PERFORMANCE EFFICIENCY OF WET SCRUBBER IN INDUCTION FURNACE TOWARDS GREEN REVOLUTION- A CASE STUDY IN INDIAN FOUNDRY

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Received November 25, 2011 *Accepted March 5, 2012*

ABSTRACT

Samples of dust emissions were collected from induction furnace using wet scrubbers in small, medium and large scale foundries in Coimbatore from march 2010 to Feb. 2011. These samples were collected using stack monitoring kit APM 621.The emission fraction was measured by the Barium Thorium Titration Method which was designed to cover high concentration factor through the minimum value recommended of 1 ppm, this method gives the better result at higher concentration .Additionally the emission factor were calculated for various flow rate of flue gas and comparative performance characteristics curves were analyzed.

Key Words : Induction furnace, Wet scrubber, Emission, Foundry, Stack monitoring

INTRODUCTION

The foundry sectors is a crucial components of a Indian economy with strategic importance and the play major role the recycling of metals and reshape them into product through pouring and solidification of molten materials. The main market several by the foundry industry are the automotive(50% of market share, general engineering 30% and construction 10% sector's growing shaft of the automotive industry towards lighter vehicles as been reflector in the grown in the market for the aluminum and magnesium castings. Today with the increases of indoctrination and urbanization air pollution is an burning problem in the presents in scenario. Foundry process as multiple source of particulate the major sources furnace poured melting. Short blasting, machining and felting operation, core production and sand plant. This emission are exist ion to went stock. The results also showed that adhesive and plowing wear dominant for regular samples with a relatively low hardness while the wear shapes exhibited smoother ones by abrasion and plowing as the hardness of samples increases. A significance of electrical energy which is supplied to an induction furnace is converted into waste heat.[1] Investigated mass transfer coefficient for two-phase countercurrent flow in a packed column with a novel internal. The mass transfer coefficient is directly proportional to the liquid hold-up, which depends on the structural parameters of the internal, the superficial liquid flow velocity and the porosity of the packing bed. A suitable internal should be made of many springs of small diameter, the furnace cooling circuit not only deals with the electrical losses but also protects the coil from the hot metal in the crucible. Pressure drop and flow regimes in co-current gas-liquid upflow through packed beds[2]. The pressure drop is dependent on all the variables

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viz., phase flow rates, physical properties of the gas and liquid systems (density, viscosity and surface tension) and structural parameters of the porous medium (packing size, shape and bed porosity) used. When metallic charges materials are added to a molten heel in an induction melting furnace the presence of water in the scrap can potentially be dangerous. The utilization of ferrous wastes in a blast furnace is a well established recycling process to cope with the enormous amounts of ferrous residues in the iron and steel industry[3]. The further input flows of this process, that is especially coke and fluxes, as well as its output flows, that is pig iron and by-products, are highly dependent on the blending of the ferrous wastes while they differ highly in the revenues gained for the treatment and their chemical composition. Recovery of secondary aluminium requires a furnace[4]. Induction furnaces offer several advantages over direct-fired furnaces: low melt loss, good metal quality, and high efficiency. Some metal-melting induction furnaces suffer refractory failure through cracking during the cooling period that follows steel discharge[5-7]. Over the last decades improvements have been achieved in industry regarding several major polluting substances and gradually the environmental impact has shifted towards the so-called diffuse sources of pollution. A large number of these obligations derive from the IPPC Directive, which aims at the protection of the environment as a whole. Combustion emissions account for over half of the fine particle (PM2.5)[8-12] air pollution and most of the primary particulate organic matter. C. Vijayanand et al (2008) explained Industrialization and urbanization are the two major causes of deteriorating air quality. To evaluate the ambient air quality of the Coimbatore city, suspended particulate matter (SPM) was collected at ten stations and analysed for the heavy metals content. Established a program to support developing countries in protecting the global environment[13-14]. In collaboration with The Energy and Resources Institute (TERI), New Delhi, SDC India selected the foun. Explained Some metal-melting induction furnaces suffer refractory failure through cracking during thecooling period that follows steel discharge[5]. A mathematical model to predict the unsteady-state temperature distribution of a furnace of this type during cooling is presented in this workdry industry as one of the prominent areas in which to introduce environment-friendly technologies. The normal furnace cooling facilities must be kept operating during the summer period and at other times when the space heating facilities are not extracting an appropriate quantity of heat from the furnace cooling system. It is essential to ensure the integrity of the furnace cooling system. The whole installation must be designed to be fail safe, to protect the integrity of the furnace at all times. Also water returning to the furnaces must be too cold(i.e not bellow 30^{0}C). temperature operated alarms should be provided and emergency bypass pipe work with easily accessible manual control valves, should be installed, to ensure that the heat recovery facilities can be isolated quickly from the primary cooling circuit in the event of any problems A number of factors are often important in determining the best way to control particulate emissions. This includes loading density, size distribution, shape, density, stickiness, corrosively, reactivity and toxicity. Therefore it is important to sample the particulates in a given exhaust gas stream to determine these properties and determine its emissions are within regulatory limits. Since no coal is burned in the induction furnace and no refining procedures are executed. The emissions are solely depending on cleanliness of the composition of the charged material. In order to give the source of emissions in the foundry, here we consider the iron foundry. In the malleable iron foundry metallic's and fluxes are the major materials for furnace charging. Iron, steel scrap and foundry returns form the metallic materials.limestone, dolomite, fluoride and carbide compounds comes under the fluxes. For example in a foundry if we melt 600 tones[8] of iron per day, nearly half of it will be recycled[4]. From the various sources, additional metal scrap will is obtained. The scrap normally contains chromium, zinc, aluminum in the form of pieces. Emissions generated during handling and raw materials preparation forms the fugitive particulate matter produced from the receiving, un loading, storage and conveying of raw materials. These emissions cannot be controlled. Mostly for the metal melting in the iron foundry, we make use of cupola, electric arc and electric induction furnaces. For safety reasons the scrap metal added to the furnace is cleaned and heated before being introduced into the furnace.

There is an opening in the top of the furnace in order to allow oxygen for burning and it is a continuous source of emissions. During preheating of the scrap metal, particulate matter, chlorides and fluorides are produced from incomplete combustion of coke, carbon additives, flux additions and dirt on the charge scale. The highest furnace emissions takes place during charging, back charging, inoculation, removal and tapping operations when the furnace is open. Emissions released from the furnaces include carbon dioxide, organic compounds, sulfur dioxide, nitrogen dioxide, particulate matter, and some quantities of chloride and fluoride compounds. Fine particulate fumes emitted from the melting furnaces come from the condensation of volatilized metal and metal oxides. Carbon monoxide is produced by the combustion of organic material on scrap and carbon added to the charge. Hydrocarbon emissions come from the vaporization and partial combustion of any oil remaining on the scrap, which is used as a charge. The emissions depend on the material composition, the melting rate, the melting method and purity of the metals used. The sources of the emission may also include paint on the scrap, various deposits on the scrap, carbon or graphite or other additions in powder form, zinc on galvanated scrap or contained in zinc die castings and iron and steel containing non ferrous alloys or plating. There are number of gases that are emitted from the induction furnace.

MATERIAL AND METHODS

Sampling

Sample gas is contacted successfully by a series of chemically reactive solutions. Each solution removes a specific constituent of the sample gas mixture with the corresponding decrease in gas volume at each step representative of the volume of the specific gas removed. A leveling bulb is used to adjust all gas volume measurements to atmospheric pressure. Ordinarily, the analysis is applied in the field using the portable, orsat apparatus to determine the volume composition of carbon monoxide, carbon dioxide, oxygen and unsaturated hydrocarbons[15-21] in the gaseous emission from combustion processes. Results are usually expressed in volume percent of each component gas. The limit of detection for each component is given as 0.2 percent of the total volume based on a 100.0 ml sample.

Errors due to physical absorption can be minimized by proper air-solution contact time for proper equilibrium. Otherwise, no interference is observed from components of ordinary combustion air at levels normally encountered. Negligible interference results from the presence of hydrocarbon sulphide, sulphur dioxide and acid gases which are absorbed by the caustic solution and reported as carbon dioxide.

Measurement techniques

The portable orsat apparatus is fitted with a wooden carrying case and uses a shortened form of burette with three gas absorbing pipettes. In order, starting from the burette, the pipettes are filled with potassium hydroxide, pyrogallol and cuprous chloride respectively. After filling the above pipettes to the engraved mark with the above solutions and before starting the test adjust the level of each to atmospheric pressure using the leveling bulb. Open the stopcock with salt water (saturated). Connect the stopcock of the burette to the atmosphere to be sampled or to a sample container and fill the burette with sample gas by lowering the leveling bulb until the meniscus of the water reads the desired volume in the burette (V_1). Open the stopcock connecting the burette to manifold of the absorbing system and also open the stopcock of the potassium hydroxide pipette. Pass the gas contained in the burette into the potassium hydroxide pipette by first raising and then lowering the leveling bottle. Repeat until three to five full contacts have been made. Return the remainder of the gas sample to the burette using the leveling bulb-until the level of potassium hydroxide solution returns to the engraved mark and with the pipette stopcock closed, again, adjusts the water level in the burette to atmospheric pressure using the leveling bulb. Similarly, oxygen is removed from the remaining gas volume V_2 by passing this gas into the pyrogallol solution in the second pipette. Sulphur dioxide and nitride is measured by manipulating the remaining gas volume V_3, as done previously to admit this sample into the pipette containing copper (II) chloride. However before returning the gas volume V_4 to the burette for measurement volume V_4 is passed once into the potassium hydroxide pipette to remove any hydrochloric acid vapors evolved from copper (II) chloride.

RESULTS AND DISCUSSION

Particulate emission is determined from stationary sources, which concerns positive pressure fabric filters also known bag houses, where it has particular emphasis and sample location. Total dust and tin fume concentration were compared with exposure limits standards. They were lower than exposure limits standards but total dust concentration was exceeded a half of exposure limits standards. Copper fume concentration was higher than exposure limits standards so much. So that majority particles emissions at working area were total dust. The **Table 1** gives the particulate matter, SO_2 and N_2 discharge at various flue gas discharge. It is seen that as the discharge of the flue gas increases the emission of the particulate matter increase.

Pressure drop the parameter present pressure losses within the packed bed scrubber type counter current flow. The pressure drop included scrubber mechanism loss, materials loss and packing loss. The pressure drop of the scrubber was static pressure between inlet and outlet duct while melting and pouring bronze process. **Fig.2** shows the variation of particulate matter for various months. **Fig.3** shows the variation of SO_2 for various months. **Fig.4** depicting the variation of gas discharge for various months. **Fig.5** depicts the variation of flue gas discharge for various months. **Fig.6** shows the variation of stack temperature for various months. **Fig.7** depicts the variation of oxides of N_2 for various months. **Fig.8** shows the various furnaces used in Coimbatore. **Table-3** shows the variation of emission rates for different raw material being used. **Fig.9**

Weight limits on particulates

The equivocal method of characterizing and specifying limits limits on particulate emissions is according to weight, either in terms of a rate (weight emissions per unit time) or in terms of (weight per unit volume). Measurement of emission weights must be done by isokinetic sampling of a gas stream. Although the principles of such measurement are simple they are difficult and time consuming when applied with accurate

Table 1 : Variation of temperature and particulate matter with gas discharge

Month	Height	Dia	Cross Sectional Area	Stack Temp.	Flue Gas	Gas Discharge	Particulate Matter	So$_2$	Oxide of N$_2$
	m	m	m^2	Deg C	m/s	m^3/hr	Mg/m^3	Mg/m^3	Mg/m^3
Feb-11	15	1	0.785	51	10.5	27107.2	36.7	37.8	52.3
Jan-11	15	1	0.785	56	11.2	28474	39.4	32.6	47.8
Dec-10	15	1	0.785	38	7.3	19638.7	37.5	60.7	68.5
Nov-10	15	1	0.785	38	6.3	16944.4	26.8	54.3	66.4
Oct-10	15	1	0.785	43	10.4	27531.2	22.7	28.6	45.2
Sep-10	15	1	0.785	32	7.2	19742.6	24	46.6	46.8
Aug-10	15	1	0.785	40	9.6	25657.8	22.4	32.5	47.3
Jul-10	15	1	0.785	45	10.2	26832	23.9	37.6	46.2
Jun-10	15	1	0.785	50	10.5	27196.4	36.4	38.2	48.2
May-10	15	1	0.785	51	10.7	27624	36.8	38.1	51.8
Apr-10	15	1	0.785	53	10.9	27966.2	37.6	60.8	67.7
Mar-10	15	1	0.785	54	11.3	28905	38.2	33.2	48.6

Fig. 1 : Gas analyser

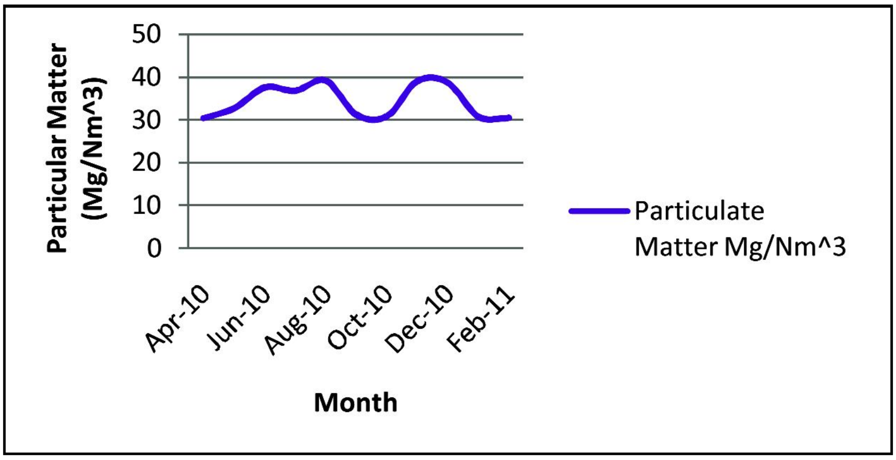

Fig. 2 : Graph depicting the variation of particulate matter with time

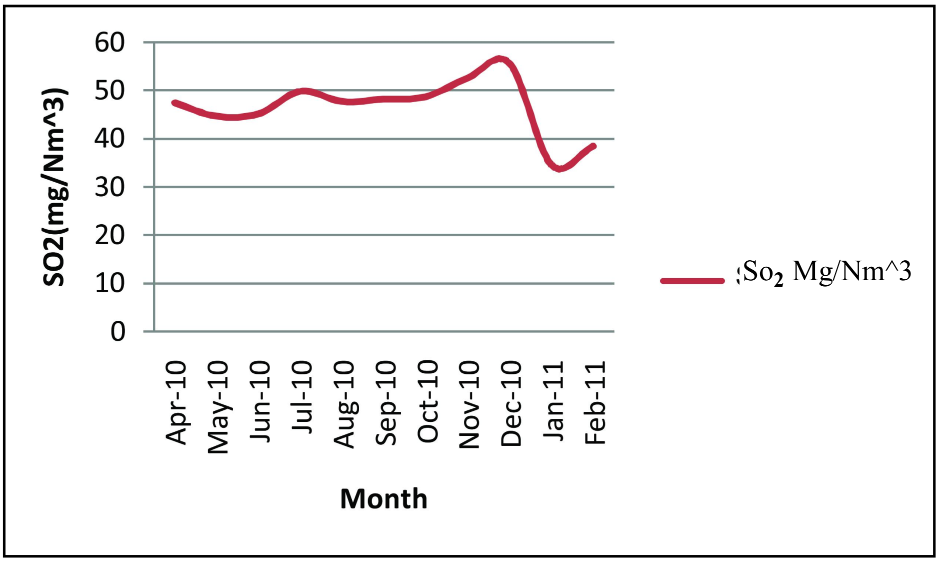

Fig. 3 : Graph depicting the variation of SO_2 with time

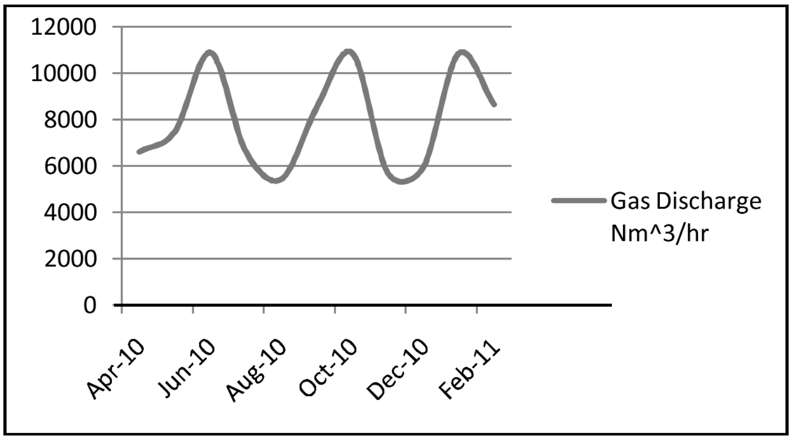

Fig. 4 : Graph depicting the variation of gas discharge with time

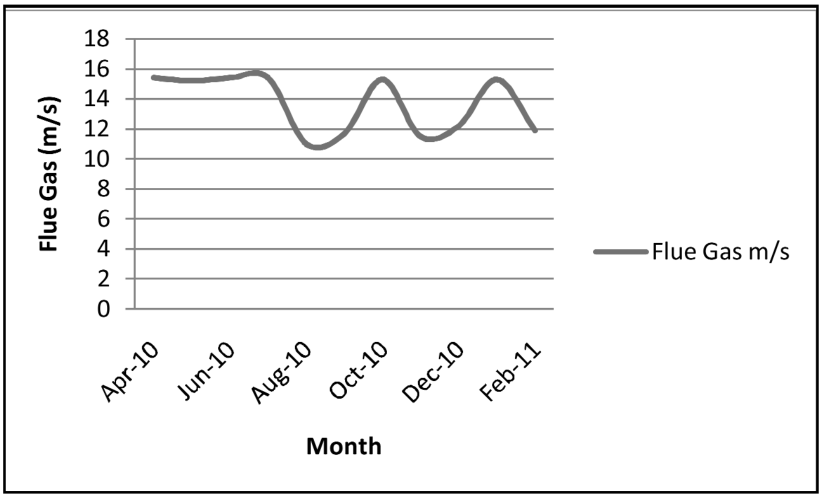

Fig. 5 : Graph depicting the variation of flue gas with time

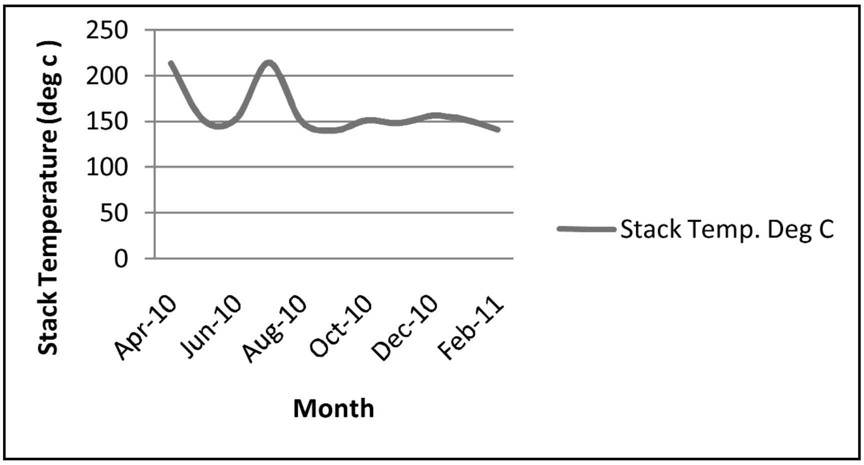

Fig. 6 : Graph depicting the variation of stack temperature with time

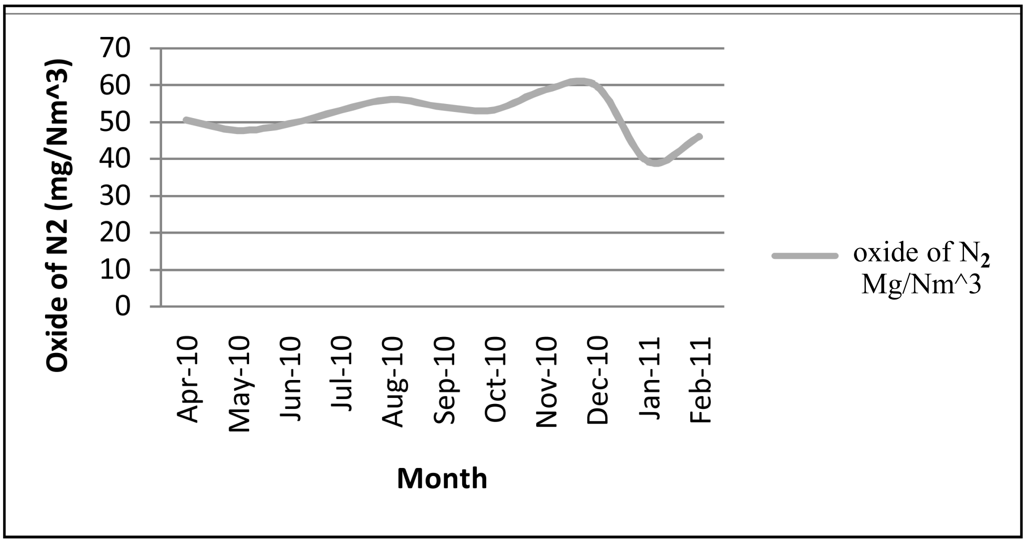

Fig. 7 : Graph depicting the variation of N_2 oxide with time

methodology to commercial installations. For this reasons such measurements are not previously been required in many jurisdictions and are almost never used as a continuous monitoring technique. Limits on weight rate of emissions are usually dependent on process size. The particulate weight limits for larger plants are restricted to 40lbs/hr. For furnaces, the determining factor is often heat input in BTU/hr rather than process weight. In cases where a particular plant location may be having several independent units carrying out same or similar processes regulations often require that capacities are combined for the purpose of calculating combined emissions.[9]

Induction furnace waste heat utilization

A significant proportion of the electrical energy which is supplied to an induction melting furnace is covered into waste heat. About 20 to 30% of the energy input to the plant is dissipated through the cooling system. The furnace cooling circuit not

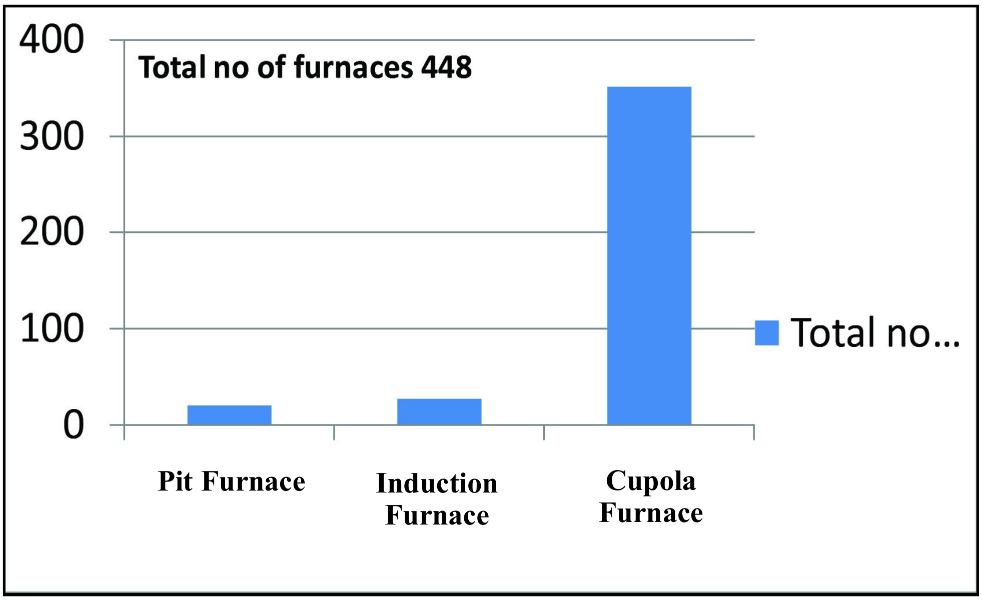

Fig. 8 : Furnace usage in Coimbatore

only deals with the electrical losses in the induction coil, but also protects the coil from heat conducted through the furnace lining from the hot metal in the crucible. The heat in the furnace cooling system is used in some installations for space heating of shower water and for drying raw materials.[3]

CONCLUSION

The emission composition data of air particulate matters such as SPM, So_2 and N_2 collected through sample testing from small, medium and large scale foundries in Coimbatore were studied for the induction furnace using wet scrubbers.

Table 2 : Emission rate for various raw material being used

S/N	Plant	Cupola Inner Dia (m)	SPM (mg/m^3) (Cupola)	CO_2 (mg/m^3)	SO_2 (mg/m^3)
1	A	0.84	340	127	-
2	B	0.84	980	67	230
3	C	0.81	398	130	
4	D	0.86	340	110	120
5	E	0.81	400	162	-

Table 3 : Emission rate for various raw material being used

Raw Material			Height	Dia	Velocity	Volume Flow Rate	Temp	PM	Co_2	So_2
Raw Material	Purpose	Quality T/Month	m	m	m/s	M^3/Sec	^0C	mg/m^3		
Pit Iron scrap foundry return Ferro Silicon	Changing into Induction Furnace	50 450 166 3.5	12	0.3	15	0.99	42	50	BDL	BDL
Pit Iron scrap foundry return Ferro Silicon	Changing into Inducton Furnace	62 500 180 6.5	14	0.4	71.2	2.05	41	45.5	BDL	BDL
Pig Iron	-	983.33	15	0.6	12	3.19	308.2	50	BDL	BDL
Pig Iron scraps foundry return ferro Silicons	Changing into Inducton Furnace	40 360 327 3	10	0.3	12	0.85	40.45	50	BDL	BDL
Pig Iron	Before Ext 600 Aft Ext 150	48 390 280 5.5	15	0.3	12.5	0.814	50	58.5	BDL	BDL

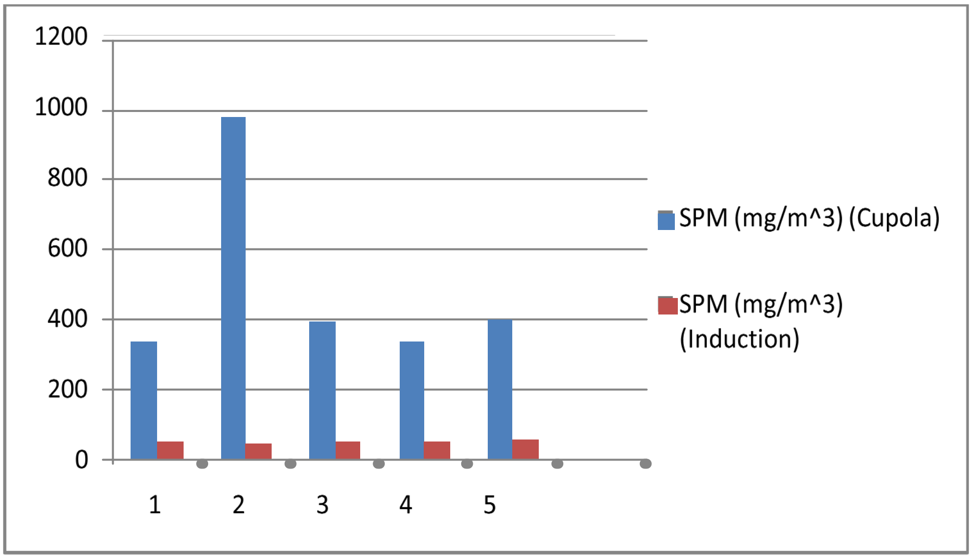

Fig. 9 : Variation of SPM in induction and cupola

Performance of wet scrubber were also been discussed through continuous monitoring for a period of one year and the performance were plotted for their distribution for different months in different locations. It is absorbed that Technology up gradation of the furnace crucible type holder instead of channel holder , charging time reduction through automation, adapting best practices and eliminating various delays in the melting process can be followed. (Charging /Chemistry clearance/Tapping/etc.,). Exactness in the input materials of induction furnaces are recommended.

ACKNOWLEDGEMENT

The authors wish to thank DST(Department of science and technology) Government of India ministry of science and technology for awarding inspire fellowship (No. DST / Inspire Fellowship / 2011 / IF 110324)and supporting to complete the work successfully.

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