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Design and Fabrication of Briquetting Device and Reuse of ETP Sludge as Fuel for Safe Disposal in an Automotive Industry

M.K. Marichelvam[1], A. Pradeep Kumar[2]
[1,2]Department of Mechanical Engineering,MepcoSchlenk Engineering College,Sivakasi, Tamilnadu, 626005,India.
mkmarichelvamme@gmail.com[1]

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Abstract

Manufacturers of wind turbines, heavy machineries, gear grinders, bearings, and other industrial products constantly struggle with the problem of safe disposal of the Effluent Treatment Plant (ETP) sludge produced during the manufacturing processes. Although grinding is an important process to attain the desired surface finish of many components, the grinding sludge creates environmental impact [1]. The sludge often consists of the grinding oil, which is more expensive. So, the manufacturers have wrestled with this issue for the past several decades. In this paper, an overview of grinding sludge characteristics and energy recovery routes is presented. The most important disposal methods are presented. A Briquetting device is designed and fabricated. Samples are taken from the ETP of a leading automobile industry in India. The analysis of the elementary chemical composition of grinding sludge, the composition of the ash content, volatile mater and fixed carbon analysis were carried out. The results show that the prepared briquettes could be used as a fuel [2].

Keywords; *Effluent Treatment Plant (ETP); Grinding; Sludge; Briquetting, Fuel*

I. INTRODUCTION

Wind turbine manufacturers, heavy machinery, gear grinders, bearings and other industrial products are constantly struggling with how the grinding sludge produced during manufacturing processes can be disposed of safely and efficiently. This is particularly true of the large volumes of sludge produced during high-precision gear grinding [6].

The disposal of grinding sludge is costly and time-consuming in most cases. Large amounts of oil and fluids are used to be accurate in the manufacturing processes, but nearly 50% to 60% of them are wasted. Thankfully, today's sludge-producing factories have found an environmentally sustainable, safer, and more cost-effective way of disposing of their waste while preserving some of the interest lost within the briquetting of sludge. For years, this form of disposal of sludge was gaining momentum in Europe and is becoming increasingly popular in North America.

II. METHODOLOGY

The following methodology is used in this project.

1. Literature study related to sludge management
2. Problem identification
3. Field study in effluent treatment plant
4. Collect the sample and test the calorific value
5. Conduct proximate analysis and ultimate analysis
6. Design of Briquetting Device
7. Fabricating the Briquetting Device

Process of briquettes:

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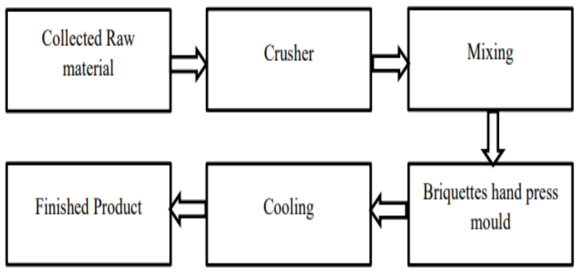

Figure 1 Process flow chart of briquettes

Advantage of bio fuel briquettes:

- Briquettes are cheaper than coal.
- Oil, coal or lignite, once used, cannot be replaced.
- There is no sulphur in briquettes, thus does not pollutes the environment.
- Biomass briquettes have a higher practical thermal value.
- Briquettes have much lower ash content (2-10% as compared to 20-40% in coal).

Physico-chemical characterization of ETP sludge:

The following tables are indicate the Physico-chemical characterization of ETP sludge.

S.NO	PARAMETERS	VALUE
1	Calorific value	16.78 MJ/Kg
2	Moisture content	1.62%
3	Volatile Matter	29.48%
4	Fixed Carbon	60.34%
5	Ash Content	8.56%
6	Carbon	64.22%
7	Hydrogen	2.74%
8	Oxygen	32.48%
9	Nitrogen	0.56%

Table 1 Physico-chemical characterization of ETP sludge as fuel

The following test are taken in Environmental Engineering Laboratory recognized by Central Pollution Control Board located in chennai. They follow ASTM standardization (American Society for Testing and Materials).

Comparison the etp sludge calorific value to other biofuels [3]:The heating quality is the standard measure of a fuel's energy content. It is defined as the amount of heat released when a fuel unit weight is completely burned and the products of combustion are cooled to 298K. When the calorific value includes the latent heat of water condensation, it is called the gross calorific value or the higher heating value. Subtracting the condensation energy of this liquid from the gross calorific value is therefore useful. The result is referred to as net heating or lower heating value. Therefore by testing the sample by using bomb calorimeter the calorific value is 16.78MJ/Kg .

S.NO	FUELS	CALORIFIC VALUE
1	Cashew shell	19.60 MJ/Kg
2	ETP sludge waste	16.78 MJ/Kg
3	Grass	13.01 MJ/Kg
4	Rise husk	13.67 MJ/Kg

Table 2 Comparison of ETP sludge with other bio fuel

Proximate analysis [1]: The proximate analysis is a standardized process of analysis that attempts to quantify some of the key physical characteristics of fuel briquettes that affect their properties of combustion. This analysis consists of four main components, i.e. the estimation of fixed carbon, volatile matter, moisture content and ash, followed by different procedures to determine the relative proportions of these. The analysis done using a bomb calorimeter is explained in the following sections and a brief description of what each of these components is, how each is found in the fuel

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briquettes and their significance is given in burning the briquettes.

Volatile matter: Volatile matter represents the carbon, hydrogen and oxygen components present in the fuel, which is usually a mixture of long-and short-chain hydrocarbons converted into vapor when heated. The volatile matter is lower in almost all oil than in bituminous coal. In general, fuel has a volatile content of about 70-86% of the dry fuel weight compared to coal, which contains only about 29.48% volatile matter. Consequently, the volatile material's fractional heat contribution is more for fuel. This makes fuel more reactive than coal, resulting in a much faster rate of combustion during the phase of devocalization [1].

Generally, higher percentage of volatile matter is an indication that the ignition rate will be high. The briquettes volatile matter is a little more than conventional coals, thus enhancing the fuel's burning characteristics.

Ash content:: Ash is a fuel's non-combustible component, and the higher the ash content of the fuel, the lower its heat quality. It is formed from both the mineral material bound in the fuel's carbon structure during its combustion (the built-in ash) and is present in the form of dirt and clay particles added during processing (trained ash). Ash is known to cause problems in combustion systems, due in particular to the formation of slag and deposition on the metal surface and its tendency to increase the rate of metal corrosion in the system. These are primarily for fuels like coal and have been shown to be of limited fuel value. For example, straws and grasses have relatively high alkaline indices that are consistent with these fuels high ash content.

Nevertheless, the residual ash, if not completely eliminated, can adversely affect the stream of clean air into the boiler if fuels with high ash content are burned in cooking stoves. It is clear that reducing the content of coal and rising the biomass would lead to a decrease in the content of ash. Lower ash content (8.56%) is valuable while excess ash causes trouble during burning; ash is capable of blocking air from penetrating the boiler, thereby retarding such briquette's burning rate unless the stove is frequently shaken to clear the ash during boiling [1].

Fixed carbon content: Ash and fixed carbon remain in the solution after the release of volatile matter and humidity. The percentage of fixed carbon (60.34%) is usually determined by the difference in percentage of total fuel in the other amounts, such as humidity, volatile matter, and ash content. Essentially, a fuel's fixed carbon is the amount of carbon required for char combustion after the fuel eliminates all the volatile content [1]. This is not equal to the total amount of carbon in the gas (the main oil) because the volatile matter still releases a significant amount as hydrocarbons. Fixed carbon is an important indication of the fraction of the char that remains after the phase of devocalization. These carbons are going to react to release heat with the oxygen. The heat quality will be increased by a high percentage of fixed carbon, but the fixed carbon content and the heat price of the above mentioned briquettes are lower than oil. Therefore, compared to conventional fuels and firewood, the heating quality is low; but, compared to conventional coals, the cost of briquettes is high.

The ultimate analysis: Overall research includes estimating percentage-based significant chemical elements that are part of the gas, namely carbon, hydrogen, oxygen, nitrogen and sulfur. Fuel analysis using this approach shows the primary element as carbon, which accounts for 64.22% of dry matter. Normally, after that, 32.48% is made up of oxygen. Hydrogen is the third major constituent 2.74%. Nitrogen and sulfur (and chlorine) are usually less than 1% of the dry oil.

Calorific value: The heat value (or heating value) is the standard measurement of a fuel's energy content. It is defined as the amount of heat released when a fuel unit weight is completely burned and the products of combustion are cooled to 298K. When

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the calorific value contains the latent heat of water condensation, it is called the net calorific value or the higher heating value. For stoves, however, any moisture that is present in the fuel that is produced during the process of combustion is carried away as water vapor, so that its heat is not usable. Subtracting the heat of condensation of this water from the gross calorific value is therefore useful. The result is referred to as the net or lower heating value [9].

The carbon-containing fuels with a higher degree of oxidation will have a lower heating quality as their full oxidation requires less oxygen. Nevertheless, when fuels contain compounds such as hydrocarbons with a lower oxidation degree, this tends to increase the fuel's heating efficiency. It is for this reason that fuels have a lower heating value than coal in which the carbon is present in a partially oxidized form. Various attempts have been made to compare the heating quality with the material composition and it has been found that the chemical composition can play a vital role in the fuel's heating value.

Design of briquetting device: The below figure clearly explain about the concept and design of the device in a clear manner.

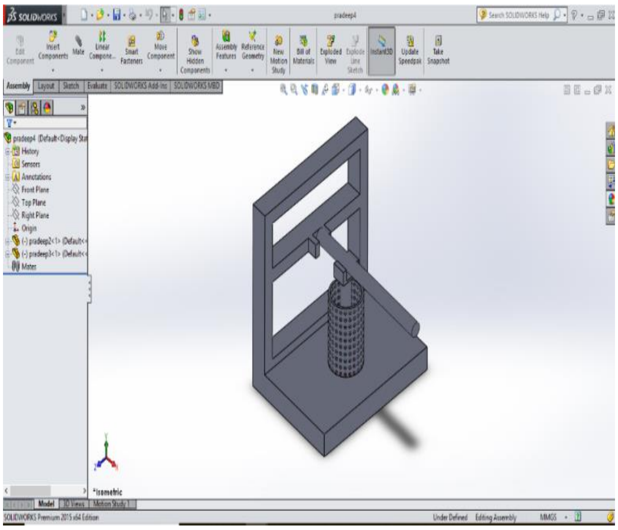

Figure 2 Design of briquetting device

Design calculation:

Calculation for punching force

Where Lh= Length of handle rod = 400mm.

m= 50Kg (Assume a person can apply an average force of m (N) with arm)

M=mg =50 x 9.81=490.5N

Punch is the part used for the pressing operation. It is made up of mild steel. Punch pressurizes the raw material present in the die. It densifies the raw material

Lm= (2t/8) × (E/f×t)×0.5

Lm=length of punch

t= thickness

F=shear force

E= Modulus of elasticity=200×10³ N/mm²

Lm= (2×3/8) × (200×103/250×3)×0.5

Lm=100mm

For safe design we take 104mm

Design of Die :

From book ‘Metal Forming Process’ by G.P.Nagpal

t=3mm,When P=75 to 350mm

P= Blanking Perimeter

P =π D =π×100 =314 mm

So, Required thickness of die block is 3 mm

As per the above mentioned design calculation the die and punch rod calculation is much important and the other dimension vary and it’s not mandatory.

Fabrication of briquetting device:

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Figure 3 Finished fabrication of briquetting device

Working process:

• Firstly, we must properly put the raw material in the die. Place the die plate below the die plate.

• Begin the punching motion of the machine by rotating the handle after putting the raw material. This will continue the punch movement downward. The punch now exerts the raw material's force and densifies the material.

• After few seconds release the handle afterwards. Briquetting device assembly shown in the image above.

• Now remove the die from the base and remove the die plate. After which fix die properly in base operate the handle again and again to remove briquette from die.

• This is the function of the machine. Die has holes to remove excess oil from the briquette on his periphery.

Drying of briquettes: They need to be dried after removing the briquettes from the mold. When left outside, the moisture content of the briquettes fluctuates as temperature and humidity change, depending on the climatic conditions of the drying area.

Figure 4 Compressed briquette

III. RESULT AND DISCUSSION

It can be inferred from the results obtained in this analysis that the ETP sludge from the industry's can be formed as briquettes. This study indicated good fuel properties for the briquettes. Research shows that the shaped briquettes will be used for thermal use. A relatively high calorific value (about 16.78 MJ / kg) characterized the preferred fuel. The proposed method of briquetting ETP sludge is the first step towards its thermal use. In this project the fuel characteristics was tested, first the calorific value was tested. Then followed by Proximate analysis and ultimate analysis were tested in laboratory. With the help of these tests we came to conclusion that our fuel have high thermal characteristic. The future work of this project will carry on dry analysis, water boiling test to evaluate the briquettes thermal efficiency and combustion analysis. And the final test will be the metal ash content analysis to evaluate the briquette efficiency.

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