The Use of Energy in The Production Process of Hot Mix Asphalt in Asphalt Mixing Plant (AMP)

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Abstract. Asphalt mixing plant (AMP) is a set of tools used to produce hot mix asphalt (HMA) in a location/place. This study is intended to determine the energy use of diesel fuel sets in the production process by measuring the energy use of both types of fuel including fuel consumption and energy, temperature, and the quantity of production from HMA in the AMP. The conclusion of this research is that changes in temperature and length of time of production will affect the use of diesel fuel and energy use, with the longer the production time and the temperature instability to heat the aggregate in the dryer, it will consume huge fuel and energy usage and the results of the calculation analysis were also obtained by producing a HMA weighing 130.640 tons requires consumption of diesel fuel of 1,477.25 liters which is equivalent to the fuel consumption of oil palm shell waste of 6.01 ton and also which is equivalent to energy use of 52,280.99 MJ, for each production of 1 ton of HMA required consumption of diesel fuel of 11.31 liters. Meanwhile, to increase 1°C requires 8.09 liters of diesel fuel consumption which is equivalent to energy use of 290.16 MJ.

1. Introduction
The Asphalt mixing plant / AMP (asphalt mixture production unit) is a set of mechanical and electronic equipment where aggregate is heated, dried and mixed with asphalt to produce a hot mix asphalt (HMA) that meets certain requirements. AMP can be located in a permanent location or move from one place to another.[1] With the increase in road infrastructure, the higher the demand for HMA production will also increase. One of the things that is quite crucial in AMP production is the problem of energy needs, because the majority of AMPS in Indonesia still use diesel fueled generators as a source of power, although some have switched to using PLN electricity[2].

Meanwhile, diesel is a non-renewable fuel and has many negative impacts on the surrounding environment. With the increasing need for diesel fuel for AMP, it is deemed necessary to create new innovations from other fuels derived from organic and inorganic materials which are more environmentally friendly, cheaper, effective and efficient.

Several studies that have been carried out related to these innovations include; research on the use of coal as a substitute for kerosene to save production costs, proves that coal can be used as a substitute for kerosene by using coal that is more efficient and with the same engine performance[3].
Meanwhile, research on the comparison of the use of coal and diesel in AMP, proves that the use of coal produces a higher filler content, namely 2.84% from the original plan[4]. Where it turns out that coal can be used as an alternative fuel for aggregate heating as long as it meets the material and equipment requirements stipulated in the Technical Arrangement for the Production Unit of Hot Asphalt Mixtures Using Coal Fuel for Aggregate Heating issued by the Directorate General of Highways[5,7].

Another innovation that needs to be studied in relation to this substituted fuel is the potential for waste from palm kernel shells. Based on research by the Oil Palm Plantation Team from Sebelas March University Surakarta, oil palm waste has a calorific value of 16,900 kJ/kg, and contains small solid particles, ash and tar[6].

This research will focus on examining the potential extent of diesel fuel which includes the amount of consumption, temperature, and production quantity which will later become input for broader research on oil palm shell waste research.

2. Experimental
2.1 Materials
The data source in this research is divided into Primary and secondary data, where primary data includes data on energy use, temperature and hot asphalt mixture production results obtained by direct observation of AMP production and secondary data including machine specification data and job mix design obtained from AMP PT. Nusantara Makmur Sadhana, Madiun, East Java

2.2 Methods
This research is an observational research through analyzing the production process of the asphalt mixture at AMP and data calculations. In analyzing the data in this research, it is divided into 2 stages of calculation

2.2.1 Fuel use and in the aggregate recognition process.
The use of energy used to heat the aggregate in the drying machine is measured by measuring the consumption of diesel fuel by calculating the volume of consumption then entering the energy unit and measuring the temperature in the process which can be calculated by the following formulas (1),

\[
tank \ volume = p \times l \times t_{\text{decrease}} \tag{1}
\]

1 liter of diesel fuel = 35.86 MJ[8]
\(p\) is the length of the tank (cm); \(l\) is the tank width (cm); \(t_{\text{decrease}}\) is the decrease in diesel fuel (cm)

2.2.2 The Use of Fuel and Energy in Machine Operations and Production Units.
The use of energy in machine operations is to measure the length of time of production, production, and calculate the use of electric power and electrical power that work and then convert it into units of energy that can be calculated with the following equations (2) and (3),

\[
Power \ (W) = V \times I \times 1.73 \times \cos \phi \tag{2}
\]

\[
\text{power that works (kWh)} = \frac{W \times t}{1000} \tag{3}
\]

1 kilowatt hours (kWh) = 3.6 \times 10^6 Joule = 3.6 MJ[10]
\(V\) is the power supply voltage (Volt); \(I\) is the electric current (Ampere); \(W\) is electric power (Watt); \(t\) is the length of production time (hours)
3. Results and Discussion
The following are the results of data recapitulation obtained from primary data collection (Table 1.) and the discussion will be divided into 3 sub-discussions as follows,

**Table 1. Recapitulation Data**

| Dump Truck | Energy Use (MJ) | Average Temperature (°C) | Production Result Data | Production time (minutes) |
|------------|----------------|--------------------------|------------------------|--------------------------|
| 1          | 2,466.39       | 159                      | 9.830                  | 9.997                    | 15                      |
| 2          | 2,466.39       | 165                      | 9.980                  | 9.985                    | 11                      |
| 3          | 2,738.32       | 173                      | 10.080                 | 10.078                   | 18                      |
| 4          | 3,010.25       | 170                      | 10.020                 | 10.009                   | 10                      |
| 5          | 3,554.11       | 176                      | 10.140                 | 10.115                   | 13                      |
| 6          | 4,097.97       | 171                      | 10.200                 | 10.075                   | 18                      |
| 7          | 4,369.90       | 179                      | 10.330                 | 10.028                   | 21                      |
| 8          | 4,369.90       | 178                      | 10.000                 | 9.986                    | 9                       |
| 9          | 4,913.76       | 185                      | 10.300                 | 10.106                   | 9                       |
| 10         | 4,913.76       | 187                      | 10.330                 | 10.111                   | 16                      |
| 11         | 5,185.69       | 176                      | 10.180                 | 10.033                   | 19                      |
| 12         | 5,158.21       | 167                      | 10.180                 | 10.106                   | 16                      |
| 13         | 5,729.55       | 161                      | 9.070                  | 9.047                    | 17                      |
| Average    | 4,074.94       | 173                      | 10.049                 | 9.975                    | 15                      |
| Total      | 52,974.19      | 130.640                  | 129.674                | 192                      |

3.1 The analysis of the relationship between the amount of fuel consumption and temperature in the Asphalt Mixing Plant

**Table 2.** The results of the analysis of the relationship between the amount of fuel consumption and temperature in the Asphalt Mixing Plant

| Dump Truck | Use of Diesel Dryer Fuel (liters) | Dryer Average Temperature (°C) | Production Time (minutes) |
|------------|-----------------------------------|--------------------------------|---------------------------|
| 1          | 108                               | 159                            | 15                        |
| 2          | 79.2                              | 165                            | 11                        |
| 3          | 129.6                             | 173                            | 18                        |
| 4          | 72                                | 170                            | 10                        |
| 5          | 93.6                              | 176                            | 13                        |
| 6          | 129.6                             | 171                            | 18                        |
| 7          | 151.2                             | 179                            | 21                        |
| 8          | 64.8                              | 178                            | 9                         |
| 9          | 64.8                              | 185                            | 9                         |
| 10         | 115.2                             | 187                            | 16                        |
| 11         | 136.8                             | 176                            | 19                        |
| 12         | 115.2                             | 167                            | 16                        |
| 13         | 136.8                             | 161                            | 17                        |
| Average    | 107.4                             | 173                            | 15                        |
| Total      | 1,396.8                           |                                | 192                       |
Based on the three graphic images above (Figure 1, Figure 2, and Figure 3), the results show that changes in temperature and production time will affect the use of diesel fuel which will also affect energy use. With the longer production time and temperature instability to heat the aggregate in the dryer, it will result in the use of large fuels.

As seen in the production process of the asphalt mixture for the 7th dump truck, where it takes 21 minutes of production time with an average temperature of the dryer of 179°C, it will require a fuel supply of 129.6 liters.
3.2 The analysis of the relationship between the amount of fuel used and energy in the Asphalt Mixing Plant

**Table 3.** Results of the analysis of the relationship between the amount of fuel used and energy in the Asphalt Mixing Plant

| Dump Truck | Diesel Fuel Energy (MJ) | Use of Diesel Fuel (liters) |
|------------|-------------------------|-----------------------------|
| 1          | 2,466.39                | 68.78                       |
| 2          | 2,466.39                | 68.78                       |
| 3          | 2,738.32                | 76.36                       |
| 4          | 3,010.25                | 83.94                       |
| 5          | 3,554.11                | 99.11                       |
| 6          | 4,097.97                | 114.28                      |
| 7          | 4,369.90                | 121.86                      |
| 8          | 4,369.90                | 121.86                      |
| 9          | 4,913.76                | 137.03                      |
| 10         | 4,913.76                | 137.03                      |
| 11         | 5,185.69                | 144.61                      |
| 12         | 5,158.21                | 143.84                      |
| 13         | 5,729.55                | 159.78                      |
| Total      | 52,974.19               | 1,477.35                    |

![Image of Figure 4](image)

**Figure 4.** Graph of the relationship between the use of diesel fuel energy and the use of diesel fuel

Based on the first graph (Figure 4.), it is found that in large bushes the use of diesel fuel will increase the use of existing energy. As seen in the production process of the asphalt mixture for the use of diesel fuel, the largest amount is 159.78 liters, it will use energy of 5,729.55 MJ.

3.3 The analysis of the relationship between the amount of fuel used and the yield at the Asphalt Mixing Plant

**Table 4.** The results of the analysis of the relationship between the amount of fuel used and the yield at the Asphalt Mixing Plant

| Production Time | Production Result (ton) | Total Diesel Fuel Consumption (liters) |
|-----------------|-------------------------|--------------------------------------|

...
| Time Period      | Production (Ton) | Diesel Fuel Usage (Liters) |
|------------------|------------------|---------------------------|
| 08.00-09.00      | 29.890           | 335.25                    |
| 09.00-10.00      | 30.360           | 312.50                    |
| 10.00-11.00      | 40.960           | 419.19                    |
| 11.00-11.35      | 29.430           | 410.31                    |
| Total            | 130.640          | 1,477.25                  |

**Figure 5.** Graph of the relationship between Production and Total Diesel Fuel Usage per Hour

From the graph above it can be obtained that the total use of diesel fuel to produce 130.640 tons of asphalt mixture is 1,477.25 liters. With the rate of fluctuation increasing from the initial use of 335.25 liters for the production of asphalt mixture of 29.890 tonnes then to the largest asphalt mixture production with a weight of 40.960 tonnes using diesel fuel of 419.19 liters. Then it decreased to 410.31 liters to produce an asphalt mixture weighing 29.430 tons. This happens because the active power used and changes in temperature, as well as the production time which initially increases then decreases will affect the use of diesel fuel.

In the research on the production process at AMP by the UNS research team which examined the use of palm oil waste in each production, it was found that every 1 ton of hot asphalt mixture production needed 44-46kg\(^1\). So the researcher made the conversion of the analyzed production results, 130.640 ton x 0.046 ton = 6.01 ton

4. Conclusion

The conclusion of this research is that changes in temperature and length of time of production will affect the use of diesel fuel and energy use. With the longer the production time and the temperature instability to heat the aggregate in the dryer, it will result in a large use of fuel, where the more use of diesel for the dryer, the greater the energy use and the results of the calculation analysis were also obtained by producing a mixture of asphalt weighing 130.640 tons requires diesel fuel of 1,477.25 liters which is equivalent to the fuel consumption of oil palm shell waste of 6.01 ton and also which is equivalent to energy consumption of 52,974.2 MJ. Where to produce 1 ton of asphalt mixture requires diesel fuel of 11.31 liters and to increase 1°C requires energy of 290.16 MJ or equivalent to the use of diesel fuel of 8.09 liters.

References

[1] Bina Marga 2004 *Manual Pemeriksaan Peralatan Unit Pencampur Aspal Panas* (Bina Marga : Jakarta)

[2] Sarjono 2019 *Use of PLN Electricity and Generators for AMP*, Results of Personal Interview: 27 July 2019, AMP PT. Selo Manunggal Sejati (Ngawi, East Java)
[3] H Yunan and Wegie Ruslan 2016 *The Use of Coal as a Kerosine Substitute to Save the Cost of Producing Hot Asphalt Mixtures Cyberentrepreneurship Innovative and Creative Exact and Social Science*, 21 49-54.

[4] H Yusnita 2016 *Comparison of Coal Asphalt Mixing Plant (AMP) and compared to Asphalt Mixing Plant (AMP) BBM RACIC: Jurnal Teknik Sipil Universitas Abdurrab*, 101 36-54.

[5] S Enny 2011 *Analysis of the Use of Coal as an Alternative Fuel for Aggregate Heating in the Asphalt Mixture Production Unit (AMP) (South Sumatra, South Sumatra University)*

[6] Pranolo, S. H. 2015 *Feasibility of Oil Palm Shell Gasification Operations for Asphalt Mixing Plant (AMP) Heating Needs* presented at the Bioenergy Directorate, Directorate General of Renewable Energy and Energy Conservation, Ministry of Energy and Mineral Resources, Jakarta, Indonesia

[7] Bina Marga 2005 *Guidelines for the Inspection of Asphalt Mixed Production Unit Equipment Pd T-03-2005-B Panas* (Bina Marga : Jakarta)

[8] Ministry of Environment 2012 Guidelines for implementing national green house gas inventory *Methodology of Calculation of Green House Gas Emissions Procurement and Use Activities Energy* 1 152-22

[9] H Purnomo 2017 *Electric Circuit* 1 135-28

[10] Widjayanti, W 2007 *Profile of Electrical Energy Consumption in Residential Houses A Case Study of Minimalist Design Houses in terms of Artificial Lighting Aspects Enclosure 6* 2 97-106

[11] Putro, F., Pranolo, S., Waluyo, J., & Setyawan, A. 2020 *Thermodynamic Study of Palm Kernel Shell Gasification for Aggregate Heating in an Asphalt Mixing Plant. International Journal of Renewable Energy Development*, 92 311-317