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Management of Rejected Plastic Packaging as an Alternative Industrial Fuel

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Abstract: Solutions are needed to cope with the reject plastic packing waste that the plastic packaging industry produces. Using rejected plastic packaging waste as a coal substitute and lowering environmental pollution to feed a cement kiln by co-processing method are the goals of this project in West Java (Indonesia). Rejected plastic packaging is shredded, wrapped in large plastic packaging, sent to the cement factory by truck, and when it arrives at the cement factory, the plastic waste is mixed with other solid waste and immediately used as alternative fuel. This stage is a co-processing method applied in the process of managing rejected plastic packaging. With a length of less than 5 cm, the resultant dry plastic shreds. 8.269 kcal/kg of calories, 0.54% moisture, 5.39% ash content, and 0.13% sulfur were found in the study's results. According to these findings, waste from rejected packaging plastic can be utilized to substitute coal in the cement industry (kiln) as an alternative fuel without having any negative effects.

Keywords: reject, plastic packaging, coal, fuel, calorie.

INTRODUCTION

Coal is an example of a fuel that is widely utilized in industry, including the cement industry, which requires vast quantities of coal. A cement factory in West Sumatra, Indonesia, uses approximately 3500 tons of coal per day for manufacturing (Sawir, 2016). Using a lot of coal will also raise production expenses. The limited availability of coal and the high cost of providing coal are major issues for the cement industry. Coal is a nonrenewable natural resource that will deplete if used constantly. Meanwhile, direct coal combustion provides 44% of total world CO_2 (carbon dioxide) emissions and is the main source of greenhouse gas (GHG) emissions such as CO_2 (Zaman et al., 2020). As a result, new alternative fuels are required to minimize and even replace coal, specifically plastic waste. Plastic is a superior alternative fuel since it has the same calorific value as fossil fuels (Helmy et al., 2020). Plastic waste is an inorganic waste that is difficult to dissolve in soil, taking 50–80 million years (Jambeck Jenna R. et al., 2015). Using plastic waste as an alternative fuel decreases environmental impact and air pollution.

Plastic packaging is one of the primary sources of plastic waste. Plastic packaging has become increasingly popular as people's lifestyles have changed (Chaerul et al., 2014). This demand for plastic is mostly driven by the relatively high growth rate of the food and beverage industry (8%–10%) from year to year, which is the major user of plastic packaging. The total plastic packaging industry in Indonesia is composed of 1580 firms dispersed across Java (87%), with 448 companies in West Java (almost 40%) in 2014 and 13% outside Java (Direktur Industri Kimia Hilir dan Farmasi, 2019). The majority of plastic consumed in Indonesia is for packaging (34.88%), followed by plastic for automobiles (22.09%), buildings (5.35%), electronics (4.42%), and others (33.26%). Indonesia's plastic packaging manufacturing grows at an average yearly rate of 4.65%. (Danareksa, 2023). Global challenges about the detrimental effects of plastic consumption endanger the sustainability of businesses and the environment. The Indonesian government released Minister of Environment and Forestry Regulation Number 75 of 2019 regarding the Roadmap for Producer Waste Reduction, which included one of the phases for Solid Waste Reduction and Processing, namely reducing solid waste sources. Rejected plastic packaging is an example of solid waste.

METHOD

This study was carried out in the West Java region (Indonesia), with rejected plastic packaging supplied from companies in Cikarang and Cibitung. Meanwhile, the cement factory in Cileungsi (West Java) uses recycled plastic packaging as an alternative fuel to replace coal. The rejected plastic packaging code used is code 1: PET/PETE (Polyethylene Terephthalate), which is used in soft drink and mineral water bottles, sleeping bag fillers, and textile fibers, and code 4: LDPE (Low Density Polyethylene), which is used in ice cream boxes, waste bags, and black plastic sheets. At the plastic packaging facility, the plastic material for the rejected package is first chopped to around 5 cm and dried.

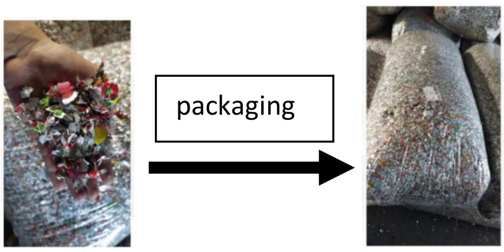

Figure.2 Rejected packaging plastics shred

. Figure 2 shows a sample of rejected plastic packaging waste measuring < 5 cm. This Rejected plastic packaging waste was delivered by a plastic packaging company utilizing a CDD vehicle and wingbox. The shipping capacity of shredded rejected plastic packaging waste is 12 tons per day. The transportation distance for rejected plastic packaging from the factory that produces it to the cement factory that uses alternative fuels is less than 50 kilometers, ensuring that the unit price of this alternative fuel material is affordable while maintaining material quality during delivery. This study was carried out from July 2023 to December 2023.

This research methodology (according to figure 3):

1. Samples of several types of rejected plastic waste were collected at the plastic packaging facility and diced to a size of around 5 cm to determine their gross calorific content.
2. The rejected plastic packaging waste is then transported to the cement factory by a CDD or wingbox vehicle. Rejected plastic packaging waste has been wrapped with rejected plastic also.
3. During the co-processing of rejected plastic packaging waste, characteristic testing is carried out.

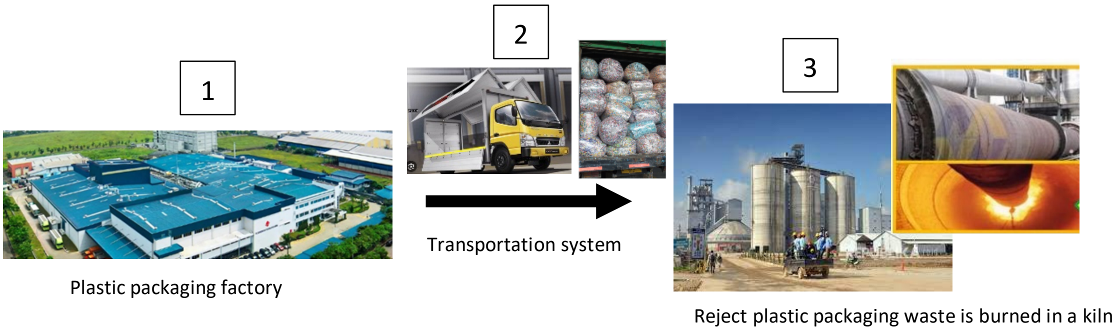

Figure 3. Methodology flow

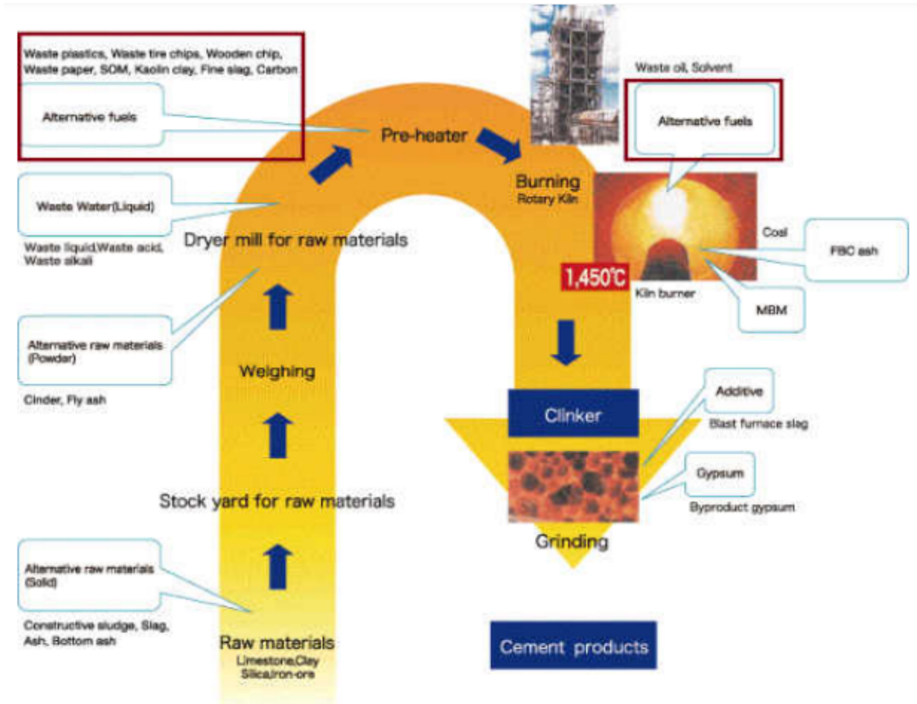

Figure 4. Procedure flow for co-processing of packaging plastic rejected in cement kiln

The results of these characteristic tests will be compared to the values found in coal. According to Lestari and Hidayatullah (2016), the cement industry requires:
a. Coal with a high net combustion value (>6000 cal/gr)
b. Maximum medium volatile matter (36-42%), and high efficacy.
c. Maximum moisture content: 12%
d. Maximum ash content: 6%
e. Maximum sulfur content is 0.8%.

Meanwhile, Figure 4 depicts the flow of procedures for co-processing plastic waste in a cement kiln, as well as the plastic waste feeding point (CPCB India, 2017).

RESULT AND DISCUSSION

Before beginning the process of destroying plastic waste from shredded rejected packaging using a co-processing system at this cement factory, the plastic packaging waste from reject chopped plastic packaging is first tested for material characteristics in the laboratory, as shown in Table 1:

Tabel 1. Characteristics of shredded plastic packaging waste

No	Parameter	Unit	Result
1	Heat content	Kcal/kg	8269
2	Moisture	%	0,54
3	Ash	%	5,39
4	Sulphur	%	0,13
5	PSD <25 mm	%	100

According to Table 1, the calorific value, water, ash, and sulfur content of rejected plastic packaging waste exceeds the value of coal with great efficacy. The *PSD* (particle size distribution) of this rejected plastic packaging waste is similarly less than 50 mm. Meanwhile, the unit price of rejected plastic packaging waste is lower than the price of coal. When used as a coal substitute, this plastic waste from shredded rejected packaging can be combined with other waste to produce *RDF* (refused derived fuel) for the cement industry. Table 2 displays the properties of this RDF.

Tabel 2. Characteristics of shredded rejected plastic packaging waste that is made into RDF (feeding to cement kiln)

No	Parameter	Before feeding to kiln	After feeding to kiln
1	CO2 saving (ton/day)	-	65,8
2	Pengurangan Emisi (GHG) (USD/day)	-	0,35
3	Coal saving (USD/day)	-	70

Table 2 indicates that by combining rejected plastic packaging waste with municipal waste (total waste of 120 tons per day), coal and CO2 are used more efficiently, and greenhouse gas emissions are minimized. Aside from the technical advantages listed above, managing the use of rejected plastic packaging waste offers new jobs. This study is also based on prior studies.

According to a previous study, the calorific value of employing plastic waste as an alternative fuel for the cement industry via co-processing is around 8500 kcal/kg, whereas the calorific value of coal is roughly 4500 kcal/kg. The concentration of hazardous gas emissions of dioxin and furan is 0.019 ngTEQ/Nm3, compared to the standard of 0.1 ngTEQ/Nm3 (Suthar et al., 2020). Other research found that implementing waste optimization measures at PT XYZ greatly contributes to saving energy and raw material costs incurred by companies, thereby supporting cost leadership strategies in facing increasingly strong competition (Harlan & Lukman, 2020). Other studies define waste plastic briquettes as having a calorific value of 10.112 cal/gram, an ash content of 3.90%, a water content of 0.36%, and a volatile content of 94.74%; these briquettes are also utilized as a substitute fuel for coal in factories Cement in West Sumatra (Sawir, 2016). Other experts claim that rejected plastic waste can be converted into plastic pellets with a high calorific value (7,207–8,730 cal/g), low sulfur content (0.14–0.17%), low ash mineral content, and an ash fusion temperature (AFT) above the boiler operating temperature (900o), which can be used as a coal substitute for paper factory boiler fuel (Setiawan et al., 2016). Other experts have also studied the use of plastic waste, and they claim that with the RDF system, plastic waste, including chopped plastic packaging, can be used as an alternative fuel to replace coal, with many benefits, including financial, technical, environmental, social, and technological. (Yansen et al., 2021). Because it is light, this plastic packaging debris may be transported into and out of vehicles using human effort, making it effective and efficient, as seen in Figure 5.

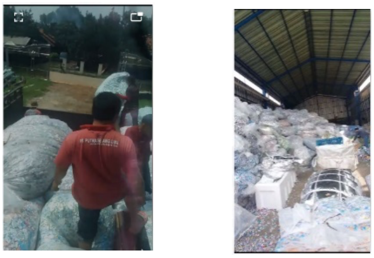

Figure.5 Loading and unloading shredded plastic rejected packaging manually

Because plastic is light and watertight, this plastic waste from rejected packing should be stored in a warehouse or chamber with a ceiling to retain the water content. Given that West Java has the most plastic packaging factories in Indonesia, rejected plastic packaging waste is abundant, so it is hoped that in the future, this plastic waste will be used as much as possible as an alternative fuel to replace coal in the cement industry, steam power plants (*PLTU*) or other power plants, and industries that use boilers.

CONCLUSION

When plastic waste, including rejected plastic packaging, is placed at a landfill (final disposal site), it has negative consequences such as reducing the nutritional quality of the soil, polluting the ecosystem, and emitting unpleasant odors. Meanwhile, if plastic is burned (pyrolyzed), it will pollute the air and produce leftover ash. As a result, this rejected plastic packaging waste can be recycled into alternative fuel (reuse), particularly as a substitute for coal in the cement industry via a co-processing system, which decreases environmental, odor, and soil pollution. Aside from that, shredded plastic waste packaging has a higher calorific/heat value than coal (> 7000 kcal/kg), therefore its economic value will boost cement manufacturing. There is no combustion residue at kiln temperatures above 1400 degrees Celsius. This study was restricted to the cement industry; the rejected plastic packaging waste was combined with other material waste, and other mixed material waste was not investigated. It is hoped that future researchers will be able to improve it based on the findings of this research.

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Conflict of Interest

The author claims that the data presented in this publication has no conflict of interest for any party. If this is uncovered later, the author accepts full responsibility.

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