PHYSICAL & CHEMICAL PROPERTIES OF PULVERISED FUEL ASH

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Abstract
Pulverised fuel ash is the finely divided mineral residue resulting from the combustion of coal in electric generating plants. Pulverised fuel ash consists of inorganic, incombustible matter present in the coal that has been fused during combustion into a glassy, amorphous structure. Pulverised fuel ash particles are generally spherical in shape and range in size from 2 µm to 10 µm. They consist mostly of silicon dioxide (SiO_2), aluminium oxide (Al_2O_3) and iron oxide (Fe_2O_3). Pulverised fuel ash like soil contains trace concentrations of the following heavy metals: nickel, vanadium, cadmium, barium, chromium, copper, molybdenum, zinc and lead. The chemical compositions of the sample have been examined and the fly ash are of ASTM C618 Class F.

Introduction
The amount of pulverized fuel ash generated by electric power plant in Malaysia is increasing year by year in Malaysia. According to the statistic reported for years 1987 – 1989, 415 million tons of pulverized fuel ash ash was produced all over the world. Only 16 % of the totals were utilised in construction sector (Baykal & Doven, 2000). The combustion of coal at high temperatures and pressures in power stations produces different types of ash. The 'fine' ash fraction is carried upwards with the flue gases and captured before reaching the atmosphere by highly efficient electro static precipitators. This material is known as pulverised fuel ash. It is composed mainly of extremely fine, glassy spheres and looks similar to cement. The coarse ash fraction falls into the grates below the boilers, where it is mixed with water and pumped to lagoons. This material, known as bottom ash has a gritty, sand-like texture. The use of pulverised fuel ash and bottom ash in construction has been established for decades. Applications range from providing the cementations material in concrete, to use as a simple fill material or a lightweight aggregate in the manufacture of blocks. Using pulverised fuel ash makes a positive contribution to the environment. Pulverised fuel ash is used in many applications to replace naturally occurring aggregates and minerals, which can reduce significantly the demand for normal aggregates (granite). Pulverised fuel ash is also used as a component in the production of flowable fill which is used as self-leveling, self-compacting backfill material in lieu of compacted earth or granular fill. Flowable fill includes mixtures of Portland cement and filler material and can contain mineral admixtures, such as pulverized fuel ash. Filler material usually consists of fine aggregate (in most cases, sand), but some flowable fill mixes may contain approximately equal portions of coarse and fine aggregates.

The most-often-used specifications for pulverized fuel ash are ASTM C 618 and AASHTO M 295.Two major classes of pulverized fuel ash are specified in ASTM C 618 on the basis of their chemical composition resulting from the type of coal burned; these are designated Class F and Class C. Class F is pulverized fuel ash normally produced from burning anthracite or bituminous coal, and Class C is normally produced from the burning of subbituminous coal and lignite. Class C pulverized fuel ash usually has cementitious properties in addition to pozzolanic properties due to free lime, whereas Class F is rarely cementitious when mixed with water alone.

There are also wide differences in characteristics within each class. Despite the reference in ASTM C 618 to the classes of coal from which Class F and Class C fly ashes are derived, there was no requirement that a given class of pulverized fuel ash must come from a specific type of coal. For example, Class F ash can be produced from coals that are not bituminous. and bituminous coals can produce ash that is not Class F (Halstead,1986). It should be noted that current standards contain numerous physical and chemical requirements that do not serve a useful purpose. According to ASTM C618, three-fourths of the ash must have a fineness of 45 µm or less, and have carbon content, called the loss on ignition (LOI), of less than 4%.

Experimental Investigations
The following tests have been conducted to characterize this sample of pulverized fuel ash which has been collected from Stesen Janakuasa Elektrik Sultan Abdul Aziz Shah, Kapar, Selangor.

Chemical composition
The chemical composition of the sample has been obtained with the help an X-ray fluorescence (XRF) setup *(model Rigaku RIX 3000)*

Table 1: Chemical composition of the pulverised fuel ash used

Compound	Content, % wt
SiO_2	59.00
Al_2O_3	21.00
Fe_2O_3	3.70
CaO	6.90
MgO	1.40
SO_3	1.00
K_2O	0.90
LOI	4.62

Particle size distribution

A laser particle size analyzer,*Huriba Capa-7000 Particle Analyzer,* have been used to study the particle size distribution of the pulverized fuel ash sample (figure 1).

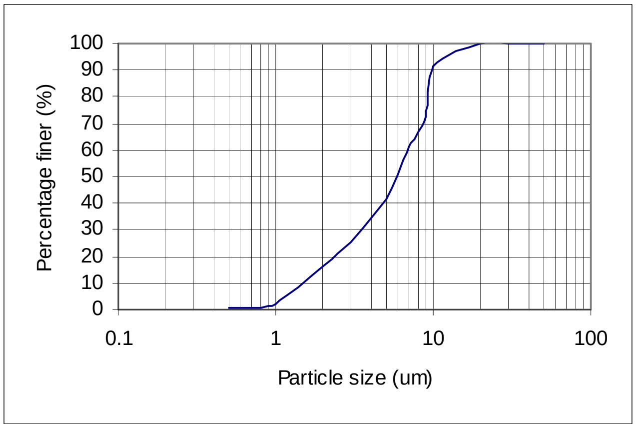

Figure. 1: Particle size distribution characteristics for PFA sample

Scanning Electron Microscope (SEM)

LEO scanning electron microscope was used to study the morphology of the pulverized fuel ash particles. Examination under the scanning electron microscope showed that the samples had the usual pulverized fuel ash morphology and were composed of mostly small, spherical particles. Figure 2 shows SEM micrograph of the cenospheses particle. It can be noticed that the fly ash sample consists of almost regular spherical (cenospheres) particles ranging 2 um to 14 um in diameter. Figure 2 shows micrograph of cenospheres particle. Usually, pulverized fuel ash composed of mostly small and spherical particles (Swamy & Lambert, 1981)

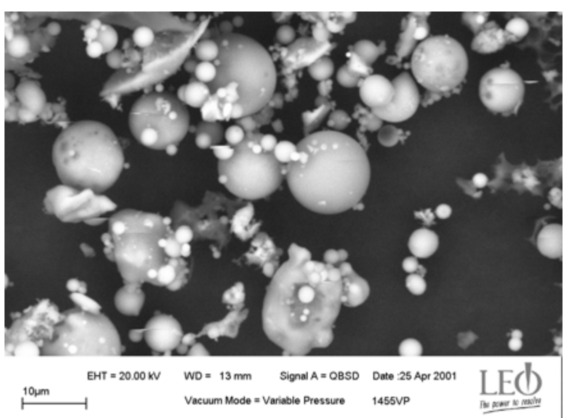

Figure 2 : SEM micrograph for the cenospheres particle (2.20kx)

Mineralogical Composition

The sample has been evaluated for its mineralogical composition by X-ray diffraction (XRD) spectrometer (Shidmazu), with graphite monochromator and Fe Ka radiation. The sample is scanned from

2q of 0±80°. The search match JCPDS data files have been used for identification of the minerals present in the sample (figure 3).

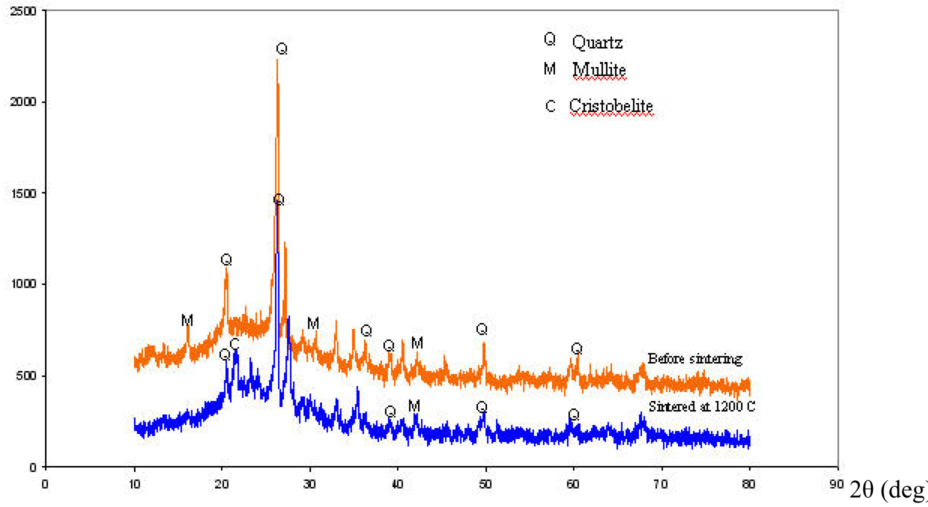

Figure 3 : X-Ray diffraction pattern of pulverized fuel ash sample

Results and Discussion

Results of the tests conducted, and mentioned above, on the pulverized fuel ash sample are being presented in the following. The results of XRF study are presented in Table 1. It can be noticed that for the pulverized fuel ash sample, the percentage of SiO_2, $Al_2 O_3$, and Fe_2O_3 is 59.0%, 21.0%, and 3.7 %, respectively. Figure 1 presents particle size distribution of the pulverized fuel ash sample using a laser particle size analyzer. From figure 1, it can be noticed that the fly ash sample consists of particles with diameter ranging from 2 um to 10 um. However, few particles with maximum diameter of 15 um are also noticed in the sample. Figure 3 shows the X-ray diffraction pattern of the pulverized fuel ash sample. From the figure, presence of quartz, mullite and cristobelite can be noticed. However, quartz is the most predominant mineral present in the fly ash sample. The average specific gravity of the fly ash sample is found to be 2.288 as shown in table 2. The average particle size of pulverized fuel ash sample is 6.92 μm.

Table 2: Physical properties of the pulverized fuel ash used

Color	Whitish grey
Bulk density (g/cm^3)	0.994
Specific gravity	2.288
Moisture (%)	3.14
Average particle size (μm)	6.92

Conclusion

Pulverized fuel ash is the residue from the combustion of bituminous coal, generally as a result of the generation of electricity at thermal power generation plant. In Malaysia, about 1200 MW or 20% of national electricity is supply by thermal power plant which is using coal as fuel (8th Malaysia Plan, 2000). Stesen Janakuasa Elektrik Sultan Abdul Aziz Shah, Kapar, Selangor is using 100 tonne coal per hour to generate 1200 MW for the national grid. As a result it will produced 15 to 20 tonne PFA per hour. Millions of tons of pulverized fuel ash produced each year due to the massive consumption of coal. The industry is facing problem to develop efficient and economical technique recycle these materials. Recycling of pulverized fuel ash will conserve the natural raw materials and abridge the disposal cost. It will also create new revenues and business opportunities while protecting the environment. The chemical compositions of the sample have been examined and the pulverized fuel ash is of ASTM C618 Class F.

Acknowledgment

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