International Journal of Scientific & Engineering Research Volume 2, Issue 7, July-2011
ISSN 2229-5518

A Journey towards Green Revolution- A case study of foundry

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Abstract - The objective of this study is to evaluate the stack emission and ambient air quality of a dust collector in a foundry. Suspended Particulate Matter (SPM) was analyzed along with SO_2, NO_2 and CO hence, its level was found to be appropriate with all the locations of sampling stations. The factors affecting dust concentration were also discussed along with the results indicating lowest dust exposure, moderate and highest dust concentration based on the stack height with various levels were varied with respect to port hole, stack diameter and temperature with its metrological indication. Even though our study specifically focuses on a particular plant, the results may be interesting on reducing of dust particles.

Keywords- emission, spm, ambient air quality, Wet scrubber, induction furnace, dust collector, fume extraction

1. INTRODUCTION

Foundry practices mainly include melting ferrous, nonferrous metals and alloys and reshaping them in to products of finished shape by pouring and solidification of molten metal or alloy in to any mould. The foundry industry plays an important role in recycling of metals. Steel, cast-iron and aluminum scrap are casted into new products. Most possible hazardous environment effects of foundries are related to the presence of thermal process and the use of mineral additives. Emissions are the key environment problem that creates mineral dust organic carbons emitted from melting, sand molding, casting and finishing [1]. The present paper uses dust collector as an effective pollution control tool. In most of the plant, dusts are spread across the industrial site resulting in pollution. Effective dust control on foundries depends on initial design of machinery installation and operation. Dust control measures were not implemented in many foundries because of various aspects hence dust control and evaluation programs are in effect in only large foundries. Continuous dust monitoring was not routine in any foundry and only periodic dust measurements had usually been made.[3]. Many of the materials contain metallic oxides and non metallic compounds in the form of loose particles. The hot gases mainly CO_2 (Carbon dioxide), CO (carbon monoxide) and SO_2 (sulphur dioxide) from the burned coke and are in a form of a residue of fine ash. As the hot gases rise they trap some of the ash[1], as well as the tiny particles generated by change the materials, as a result they form a characteristic plume above the stack, thus the major pollutants are SPM and SO_2 . .All industrial activities are bound to have its impact on environment. They lead to consumption of natural resources will be which may lead to environmental pollution of air, water, etc. Foundry industry which when operated is expected to generate pollution. In order to counter this modern technology is being employed in the foundry industry like automated molding line, electric induction furnaces, etc. which with a proper planning takes care of the environmental issue. The major constituents of RSPM are organic and element carbon, metals elements like silicon, magnesium, iron, ions like sulphates, nitrates, ammonium etc. Composition of particulate matter varies from place to place depending upon sources present. Carbon monoxide is a colorless, odorless and poisonous gas. Incomplete combustion of carbon produces CO. Unlike the individual gaseous pollutants, particles in the atmosphere are composed of a wide range of materials arising from a variety of sources. Concentrations of PM comprise coarse particles, suspended soils and dusts, arising from combustion sources. Mainly sulphates and nitrates are formed by chemical reaction in the atmosphere. The relative contribution and composition of each source type varies from day to day, depending on meteorological conditions and quantities of emissions from mobile and static sources. The major barrier is lack of attitude towards adaptation and standard operating practice as it is economically inefficient. It would be more efficient if arge particles are removed either by means of settling chamber or any other suitable device before passing through scrubber. [4]. There are air emission limitations and target values for particulate matter from furnace to recover metals from collected dust and die casting machinery is not to

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exceed 0.5 kg per ton of molten metal after the control. Monitoring data should be reviewed at regular interval to maintain the dust emission in an acceptable form[5]

MATERIALS AND METHODS:

Wet scrubber is a device where the flue gases are pushed against down falling water (liquid) current. The particulate matter along with water droplets fall down and get removed. In these devices the liquid assists the PM to fall and settle down. In these devices water is the mostly used as scrubbing liquid. In these wet collectors the particulates are with water and then separated. For particulate matter the material transfer between the gas and the liquid phases may be variety of mechanisms that include inertial, gravitational, electrostatic, and diffusion phenomenon. For gaseous molecules it is mainly by diffusion. Wet scrubbers have the advantage of handling hot gases and sticky particulates and liquids. They require quantity of water and gas in the range of 0.005-0.20m3 of H2O per 100 cm3 of gas thus producing more quantity of sludge's. In these both gaseous pollutants and particulate pollutants can be removed instantly. Hot gases can be cooled down where corrosive gases can be recovered and neutralized. A proper operation/maintenance of dust collector and wet scrubber attached to shot blasting machines and to induction furnaces are carried out to minimize air pollution load at the outlet of the air pollution control system and to ensure safe working environment, maintenance work. There are various aspects of maintenance. Any accumulation of dust in the hopper of the dust collector should be properly cleaned. Special care should also be given to mechanical parts, which require lubrication such as bearings. Fabric filters commonly known as bag houses, fabric collectors use filtration to separate dust particulates from dusty gases. They are one of the most efficient and cost effective and cost efficient and cost effective types of dust collectors available and can achieve a collection efficiency of more than 99% for very fine particulates. Dust-laden gases enter the bag house and pass through fabric bags that acts as filters. The bags can be of oven or felted cotton, synthetic or glass-fiber material in either a tube or envelope shape. The high efficiency of these collectors is due to the dust cake formed on the surfaces of the bags. The fabric primarily provides a surface on which particulates collect through the following four mechanisms :inertial collection – dust particles strike the fibers placed perpendicular to the gas-flow direction instead of changing direction with the gas stream. Interception – and compared with the operating standards so that if any necessary corrective action is needed, can be taken particles that do not cross the fluid streamlines come in contact with fibers because of the fiber size. Brownian movement- submicrometre particles are diffused, increasing the probability of contact between the particles and collecting surfaces. Electrostatic forces-The presence of an electrostatic charge on the particles and the filter can increase dust capture. A combination of these mechanisms results in formation of the dust cake on the filter, which eventually increases the resistance to gas flow, the filter must be cleaned periodically. The performance of the scrubber was found to be in permissible limit in induction furnace for its successful adaptation water treatment must be devised to maintain required quality of water for circulation and disposal of solid waste. [4] The level of ambient SPM was quantified through a Hi-Volume air sampler operated at a suction rate of 1.2 m3 /min. The total SPM collected over a period of 24 hours on preweighed glass fibre filter paper was reweighed after sampling for gravimetric evaluation of SPM and was reported as mg/m3. Atmospheric SO2 concentrations were determined at the impingement rate of 1 litre/minute for an average period of 4 hrs through West and Gack methods. The method used for ambient NOx levels was Jacob and Hochhesier, keeping the same impingement rate and averaged over 4 hrs. Stack sampling was carried out using Enviro Care APM 620 Stack Monitoring Kit.[6]

DESIGN DETAIL FOR INDUCTION FURNACE STACK

(The minimum stack height required has been calculated based on the CPCB formula)

Gas emissions has been theoretically calculated

Stack height requirement – as per SO_2 emissions

Quantity of gaseous emission : 59,770 Nm^3 /day.

Emission of SO_2 : 5.0 mg / Nm^3

Total emission per hour : 59,770 x 5.0 /1000 x 1000 x 24 : 0.012 kg /hr.

Required stack height : $H = 14 (Q\ SO_2)^{0.3}$

(Where Q SO_2 is total SO_2 emission kg / hr)

: $14 \times (0.012)^{0.3}$

: 3.71 m

(The stack height required as per the CPCB guidelines is 3.71m for SO_2 emissions)

Stack height requirement – as per SPM emissions

Emissions of SPM : 52.0 mg / Nm^3

Total emission per hour :

59,770x52/1000X1000 × 1000 × 24 : 0.00013 T /hr

Required stack height : $H = 74 (Q SPM)^{0.27}$

(The stack height required as per the CPCB guidelines is 6.61m for SPM emissions)
However it has been proposed to establish a stack of height – 8.50m with Wet Scrubber system by the unit.

DESIGN DETAILS OF THE WET SCRUBBER ATTACHED TO INDUCTION FURNACE

The basic function of the wet scrubber is to provide contact between the scrubbing liquid, water and the particulars to be collected. The polluted gas flows upward and the particle collection results because of inertial impaction and interception of the droplets.

Expected stack gas discharge = 0.920 m^3 / sec.
Expected suspended particulate matter = 40 ppm
Diameter of the scrubber = 0.5m
Area of the scrubber= $(\Pi / 4) \times (0.5)^2 m^2 = 0.196 m^2$
The terminal velocity of water should not exceed the upward velocity of air.
The terminal velocity of water droplet should be more than gas velocity.
Individual drop collection efficiency is maximum for droplet diameter of 2 -4 mm is 0.65.
Over collection efficiency is = $h_{sc} = 1 -(1 -nd)^n$
n = number of collecting droplets encountered by a group of particles
nd = individual drop collection efficiency

GUIDELINES FOR SELECTING A DUST COLLECTOR

Dust collectors vary widely in design, operation, effectiveness, space requirements, construction and capital, operating and maintenance costs. Each type has advantages and disadvantages. However the selection of a dust collector should be based on the following general factors.[2]

- Dust concentration and particle size-for minerals processing operations, the dust concentration can range from 0.1 to 5.0 grains(0.32g) of dust per cubic feet of air (0.23 to 11.44 grams per standard cubic meter) and the particle size can vary from 0.5 to 100µm.
- Degree of dust collection required –The degree of dust collection required depends on its potential as a health hazard or public nuisance, the plant location, the allowable emission rate, the nature of the dust, its salvage value and so forth. The selection of a collector should be based on the efficiency required and should consider the need for high-efficiency, high cost equipment, such as electrostatic precipitators; high efficiency, moderate-cost equipment, such as bag houses or wet scrubbers; or lower cost, primary units, such as dry centrifugal collectors.
- Characteristics of airstreams- the characteristics of the air stream can have a significant impact on collector selection. For example, cotton fabric cannot be used where air temperatures exceed 180'F(80'C). Also condensation of stream or water vapour can blind bags. Various chemicals can attach fabric or metal and cause corrosion in wet scrubbers.
- Characteristics of dust- Moderate to heavy concentrations of many dusts (such as dust from silica sand or metal ores) can be abrasive to dry centrifugal collectors. Hygroscopic material can blind bag collectors. Sticky material can adhere to collector elements and plug passages. Some particle sizes and shapes may rule out certain types of fabric collectors. The combustible nature of many fine materials rules out the use of electrostatic precipitators.
- Methods of disposal- Methods of dust removal and disposal vary with the material, plant process, volume, and type of collector used. Collectors can unload continuously or in batches. Dry materials can create secondary dust problems during unloading and disposal that do not occur with wet collectors. Disposal of wet slurry or sludge can be an additional material-handling problem; sewer or water pollution problems can result if wastewater is not treated properly.

PARAMETERS INVOLVED IN SPECIFYING DUST COLLECTORS

Important parameters in specifying dust collectors include airflow the velocity of the air stream created by the vacuum producer; system power, the power of the system motor, usually specified in horsepower storage capacity for dust and particles and minimum particle size filtered by the unit. Other considerations when choosing a dust collection system include the temperature, moisture content and the possibility of combustion of the dust being collected. Systems for fine removal may only contain a single filtration system (such as filter bag or cartridge). However, most units utilize a primary and secondary separation/filtration system. In many cases the heat or moisture content of dust can negatively affect the filter media of a bag house or cartridge dust collector. A cyclone separator or dryer may be placed before these units to reduce heat or moisture content before reaching the filters. Furthermore, some units may have third and fourth stage filtration. All separation and filtration systems used within the unit should be specified.

RESULTS AND DISCUSSIONS

Table : 1

National Ambient Air Quality Standards:

		Concentration in ambient air			
Pollutant (1)	Time Weighted Average (2)	Industrial Area (3)	Residential rural and other areas (3)	sensitive areas (4)	method of measurement (5)
Sulphur Dioxide (so_2)	Annual Average 24 hrs	80 µg/m³ 120µg/m³	60µg/m³ 80µg/m³	15µg/m³ 30µg/m³	Improved west and gaeke method Ultra violet fluorescence
Oxides of nitrogen (nox)	Annual Average 24 hrs	360µg/m³ 500µg/m³	140µg/m³ 200µg/m³	70µg/m³ 100µg/m³	High volume Sampling (average flow rage not less than 1.1 m³ per minute)
Respirable particulate matter (size less than 10µm) (rpm)	Annual Average 24 hrs	120µg/m³ 150µg/m³	60µg/m³ 100µg/m³	50µg/m³ 75µg/m³	Respirable particulate matter sampler
Lead (pb)	Annual Average 24 hrs	1.0µg/m³ 1.5µg/m³	0.75µg/m³ 1.0µg/m³	0.5µg/m³ 0.75µg/m³	Aas method after using EPM 2000 or equivalent filter paper

Carbon monoxide (CO)	8 hours 1 hour	5.0µg / m³ 10µg / m³	2.0µg / m³ 4.0µg / m³	1.0µg / m³ 2.0µg / m³	Non dispersive infrared spectroscopy

REPORT OF ANALYSIS : AMBIENT AIR SURVERY 1

Table : 2

sampling stations, emissions of pollutants – (ambient air survey – I)

Station No	Location of the sampling station	Sample Code	Pollutant (µg/m³)				
			SPM	SO2	NO_X	CO	Pb
A1	Near the Power House (South East)	AA 01	286	15.6	18.2	Nil	BDL
A2	Near sump – F (south West)	AA 02	298	18.2	20.1	Nil	BDL
A3	Near Office (North West)	AA03	280	14.8	16.8	Nil	BDL
A4	Near Time Office (North East)	AA 04	278	15.2	17.4	Nil	BDL
	CPCB Standard		500	120	120	5.0(mg / m³)	1.5

Remarks:

All tested values for ambient air quantity are with in the standards prescribed by CPCB.

REPORT OF ANALYSIS : AMBIENT AIR SURVERY - II

Table : 2 Air Pollution Control System

Sl.No.	Source Emission	Dust collection	Stack Details	
			Diameter (mts)	Height (mts)
1	Induction furnace – 0.8T	Common scrubber		
2	Induction furnace – 1.5T	Common scrubber		
3	Rotary furnace – 2T	Common scrubber	0.5	14
4	Cupola Furnace – 1.5T	Common scrubber		
5	Shot blasting	Bag filter	0.5	14
6	Moulding	Dry type scrubber	0.5	06
7	Sand plant	Dry type scrubber	0.5	14
8	Core oven – 1	Stack	0.15	12
9	Core oven – 2	Stack	0.15	12
10	320 KVA DG Set	Stack	0.15	4

11	180 KVA DG Set	Stack	0.15	4
12	60 KVA DG Set	Stack	0.15	3

Table 3 Report of analysis: stack (source) emission

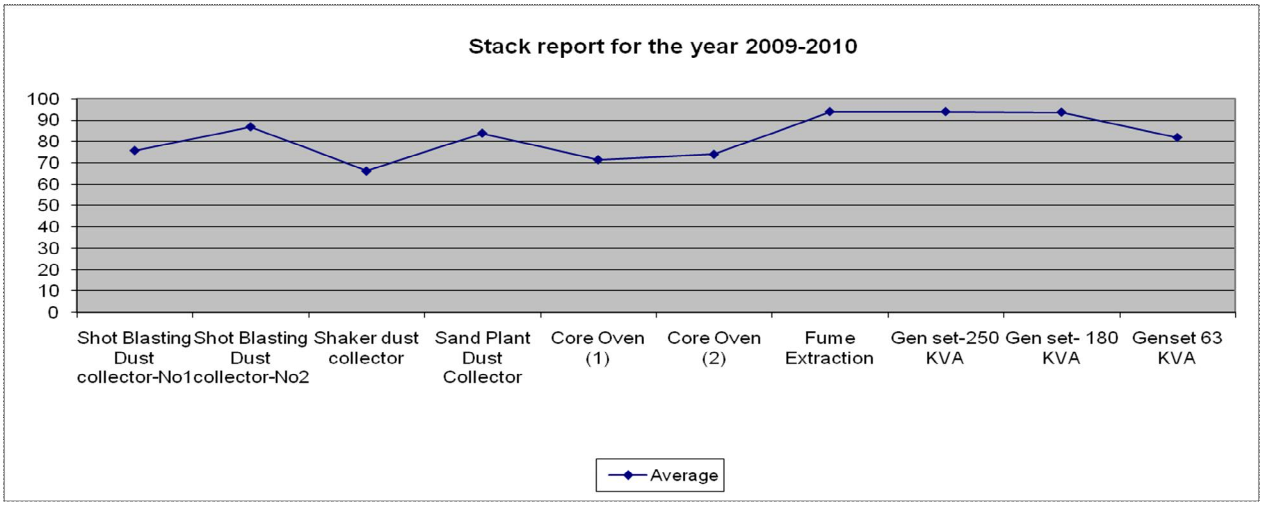
Stack	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
Sack Height from Ground height	9.0	8.5	8.5	9.0	6.0	9.0	10	14	7.5	6.5	4.9
Port Hole Height from Ground Level(m)	8.0	6.5	6.5	4.5	4.6	3.5	3.5	6.6	7.0	5.0	4.4
Stack Diameter(m)	1.6	1.0	0.6	1.6	1.6	0.7	0.8	1.0	0.5	0.5	0.25
Stack Temperature(°K)	311	310	309	308	312	380	381	328	389	386	369
Ambient Temperature(°K)	304	304	304	304	304	304	304	304	304	304	304

Trend Chart for NOx levels at Various Points for the year 2008-2009										
	Shot Blasting Dust Collector-No1	Shot Blasting Dust Collector - No2	Shaker dust collector	Sand Plant Dust Collector	Core Oven-1	Core Oven-2	Fume Extraction	Gen set-250 KVA	Gen set-80 KVA	nset 63 VA
Sep-09										
Oct-09										
Nov-09	-	-	-	-	BDL	BDL	1	7.8	6.2	.9
Dec-09										
Jan-10										
Feb-10	-	-	-	-	BDL	BDL	1	7.2	6.4	.4
Mar-10										
Apr-10										
May-10	-	-	-	-	BDL	BDL	1	5.6	5.8	.2
Jun-10										
Jul-10										
Aug-10	-	-	-	-	BDL	BDL	1.8	5.2	5	4
Average	0	0	0	0	0	0	1.2	6.45	5.85	375

BDL –Below detectable level

Trend Chart for S02 levels at Various Points for the year 2009-2010										
Month	Shot Blasting Dust collector-No1	Shot Blasting Dust collector-No2	Shaker dust collector	Sand Plant Dust Collector	Core Oven-1	Core Oven-2	Fume Extraction	Gen set-250 KVA	Gen set-180 KVA	Genset 63 KVA
Sep-09										
Oct-09										
Nov-09	-	-	-	-	1.4	1	1.8	63.2	52	49.4
Dec-09										
Jan-10										
Feb-10	-	-	-	-	1.2	0.8	1.3	58.2	54	46.8
Mar-10										
Apr-10										
May-10	-	-	-	-	1.3	1.1	1.3	45.6	44.8	40.2
Jun-10										
Jul-10										
Aug-10	-	-	-	-	2	1.8	2.2	43.4	41.2	38.7
Average	0	0	0	0	1.475	1.175	1.65	52.6	48	43.775

Trend Chart for SPM levels at Various Points for the year 2009-2010										
Stack No	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Month	Shot Blasting Dust collector-No1	Shot Blasting Dust collector-No2	Shaker dust collector	Sand Plant Dust Collector	Core Oven (1)	Core Oven (2)	Fume Extraction	Gen set-250 KVA	Gen set- 180 KVA	Genset 63 KVA
Sep-09										
Oct-09										
Nov-09	79	96	68	88	72	74	90	104	98	87
Dec-09										
Jan-10										
Feb-10	74	90	64	82	70	75	92	98	96	79
Mar-10										
Apr-10										
May-10	78	86	65	84	74	73	96	82	92	82
Jun-10										
Jul-10										
Aug-10	72	76	68	82	70	74	98	92	89	80
Average	75.75	87	66.25	84	71.5	74	94	94	93.75	82



CONCLUSION

The study revealed that the emissions levels were below the standard limit with the appropriate usage of dust collectors and the ambient air quality survey concludes that there must be separate zone for the sensitive area of the sampling stations . A monitoring study has been undertaken to measure the concentrations of suspended particulate matter and variations in air quality both before and after the implementation of the zones. An emission estimation and simple dispersion modeling study has also been undertaken using survey data collections in various zones at corresponding periods. The ambient air quality measurements and the modeling predictions assess their concentration level within time and the results were discussed.

ACKNOWLEDGEMENT

The author wishes to thank Dr. A.R.Ramanathan formally prof essor and Head of the department of Mechanical Engineering, Annamalai university for his valuable suggestion and guidance and special thanks to Mr. J.Prabu Lawer chamber the Nilgiris for assisting financially to carry out the work very successfully. And also sincere thanks to Mrs. M. Premalatha, B.E Computer Science and Engineering , AUTCBE, Coimbatore for assisting the work with fulfillment.

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