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BALL MILLING OF AUSTRALIAN COAL - WASTE-FLY ASH TO REDUCE THE PARTICLE SIZE

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ABSTRACT

Fly ash (FA) is a 'waste' by-product produced in large amounts in coal thermal power stations to generate energy. Fly Ash consists of a wide range of rigid ceramic oxides as well some unburnt carbon. Fly ash properties are equal or better than the properties of other filler materials. FA is useful as a filler to improve mechanical properties of polymers, reduce the cost of product and to get lightweight composites.

Work was undertaken to try the possibility of reducing the particle size and increasing the particle surface area of the Australian Fly Ash by using conventional ball milling. Increasing the particle surface area is very important; which gives better adhesion to other materials in order to make composites.

As a result, a 10 hrs ball milling was done to reduce the particle size by approximately 50%. Using ball milling compared to as received raw fly ash generated a 4-times surface area. X-Ray Diffraction peaks of the ball-milled Fly Ash showed evidence of some line broadening, possibly due to residual stress caused by the grinding process. SEM shows irregular shaped of ball milled Fly Ash particles and also found reduction in size.

Keywords: Fly Ash (FA), ball milling, Particle Size Analysis (PSA), X-Ray Diffraction (XRD), and Scanning Electron Microscopy (XRD).

I. INTRODUCTION

Fly Ash

Fly Ash is a fine powder, grey in colour, spherical in shape[Wikipedia 2017].Fly ash generated in large quantities from burning coal to generate electricity in coal power stations[Kim D.Basham et]. Fly Ash consists of mixture of oxides such as SiO_2, Al_2O_3, Fe_2O_3, and CaO[Wikipedia 2017].

There are two types of Fly Ash; class C and class F [Wikipedia 2017, Kim D.Basham et. Al]. The main difference between them is Lime content in class F fly ash is around 10% whereas in class C it is usually more than 20%[Kenneth et. al2006].

Fly ash used

- Concrete; [ACAA 2008, Raask et. al. 1968],
- Cement; [ACAA 2008, Raask et. al.1968],
- Grout; ACAA 2008,
- Pavement; [ACAA 2008, Raasket. al.1968],
- Sub- bases; [ACAA 2008; ACAA 2008],
- Structural applications as fillers; [ACAA 2008],
- In asphalt as a mineral fillers; [ACAA 2008],
- In polymers as filler;[Raask et. al.1968], and
- For soil modification as an ingredient[ACAA 2008].

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Ball milling fly ash

Materials

Fly ash class F samples were collected from Tarong power plant Queensland, Australia, from fourth hopper. Ball Milling Machine used is: manufactured by Star Machinery Pty Ltd, Alexandria, New South Wales Australia. The ball milling was carried out in Shear Mode by using alumina balls 10 mm diameter, in a 1000 ml container as shown in figures 1 - 4.

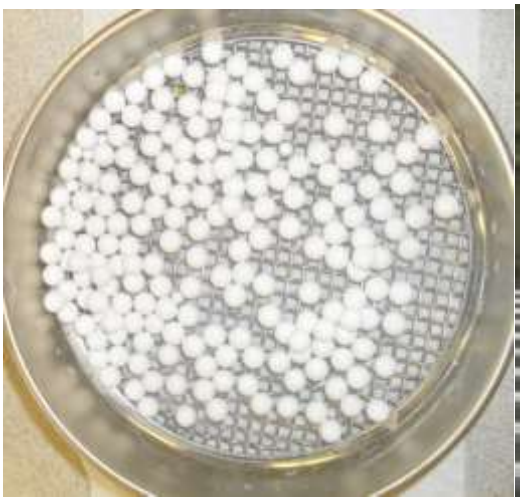

Figure 1: 10 mm Alumina balls

Figure 2: 1000 ml plastic Container

Figures 3: Show thecontainer filled

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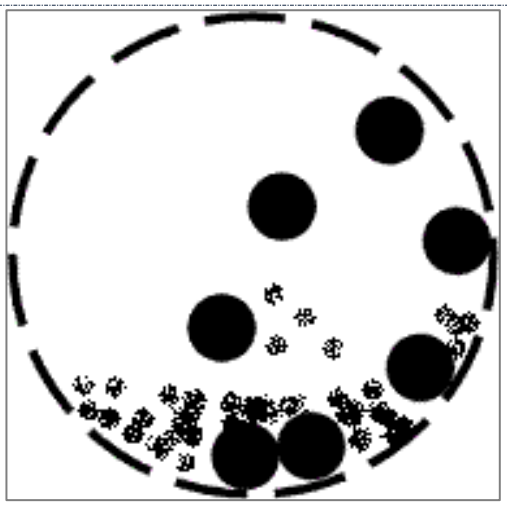

Figure 4: Dry shear ball milling technique with fly ash and alumina ballsduring of the fly ash in 1 litrecontainer ball milling process using 10 mm size balls

Figure 5: Raw fly ash

Figure 6: Ball milled fly ash

In figure 5 shows raw fly ash prior to ball milling, then in figure 6 shows fly ash after ball milling.

Scanning Electron microscopy (SEM):
TM 3000 Table Top Microsoft scanning electron microscope was used to examine the morphology of the raw fly ash and ball milled fly ash.

Particle Size Analysis (PSA)
Particle size analysis of fresh (raw) and ball milled fly ash was determined by dynamic laser scattering technique (particle size analyser- LS230) at room temperature for one minute, with water as media (without any dispersing agent).

X-Ray Diffraction (XRD):
Sample was placed in a sample holder, a cylindrical recess with a diameter of 10 mm and depth 3 mm. The top surface was smoothened using a flat glass plate. The filled sample holder was placed on a Siemens 500 XRD stage and then was analysed from 20 º to 80 º at a speed of one degree per minute. X-ray diffraction measurements were carried out to find the crystallite size of the quarts phases. The result from this analysis is qualitative only.

SEM test results and discussion:
The typical SEM micrograph of the fly ash used in this project is shows in figure 7 and the Ball Milled fly ash is shows below in figure 8.

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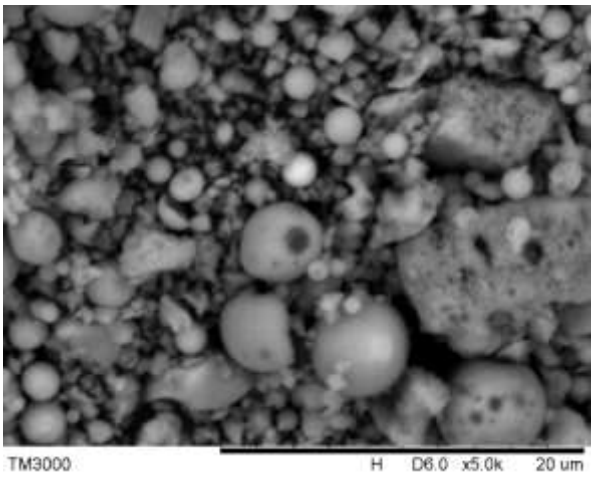

Figure 7: SEM micrograph of Fly Ash

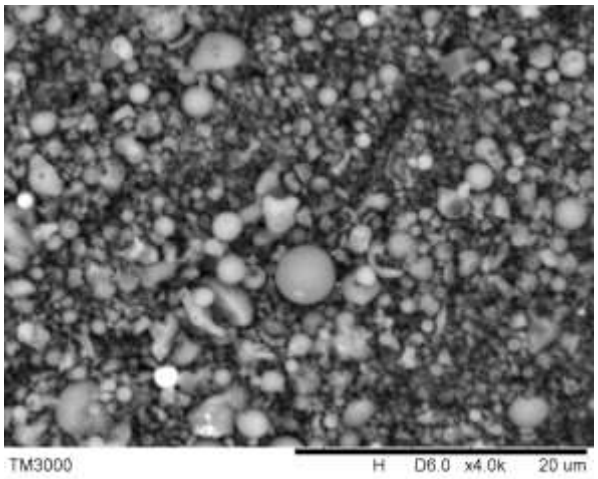

Figure 8: SEM micrographs for the 10 hours ball before ball millingmilled fly ash

- The fineness of the ball milled fly ash is clear in figure 8 (compared to the SEM of the as received fly ash particles shown in figure 7 under same magnification. It is to be noted that the fly ash particles were 'uncoated', and a much lower voltage (4 kV) was used for figures 8 as well as 7.

Particle Size Analysis results and discussion:

- Figure 9 shows the particle size analysis for fly ash before milling, and figure 10 shows the particle size distribution after ball milling for 10 hours.

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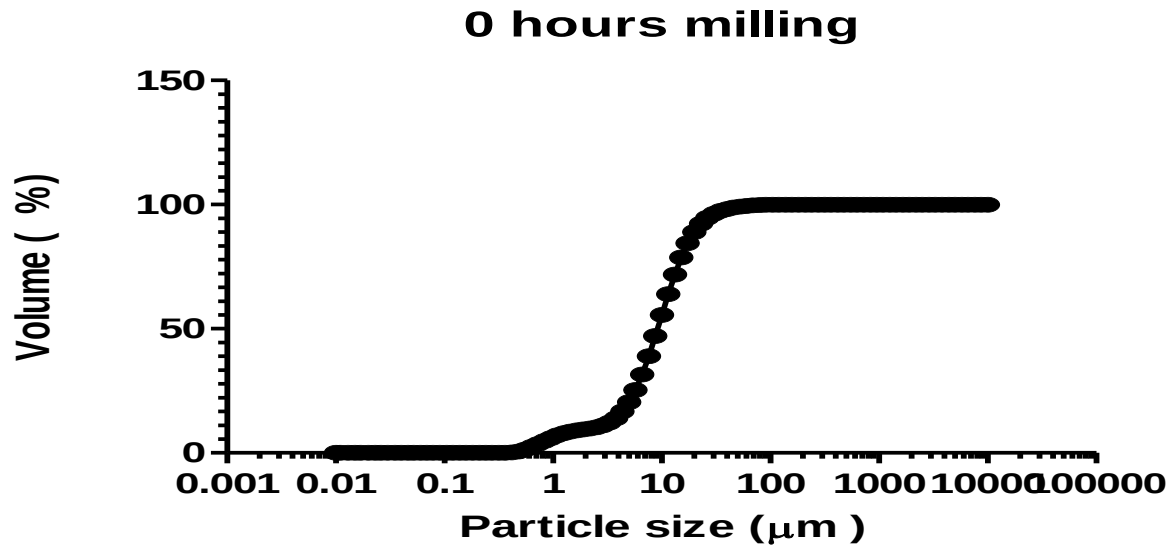

Figure 9: Particle size distribution of raw fly ash

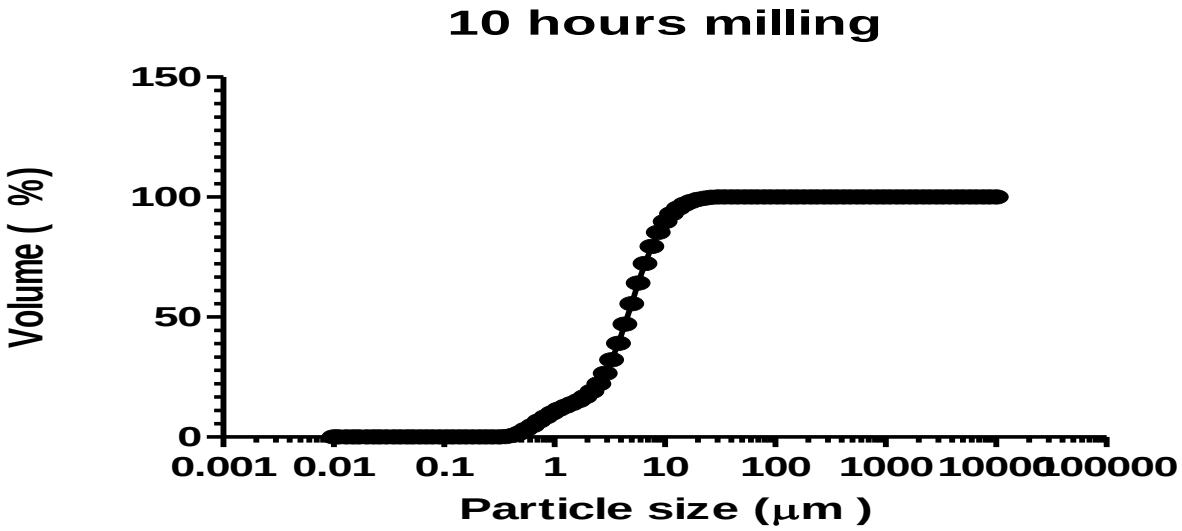

Figure10: Particle size distribution of the FA after 10 hours milling

- Table 1 provideremarkable results in relation to the particle size analysis of the raw fly ash and the 10 hrs.Ball milled (dry) fly ash.

Table 1: Comparison between the P.S.A. of the (raw) fly ash and after 10 hrs milling (dry)

Particle size (Microns)	Milling time	
	0 hours	10 hours
D 10	1.905	0.955
D 50	8.7	4.365
D 90	19.953	8.71

- As can be seen from Table 1, the particle size ball milling reduced particle size of the fly ash by 50%, which is a reasonable achievement.

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- This means for the same mass of fly ash, a 4-times surface area is generated compared to the as received raw fly ash.

X-Ray Diffraction results and discussion

- X-Ray diffraction was used to determine the crystallite phase of normal Fly Ash and Ball Milled Fly Ash.
- Ball milling shows some apparent peak broadening, because of the decreasing in crystallite size, as a result of ball milling[Roberto Tomasi, at. al. 1998].
- As can be seen in figure 11 and figure 12 the bigger peaks belong to the quartz and the smaller peaks belongs to mullite and there is presence to glass phase.
- Intensity of the main quartz peak is significantly reduced (approximately 50%) by ball milling. The intensity of other quarts and mullite peaks as well are reduced after ball milling.

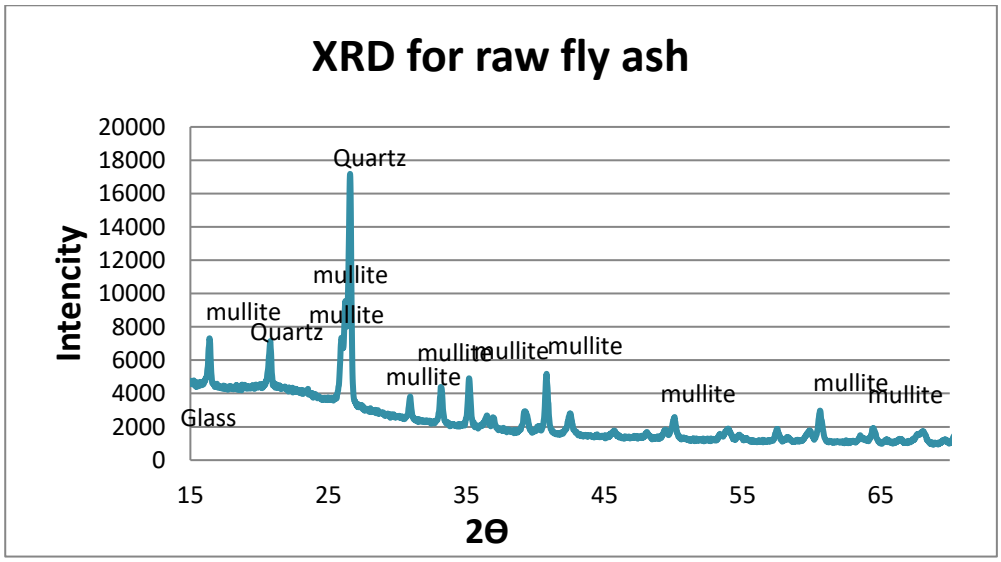

Figure 11: XRD for raw fly ash

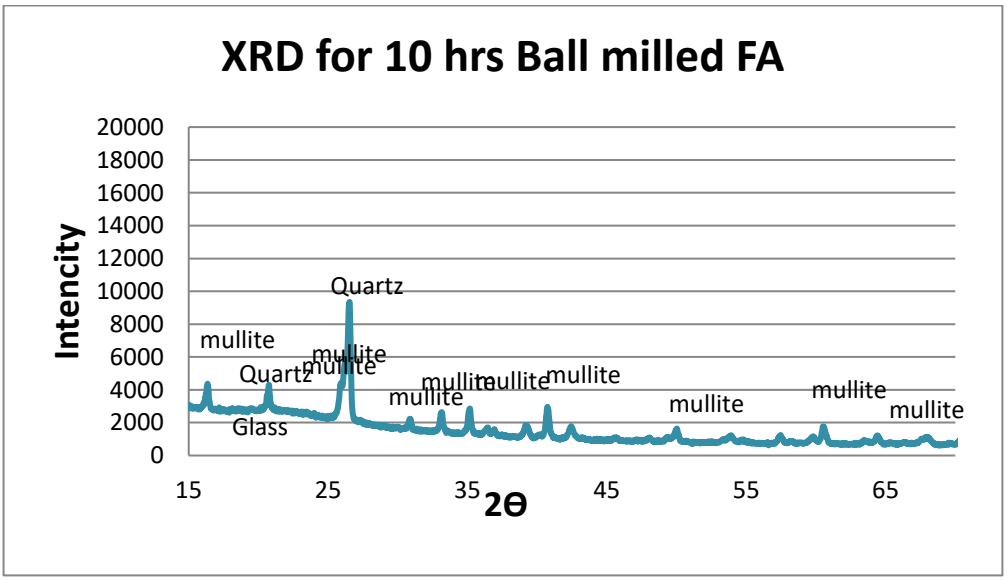

Figure 12: XRD for fly ash samples after 10 hours ball milling

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II. CONCLUDING REMARKS

Ball milling for as received fly ash under dry, shear deformation mechanism, gives an encouraging result that a 50% reduction in particle size is obtained.

The fact that the main quartz peak was significantly reduced (approximately 50%) by ball milling, detected using XRD test, – as well as other peaks from quartz and mullite reduced in intensity –.

Also; SEM study of as-received fly ash and ball milled fly ash showed remarkable observations; which support PSA results in reducing the particle size of the fly ash

III. REFERENCES

1. Wikipedia, Fly Ash, 2017
2. Kim D. Basham, Michael Clark, Tim France, Patrick Harrison. "WHAT IS FLY ASH?". December 7, 2007. Concrete Construction, Materials
3. Kenneth S. Sajwan, Irena Twardowska, Tracy Punshon, Ashok K. alva, (2006), "Coal Combustion Byproducts and environmental issues", Springer science + Business media Inc.
4. The American Coal Ash Association (ACAA) http://www.acaa-usa.org/ , Copyright 2008 ACAA
5. Raask E. Cenospheres in pulverized-fuel ash. J Inst Fuel 1968; 41(332):339–44.
6. Roberto Tomasi, Adriano A.Rabelo, Adriana S.A. Chinelatto, Laudo Reis, and Walter J. Botta. "Characterization of high-energy milled alumina powder". Cerâmica vol.44 n.289 São Paulo Sept./Oct. 1998 http://dx.doi.org/10.1590/S0366-69131998000500003

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