Research Progress in Mechanical and Manufacturing Engineering Vol. 4 No. 1 (2023) 333-338
© Universiti Tun Hussein Onn Malaysia Publisher's Office

RPMME

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/rpmme
e-ISSN : 2773 - 4765

Study of Low Density Polyethylene Melting Process and Energy Saving in Recycling Industries

Muhammad Muqtadir Azman[1], Zamri Noranai[1]*

[1]Faculty of Mechanical and Manufacturing Engineering,
Universiti Tun Hussein Onn Malaysia 86400 Parit Raja, Batu Pahat, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rpmme.2023.04.01.038
Received 25 August 2022; Accepted 31 January 2023; Available online 01 June 2023

Abstract: The effects of various Polyethylene recycling methods, the temperature required during the recycling process, the time required for the Polyethylene to be completely recycled, the energy required to recycle the materials, and the reduction of waste during the recycling process. The primary objectives of this research are to study LDPE physical characteristic before beginning the process, to identify LDPE recycle melting process, to propose potential energy saving at melting process and to estimate potential energy saving. This study's scope defines the Current melting process at Kinta Recovery Recycling Sdn Bhd in order to collect data. Then, calculate the difference between the existing heater of the process and the potential energy savings if an induction heater is utilized. Consequently, conclude that conducting the injection molding process in accordance with the specified instructions will result in energy savings

Keywords: Energy Saving, Plastic Recycling Industries, Induction Heater

1. Introduction

Since the discovery of numerous routes for the manufacturing of polymers from petrochemical sources, the plastics industry has grown tremendously in scope and sophistication. Plastics have significant advantages over many other types of materials in terms of weight, durability, and cost, and they are particularly advantageous when compared to metals.[1] It is estimated that approximately 4% of global oil and gas production, which is a nonrenewable resource, is utilized as feedstock for plastics, with a further 3% to 4% of that amount needed to provide energy for their creation.[2]

There are four objectives of this research. This research will cover plastic characteristic, the process, and potential saving. The objectives are to study LDPE physical characteristic before beginning the process, to identify LDPE recycle melting process, to propose potential energy saving at melting process and to estimate potential energy saving.

*Corresponding author: zamrin@uthm.edu.my
2023 UTHM Publisher. All right reserved.

The expectation of the research at the end is the physical characteristic of LDPE has been identified, the recycle melting process also identified, several improvements will be suggested and the saving benefit to factory.

2. Materials and Methods

The materials and methods chapter, also called the methodology section. Methodology is systematic and standardized approach or process that can be applied to a particular subject of study. This chapter will cover the method/process used to undertake this case study. A research must have a clear methodology that provides a distinct frame of mind to aid in achieving its purpose.

2.1 Materials

Kinta Recovery & Recycle Sdn Bhd is recycling factory located in Plot 29, Kawasan Perindustrian Seramik, Jalan Seramik Chepor 11/4, 31200, Chemor, Perak. Kinta recycle factory are specialized in handling LDPE plastics and papers. In this project are going to study on the type of plastics recycling process options and to learn what type of the melting processing can be used.

2.2 Methods

Based on the information shown in Figure 1, it is necessary to conduct an investigation right at the beginning of the research process in order to guarantee that the research will proceed in an orderly way.

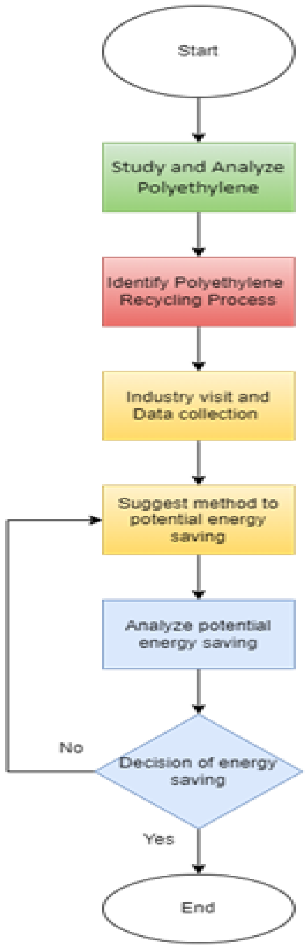

Figure 1 : Flow Chart of Methodology

In the first place, concentrate on studying and analysing polyethylene at the manufacturing. The next step is to locate the melting process for recycled polyethylene before conducting an industry visit.[3] Following that, going to the factory to gather the data. In addition, methods that may have the ability to save energy should be suggested, and the potential for energy savings should be analysed. The research will come to a close with an emphasis on energy efficiency in industrial settings.

The equation that used in this research is stated below:

The total amount of heat that is generated, $Q_c = I^2R = VI = {V^2}/{R}$ Eq. 1

Breakdown of the heat produced by a three-phase circuit, $QC = 3VI$ Eq. 2

The heat transmission, $Q = 2\pi kN \frac{(T_p - T_i)}{\ln(R_i/R_p)}$ Eq. 3

The amount of energy needed, $E = (M \times C_p \times \Delta T)$ Eq. 4

3. Results and Discussion

The outcomes of the research study, together with their analysis and discussion, are presented and discussed in this chapter. The purpose of the study was to determine whether or not there is a connection between insulated Materials and the amount of heat that is lost. The difference between the conventional heater used for injection moulding and the potential application of an induction heater, in addition to the disparity in the amount of energy required to maintain each temperature.

3.1 Energy Contribution

The comparison of the current heaters that used in industries and the induction heater band[4] that suggested has been show in Table 1.

Table 1 : Comparison between Current and Induction Heater

	Current Heater Band	**Induction Heater Band**
Energy Contribution	$258.552 \times 10^6\ Joule$	$102.816 \times 10^6\ Joule$
Energy Intensity	$0.01197 \frac{\frac{kW}{h}}{kg}$	$0.00476 \frac{\frac{kW}{h}}{kg}$

Based on the information presented in Table 1, it is able to draw the conclusion that the current heater band has an energy consumption value that is equal to 258.552×10^6 Joules for an hour of continuous operation, whereas the induction heater band has the potential to consume 102.816×10^6 Joules for an hour of continuous operation. In addition, the potential energy intensity of the induction heater band is just 0.00476 (kW/h)/kg, while the energy intensity of the current heater band is 0.01197 (kW/h)/kg.

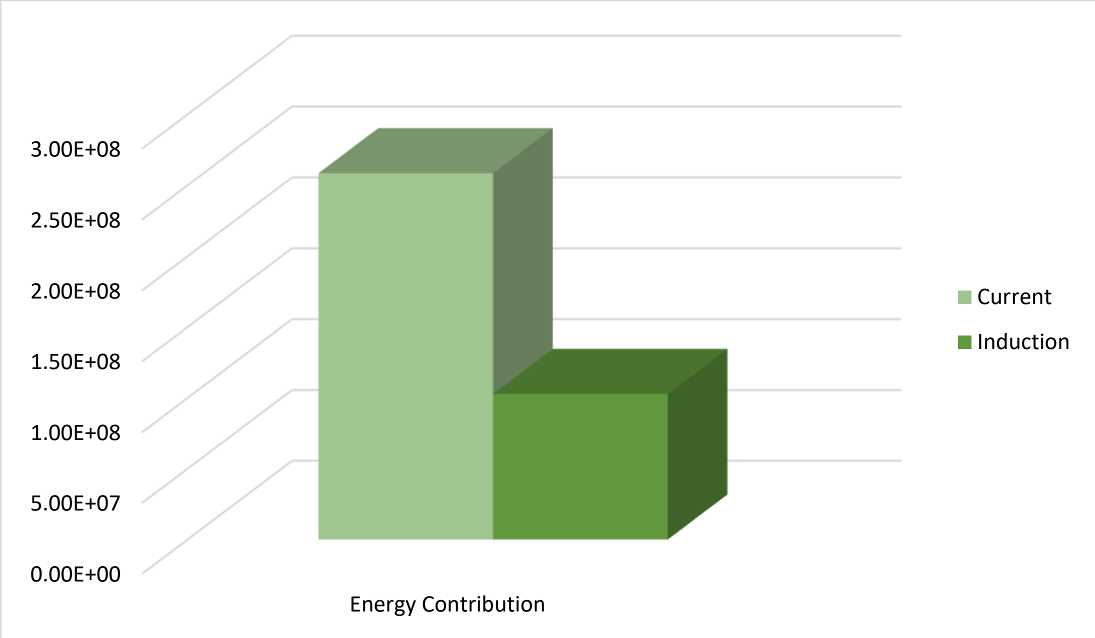

Figure 2 : Energy Contribution Current vs Induction

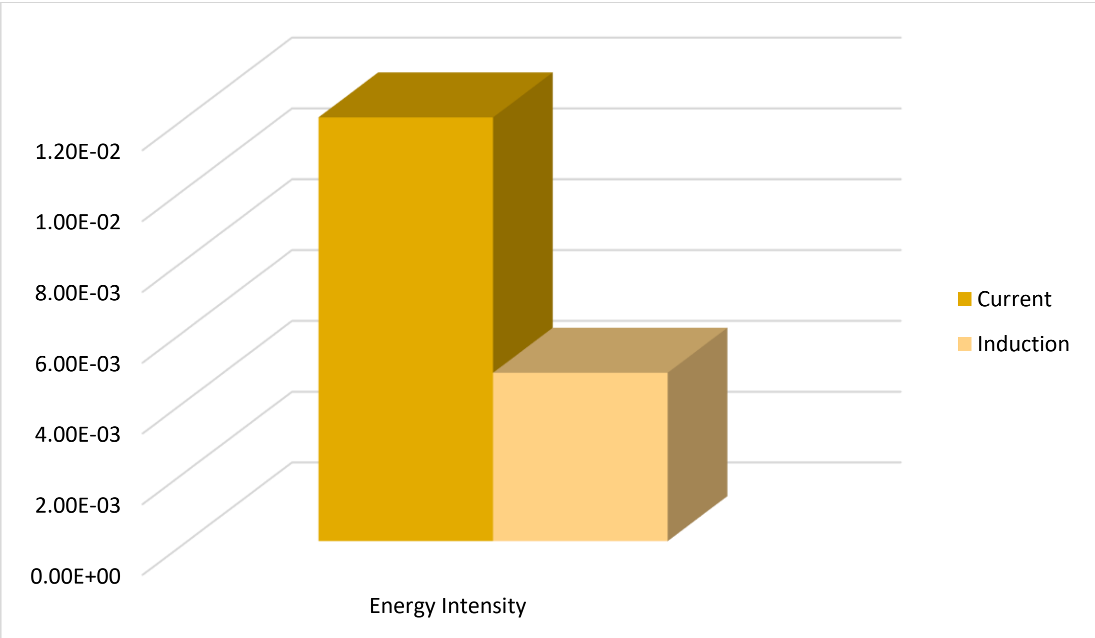

Figure 3 : Energy Intensity Current vs Induction

3.2 Comparison of Insulation Material

Fiberglass,[5] calcium silicate,[6] cellular glass,[7] and ceramic fiber[8] were the most common types of insulating materials that could be obtained. The optimal thickness for the above materials to achieve acceptable insulation is summarized in the following table, which may be found below. While the surface area of the materials virtually linearly increases with increasing thickness, the rate of heat loss reduces exponentially across the board for the various insulating materials that were investigated.[9]

Table 2 : Comparison between insulation materials

Materials	Thickness	Heat loss
Fibreglass	45 mm	243.51 W/m^2
Calcium Silicate	50 mm	312.40 W/m^2
Cellular glass	40 mm	484.02 W/m^2
Ceramic fibre	42 mm	688.02 W/m^2

Based on the information presented in Table 2, the conclusion that the optimum material for insulation is fiberglass because it has the lowest rate of heat loss despite having one of the appropriate thicknesses suggested by TIASA[10], which is 50 mm for 350 degrees Celsius. The insulation can be as thick as 45 millimeters, yet the heat loss will still be 243.51 watts per square meters. As a result, we are able to propose that fiberglass will be utilized as the insulation material for this particular project.

3.3 Energy of Melting Process through different Temperature

Based on the information presented in Figure 4, the conclusion that the energy needed to complete the melting process is 3.90×10^9 Joule. While the potential energy usage is 2.106×10^9 Joule. If the temperature is optimised, we can achieve a 46 percent improvement in energy production even if the melting temperature is maintained at 135℃.

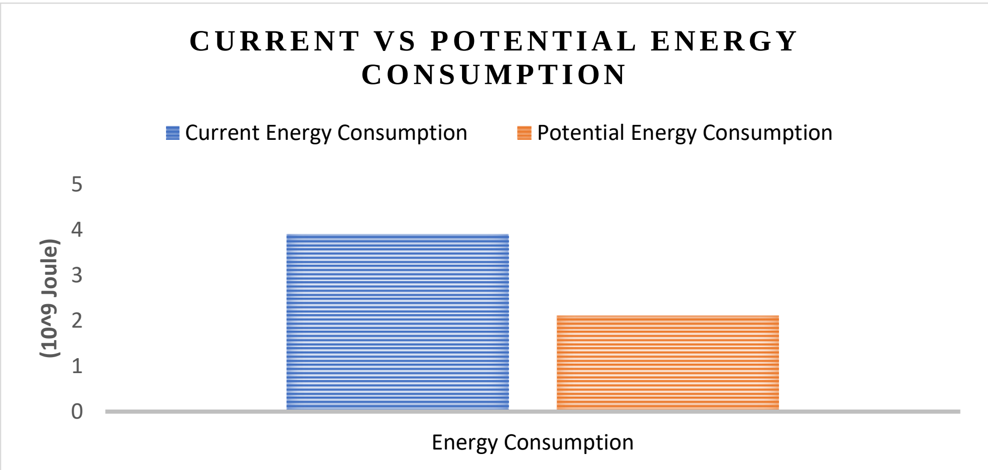

Figure 4 : Energy consumption by Temperature

4. Conclusion

The current heater band is significantly different from the induction heater band. The current heater band consumes 258.552 106 Joules per hour, while the induction heater band consumes 102.816 106 Joules. Insulated induction heater bands can reduce energy consumption by 60.23% , improving efficiency. The current heater band's energy intensity is 0.01197 (kW/h)/kg, while the induction heater band's is 0.00476 (kW/h)/kg. Induction heater bands can enhance energy intensity by 60.23%. Comparing fiberglass, cellular glass, calcium silicates, and ceramic fiber shows that fiberglass has the lowest heat loss at 243.51 W/m2 and 45mm thickness. Cellular glass and ceramic fiber have the maximum heat loss, while Calcium Silicate has the second lowest.

Third, mass and energy estimations imply that lowering the LDPE melting temperature can conserve more energy. Based on chapter 4.4, we may conclude that the melting process currently consumes 3.19 109 Joules and will consume 2.106 109 Joules in the future. If the melting temperature is 135°C, yes. If we alter the temperature to where LDPE melts best, we can cut energy use by 46%. In conclusion, we are able to draw the conclusion that operating the injection molding process with suggested methods, such as modifying the induction heater band, applying insulation to the heater, and lowering the temperature to its ideal LDPE melting point, will result in savings in energy consumption. A decrease in energy intensity will result in a rise in production, which, in turn, will improve the profit that the firm makes, in addition to the positive effects on the environment.

Acknowledgement

The authors would like to thank the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia for giving the opportunity to finish up this research report.

References

[1] K. Ragaert, L. Delva, and K. Van Geem, “Mechanical and chemical recycling of solid plastic waste,” *Waste Manag.*, vol. 69, pp. 24–58, 2017,

[2] A. L. Andrady and M. A. Neal, “Applications and societal benefits of plastics,” *Philos. Trans. R. Soc. B Biol. Sci.*, vol. 364, no. 1526, pp. 1977–1984, 2009,

[3] E. Takeda and K. Takenaka, *Polymer Extrusion*, vol. 33, no. 7. 2021.

[4] H. Kagimoto, D. Miyagi, N. Takahashi, N. Uchida, and K. Kawanaka, “Effect of temperature dependence of magnetic properties on heating characteristics of induction heater,” *IEEE Trans. Magn.*, vol. 46, no. 8, pp. 3018–3021, 2010,

[5] “Natural Fiber Composites : A Review,” no. March, 2010.

[6] C. Labbez, A. Nonat, I. Pochard, and B. Jönsson, “Experimental and theoretical evidence of overcharging of calcium silicate hydrate,” *J. Colloid Interface Sci.*, vol. 309, no. 2, pp. 303–307, 2007,

[7] C. Maes, A. Van Moffaert, H. Frederix, and H. Strauven, “Criticality in creep experiments on cellular glass,” *Phys. Rev. B - Condens. Matter Mater. Phys.*, vol. 57, no. 9, pp. 4987–4990, 1998,

[8] G. Gouadec, S. Karlin, J. Wu, M. Parlier, and P. H. Colomban, “Physical chemistry and mechanical imaging of ceramic-fibre-reinforced ceramic- or metal-matrix composites,” *Compos. Sci. Technol.*, vol. 61, no. 3, pp. 383–388, 2001,

[9] S. Schiavoni, F. D’Alessandro, F. Bianchi, and F. Asdrubali, “Insulation materials for the building sector: A review and comparative analysis,” *Renew. Sustain. Energy Rev.*, vol. 62, pp. 988–1011, 2016,

[10] Ö. A. Dombayci, M. Gölcü, and Y. Pancar, “Optimization of insulation thickness for external walls using different energy-sources,” *Appl. Energy*, vol. 83, no. 9, pp. 921–928, 2006