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A Comparative Study of Particulate Matter Emission Reduction from Different Size of Operational Sponge Iron Kilns at Raipur

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Abstract:- The Iron and Steel Industry has been considered as one of the most important industrial sectors, which has a large share in India's GDP and the overall development. The sector is obtaining all essential ingredients needed for dynamic growth in India. The Indian Government's National Steel Policy 2017 aims to increase the per capita steel consumption to 160 kilograms by 2030-31.

Sponge iron industries study shows continuous improvement in technologies for better precautionary measures. This study depicts how the kiln size plays a pivotal role in emission control by reduction of particulate matter of existing sponge iron plants without any change in operational technology. The reduction proposed in this study can be achieved by the modification of existing ESP's. The particulate matter level from various sponge iron plants situated at Siltara and Urla industrial area can be reduced significantly in Raipur district for safe and healthy environment.

AIM: A Comparative Study of Particulate Matter Emission Reduction From Different Size of Operational Sponge Iron Kilns at Raipur.

Keywords:- *Sponge Iron Kiln, Direct Reduction Process, Emission Estimation Technique, Particulate Matter Emission, Pollution Control Equipment.*

I. INTRODUCTION

In general, there are four types of emission estimation techniques (EETs) that may be used to for estimation of Particulate Matter emissions are:

- sampling or direct measurement;
- mass balance;
- modelling
- emission factors.

Selection of the EET (or mix of EETs) is most important factor for appropriate estimation of Particulate Matter emissions. For example, we might choose to use a mass balance to best estimate fugitive losses from pumps and vents, direct measurement for stack and pipe emissions, and emission factors when estimating losses from storage tanks and stockpiles.

In general, direct measurement is the most accurate method for characterising emissions and, where available, such data should be used in preference to other EETs. Direct monitoring may be undertaken as an element of other EETs.

In developing an inventory of emissions, it is important to utilise the best information available to develop emission estimates. Ideally, this data is obtained through source testing of emission points, although it is recognized that in many situations sampling data is not available.

II. METHODOLOGY

Emission factors technique is considered for calculating particulate matter emission from stack of the industry. If any operating industry have ESP which has been designed to achieve Particulate Matter [PM] emission level below 50 mg/ Nm3; plans to upgrade its ESP to achieve Particulate matter emission level below 30 mg/ Nm3, then certainly it will have positive impact on environment.

For calculation purpose we have taken standard condition for 100 TPD Sponge Iron kiln, 350 TPD Kiln and 500 TPD Kiln.

Calculation of Volumetric Flow for 100 TPD Kiln:

For Calculation of volumetric flow from a stack, firstly we have to calculate Stack gas velocity. For this we required stack gas analyzer. To determine the velocity first we have to calculate the differential pressure of stack gas velocity; which can be calculate with the help of "S" type pitot tube and oil manometer.

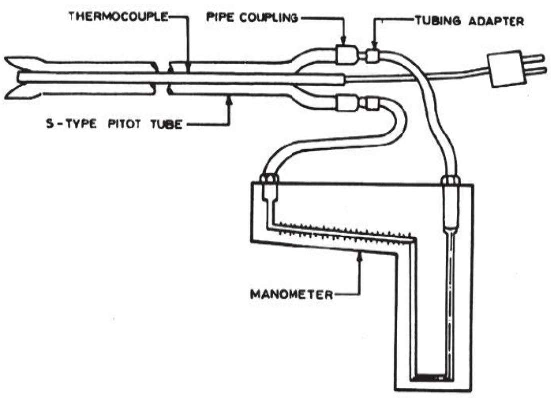


Fig 1:- View of S- type Pitot Tube

Determination of stack gas velocity:

$$Us = Kp \times Cp \times (\Delta P)^{1/2} [Ts / (Ps \times Ms)]^{1/2}$$

Where

Us	=	Stack gas velocity, m/s
Kp	=	Constant, 33.5
Cp	=	S- type pitot tube coefficient.
Ts	=	absolute stack gas temperature, °K
P	=	Stack gas velocity pressure, mm water column
Ps	=	Absolute stack gas pressure, mm Hg
Ms	=	Molecular weight of stack gas on wet basis, Kg / Kg –mole

Calculation of stack gas velocity for 100 TPD DRI Kiln:

Us	=	stack gas velocity	To be calculate
Kp	=	Constant	33.5
Cp	=	Pitot tube coefficient	0.834
Δ P	=	pressure difference	1.35
Ts	=	stack gas temperature [K]	414.15
P	=	stack gas velocity pressure	5
Ps	=	absolute pressure	760
Ms	=	Molecular weight of stack gas on wet basis	2.75

$$Us = Kp \times Cp \times (\Delta P)^{1/2} [Ts / (Ps \times Ms)]$$

US = 33.5 x 0.834 x (SQRT OF 1.35) X (SQRT OF [414.15÷(760X2.75)]
US = 6.45195 meter/ sec

Determination of volumetric flow:

$$Qs = 3600 (Us) \times As (1 - B_{WO}) \times (Tref / Ts) \times (Ps / Pref)$$

As	=	Area of the stack (duct), m2
BWo	=	Proportion by volume of water vapour in stack gas.
Tref	=	298 °K
Pref	=	760 mm of Hg
Ts	=	Absolute stack gas temperature, °K
Ps	=	Absolute stack gas pressure

For 100 TPD DRI Kiln:

Qs	=	volumetric flow	to be calculate
As	=	Area of stack	1.5386
BW0	=	ratio of water vapour	0.02
Tref	=	Reference temperature	298
Pref	=	Reference pressure	760
Ts	=	stack gas temperature	414.15
Ps	=	absolute pressure stack	755
US	=	stack gas velocity	6.451946

$$Qs = 3600 (Us) \times As (1 - B_{WO}) \times (Tref / Ts) \times (P$$

QS = 3600 (US) x As (1-BWO) x [Tref÷Ts] x [Ps÷Pref]
QS = 3600 (6.451946) x 1.5386 (1-0.02) x [298÷414.15] x [755÷760]
QS = 25000 Nm3/ hour
Stack gas velocity = 6.451946 m/ sec
Volumetric flow = 25000 Nm3/ hour

Particulate Matter [PM] emission level below 50 mg/ Nm3;
Outlet PM emission = 25,000 x 0.05
= 1.25 kg/ hour

Particulate Matter [PM] emission level below 30 mg/ Nm3;
Outlet PM emission = 25,000 x 0.03
= 0.75 kg/ hour

Calculation of stack gas velocity for 350 TPD DRI Kiln:
US = 33.5 x 0.834 x (SQRT OF 1.37) X (SQRT OF [413.15÷(760X2.75)]
US = 6.639181 meter/ sec

Determination of volumetric flow:
For 350 TPD DRI Kiln:
QS = 3600 (US) x As (1-BWO) x [Tref÷Ts] x [Ps÷Pref]
QS = 3600 (6.639181) x 7.690567 (1-0.03) x [298÷413.15] x [740÷760]
QS = 125000 Nm3/ hour
Stack gas velocity = 6.639181 m/ sec
Volumetric flow = 1,25,000 Nm3/ hour

Particulate Matter [PM] emission level below 50 mg/ Nm3;
Outlet PM emission = 1,25,000 x 0.05
= 6.25 kg/ hour

Particulate Matter [PM] emission level below 30 mg/ Nm3;
Outlet PM emission = 1,25,000 x 0.03
= 3.75 kg/ hour

Calculation of stack gas velocity for 500 TPD DRI Kiln:
US = 33.5 x 0.834 x (SQRT OF 1.38) X (SQRT OF [413.15÷(760X2.75)]
US = 6.684564 meter/ sec

Determination of volumetric flow:

For 500 TPD DRI Kiln:
QS = 3600 (US) x As (1-BWO) x [Tref÷Ts] x [Ps÷Pref]
QS = 3600 (6.684564) x 10.74665 (1-0.03) x [298÷413.15] x [735÷760]
QS = 175000 Nm3/ hour

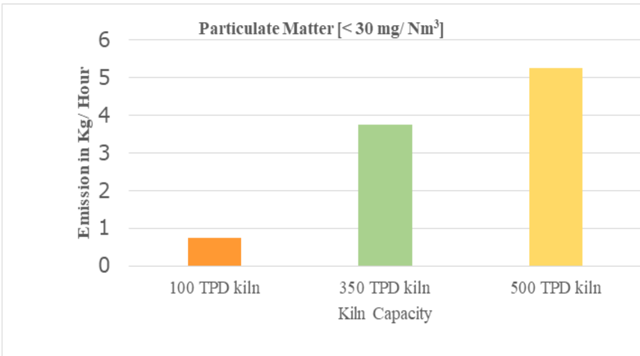
Stack gas velocity = 6.684564 m/ sec
Volumetric flow = 1,75,000 Nm3/ hour

Particulate Matter [PM] emission level below 50 mg/ Nm3;
Outlet PM emission = 1,75,000 x 0.05
= 8.75 kg/ hour

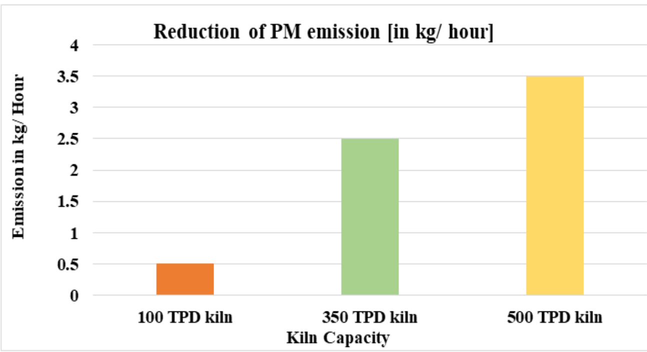
Particulate Matter [PM] emission level below 30 mg/ Nm3;
Outlet PM emission = 1,75,000 x 0.03
= 5.25 kg/ hour

III. RESULT

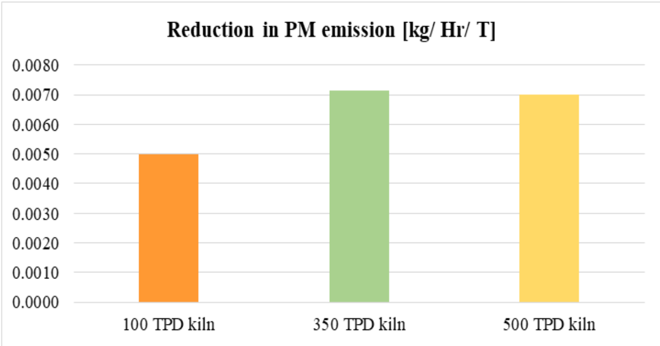
Below tables stipulates the scenario of existing norms and proposed norms for different capacity sponge iron plants. If industry follows the stringent Particulate Matter emission norms i.e. below 30 mg/ Nm3 the reduction in Particulate Matter emission that for 100 TPD DRI Kiln, Particulate matter emission will reduce from 1.25 kg/ hour to 0.75 kg/ Hour; for 350 TPD DRI Kiln, PM emission will reduce from 6.25 kg/ hour to 3.75 kg/ Hour and for 500 TPD DRI Kiln, Particulate matter emission will reduce from 8.75 kg/ hour to 5.25 kg/ Hour.



There will be net reduction of 0.5 kg/ Hour, 2.5 kg/ hour and 3.5 kg/ Hour in Particulate Matter emission level for 100 TPD, 350 TPD and 500 TPD DRI kilns respectively.



Taking it to per tons basis for all three kilns Particulate matter emission level will be reduced by 0.005 kg/ Ton/ hour for 100 TPD Kiln; 0.0071 kg/ Ton/ hour for 350 TPD Kiln and 0.0070 kg/ Ton/ hour for 500 TPD Kiln.



IV. CONCLUSION

There is need for revamping the emission norms in Siltara and Urla industrial area for improvement in air quality of the areas. Reduction in emission norms of particulate matter will reduce the overall pollution load in the air which will improve the environment. As introducing clean technology in the whole industrial sector is not an easy process,as the analysis shows significant reduction in air pollution load can be achieved by less changes in available resources. The study also reveals how reductions in Particulate matter emission norms will more effective in larger size of kilns.

REFERENCES

[1]. *Transport Phenomena by R. Byron Bird, Warren E. Stewart, Edwin N. Lightfoot*, John Wiley & Sons, Inc. Page no. 514 to 536.
[2]. *A textbook of Fluid Mechanics and Hydraulic machines by Dr R.K.Bansal*, Revised Ninth Edition, Laxmi Publications (P) ltd. Page no. 280 to 295.
[3]. *Mass Transfer Operation by Robert E. Treybal* 3rd Edition, McGRAW- Hill Inc Page no. 22 to 33.
[4]. Essential of *Fluid Mechanics by John M. Cimbala and Yunus A. Cengel* McGRAW- Hill Inc Page no. 49 to 60.