment of an energy policy aimed at improving the energy efficiency of processes, thus determining equipment and sub-processes that consume energy significantly, foreseeing projections and quantifying potential savings associated with production, and their respective action plans to achieve these potentials [16]. The standard proposes a four-stage model: energy policy, energy planning, implementation and verification all inserted in the cycle of continuous improvement, where it is emphasized that energy planning with its main constituent elements are the foundation of strategies to improve energy performance [17]. To implement the energy management system, it is necessary to follow a series of steps to reach the proposed objectives in the energy policy and to achieve efficiency and the use of energy resources. Therefore, the first stage is the strategic decision. Figure 1 shows the components and stages with the corresponding activities for the implementation of the energy management system.

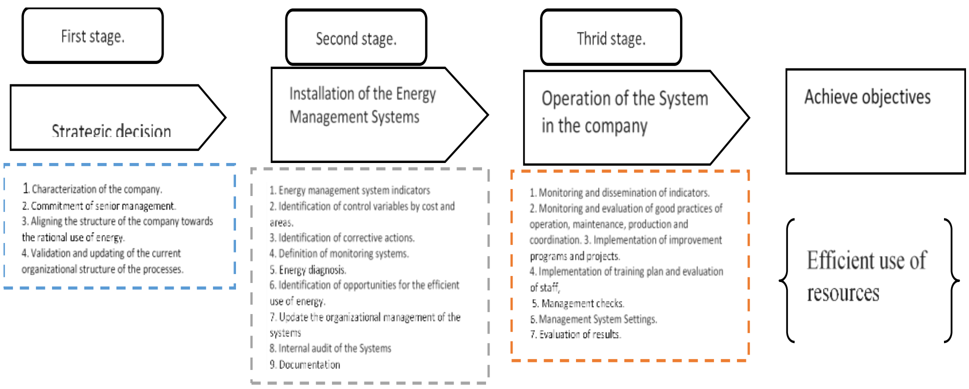

Figure 1. Components in energy management system

2.2. Energy performance indicators

In order to quantify and calculate the energetic performance indicators, it is necessary to follow a methodology, starting at the statistic treatment of energy consumption, process and production information, then, estimating baselines and goals for each process, calculating later the results for: Consumption index, base 100 efficiency, and trend graphs, looking forward to a permanent improvement of the process [18].

For the filtering of information, which is a pre-treatment of statistical data relevant to the study of the process, it is necessary to take an interval of one standard deviation as shown in equations 1 and 2.

$$Upper\ limit = E_t + 1 * Standar\ Deviation\ , \quad (1)$$

$$Lower\ limit = E_t - 1 * Standar\ Deviation, \quad (2)$$

where, E = Energy consumption in time t.

After the filtering, where it is necessary to comply withU$pper\ limit\ > E_{actual} > Lower\ limit$, the following is to proceed with the establishment of a goal-line, using real consumption data below the baseline of energy consumption, according to

ETheoretical – Eactual > 0. (3)

Later, the real consumption index (IC) is built with energy consumption and production (p) as shown as follow

$$IC_{Acual} = \frac{E_{Actual}}{P}, \quad (4a)$$

while, theoretical consumption index is calculated as

$$IC_{Theoretical} = \frac{E_{theoretical}}{P}. \quad (4b)$$

The energy base line is obtained from the linear regression of historical data of energy consumption and production; energy base line has the linear form as in equation 5.

$$y = mx + b \quad (5)$$

Another key indicator is the graph of cumulative trend, which is a tool that allows to monitor the company’s energy consumption with respect to a baseline period. Finally, efficiency Base 100 index, is a tool for energy management that helps to evaluate the behavior of energy consumption measured during a period of production time in plant comparing with theoretical values calculated using the baseline. This index is calculated using equation 6.

$$Base\ 100 = \frac{E_{theoretical}}{E_{Actual}} \times\ 100\%. \qquad (6)$$

This indicator generates warnings regarding positive or negative variations in the energy efficiency of the process, thus facilitating the analysis and proposal of action plans in function of energy improvements, allowing the analytical interaction between production and energy consumption, aiming at a better process energy performance.

2.3. Application case: Pickling line in metal- mechanic company

The company where the present studied was carried out is a company from the Colombian metalworking sector that produces galvanized steel and metallic architecture products. The plant has pickling line where a surface treatment is made to the metal parts using a chemical attack with an acid to remove rust or impurities present that are attached to the surface of the metal. Pickling line is shown in Figure 2.

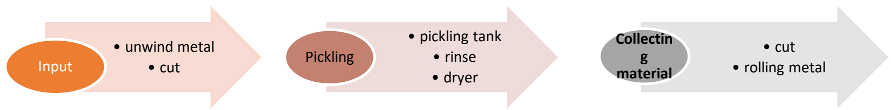

Figure 2. Flow diagram of process studied

3. Results and Discussion

The energy characterization results and energy performance indicators analysis for a pickling line are presented below. As for the control limit graph, which established an upper limit and lower limit separated by three times the standard deviation of the average of the electric consumption data as shown in Figure 3. According to the result July 7th, September 27th and 29th consumption was above the upper limit of consumption, therefore these data were considered atypical and were not be taken into account for the energy performance indicators analysis.

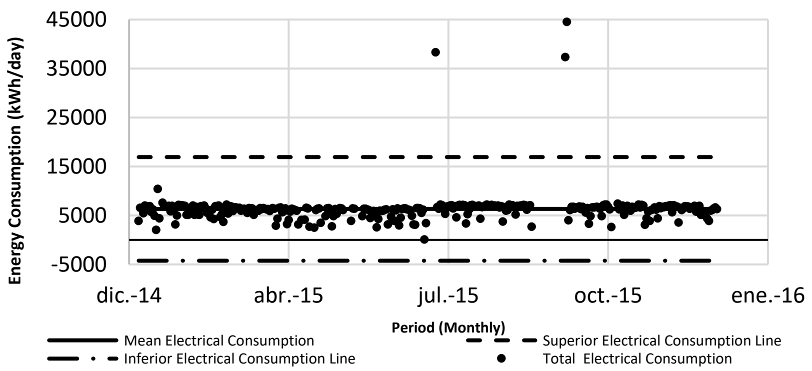

Figure 3. Control limit graph for the electric consumption of the pickling line.

On the other hand, Figure 4 shows the control limits plot for the production data, indicating that the production records for April 14th and 22nd are below the lower production limit, therefore, these data were not included in the energy analysis of the pickling line.

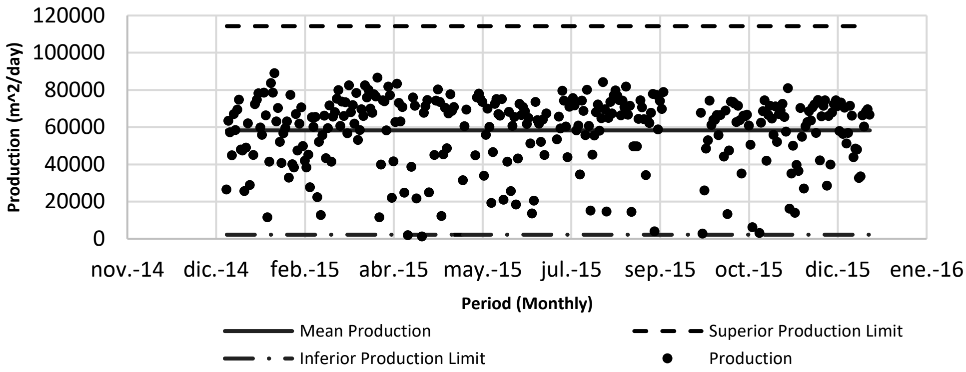

Figure 4. Control limit graphic for the production of the pickling line.

According to the energy consumption and production over time behavior, presenting similar behavior in the variation, however it is possible to observe atypical behaviors that can be explained by maintenance days or unmoral operation condition in the production line. When obtaining the energy and production plot, the baseline was initially obtained with a linear correlation of $R^2 = 0.5338$, requiring data filtering in order to achieve an acceptable correlation for the analysis of the energy performance indicators without losing the functionality between the production and the energy, obtaining the baseline (dashed line) and the target line (solid line) as shown in Figure 5. The results show potential for energy savings associated with good manufacturing practices, due to the target line was constructed from the production data and power consumption below the baseline.

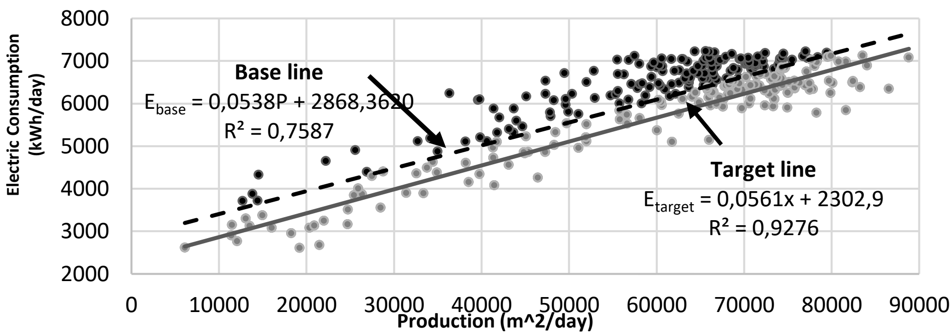

Figure 5. Target line graph for pickling line.

The comparison of the real consumption index versus the theoretical consumption index is shown in Figure 6, where the actual consumption index varies between

0.429 and 0.073 kWh/m^2. It is observed that the pickling line has production levels below the critical production related to the plant technology, which is calculated as 100000 m^2/day according to the theoretical consumption index, however the company has production levels of less than the critical production, of which the average production rate for the company is estimated to be approximately 59200 m^2/day, which indicates that the pickling line can present better levels of energy performance, reaching lower consumption rates, through better production planning in the pickling line and in the plant.

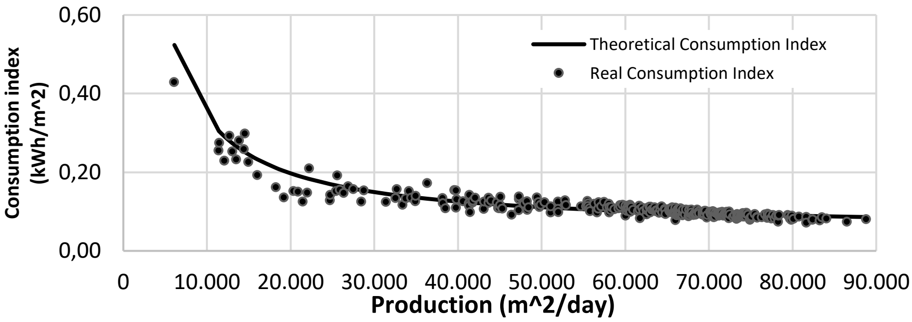

Figure 6. Actual consumption index vs. theoretical consumption index for the pickling line.

Taking into account 2015 year as studied period in Figure 7, three periods of time with a clear tendency are observed, the first period presents from the beginning of February until the first week of March where was presented a stable behavior with a low energy performance, the second period is clearly visible from the second week of March to the end of June, where an economic saving was presented associated to a good energy performance, the third period clearly visible during the second half of the year with a tendency towards poor energy performance. Additionally, for the pickling line was identified periods of random peaks that do not represent any trend, explainable by phenomena such as maintenance days or plant stops.

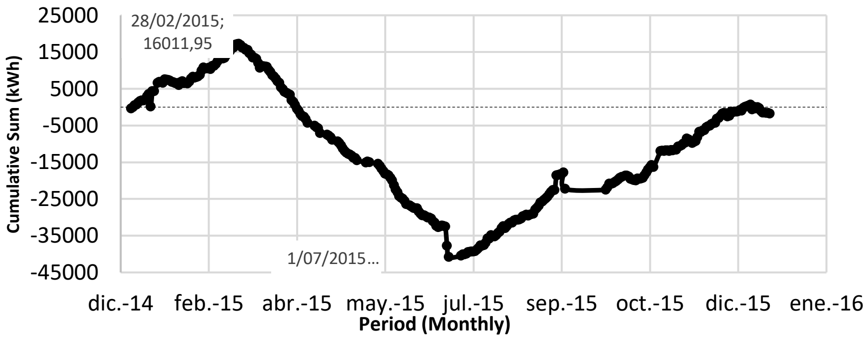

Figure 7. Cumulative trend graph for the Pickling line in 2015.

For the application of the base 100 efficiency index to the pickling line shown in figure 8, the points above the line are considered good energy performance data located in the energy efficiency zone of the plant. Otherwise, when the efficiency index is less than 100 %, the data are located below the line and it indicates that the data belong to a zone of energy inefficiency of the plant.

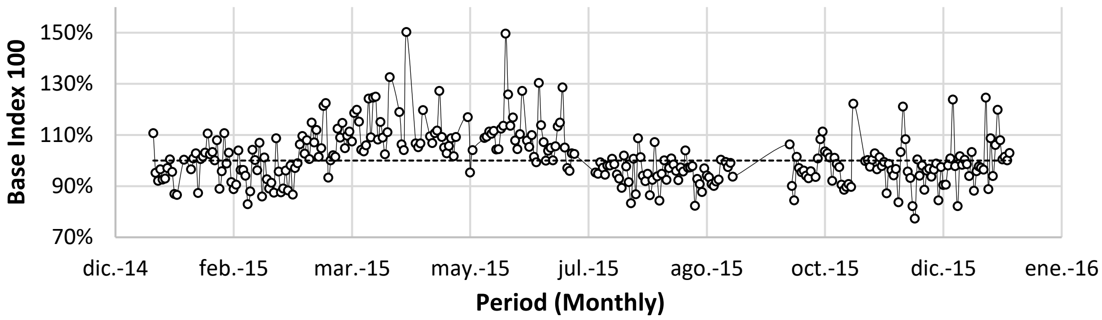

Figure 8. Base 100 efficiency index for the pickling line.

Finally, the analysis of the potential for saving by good non-production energy manufacturing practices can be reduced by 19.7 %, which translates to 565.69 kWh, while the savings potential associated with production is 1722.72 kWh, considering that the line has a critical production of 100000 m2/day and an average production of 59200 m^2/day.

4. Conclusions

The successful results of an energy planning in the line were achieved, according to the implementation of an energy management system based on the ISO standard 50.001 in a metal-mechanic company in Colombia, identifying the significant uses of energy in the plant. In order to keep the continuous energy saving, it is necessary to develop the phase of implementation of the system, in order to register and control of energy indicators, a later verify the energy saving. The results showed a powerful method to improve the use of energy and the sustainability of the reduction of energy for the company with low investment measures, based on good manufacture practices for each significant use on the line. Finally, the last phase of monitoring and adjustment is been conducted, in which the measurement, evaluation and monitoring of the energy savings are developed in order to incorporate to the management system of the company the ISO 50.001 methodology.

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