Recovery Of Cenosphere From Fly Ash

Nur Ain binti Sumari, and Miss Christina Vargis

Faculty of Chemical Engineering, Universiti Teknologi Mara

***Abstract*— All power plants that are generating electricity from coal have huge amount of fly ash abandoned per day. The combustion residual disposed without any recovery could lead to environmental concern due to the high contents of metals.**

From this project, fly ash sample obtained from Kapar Power Plant was investigated to identify the amount of cenospheres composition. Cenospheres are in hollow spheres and can be obtained about 2 % from the fly ash sample.

The purpose of this project is to recover cenopshere from fly ash by using one of wet separation method which is float sink test. This test yields an amount of cenosphere due to the water density that is less than 1 g/cm^3. The floated particle which is cenosphere and fly ash are sedimented. Portion of recovered cenosphere and fly ash were analysed in term of their particle size distribution by using particle size analyser. Regarding the process, there are justification between the properties of fly ash and recovered cenosphere of the same sample fly ash. Regarding the process, there is correlation between particle size distribution with application of cenosphere. The distribution happened on range size of 20 to 40 µm for each particular sample of fly ash and cenosphere. The size of particle distribution of cenosphere is much higher than fly ash. This result was proved by previous researcher which explained that cenosphere is a hollow particle that consists of 0.01mm to 1mm in diameter. The cenosphere can only be constituted about 1 to 2% of the fly ash obtained from the coal combustion process. Regarding to this research, 90% of the cenospheres have diameters between 0.1 to 0.42mm while the remaining of 10% have diameters lower than 0.1mm.

Keywords*— *fly ash, cenosphere, particle size analyzer

I. Introduction

Nowadays, power plants have enlarged all over the world and using coals as their sources of fuel instead of gas. Coals are composed of combustible organic matter with a variable amount of inorganic mineral matter. This can be proved as billion metric tons of coal mined annually in the United States which estimated about 90% is used for combustion in order to obtain energy that can generate electricity (Barbara and Ann, 2006).

In 2008, United States produced about 136.1 million tons of coal combustion residues. Ward (2010) claimed that 44.5% of the residues were utilized in beneficial manner and the remaining just being disposed in ash pond. Coal combustion residue consists of two by product which are fly ash and bottom ash. Fly ash is constituted as the huge quantity production which urges significant pressure towards environment as well as waste management system. Rather than risking the landfill to be occupied by residue to some extent, exploitation on the fly ash by discrete useful components may add some value to fly ash as raw materials.

One of the valuable content inside fly ash is cenospheres that is defined as hollow spheres (Kruger and Toit,1991). It is lightweight, mostly occupied by air or gases and hollow ceramic and acts as vital value added inside fly ash. Two most important factors that affect the properties of cenosphere are the consistency of coal used and operating condition of power plant. Cenosphere produced from coal combustion residue would not make any changes as long as these key factors are remained constants. Based on these activities, only some cenosphere can be obtained from fly ashes and generally it is on low numbers about 0.3 to 1.5% (Acar and Atalay, 2016).

Cenopshere of fly ash is one of valuable contents that have unique properties such as lightweight, fillers in polymer, low dielectric, high resistance of heat and insulation (Joseph et al. 2013). In addition, cenosphere is familiar in several applications including of plastics, construction, recreation and automotive. Usually, it is used to improve the properties of materials as light weight fillers.

In this research, wet separation is chose in order to separate the cenosphere by implement concept of float and sink due to having lower density than 1 g/cm^3. In this experiment, the most important parameter is the density of cenosphere and the characteristics. The density is the only way to distinguished between cenosphere and fly ash.

Further analysis on properties of cenospheres was conducted particle size analyser (PSA). The particle size analyser was used in order to investigate the particle size distribution of sample. There are two objectives to be approach which are recovering the cenosphere from fly ash using float and sink method also investigating the particle size distribution of fly ash and cenosphere using particle size analyzer analysis.

II. Methodology

A. Materials

Coal fly ash is obtained from Kapar Power Plant at Selangor were used in this study. It was collected from silo fly ash of power plant. This fly ash was captured by electrostatic precipitator zone because most of fly ash ends up there. In this experiment, sample of fly ash was weighted at 150g and poured with distilled water to undergo float sink method.

Figure 1 : Sample of coal fly ash that obtained from Kapar Power Plant.

Figure 2 : Distilled water used as agent for separation.

Fly ash was poured with distilled water for separation of cenosphere from fly ash. Distilled water was decided as separation agents that enable cenosphere have density lower than 1 g/cm^3.

B. Sample Preparation

Figure 3 : Distilled water and fly ash were stirred for achieve complete mixture.

The average mass of collected sample fly ash was weighed about 150 g. Separation process was carried out by float sink test of wet separation process. The process held by poured fly ash sample with distilled water. They were stirred for 5 minutes using rod stirrer and left the mixture for undergoes sedimentation phenomenon about 24 hours.

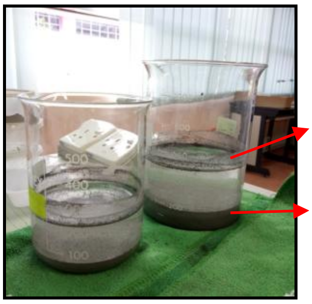

Figure 4 : Sedimentation process of sample.

Figure 5: Portion of fly ash samples was skimmed and drained to ensure water content was eliminated.

On the next day, the floated particles were indicated as cenospheres from sedimentation were skimmed and drained. The samples were then dried in a Universal oven which is located at Multipurpose Laboratory Level 6 by using a temperature of $105^{o}C$ for 2 hours to ensure it has zero moisture content.

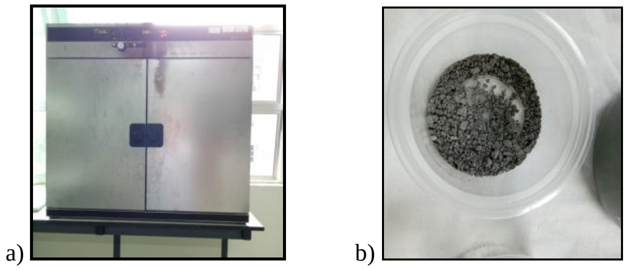

Figure 6 a and b: Sample of cenopshere undergoes drying process in an oven to eliminate moisture.

Afterwards, the weight of sample was measured and underwent for further analysis on the distinguished of particle size distribution between fly ash and cenospheres by using particle size analyzer.

III. RESULTS AND DISCUSSION

A.Estimation Separation Method

In this research, our estimation of separation was based on the density of particles with distilled water which was decided as separating agent. Result of separation indicates that the amount of separated cenospheres only consists of 0.2% which only contains about 0.3 g from 150g of fly ash sample. Table 1 below showed the quantity of recovered cenosphere.

Table 1 : Quantity of recovered cenosphere

Mass of fly ash used	Mass yield of cenosphere
150 g	0.3 g

The separation of cenospheres was attributed by several factors. Likewise, Acar and Atalay (2016) stated in their research that, the important parameters for separation method are the stirring time, revolution speed and solid to liquid ratio. The obstacle from this recovery hard to manage when there is agglomeration of particle. This is because the hollow particles enfold with solid fly ash particles that consist of alumino-silicate shell alone or may with iron oxide. Hence, it is much difficult for cenosphere to be rise up to the surface.

B.Particle Distribution of samples

Particle size distribution also is a better indicator of the fineness of particles. Particle size distribution of the fly ash sample obtained from Kapar Power Plant consists of particles with diameter ranging from 0.006516mm to 0.121763mm. From figure 1, it has been found that the average diameter of the fly ash particle is 0.04163mm that composed about 4.27% volume in.

Fly ash has the following distribution: 0.01 to 2.64% of fly ash particles are found between 0.001 and 0.01mm. 2.84 to 2.97% particles lie in the range of 0.01mm to 0.100mm. Nearly 14% of particles, in the range between 0.100mm to 0.500mm give the solid evidence regarding the bulkiness of the light weight particles.

As we can compare, the diameter range of cenosphere is between 0.007629mm to 0.1248mm. cenosphere has the following particle size distribution: the distribution between 0.001mm to 0.01mm is composed about 2.05% of volume in. Meanwhile, the number of volume that has a particle distribution of 0.01mm to 0.1mm is at the highest range which is lies at 4.27%. For the range of distribution between 0.1mm to 1.00mm is composed about 2.0 to 1.0% of volume in only.

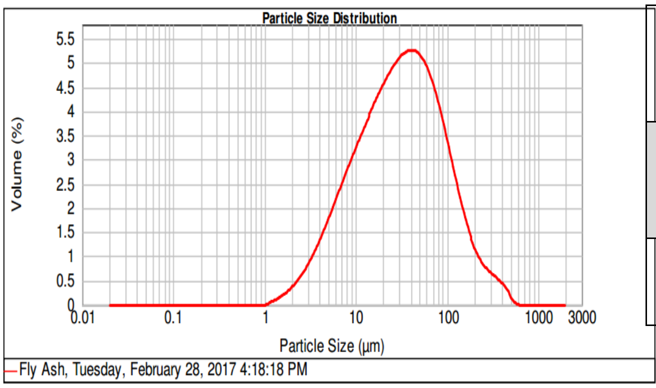

Fig. 1: Particle Distribution of fly ash sample.

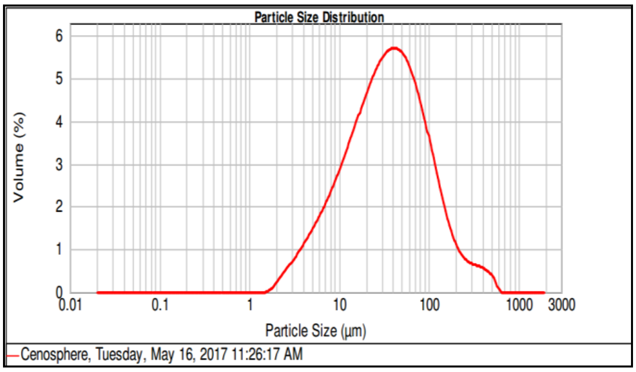

Figure 2 : Graph of Particle Distribution of Cenosphere sample.

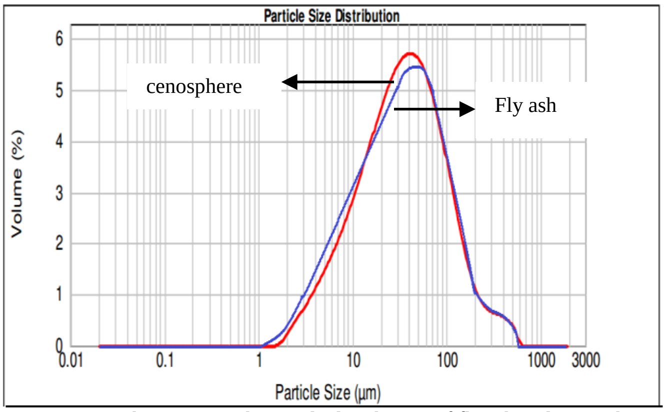

Figure 3 : Combination graph particle distribution of fly ash and cenosphere

Table 2 : Analysis data of particle distribution between fly ash and cenosphere.

Different of pattern, µm	Size,µm	Volume in %	
		Fly ash	Cenosphere
5.0	0.0 – 5.0	6.23	5.02
	5.0 – 10.0	12.63	10.54
	10.0 – 15.00	9.13	8.38
	15.0 – 20.0	10.74	10.82
10.0	20.0 – 30.0	15.85	16.74
	30.0 – 40.0	16.96	13.68
	40.00 – 50.0	8.46	13.81
	50.0 – 60.0	4.08	8.96
15.0	60.0 – 75.0	7.52	8.11
	75.0 – 90.0	6.3	10.66
	90.0 – 105.0	5.57	5.93
	105.0 – 120.0	4.82	5.07
20.0	120.0 – 140.0	4.07	4.22
	140.0 – 160.0	3.37	3.42
	160.0 – 180.0	2.75	2.71
	180.0 – 200.0	2.23	2.13
25.0	200.0 – 225.0	1.81	1.69
	225.0 – 250.0	1.49	1.38
	250.0 – 275.0	1.26	1.19
	275.0 – 295.0	0.58	0.56
30.0	295.0 – 325.0	1.08	1.08
	325.0 – 355.0	0.50	1.01
	355.0 – 385.0	0.43	0.49
	385.0 – 415.0	0.77	0.94
35.0	415.0 – 450.0	0.57	0.82
	450.0 – 485.0	0.23	0.37
	485.0 – 520.0	0.23	0.37

Table 3 : Different between fly ash and cenosphere

Properties	Fly ash	Cenosphere
Specific surface area, m^2/g	0.379	0.326

Based on the analysis, the test showed that the size of particle distribution of cenosphere is much higher than fly ash. This result was proved by previous researcher which explained that cenosphere is a hollow particle that consists of 0.01mm to 1mm in diameter. The cenosphere can only be constituted about 1 to 2% of the fly ash obtained from the coal combustion process. Regarding to this research, 90% of the cenospheres have diameters between 0.1 to 0.42mm while the remaining of 10% have diameters lower than 0.1mm.

According to table 2, the distinguished between fly ash and cenosphere are not really much different as it can be seen through the pattern of volume in respected to its size. Clearly, the distribution happened on range size of 20 to 40 µm for each particular sample of fly ash and cenosphere. Apparently, based on the result, cenosphere has slightly higher distribution than fly ash. This can be related to the specific surface area of particles. Generally, the specific surface area is the area of a unit of mass which measures the resistance of compacted particles to an air flow.

The particle size analyzer managed to determine the specific surface area of fly ash and cenosphere. Based on table 3, the specific surface area of fly ash and cenosphere are 0.379 m^2/g and 0.326 m^2/g. From this information, it can be related on the physical properties of cenosphere which is bigger than fly ash but has a hollow surface. Therefore, the distribution of cenosphere are much scattered than fly ash sample as it shown at figure 3. In fact, for all this matter, this also proved that the cenosphere has lower density than fly ash.

IV. Conclusion

Results disclosed to give a disproportion in the content between cenosphere and fly ash sample. This may able to give the possibility to investigate them in order to determine any factors which could promote the increment of cenospheres from coal combustion process. A separation method was developed which by using float and sink method in order to success fully separated. The separation method was able to yield about 0.3g of which equal to 0.2% from the fly ash sample. The separation was affected by few factors such as the stirring time and also the nature formation of coal itself at first place.

The separated cenosphere present as speherical shape with diameters from about 0.007629mm to 0.1248mm in term of size and shape. This can be described that, the smaller particles are mostly transparent, while the larger particles are mostly opaque and have different hues. In term of structure, the cenosphere turned out to be mainly amorphous, with the formation of crystalline phases such as quartz, mullite and calcite. This indicates the glass formation process has occurred inside the pulverized coal combustion boiler. In glass formation, silica formed due to the high viscosity while high of alumina content showed that the cenosphere has a good mechanical strength.

For future investigation, some precautions need to take action while doing the filtration method. The apparatus to be use must be appropriate and the filtration must be keep repeating in order to obtain more separated cenosphere. This is due to the cementitious particles which make some particles are hard to separate and may need a longer time to float at the surface of water.

Acknowledgment

Thank you to my supervisor, Miss Christina Vargis also to all faculty members of Chemical Engineering Universiti Teknologi Mara who guided me throughout the project and made it achieve to completion with success.

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