Capacity Building workshop

Pollution Control System

2nd March 2018 at Coimbatore

Under the project
Capacity Building of Local Service Providers (LSPs)

Supported by
GEF-UNIDO-BEE Project
Promoting Energy Efficiency and Renewable Energy in selected MSME clusters in India

teri gef UNIDO BEE COINDIA
COIMBATORE INDUSTRIAL INFRASTRUCTURE ASSOCIATION

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Workshop summary

Overview of workshop

A capacity building workshop of Local Service Providers (LSPs) on Pollution control systems for foundry industry was organized by TERI on 2nd March 2018 in association with COINDIA under GEF-UNIDO project. A total 53 participants attended the workshop and for the industry visit, which was organized after the workshop. Agenda of the workshop and list of participants are attached in Annexures 1 and 2 respectively.

Summary of points discussed in the meeting

The welcome address was made by Mr. S Kuppusamy, President & MD/CEO, COINDIA. He emphasized the importance of the pollution control measures in foundry, as the industry is often perceived to be dark, dirty and dangerous (3D).

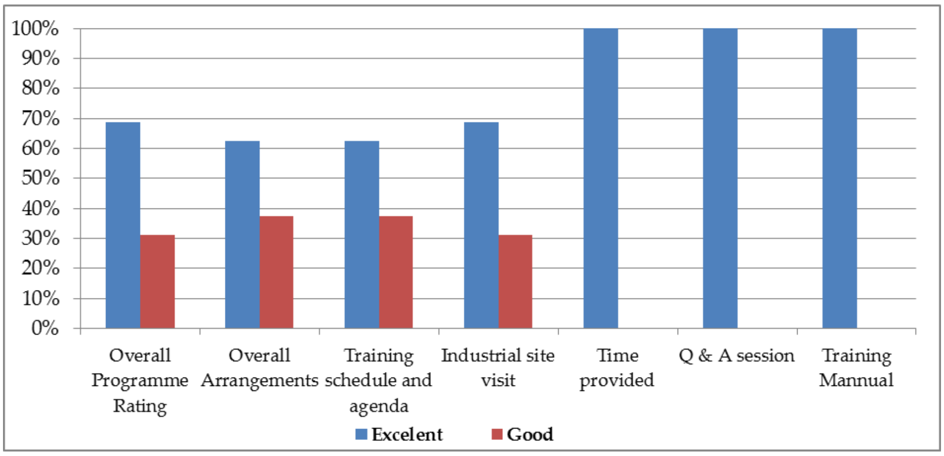
Mr. Prosanto Pal, TERI, made a presentation on common types of pollution control systems (PCS), stack monitoring done by TERI for cupola furnaces and issues in taking correct measurement of the stack. PCS can be broadly classified into four categories (a) Initial separators (settling chamber, baffle chamber) (b) Centrifugal separators (cyclone, multiple cyclone) (c) Low energy scrubbers (spray tower, centrifugal wet cyclone) and (d) High energy scrubbers (venturi-scrubber, fabric filter). Fines in cupola emissions is high (about 16% by weight of particles are < 5 µm 16%). With such high percentage of fines, only high energy scrubbers are useful.

Mr Debasis Bandyopadhyay, GEA Process Engineering, made detailed presentation of the emissions from foundry industry and pollution control systems used. Design of the hood is very important for induction furnaces. He elaborated a special type of wet collector developed by GEA having very high collection efficiency but cheaper compared to venturi scrubber. He explained in detail the operation of venturi-scrubber. The principle of bag filters (pulse jet was explained by him. He mentioned that the temperature of gases is a limiting factor in use of bag filters. The temperatures should be less than 240^{o}C for fabric filters. His presentation was followed by a detailed Q&A session.

After the lunch, plant tour through the M/s PSG Foundry Division was arranged. The foundry has a variety of PCS like venturi-scrubber and bag filter. Hence the participants could see actual implementation of pollution control measures and benefit from the site visit. Selected photos of the workshop and visit are attached in the Annexure 3.

Feedback forms

Based on the analysis of the feedback forms received from the participants, it is observed that workshop was well received by the participants and 100% participants were satisfied with foundry visit, Q&A session and training module provided to them. About 65% participants have rated overall program as “excellent” while rest of them have rated it as “good”. More than 75% of participants were satisfied with arrangements made, training schedule and agenda of the program. Few sample feedback forms are attached in the Annexure 4.



Analysis of feedback forms

Suggestions by participants

Some participants have made suggestions as follows;

1) Animation and video based material
2) Regular interaction and periodic meetings on PCS
3) Implementation of air quality management system

Learning's by participants

Some of the topics learned by the participants and mentioned by them are listed below;

1) Sand plant duct collector system
2) Purpose of hoods and its proper utilisation
3) Stack monitoring
4) Wet scrubber with venturi
5) Selection of PCS

Annexures

Annexure 1: Agenda of the program

Capacity Building workshop

Pollution control systems for foundry industry

2 March 2018

Coimbatore PSG iTECH College, Neelambur campus,

Hall No 304, E4 Seminar Hall, Computer Science Engineering Block - II Floor

Under the project:

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Agenda

10:00 – 10:30	Registration
10:30 – 10:40	**Welcome Address** Mr S Kuppusamy, President & MD/CEO, COINDIA
10:40 – 10:50	**GEF-UNIDO-BEE project and initiatives in Coimbatore cluster** Mr R Sivakumar, UNIDO Cluster Leader - Coimbatore
10:50 – 11:50	**Pollution norms, stack monitoring protocol and commonly used pollution control systems** Mr Prosanto Pal, TERI
11:50 – 12:50	**Air pollution control systems for foundries – selection, design and performance** Mr Debasis Bandyopadhyay, GEA Process Engineering (india) Pvt. Ltd, Mumbai
12.45 – 13:00	Q&A
13:00 – 14:00	Lunch
14:00 – 16:00	**Site Visit / On-site training** Visit to PSG Foundry Division,
16.00 – 16:30	Feedback from participants
16:30 – 16:45	**Vote of thanks**

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Annexure 2: List of participants

S. No	Name	Organization	Mobile No	Email ID
1.	Mr A Pradeepan	Indo Shell Cast Pvt Ltd Unit II	9965488444	mtc2@indoshellcast.com
2.	Mr P Naresh Kumar	Indo Shell Cast Pvt Ltd Unit II	9952881532	mtc2@indoshellcast.com
3.	Mr M Tamilarajan	Vasanthi Foundry	9655506468	vasanthifoundry@gmail.com
4.	Mr R Arunachala Moorthi	Aquasub Engg Foundry-I	9843855004	fdypurchase@aquagroup.in
5.	Mr R Subramaniam	Vasanthi AM Foudry	7598579312	vfoundry@gmail.com
6.	Mr P Sankar	Aquasub Engg Foundry-I	9842114113	fdypurchase@aquagroup.in
7.	Mr S Vijayakumar	Mahedra Pumps Pvt Ltd, Foundry Division	8778765081	U4electrical@mahendrapumps.in
8.	Mr Rajith G	Mahedra Pumps Pvt Ltd, Foundry division	9952285854	ranjith.jao@gmail.com
9.	Mr V Krishna Dass	Acetech Machine Components Pvt Ltd	8973554545	Krishnadass4u@gmail.com
10.	Mr A Periyakuppapillai	Flow Link System (P) Ltd, Fdy-01	9629429253	parthiban0423@gmail.com
11.	Mr R Bala Marugan	Flow Link System (P) Ltd, Fdy-01	7806830947	Bala.dhina123@gmail.com
12.	Mr s Kannabairan	Flow Link System (P) Ltd, Fdy-02	8870069182	Kannaneee371@gmail.com
13.	Mr S Sethpathi	Craftsman Automation	9786205552	sethpathi@craftsmanautomation.com
14.	Mr R Manikandan	Craftsman Automation	9943987012	Manikandan_vz@craftsmanautomation.com
15.	Mr M Mososbabu	Koso India Pvt Ltd	9489905690	mososbabu@koso.co.in
16.	Mr M Jeevanantham	Eltex Super Castings	8825751347	jeevananthamar@gmail.com
17.	Mr C Balaji	Eltex Super Castings	9943605508	Balamech567@gmail.com
18.	Mr B Prasath	Acetech Machinery	9585068000	safety@acetchindia.in
19.	Mr J Elanchelian	Ammarun Foundry	9942994151	production@ammarun.com
20.	Mr S Muthiah	Ammarun Foundry	9095053535	asmuthiah@gmail.com
21.	Mr P Krishnan	United Group of Co's	9159033552	uc@unitedgroupcompanies.com
22.	Mr I Pownraj	Integra Automation	9865318245	fdy-hr@intergraautotmation.net
23.	Mr Ponmalar	Integra Automation	8220000718	fdy-hr@intergraautotmation.net
24.	Mr D Manikandan	Agna Inc	9894930912	admin@agnainc.in
25.	Mr P Rajanagam	Agna Inc	9894930912	admin@agnainc.in
26.	Mr S Manoj Kumar	Janaticks (I) Pvt Ltd	9750331555	jayamohan@janatics.co.in
27.	Mr H Manikandan	Janaticks (I) Pvt Ltd	9894146696	jayamohan@janatics.co.in
28.	Mr K Boopathi	Suguna Machine Works	9442221267	Boopathi4uall@gmail.com

S. No	Name	Organization	Mobile No	Email ID
29.	Mr R Theivendra	Bakgiyan (P) Ltd	9443316943	theindran@bakgyan.com
30.	Mr P Chelluthang	Bakgiyan (P) Ltd	9442116949	Lab@bakgyan.com
31.	Mr Arun Ayyapapa	Rajpreath Industries	9443355533	rajpreath@gmail.com
32.	Mr Guna Shekar	Ramakrishna Foundry	7200428295	Guna.shekar05@googlemail.com
33.	Mr G Shanmugasundaram	S G Pneumatics	9655503167	sales.cp3@sgpneumatics.com
34.	Mr R Ranganathan	A R Engineering	9790383850	a.r.engineeringabe@gmail.com
35.	Mr Debasis Bandyopadhyay	Gea Process Engineering	8452845471	Debases.bandyopadhyay@gea.com
36.	Mr Ram Prakash R	Best Engineering Pumps Pvt Ltd	9003789003	bestlcnc@gmail.com
37.	Mr V P Ramesh	Best Engineering Pumps Pvt Ltd	9843519985	bestlcnc@gmail.com
38.	Mr S Krishna Prasad	Best Engineering Pumps Pvt Ltd	9843362987	bestlcnc@gmail.com
39.	Mr P Kuruppu Soy	Auto Shell	9344331019	hr.ascpc@autoshell.com
40.	Mr T Sivakumarji	Auto Shell	9344397469	hr.ascpc@autoshell.com
41.	Mr Prosanto Pal	TERI	9811799933	prosanto@teri.res.in
42.	Mr T Sarovarnam	Soram Associate	9443036282	Sorranassociates@hotmail.com
43.	Mr S Kothandarama	QFocus Engg	9047589630	Q1947skr@gmail.com
44.	Mr N Jayapathi	TECA	9363228913	jayapathi@gmail.com
45.	Mr R Arun	Suguna	9524683333	arun@sugnagroup.com
46.	Mr S Kuppusamy	PSG Foundry	9952427227	Kuppusamy.s@gmail.com
47.	Mr R Siva Kumar	UNIDO Project	9965250504	Siva.raja076@gmail.com
48.	Mr Hari Bharath K	Vinayaga Castings	9994684086	haribharath@gmail.com
49.	Mr T Bakthivathsalam	Beena Consultancy	9894633883	Bakthavathsalam.t@gmail.com
50.	Mr S R M D Choudhri	Beena Consultancy	9600652985	Srmd1181@gmail.com
51.	Mr G Sethil	LEED	7200784430	water@lrtltd.com
52.	Mr R Padmanaban	V K Foundry	9944148489	Padmanabancoimbatore@gmail.com
53.	Mr S Arjunan	Sree Bakgiyam Engg Corp	7397518555	mr@bakgiyam.com

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Pollution control systems for foundry industry

2 March 2018, Coimbatore PSG iTECH College, Neelambur campus, Hall No 304, E4 Seminar Hall
Computer Science Engineering Block - II Floor

S. No	Name	Organization	Mobile No	Email ID	Signature
1.	A. Pradeepan	Indo Shell Cast Pvt Ltd Unit-II	9965488444	mtc2@indoshellcast.com	[signature]
2.	P. Naresh Kumar	"	9952881532	"	P. Naresh
3.	M. Tamilarasan	Vaijanthi Foundry	9655064647	vaijanthifoundry@gmail.com	[signature]
4.	R. Arunachala Moorthi	AQUA SUB Engg Foundry	98438 55004	fdypurchase@aquagroup.in	R. [signature]
5.	R S Subramaniam	Vaijanthi Am Foundry	7598579312	v-foundry@gmail.com	[signature]
6.	P. Sankar	Aqua sub Engg fdy-I	9842114113	fdy purchase@aquagroup.in	[signature]
7.	S. VIJAYAKUMAR	Mahendrapumps Foundry division	8778765081	V4 electrical@mahendrapumps.in	[signature]

S. No	Name	Organization	Mobile No	Email ID	Signature
8.	RANJITH. G.	MAHENDRA PUMPS PVT LTD Foundry Division	9952285854	ranjith.jao@gmail.com	
9.	V Krishna Dass	Acetech machine Components Pvt. LTD	8973554545	krishnadass[illegible]@gmail.com	
10	A. Periyakaruppapillai	Flow Link System (P) Ltd Fdy-01	9629429253	Parthiban0423@gmail.in	
11	R. Bala murugan	"	7806830947	baladhinc123@gmail.com	
12	S. KANNABIRAN	Flow Link System (P) Ltd Fdy-02	8870069182	kannanEEE371@gmail.com	
13	S. Sethupathi	Craftsman Automation	9786203552	Sethupathi@craftsmanautomation.com	
14	R. Manikandan	"	9943987012	manikandan_va@craftsmanautomation.com	
15	M. MOSESBABU	KOSO INDIA PVT LTD	9489905690	mosesbabu@koso.co.in	
16	M. Jeevanantham	Eltex Super Castings	8825751347	jeevananthamar@gmail.com	
17	C. BALAJI	ELTEX SUPER CASTINGS	9943605508	balamech567@gmail.com	

S. No	Name	Organization	Mobile No	Email ID	Signature
18	B. Prasadh	Acetech Machinery	9585068000	safety@acetechindia.in	B.Prasath
19	J. ELANCHEZIAN	Ammurun Foundry	9942994151	production@ammurun.com	J.El.
20	S. MUTHIAH	AMMARun Foundries	9095053535	as Muthiah @gmail.com	S.Muthy
21	P. KRISHNAN	United Group Co's	9159033552	uc@unitedgroup.co.in	[illegible]
22	I. Pownraj	Integra Automation	9865318245		[illegible]
23	Pon Malar	" "	8220000719	fdy-hr@integraautomation.net	[illegible]
24	D. Manikandan	Agna Inc	9894930918	admin@agnainc.in	D.Manik
25	P. Rajangam	Agna Inc	"	"	[illegible]
26	S. Manojkumar	Janatics (I) Pvt ltd.	9750331555	Jayamohan @ Janatics.co.in	[illegible]
27	M. Manisundan.	Janatics India Pvt Ltd.	9894146696	Jayamohan @Janatics.co.in	M.Mani

S. No	Name	Organization	Mobile No	Email ID	Signature
28	K. BOOPATHI	Suguna Machine Works	9442221267	boopathi4uall@gmail.com	[illegible]
29	R. Theivendran	Bakgiyam (P) Ltd	9443316943	Theivendran@bakgiyam...	[illegible]
30	P. Chelluthangam	Bakgiyam (P) Ltd	9442116949	Lab@bakgiyam.com	[illegible]
31	ANBU AYYAPPAN	RAJPRAKATH Industries	9443355533	rajprakath@gmail.com	[illegible]
32	Gunasekaran	Ramakrishna Foundry	7200428295	guna.shekaro5@google mail.com	[illegible]
33	G Shanmugasundaram	SG Pneumatics	9655503167	sales.cp3@sgpneumatics.com	[illegible]
34	L. Ranganathan	A.R. Enginiring	9790383850	a.r.engineering@gmail.com	[illegible]
35	DEBASIS BANDYOPADHYAY	GEA PROCESS ENGINEERING	8452845471	debasis.bandyopadhyay@gea.com	[illegible]
36	RamPrakash.R	BEST ENGINEERS PUMPS PVT. LTD	9003789003	bestlcnc@gmail.com	[illegible]
37	V.P. Ramesh	" "	9843519985	"	[illegible]

S. No	Name	Organization	Mobile No	Email ID	Signature
38	S. Krishna Prasad	BEST ENGINEERS PUMPS PVT. LTD	9843362987	bestknc@gmail.com	[signature]
39	P. Karuppusamy	Auto Shell	9344331019	hr.ascpc@autoshell	[signature]
40	T. Sivakumar	Auto Shell	9344397469	"	[signature]
41	Prosanta Pal	TERI	9811799533	prosantap@teri.res.in	[signature]
42	T. Saravanan	Sarram Assure	94430362[illegible]	Sarram associates @ hotmail.com	[signature]
43	S. Kothandaraman	Q Focus Engg	90475896[illegible]	[illegible]1947 sk@gmail.com	[signature]
44	N. JAYAPATHI	ADVISER, TECA	9363228913	jayapathi@gmail.com	[signature]
45	R. Arun	Suguna	9524683333	arun@sugunagroup.com	[signature]
46	S. KUPPUSAMY	PSG Foundry	99524 27227	kuppusamy.s @gmail.com	[signature]
47	R. Sivakumar	UNIDO Project	9965250504	Siva.raja076 @gmail.com	[signature]

S. No	Name	Organization	Mobile No	Email ID	Signature
48	HARI BHARATH .K .	VINAYAGA CASTINGS	9994684086	haribharath@gmail.com	[signature]
49	T. BAKTHAVATHSALAM	Beam Comm	98946 33883	bakthavathsalam.t@gmail.com	[signature]
50	S RMD Chandhar		9600652985	srmd1181@gmail.com	[signature]
51	G. Senthil	LEED	7200784430	water@lrtltd.com	[signature]
52	R Padmanabhan	V.K foundry	9944148489	Padmanabhan.coimbatore@gmail.com	[signature]
53	S. ARJUNAN	SREE BAKGIYAM ENGINEERING CORP	7397518555	ms@sakgiyam.com	[signature]
54					
55					
56					
57					

Annexure 3: Selected photographs of the event




Annexure 4: Sample feedback forms

Capacity building workshop

Pollution control systems for foundry industry

2 March 2018

Coimbatore PSG iTECH College, Neelambur campus, Hall No 304, E4 Seminar Hall

Computer Science Engineering Block - II Floor

Supported by:

GEF-UNIDO-BEE Project

Promoting Energy Efficiency and Renewable Energy in selected MSME clusters in India

Evaluation Sheet for Participants

Feedback Form for Participants			
Parameter	***Feedback***		
	Excellent	Good	Average
How would you rate the overall programme?	✓		
How would you rate overall arrangements?	✓		
How was the training schedule and agenda?	✓		
How was the industrial site visit?	✓		
Do you think that adequate time was provided for each topic?	Yes [✓]	No [ ]	
Do you think that satisfactory answers were given to your questions during the training programme?	Yes [✓]	No [ ]	
Do you think that the background training manual is informative and useful enough?	Yes [✓]	No [ ]	
Do you think that the discussion on EE/RE will help you in your work?	Yes [✓]	No [ ]	

Suggestions & Recommendations for improvement:

If possible selection person can maintain the pollution control systems and give manage that person and also good Engineers

Name two learning, which from this programme you will be able to implement in your plant?

Signature:	[signature]
Name of participant:	ANGAN AIYAPPAN
Organization:	RAJPRBATH INDUSTRIES
Mobile No:	94433 55533
Email ID:	rajpraath@gmail.com

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Capacity building workshop

Pollution control systems for foundry industry

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Do you think that the background training manual is informative and useful enough?	Yes [✓]	No [ ]	
Do you think that the discussion on EE/RE will help you in your work?	Yes [✓]	No [ ]	

Suggestions & Recommendations for improvement:

In this program only covered the furnace side, we are interested in moulding sand dust cleared and reusable method in modern foundries.

Name two learning, which from this programme you will be able to implement in your plant?

- New design in wet scrubber
- Bag filter for collecting fumes

Signature: [signature]

Name of participant: S. Sethupathi.

Organization: Craftsman Automation private limited.

Mobile No: 9786205572

Email ID: Sethupathi@ Craftsmanautomation.com

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How was the industrial site visit?	✓		
Do you think that adequate time was provided for each topic?	Yes [✓]	No [ ]	
Do you think that satisfactory answers were given to your questions during the training programme?	Yes [✓]	No [ ]	
Do you think that the background training manual is informative and useful enough?	Yes [✓]	No [ ]	
Do you think that the discussion on EE/RE will help you in your work?	Yes [✓]	No [ ]	

Suggestions & Recommendations for improvement:

More Topics on particles Emissions.

Name two learning, which from this programme you will be able to implement in your plant?

velocity, Particle size filtering

Signature: [signature]

Name of participant: K. BOOPATHI

Organization: SRI SUGUNA MACHINE WORKS - V.K. Road CBE-35

Mobile No: 9442221267

Email ID: boopathi4uall@gmail.com / boopathi_k2004@yahoo.co.in.

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Do you think that the background training manual is informative and useful enough?	Yes [✓]	No [ ]	
Do you think that the discussion on EE/RE will help you in your work?	Yes [✓]	No [ ]	

Suggestions & Recommendations for improvement:

NIL

Name two learning, which from this programme you will be able to implement in your plant?

Signature: [signature]

Name of participant: Arun Ranganathan

Organization: Suguna

Mobile No: 9524683333

Email ID: arun@sugunagroup.com

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Annexure 5: Copy of presentations

Stack monitoring and commonly used pollution control systems in foundries

Training program under GEF-UNIDO-BEE project

Coimbatore

Prosanto Pal
Senior Fellow, TERI, New Delhi
prosanto@teri.res.in

2 March 2018

Outline

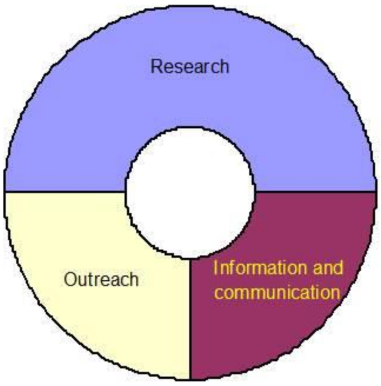
- About TERI
- Common types of pollution control systems used by foundries
- Stack monitoring results
- TERI-SDC technology demonstration for cupola foundries
- Issues in stack monitoring

Origins of TERI

- Conceived by Late Sri Darbari Sethi of Tata Chemicals
- Registered as 'Tata Energy Research Institute' in 1974
- 1974-82 – operated from Mumbai
- Moved to Delhi in 1982
- Own premises at India Habitat Centre in 1994

Research orientation

- Independent, non-profit, research institute
- Core competencies – research, information & communication and training & outreach
- Undertakes sponsored research projects in energy, environment and sustainable development areas
- Major sponsors include GOI, corporate, multilateral & bilateral agencies



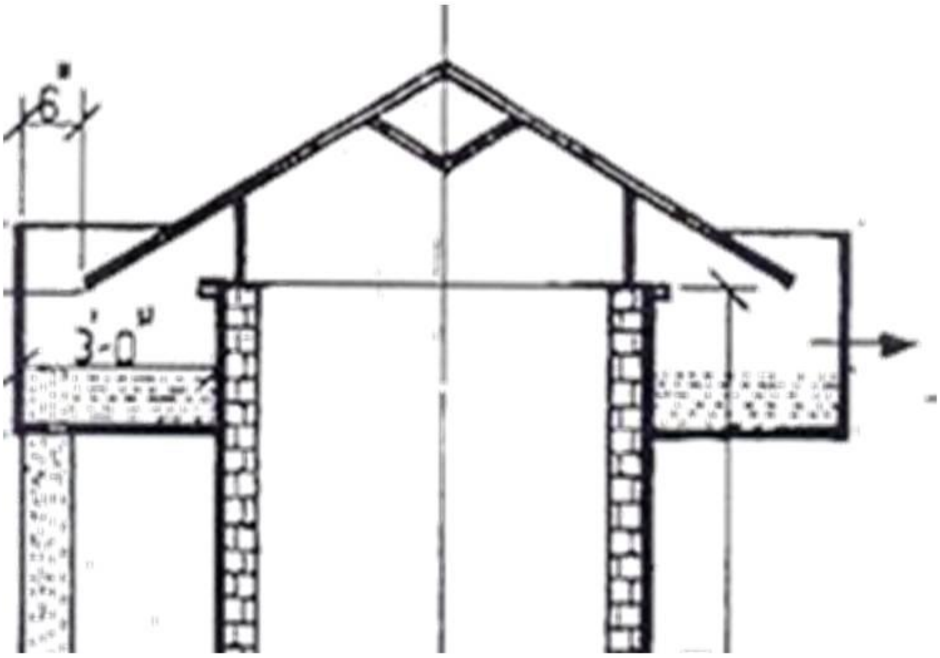
Present PCS status in foundries

- Variety of PCS designs used
- Installed PCS have short life span
- Foundries have poor knowledge on selection of PCS
- Selection of PCS based on informal feedbacks from SPCB
- Lack of knowledge on proper stack monitoring

Important considerations in PCS selection

- Gas velocity and temperature (IS: 11255 (Part III): 1985)
- Dust concentration (IS: 11255 (Part -1): 1985)
- Particle Size Distribution (sieve arrangement)
- Quantify of gases like CO, NOx, SO2 etc (analysers required)

Initial separator - spark arrestor

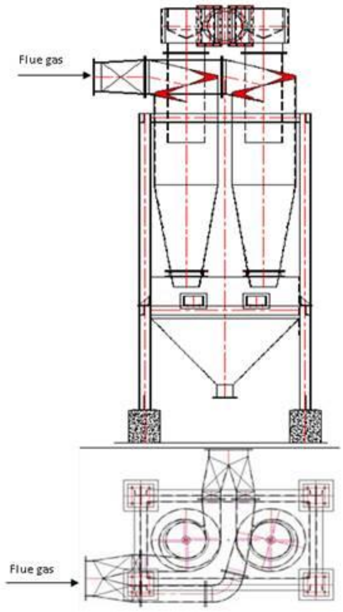


Selection of PCS

*Initial separators (*settling chamber, baffle chamber)

- remove about 90% of larger particles (> 50 µm)
- overall collection efficiency is low (30 - 40%)

Centrifugal separator - cyclone



9

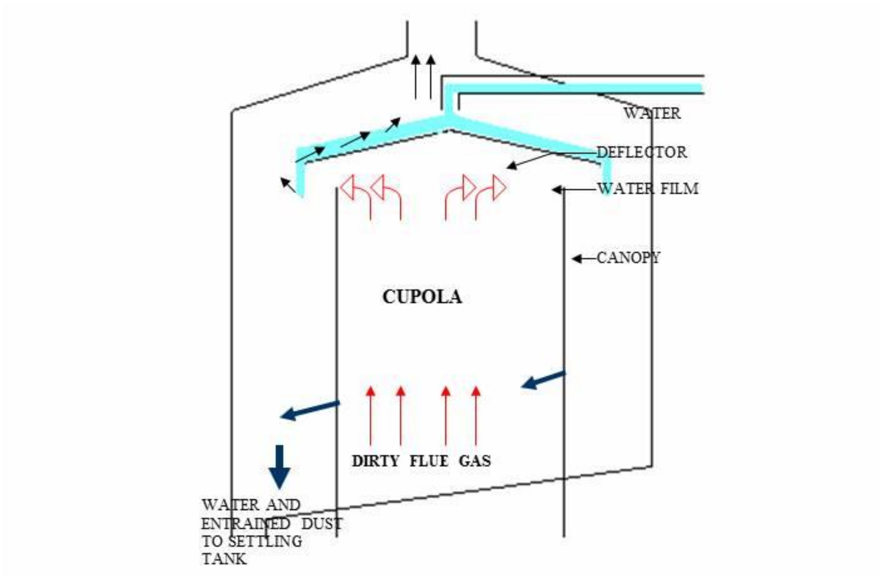
Selection of PCS

Centrifugal separators (cyclone, multiple cyclone)

- remove about 90% of the particles above 10 μm
- overall collection efficiency are about 70%

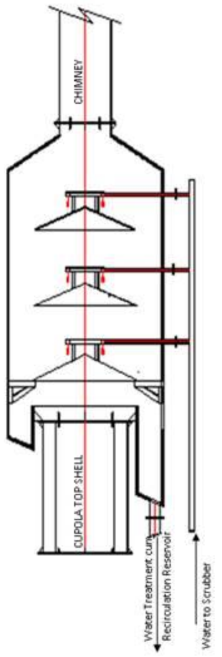
10

Low energy wet-scrubber system



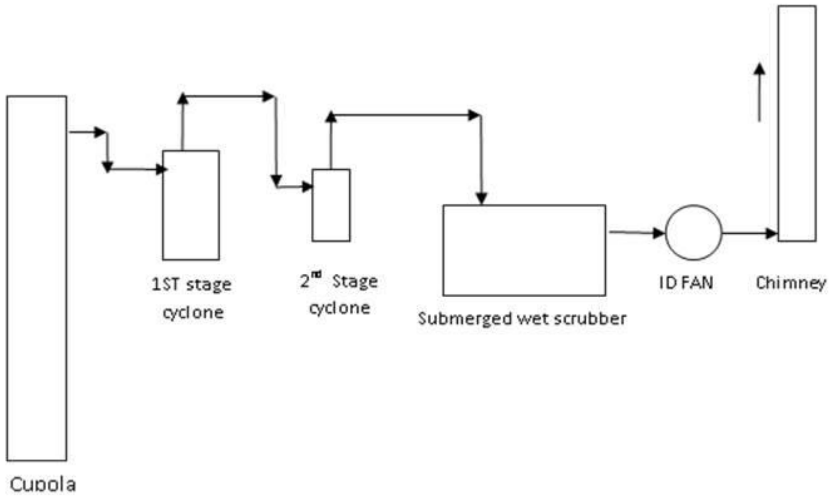
11

Three stage wet-scrubber system



12

Combination of cyclone and wet scrubber



13

Selection of PCS

Low energy scrubbers (spray tower, centrifugal wet cyclone)

- remove the particle size more than 5 µm
- with the overall efficiency of 90%
- Have an added advantage of removing gaseous pollutants like NOx, SO2

14

Selection of PCS

High energy scrubbers

Venturi scrubber

- Particles upto 0.5 µm can be collected with an efficiency of 99%

Fabric filter

- Can remove 0.2 µm size particles with 99% efficiency

15

Commonly used PCS

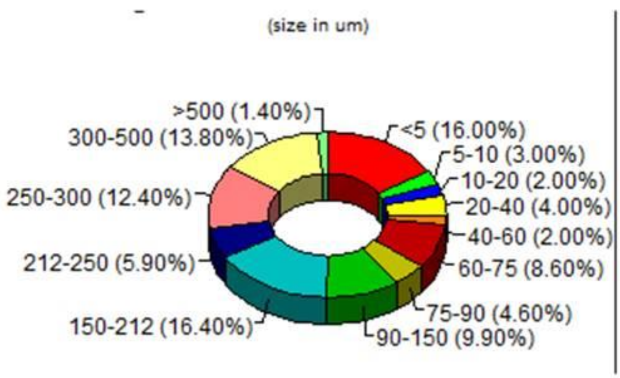
	Minimum Particle size, µm	Collection efficiency, %
Initial separators (settling chamber, baffle chamber)	> 50 µm	30-40
Centrifugal separators (cyclone, multiple cyclone)	> 10 µm	70
Low energy scrubbers (spray tower, centrifugal wet cyclone)	> 5 µm	90
Venturi-scrubber	> 0.5 µm	99
Fabric filter	> 0.2 µm	99

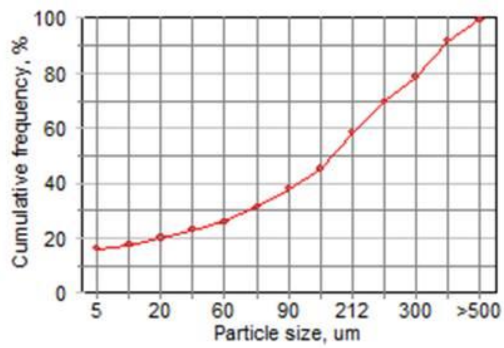
16

Stack monitoring results

17

Particle size distribution of cupola flue gas analysed by centrifugal dust classifier





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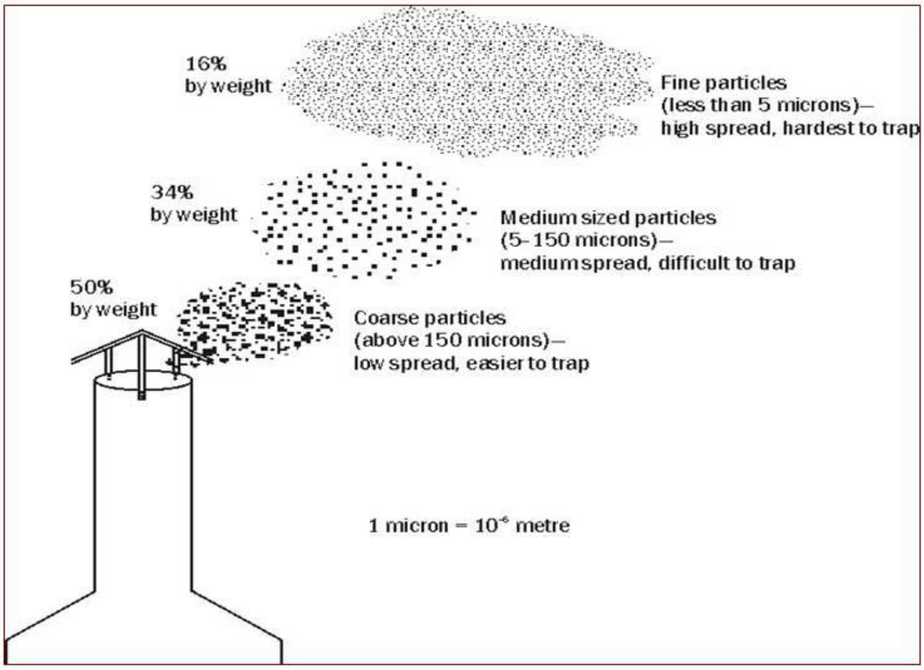

Figure 3

19

Typical emission levels from cupola

Unit	Location	Particulate matter emission, g/Nm^3
Foundry 1	Below scrubber, charging door open	1.17
	Below scrubber, charging door open	2.20
Foundry 2	Sampling port, charging door open	1.38
	Sampling port, charging door open	3.94

20

Selection criteria of PCS

- Fines in cupola emissions is high (< 5 μm 16%)
- Ability to meet the 150 mg/Nm3 norm
- Life of the equipment
- Ability to control SO2 emissions

21

TERI-SDC demonstration Plant

Demonstration Plant at Bharat Engineering Works, Howrah

Commissioned 1998

DBC – Divided Blast Cupola

Bucket charging system

PCS – Pollution Control System (venturi-scrubber)

100 ft free standing chimney

22

Salient features of the new design

- Divided blast cupola
- Venturi scrubber system
  - fitted with variable throat
  - critical surfaces made of stainless steel
  - gas tight construction with explosion doors

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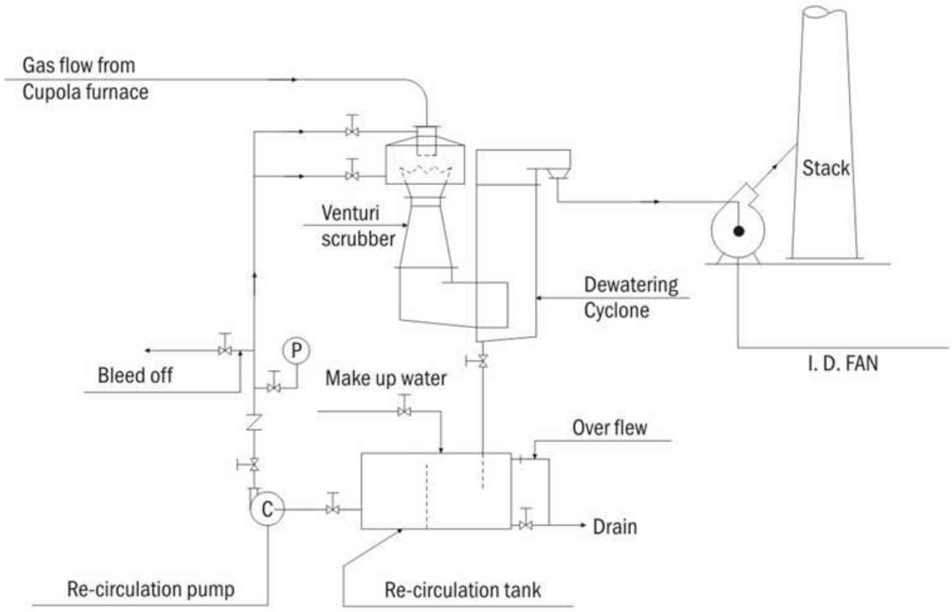
Selection criteria of PCS

Schematic Diagram for Venturi Scrubbing System



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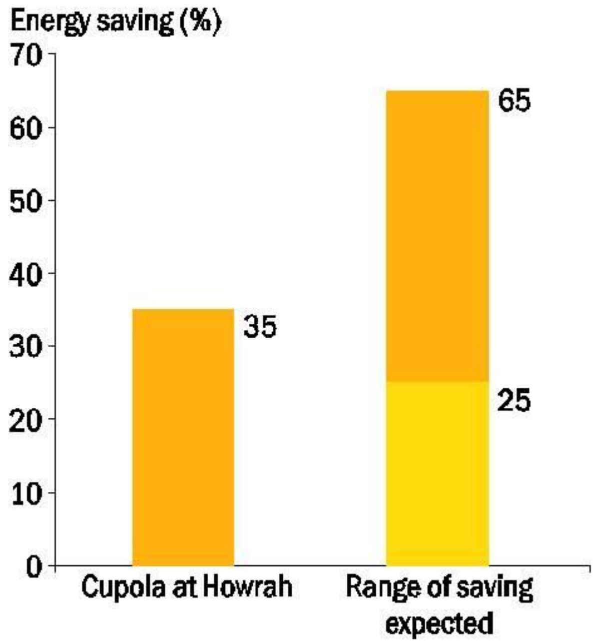
Energy performance

Coke charge in CC 13.6%

Coke charge in DBC 8.8 %

Energy savings 35 % [(13.6 – 8.8)/13.6]



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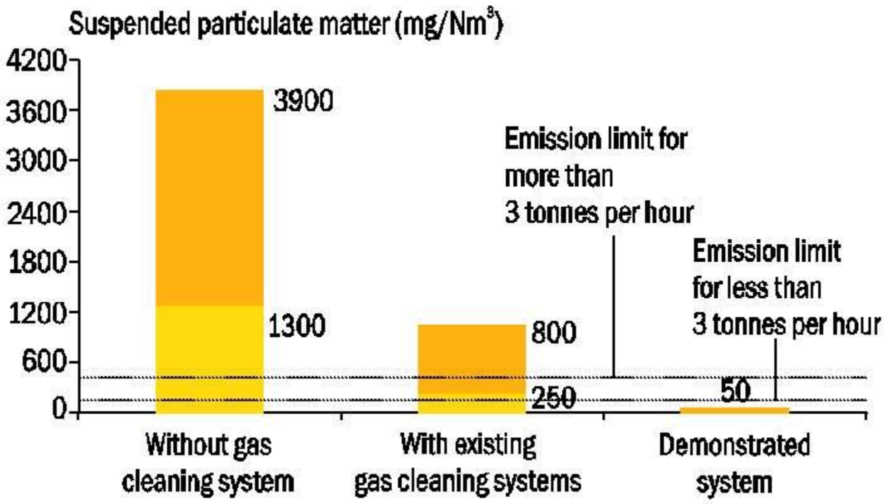
Environment performance



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Issues in iso-kinetic sampling

- Gas velocity needs to be calculated at different traverse points in the stack
- Gas flow rate (m3/hr) is then calculated from average velocity and duct cross-sectional area
- Correct determination of the average velocity of flue gas is most important
- Velocity of flue gas also determines iso-kinetic sampling required for emission measurement
- About 5 Pa is the lowest pressure difference that can practically be measured under field conditions using standard pitot tube and inclined mannometer. This is equivalent to a gas velocity of about 3 m/s

Issues in measuring dust concentration

- Particle size distribution of the flue gases is the most important guiding factor for selection of pollution control devices
- It is a recognised fact that the correct determination of particle size distribution of the stack flue gases is the difficult task
- Usually fibre glass filter papers are used during sampling of stack particulate emission. Finer particulates get deposited on the fibre glass filter paper, due to having fibre on filter paper, it is very difficult to remove particulates from filter paper which would lead to erroneous results. Image analyzer would be better choice for particle size analysis

Thank you
for your kind attention!


GEA Process Engineering
Air pollution control systems for foundries – selection, design and performance
DEBASIS BANDYOPADHYAY- 02-03-2018
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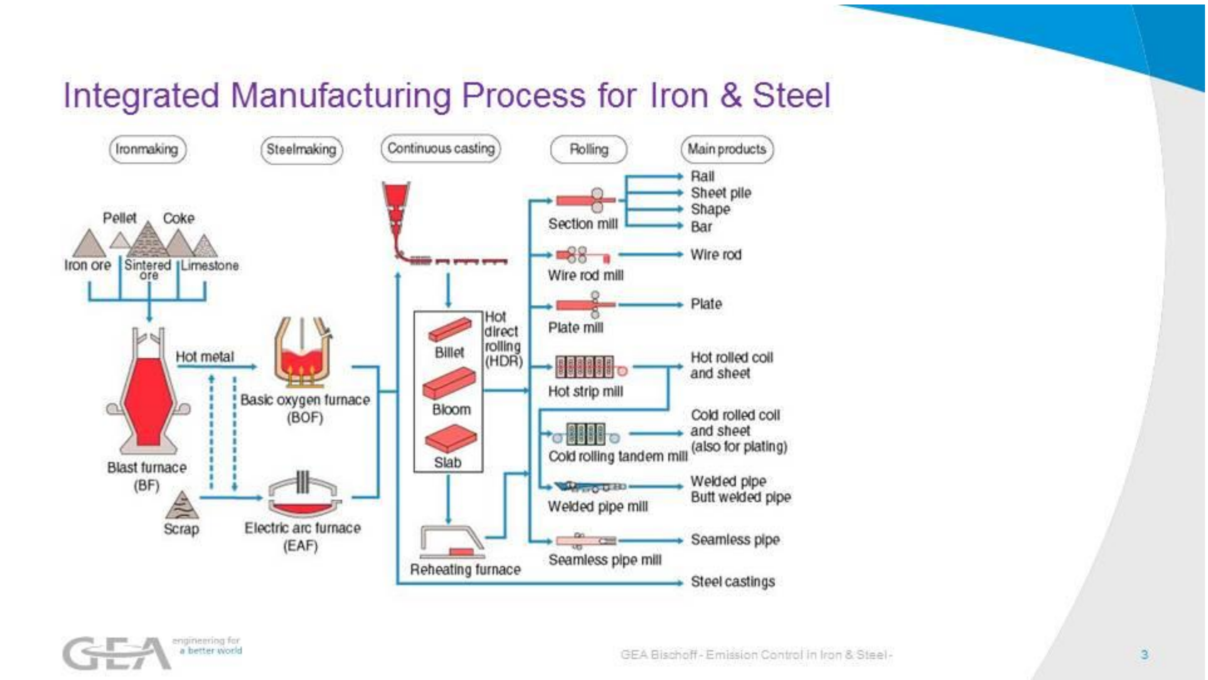
Iron and Steel - Summary of References
Coking Plants > 320 units
Ore beneficiation > 310 units
Pig Iron > 120 units
Steel Making > 230 units
Rolling Mill > 30 units
GEA Bischoff References in the Iron and Steel Industry > 1000 units
GEA
2


Integrated Manufacturing Process for Iron & Steel
Ironmaking
Steelmaking
Continuous casting
Rolling
Main products
Pellet
Coke
Iron ore
Sintered ore
Limestone
Hot metal
Basic oxygen furnace (BOF)
Blast furnace (BF)
Scrap
Electric arc furnace (EAF)
Billet
Bloom
Slab
Hot direct rolling (HDR)
Reheating furnace
Section mill
Wire rod mill
Plate mill
Hot strip mill
Cold rolling tandem mill
Welded pipe mill
Seamless pipe mill
Rail
Sheet pile
Shape
Bar
Wire rod
Plate
Hot rolled coil and sheet
Cold rolled coil and sheet (also for plating)
Welded pipe
Butt welded pipe
Seamless pipe
Steel castings
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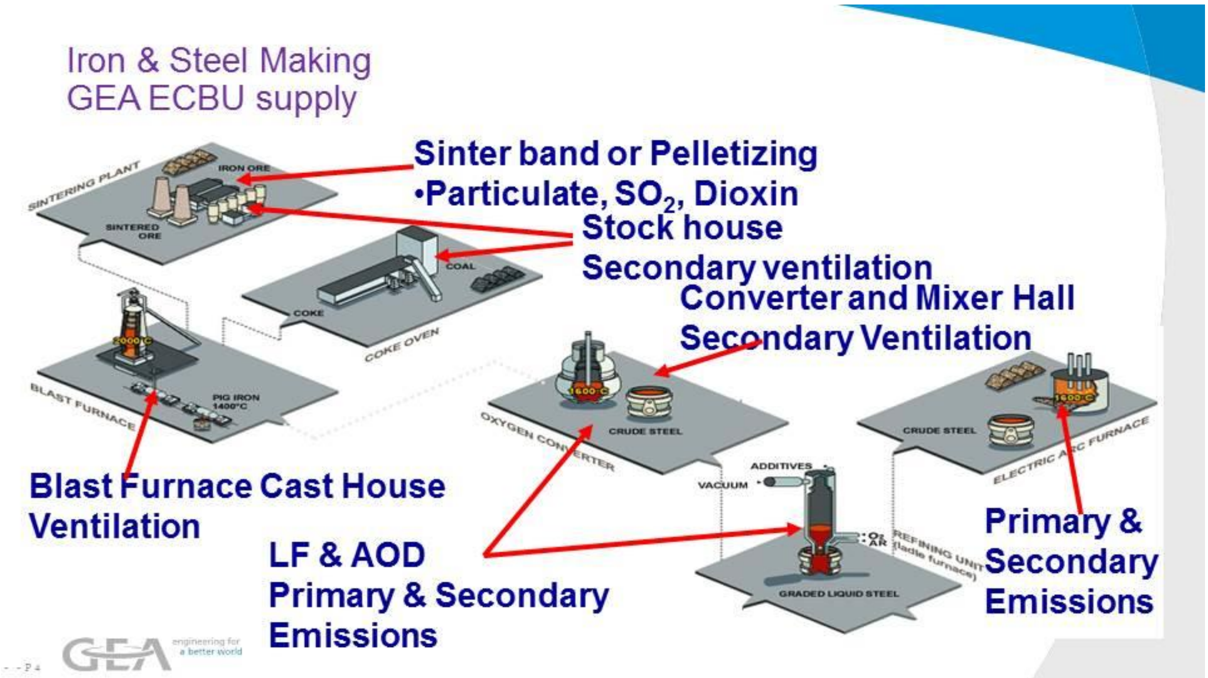
GEA Bischoff - Emission Control in Iron & Steel -
3


Iron & Steel Making
GEA ECBU supply
Sinter band or Pelletizing
•Particulate, SO2, Dioxin
Stock house
Secondary ventilation
Converter and Mixer Hall
Secondary Ventilation
Blast Furnace Cast House
Ventilation
LF & AOD
Primary & Secondary
Emissions
Primary &
Secondary
Emissions
SINTERING PLANT
IRON ORE
SINTERED ORE
COAL
COKE
COKE OVEN
BLAST FURNACE
PIG IRON 1400°C
OXYGEN CONVERTER
CRUDE STEEL
ADDITIVES
VACUUM
GRADED LIQUID STEEL
ELECTRIC ARC FURNACE
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Cast Iron Foundry

Cast Iron Foundry

- A **Foundry** is a factory that produces metal castings.
- Metals are cast into shapes by melting them into a liquid, pouring the metal in a mold.
- **Cupola furnace** is a melting device used in foundries to melt cast iron.

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Cast Iron Foundry

Typical gas conditions

	Typical	Max	Min
Temperature [°C]	200	350	100
Moisture [% v/v]	xx	xx	xx
Composition N_2	76		
[%v/v (dry) O_2	2		
CO_2	17		
SO_2	5		

Typical dust properties

	Typical	Max	Min
Inlet burden [g/Nm^3 (wet)	7	10	2
Resistivity	xxxxxx		
Grain size d50 [u]	xx		
Composition [%w/w]	Oxides of Fe, Si, Cu		

Process description:

The cupolas are used for melting of cast iron, which is produced by re melting pig iron and cast iron scrap in a suitable composition. The cupola is like a blast furnace or a shaft furnace, where the inlet for the feed material and the outlet for some of the flue gas are at the top of the furnace and the outlet for the final product and the inlet for the air are at the bottom of the furnace. There is also an outlet for flue gas at the middle of the furnace. This flue gas goes into a combustion chamber and a heat exchanger, where the blast air is pre-heated.

There are usually at least two parallel furnaces, since the furnace can be in operation just 10-12 hours before it needs one day maintenance.

In the cold blast cupolas the blast air is not -pre-heated and the flue gas will therefore have a higher temperature.

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Cast Iron Foundry

What type of air pollution is emitted from foundries?

Foundries emit air pollution from several different processes. These processes include ferroalloy production, aluminum scrap processing, and other metal melting/alloying processes. Potential sources of air pollution exist within each process, including emissions from scrap pretreatment, melting, tapping, chlorine de-magging, and sand handling. The main types of air pollution emitted from foundries include:

- **Particulates** from mold making, melting, tapping, blasting, grinding and finishing.
- **Volatile Organic Compounds (VOCs)** emitted when materials covered with cutting fluids or oils undergo scrap pretreatment. VOCs are also generated during mold and core making.
- **Chlorine emissions** from chlorine de-magging processes associated with aluminum scrap processing.
- **Combustion by-products, such as carbon monoxide (CO) and nitrogen oxide (NOx)** emitted from gas-fired smelters. **VOCs** from incomplete combustion can also be generated, particularly if specialty alloys are used or produced.

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Foundry ventilation, general

Typical gas conditions

	Typical	*Max*	*Min*
Temperature [°C]	50	100	20
Moisture [% v/v]	xx	xx	xx
Composition N_2	xx		
[%v/v (dry) O_2	xx		
CO_2	xx		
SO_2	xx		

Typical dust properties

	Typical	*Max*	*Min*
Inlet burden [g/Nm^3 (wet)	3	5	1
Resistivity	xxxxxx		
Grain size d50 [u]	xx		
Composition [%w/w]	xx		
	xx		

Process description:

There are several different applications collected under this process number and it is not possible to give a good process description. The process has to be studied for each specific case.

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Foundries- CPCB Emission Standards

31.0 FOUNDRIES : EMISSION STANDARDS

		Pollutant	Concentration (mg/Nm^3)
(a)	Cupola Capacity (melting rate):		
	Less than 3 tonne/hr	particulate matter	450
	3 tonne/hr and above	-do-	150
(b)	Arc Furnaces Capacity: All sizes	particulate matter	150
(c)	Induction Furnaces Capacity: All sizes	-do-	150

Note:

(i) It is essential that stack is constructed over the cupola beyond the charging door and the emissions are directed through the stack which should be atleast six times the diameter of cupola.

(ii) In respect of arc furnaces and induction furnaces, provision has to be made for collecting the metal fumes before discharging the emissions through the stack

Source : EPA Notification
[G.S.R. 742(E), dt 30th Aug., 1990]

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21.0 CUPOLA FURNACE: EMISSION STANDARD

Parameter	Emission limit
Sulphur dioxide (SO_2)	300 mg/Nm^3 at 12% CO_2 corrections

To achieve the standard, foundries may install scrubber, followed by a stack of height six times the diameter of the Cupola beyond the charging door.

Note :
In case due to some technical reasons, installation of scrubber is not possible, then value of SO_2 to the ambient air has to be effected through the stack height.

Source : EPA Notification
[GSR No. 176(E), April 2, 1996]

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4-26 **Industrial Ventilation**

Table 4–3. Dust Collector Selection Guide

Operation	Concen-tration Note 1	Particle Sizes Note w	Collector Types Used in Industry: Dry Cen-trifugal Collector	Wet Collector	Fabric Collector	Low-Volt Electro-static	Hi-Volt Electro-static
FOUNDRY							
a. Shakeout	light-moderate	fine	N	O	O	N	N
b. Sand handling	moderate	fine-medium	N	O	O	N	N
c. Tumbling mills	heavy	medium-coarse	N	S	O	N	N
d. Abrasive cleaning	moderate-heavy	fine-medium	N	S	O	N	N
METAL MELTING							
a. Steel blast furnace	heavy	varied	N	O	S	N	S
b. Steel open hearth	moderate	fine-coarse	N	O	S	N	S
c. Steel electric furnace	light	fine	N	S	O	N	S
d. Ferrous cupola	moderate	varied	N	O	O	N	
e. Non-ferrous reverberatory	varied	fine	N	S	O	N	N
f. Non-ferrous crucible	light	fine	N	S	O	N	N

Note 1: Light: less than 2 gr/ft³; Moderage: 2 to 5 gr/ft³; Heavy: 5 gr/ft³ and up.
Note 2: Fine: 50% less than 5 microns; Medium: 50% 5 to 15 microns; Coarse: 50% 15 microns and larger.
Note 3: O = often; S = seldom; N = never.

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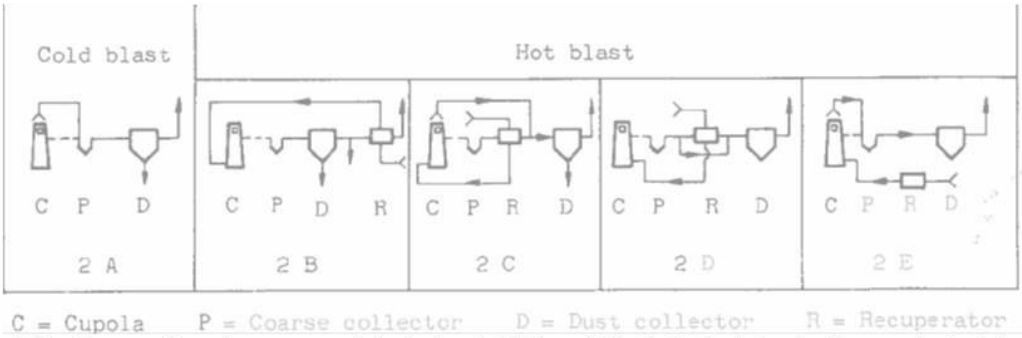
Alternatives for connecting dust collector to Cupola



In all alternatives as per figures above, a coarse collector has been installed immediately after the Cupola to reduce the coarse abrasive dust passed on the recuperator or dust collector.

In case of alternatives 2A and 2E, a spray chamber may also be mounted directly on top of furnace, if the purification requirement fall within the capacity of this dust collector

Locating the recuperator ahead of the the dust collector as in figures 2C and 2D will result in higher maintenance costs for the recuperator as compared with figure 2B, where the same has been located after the dust collector

In the case of all alternatives above, higher gas temperature are encountered during burn down and the extraction systems must thus be designed with this in mind.

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U.S. Patent Aug. 3, 1976 3,972,518

[57] **ABSTRACT**

The invention discloses a method and apparatus for conditioning the gases discharged from a cupola. The apparatus consists of three flow connected vessels comprising first the cupola with improved gas conditioning means therein, secondly, a water spray tower and thirdly, a baghouse dust collector. The improved gas conditioning method and apparatus comprises a movably mounted conduit and nozzle for spraying cooling water through the cupola charge door during the burn-down period of cupola operation when the bed gas is not used to pre-heat the new charges in the cupola. The cooling water is used instead of large quantities of dilution air to temper the discharge gas at this point. Therefore, by the improved method, during burn-down the temperature of the discharged gas can be maintained at slightly above the normal cupola operational temperature without requiring discharge ducts and dust collection capacity for the additional dilution air. The elimination of the additional dilution air results in a corresponding decrease in the size and expense of the discharge ducts and the dust collecting system.

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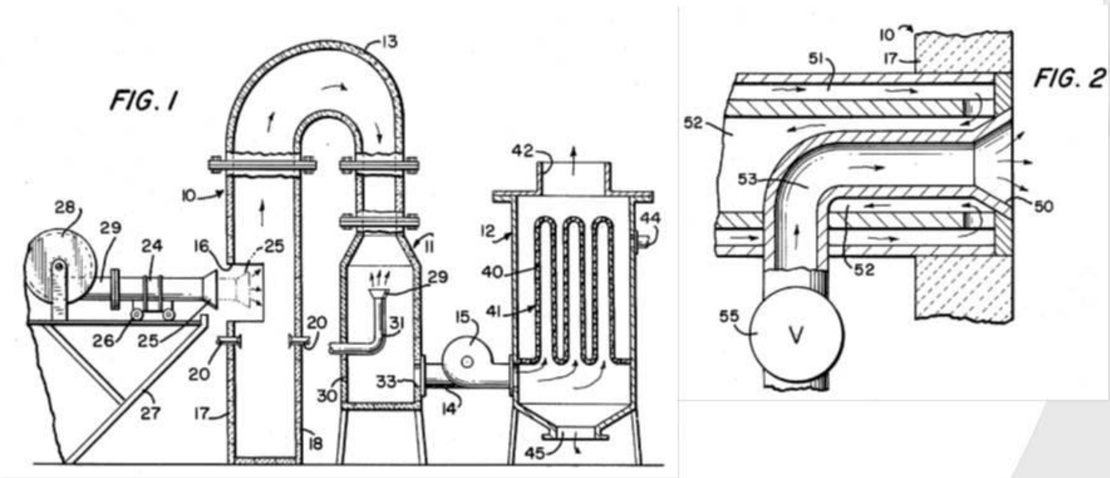
U.S. Patent Aug. 3, 1976 3,972,518



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Induction Furnace

An **Induction Furnace** is an electrical furnace in which the heat is applied by induction heating of metal.[1][2][3] Induction furnace capacities range from less than one kilogram to one hundred tonnes, and are used to melt iron and steel, copper, aluminium, and precious metals.

The advantage of the induction furnace is a clean, energy-efficient and well-controllable melting process compared to most other means of metal melting.

Most modern foundries use this type of furnace, and now also more iron foundries are replacing cupolas with induction furnaces to melt cast iron, as the former emit lots of dust and other pollutants.[4]

Since no arc or combustion is used, the temperature of the material is no higher than required to melt it; this can prevent loss of valuable alloying elements.[5]

The one major drawback to induction furnace usage in a foundry is the lack of refining capacity; charge materials must be clean of oxidation products and of a known composition and some alloying elements may be lost due to oxidation (and must be re-added to the melt).

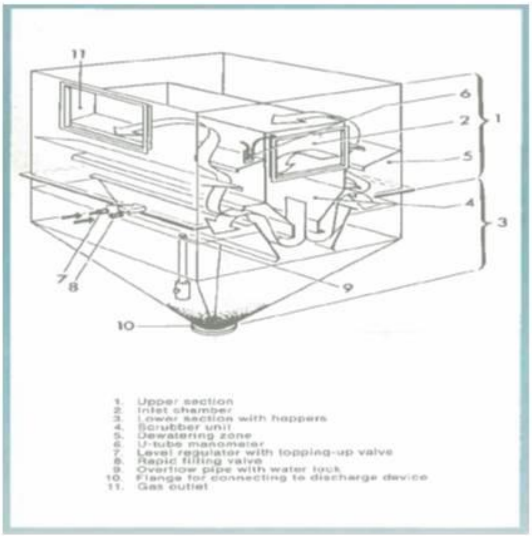
Table 12.13-1 (Metric Units). EMISSION FACTORS FOR STEEL FOUNDRIES

Process	Filterable Particulate[a] (TSP)	EMISSION FACTOR RATING	Nitrogen Oxides	EMISSION FACTOR RATING	Filterable PM-10	EMISSION FACTOR RATING
Melting						
Electric arc[b,c] (SCC 3-04-007-01)	6.5 (2 to 20)	E	0.1	E	ND	NA
Open hearth[d,e] (SCC 3-04-007-02)	5.5 (1 to 10)	E	0.005	E	ND	NA
Open hearth oxygen lanced[f,g] (SCC 3-04-007-03)	5 (4 to 5.5)	E	ND	NA	ND	NA
Electric induction[h] (SCC 3-04-007-05)	0.05	E	ND	NA	0.045	E
Sand grinding/handling in mold and core making[j] (SCC 3-04-007-06)	ND	NA	NA	NA	0.27[k] 3.0	E E
Core ovens[j] (SCC 3-04-007-07)	ND	NA	ND	NA	1.11[k] 0.45	E E
Pouring and casting[j] (SCC 3-04-007-08)	ND	NA	ND	NA	1.4	E
Casting cleaning[j] (SCC 3-04-007-11)	ND	NA	NA	NA	0.85	E
Charge handling[j] (SCC 3-04-007-12)	ND	NA	NA	NA	0.18	E
Casting cooling[j] (SCC 3-04-007-13)	ND	NA	NA	NA	0.7	E

[a] Expressed as kg/Mg of metal processed. If the scrap metal is very dirty or oily, or if increased oxygen lancing is employed, the emission factor should be chosen from the high side of the factor range. SCC = Source Classification Code. ND = no data. NA = not applicable.
[b] Electrostatic precipitator, 92 to 98% control efficiency; baghouse (fabric filter), 98 to 99% control efficiency; venturi scrubber, 94 to 98% control efficiency.
[c] References 2-7.
[d] Electrostatic precipitator, 95 to 98% control efficiency; baghouse , 99.9% control efficiency; venturi scrubber, 96 to 99% control efficiency.
[e] References 2,8-10.
[f] Electrostatic precipitator, 95 to 98% control efficiency; baghouse, 99% control efficiency; venturi scrubber, 95 to 98% control efficiency.
[g] References 5,11.
[h] Usually not controlled.
[j] Reference 13.
[k] Emission factor expressed as kg of pollutant/Mg of sand handled.

1/95
Metallurgical Industry
12.13-5

Wet Collector – Medium efficiency



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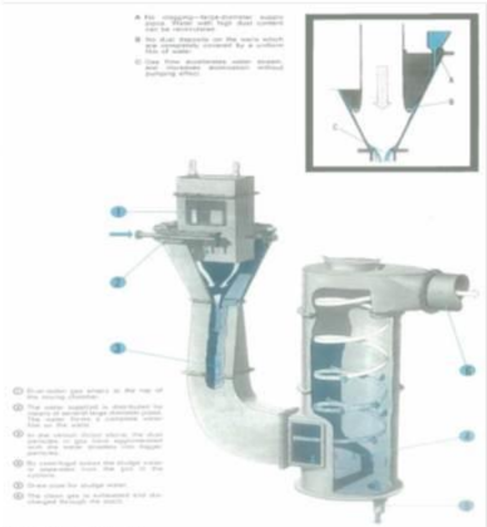
The figure shows a type of Wet collector which offers 60-85% efficiency approximately.

This kind does not utilize circulating water.

Normally, the gas temperature must be reduced to 200-400 deg.C before entering the collector due to mechanical design.

High Efficiency Wet type collector using Venturi Principle



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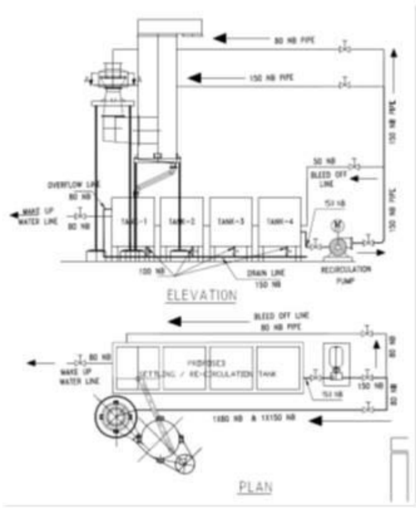
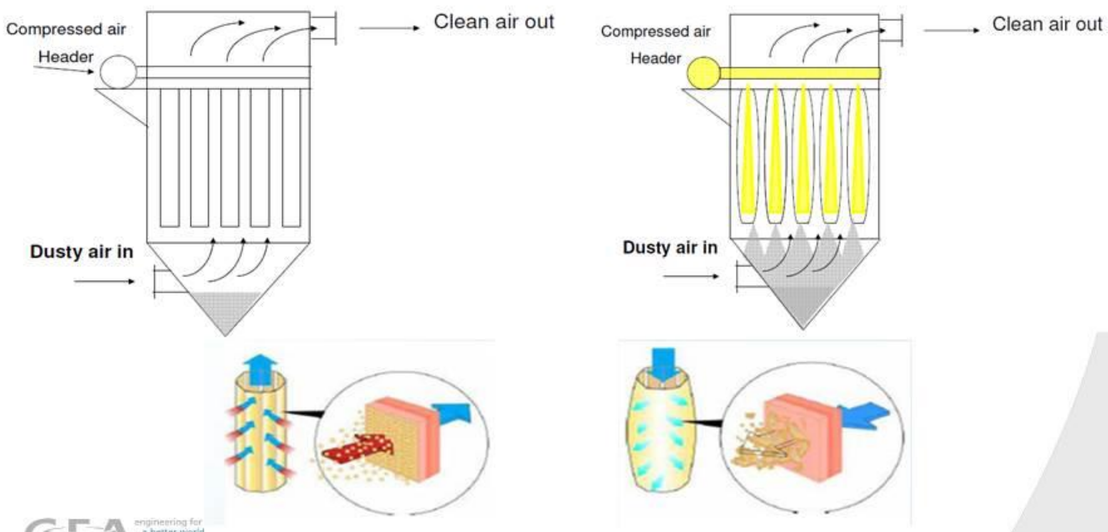
- The Venturi principle (allowing the attainment of great differences in velocity between water droplets and dust particles) is employed for high efficiency collection
- The dust finer dust particles encounter water droplets in the venture throat causing them to agglomerate. These agglomerates thus formed are subsequently collected in mechanical collector of cyclone type.
- In general, it may be said of wet type collectors for cupola pollution control that water may absorb upto 70-80% of the SO_2 according to type of collector and the pH of water.
- In order to avoid water pollution it is normal to employ a closed circulating system. In such a system, the pH of the water must be checked in order to avoid corrosion of the parts of the system that are in contact with theshould be water.
- For full protection against corrosion, the entire wet collector should be built of corrosion resistant materials, since sulphuric acid may condense in parts of the system which are not flushed by water- e.g. in greater part of cyclone as well as in Fan and Stack.

Schematic of Water Circuit - Typical



- The treatment system for the sludge water may be arranged in many ways, depending on factors such as volume of water in circulation, the amount of dust, and the sensivity of the Wet type collector in presence of dust in the water.
- Since the Cupola will normally operate only for a limited no. of hours each day, it is often possible to allow the dust content of the water to rise during operation, the finer dust settling later during the period of shutdown. This permits keeping the dimensions of the settling arrangements to a minimm.
- Most designs of Wet type collector have no moving parts and hence none of the associated wear and clogging problems. They are highly reliable and have lower Installation cost compared to dry collectors like Bag Filter
- However, they do have the higher power consumption compared to dry collectors.

Pulse Jet Bag House



Dry dust collector – Fabric Filter

A Fabric Filter separates dust from gas flow by a Strainer effect. The dust collected on the Fabric is removed by reverse pulse jet by compressed air.

In view of the greater sensivity of fabrics to temperature, the equipment for lowering gas temperature must be reliable. The following alternatives are available for the reduction of temperature of the gases, which may be as hot as 1200 deg.C during blow out.

- Dilution with air: Easiest method with least risk of operating troubles. Gives the highest volume of gases to be handled by the collectors and hence higher installation cost.
- Cooling by water in a spray tower: The most efficient method but can give rise to condensation problems if temperature are not watched carefully. Is best used in combination with air dilution.
- Radiation: Final temperature is difficult to monitor and the method should be used in combination with some other. Require large cooling surfaces
- Recuperator: Best combined with some other method, since the final temperature is difficult to monitor

- To prevent the formation of pockets of explosive gases and reduce the amount of oily contaminants etc., it is best to burn the gases before they enter the fabric collector installation. Combustion may take place in a combustion chamber/recuperator or above the charge in the Cupola with the aid of an auxiliary burner.
- Fabric Filters achieve very high efficiency and work at lower pressure drops compared to wet collectors.
- They are however, sensitive to temperature and gas conditions and also require regular maintenance due to intermittent operation characteristics of Cupola Furnace

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Filter Media - Material Summary

Filter media summary

Material	PES	PAC	PPS	PI	PTFE	GLS
Polymer Common trade name	Polyester	Dolanit Ricem	Ryton Procon Torcon	P84	Teflon	Fibreglass
Temperature degC						
Continuous	135	125	175	200	240	240
Peak	150	130	200	260	260	280
Resistance						
Acid	3	4	4	3	5	4
Alkali	2	3	4	3	5	3
Hydrolysis (H2O)	2	4-5	5	3	5	5
Oxidation (O2)	5	3	3	3-4	5	5
Abrasion	5	3-4	3-4	4	3	1
Price rel. to PES	1	1.5	3.5	6.5	15	2.5

1 = Bad, 2 = Mediocre, 3 = Generally good, 4 = Good, 5 = Excellent

- This table summarizes the properties of the most common filter materials. The table also includes material resistance rankings with regard to acid attack, hydrolysis (moisture attack) etc.
- The Gas temperature and dust analysis are decisive in the choice of fabric.
- Since glass fibre is sensitive to flourine compounds, it cannot be used if fluorspar is added to the Cupola charge

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Fabric Filter Design

- **Filter Type and Size** (**A/C Ratio**- Application specific)
- **Filter Bag Material** (Chosen as per requirements of service life, pressure drop and dust emission)
- **Bag Geometry** (Depends on type of filter design, round for HPBH and elliptical for LPBH, Bag Length-Standard available, selection is based on Process application, foot print)
- **On-Line Maintenance** (Compartmentalized design, one compartment can be maintained On-line at a time)

Structural/Modular Fabric Filter *(One row or two rows- maximum 3 modules/compartments per row is recommended)*

- **Inlet/Outlet Plenums** (For proper gas distribution)
- **Dampers** (For Isolation during on line maintenance)
- **Hoppers** (To ensure proper dust discharge)
- **Maintenance Access**
- **By-Pass** – Process application specific.
- **Thermal Expansion** – as required.
- **Controls and Monitoring**

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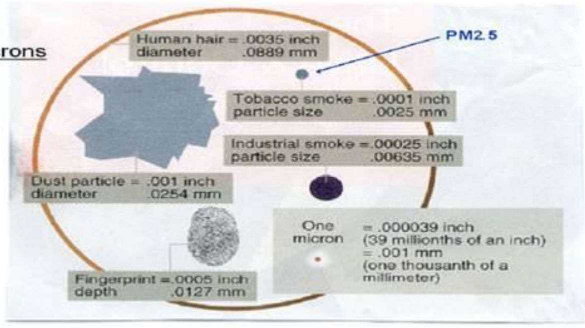
Dust Particle Size Information

What is PM2.5?

Particulate Matter <2.5 microns
Solid Particles
Metals
Hg^O & Hg^P
Acid Mists
Liquid Droplets



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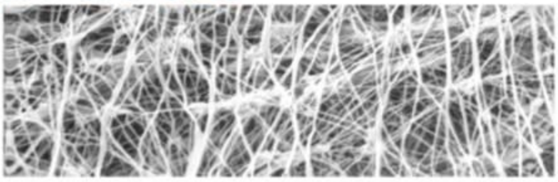
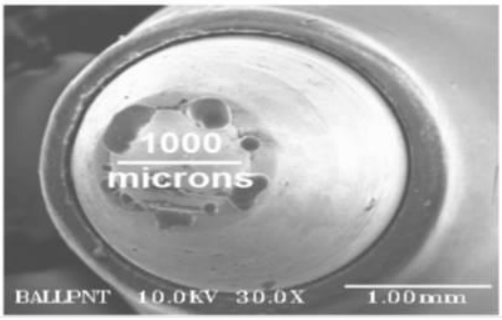
Felt Pore Size





-Average Membrane Pore Size 0.5 - 1 micron, effective pore size much smaller.

-Traditional woven / felts typically have a 20 micron pore size.

-Can fit approximately 1000-2000 pores across the tip of a ball point pen.

-100 million pores per square centimeter

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Compressed Air Supply

- For the function of the total filter as well as the cleaning system it is of great importance that the compressed air has a good quality and that the system has sufficient capacity .
- A bad quality may give corrosion in the pressure tank, disturbances in the function of the pulse valve and clogging of filter bag.
- Insufficient capacity will give a too long pause-time which will reduce the possibility to clean the filter bags during high load resulting in high pressure drop and decreased gas flow.
- General demands for the compressed air

Filter classes according to ISO 8573.1:2001:

Water content	Filter CLASS 4
Particle content	Filter CLASS 3
Oil content	< 0,02g/Nm³

The absolute values for each class can be read in the table

Compressed Air Purity Classes A, B, C:

Where:
A = solid particle class designation
B = humidity and liquid water class designation
C = oil class designation

CLASS	SOLID PARTICLES, PARTICLE SIZE, d (mm)			HUMIDITY AND LIQUID WATER		OIL	
	0.10 < d ≤ 0.5	0.5 < d ≤ 1.0	1.0 < d ≤ 5.0	PRESSURE DEW POINT		TOTAL CONCENTRATION: AEROSOL, LIQUID AND VAPOR	
	MAXIMUM NUMBER OF PARTICLES PER m³			°C	°F	mg/m³	ppm/w/w
0	As Specified			As Specified		As Specified	
1	100	1	0	≤-70	-94	≤0.01	≤0.008
2	100,000	1,000	10	≤-40	-40	≤0.1	≤0.08
3	—	10,000	500	≤-20	-4	≤1	≤0.8
4	—	—	1,000	≤+3	38	≤5	≤4
5	—	—	20,000	≤+7	45		
6				≤+10	50		
				LIQUID WATER CONTENT Cw g/m³			
7				Cw ≤ 0.5			
8				0.5 < Cw ≤ 5			
9				5 < Cw ≤ 10			
PER ISO8573-1: 2001(E)							

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Thank you !
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