Poll Res. 40 (May Suppl. Issue) : S140-S144 (2021)

ISSN 0257–8050

EMISSIONS OF PARTICULATE MATTER (PM), PM10 AND PM2.5 FROM BOILERS USING HUSK AS FUEL – A REPORT

I. KARUPPIAH* AND S. SUMATHI*

**Department of Chemistry, Hindustan Institute of Technology and Science, Chennai, 603 103, India*

(Received 28 November, 2020; accepted 14 December, 2020)

ABSTRACT

The present study of stack emissions from the boilers that employ husk as fuel was carried out in three rice mills situated in Southern India. The boiler capacities studied were generating 10t, 8t and 5t of steam. The studies revealed large quantity of Particulate matter (PM) emitted is more compared to PM 10 and PM 2.5. The boilers provided with APCD emitted particulate matter 10.9 and 19.1 g/kg of husk burned whereas boiler without APCD emitted 36.9 g/kg of husk burned.

KEY WORDS : Air Pollution, Stack Monitoring, Bio Mass Fuel, Stack Emissions, PM10 and PM2.5

INTRODUCTION

Air pollution in India is a serious issue that causes much concern and hence, needs a greater attention. Though natural sources, vehicle emission and traffic congestion linked to the population growth also contribute to air pollution, the major sources of emissions are from plants that burncoal, liquid fuels (Furnace oil and Light Diesel oil), fuel wood and biomass for the generation of steam. Ambient air monitoring is being carried out in India since 1981 for air pollutants such as suspended particulate matter, Oxides of Nitrogen and Sulphur Dioxide only following the Air (Prevention and Control of Pollution) Act in 1981. Since 1986 onwards, the focus was shifted from total particulate matter monitoring to the particulate matter of PM10 (particle size less than 10μ) and from 2009 onwards monitoring of fine particulate matter PM2.5 (particle size less than 2.5μ). Again, the sources for contribution of PM2.5 and PM10 to ambient air are attributed to Industrial emissions, vehicular emissions and various other sources.

National Clean Air Program (NCAP) was finally approved by Ministries and States in October 2018. Under this program, State Pollution Control Board was directed by Central Pollution Control Board to implement the NCAP directions to regulate emissions particularly, PM10 and PM2.5 from stationery sources and industries were advised to provide suitable control measures to reduce these emissions.

India is the second largest paddy-growing country in the world on an average with annual production of 93 million tonnes as rice being the staple food for the Indian population especially in the southern states. For the processing of paddy, about 30,000 rice mills exist in the rural areas and most of them are owned by private entrepreneurs. These mills produce rice husk. During the processing, mills require steam for this purpose. They utilise husk generated in the mill as fuel in the boilers for producing steam. Also, India is the world's largest consumer of fuel wood, agricultural waste and biomass for energy purposes. (Yadav and Singh, 2011). Most of the rice mills use husk which is readily available.

The present study was taken up to understand the contribution of PM 10 and PM 2.5 emissions to the atmospheric pollution from boilers using bio mass fuel (Husk).

LITERATURE REVIEW

In a comparative study on PM, in a smelting industry done for the fuels such as wood biomass and brown coal, the stack emission monitoring by thermo-gravimetric analyser showed that the

particulates from the coal stacks were more than that of the bio-mass stack (Nikola Kantova, 2017). In the above study connected to the biomass plant, fuels used for the biomass ignition were wood chip and coal. In another report, it is stated that the PM concentration, monitored from the stack assembly, showed a higher value for the coal fired stack when compared to the wood burned stack. Report on the Environment by EPA with respect to particulate matter mentions the emission data are made mostly based on theoretical models only and not by actual measurements. For most industrial sources and fuel combustion sources, the estimations are done using the emission factors provided by the state, local and tribal air quality management agencies.

Nikola Kantova *et al*. compared particulate matter properties in combustion of wood biomass and brown coal (Nikola Kantova *et al*. 2017). PM from Wood biomass has the form of fibres, rods or needles and where as PM from brown coal has the form close to sphere or a cube. Bing Pei *et al*. stated that there is an urgent need to establish source profiles to reduce PM source apportionment uncertainties in China as observed by Zheng *et al*., 2013. This information is critical for PM prevention and control and for ambient air quality compliance (MEP 2013b).

The objectives of the research are set as follows

- Selection of suitable industry area based on fuel used.
- Identifying the stack located within the Industry.
- To study on the stack characteristics for iso-kinetic sampling.
- Sampling the stack emissions by using Stack Monitoring Kit.
- Interpretation of results.

MATERIALS AND METHODS

The industry considered for the study was rice mills. The research work was carried out for the boilers operated using bio mass fuel "Husk" of capacity 10t, 8t and 5t. The emissions were measured as prescribed in IS: 11255 (Part 1), standard operating procedure for Total particulate matter (PM). For coarse particulate matter (PM 10) and fine particulate matter (PM 2.5), Sampling procedure was carried out as per EPA Method 201 and 201Ain the measurement of stack monitoring was "Sampling train". Stack velocitykit, Envirotech Make, APM – 602was used for determining the stack velocity. For iso-kinetic sampling of particulate matter Stack monitoring kit, Envirotech make, APM – 620 was used. Total particulate matter was collected in micro glass fibre thimble. Standard equipment used with filter holder after PM10 and PM2.5 Cyclones was used for sampling PM 10 and PM 2.5. Sampling Kit and all accessories were physically carried up to the stack and positioned on the platform adjacent to the port hole provided for the purpose of stack emission monitoring where the laminar flow was available. Suitable nozzle was selected as per the iso-kinetic sampling requirement. Flue gases enter the system through the nozzle at the tip and then pass through the filter where suspended particulate matter (PM) gets collected. From the filter, gas stream passes through the cold box section, where the flue gases cool down, releasing any condensable moisture present in the gas. Relatively clean then passes through a condenser followed by silica gel, to rota meter for adjusting the flow rate of particulate matter. Sampling time was adjusted as per requirement. As per the methodology and standard procedures, the flue gas emissions were obtained for the various boilers stacks.

RESULTS AND DISCUSSION

Study was carried out on three boilers located in three different Rice mills. Details of the boiler specifications and operating conditions during the test period were given in Table 1.

Table 1. Stack Specifications and Operating Conditions of Boilers during the Test Period

Particulars	Boiler -1	Boiler -2	Boiler - 3
Stack Height (m)	30.0	30.0	30.0
Stack Diameter (m)	0.85	0.85	0.85
Capacity of Boiler	10t	8t	5t
Purpose	Steam Generation	Steam Generation	Steam Generation
Fuel	HUSK	HUSK	HUSK
Fuel Feed Rate(Kg/Hr)	3000 Kg/Hr	2400 Kg/Hr	1500 Kg/Hr
Air Pollution Control Device	Yes	No	Yes

The boiler was used for steam generation. The fuel used was husk. The feed rate of husk depends on the capacity of the boiler. The boiler capacity was 10t, 8t and 5t respectively. The boiler 1(10 t) and 3 (5 t) were fitted with Air pollution Control Device (APCD). The boiler 2 (8 t) was not provided with APCD.As detailed in the methodology adopted, sampling of flue gas was carried for PM, PM10 and PM2.5. The results obtained were given in Table 2, 3 and 4. Graphical representation of results is given in Fig. 1, 2 and 3.

From the Table 2, PM emitted from the Boiler 1 was varied from 93.9 mg/Nm^3 to 110.54 mg/Nm^3, while PM10 varied from 40.74 mg/Nm^3 to 46.78 mg/Nm^3 and PM2.5 12.18 mg/Nm^3 to 14.11 mg/Nm^3. From the Table 3, PM emitted from the Boiler 2 was varied from 234.75 mg/Nm^3 to 317.87 mg/Nm^3, while PM10 varied from 68.22 mg/Nm^3 to 72.84 mg/Nm^3 and PM2.5 varied from 25.62 mg/Nm^3 to 31.56 mg/Nm^3. From the Table 4, PM emitted from the Boiler 3 was varied from 88.52 mg/Nm^3 to 102.3 mg/Nm^3, while PM10 varied from 35.64 mg/Nm^3 to 47.14 mg/Nm^3 and PM2.5 varied from 12.92 mg/Nm^3 to 15.18 mg/Nm^3. Table

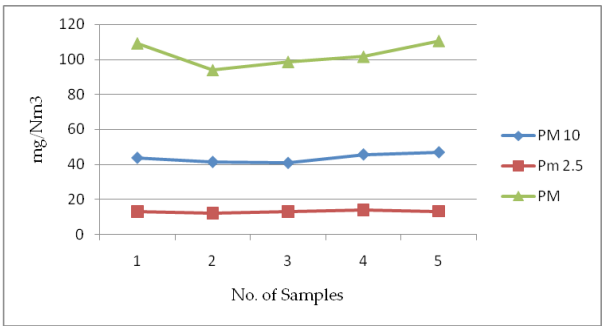

Fig. 1. Variaton of PM10, PM 2.5 and PM for Boiler 1.

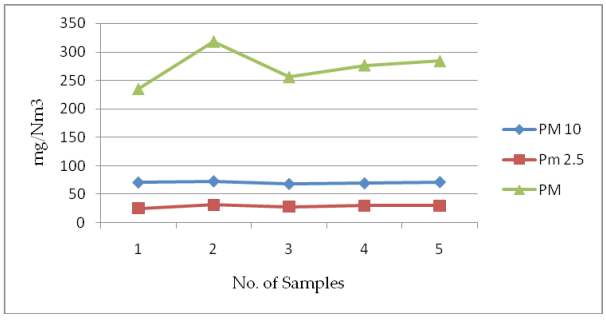

Fig. 2. Comparision of PM10, PM 2.5 and PM for Boiler 2

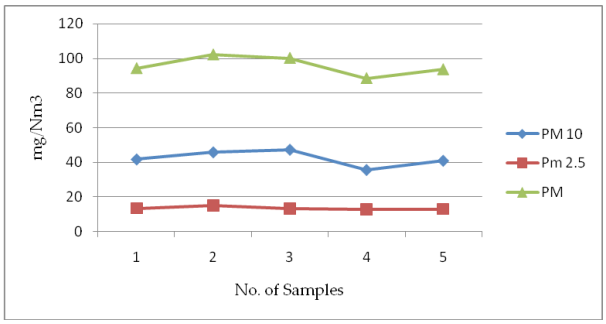

Fig. 3. Comparision of PM10, PM 2.5 and PM for Boiler 3.

Table 2. Results of Boiler 1

Capacity – 10t. Fuel: Husk Feed Rate: 3000Kg/Hr.

Sl.No	Parameter	Results				
1	Temperature °C	122	125	116	123	127
2	Temperature °K	395	398	389	396	400
3	Velocity m/s	8.94	8.3	8.82	8.62	8.27
4	Gas Discharge Nm^3/Hr	13784	12700	13809	13242	12592
5	PM 10 mg/Nm^3	43.64	41.28	40.74	45.55	46.78
6	Pm 2.5 mg/Nm^3	13.14	12.18	12.98	14.11	13.36
7	PM mg/Nm^3	109.17	93.9	98.58	101.53	110.54

Table 3. Results of Boiler 2

Capacity – 8t. Fuel: Husk Feed Rate: 2400Kg/Hr.

Sl. No	Parameter	Results				
1	Temperature °C	97	100	95	98	101
2	Temperature °K	370	373	368	371	374
3	Velocity m/s	8	8.68	8.02	8.34	8.08
4	Gas Discharge Nm^3/Hr	13168	14172	13273	13691	13157
5	PM 10 mg/Nm^3	70.8	72.84	68.22	69.38	71.44
6	Pm 2.5 mg/Nm^3	25.62	31.56	28.51	30.57	29.88
7	PM mg/Nm^3	234.75	317.87	255.64	276.31	283.44

Table 4. Results of Boiler 3
Capacity – 5t. Fuel: Husk Feed Rate: 1500Kg/Hr.

Sl.No	Parameter	Results				
1	Temperature ^oC	106	96	118	103	130
2	Temperature ^oK	379	369	391	376	403
3	Velocity m/s	7.4	6.93	8.89	7.32	8.74
4	Gas Discharge Nm^3/Hr	11891	11437	13847	11856	13208
5	PM 10 mg/Nm^3	41.64	45.68	47.14	35.64	40.86
6	Pm 2.5 mg/Nm^3	13.58	15.18	13.43	12.92	13.14
7	PM mg/Nm^3	94.3	102.3	100.27	88.52	93.68

Table 5. Rate of particulate matter emission per kg of Husk burned

Particulars	Boiler 1With APCD	Boiler 2Without APCD	Boiler 3With APCD
Husk Feed Rate Kg/hr	125	100	62.5
Gas Discharge Nm^3/Hr*	13225	13492	12447
PM 10 mg/Nm^3*	43.6	70.54	42.19
PM 2.5 mg/Nm^3*	13.15	29.23	13.65
PM mg/Nm^3*	102.74	273.6	95.81
PM 10 gm/hr	577	952	525
PM 2.5 g/hr	174	394	170
PM g/hr	1359	3691	1193
PM 10 g/kg of Husk	4.6	9.5	8.4
PM 2.5 g/kg of Husk	1.4	3.9	2.7
PM g/kg of Husk	10.9	36.9	19.1

*Results given in the table are average of concentration of samples collected

5 gives particulate matter released to the ambient air per kg of husk burned. It can be seen that PM released from Boiler 1 was varied from 10.90 g per kg of husk burned while PM10 4.6 g per kg of husk burned and PM2.5 1.4 g per kg of husk burned. Particulate matter released from Boiler 2 is 36.9 g per kg of husk burned while PM10 9.5 g per kg of husk burned and PM2.5 3.9 g per kg of husk burned. Particulate matter released from Boiler 3 was 19.1 g per kg of husk burned while PM108.4 g per kg of husk burned and PM2.52.7 g per kg of husk burned. From the Fig. 1, 2 and 3, boiler 1 and 3 provided with APCD, it was observed that PM emitted was less compared to the boiler 2 which not provided with APCD.

CONCLUSION

Stack emission studies were carried out on the boilers operated in rice mills. These boilers were used for steam generation using husk as fuel. Out of the three boilers studied two boilers were fitted with APCD (Boiler 1 and 3). The boilers having APCD on an average emitted PM 102.74 mg/Nm^3 in Boiler 1 and 95.81 mg/Nm^3 in Boiler 3 and 10.9 and 19.1 gm/kg of husk burned respectively. Whereas without APCD in Boiler 2, PM emitted 273.6 mg/Nm^3 and 36.9 g per kg of husk burned. The removal efficiency of PM10 and PM2.5was not high compared to PM in boilers provided with APCD also.

REFERENCES

Wang, A.O., Qiang Song, GongmingTu, Hui wang, Yong Yue and Qiang Yao, 2014. Influence of flue gas cleaning system on characteristics of PM2.5 emission from coal-fired power plants. *Int. Journal Coal Sci. Technology*. 1 (1) : 4-12.

Bing Pei, Xialongwang, Yihua Zhang, Ming Hu, Yanjing Sun, Ji Deng, Li Dong, Qingyan Fu, Naiqiang Yan. 2016. Emissions and source profiles of PM2.5 for coal-fires boilers in the Shangai megacity, China. *Atmospheric Pollution Research.* 1-8.

IS 11255 (Part 1): 1985. Methods for Measurement of Emission from Stationary Sources, Part 1,2,7.

Rukmini., Nadjamuddinharun., Sak Tiadji Adisasmita and Ganding Sitepu, 2014. Estimated emissions form Diesel Generators of Containercranes at Makassar container Terminal. *International Journal of Mechanical and Production Engineering.* 2 : 20-25.

MEP, 2013b, Technical Policy on the Comprehensive

Prevention and Control of Atmospheric Fine Particulate Matter Pollutuion, Ministry of Environmental Protection of the People's Republic of China.

Nikola Kantova, Michel Holubcik, Jozef Jandacka and Alexander Caja, 2017. Comparison of particulate matters from combustion of wood biomass and brown coal. *Procedia Engineering.* 192 : 416-420.

Yadav, J.P. and Bharat Raj Singh, 2011. Study on Comparison of Boiler Efficiency Using Husk andCoal as Fuel in Rice Mill, S-JPSET: ISSN: 2229-7111, 2(2).

Win Lee, S., Herage, T., He, I. and Young, B. 2008. Particulate Characteristics data for the management of PM2.5 emissions form stationary combustion Sources. *Science Direct, Powder Technology.* 180: 145-150.

Win Lee, S., He, I. and Young, B. 2004. Important aspects in source PM2.5 emissions measurement and characterization from stationary combustion systems. *Fuel Processing Technology.* 85 : 687-699.

Zizhen Ma, Jingkun Jiang, Zhen Li and Shuxiao Wang, 2017. PM2.5 Emission Reduction by Technical Improvement in a Typical Coal-Fired Power plant in China. *Aerosol and Air Quality Research.* 17 : 636-643.