Studies on development of online measurement of $PM_{2.5}$ and PM_{10} releasing from industrial flue gas stack

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Abstract*: *The industrial area is facing the problem of deteriorate ambient air quality due to excessive industrial pollution. Exposure to air borne fine particular matter is a major threat to human health. National ambient air quality standards for $PM_{2.5}$ and PM_{10} are 100μg/m^3 and 80μg/m3 respectively in ambient air. At preset statutory norms are available for measurement of particular matter in stack only due to unavailability of $PM_{2.5}$ and PM_{10} measurement techniques. The current study focuses on the development of online method for continued measurement of $PM_{2.5}$ and PM_{10}.

***Keywords*: online measurement method, $PM_{2.5}$ and PM_{10}**

(Article history: Received: 6 th February 2021 and accepted 20 th March 2021)

I. Introduction

India's coal consumption reported at 1.04 thousand tonnes and likely to grow at a compound annual growth rate (CAGR) of 5.4 % to reach 1076 million tonnes in 2022-23. Moderate statistically significant Association exists between the occurrence of adverse health effects in its active duty population and ambient particulate matter levels [1], [2]. Due to increase in Coal Consumption the air quality gets deteriorated [3]. At present $PM_{2.5}$ and PM_{10} measurement techniques are available for ambient air monitoring [1].

Potential health issues are directly linked with the size of particulate matter. Fine particle ($PM_{2.5}$) leads to the serious health hazard as fine particles can get penetrated into lungs and even into bloodstream. Exposer to these particles can affect lungs, and heart whereas coarse particles ($PM_{2.5-10}$) are of less risky, although they can irritate eyes nose and throat which ultimately leads to risks associated with asthma, lung cancer, heart disease, including premature death[4].

As per comprehensive environmental pollution index (CEPI) issued by central pollution control board in 2016 are more than 40 industrial cluster in 16 states are identified as critically polluted industrial clusters. One of the parameters to calculate CEPI are concentration of $PM_{2.5}$ and PM_{10} in ambient air[5].

Though stationary sources are the major contributor of Particulate matter in ambient air[6]. Existing regulation for stationary sources is based on concentration of particulate matter only. Due to lack of measurement techniques for $PM_{2.5}$ and PM_{10} in stack.

Based on the light scattering and particle absorbance theories, portable and direct reading of $PM_{2.5}$ and PM_{10} is done[7]. The study focusses on the development of an online method for the measurement of $PM_{2.5}$ and PM_{10} and comparing the results with filter based gravimetric method (USEPA), regarded as reference standard method[7].

The advantage of online instrument is to minimize the error identified in the FBC Boiler with air pollution control equipment. The particulate removal efficiency depends on the particle size of particles in the existing equipment cyclone separator followed by Electro static Precipitator to remove the larger particles. The sampling is carried out with online measuring device. It is required to study the particle size which is emitted from the boiler stack[8][9][10][11].

The aim of the present study is to develop online method to measure $PM_{2.5}$ and PM_{10} released from stationary sources to obtain real time data.

II. Materials and methods

The present study is focused on the measurement of $PM_{2.5}$ and PM_{10} released from coal fired fluidised bed combustion type boiler (10 TPH). Imported coal was used as a fuel.

Pulverized imported coal (240, 260 and 280 kg/h) from a Conveyer belt and carried by transport air through a fuel injector into the boiler.

This existing facility, operated with 3 TPH of steam (coal feed rate 240 TPH), is equipped with multi cyclone separator followed by electrostatic precipitator and Induced draft fan. Data presented in this study were collected from sampling location of stack.

Stack measurements were carried out at isokinetic conditions according to the specified in IS standard IS: 11255 (Part 1) - 1985 (Reaffirmed 1995).

All process parameters were observed and measured parameters were documented.

A. USEPA method,

To measure concentration of PM_{10} and $PM_{2.5}$, sample of gas at a set constant flowrate. These particulate matters were passed through particle sizing device which is used to separate particles based on nominal diameters of 10 µm and 2.5 µm. To measure $PM_{2.5}$, $PM_{2.5}$ cyclone was attached downstream of the PM_{10} cyclone. Conventional five-stage cascade cyclone train including $PM_{2.5}$ and PM_{10} cyclones were utilized to measure particulate matter. To minimize the variations, isokinetic sampling condition should be maintained in well-defined limits. The gravimetric analysis was performed to determine the mass of each size fraction after removing uncombined water from the collected sample. To measure PM_{10} and $PM_{2.5}$, $PM_{2.5}$ cyclone was added between the PM_{10} cyclone and the stack temperature filter in the sampling train. supplements the measurement of PM_{10} with the measurement of $PM_{2.5}$.

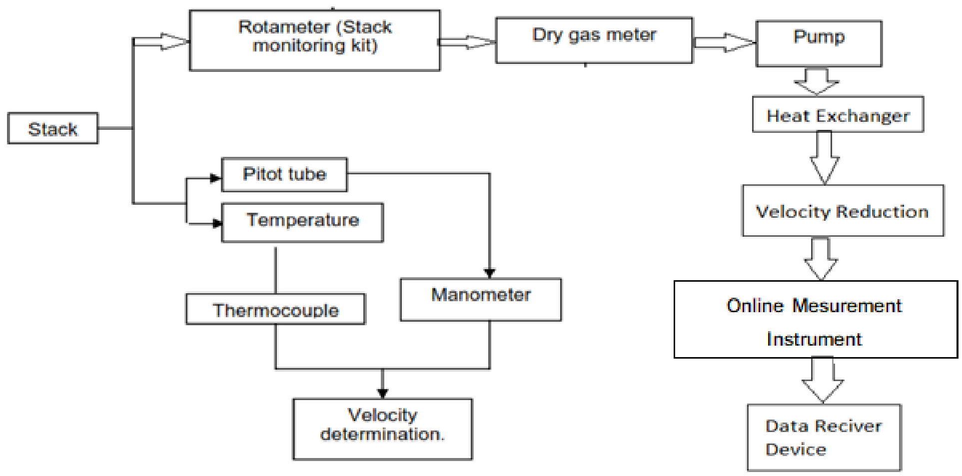

Figure 1 Sampling train of Online Measurement

B. Online Method

Figure 1 Shows the Sampling train for Online measurement of $PM_{2.5}$ and PM_{10}. Stack monitoring was carried out at isokinetic conditions for sampling as per IS Standard. The Flue gas temperature as well as the velocity needs to be reduced in order to pass in Online measurement device. The device data receiver shows the continuous data i.e. the concentration of $PM_{2.5}$ and PM_{10}.

Online Measurement device provides the data in one-minute interval continuously. The device accuracy is ± 0.01%.

C. Laser based instruments Overview

LDM-100 adopts reflecting style design, making all the photoelectric parts (sensors, laser) being the same environment temperature and rising the stability when rising measuring optical length and sensitivity.

D. Measurement Principle:

LDM-100 adopts Laser Transmission Method to measure the dust concentration. Figure 1 Shows the basic principle using diode laser as the lamp- house. After passing the detected laser beams through the spectroscope, the reflected light is detected by the detector and forms referenced signals. Transmission light shines to the reflecting material through the measured environment with dust. After the reflected light traverses the measured environment again, it is detected by detector and forms measuring signals. According to the contrast of referenced signals and measuring signals, transmittance information caused by dust is obtained.

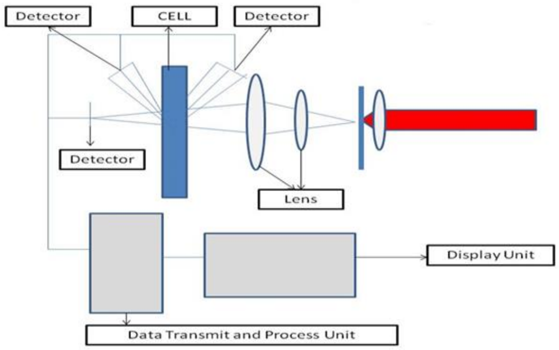

Figure 2 Laser Scattering Mechanism Diagram

III. Result and discussion

Figure 3 shows the concentration of $PM_{2.5}$ and PM_{10} at different observation at 240kg/hr coal feed rate as per USEPA 201 method. The results of $PM_{2.5}$ in the range of 8.3 to 8.43 mg/Nm^3 and the average is 8.38 mg/Nm^3 and PM_{10} in the range of 10.56 to 11.36 mg/Nm^3 and the average is 10.83 mg/Nm^3

In the case of online measurement from the figure 4 the concentration of $PM_{2.5}$ and PM_{10} were observed at 240kg/hr coal feed rate. The average result of $PM_{2.5}$ was 12.29 mg/Nm^3 and the average result was 13.98 mg/Nm^3 for PM_{10}

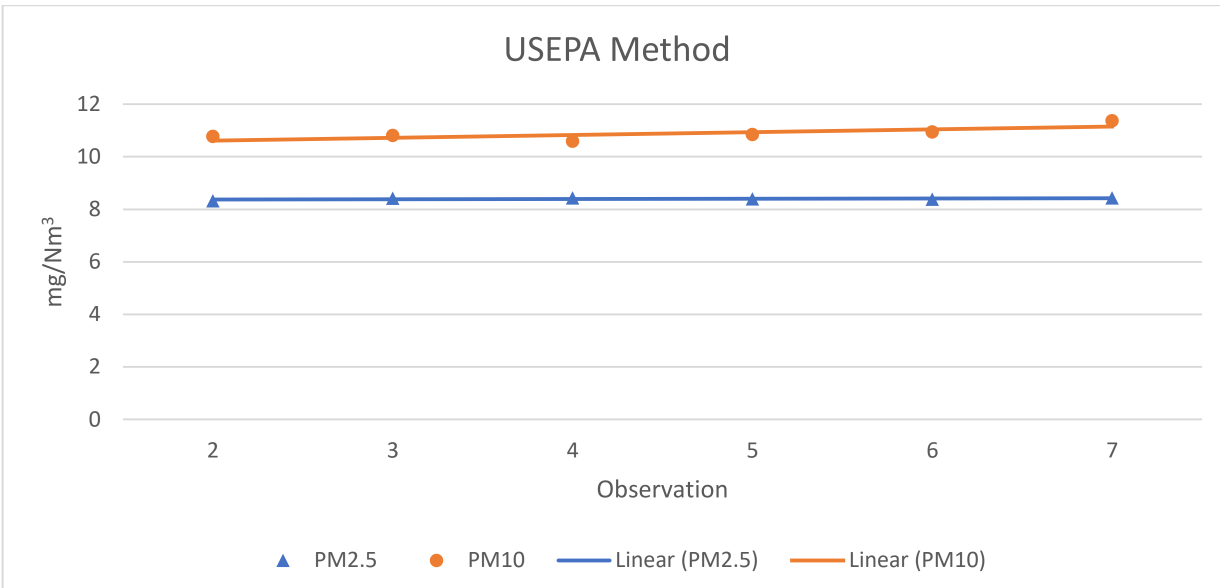

Figure 3 $PM_{2.5}$ and PM_{10} Vs Observation at 240 Kg/hr. coal feed rate for USEPA method

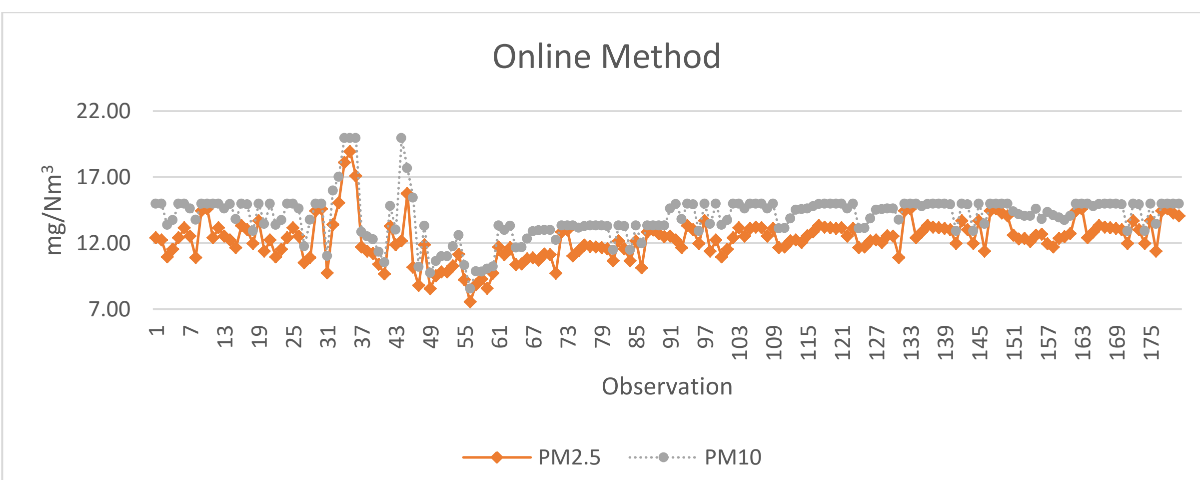

Figure 4 $PM_{2.5}$ and PM_{10} Vs Observation at 240 Kg/hr. coal feed rate for Online Method

Figure 5 shows the comparison of concentration of $PM_{2.5}$ at 240kg/hr coal feed rate as measured by USEPA and Online Method. In Online method the average concentration of $PM_{2.5}$ is 12.23 mg/Nm^3 and the average concentration of $PM_{2.5}$ is 8.38 by USEPA method.

Figure 6 shows the comparison of concentration of PM_{10} at 240kg/hr coal feed rate as measured by USEPA and Online Method. In Online method the average concentration of PM_{10} was 13.88 mg/Nm^3 and the average concentration of PM_{10} was 10.83 by USEPA method.

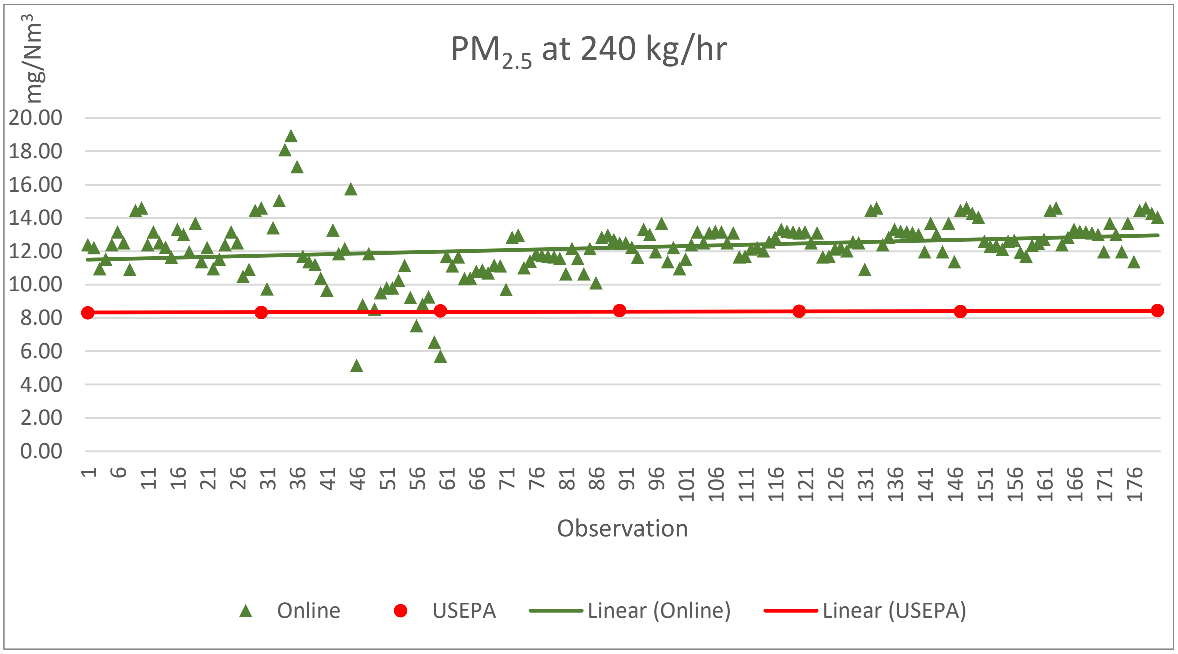

Figure 5 $PM_{2.5}$ Vs Observation at 240 Kg/hr. coal feed rate for USEPA and Online method

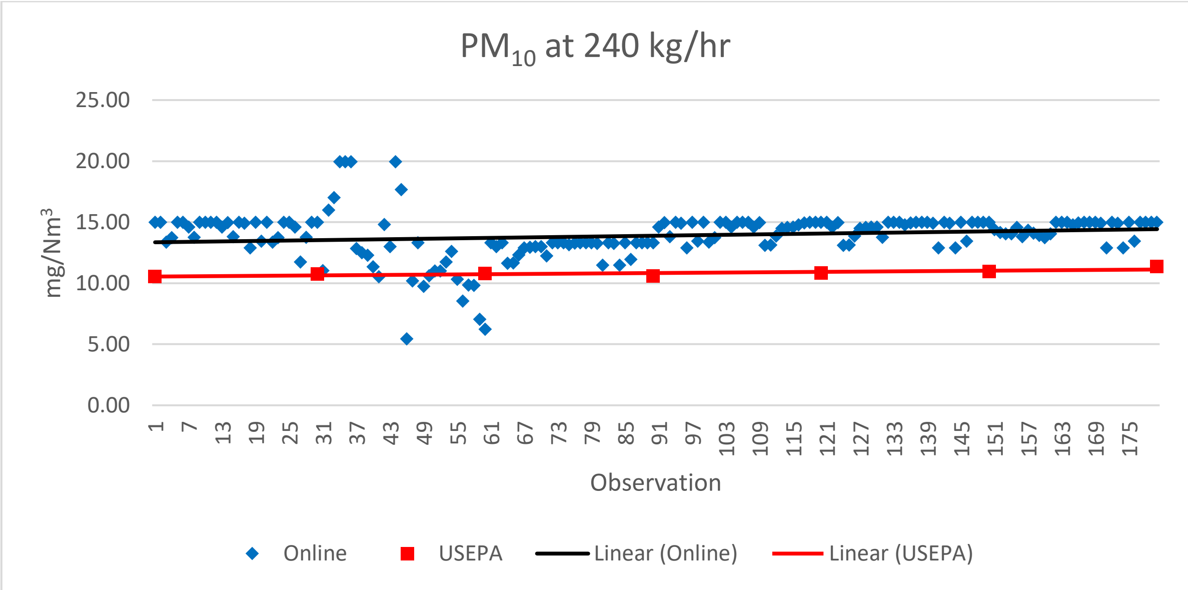

Figure 6 PM_{10} Vs Observation at 240 Kg/hr. coal feed rate for USEPA and Online method

IV.CONCLUSION

The result obtained using online measurements are comparatively higher but consistent in nature. As compared to USEPA method, $PM_{2.5}$ and PM_{10} concentration are found to be higher may be due to variation in the relative humidity as well as the temperature. The small variation in online measurement may be due variation in coal feed rate at particular time interval. The average concentration of $PM_{2.5}$ obtained using Online measurement is higher than values obtain via USEPA method. Similarly, in case of $PM_{10,}$ concentration is higher as compared to USEPA method. Therefore, the study proves to be consistent in results and need further finetuning for obtaining accurate results. However, the measurement of particles is often affected by water vapor or droplets in air which can be assessed by measuring relative humidity (RH). Other factors include particle size distribution, particle morphology and chemical constituents also influence the measurement of $PM_{2.5}$ and PM_{10}. Further, more research work can be done by the variation of factors affecting the online method of measurement.

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