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A Perception of an Eco friendly Furnace for Environmental Conservation in Foundry Industries

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Abstract: The large amount of flue gases produced by cast iron foundries using Coke fired cupolas for melting, contains injurious elements like SO_2, CO_2, CO, H_2S, NOx, SPM etc. which damages the environment and are dangerous to all living beings. The emissions of SO_2, CO_2, CO, H_2S, suspended particles, dust and grit have not been found within the pollution control limit as set down by central pollution control board of India. Therefore all the foundries in Taj Trapezium Zone (TTZ) have been ordered to be closed down by a recent order of the Honourable Supreme Court of India. It is not only the problem of India but is a global one. As per instructions of Hon'ble Supreme Court of India the cleaner technology should be used instead of cupola furnace. The author conducted a series of experimental investigations on the rotary furnace, installed at industries at Agra. These experimental investigations on the rotary furnace revealed that by reducing rpm from 2 to 1 not only the fuel consumption and emission levels were drastically reduced but its performance was also significantly improved

***Keywords*-- Rotary furnace, SPM, CO, Emission level, RPM, CPCB**

I. INTRODUCTION

The effects of carbon on the solidification of nodular cast iron are significant for environmental conservation and if properly controlled the emissions of poisonous gases can be reduced [1]2017.The Dust and fumes pollutes the environment and sand dilation on distortions and pattern allowances have a considerable effect on these emissions [2]2017.The beehive matrices analysis and ant biodiversity were employed to study heavy metal pollution impact on environment of foundry using Spinola 1806 as bio indicator[3]. Graphite expansion during eutectic solidification of cast iron plays an important role for emissions of carbon dioxide during casting solidifications. This should be extremely slowly rather than at a faster rate [4]2014.

The environmental pollution mainly from foundry industries is creating a disastrous effect not only on all living beings but also on agriculture. On the basis of a case study it was concluded that SPM and CO are more dangerous to crops [5]. The SPM (Suspended particulate materials has degraded epicuticular waxes and decreased the draught

tolerance of Scots pine [6]. The effect of ambient concentration of pollutants (O_3, SO_2, CO and PH_{10}) in different months is different [7].

The small and medium industries are creating permanent environmental degradation, due to their obsolete operating methods. The projects should be made more Eco-friendly to save the environment [8]. The government should play a greater role and speed up the Greenisation in country by broadening the dissemination of environmental logistics offering the financial assistance [9]. India is third largest producer of industrial castings, after china and USA with total production of 9.344 million metric tons [10]. The carbon dioxide is most important tropogenic greenhouse gas contributing to global climate change. In peninsular Malaysia its concentration increased by 15 Ppm from 2003 to 2009 [11].While monitoring the air quality, using

passive samplers, in a Brazilian university the higher concentration of pollutants were observed near the energy generating and boiler units using fossil fuels [12]. The lean re-burn system of fuel, in an oxygen enhanced combustion, was investigated on experimental basis and concluded that it reduces the NO_x and CO emission levels [13]. The ambient air quality and cumulative pollution is causing heavy losses to the crops[14].The emission levels of major industries are damaging the environment and greenhouse effect is gradually increasing in SARC nations[15].The carbon credits are responsible for carbon dioxide emission [16]. The industrial emissions of SPM in urban area of NW Spain are significant mainly due to combustion of fossil fuels. SPM (suspended particulate matters) have strong influence in many atmospheric processes with ill environmental effects on human health and other animals [17]. Out of all pollutants, emitted by the foundries, the suspended particles are most dangerous to all living beings, as they tend to disturb the respiratory system [18]. The urban environment in developing countries is deteriorating and mitigating the air pollution crisis, due to consumption of fossil fuel by majority of industries. It leads to several harmful diseases and Musculoskeletal problems [19]. (Atash F. 2007).The effect of SPM air pollution on respiratory diseases, were studied, and found increased number of respiratory emergency hospital admissions in Brisbane Australia. The majority of respiratory diseases occurring in urban cities are due to
increased SPM air pollution [20]. The effect of CO_2 in ambient air is disastrous. It leads to severe thrombosis and other diseases in all living beings [21].The SPM has major effect on death rate due to cardio vascular and respiratory system diseases, as they tend to deposit in the system [22].

II. THE FOUNDRY INDUSTRY

The ferrous foundry industry is one of the largest and most ancient methods of production. It plays an important role in industrial development of any country. India has been the major producer of foundry products which are not only used in domestic markets but are also exported worldwide.

SN	Year	Production of industrial castings in million metric tones.
1	2007-2008	7.7711
2	2008-2009	6.8405
3	2009-2010	7.4432
4	2010-2011	9.0532
5	2011-2012	9.994
6	2012-2013	9.3444
7	2013-2014	9.810
8	2014-2015	10.021
9	2015-2016	10.77
10	2016-2017	11.35

Table 1 Total Production of industrial castings in India (million metric tones.)

A. Role in Manufacturing Sector:

The new manufacturing policy envisages the increase in the share of manufacturing in the GDP to 25% from current 15% & to create 100 Million additional jobs in next 10 years. Since all engineering & other sectors use metal castings in their manufacturing, the role of foundry industry to support manufacturing is very vital. It is not possible to achieve the above goal without the sustainable corresponding growth of the foundry sector. Production of different types of industrial castings in India in million metric tones from (2007-08) to (2011-12) is given in table 2 and from (2012-13) to (2016-17) is given in table 3.

sn		2007-08	2008-09	2009-10	2010-11	2011-12
1	Grey cast iron	5.332	4.532	5.05	6.18	6.798
2	S.G	0.802	0.785	0.8	0.984	1.09
3	Malleable	0.0651	0.0605	0.0602	0.0692	0.066
4	Steel	0.964	0.916	0.88	1.07	1.14
5	Non ferrous	0.608	0.547	0.653	0.75	0.9
	Total	7.7711	6.8405	7.4432	9.0532	9.994

Table 2 Production of different types of industrial castings in India in million metric tones (2007-08) to (2011-12)

		2012-13	2013-14	2014-15	2015-16	2016-17
1	Greycast iron	6.254	6.71	6.83	7.41	7.89
2	S.G	0.981	1.000	1.07	1.18	1.18
3	Malleable	0.0604	0.060	0.06	0.05	0.05
4	Steel	1.158	1.100	0.968	0.88	1.10
5	Non ferrous	0.831	0.95	1.093	1.25	1.22
	Total	9.3444	9.810	10.021	10.77	11.35

Table 3 Production of different types of industrial castings in India in million metric tones (2012-13) to (2016-17)

The diagrammatical presentation Production of different types of industrial castings from (2012-13) to (2016-17) in India in million metric tones is given in figure 1

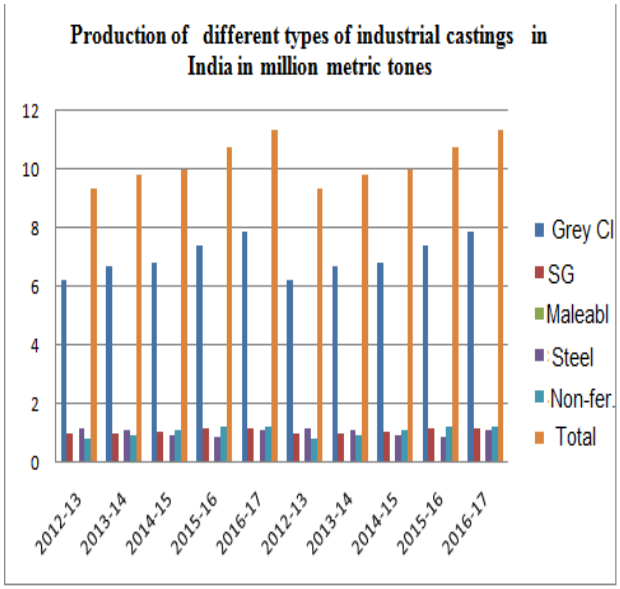

Fig. 1 The diagrammatical presentation Production of different types of industrial castings from (2012-13) to (2016-17)

B. Export orientation- export import trend

The foundry industry is also an export oriented industry. The export **import trend** of industrial castings from India is given in table 4.The Exports have been showing healthy trends approx. 25-30% YOY till 2011-12 after that there was slow down in export. However, the current exports for FY 2016-17 are approx. USD 2.33 billion

S.N	Year		In million us dollars
1	2012-2013	Exports	2572
		imports	1013
2	2013-2014	Exports	2618
		imports	927
3	2014-2015	Exports	2729
		imports	946
4	2015-2016	Exports	2503
		imports	926
5	2016-2017	Exports	2366
		imports	962

TABLE 4-- THE EXPORT IMPORT TREND OF INDUSTRIAL CASTING FROM INDIA

The export import trend of industrial casting from India is presented graphically in figure 2

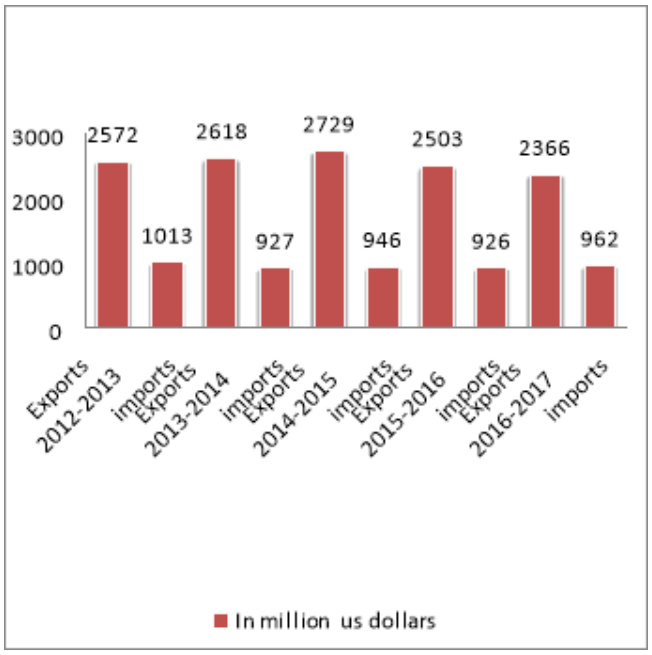

Fig.2.-- The export import trend of industrial casting from India

C. Sector wise major consumption of castings

The Sector wise major consumer of castings is given in table 5 and diagrammatically presented in fig. 3

sn	particulars	%
1	Auto	32
2	Agriculture machinery	7
3	earthmoving	2
4	Pumps and compressors	5
5	valves	5
6	Diesel engine	3
7	Electrical equipment	3
8	Machine tools	2
9	Industrial machines	6
10	Pipes and fittings	7
11	railways	6
12	power	6
13	others	10

Table 5-- The Sector wise major consumer of castings

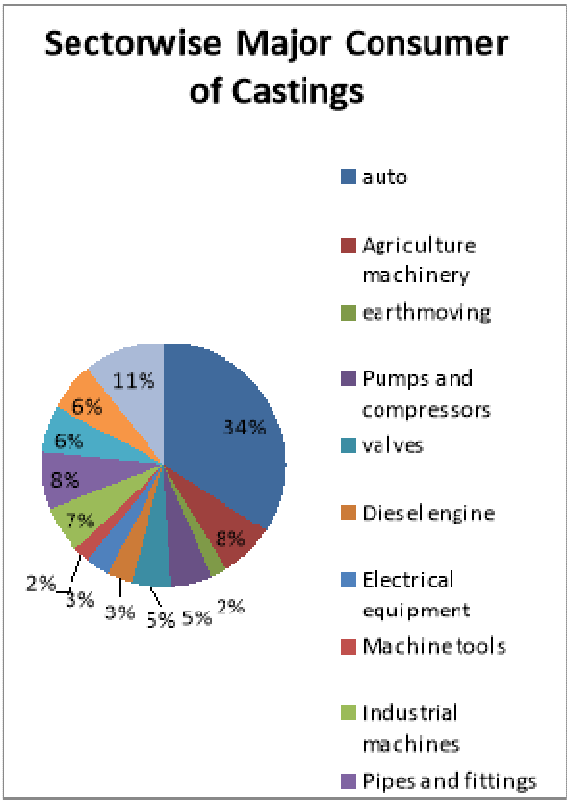

Fig. 3- Sector wise major consumption of castings

III. Major Foundry Clusters:-

Each cluster is known for its products. The major foundry clusters are located in Batala, Jalandhar, Ludhiana, Agra, Pune, Kolhapur, Sholapur, Rajkot, Mumbai, Ahmedabad, Belgaum, Coimbatore, Chennai, Hyderabad, Howrah, Kolkata, Indore, Chennai, Ahmedabad, Faridabad, Gurgaon etc.

Typically, each foundry cluster is known for catering to some specific end-use markets. For example, the Coimbatore cluster is famous for pump-sets castings, the Kolhapur and the Belgaum clusters for automotive castings and the Rajkot cluster for diesel engine castings, Howrah cluster for sanitary castings etc.

IV. Major Problems being faced by Indian Foundry Industry

The following problems are being faced by Indian Foundry Industry -

(2)Energy consumption and its availability

(3 Restriction by Central Pollution Control Board

A. Restriction by Central Pollution Control Board

Recently the major problem being faced by the foundries has been the "Environmental Protection Act". The Ministry of Environment, Govt. of India, notified emission standards for cupola furnace on August 30th 1990 for implementation throughout the country. Further standards were modified on 2nd April 1996. The emission limits in mg/m^3 as measured at standard conditions at 273^{0}K and 101.3 Kpa, without correction for water vapour- C.P.C.B. Emissions Standards for Cupola furnace are given in table 6**.**

V. Foundry industry of Agra-

Agra has an important place in the industrial map of India producing all grades of casting ranging from normal grey iron casting to graded and ductile castings .There are approximately 360 registered small scale and medium scale cast iron foundries in Agra. They are manufacturing general casting along with graded and quality casting, as required by large and renowned companies like Escorts, Kirloskar, Maruti, Asea Brown Boveri Ltd., Punjab Tractors, and Bharat Heavy Electricals Ltd., etc. The quality produced is excellent and because of it only they are getting huge repeated orders. Several units are not only exporting C.I. pipes, S-trap, P-

Trap, bend etc to Middle East, Great Britain and African countries but they are also being used in domestic markets.

SN	Particulars of unit operation	Pollutants	Concentration
1	For melting rate <3Mt/hr Cupola furnace	SPM suspended particulate matter	450 mg/m^3
2	For melting rate>3Mt/hr	SPM	150 mg/m^3
3	Burnt sand particles adhering to foundry remelt	Coarse solids	+44micorns
4	Finely divided material	Fine particles	2 to 44 microns
5		NO_x	120 mg/m^3
6		SO_2	120 mg/m^3
7		Noise level	Day-75db,Night-70db
8		Lead	1.5 mg/m^3
9		CO	5.0 mg/m^3
10		CO_2	4.0 mg/m^3
11		O_3	100-120
12	Fans, power systems Blowers	Color, fumes water	Nil
13	New Cold Blast furnace	Grit , dust, fumes	100 mg/m^3
14	Existing cold Blast Plants > 4MT/hours	Pollution control equipment must be installed for SPM,$SO_2$$NO_X$, CO,$CO_2$etc	115mg/m^3 (Max)

Table 6-CPCB Emissions Standards for Cupola furnace

A. Survey of Agra Foundries-

The survey was conducted in some of the major medium and small scale foundries of Agra, using coke fired cupola (melting rate>3Mt/hr) and relevant data were collected. The same have been used for analysis of technical and economic feasibility of various options. The emission levels of SPM SO_2 CO, CO2 are given in mg/m^3.

B. Emission level

It is found that the emission levels (given in mg/m^3) from these foundries are very high than the CPCB permissible limits (in mg/m^3) as can be seen from table 7

SN	Cupola Inner dia.cms	Name of foundry	SPM	SO_2	CO	CO_2
1.	84	A	1130-2096	254	50.43	71.23
2.	84	B	349		42.33	128.61
3.	81	C	949		124.93	132.50
4.	84	D			50.41	72.55
5.	86.5	E	398	174	61.21	106.18
6.	81	F	309	255	30.50	120.0
7.	66	G	688	169	28.96	66.15
8.	61	H			57.08	83.68
9.	61	I	800	213	56	98
	CPCB permissible Limits (mg/m^3)		150	120	5.0	4.0

Table 7 -CPCB limits and cupola emission level of Agra foundries
These emission level have been experimentally measured in foundries using neck tell gas analyser

VI. Requirement of an ecofriendly furnace

The environmental legislation has made the major impact on the foundry industry and has resulted in closure of foundries in TTZ and Howrah region of West Bengal which has hampered the industrial growth of India. For meeting the CPCB norms, one way is to use different pollution control equipment's like high-energy scrubbers, bag filters, and electrostatic precipitators. However, they are expensive and also consuming more energy. The better alternative, as suggested by the Hon'ble Supreme Court is to clear up the emission of foundries by using suitable technologies to bring down the emission level. The Supreme Court ordered the Central Government to explore the possibility of providing gas as fuel for foundries and to take other suitable measures to bring down

the emission level. Therefore technology used for the furnace must use minimum fuel and emission level of exhaust gases generated must be within the CPCB norms.

SN	Emission level	CPCB Limits mg/m^3	Cupola	Cokeless Cupola oil gas		Induction	Plasma	Arc	Rotary	Crucible
1	SPM<3MT >3MT	450 150	309-2096	35-40	10 <10	300-350	200-250	350-400	40-60	970-1000
2	SO_2	120	169-255	88-90	<40	150-160	120-130	100-150	90	175
3	CO	5.0	28.96 24.93			4-5	4-5	6-7	4.0	6.0-7.0
4	CO_2	4.0	5.3-10.6			3-4	4-5	5-6	3.8	5.0-6.0
5	NO_x	120	166-196							
6	Dust fumes	100	150-200		30-40	60-70	200-220	250-300		125-160

Table 8- Emission level of different furnaces

This needs the design and development of an ecofriendly for ferrous foundries. It will also help in following the orders of Honble Supreme Court, and ultimately prevent the collapse of environment and of foundry industry in our country.

A. Comparison of Emission level of all furnaces with CPCB norms --

The emission levels (mg/m^3) of different furnaces were measured and compared with CPCB limits as given below in table 8-

The Rotary furnace has optimal values for almost all the parameters and aspects. After selecting rotary furnace the experimental investigations have been carried out to further reduce the emission levels of SPM, SO_2, CO_2, CO etc. and make furnace more eco-friendly.

VII. Experimental section (investigations):-

The experimental investigations were carried out to see the effect of identified parameters on the performance of rotary furnace. For this purpose a 200.0 kg rotary furnace was designed and fabricated. The designed rotary furnace was installed at foundry

Shop of M/s Harbhajan Singh Namdhari Enterprises, Industrial estate, Nunihai, Agra. Few experiments have also been conducted on another 200.0 kg rotary furnace installed at foundry shop of the department of Mechanical engineering, faculty of engineering, Dayalbagh Educational Institute (D.E.I.), (a self-deemed university), Dayalbagh), Agra(U.P.) India

A. Description of rotary furnace:-

The rotary furnace consists of a horizontal cylindrical drum, the length and diameter of drum depends upon capacity of furnace, which varies from

200.0 kg/hr to 5.0tone/hr. This drum is mounted on rollers, which are driven by electric geared motor. Two cones one on each side are welded to the drum. The plant lay out is shown in fig.4

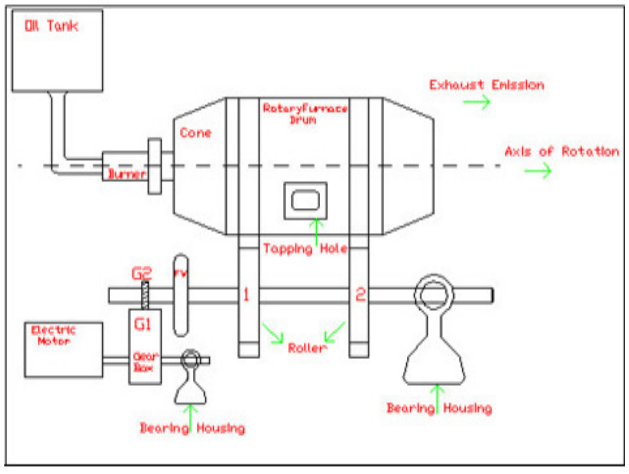

Fig.4-The oil fired rotary furnace

B. Melting Operation-

The process of melting the charge is carried out in the following steps:-

(I) ***Preheating of oil and furnace-(II) Charging– (III) Rotation- (IV) Melting-(V) Inoculation*****-(VI) Pouring–**

C. Operating furnace under existing conditions of operation—

The furnace was operated at 2.0 rpm, as per existing conditions; the charge per heat is 200.0 kg. In first heat, as furnace started from room temperature, more air was required, the flame temperature, preheated air temperature, and melting rate were less, but time and fuel consumption were more. In subsequent heats, the air was reduced, flame temperature, preheated air temperature and melting rate increased whereas the time and fuel consumption decreased. The emission levels remained the same. Observations taken during the experiment are given in table 9-

SN	Heat no	Rpm	Time min	Fuel lit.	Spec. Fuel (lit/kg)	Emission levels- mg/m^3			
						SOx	SPM	CO_2	CO
1	1	2.0	50.0	92.0	0.460	90.0	40.0	4.0	4.0
2	2	2.0	47.0	90.0	0.450	90.0	40.0	4.0	4.0
3	3	2.0	46.0	87.0	0.435	90.0	40.0	4.0	4.0
4	4	2.0	46.0	86.0	0.430	90.0	40.0	4.0	4.0
5	5	2.0	45.0	83.0	0.415	90.0	40.0	4.0	4.0

Table 9-Performance and emission levels of furnace, operated at 2 rpm

A. the Experimental Investigation carried out- the experimental investigations carried out are given in following sections;

(I) Effect of Rotational Speed on energy consumption, emission levels and performance of Furnace-

Under existing conditions the Iron is melted in Rotary furnace by rotating it at rotational speed of 2.0 rpm. The rotation of furnace is very important input parameter. If rotation is high the time of contact between charge and heated refractory will be very less consequently, the rate of heat transfer between the charge and refractory will be very low. Also at higher rotational speed the heat transfer will not be uniform. The air gets trapped inside which increases the blow holes formation and fuel consumption resulting into the reduced melting rate and more rejection of castings.

To study the effect of rotational speed the investigations have been made between 0.8 to 2.0 rpm as described below. The rotational speed is changed from 2.0 rpm to 1.6 rpm and then in steps of 0.2 rpm. Experiments have been conducted at different rotational speeds varying from 0.8 to 2.0 rpm. It was difficult to rotate the furnace below 0.8 rpm. Emission level was measured using Neck tells gas analyser at different rotational speed. For each rotational speed several observations are taken as given in table 10 –

(II) Graphical representation -the graphical representation of effect of rpm on emission levels of SOX, SPM, is shown in fig 5 and on CO_2, CO is shown in fig 6 respectively

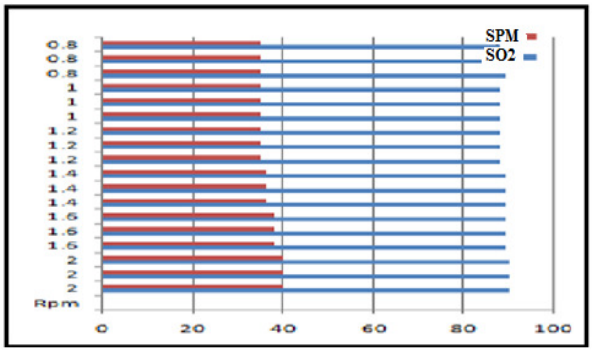

Fig 5-Effect of rpm on emission levels of SO_X, SPM,

SN	Emission levels	Absolute reduction		% Reduction
		2.0rpm	1.0 rpm	
1	SOx	90	88.00	0.02%
2	SPM	40	35.00	2.22%
3	CO_2	4.00	3.90	12.50%
4	CO	4.00	3.90	12.50%

Table 10- Effect of rotational speed on fuel consumption, emission levels and performance of Furnace

VIII. Results and discussions—

The results of above experimental investigations, of reducing rpm from 2.0 to 0.8 are studied and then the optimal values are obtained for energy consumption and emission level of pollutants. These values are obtained at 1.0 rpm. The improvements in performance of furnace by changing rpm from 2.0 to 1.0 are given in table 11–

Table 11- The improvement in performance of furnace by changing rpm from 2.0 to 1.0

S.N	Rpm	Time (min)	Fuel (lit.)	Melting rate kg/hr	Emission levels (mg/m^3)			
					SOx	SPM	**CO_2**	CO
1	2.0	50.00	92.0	240.0	90.0	40.0	4.0	4.0
2	2.0	47.00	88.0	255.0	90.0	40.0	4.0	4.0
3	2.0	45.00	83.0	266.0	90.0	40.0	4.0	4.0
4	1.6	48.00	88.0	250.0	89.0	38.0	4.0	4.0
5	1.6	45.00	83.0	266.0	89.0	38.0	4.0	4.0
6	1.6	43.00	80.0	279.0	89.0	38.0	4.0	4.0
7	1.4	42.00	83.0	286.0	89.0	36.0	4.0	4.0
8	1.4	40.00	80.0	300.0	89.0	36.0	4.0	4.0
9	1.4	39.0	78.0	308.0	89.0	36.0	4.0	4.0
10	1.2	40.00	80.0	300.0	88.0	35.0	4.0	4.0
11	1.2	38.00	78.0	316.0	88.0	35.0	4.0	4.0
12	1.2	37.00	77.0	324.0	88.0	35.0	4.0	4.0
13	1.0	38.00	79.0	316.0	88.0	35.0	3.95	3.90
14	1.0	36.00	77.0	333.0	88.0	35.0	3.95	3.90
15	1.0	35.00	76.0	343.0	88.0	35.0	3.90	3.90
16	0.8	42.00	79.0	286.0	89.0	35.0	3.90	3.90
17	0.8	40.00	78.0	300.0	88.0	35.0	3.90	3.90
18	0.8	38.00	77.0	316.0	88.0	35.0	3.90	3.90

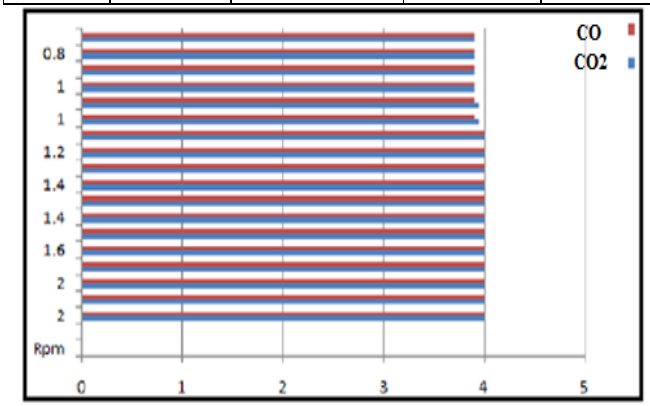

Fig 6-Effect of rpm on emission levels of CO_2, and CO

IX. Conclusions-

It is concluded from these Experimental Investigation that optimal rotational speed of rotary furnace is 1.0 rpm. At this rotational speed, the rate of heat transfer between the charge and heated refractory is optimum which leads to significant reduction in melting time/heat and fuel/heat. It has reduced the emission level of pollutants on an average by7.36%. At this rotational speed it is an *"Eco friendly Furnace for Environmental Conservation in Indian Foundry Industries.*

X. Acknowledgement-

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References

[1]. Abel Tadesse & Hasse Frederickson, "The effects of carbon on the solidification of nodular cast iron– its study with the help of linear variable differential transformer and micro structural analysis" International Journal of Cast Metals Research, vol. 5,issue 9 , sep 2017, Pp: 108-117

[2]. D. Galles & C. Beckerman "Effect of sand dilation on distortions and pattern allowances during steel sand casting" International Journal of Cast Metals Research, vol. 5,issue 2 , February 2017, Pp: 257-275

[3]. A Giglio, A Ammendola, SBattistella "Apismellifera ligustica, Spinola 1806 as bioindicator for detecting environmental contamination: a preliminary study of heavy metal pollution in Trieste, Italy." Environ Sci Pollut Res Int. 2017 Jan;24(1):659-665 Springer

[4]. Alonso et al. "Kinetics of graphite expansion during eutectic solidification of cast iron" "Kinetics of graphite expansion during eutectic solidification of cast iron" Volume 27, Issue 2, 2014 Pp:9 8-107 Published online: 5 Mar 2014

[5]. Agrawal M, Singh B, (2014), "Effect of Air pollution on urban agriculture –A case study" Environmental pollution, 1: 3, 323-329.

[6]. Burckhardt Jeurgen, Pariyar Shyam (2014) "Particulate pollution are capable to degrade epicuticular waxes and to decrease the draught tolerance of Scots pine" Environment and Pollution 184:3, 659-667

[7]. Mansouri B, Hoshyari E, Mansouri A.(2014), "Study on ambient concentration of pollutants (O_3, SO_2, CO and PH_{10}) in different months in shiraz city, Iran". International Journal of Environmental Sciences 1:7, 1440-1446.

[8]. Kumar B. Ganesh, and Prabhakaran N., (2014)."Modified EIA for small and medium projects – An effective method to make the projects Eco-friendly" International journal of environmental sciences. 1:1, 55-65

[9]. Chen Si-Hua (2013), "The game analysis of negative externality of environmental logistics and government regulations", International Journal of environment and pollution, 51:3-4, 143-155,

[10]. Modern casting staff USA. (2013), 47th Census of world casting production, "Dividing Up The Global Market" a Modern casting staff report, December 2013,18-23

[11]. Tan Kok Chooi, Lim, Hwee san Jafri Mohd.Zubir Mat(2013) "Investigation on the annual variability of carbon dioxide column averaged mole fraction in peninsular Malaysia" International Journal of environment and pollution, 53: 1-2, 159-168,

[12]. Vieira Leticia Canal, Korf Eduardo Pavan, Brandi Luciana londero (2013) "Passive samplers for air quality monitoring in a Brazilian university" International Journal of environment and pollution, 53: 1-2, 148-158,

[13]. Hak Young Kim, Seung Wook Beek. (2012) "Experimental study of fuel lean re-burn system for NO_x reduction and CO emission in oxygen enhanced combustion". International Journal of Energy Research, 35:8, 710-720

[14]. Harjani K., Manderia S (2012) "Assessment of ambient air quality and quantitavely crops loss due to cumulative pollution load in south west M.P. India", Third international conference on climate change and sustainability management, ITM University, Gwalior, CP: 25

[15]. Sohail Mohd. Etal (2012),-"Greenhouse emission in SARC nations" Third international conference on climate change and sustainability management, CP-3, ITM University, Gwalior, CP:3,

16. Rastogi Neha, Dixit Neelanchal, Pallavi Pusp,(2011), "Carbon credits and reduction in carbon dioxide emission" intl. conf.-Recent advances in Mechanical Engineering, B.S.A.C.E.T. Mathura, 261-269.

[17].Sanfurjo Jorge, and Sanchez. (2011) "Atmospheric particulate matter concentration and annual variability in an urban area of NW", Spain International journal of environmental sciences, 1:6, 1217-1230.

[18]. Jain RK, Gupta BD, (2010) "Indian ferrous foundries – an overview" Indian Foundry Journal, 56:6, 34-38

[19]. Atash F., (2007) "The deterioration of urban environments in developing countries –Mitigating the air pollution crisis in Tehran, Iran", Cities, 24: 6, 399-409

[20]. Chen L, Markesan K.L, Tong S., (2007) "Spatiotemporal relationship between particle air pollution and respiratory emergency hospital admission in Brisbane, Australia, "Science of the total environment, 373:1, 57-67.

[21]. Franchini M, Manucci PM., (2007)- "Effect of Co_2 on living beings", Journal of Thrombosis and Homeostasis,.5:11, 2169-2174.

*[22]. Anatilis A, Katsouyammi S., (2006) "Short term effect of ambient particles on cardiovascular and respiratory mortality". Epidemiology, 17:3, 230**-233.***