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Energy Effectiveness and Conservation of Pipeline Construction Industry Using Iso 50001 Energy Management System

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Abstract

The number of pipeline construction industry and electricity prices in Indonesia from 2013 to 2019 has increased. In order for the pipeline construction industry to be sustainable and competitive, the industry must strive to reduce electricity consumption, one of which is the ISO 50001 energy management system approach. This research identifies energy intensity data; energy performance data from Significant Energy Use (SEU) in the production process of the pipeline construction industry and comparing it with baseline values; targets to be achieved; and analyzing the effects of machines, materials, methods, human and environmental factors on energy consumption. Based on the results of the discussion, this research can conclude that the construction of piping work requires electricity for the cutting and welding process. The highest electrical intensity intensity is in the welding process, which averages 16.4 KJ/cm (88.2% of total energy consumption) and the cutting process is 2.2 KJ/cm (11.8% of total energy consumption). So a significant use of energy for corrective action is that the pipe work process is a welding process. Factors that cause high energy consumption/energy intensity in pipe construction work include method and material factors. Result of every factors can reduce the electricity consumption of the welding process from 16.4 KJ/cm to 7.5 KJ/cm (54.3%).

Keywords: ISO 50001 energy management system, Energy intensity, Energy performance, Seven tools.

1 | Introduction

The construction industry plays an important role in the Indonesian economy. According to the Central Statistics Agency (CSA), the value of the construction sector's contribution to Gross Domestic Product (GDP) is 10.49% or Rp 367.8 trillion. Meanwhile, the number of construction industry and pipeline construction industry, which is the industry that built pipe and pipe installation from 2013 to 2019 increased. According to the National Association of Piping Contractors (AKPINAS) in 2019, it is stated that the cost of electricity contributes about 18% of the total cost. The intensity of electrical energy used in the classification process ranges from 15.6-17.1 KJ/cm greater than the reference value of 8.3 KJ/cm [1]. In a situation like this, in order for the pipeline construction industry to be sustainable and competitive, the industry must strive to reduce production costs and one of them is to reduce electricity consumption.

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In previous research, it was stated that one of the most effective methods in reducing energy consumption and energy-related costs is the application of energy management. The application of energy management in the construction industry sector can reduce electricity consumption [2]. The development of standards on the ISO 50001 energy management system has attracted the attention of top management in continuous improvement [3]. By determining the Significant Energy Use (SEU), we can determine the focus on energy reduction performed [4]. Next step is identifying potential energy savings and suggest corrective measures. These steps require a detailed analysis of the technical factors and organizational structure in the production process. These measures are evaluated based on the criteria determined by the PDCA cycle required to run the energy management system [5].

2 | Literature Review

Pursuant to Government Regulation Number 70 of 2009 in Article (1) paragraph (1): energy conservation is a systematic, planned and integrated effort to save domestic energy resources and improve the efficiency of their use [16]. Meanwhile, according to Regulation of the Minister of Energy and Mineral Resources Number 14 of 2016 on the implementation of energy conservation services business in article 1 paragraph 3: Energy efficiency is an effort to use energy efficiently and effectively without reducing comfort, safety and productivity. Energy management involves the monitoring, measurement, recording, analysis, critical inspection, control, and directing of energy and materials flowing through the system to the point where less energy is expended to achieve useful goals [3]. Energy efficiency aims to control the cost of energy consumption and minimize unnecessary energy [6]. The ISO 50001 standard provides a standard framework to assist organizations in building energy management systems and energy management processes required in order to improve energy performance [7]. Proper organizational orientation of the company is necessary to achieve energy management goals [8]. The ISO 50001 energy management system model can be used by companies effectively in an effort to develop energy planning and improve energy performance [9]. Another goal to implement ISO 50001 is facility maintenance and scale-based and sustainable [10]. In industry, energy efficiency can be improved with three different approaches, including energy saving management, energy efficient technology, and regulations on energy saving [11]. The application of ISO 50001 is to measure the energy produced, fuel consumption, electricity consumption, heat consumption, number of buildings under building management, change in number of transport vehicles, fuel consumption, etc. [12]. Evaluation criteria are set including effectiveness, cost, ease of implementation, time and impact on the environment [13]. To be more effective, the energy management program consists of four main parts, namely: Audit of historical data analysis and energy accounting; Technical analysis and investment recommendations based on feasibility studies; and training and information staff [11]. Companies with ISO 50001 certification can implement energy management with better management commitment, energy knowledge, and energy audit compared to companies that do not have ISO 50001 certification [14]. Energy management design based on ISO 50001 refers to Law No. 14 of 2012 implemented by making policies, energy management planning, energy saving principles, implementing energy plans, evaluating energy management with reference to audit findings and reviewing energy management occurring [15]. The goal of ISO 50001 is to provide the standard framework needed to improve energy performance. The ISO 50001 approach encompasses measures to improve energy performance consisting of management measures and technical measures [7].

3 | Methods

This study uses a mixed method with case study design. These research activities include: Identification of energy intensity data; energy performance data from SEU in the production process of the pipeline construction industry; comparing performance with baseline values; and analyzing the effects of machines, materials, methods, human and environmental factors on energy consumption. SEU is calculation of large energy consumption or offers great potential to improve energy performance. The primary data is collected by using field observation methods, secondary data using energy consumption records, and equipment-related reports in significant energy consumption in the pipeline construction industry. The population in this research is the business actors in the pipeline construction industry serving plumbing construction for the chemical and petrochemical industries as the largest consumer of the pipeline construction industry. Selection of study sample was done by using non-probabilistic sampling technique, and the selected study sample in a pipeline construction industry serving the chemical and petrochemical industries. Problem solved conservation and energy efficiency problems using the ISO 50001 approach focusing on technical steps with the following levels (as shown in *Fig. 1*).

Data collection on energy intensity in the pipeline construction industry was based on the ISO 50001 Energy Management System including:

I. Identifying each energy source and the amount of each energy source (using the same unit) used in the production process in a given period.
II. Calculating large energy consumption and offers great potential for improved energy performance.
III. Indicating the amount of energy required by the company to produce one unit of product.
IV. Operating variables that influence changes in the Net Plant Heat Rate.
V. Using the realization of energy performance measures in previous periods to determine quantitative references that provide a basis for energy performance comparisons.
VI. Develop a function between energy consumption and total production.

Next is Comparing and identifying achievements with targeted energy performance indicators for significant energy consumption in the ISO 50001 Energy Management System, and the finale step is perform cause and effect analysis on energy performance indicators (achievements) that exceed the target value as a reference in the ISO 50001 Energy Management System using fishbone diagram. Factors analyzed include machines, materials, methods, humans, and the environment.

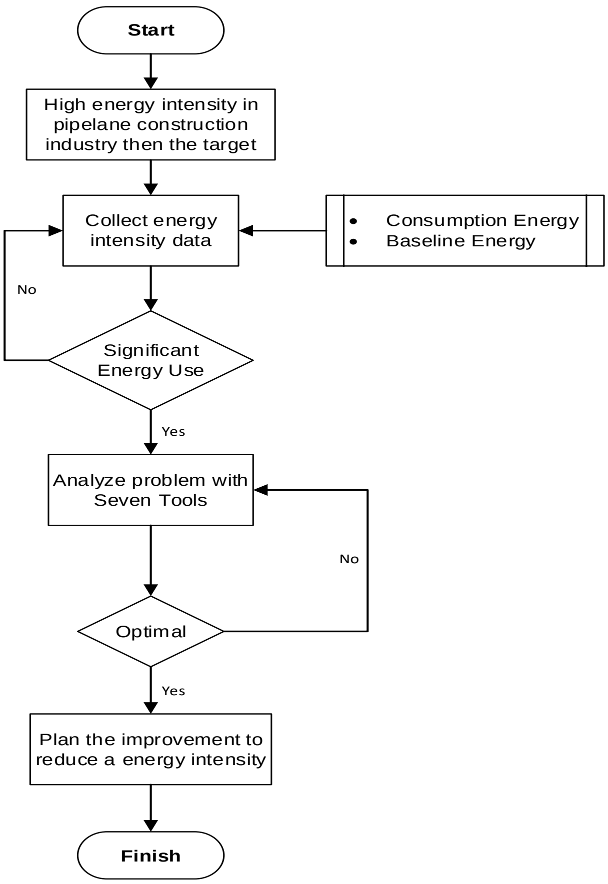

Fig. 1. Research framework.

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4 | Result

At this stage, the data required in this study are energy intensity data on pipe construction work. The data obtained in the study sample from 2015 to 2019 are as follows:

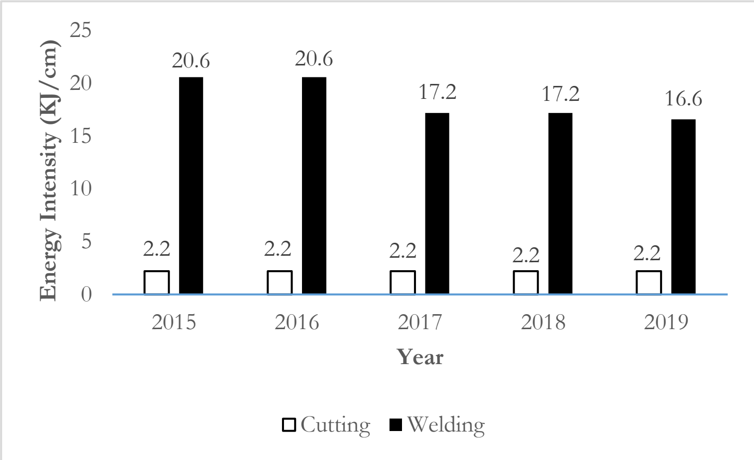

Fig. 2. Energy intensity of the pipeline construction workforce in 2015-2019.

In *Fig. 2*, it is explained that in 2017 it was observed that the use of energy (energy intensity) electricity for pipe construction work decreased by 11.34% for the cutting process and 88.66% for the welding process from the previous year with the increase of cable and welding machine replacement the energy intensity required is reduced. Meanwhile, in 2020, it was observed that the use of electricity (energy intensity) for pipe construction work decreased by 11.70% for the cutting process and 88.30% for the welding process by changing the welding method by shortening the distance between the welding machine and the workpiece from the previous year. Then the energy intensity value obtained in 2019 is used as the energy baseline for 2020. Further, the data studied are the types of pipes processed in pipeline construction work in 2019 as follows:

Table 1. Types of piping materials in the pipeline construction work process in 2019.

No.	Material	Number of Joints (DB)	Percentage (%)	Cumulative (%)
1	Carbon Steel	15478	11,01	11,01
2	SUS 304L	26736	19,01	30,02
3	SUS 316L	92336	65,67	95,69
4	SUS 317L	6061	4,31	100,00
TOTAL		140611	100,00	

Based on the information in *Table 1*, the type of material processed for production in 2019 shows that the construction of SUS 316L material pipe is the material most processed by production, which is 65.67% of the total production. Further in *Table 2*, in implementing energy efficiency with the energy management system approach, ISO 50001 is to determine the SEU of the average energy intensity of pipe construction work in 2019.

Table 2. Average energy intensity of pipeline construction process in 2019.

No	Process	Energy Intensity (KJ/cm)	Percentage (%)	Cumulative (%)
1	Welding	16,4	88,17	88,17
2	Cutting	2,2	11,83	100,00
TOTAL		18,6	100,00	

Table 2 shows that the highest average electrical energy intensity is in the welding process, which is 88.17% of total energy consumption, so significant energy consumption in the piping work process is a classification process. The next level of the ISO 50001 energy management system method is to determine the energy baseline as the reference value of achievement in a given period, in this case, for 5 years from 2014 to 2018 of 16.6 KJ/cm for the welding process.

The next step is to determine the energy consumption targets that will be achieved in the welding process. As seen in the data on the type of pipe material in the pipeline construction work process in 2019, the type of pipe material used is dominated by SUS 316L material (65.67%). From the reference, the energy intensity value for SUS 316L welding process is around 8.3 KJ/cm [13]. The performance of the energy performance indicator is the energy intensity value of the welding process obtained from the data in 2019 with an average of 16.4 KJ/cm, while the target of energy performance indicator according to reference is 8.3 KJ/cm. Achievement energy intensity values can reach baseline values but do not reach the target to be achieved, which means that the energy consumption process for welding is inefficient.

Next, an analysis of why the energy intensity of the classification process is greater than the baseline (inefficient). Performing the analysis tool used is a cause and effect diagram (fish bone chart). The method used to make the causal diagram is through Focus Group Discussion (FGD) with the relevant parties in the welding process. The results of brainstorming by conducting FGD related to the causes and factors that influence energy consumption in the welding process by production, engineering, and quality control are shown in *Table 3*.

Table 3. Contributes to the causes of high energy consumption in the classification welding process.

No	Causes	Factor
1	Total flow of energy that does not follow the standard (60-90 A).	Method
2	The speed of the welding process does not follow the standard (5-8cm/minute).	Method
3	Root gap is too large (2-3, 2mm).	Method
4	Use of filler metal in damp conditions.	Material
5	Use of pipes in damp conditions.	Material
6	Does not have a standard for optimal energy flow.	Method
7	Does not have a standard for optimal welding speed.	Method
8	Does not have a standard for root gaps.	Method
9	Incompatible filler metal diameter (2.0-3, 2 mm).	Material
10	Do not have a standard for cleaning / drying filler metal.	Material
11	Do not have a standard for cleaning/drying pipes.	Material
12	Do not have a standard for the optimal size of the filler metal.	Material

The results of brainstorming on the causes of high energy consumption in the classification process are 6 method factors and 6 material factors from this result. Furthermore, the principles used in making fish bone diagrams use references from the results of brainstorming. *Fig. 3* is a diagram of the causes (fish bones) of the causal factors of the method. Based on the results of the fish bone diagram, it is explained that there is no standard suitable root gap, flow, and classification speed of the method factor. Next, the causal diagram (fish bone diagram) of the material factors in *Fig. 4*.

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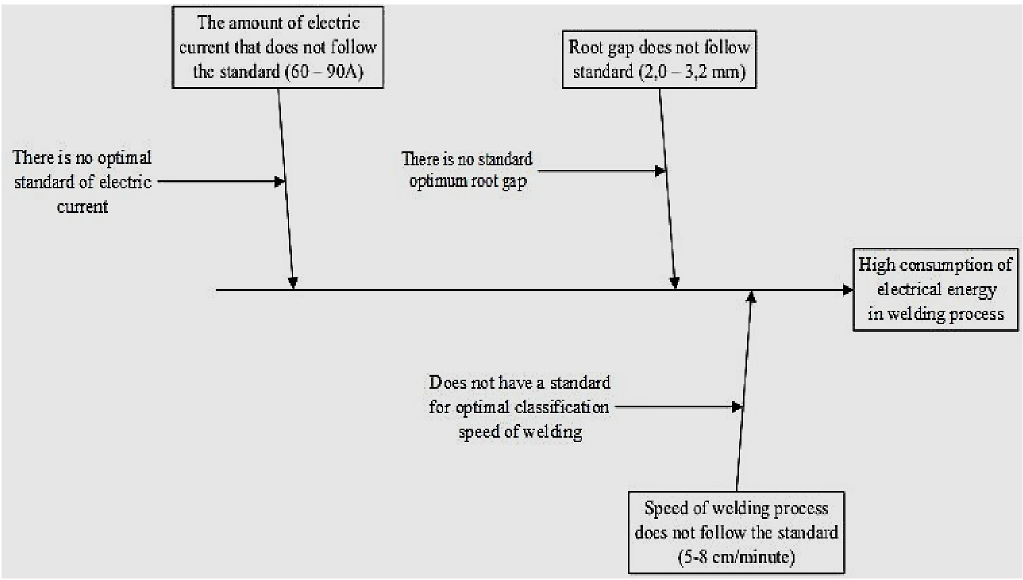

Fig. 3. Fishbone diagram of method factor.

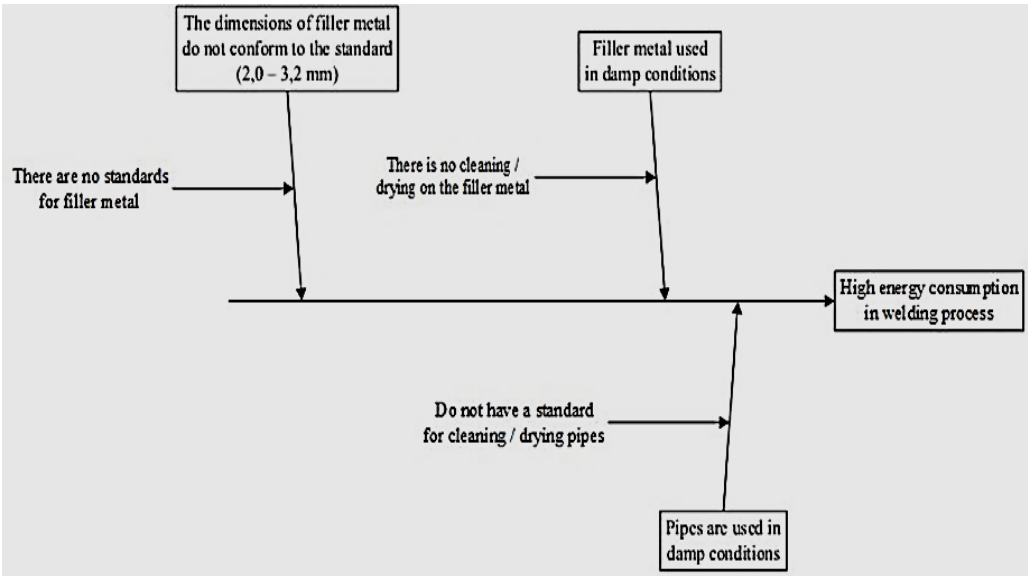

Fig. 4. Fishbone diagram of material factor.

Based on the results of the fishbone diagram, it is explained that there are no suitable filler metal measurement standards and there is no cleaning/drying of filler metal and pipes from material factors. From the results of the analysis, recommendations are made for improvements to two factors that are problematic in welding process. There are several suggestions for improvement to address this issue including:

- *Standard for the amount of current in the welding process 50 A.*
- *Standard for welding speed 8 cm/minute.*
- *Standard for 1.5 mm root gap size.*
- *Standard for filler metal with a diameter of 2.4 mm.*
- *Standards for cleaning metal and filler pipes before welding.*

The proposed improvements are made in an effort to minimize energy consumption that exceeds the target so that energy intensity can be maintained.

5 | Conclusion

Based on the results, this research can conclude that the pipeline construction work requires electricity for the cutting and welding process. The welding process is the most significant process of energy consumption. The average energy intensity of the SUS 316L material pipe welding process after repair efforts decreased by 54.3% from 16.4 KJ/cm to 7.5 KJ/cm. Factors that cause high energy consumption/energy intensity in pipeline construction work include not available of standard for optimal current, not available of standard for optimal welding speed, not available of standard for root gap, not available of standard for cleaning/drying metal and pipe filler. The need for further research by conducting research on some pipe measurements and other types of materials and further research is need on influence of welding capabilities/skills on energy consumption required for pipe construction work.

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