Chapter 8
The Effect of Composition and Particle Size of Mixed Briquettes Making Process on Temperature Combustion and Calorific Value

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Abstract This research was motivated by the fact that the price of fuel, both gas and oil is expensive. In order to overcome the high price of fuel, it is necessary to develop an alternative energy. Producing alternative fuel consisting of a mixture of rice husks and coal is important as this fuel is cheaper and the materials are abundant. Some steps must be undertaken to make mixed briquettes. First, rice husk is the main material, processed into charcoal. The next step is the preparation of materials from particles of different sizes and compositions using the congestion pressure (compacting) of constant briquettes. The particle sizes used are 40 mesh (I), 60 mesh (II) and 80 mesh (III), with the following compositions: (I) coal—65%, rice husk—25%, starch—10%; (II) coal—55%, rice husk—35%, starch—10%; and (III) coal—45%, rice husk—45%, tapioca starch—10%; the compressive pressure for processing briquettes was 78 kg/cm^2. After that, it was performed the sintering at 100 °C for 30 min. The analysis, test and trials show the highest calorific value of fuel was equal to 4790.78 kcal/kg and the combustion temperature of 365 °C is for the 40-mesh particles with a composition of 65% coal, 25% rice husks, and 10% tapioca flour, at pressure of 78 kg/cm^2. The highest burning time was in briquettes with the particle size of 80 mesh, and a composition of 65% coal 25% rice husks and 10% tapioca, obtained at initial flame temperature of 390 °C during 4 min, and the final flame temperature was equal to 310 °C during 29 min. The highest compressive strength and density (bulk density) can be found in the briquettes with particle size of 80 mesh, and a composition of 65% coal, 25% rice husks and 10% tapioca flour, at pressure of 78 kg/cm^2, the compressive strength of 2.11 kg/cm^2 and a density value (bulk density) was 0.89 g/cm^3.

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8.1 Introduction

Briquette is a solid fuel with specific size and shape, which is composed of granules of coal and materials used to dilute it (such as organic waste, clay, rice husks, etc.); it consists of two materials or more and is processed with a specific press power, to make the material easier to handle and has more value in its utilization. (Source: Centre for Research and Development of Mineral and Coal Technology)

Briquettes are generally composed of two major parts of the base material, a matrix and a filler. The requirement to make the briquettes is the surface bonding of matrix and filler. Matrix is engineering materials whose aim to improve the basic properties, and filler can be regarded as materials engineer.

The requirements to energy in these days increases steadily together with the progress in technology, as well as the rapid growth of the world population. Currently, Indonesia is facing problems of energy supply due to the increasing need of national energy every year. Meanwhile, the oil reserves in Indonesia are dwindling and will be running out of oil within 10 years [1].

8.2 Review of Related Literature

8.2.1 Briquettes

Coal is a combustible organic mineral, formed from remains ancient plant, which further deformed due to physical and chemical processes that took place over millions of years. Therefore, coal is included in the category of fossil fuels [2]. It can also be called as a solid hydrocarbon fuels formed from plants in an oxygen-free environment and exposed to the effect of heat and pressure that lasts longer [3].

Chemical Compositions of briquettes, used for this study, were obtained from Limited Company Coal Mine Hill Acids Gresik, East Java Indonesia. The chemical composition of the briquettes is present in Table 8.1.

Table 8.1 Chemical composition of coal used

Parameter	Unit	Element value
Total moisture	%	28
Inherent moisture	%	15.0
Ash content	%	8.0
Volatile matter	%	40
Fixed carbon	%	37.0
Total sulfur	%	0.8
Gross calorific value	kcal/kg	5800

Source Limited Company Coal Mine Hill Acids Gresik, East Java Indonesia

8.2.2 Rice Husk

Rice husk is produced from rice milling process. As waste, husks often cause problems. In fact, it has a great potential as cheap raw materials for the source of alternative energy. The chemical composition of rice husk can be seen in Table 8.2.

The husk is the outer portion of the grain that is a byproduct during the rice milling process. The weight of Rice consists of approximately 20–30% rice husk and more than 15% of it (husk) is ash. The moment of energy crisis like today is the right time to promote the husk as a source of alternative energy. Utilization of rice husks will provide choices to the public regarding the fulfillment of the energy source that is economical and advantageous, because the products of coal combustion can be utilized as mix materials in the manufacture of hydraulic cement, pressed brick, and the rubber processing.

One of the materials used in processing the briquettes is rice husk, which has been charred before proceeding to the next stage. The making of husk charcoal is intended to improve the physical properties of it. If the husk is used directly as a thermal energy source, it will cause smoke when burned. In addition to air pollution, the produced smoke can also change whiff and color of the dried material. The process of charcoaling is done by heating the chaff in the drum. The process ends, if the chaff becomes dark as burned (Erliza Hambali et al., Bioenergy Technology). The analysis can be seen from Table 8.3.

8.2.3 Adhesive

Adhesive is a material that has the ability to unit similar or unsimilar objects through bonding surface. The addition aims is to increase the adhesive strength of the produced briquettes [4].

The use and choice of adhesive material is carried on the base of some criteria such as good absorption of the water, relatively inexpensive and easy to obtain. The

Table 8.2 Chemical composition of rice husk

Component	Content (%)
Water content	9.02
Protein rough	3.03
Fiber rough	35.68
Ash	17.71
Carbohydrates rough	33.71
Hydrogen	1.54
Oxygen	33.64
Silica (SiO_2)	16.98

Source Research Institute of Post Harvest 2006

Table 8.3 Results of the analysis of the composition of rice husks already charred

Parameter	Unit	Analysis results	Method
Moisture content	%	5.35	ASTM. D 3302-97
Volatil matter	%	22.42	ASTM. D 3175-89
Ash content	%	8.35	ASTM. D 3174-97
Fixed carbon	%	63.88	By different
Heating value	kcal/kg	3734.38	ASTM. D 1989-97

Source Laboratory tests. Team Consulting Industry and Technology Institute of Sepuluh Nopember Indonesia affiliates, August 12, 2008

selection of adhesive materials affects the quality of briquettes [4]. Adhesives can be distinguished by the original material, i.e. organic and synthesis.

Tapioca is organic adhesive material, which is cheap and easy to obtain. Tapioca starch composition of the raw material briquettes are as much as 5% of the weight of briquettes itself. Starch and gluten are nonperishable because of the influence of fermentation.

8.2.4 Briquetting Process

According to [4], briquetting a material consists of several stages, presented below.

8.2.4.1 Enrichment and Weighing

Enrichment and weighing process is essential before doing the next step, due to determining the sizes and distribution of particles. This process is important to obtain the homogeneous materials.

8.2.4.2 Mixing

The mixing process serves to bind so that it will increase the strength of the briquettes. There are two methods can be used, namely:

(i) *Wet Mixing*.

Wet mixing is a mixing process, in which the powder matrix and filler mixed first with the solvent. This method is used, when the materials (matrix and filler) are susceptible to oxidation. The purpose of adding the solvent is to simplify the process of mixing the materials and to coat the surfaces of materials to protect the material from air and to prevent oxidation of the used materials.

(ii) *Dry Mixing*.

Dry mixing is a mixing process without using a solvent to dissolve and is done outdoor. This method is used, when the materials (matrix and filler) are not easily oxidized.

The mixing speed, the length of mixing time and the mixed particle size determine the homogeneity of particle distribution. The greater of mixing speed, the longer mixing time and the mixed smaller sizes cause the more homogeneous particle distribution. The homogeneity of mixing affects the process of compacting, since the compressive force is given at the time of compacting will be distributed evenly. So the quality of the bond between the particles is better.

8.2.4.3 Compaction

Compaction is the process of compacting powders into a sample. There are two methods used, namely:

(i) *Cold Compressing* is performed at room temperature. This method is used, when applied materials are easily oxidized.
(ii) *Hot Compressing* is performed at temperatures above room temperature. This method is used, when applied materials are not easily oxidized.

8.2.4.4 Sintering

The drying process can be defined as a process for separating water from the material. Drying can also be used for the preservation process. When the water content is reduced to lower 10%, the microorganisms cannot exist [5]. Based on the research, conducted by Widyaningsih [5], drying the briquettes can also determine the calorific fuel value. These results follow of Table 8.4.

8.3 Procedures of the Research

The material used in this experiment was a mixture of coal, rice whaff and organic adhesive, the composition can be seen as follows:

Table 8.4 Effect of drying method on calorific value of fuel [5]

Drying method	Calorific value (cal/g)
Heating the oven	2435.24
Direct solar heating	2425.95
Indirect solar heating	2425.85

(i) 65% coal, 25% rice husk, 10% tapioca flour
(ii) 55% coal, 35% rice husk, 10% tapioca flour
(iii) 45% coal, 45% rice husk, 10% tapioca flour

The first step is to pulverizing coal and charcoal powder of rice whaff with sizes of 40, 60 and 80 mesh, with a pressure of 78 kg/cm^2. Each sample consists of 5 pieces. Furthermore, all of the samples are pressured under 78 kg/cm^2, and sintered at 100 °C for 30 min. The next step is testing on compressive strength, density, calorific value and combustion temperature [6–10]. The scheme of performed experiments is present in Fig. 8.1.

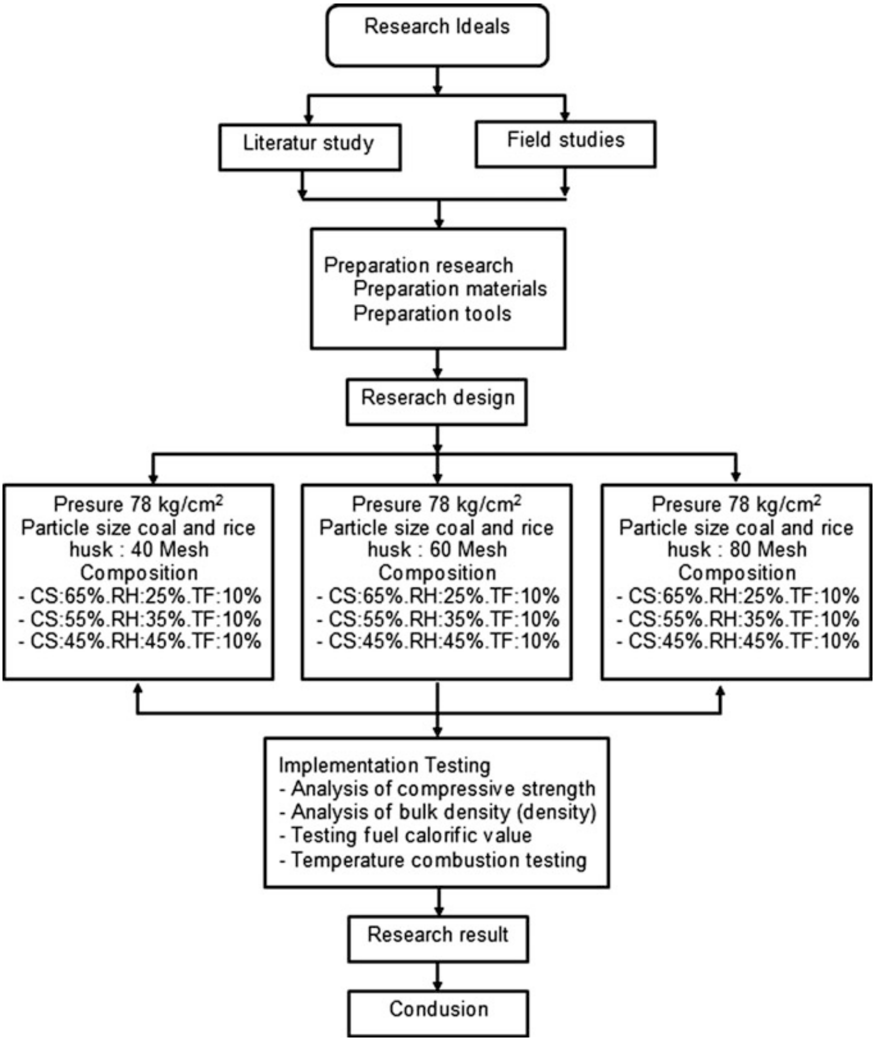

Fig. 8.1 Flowchart of research methods

8.4 Results and Discussion

After undertaking the tests and data analysis, the results can be presented in the form of graphs presented in Figs. 8.2, 8.3, 8.4, 8.5, 8.6, 8.7 and 8.8.

Figure 8.2 indicated in the analysis of compressive strength in the process of briquetting the mixture of coal and rice husk, that the highest value is attained in the briquettes with a particle size of 80 mesh, and the composition of 65% coal, 25% rice husk and 10% tapioca at the pressure of 78 kg/cm^2; this compressive strength is equal to 2.11 kg/cm^2. At the same time, the lowest value of compressive strength is occurred for briquettes particle size of 40 mesh, and the composition of 45% coal, 45% rice husk and 10% tapioca at the pressure of 78 kg/cm^2; this compressive strength is equal to 1.21 kg/cm^2. The briquette compressive strength can be affected by the level of particle fineness and fraction of matrix (coal) composition. When the particle size is finer, the bonds between the particles are more dense compared to the larger particle sizes. So the existing compressive strength of briquettes will affect bulk density.

Figure 8.3 shows the effect of composition and particle size in the process of briquetting the mixture of coal and rice husk on the values of bulk density. This figure demonstrates the value of the highest density occurs in briquettes with a particle size of 80 mesh, and the composition of 65% coal, 25% rice husk and 10% starch at the pressure of 78 kg/cm^2; this value of bulk density of briquettes is 0.89 g/cm^3. The lowest value of bulk density found in briquettes with a particle size of 40 mesh, the composition of coal is 45%, of rice husk 45%, tapioca 10%, pressure of 78 kg/cm^2 with a value of bulk density of briquettes is 0.78 g/cm^3. The value of the bulk density of briquettes is influenced by the fineness of the grain particles and the fraction of the matrix (coal). When the bonding matrix grains (coal) is higher, then the value of density (bulk density) is also greater.

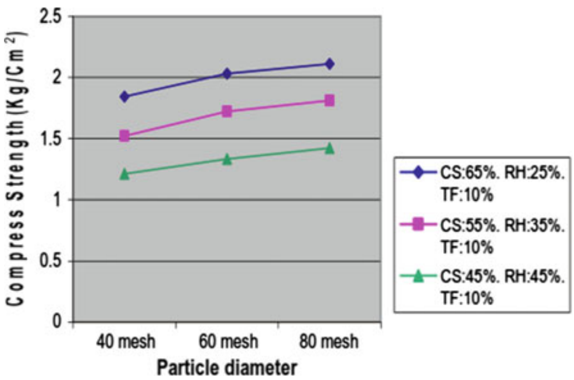

Fig. 8.2 Effects of the composition and size of briquettes particles on compressive strength

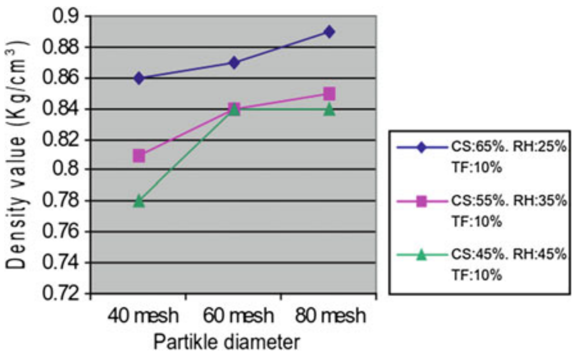

Fig. 8.3 Effects of the composition and diameter of briquettes particles on density

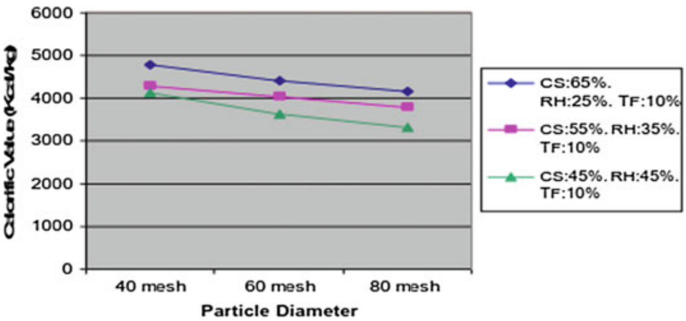

Fig. 8.4 Effects of the composition and diameter of briquettes particles on calorific value of burned briquettes

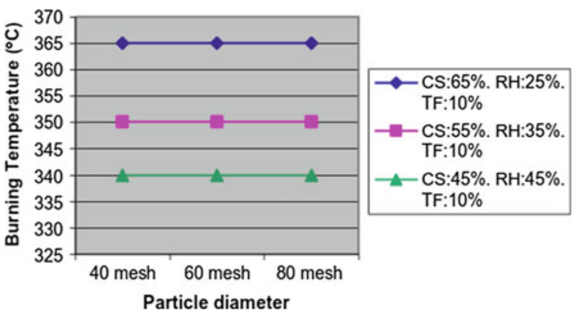

Fig. 8.5 Effects of the composition and diameter of briquettes particles on briquette combustion temperature

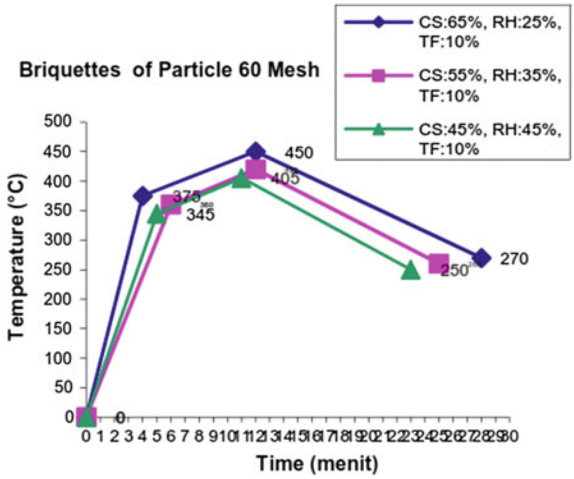

Fig. 8.6 Effect of burning rate on the mixture of coal briquettes and rice husk with particle sizes of 40 mesh

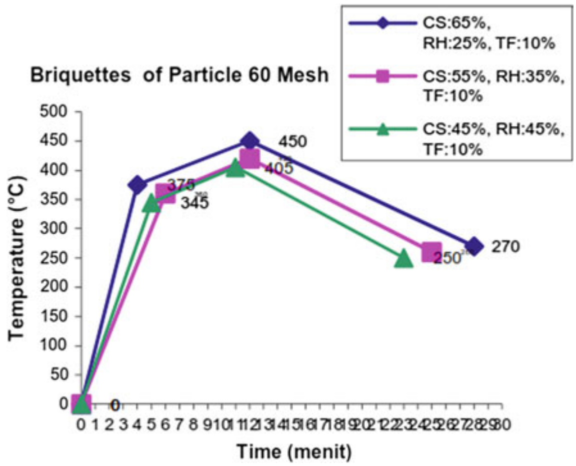

Fig. 8.7 Effect of burning rate on the mixture of coal briquettes and rice husk with particle sizes of 60 mesh

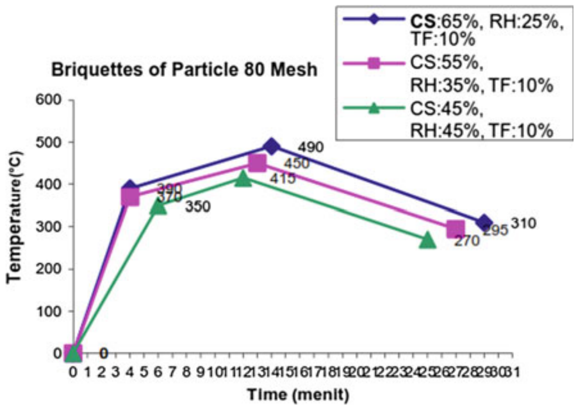

Fig. 8.8 Effect of burning rate on the mixture of coal briquettes and rice husk with particle sizes of 80 mesh

8.5 Conclusion

From the analysis conducted in this study, we made the following conclusions:

1. By comparing of different compositions and particle sizes in the process of briquetting the mix of coal and rice husk, we stated effects of these parameters on the compressive strength of briquettes and bulk density.
2. By comparing of different compositions and particle sizes in the process of briquetting the mix of coal and rice husk, we stated effects of these parameters on the calorific fuel value. However, the temperature of the burning briquettes was only influenced by the composition, while the size of the particles did not affect the value of briquettes combustion temperature.
3. From the performed analysis, we obtained:

   (i) the highest value of compressive strength in the process of briquetting of coal and rice husk was equal to 2.11 kg/cm^2, for the particle size of 80 mesh, at the composition of 65% coal, 25% rice husk and 10% tapioca and pressure of 78 kg/cm^2;
   (ii) the highest value of bulk density in the process of briquetting the mixture of coal and rice husk was equal to 0.89 g/cm^3 and occurred at the composition 65% coal, 25% rice husks and 10% tapioca flour, for the particle size of 80 mesh, and pressure of 78 kg/cm^2.

4. From the tests, we obtained:

   (i) the highest value of the calorific fuel in the process of briquetting the mixture of coal and rice husk was 4790.78 kcal/kg and occurred in the composition of 65% coal, 25% rice husk and 10% tapioca flour, for the particle size of 40 mesh, and pressure of 78 kg/cm^2;
   (ii) the highest temperature of combustion in the process of briquetting the mixture of coal and rice husk was 365 °C and occurred in the composition of 65% coal, 25% rice husks and 10% tapioca flour, while the particle size has no effect on the combustion temperature

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