

RRST-Environmental Science

## Co-processing of ETP Sludge of ACC Madukkarai

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Article Info	Abstract
<b>Article History</b> <i>Received</i> : 13-04-2011 <i>Revised</i> : 05-10-2011 <i>Accepted</i> : 05-10-2011	M/S Ford India private Limited, it is one of the leading vehicles manufactures generated large amount chemical sludge and oil wastes during its manufacturing operations. The hazardous waste generates from ford company was co-processed during the trial burn conducted at ACC Madukkarai cement works. Co-processing of ETP- sludge the cement kiln is the most scientific and environmentally sound manner without influencing emissions on partial replacement of traditional fuel. Co-processing in cement kiln ranks higher in the waste management hierarchy, when compared to other disposal options such as incineration and landfill, Co-processing does not leave behind any residue that might have harmful impacts on the environment. Thus it is an ecologically sustainable solution for waste management. All the results are under permissible limit as per Central Pollution Control Board for the common hazardous waste incinerators.
<b>*Corresponding Author</b> <i>Tel</i> : +9107614042780 <i>Fax</i> : +9107614042780  <i>Email:</i> psbundela@hotmail.com	<b>Key Words:</b> Clinker, Cement, Heat, Hazardous waste, Disposal

### Introduction

India is the second fastest growing major economy in the world, with a GDP growth rate around 8%. Due to the boom in the economy and enhanced industrial growth, the management of wastes generated, is posing a very serious threat to the society from the health, safety and environmental viewpoint. The generation rate of hazardous wastes in the country, as per the official records, is estimated to be about 4 million tons per annum and that of the Municipal Solid Waste (MSW) is about 40 million tons per annum. There are also numerous non-hazardous wastes from agricultural activities and industries, the generation rate of which is about 400 million tons per annum. Proper measures and guidelines are required for the management of these huge quantities of wastes, whether it be for their disposal or for their gainful utilization. Co-processing refers to the use of waste materials in industrial processes as alternative fuels and raw materials (AFR) to recover energy and material from them. Due to the high temperature and long residence time in cement kiln all types of wastes can be effectively disposed without any harmful emissions [1]. Co-processing is a more environmentally friendly and sustainable method of waste disposal as compared to land filling and incineration because of reduced emissions and no residue after the treatment. The purpose of co-processing trial is to demonstrate that the kiln is able to co-process hazardous waste in an environmentally safe and sound manner. The emission monitoring results of the trial burn forms a basis, to demonstrate that co-processing is an environmentally sound, effective waste disposal/recovery technology, to the authorities and other stakeholders associated with the activity. The co-processing trial is carried out in three phases, namely, pre co-processing, co-processing and post coprocessing, in order to

monitor the kiln stack emission before, during and after the coprocessing of the waste material. All concerned stakeholders are informed about the trial in advance [2-3]. During the co-processing trial burn of Chemical ETP Sludge waste from Ford India Private Limited conducted from 22nd to 26th June, 2008 at ACC Madukkarai Cement Works, an experienced team comprising of senior officials from ACC and representatives from Ford India Private Limited were involved.

### Materials and Methods

#### *Plant, Kiln and Control System Description*

ACC Madukkarai Works was established in 1934 as a semi wet process with 5 kilns and a clinkerization capacity of 1200 tones per day. The inception of single kiln based on Semi wet process was in 1989 with capacity of 1500 TPD. Currently the plant has kiln with a capacity of 2400 TPD. The plant is located in the Coimbatore district of Tamil Nadu. The two mines namely Madukkarai and Walayar serve as the limestone source for the plant and other major raw material components include clay, sandstone, blue dust and bauxite [4]. The flow sheet for the manufacturing of clinker (intermediate product) is attached as figure 1 and 2.

#### *Cement Production Process in Brief*

Cement is made by heating a mixture of calcareous and argillaceous materials to a temperature of about 1450oC. In this process, partial fusion occurs and nodules of clinker are formed. The cooled clinker is mixed with a few percent of gypsum, and sometimes other cementitious materials, and ground into a fine meal - cement. The schematic diagram of the cement production process is given below figure 1.

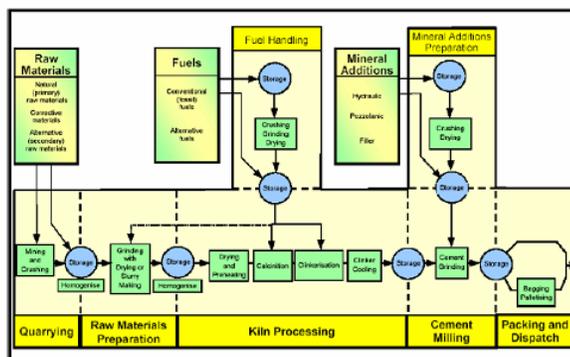


Figure 1. Schematic Diagram of Cement Production Process

The main components of clinker are lime (CaO), silica (SiO<sub>2</sub>), alumina (Al<sub>2</sub>O<sub>3</sub>) and iron oxide (Fe<sub>2</sub>O<sub>3</sub>). The first stage in the industrial process of cement manufacture is the quarrying of raw materials. To obtain the proper composition of the raw mix, corrective ingredients normally have to be added to the quarried raw materials. Examples of corrective materials are sand, bauxite and iron ore; which compensate for deficiencies of silica, alumina and iron oxide, respectively. After pre-blending, the chemically balanced raw mix passes through the mill feed system, to the 300 tons per hour roller mill. The mill is fed with hot gases from the kiln to dry the raw mix to less than 1% humidity. The dried material is then conveyed to the blending silo where continuous homogenization ensures the correct raw meal composition. The clinker production is

performed in a dry suspension pre-heater cement kiln equipped with a pre-calciner. The kiln rotates with a speed of 2.4 rounds per minute, is 3.75 meter in diameter and 55 meter long. It has a two string pre-heater tower (4 stages and 2 stages respectively) and produces approximately 2400 tones of the intermediate product - clinker - per day. The clinker is cooled in a grate cooler, 20.57 meter long and 2.45 meter wide. The maximum feeding capacity is 160 tons of raw meal per hour to the second stage cyclone from the top. The main burner is a Duflox, usually fired with 3 tons of coal per hour. After the clinkerisation process the material is sent to the cement mill where the mineral component such as fly ash and gypsum are added to produce Portland Pozzolona cement [5].

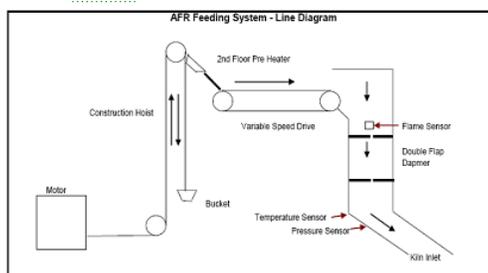


Figure 2. Line diagram of waste feeding system

**Feeding Arrangement for the Waste Material**

The feeding system installed for the waste co-processing consists of construction hoist with bucket, hopper, belt conveyer, double flap damper and shut off gate. The hoist lifts the waste material packed in bags from the ground level to the 2nd floor of the preheater tower. The capacity of the hoist is 3 tons. The volume of the hoist bucket is 0.4m<sup>3</sup>. The material is unloaded from the bucket on the feeding platform. The waste packed in bags are then fed into the opening of feeding chute through a variable speed belt conveyor. A double flap damper is used in order to avoid the false air entry. A shut off gate has been incorporated in the system keeping safety considerations in view. Both the double flap damper and the shut off gate are interlocked with kiln operation ensuring safety in case of back firing. In order to maintain the feed rate of waste material, a counter is placed on the belt to check the number of bags co-processed. A hooter has been provided at the platform which

gives signal to the trained labour to put the waste packed in bag on to the belt at the pre-decided frequency according to the set point set from the central control room. Fire, temperature and pressure sensors are also provided at the chute ensuring proper flow of material as well as safety.

**Co-processing Trial  
Hazardous Waste Used for Trial**

Ford Motor Company, an American company, manufactures and sells automobiles worldwide. Ford introduced itself in India in 1988 as M/s Ford India Private Limited, Chengalpattu, Kancheepuram, Chennai. It's one of the leading vehicle manufacturers in India. The products manufactured are Fusion, Fiesta, Mondeo and Endeavour with a capacity of 1, 00,000 vehicles per annum. Ford India Private Limited generates Chemical ETP Sludge, Phosphate Sludge and oily rags waste during its manufacturing operations. The flow chart of waste generation from production activities at

Ford India Private Limited is attached as respectively. Ford's authorization for transportation and disposal of hazardous waste from Tamil Nadu Pollution Control Board is attached.

The following hazardous waste from Ford was co-processed during the trial burn conducted at ACC Madukkarai Cement Works from 22nd to 26th June 2008. Ford had forwarded the sample of the Chemical ETP Sludge waste to ACC for the evaluation of co-processing feasibility. The waste was analyzed at the R&D of ACC Limited located at Thane. The analysis result of the Chemical ETP Sludge is attached.

Based on the analysis, ACC confirmed to Ford that the Chemical ETP Sludge waste can be disposed by co-processing at cement kiln in ACC Madukkarai Works.

#### ***Receipt of Chemical ETP Sludge Waste from Ford for Trial***

Ford India Private Limited delivered 86.49 tons of Chemical ETP Sludge waste for trial purpose. Total material was delivered in four trucks, bearing the following details in table-1:

Table 1. Transportation Details of Chemical ETP Sludge

<i>Truck No.</i>	<i>Quantity (MT)</i>	<i>Received On</i>
TN21 AY 6031	24.52	28th Feb. 08
TN21 AZ 7745	18.10	28th Feb. 08
TN21AX 2011	22.00	20th Mar. 08
TN21 AY 0213	21.87	02nd Jun. 08

#### ***Hazardous Waste Storage and Handling***

##### ***Hazardous Waste Storage and Handling at Ford India***

The Chemical ETP Sludge was stored in HDPE bags (approx. weight 12.5 kg) in Ford's hazardous waste storage shed. The waste was transported to ACC Madukkarai Works by State Pollution Control Board authorized transporter.

##### ***Temporary Hazardous Waste Storage Shed at ACC Madukkarai Works***

The Chemical ETP Sludge was stored in two containers (40 Feet long) having a ventilation window and the separation was made with in the containers in order to avoid mixing of waste. Boards displaying precautionary measures, safety signs and waste specific workplace labels for handling hazardous waste material were displayed at strategic locations. Fire extinguishers - both dry & CO<sub>2</sub> type - were available near the storage container. Risk Assessment Procedure (RAP) and Safety Manual were prepared by ACC safety team in association with Ford India safety team for Chemical ETP Sludge before transportation of waste from Ford India to Madukkarai Works. The RAP and workplace label for Chemical ETP Sludge waste are attached.

Both the containers were located at a distance of 150 - 200 m away from the bucket loading point.

##### ***Hazardous Waste Handling at ACC Madukkarai Cement Works***

The unloading operation was performed at ACC Madukkarai by four persons equipped with personal protective gear. The bagged wastes were unloaded manually and stored at designated sites in the container. The workers & supervisors were trained in handling and safety aspects of hazardous waste well in advance of the trial burn. Concerned personnel were also trained on precautions to be undertaken, emergency measures, potential spill abatement, proper use and upkeep of PPEs, etc. At the time of feeding the bags were loaded on Trolley to transport the material from the containers to the hoist. The entire unloading and storage operation were carried out under the supervision of AFR Coordinator of ACC Madukkarai [6].

#### ***Standard Operating procedure for the waste material***

Following are the SOP implemented during the Co processing Trial

1. The Truck containing the waste from Ford India Private Limited, entered the premises of ACC Madukkarai Works through the weigh bridge, where the weight was recorded. The truck then moved towards the temporary storage area.

2. The concerned officer (AFR Coordinator) was informed by the security. The concerned officer checked the manifest related to transportation of waste.

3. Waste was unloaded from the truck with the help of laborers in presence of security guards, safety officer and kept in storage containers separately.

4. The weight of the material was recorded in the log book.

5. Empty truck was again weighed to check on the net weight of the material received.

6. The net weight of the truck was also recorded in the log book.

7. For co processing, the waste material packed in bags was loaded into the trolley

(Dedicated for transporting the Hazardous waste) with the help of labor and transported to the ground floor of the pre heater (near to the bucket of construction hoist) under the vigilance of guard and AFR coordinator.

8. Separate register was maintained for keeping the records of the material flow for the waste.

9. The waste was fed in the bucket and was lifted to the 2nd floor having the feeding arrangement to the Kiln inlet.

10. The bucket was tilted to towards the conveyor belt.

11. The labor after receiving the signal from hooter (frequency of the hooter can be controlled from the CCR) put the bag containing waste on the belt conveyor and the bags enters in the kiln inlet through a chute.

#### ***Outline of Monitoring Plan during Co-processing Trial***

The purpose of the co-processing trial is to demonstrate that the kiln is able to coprocess hazardous waste in an environmentally friendly manner. The emission monitoring results from the trial burn serves as a basis to demonstrate the environmentally sound performance of co-processing to the authorities and other stakeholders in the waste disposal activity.

The co-processing trial of Chemical ETP Sludge waste from Ford, which was conducted between 22nd to 26th June, 2008 was carried out in three phases (namely, Pre Co-processing, Co-processing and Post Coprocessing) and was as per the Holcim

EMR Guidelines. There was a kiln stabilization period with conventional fuel for a span of 24 hours before the start of the trial. Table 2 provides the list of emission parameters which were monitored during each phase of the trial.

Table 2. Emission Monitoring during Each Phase of the Co-processing Trial

S. No	Parameter	Method	No. of Sample	Frequency
1.	Particulate Matter	USEPA (5/17)	3	Once in each shift
2.	SO <sub>2</sub>	USEPA (6A/B)	3	Once in each shift
3.	HCl, HF	USEPA 26 (ion chromatography)	3	Once in each shift
4.	HBr	USEPA 26 (ion chromatography)	3	Once in each shift
5.	NO <sub>x</sub>	Instrumental (electro-chemical sensor)	3	Once in each shift
6.	Hg (particulate & gaseous)	USEPA 101 A (cold vapour AAS)	3	Once in each shift
7.	Metals (particulate & gaseous) - Antimony, Arsenic, Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Nickel, Thallium, Vanadium, Zinc.	USEPA 29 (IP-MS)	3	Once in each shift
8.	Dioxins & Furans (I-TEF)*	USEPA 23A	3	Once in each shift
9.	TOC / Total Hydrocarbon (continuous monitoring for 24 hours)	USEPA Method 25 A	1	Once over a period of 24 hours
10.	Benzene	NIOSH 1503	3	Once in each shift
11.	PAH (particulate & gaseous)	TO13	1	Once in each phase
12.	NH <sub>3</sub>	Indo phenol	3	Once in each shift

\*Sampling by SGS India & testing by SGS Institute for Applied Chromatography, Belgium, accredited to ISO 17025 by Beltest.

Hourly samples of all raw materials (lime stone, bauxite & iron ore), raw meal, kiln coal, calciner coal, clinker and Chemical ETP Sludge waste were collected and one

composite sample on daily basis was made. The parameters that were analyzed in all the samples mentioned above are listed in Table 3, 4 and 5.

Table 3. Analysis Parameters for Raw Meal and Coal Samples

S. No	Parameter	Method	No. of Sample
1	Antimony, Arsenic, Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Nickel, Thallium, Vanadium, Mercury, Zinc.	Microwave digestion & AAS/ICP MS/APHA	1
2	Total Organic Carbon	NCEA-C-1282	1

Table 4. Analysis Parameters for Clinker Samples

S. No	Parameter	Method	No. of Sample
1	Antimony, Arsenic, Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Nickel, Thallium, Vanadium, Mercury, Zinc	Microwave digestion & AAS/ICP MS/APHA	1

Table 5. Analysis Parameters for Chemical ETP Sludge Samples

S. No	Parameter	Method	No. of Sample
1.	Antimony, Arsenic, Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Nickel, Thallium, Vanadium, Mercury, Zinc.	Microwave digestion & AAS/ICP MS/APHA	1
2.	Gross Calorific Value	By Bomb Calorimeter	1
3.	Ultimate Analysis (C, H <sub>2</sub> , N <sub>2</sub> , O <sub>2</sub> )	By CHNSO Analyzer	1
4.	Proximate Analysis (Moisture, Ash, Volatile Matter, Fixed Carbon)	By Thermo Gravimetric Analyzer	1
5.	Total Organic Carbon	NCEA-C-1282	1
6.	Total Petroleum Hydrocarbon	EPA 1664	1
7.	Organo Chlorine Compound	AOAC 8270 C	1
8.	VOCs & Semi VOCs	ASTM 3686	1
9.	PCBs	EPA 8082	1
10.	PCPs	EPA 8270C	1



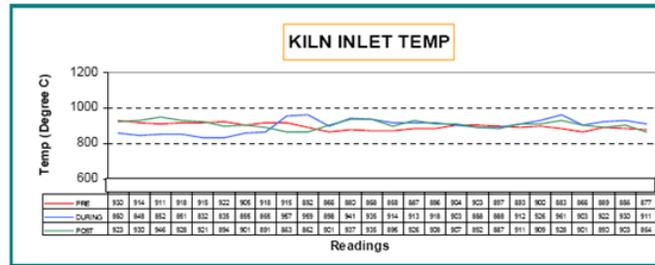


Figure 2.4. Kiln Inlet Temperature (°C)

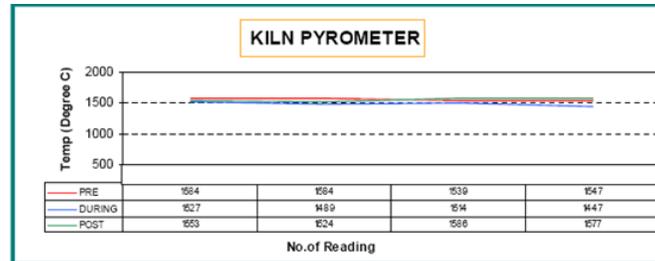


Figure 2.5. Kiln Pyrometer (°C)

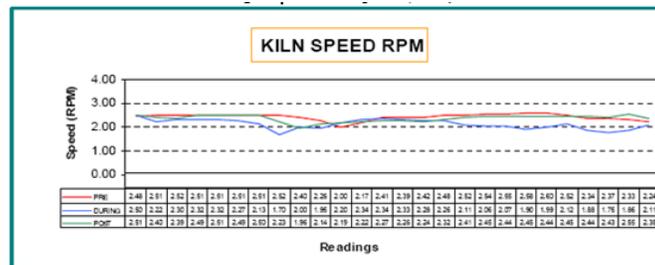


Figure 2.6. Kiln Speed (RPM)

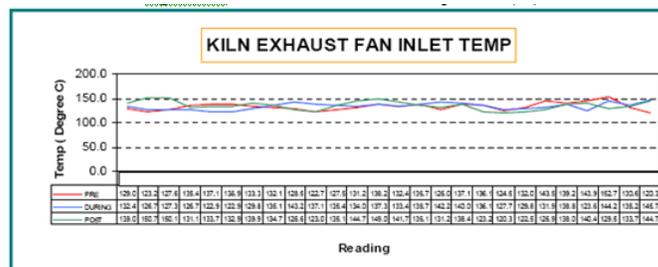


Figure 2.7. Kiln Exhaust Fan Inlet Temperature (°C)

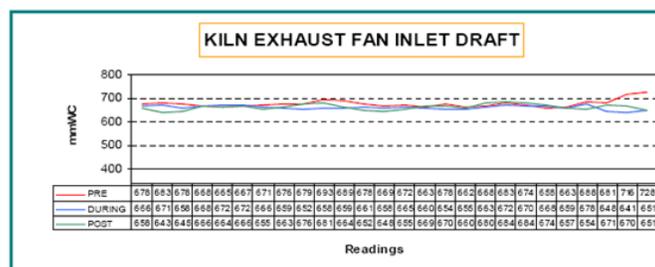


Figure 2.8. Kiln Exhaust Fan Inlet Draft (mmWC)

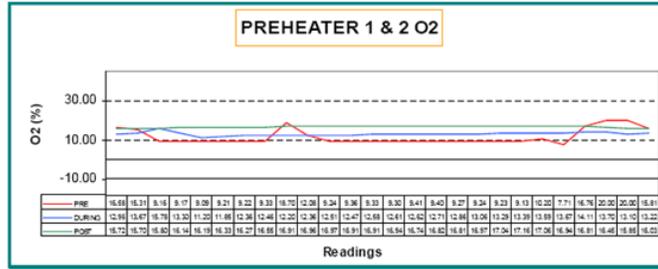


Figure 2.9. Pre Heater Outlet O<sub>2</sub> (%)

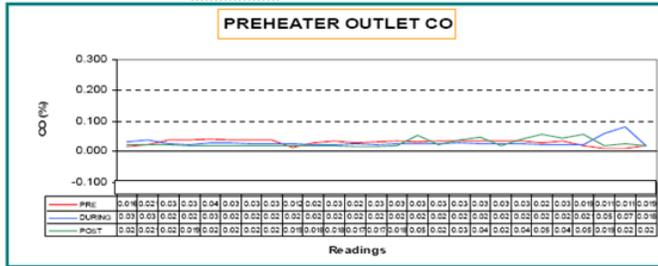


Figure 2.10. Pre Heater Outlet CO (%)

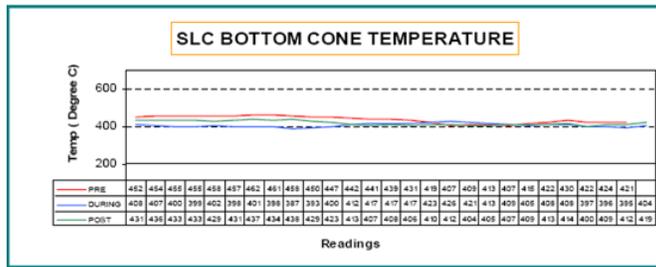


Figure 2.11. SLC Bottom Cyclone Temperature (°C)

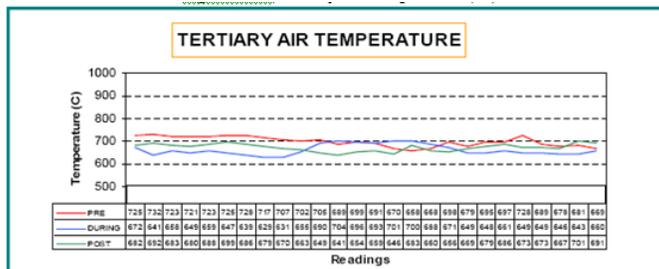


Figure 2.12. Tertiary Air temperature (°C)

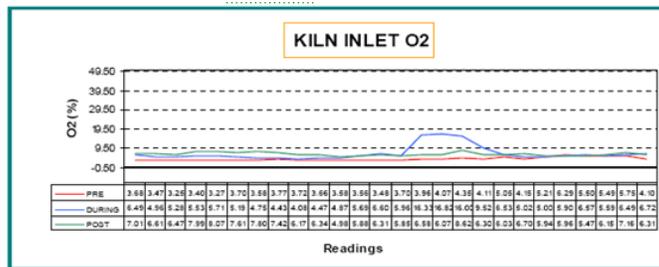


Figure 2.13. Kiln Inlet O<sub>2</sub> (%)

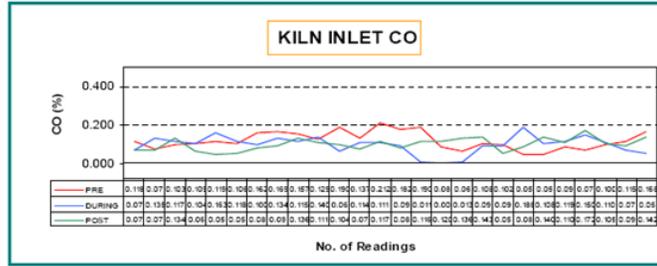


Figure 2.14. Kiln inlet CO (%)

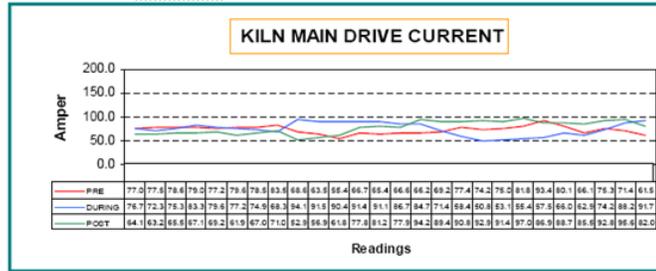


Figure 2.15. Kiln Main Drive Current (Ampere- Amp)

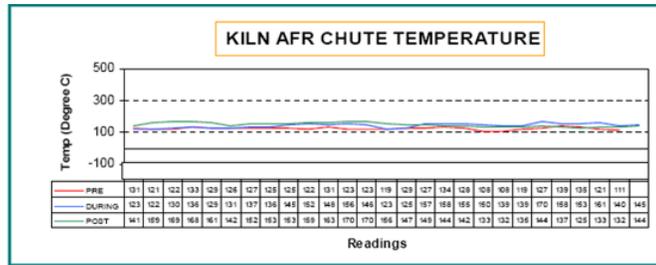


Figure 2.16. Kiln AFR Chute Temperature (°C)

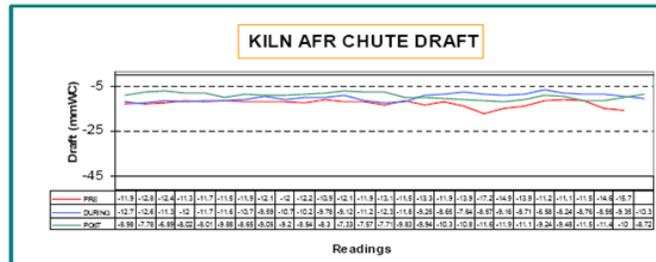


Figure 2.17. Kiln AFR Chute Draft (mmWC)

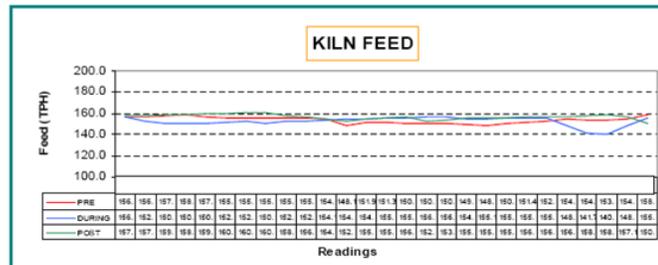


Figure 2.18. Kiln Feed

Table 7. Sampling Conditions & Stack Parameters during Co-processing Trial

Operation mode	Unit	Average Reading
Stack diameter	[m]	2.6
Cross section area	[m <sup>2</sup> ]	5.312
Pressure	[mmHg]	720
Gas temperature	[°C]	134
Moisture	[vol-%]	20.6
Oxygen content	[vol-%]	10.4
Carbon dioxide content	[vol-%]	16.2
Carbon Monoxide	[mg/Nm <sup>3</sup> ]	541.8
Exhaust gas velocity	[m/s]	22.5
Exhaust gas volume (Stack conditions)	[m <sup>3</sup> /h]	430245
Exhaust gas volume (Normal, wet)	[m <sup>3</sup> n,wet/h]	297677
Exhaust gas volume (Normal, dry)	[m <sup>3</sup> n,dry/h]	236356

During the period of the co-processing trial, there were some disturbances in the process, which was rectified by taking kiln stoppages. On investigation, it was discovered that the disturbances were not due to waste co-processing in kiln, but due to some other process related technical issues. Computer printouts of the hourly process chart of Kiln 3 sections were taken during the entire period of the co-processing trial.

The following parameters were monitored:

1. SLC Vessel Temperature(°C)
2. SLC Coal Feed Rate (tons per hour - TPH)
3. Kiln Coal Feed Rate (tons per hour - TPH)
4. Kiln Inlet Temperature (°C)
5. Kiln Pyrometer (°C)
6. Kiln Speed (revolutions per minute - RPM)
7. Kiln Exhaust Fan Inlet Temperature (°C)
8. Kiln Exhaust Fan Inlet Draft (mmWC)
9. Pre Heater Outlet O<sub>2</sub> (%)
10. Pre Heater Outlet CO (%)
11. SLC Bottom Cyclone Temperature (°C)
12. Tertiary Air Temperature (°C)
13. Kiln Inlet O<sub>2</sub> (%)
14. Kiln Inlet CO (%)

15. Kiln Main Drive Current (Ampere - Amp)
16. AFR Chute Temperature (°C)
17. AFR Chute Draft (mmWC)
18. Kiln Feed

**Sampling Conditions during Co-processing Trials**

The sampling conditions and the stack parameters for Madukkarai Kiln 3 were estimated during the trial and are shown in table 7.

**Results of Emission Monitoring during Co-processing Trial**

The detailed results of the monitoring carried out during the co-processing trial are provided in the report submitted by SGS and is attached at the end of this report.

The summary of the results are elaborated below. It is to be noted that the results

are the average values for the number of samples collected at the time of emission monitoring during the trial.

**Dioxins and Furans**

Sampling Procedure – USEPA Method No. 23 A - The monitoring results for each phase of the trial are summarized in figure-4.

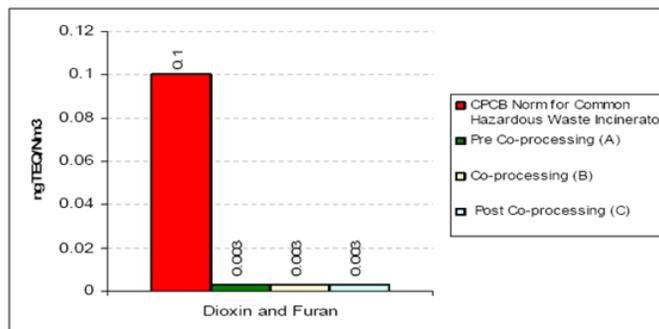


Figure 3. Emissions Results for Dioxins & Furans during Each Phase of Trial

**Total Organic Compounds**

Sampling Procedure - USEPA Method No. 25 A - It is continuous online measurement for 24 hours. Flue gas is

sampled via a heated probe and is passed through the hydrogen flame. The organic compounds gets ionization and the strength of ionization is reflected as ionization peaks in TOC analyzer screen, and the peak area gives us the TOC

content. The average emissions results during each phase of the trial burn are shown in figure 5.

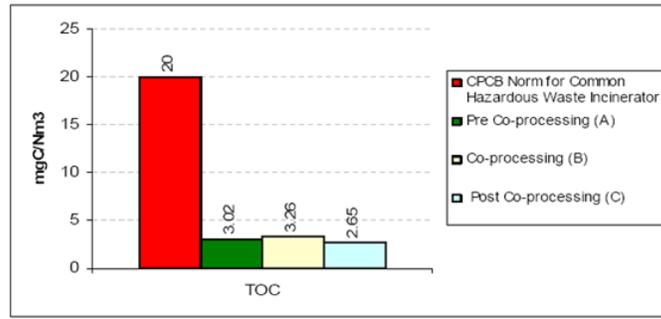


Figure 4. Emissions Results for TOC during Each Phase of Trial

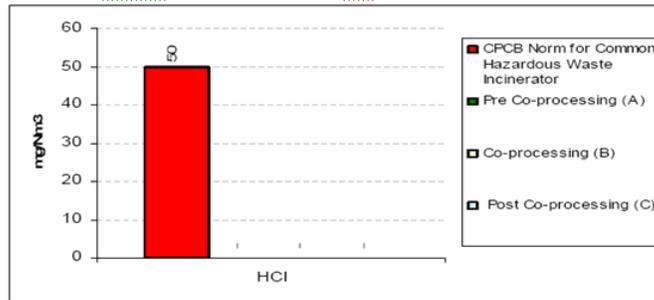


Figure 5. Emissions Results for HCl during Each Phase of Trial

**Hydrogen Chloride and Hydrogen Fluorides**

Sampling Procedure - An integrated sample is extracted from the source and passed through a heated probe and filter into dilute sulfuric acid and dilute sodium hydroxide solutions which collect the gaseous hydrogen halides and halogens respectively. The filter collects particulate matter including halide salts but is not routinely recovered and analyzed. The hydrogen halides are soluble in the acidic solution and form chloride (Cl-), bromide (Br-), and fluoride (F-) ions. The halogens have a very low solubility in the acidic solution and

pass through to the alkaline solution where they are hydrolyzed to form a proton (H+), the halide ion, and the hypo halous acid (HClO or HBrO). Sodium thio sulfate is added in excess to the alkaline solution to assure reaction with the hypo halous acid to form a second halide ion such that 2 halide ions are formed for each molecule of halogen gas. The halide ions in the separate solutions are measured by ion chromatography. Hydrogen chloride and hydrogen fluoride were monitored during all the three phases of the trial. The monitoring results for each phase of the trial are summarized in figure 6 and 7.

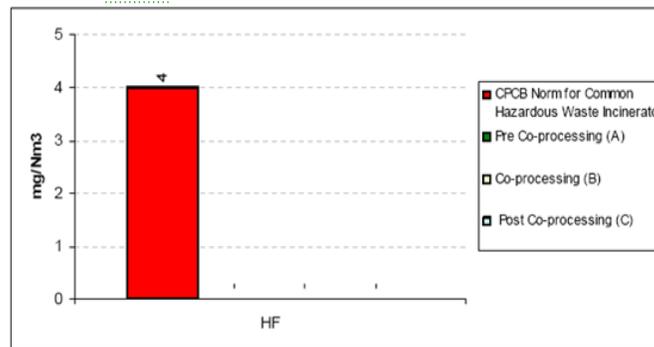


Figure 6. Emissions Results for HF during Each Phase of Trial

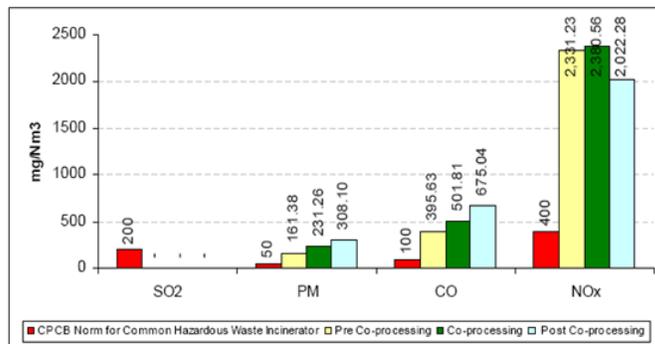


Figure 7. Emissions Results for CO, NO<sub>x</sub>, PM, SO<sub>2</sub> during Each Phase of Trial

**Carbon Monoxide, Nitrogen & Sulphur Oxides and Particulates**

Sampling Procedure - NO<sub>x</sub>, O<sub>2</sub>, CO<sub>2</sub> - Excess Air Fraction - USEPA Method No. 7 E - Instrumental method using portable digital flue gas analyzer of Quintox make. Orsat Apparatus is used to determine the O<sub>2</sub> and CO<sub>2</sub>. Flue gas is collected in the bladder and it is allowed to pass through KOH solution so that CO<sub>2</sub> present in the flue gas gets absorbed. The flue gas is again passed through Pyrogalal solution so that O<sub>2</sub> in the flue gas will get observed in it. CO is analyzed through flue gas analyzer as it cannot be determined by above method since the detection limit is 0.2% (1% = 10,000 ppm, hence it is determined by flue gas analyzer). SO<sub>2</sub> - USEPA

Method No.6 A/B - A gas sample is extracted from a sampling point in the stack. The SO<sub>2</sub> in the flue gas is absorbed in the 50 ml of 6% H<sub>2</sub>O<sub>2</sub>. The SO<sub>2</sub> and the sulfur trioxide, including those fractions in any sulfur acid mist, are separated. The SO<sub>2</sub> fraction is measured by the barium-thorium titration method. Particulate Matter - USEPA Method No. 17 - Particulate matter is withdrawn iso-kinetically from the source and collected on a glass. Fiber filter maintained at stack temperature. For these 1000 liters of flue gas is collected and made it to pass through the thimble which weight is known to us after drying. After sampling the thimble is dried and weighed to find the % of PM. The results are as shown in figure 8:

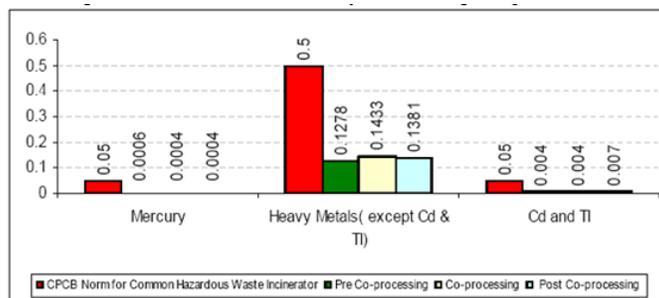


Figure 8: Emissions Results for Heavy Metals during each phase of Trial

**Heavy Metals**

Sampling Procedure - Hg & Heavy Metals - USEPA Method N. 29 - The measurements of the heavy metals namely Arsenic, Cadmium, Cobalt, Chromium, Copper, Mercury,

Manganese, Nickel, Lead, Antimony, Tin, Thallium, Vanadium and Zinc are given in the table below. The results indicate that the emissions are within the given limits of the guidelines. A stack sample is withdrawn iso-kinetically from the source, particulate emissions are collected in the probe and on a heated filter, and gaseous emissions are then collected in an aqueous acidic solution of hydrogen peroxide (analyzed for all metals including Hg) and an aqueous acidic solution of potassium permanganate (analyzed only for Hg). The recovered samples are digested, and appropriate fractions are analyzed for Hg by cold vapor atomic absorption spectroscopy (CVAAS) and for Sb, As, Cd, Cr, Co, Cu, Pb, Mn, Ni, Tl, by

inductively coupled argon plasma emission spectroscopy (ICAP) or Atomic absorption spectroscopy (AAS). Graphite furnace atomic absorption spectroscopy (GFAAS) is used for analysis of Sb, As, Cd, Co, Pb, Se, and Tl if these elements require greater analytical sensitivity than can be obtained by ICAP. If one so chooses, AAS may be used for analysis of all listed metals if the resulting in-stack method detection limits meet the goal of the testing program. Similarly, inductively coupled plasma-mass Spectroscopy (ICP- MS) can be used for analysis of Sb, As, Cd, Cr, Co, Cu, Pb, Mn, Ni, and Tl. The results were shown in figure 8.

**Conclusion**

The objective of this project was to perform a co-processing trial to demonstrate that the cement kiln is able to co-process hazardous wastes in an irreversible and environmentally sound manner, i.e. with no influence on the

emissions when traditional fuel is partly replaced by hazardous waste.

The hazardous waste, namely, Chemical ETP Sludge is generated by Ford India Private Limited, Chennai. Ford India generates Chemical ETP Sludge from its manufacturing process and it is classified as hazardous as per HWM Rules. The coprocessing trial was carried out together by ACC and

Ford India from 22<sup>nd</sup> to 26<sup>th</sup> June, 2008. The trial for Chemical ETP Sludge was carried out in three phases, namely, pre co-processing, co-processing and post co-processing. The emission monitoring was carried out by SGS Limited, Gurgaon. SGS is a CPCB approved, ISO 17025 certified, third party monitoring-agency.

Table 8. Summary of Co-processing Trial Results

Parameter	Units	Norm*	Measured stack emission during the trial			Change in Emissions during Coprocessing of the waste	Change in Emissions after coprocessing the waste
			Pre Coprocessing	Coprocessing	Post Coprocessing		
Dioxin and Furan	ng TEQ/Nm <sup>3</sup>	0.1	0.003	0.003	0.003	0	0
TOC	mgC/Nm <sup>3</sup>	20	3.02	3.26	2.65	0.24	-0.37
HCl	mg/Nm <sup>3</sup>	50	ND	ND	ND	ND	ND
HF	mg/Nm <sup>3</sup>	4	ND	ND	ND	ND	ND
SO <sub>2</sub>	mg/Nm <sup>3</sup>	200	ND	ND	ND	ND	ND
SPM	mg/Nm <sup>3</sup>		161.38	231.26	308.10	69.88	146.72
CO	mg/Nm <sup>3</sup>	100	395.63	501.81	675.04	106.18	279.41
NO <sub>x</sub>	mg/Nm <sup>3</sup>	400	2,331.23	2,380.56	2,022.28	49.33	-308.95
Mercury	mg/Nm <sup>3</sup>	0.05	0.0006	0.0004	0.0004	-0.0002	-0.0002
Heavy Metals (except Cd & Tl)	mg/Nm <sup>3</sup>	0.5	0.1278	0.1433	0.1381	0.016	0.010
Cd and Tl	mg/Nm <sup>3</sup>	0.05	0.004	0.004	0.007	0.000	0.003

\*CPCB Norms for Common Hazardous Waste Incinerator

The monitoring results are summarized in Table 7 below where the incremental variation in the emission during co-processing and post co-processing as compared with the baseline measurements are compared with the CPCB Norms for the Common Hazardous Waste Incinerators. The CPCB guideline on Common Hazardous Waste Incinerator provides emission standards for each parameter during incineration of waste. The graphs below compare these CPCB norms against the incremental variation of emissions during and after co-processing of the waste materials. The analysis results of the stack parameters revealed that the emission values are well below the standards set by CPCB for the Common Hazardous Waste Incinerators. The test results concluded that the emissions were independent of the usage of the waste materials in the cement process. The cement process perform requires high temperature in the kiln of around 1400-1450oC with a long residence time of 4-5 sec. Such high temperature conditions ensure that no noxious emissions take place during the co-processing of the waste materials. The advantages of high temperature cement kilns are widely utilized around the world and co-processing is regarded to be one of the most

cost-effective and environment friendly and viable waste management technologies available.

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