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STACK EMISSION INVESTIGATIONS IN THE PERFORMANCE OF "HIGH SPEED DIESEL GENERATORS OF VARIOUS CAPACITIES"

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ABSTRACT

Chennai, the Capital city of Tamil Nadu located at the southern part of India has a floating population of about 1.3 crore as on 2019 census. Chennai has the highest level of air pollution due to vehicular movements and various industrial activities The major Industrial areas in Chennai are classified in to Thiruvottiyur Industrial Area, Manali Industrial Area and Ambattur Industrial Area. These industries produce the continuous emissions which is been discharged in to the environment. The emissions coming out from the industries are discharged only through the stacks. Thus, the stacks serve as the interconnecting source between the Industry and the Environment. The current study involves the stack emission monitoring for the printing and packaging industry located in the Thiruvottiyur area. For this purpose, stack emission studies from 5 generators of various capacities, employing High Speed Diesel (HSD) were undertaken. The stack emission monitoring was carried out as per IS: 11255 (Part 1) – 1985. Stack monitoring kit was engaged in the stack monitoring analysis. The parameters considered for the study are particulate matters, oxides of Sulphur, oxides of Nitrogen. From the results it is been observed that the particulates coming out from the stack were all within the CPCB norms, whereas the emissions coming out from the stack of capacity 750 KVA DG SET 1 was very high due to the operation of older engine. Some of the pollution control measures were also suggested for the control of the problems associated with such emissions.

KEY WORDS : Air pollution, DG gen sets, Stack monitoring, High speed diesel, Stack monitoring kit, and stack emissions

INTRODUCTION

Chennai, is one of the Metropolitan cities located in the southern part of India. Chennai has the highest range of population of about 1.6 million according to 2019 census conducted by Chennai Corporation. And also, Chennai area is categorized in to various forms of zones such as the Industrial zone, Commercial zone, Institutional zone, Residential zone and the Silent zone. Urbanisation and the Industrial activities that happens, especially with in the city has led to a major change in the air quality of Chennai.Vehicular emissions also equally contributes the impact towards the atmospheric environment. In effect vehicular emissions and the Industrial Emissions are key issues that needs to be immediately addressed. Major Industries in Chennai City lies in the northern belt covered by the areas like Thiruvottiyur, Manali, Minjur and the Ennore. The heavy Industries located at these areas includes Rubber tyre Industry, Ennore Port, Rubber Manufacturing, Fertilizer Manufacturing, Petrol Processing, Port/Harbour, printing and packaging industry, Food processing industry and the thermal power plant (Karuppiah *et al*., 2019). All the above mentioned industries lies in Thiruvottiyur and the Manali Industrial Area. All these industries possessing huge and heavy stacks and emits continuously, the gases and the particulates in to the Ambient environment. These stack act as a connecting bridge between the industrial emissions and the atmospheric pollution (Rukmini *et al.*, 2014).

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The emissions coming out from the stacks were broadly classified in to particulate matters, Oxides of sulphur, oxides of nitrates, Carbon monoxide, ammonia, volatile organic compounds etc (Karthick 2019; Duckshin *et al.,* 2015). Most of the stacks been connected with generators using various forms of fuels. The fuels normally used for the stack operations are High Speed diesel (HSD), Furnace oil, Super kerosene (SKO), coal and gasoline (Karthick, 2019). Among these fuels, the commonly used fuel in DG is found to be High Speed petrol. Especially in food based companies, combustion process is carried out with the help of solid form of fuel namely, coal and coke. The major emission coming out from the stack was found to be the higher concentrations of PM_{10} when compare to the other gaseous emissions (Alex *et al.,* 2019, Daichi Takeuchi *et al.,* 2016). The emission studies which was carried out on two backup generators of varying in capacity. The results shows that the emissions ($SO_{x,}$ NO_x, CO, VOC_s) coming from the higher capacity stacks are much larger when compared to the lower capacity stacks (Jacquelyn Hurrya *et al.,* 2016; Farrukh Afaq Qasmi *et al.,* 2011). In iron Smelting industries the combustion process is done with the solid as well as the liquid forms of the fuel. The results show that the higher capacity liquid form of fuel produce the higher level of Nitrogen Emissions, which if very toxic to the human health and produce lots of respiratory disorders (Vicente *et al.,* 2018). Some emission studies pertaining to the stacks operated with the natural gas were also done and here natural gas coupled with hydrogen were used as the fuel (Feng Zhu *et al.,* 2018). The stack emission estimation shows that the concentration of CO_2 and CH_4 were very high in case of the emission produced by the natural gas stream coupled with the Hydrogen fuel (Xinyu Li *et al.,* 2019; Gasik *et al.,* 2017). Under Certain circumstances direct measurements were made to certain DG exhaust gen sets, especially meant to measure the gaseous emissions and the result shows that the fully loaded gen sets emits less when compared to the half loading (Andres Colorado *et al.,* 2016, Kok and Oanh, 2018). In case of Bio fuels, the emission conditions are Vice-versa, the concentration of the emitted organic gases are high when compared to the Concentration of the emitted inorganic gases (Nikola Kantováa *et al.,* 2017; Yongjin Jung *et al.,* 2016; Olave, 2017). The effect of particulate matters and the sulphur content by varying the various loads of the DG gen sets were also performed. From the results, it is inferred that the variation in the loading shows the fluctuations in the emissions and the particulate results (Phirun Saiyasitpanich *et al.,* 2005; Vicente *et al.,* 2018; Tiffany *et al.,* 2018). The study area selected for the research was Thiruvottiyur Industrial Area. Thiruvottiyur is located at the North madras and administrated by the Greater Chennai Corporation. The geographical location of Thiruvottiyur was 13.16°N 80.3°E and located at the shores of Bay of Bengal.

Based on the literature reviewed, the objectives of the research are set as follows

- Selection of suitable industry from Thiruvottiyur area.
- Identifying the stacks located within the Industry.
- To study on the stack characteristics, the stack specifications and the fuel used.
- Estimating the stack emission concentrations by using Stack Monitoring Kit.
- Interpretation of results.

MATERIALS AND METHODS

The industry considered for the study was printing and packaging industry. The research work was carried out for the diesel stack generators of capacity 750 KVA, 1010 KVA, 1500 KVA and 2000KVA. All the DG generator sets are operated with High speed diesel (HSD) as the fuel at various loading conditions. The emissions were measured as prescribed in IS: 11255 standard operating procedure. The sampling procedure was carried out as per IS: 11255 (Part 1) – 1985. The device engaged in the measurement of stack monitoring was "Sampling train". The parameters considered for the stack monitoring are Particulate Matters, Oxides of Sulphur and Oxides of Nitrogen.

As per the IS11255, Part 2 Measurement of SO_x was given by the formula (IS 11255 1985).

$$C = 0.032 \times \frac{(V - V_b)}{V_N} \times N \times \frac{V_{s0}}{V_a}$$

Where

V = volume of the sample, mL.

V_b= volume of barium perchlorate titrant used for blank, ml

N = normality of the titrate, g-eq/L

V_{s0} = total solution volume of sulphur dioxide, ml

V_a = volume of sample aliquot titrated, mL

V_N = volume of gas sampled through the dry gas meter (normal conditions), $m^{3.}$

As per IS 11255, part 7, Measurement of NO_x(IS 11255 1985).

was given by

$$C = \frac{(A_s - A_b)}{V_{sc}} \times K_c \times 1000 \times 2 \times F$$

Where

A_s = absorbance of the given sample

A_b = absorbance of the blank

C = concentration of NO_X as NO_2, corrected to standard conditions, $mg/Nm^{3.}$

F = dilution factor (that is, 25/5, 25/10, etc)

K_C = spectrophotometer calibration factor; and 2 = 50/25 the aliquot factor.

All the stack emissions were measured using standard stack monitoring Ki Envirotech, APM – 620 & APM – 602. This instrument is ideally suited for determining the various parameters of gaseous emissions from sources like chimney, stacks, Flues etc. Sampling Kit and all accessories were physically carried up to the stack and positioned above ground level on the platform adjacent to the duct / port provided for the purpose of stack emission measurement. Flue gases enter the system through the nozzle at the tip of the thimble probe and then pass through the filter thimble where suspended particulate matter (SPM) gets eliminated. From the filter, gas flows to the impinger module where the gas stream is split into two sections. One section passes at a low rate (0.5 – 3 lpm) through a series of impingers loaded with absorbing solutions for absorbing of SO_x and NOx. The remaining portion of the gas steam passes through a condenser followed by silica gel, for determining the flow rate of particulate matter. On passing through the cold box section, the flue gases cool down, releasing any condensable moisture present in the gas. Relatively clean then pass through the flow meter and dry gas meter in the control module where the volume of gas samples is measured and finally is exhausted into the atmosphere through the vacuum pump. As per the methodology and standard procedures, the flue gas emissions were obtained for the various KVA Diesel Generator stacks.

RESULTS AND DISCUSSION

The stack monitoring related to the printing and packaging industry was conducted to about 5 DG sets of varying capacity. The stack monitoring was done on hourly basis exactly during the peak flow of the plume discharge. The type, specifications, fuel used and the loading rate of all the DG sets considered in the study is mentioned in the Table 1. The fuel specifications which includes the percentage of sulphur, calorific value and the Ash content are mentioned in the Table 2. The stack parameters which are considered for the studies are stack height, stack diameter, stack velocity, stack temperature and the stack floe rate. All the above mentioned parameters are explained in brief in Table 3. The stack Emissions considered for the study are Particulate Matters, Oxides of Sulphur (SO_x) and oxides of Nitrogen (NO_x). The outcome of the Stack Monitoring results is briefed in Table 4. The comparison on the outcomes of the stack emissions from DC gen sets was explained in brief in Figure 1 to Figure 3. From the stack emission results, it has been observed that the value of particulate matter varies from 55.81 mg/m^3 to 97.65 mg/m^3, whereas the concentration of Oxides of Sulphur ranges between 13.52 mg/m^3 to 27.03 mg/m^3 and the concentration of oxides of nitrogen between 8.56 mg/m^3 to 11.08 mg/m^3. The particulate matters emitted from all the DG stacks are within the range of CPCB limit of about 150 mg/

Table 2. Characteristics of Fuel Used

Fuel Characteristics	
Fuel used	HSD
Sulphur (%)	0.15
Ash (%)	0.01
Calorific value	10700 Kcal/Kg

Table 1. Operating Conditions of Diesel Generator during the Test Period

DG sets	DG Set 1	DG Set 2	DG Set 3	DG Set 4	DG Set 5
Generator Capacity	2000 KVA	2000 KVA	1010 KVA	750 KVA	750 KVA
Purpose	Power Supply	Power Supply	Power supply	Power Supply	Power Supply
Operating load (KW)	172	172	146	137	137
Fuel	HSD	HSD	HSD	HSD	HSD
Fuel Feed Rate(L/Hr)	300	300	200	110	110

Table 3. Stack Specifications

Parameters	Results				
	2000 KVA DG Set 1	2000 KVA DG Set 2	1010 KVA DG Set	750 KVA DG Set 1	750 KVA DG Set 2
Stack Height (m)	30.5	30.5	12.80	10.30	11.30
Stack Diameter (m)	0.8	0.8	0.20	0.20	0.20
Temperature (^oC/K)	276/549	298/571	345/618	396/669	356/629
Velocity (m/s)	8.90	9.94	18.89	19.74	20.44
Gas Discharge (Nm^3/Hr)	8745	9391	1610	1035	1096

Table 4. Stack Monitoring Results

Stack Parameters	Results				
	2000 KVA DG Set 1	2000 KVA DG Set 2	1010 KVA DG Set	750 KVA DG Set 1	750 KVA DG Set 2
Particulate matter (mg/Nm^3)	55.81	62.70	79.60	97.65	87.65
Oxides of Sulphur (mg/Nm^3)	13.52	21.40	13.52	27.03	18.02
Oxides of Nitrogen (mg/Nm^3)	8.56	10.22	11.08	10.73	10.53

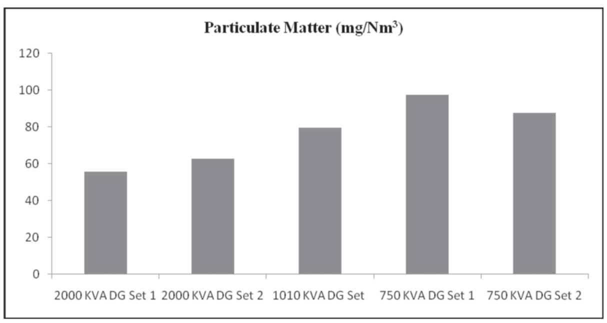

Fig. 1. Comparision of Stack Emissions (Particulate Matters)

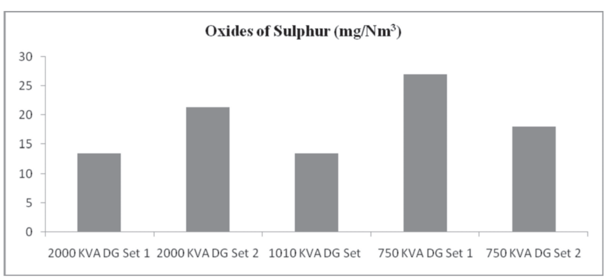

Fig. 2. Comparision of Stack Emissions (SO_x)

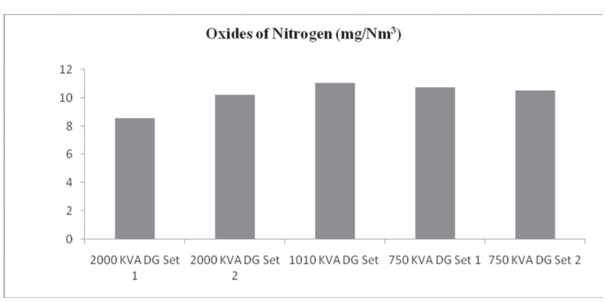

Fig. 3. Comparision of Stack Emissions (NO_x)

m^3. Whereas the level of $SO_x$and NO_xwhich is coming out from the 750 KVA DG set 1 was found to be very high, when compared with the other stacks. This is because of the engine motor related to the particular stack seems to be very old when compared to the other DG gen stacks. As a result the 750 KVA DG set 1 produce higher amount of heat of around 670 degree Kelvin and results in higher amount of generation of gaseous emissions. As a part of mitigation measures to overcome the significant impact, replacement of Engine of the respective stack was suggested to overcome the issue.

CONCLUSION

Stack emission studies were carried out for the DG gen sets operated with High Speed Diesel as a fuel in a printing and packaging industryIndustry located a Thiruvottiyur, Chennai. The total number of DG gen stacks considered for the studies are 5 of varying in capacity. The stack monitoring was carried out as per IS: 11255 (Part 1) – 1985. The parameters considered for the studies are PM, SO_x and NO_x. The results of the stack monitoring reveals that the Particulate matter emissions are within the CPCB standards whereas the emissions coming from the 750 KVA DG set 1 was found to be very high due to the usage of old engine in that respective DG gen. This produces higher temperature and increases the gaseous emissions drastically when compared to the other DG Den stacks. Some of the Pollution prevention methodology like Equipment modification (Replacement of old engine with new one) was suggested to overcome the Impact.

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