IMPLEMENTING ENVIRONENTALLY SOUND AND ECOLOGICALLY SUSTAINING WASTE MANAGEMENT IN THE COUNTRY THROUGH CEMENT KILN COPROCESSING TECHNOLOGY

A BUSINESS MODEL

Introduction:

In our country, we have been making several attempts for managing wastes of different kinds in an environmentally sound and ecologically sustaining manner. Cement kiln co processing technology is one of them and it has demonstrated, through successful implementation of >75 number of large scale co processing trials, with rigorous emission monitoring campaigns, that it provides the most optimum solution for the Indian wastes – both Hazardous and Non-hazardous, including RDF derived from MSW. Further, this technology also helps achieve the desired environmental criteria of “zero waste for future” after its treatment. This technology has also been utilized in the country to demonstrate successful destruction of POPs with the involvement of CPCB, international experts and MoEF.

Advantages

Cement kiln coprocessing technology has been implemented globally on large scale for management of wastes and has been demonstrating its success for more than three decades now. This technology utilizes wastes as Alternative Fuels and Raw materials (AFRs) in cement kiln that replace the traditional raw materials and fuels that are derived from mining activity. This technology recovers the material and energy value present in the wastes in the cement manufacturing process. It therefore helps waste of one entity to become resource of another thereby promoting the concept of circular economy.

Cement kiln coprocessing also ensures that once waste is fed into the kiln, there is no residual waste for further disposal – a situation that is invariably encountered in landfill or incineration operations. By using wastes as AFRs, cement plants are required to extract lesser quantum of natural materials such as Limestone, Coal, Iron ore, Bauxite etc. These resources, therefore, remain conserved for use in future.

Coprocessing helps the cement companies to adhere to the PAT obligations. From a country perspective, it helps to reduce GHG emissions and also helps conserve the natural resources.

Technology Status:

Globally, cement kilns have shown that it is feasible to substitute large quantum Raw materials and Fuels used in the cement manufacturing process by wastes. The different kinds of wastes coprocessed in kilns include agrowastes, whole tyres and tyre chips, RDF from MSW, Industrial wastes from almost all industries – both Hazardous and non-hazardous, etc. The fuel substitution rates in the developed countries range from 25% to 45% and there are some cement plants globally where the Fuel substitution levels are close to 95%.

In India the coprocessing exercise was initiated in 2004 when a few coprocessing trials, with rigorous emission monitoring exercise, were implemented by CPCB. Since then many coprocessing trials (>75 in numbers - the largest number of trials ever done by any country) have demonstrated that waste coprocessing in cement kiln does not add to the environmental burden. In India this technology is now being implemented by many cement companies such as ACC, Ambuja, Ultratech, Shree Cements, JP, Dalmia, Lafarge, India Cements, Bharati Cement, CRH, Hiedelberg, Zuari Cement, Madras Cement, etc. The fuel substitution in some of these plants has crossed the 10% mark. Overall, the average fuel substitution in the country is < 2%.

Economics

Cement kiln coprocessing solution has been demonstrated in most of the countries as one of the most optimum solution for waste management. Cement kiln coprocessing has sustained as a solution for management of wastes in these countries for about three decades now because of the inherent economic viability in this concept. Through this technology, in most of the cases, wastes get disposed at a lesser cost than other technologies. This is an advantage to the waste generator. In the cement plants, these wastes substitute the costly raw material and fuel resources. This is an advantage to the cement company.

Infrastructure

For implementing coprocessing of wastes in a responsible manner, cement companies need to implement necessary infrastructure of required capacity such as laboratory, storage & handling facility, properly designed AFR coprocessing (feeding) facility, Fire fighting facility, proper business processes & qualified manpower to deal with the hazards and vagaries of waste, etc. Depending upon the quantum wastes to be coprocessed and the extent of variation in their physical nature and chemical quality, a proper waste **preprocessing** facility is required. This preprocessing facility converts non-homogenous waste into a homogenous AFR having uniform physical and chemical characteristics acceptable to the specific cement kiln in which it is required to be coprocessed. The preprocessing facility generally consists of laboratory segregated storage shed, shredding, impregnation, blending, mixing, screening, segregation systems. Such preprocessing facility can be implemented within the cement plant or can be implemented at the TSDF or waste generation location. Every cement kiln has different acceptability criteria depending upon the operating chemistry at their end and the preprocessed waste needs to be tuned to match that.

Investments

Typically about 50,000 TPA AFR will be required per Annum to achieve a TSR of 25% in a million TPA Cement plant. The cost of setting up the coprocessing facility (Laboratory, storage, feeding, fire fighting and emission moniroting) of this capacity will be about Rs. 15 Crores and the preprocessing facility (Laboratory, storage, fire fighting, preprocessing, etc) will involve an investment of about Rs. 25 Crores. The total investment therefore works out to about Rs. 40 Crores for a million TPA cement plant.

Business Model

Following are the major income and expenditure streams involved in the business model of the coprocessing solution.

INCOME STREAMS	EXPENDITURE STREAMS
1. Tipping Fees from waste generator 2. Substitution benefit derived due to the replacement of traditional raw materials and fuels by wastes.	1. Waste identification 2. Laboratory assesent 3. OHS, Handling and storage costs 4. Production impact 5. Fuel usage impact 6. Interest and Depreciation costs etc.

A viable business model for coprocessing demands that income from coprocessing of wastes in cement kiln should be higher than the expenditure incurred.

Pre & coprocessing Costs

On very broad terms, the expenditure involved in coprocessing includes identification, laboratory assessment, handling and storage and feeding in the kiln – which works out to about Rs. 300 or more per T of waste. The typical costs associated with preprocessing of wastes work out to Rs. 400 or more per T of waste. Hence, the total cost of coprocessing would be minimum

Rs. 300 and the total cost of pre and coprocessing would be a minimum of Rs. 700 per T of waste.

Typical case studies

To illustrate the features of the operating business model of the coprocessing technology, following categories of wastes are considered as typical cases. The cement plant Clinkering capacity is considered as 800,000 TPA for delivering 1 Million TPA of cement. It is assumed that the fuel consumption is 700 Kcal / Kg Cl and hence the total energy consumption is 560,000 GCal per Annum. It is assumed further that the limiting elements such as alkalies or chlorine from these wastes will not be beyond the levels acceptable to the cement plant.

1. **Mill scale from rolling mills (Purchased commodity as alternative Raw material) - 10,000 TPA**
   Mill scale is available from steel rolling mills as a bi-product and it gets coprocessed as an alternative raw material in the cement kiln replacing iron ore usage. It is normally a very uniform quality material and hence it does not require any preprocessing step. This material is ***purchased*** *from the steel rolling mills or traders and is fed directly at the desired rate in the kiln.*

2. **Rice Husk from Rice mills (Purchased agrowaste as Alternative Fuel) - 10,000 TPA**
   Rice husk is available from rice mills as a bi-product and it gets coprocessed as an alternative fuel in the cement kiln. It is normally a very uniform quality material and hence it does not require any preprocessing step. This material is ***purchased*** *from the rice mills or traders and is fed directly at the desired rate in the kiln.*

3. **Processed RDF from MSW (Processed to the cement kiln acceptable specs) - 10,000 TPA**
   Combustible material segregated from MSW in the ULBs or ISWM Projects is additionally subjected to drying, shredding and wind separation process at an integrated facility within the ISWM project or elsewhere meeting the uniform quality specs as desired by the cement plants. This can then be ***purchased*** *by the cement plants and utilized as an Alternative Fuel source in the cement kiln*

4. **Expired Juice in packs (Industrial non-hazardous wastes for disposal) - 10000 TPA**
   Date expired juice packs need to be disposed in an environmentally sound manner as they pose danger of entering the market in new packs causing serious health and hygiene issues. It also poses damage to the brand of the manufacturer. Since this comes in different packaging types and sizes such as bottles, satches, tetra packs, tins etc, it is required to be preprocessed by impregnation, shredding, blending, etc. After converting it into uniform quality material in size and constituents, it is coprocessed in the cement kiln. As this is a material disposal activity, disposal fees will be charged by the cement plant to the waste generator.

5. **Distillation Residue (industrial Hazardous waste for disposal) - 5000 TPA**
Distillation residue from pharmaceutical / chemical and allied industries are hazardous wastes that need environment friendly disposal. Since this material is a waste from a manufacturing activity, it will be having different constituents and physical nature. Hence it is required to be preprocessed through processes such as shredding, blending, etc. After converting it into uniform quality material in size and constituents, it is coprocessed in the cement kiln. As this is a material disposal activity, disposal fees will be charged by the cement plant to the waste generator.

6. **RDF from MSW (Unprocessed waste from ULBs or ISWM projects) - 10,000 TPA**
Segregated combustible material from MSW gets wrongly defined as RDF and is made available for coprocessing as an Alternative Fuel. This material has huge variations in quality both – physical nature and calorific value from lot to lot. If the same has to be disposed in the cement kiln through coprocessing, then it will have to be preprocessed through shredding and blending processes to make it into uniform quality material. This uniform quality material is then coprocessed in the cement kiln as Alternative Fuel. As this is a material disposal activity, disposal fees will be charged by the cement plant to the waste generator.

7. **AF from TSDF (Semi-processed AF from TSDFs) - 5,000 TPA**
To facilitate environmentally friendly disposal of the hazardous wastes, existing TSDFs can set up simple blending or mixing facility to produce a mix of solid wastes which can be utilized by the cement plants after preprocessing it appropriately. This semi-finished AF will be received at the cement plant preprocessing facility and coprocessed after suitably preprocessing. As this is a material disposal activity, disposal fees will be charged by the cement plant to the TSDF operator.

Case Study Illustrations

Case 1 : Mill Scale from Rolling mills (Purchased Commodity as AR) - 10,000 TPA

A) INCOME					B) EXPENDITURE			
S. No.	Parameter	Unit	Rs.		S. No	Paramenter	Unit	Rs.
1	Purchase cost of Mill Scale	Rs/ T	3500		1	Coprocessing cost	Rs / T Mill scale	300
2	Iron content in Mill scale	%	75		2	Preprocessing cost	Rs / T Mill scale	0
3	Cost of Iron ore	Rs/T	3400		3	Increase in fuel cost due to moisture in Mill scale	Rs / T Mill scale	20
4	Iron content in Iron ore	%	65		4	Interest and depreciation costs of the coprocessing facility	Rs / T Mill scale	0
5	Gross Benefit of replacement	Rs / T Mill scale	423		5	Cost impact due to reduction in production quantum	Rs / T Mill scale	0
6	Net Benefit of replacement	Rs / T Mill scale	103		6	Total expenditure	Rs / T Mill scale	320
Total Mill Scale Coprocessed		TPA	10,000		Substitution benefit derived		Rs PA	1,030,769
Total energy recovered		TPA	-		Total iron ore conserved		T	11,538

Case 2 : Rice Husk from Rice mills (Purchased agrowaste as AF) - 10,000 TPA

A) INCOME				B) EXPENDITURE			
S. No.	Parameter	Unit	Rs.	S. No	Paramenter	Unit	Rs.
1	Purchase cost of Rice Husk	Rs/ T	2700	1	Coprocessing cost	Rs / T Rice Husk	300
2	Calorific Value of Rice Husk	Kcal / Kg	3000	2	Preprocessing cost	Rs / T Rice Husk	0
3	Cost of coal	Rs/T	5200	3	Increase in fuel cost due to moisture in agrowaste	Rs / T Rice Husk	20
4	Calorific Value of coal	Kcal / Kg	4000	4	Interest and depreciation costs of the coprocessing facility	Rs / T Rice Husk	625
5	Gross Benefit of replacement	Rs / T Rice Husk	1200	5	Cost impact due to reduction in production quantum	Rs / T Rice Husk	50
6	Net Benefit of replacement	Rs / T Rice Husk	205	6	Total expenditure	Rs / T Rice Husk	995
Total Rice Husk Coprocessed		TPA	10,000	Substitution benefit derived		Rs PA	2,050,000
Total Energy recovered		Gcal	30,000	Total coal saved		T	7,500

Case 3 : Processed RDF from MSW (Processed to the cement kiln specs) - 10,000 TPA

A) INCOME				B) EXPENDITURE			
S. No.	Parameter	Unit	Rs.	S. No	Paramenter	Unit	Rs.
1	Purchase Cost of RDF	Rs/ T RDF	3200	1	Coprocessing cost	Rs/ T RDF	300
2	Calorific Value in RDF	Kcal / Kg	3500	2	Preprocessing cost	Rs/ T RDF	0
3	Cost of coal	Rs/T	5200	3	Increase in fuel cost due to moisture in RDF	Rs/ T RDF	100
4	Calorific Value of Coal	Kcal / Kg	4000	4	Interest and depreciation costs of the Pre & coprocessing facility	Rs/ T RDF	750
5	Gross Benefit of disposal	Rs/ T RDF	1350	5	Cost impact due to reduction in production quantum	Rs/ T RDF	100
6	Net Benefit of replacement	Rs/ T RDF	100	6	Total expenditure	Rs/ T RDF	1250
Total RDF Coprocessed		TPA	10,000	Substitution benefit derived		Rs PA	1,000,000
Total energy recovered		Gcal	35,000	Total coal conserved		T	8,750

Case 4 : Expired Juice in packs (Industrial non- haz wastes for disposal) - 10000 TPA

A) INCOME				B) EXPENDITURE			
S. No.	Parameter	Unit	Rs.	S. No	Paramenter	Unit	Rs.
1	Tipping Fee for disposal	Rs/ T Juice pack	5000	1	Coprocessing cost	Rs / T Juice pack	300
2	Calorific Value in Juice pack	Kcal / Kg	500	2	Preprocessing cost	Rs / T Juice pack	400
3	Saw dust required for impregnation	T/T Juice pack	0.5	3	Cost of Saw dust	Rs / T	3000
4	Calorific Value of Saw dust	Kcal / Kg	3000	4	Impregnation saw dust cost	Rs / T Juice pack	1500
3	Cost of coal	Rs/T	5200	3	Increase in fuel cost due to moisture in Juice packs	Rs / T Juice pack	100
4	Calorific Value of Coal	Kcal / Kg	4000	4	Interest and depreciation costs of the pre & coprocessing facility	Rs / T Juice pack	3200
5	Gross Benefit of disposal	Rs / T Juice pack	7600	5	Cost impact due to reduction in production quantum	Rs / T Juice pack	250
6	Net Benefit of replacement	Rs / T Juice Pack	1850	6	Total expenditure	Rs / T Juice pack	5750
Total Juice pack Coprocessed		TPA	10,000	Substitution benefit derived		Rs PA	18,500,000
Total energy recovered		Gcal	20,000	Total coal conserved		T	5,000

Case 5 : Distillation residue (Industrial haz wastes for disposal) - 5000 TPA

A) INCOME				B) EXPENDITURE			
S. No.	Parameter	Unit	Rs.	S. No	Paramenter	Unit	Rs.
1	Tipping Fee for disposal	Rs/ T Dist. Resid.	6000	1	Coprocessing cost	Rs/ T Dist. Resid.	300
2	Calorific Value in Dist. Residue	Kcal / Kg	2500	2	Preprocessing cost	Rs/ T Dist. Resid.	400
3	Cost of coal	Rs/T	5200	3	Increase in fuel cost due to moisture in dist. Residue	Rs/ T Dist. Resid.	20
4	Calorific Value of Coal	Kcal / Kg	4000	4	Interest and depreciation costs of the Pre & coprocessing facility	Rs/ T Dist. Resid.	3200
5	Gross Benefit of disposal	Rs/ T Dist. Resid.	9250	5	Cost impact due to reduction in production quantum	Rs/ T Dist. Resid.	50
6	Net Benefit of replacement	Rs/ T Dist. Resid.	5280	6	Total expenditure	Rs/ T Dist. Resid.	3970
Total Dist. Resid Coprocessed		TPA	5,000	Substitution benefit derived		Rs PA	26,400,000
Total energy recovered		Gcal	12,500	Total coal conserved		T	3,125

Case 6 : RDF from MSW (Unprocessed waste from ULBs or ISWM projects) - 10,000 TPA

A) INCOME				B) EXPENDITURE			
S. No.	Parameter	Unit	Rs.	S. No	Paramenter	Unit	Rs.
1	Tipping Fee for RDF disposal	Rs/ T RDF	1000	1	Coprocessing cost	Rs/ T RDF	300
2	Calorific Value in RDF	Kcal / Kg	2500	2	Preprocessing cost	Rs/ T RDF	400
3	Cost of coal	Rs/T	5200	3	Increase in fuel cost due to moisture in RDF	Rs/ T RDF	100
4	Calorific Value of Coal	Kcal / Kg	4000	4	Interest and depreciation costs of the Pre & coprocessing facility	Rs/ T RDF	3200
5	Gross Benefit of disposal	Rs/ T RDF	4250	5	Cost impact due to reduction in production quantum	Rs/ T RDF	100
6	Net Benefit of replacement	Rs/ T RDF	150	6	Total expenditure	Rs/ T RDF	4100
Total RDF Coprocessed		TPA	10,000	Substitution benefit derived		Rs PA	1,500,000
Total energy recovered		Gcal	25,000	Total coal conserved		T	6,250

Case 7: AF from TSDF (Semi-processed AF from TSDFs) - 5,000 TPA

A) INCOME				B) EXPENDITURE			
S. No.	Parameter	Unit	Rs.	S. No	Paramenter	Unit	Rs.
1	Tipping fee of AF from TSDF	Rs/ T AF	3000	1	Coprocessing cost	Rs/ T RDF	300
2	Calorific Value in AF	Kcal / Kg	3500	2	Preprocessing cost	Rs/ T RDF	400
3	Cost of coal	Rs/T	5200	3	Increase in fuel cost due to moisture in RDF	Rs/ T RDF	200
4	Calorific Value of Coal	Kcal / Kg	4000	4	Interest and depreciation costs of the Pre & coprocessing facility	Rs/ T RDF	3200
5	Gross Benefit of disposal	Rs/ T RDF	7550	5	Cost impact due to reduction in production quantum	Rs/ T RDF	300
6	Net Benefit of replacement	Rs/ T RDF	3150	6	Total expenditure	Rs/ T RDF	4400
Total AF Coprocessed		TPA	5,000	Substitution benefit derived		Rs PA	15,750,000
Total energy recovered		Gcal	17,500	Total coal conserved		T	4,375

Business model Overall Results

The overall results of operating this activity in business mode as per the illustrated case studie are following.

Investment	Rs. Cr	40	Benefit derived	Rs Cr. PA	6.62	Pay Back Period	Years	6.04
Energy used in process	Gcal PA	560,000	Energy recovered	Gcal PA	140,000	TSR	%	25%
AFR Coprocessed	TPA	60,000	AR Coprocessed	TPA	10,000	AF Coprocessed	TPA	50,000
Coal conserved	TPA	35,000	Foreign Exchange Saved	USD PA	3,033,333	CO2 mitigated	TPA	28,000

Salient features of the Business model

1. Commodity materials such as RDF, Agro-wastes help improve the Thermal Substitution Rate (TSR%) but they contribute substantially less in the investment payback.
2. The viability of the coprocessing operations in the cement kiln largely depend upon the tipping fees associated with the environmentally sound disposal of the Industrial hazardous and non hazardous wastes.
3. If RDF derived from MSW is a non-processed non-uniform mix of combustible materials, then the same is feasible to be coprocessed only when it is received with a tipping fee.
4. If RDF from MSW is a preprocessed to the desired degree of uniformity as required by the cement kilns, then it would be feasible for the cement plants to purchase the same if it provides relevant cost advantage.
5. Coprocessing offers direct savings in the foreign exchange outgo as the same would be reducing the large scale imports of coal implemented by the cement industry.

Conclusions

The above illustrations and discussions demonstrate that there is a feasible business model on which the cement kilns can come forward to manage wastes on a large scale. To achieve this large scale management of wastes, following are the specific requirements.

1. ***The economic viability of the pre and coprocessing activity in cement kilns depends substantially on the receipt of wastes that are required to be disposed. Most of the countries, including BASEL CONVENTION, have endorsed coprocessing technology as the best technology for effective and environmentally sound management of wastes because it offers zero waste for future.***

2. *It has been demonstrated globally and also in India (through >75 successful coprocessing trials) that coprocessing provides environmentally sound and ecologically sustaining disposal of a variety of wastes starting from simple ETP sludge to most complex wastes such as POPs.*
3. *If the cement plants have to undertake large scale coprocessing activity to solve the waste management problem faced in the country, then they have to make large scale investments of the order of about Rs 40 Cr per million TPA cement manufacturing capacity.*
4. *This kind of investment gets justified only through the earnings derived out of the disposal of hazardous and non-hazardous industrial wastes.*
5. *As coprocessing technology has been demonstrated to be superior to incineration and landfill technologies, cement plants also need to be approved to receive the different kinds of Haz and non-Haz wastes in the same manner as TSDFs.*
6. *In India, at least 60% of the cement capacity is owned by large players who are interested in and committed to undertaking large scale AFR coprocessing in their plants. These cement players are also responsible in their operating behavior and are committed to implementing environmentally sound practices while undertaking disposal activities through coprocessing.*
7. *Since 1 million TPA cement plant at 25% TSR can utilise 50,000 T of wastes as AFs and can reduce about 3.3 Millon USD of Foreign Excnange, then this 60% Indian cement capacity (say 200 Mio TPA) will be able to manage atleast 10 Mio TPA of different kinds of wastes and will be able to facilitate avoidance of Foreign Exchange outgo of 600 Million USD per annum.*
8. *Considering the merits of the coprocessing technology and benefits offered by it in managing different kinds of wastes in an environmentally sound manner and that too with "zero waste for future" concept, cement industry be allowed to take up appropriate share in the clean India mission on priority by implementing required reforms in the relevant regulatory frameworks.*

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