PARTICULATE EMISSION SIZE DISTRIBUTION FROM PALM OIL MILL BOILER

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SUMMARY:. A study on the particulate emission size distribution from five different palm oil mills with boiler steam capacity ranging from 17,000 to 35,000kg/hr was investigated and is reported in this paper. The mills are all equipped with a multi-cyclones particulate arrestor. The particulate sample was collected at the stack (fly ash) and at the multi-cyclone (retained ash). The results showed that the 50% cumulative particulate emission size distribution for stack fly ash ranged between 1.3 and 38 µm and 60 to 150 µm for retained ash.
***Keywords*—**Particulate, fly ash, retained ash, palm oil mill, particle size distribution.

INTRODUCTION

The palm oil milling process generates large quantities of palm fibre and shell as solid waste annually. The biomass residue is used as fuel in the boiler to produce steam and electricity. Although this practice helps to dispose of the waste, it also create a serious particulate emission problem. It is predicted that almost 390,000 tonnes of particulate emission are being released annually from a mill [1].

Limited studies on particulate emission size distribution from palm oil mill operation had been reported. Syahirah et.al [2] reported that 2.33% and 13.7% of the total particulate mass emission concentration from a 13,600kg/hr boiler steam capacity mill consist of particulate size fraction less than 2.5 and 10 microns, respectively. While Rashid et.al [3] found that 50% cumulative particulate emission size distribution for palm oil mill boiler fly ash was between 9 and 10 µm for a water tube type boiler while for fire tube type boiler this was less than 1.5 µm. The 50% cumulative particulate size distribution is the particulate size collected at 50% collection efficiency (or cut-diameter) by the dust collector. Thus, in this regard a study on the particulate emission size distribution was performed to further investigate the contribution of fine particulate size fraction which are difficult to control in the industry. Especially, with the enforcement of the new Clean Air Regulation 2014 which require the industry to conform with a more stringent emission regulation of 150 mg/Nm^3.

2. MATERIALS AND METHODS

2.1 Data Collection

A total of five palm oil mills equipped with water tube type boiler were selected in this study. The running steam capacity of the boilers ranged between 17,000 and 35,000 kg/hr. **Table 1** presents the characteristics of the boiler and its operating conditions where fiber and shell varied between 6,000 and 12,000 kg/hr are used as fuel to generate steam to run the mill. All the boilers were equipped with multi-cyclones dust collector unit.

Table 1. Characteristics of the boiler and its operating condition

Mill	A	B	C	D	E
Boiler year	2004	2002	1983	2009	2009
BRTSC	25,000	45,000	18,000	45,000	40,000
BRSC	24,000	26,000	17,000	35,000	30,000
Boiler temp (ºC)	247	247	215	215	215
BP (psi)	300	310	300	312	300
FFB (kg/hr)	30,000	54,000	30,000	45,000	40,000
F&S feed (kg/hr)	8,000	9,000	6,000	12,000	10,000
F/S ratio	80:20	70:30	80:20	80:20	80:20

Note: BRTSC Boiler rated steam capacity (kg/hr)
BRSC Boiler running steam capacity (kg/hr)
BP Boiler Pressure

The particulate stack fly ash was collected from the stack gas downstream of a multi-cyclones particulate arrestor. Particulate matter was sampled iso-kinetically following the USEPA Method 17: 'Determination of in-stack particulate emissions from stationary sources'. A glass fiber thimble filter was used to collect the particulate. The flue gas velocity, gases component and moisture content were also measured following USEPA Method 2: 'Determination of stack gas velocity and volumetric flow rate (Type S-pitot tube)', USEPA Method 3: 'Determination of dry molecular weight', and USEPA Method 4: 'Determination of moisture content in stack gas' respectively. Meanwhile particulate removed or retained ash sample found at the bottom of the multi-cyclone was also collected.

2.2 Particulate Size Analysis

The particulate size distribution of the collected sample was determined by using a Laser Diffraction Particle Size Analyzer (SHIMADZU, SALD-2201) where the analyzer is able to measure the particulate size from 0.03 to 1000 µm. Particulate size distributions is calculated from the light intensity distribution pattern of the diffracted light emitted from particle group.

The particulate stack fly ash was disengaged from the thimble by ultra-sonification technique. Then, dispersant solution consist of water and NaHMP (act as dispersing agent) was added into a very small amount of particulate sample before the analysis. The sample was placed in the flow cell with sonification mode for better dispersion before the measurement of the particulate size distribution.

3. RESULTS AND DISCUSSION

Table 2 presents the stack parameters obtained in the study which includes stack gas temperature, volumetric flow rate, velocity, moisture content, oxygen and carbon dioxide concentration, as well as particulate concentration and emission rate. The total particulate mass concentration varied between 0.42 and 3.77 g/Nm^3 (corrected at 7% O_2) with high coefficient of variation of 82% illustrating the large variation of emission between the mills.

Table 2. Stack parameters obtained in the study.

Parameter			Mill		
	A	**B**	**C**	**D**	**E**
Stack gas temp (°C)	268	286	264	248	252
SGVF	14.2	10.0	13.7	13.5	12.9
SGV	16.2	17.2	15.6	15.4	15.8
Moisture (%v/v)	4.27	7.02	4.99	5.37	11.2
O_2 (%)	17.9	11.2	11.0	10.3	13.5
CO_2 (%)	2.9	8.5	7.3	7.9	6.7
PC	2.36 ±0.96	1.97 ±0.02	0.42 ±0.09	3.77 ±0.69	2.52 ±0.23
PER	7.46 ±3.03	13.8 ±0.13	4.20 ±0.90	53.6 ±9.84	23.9 ±2.21

Note: number of sample: 3
Nm^3 means dry gas volume corrected at T=0°C and P=101.325 kP
SGVF Stack gas volumetric flowrate (Nm^3/s)
SGV Stack Gas Velocity (m/s)
PC Particulate Concentration at 7% O_2
PER Particulate emission rate (g/s)

Figure 1 presents the cumulative particulate size distribution of the stack fly ash of different boiler types and capacities which showed the 50% cumulative particulate size distribution for mill A, B, D and E ranged between 21 and 38 µm. While for mill C this was 1.3 µm. The finding reflects that most of the mills (with the exception of mill C) may have lower particulate collection efficiency dust collector. It was observed Mill C has the smallest boiler capacity and fuel feeding compared to the others which could be one of the factors that contributes to this finding. However further investigation is warranted.

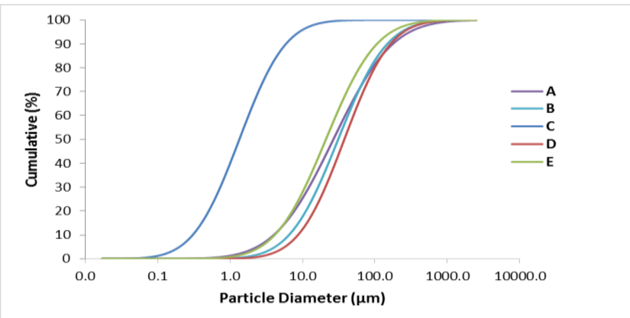

Fig. 1. Cumulative particulate size distribution of stack fly ash from different mill.

Figure 2 presents the cumulative particulate size distribution of the retained ash of different boiler capacities which showed a similar observation where 50% cumulative particulate size dsitribution of mill A, B, D and E ranged between 100 and 150 µm coarser compared to 60 µm as obtained in mill C. This illustrate that the particulate emission obtained at the bottom of the multi-cyclone are coarser than the stack emission fly ash.

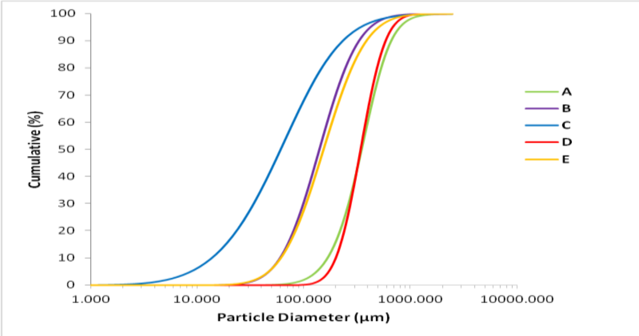

Fig. 2. Cumulative particulate size distribution of retained ash from different mill.

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