IMPROVING THERMAL SUBSTITUTION BY USING ALTERNATE FUELS IN THE INDIAN CEMENT INDUSTRY

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ABSTRACT

The current reported thermal substitution rates (TSR) in the Indian cement industry is about 1 %. However, TSR levels as high as 60 % have been achieved in some developed nations. Although numerous wastes have found application as alternative fuels (AF) in the cement industry across the globe, this paper gives a brief outline about the most promising AF in the context of Indian cement industry. The paper provides an assessment of the potential availability of the most promising AF and their Impact on the clinker quality & plant operations. The barriers which are limiting the TSR in India to a mere 1 % are briefly discussed. Action plans needed to overcome technical, financial and regulatory barriers to the growth of AF usage are also highlighted.

The paper is based upon the findings and observations derived through various studies conducted by HOLTEC on co-processing of AF in India as well as Saudi Arabia.

1. INTRODUCTION

Fuel costs contribute to a major share in the total cost of manufacturing cement. Meeting energy demands and containing carbon emissions is foreseen to be a challenge for the cement industry. The rising costs of fossil fuels and input energy reduction targets set by Bureau of Energy Efficiency (BEE) through Perform Achieve Trade (PAT) scheme are further pushing cement plants towards considering AF as an attractive option towards sustained development. However, due to various policy, technical and financial barriers, the achieved TSRso far has been low across the Indian cement industry (less than 1 %).

2. AVAILABILITY SCENARIO FOR ALTERNATIVE FUELS IN INDIA

2.1 Hazardous Waste (HW)

Hazardous wastes are categorized as recyclable, incinerable and land fillable, based on their hazard potential, ultimate disposal, and in accordance with hazardous wastes (management, handling & transboundary movement) rules, 2008. As per the estimates of Central Pollution Control Board (CPCB), about 8 million tonnes of HW is generated in India through various industries. The **Table 1** below provides details about the quantities of various categories of HW generated. At present only incinerableHW is being co-processed in Cement plants.

Table 1
HW Generation in India
as per the statistics available at CPCB website

Category	Land-fillable	Incinerable	Recyclable
Waste generation in mlntpa	3.3	0.6	4.0

At present, only a small percentage of IncinerableHW, primarily from the states of Gujarat and Andhra Pradesh, is being co-processed in cement plants in India. Taking into consideration that some of the available incinerableHW may not be compatible for co-processing, about 80 % of the total incinerable HW generated is considered to be suitable for co-processing in the cement industry. Based on the above consideration the potential availability is estimated to be about 0.48 mlntonnes.

2.2 Refuse Derived Fuel (RDF) from Municipal Solid Waste (MSW)

MSW is primarily generated in urban areas. The average MSW generation in Indian cities and towns is about 500 gm/per person per day. The estimated MSW generation from Urban India is 68-70 million tpa. RDF, the dry organic fraction of MSW, is recovered by mechanical and biological treatment of MSW. RDF primarily comprises of plastics, paper, cardboard, cloth, wood, rubber, leather etc. However, high recovery rate of combustible plastics and paper by rag pickers reduces the available combustible RDF content in MSW. The recovery of RDF from MSW is about 10 % of the MSW weight. Therefore, the total RDF that can potentially be generated from MSW is about 6.8 million tpa. Considering competition from Waste to Energy (WTE) power plants for RDF, about 20% of the potential generation (1.37 million tpa) is considered to be available for co-processing in the Indian cement Industry.

Refuse Derived Fuel (RDF)

2.3 Used Tyres

It is estimated from the data available with All India Tyre Manufacturing Association (ATMA) that about 0.83 million tonnes (estimate established based on tyre production in India in year 2011-12 as per ATMA) of used tyres are generated annually. In addition to used tyres, rubber wastes can also be co-processed in the cement industry. Used tyres are currently being used by rubber recycling industry and small scale industry such as brick kilns and industrial boilers as fuel. Considering competitive uses for old discarded tyres, only about 0.4 million tpa of used tyres are estimated to be available for co-processing.

A Tyre Shredding System

2.4 Biomass

As per the estimates of Ministry of New and Renewable Energy (MNRE), about 500 million tpa of biomass in the form of agricultural crop residue is generated in India, out of which about 120 to 150 million tpa of surplus biomass may be available. Biomass finds extensive use as a domestic fuel and source of energy for various small scale industries. It is consumed as fodder and is reserved for power generation in some of the Indian states. Although abundantly available, various competitive uses may limit the potential availability of biomass for co-processing to about 12-15 million tpa (10% of 120-150 million tpa surplus).

Rice Husk

2.5 Industrial Plastic Waste from Waste Paper Based Paper Mills

Waste paper based paper mills contribute a significant proportion of Industrial plastic wastes that can be co-processed by cementindustry. The waste paper which is used as raw material in these paper mills contains about one to two percent of plastic waste as wrappings, laminations, plastic covers, etc. The estimated generation of Industrial plastic waste in India is about 0.1 to 0.2 million tpa.

2.6 Summary of available Alternativ2e Fuels

The table below summarizes the total available volumes of short listed AF; their estimated percentage considered to be available for co-processing in the Indian cement Industry and calculated quantities of the same.

Table 2
Summary: Available Alternative Fuels

Alternative fuel	Total Availability (in miotpa)	Percentage availability considered for cement Co-processing	Calculated quantity available for Co-processing in cement plants (in mlntpa)
Hazardous Waste (Incinerable	0.60	80	0.48
RDF from MSW	6.88	20	1.37
Used tyres	0.83	50	0.40
Surplus Biomass	120-150	10	12.0-15.0
Industrial Plastic Waste	0.10 - 0.20	50	0.05 - 0.10

3. CHARACTERISTICS OF ALTERNATIVE FUELS

Physical and chemical characteristics of AF have a direct impact on the plant operations and quality of clinker produced if substituted beyond optimal TSR levels. In addition to presence of deleterious components such as chloride and sulphur, which may lead to frequent blockages, it is also observed that some AF may have significant content of heavy metals. Therefore, it is essential to assess the physical and chemical characteristics to arrive at an optimum TSR level without compromising on the product quality and trouble free plant operations. The **Table 3** below summarises the typical characteristics of these AF.

Table-3
Characteristics of AF

Alternate Fuel	NCV (kcal/kg)	Ash %	Moisture %	Chlorine %	Sulphur %
Hazardous Waste	2,500-9,500	5-20	5-20	0-2	0-2
RDF from MSW	2,500-3,000	20-25	20-25	0.5-1	0-1
Used Tyres	6,000- 6,500	2-3	0.5-1	0-0.1	1-2
Biomass	3,000-4,000	5-20	10-15	-	-
Industrial Plastic Waste	3,500-4,000	5-10	20-50	0.5-1	0.5-1

The impacts of the deleterious components such as chloride, sulphur and ash on clinker quality and plants operations are summarised below:

3.1 Ash

A high percentage of ash is typically associated with solid HW, RDF and biomass such as rice husk and rice straw. High thermal substitution of such AF leads to higher input of silica content in the clinker. The resultant high ash contribution requires adjustment of raw mix with measures such as increased percentage of high grade limestone.

3.2 Moisture

High moisture content is present in AF such as HW, RDF from MSW, biomass & industrial plastic wastes. If co-processed directly without drying an increase in specific heat consumption is expected. The high moisture content may also increases the load on the exhaust gas fans. This may affect clinker production adversely. Practices such as sun drying and using waste heat to reduce moisture content can help in efficiently using high moisture bearing AF.

3.3 Chlorine

Chlorine is one deleterious component that may have a profound effect on kiln operations and product quality. Chloride content in AF needs to be monitored very carefully in case it is present in the raw material also. HW, RDF and industrial plastic wastes often contain high levels of chloride. These high chloride levels may cause preheater blockages and in some cases a gas bypass may be required to maintain smooth plant operations. Chloride levels must be carefully monitored in the hot meal at regular intervals to control build ups in the preheater cyclones. Generally a chloride bypass may be required for smooth plant operations if total chloride input is greater than 300 g/tonne (Loss free basis).

3.4 Sulphur

Sulphur is another component which causes kiln inlet build-ups and ring formation inside the kiln. Presence of chloride further increases the volatility of sulphur compounds. Among the AF, used tyres have significant percentage of sulphur. Itsmust be carefully monitored in the hot meal at regular intervals. To prevent kiln operational issues sulphur-alkali molar ratio should be maintained in the preferable range (0.8-1.2). In case of use of high sulphur bearing fuel, a soft burning raw mix should be preferred.

In case a provision of gas bypass is not available, TSR of AF in use must be carefully adjusted so as to avoid preheater blockages that may result from enhanced levels of Chloride and/or Sulphur.

3.5 Need for Pre-Processing of AF

Most of the HW require pre-processing (e.g. blending, shredding, mixing, etc.) before they can be co-processed along with the conventional fuels. RDF has to be extracted from raw MSW using a pre-processing line comprising of operations such as sorting, drying, shredding and baling. Biomass may require drying, shredding and baling. Industrial Plastic Waste which contains high moisture needs drying and baling before being transported for co-processing. Used tyres can be co-processed at high substitution rates, if co-processed in the form of tyre chips. It is essentials that the tyre chips must be clean cut and must not possess sharp edges which may lead to clogging problem.

4. ENVIRONMENTAL CONSIDERATIONS

Co-processing of AF not only results in substantial fuel saving and equivalent CO_2 mitigation, it also helps in sustainable disposal of industrial and agricultural wastes.

Due to a gap in quantity of incierable HW generated and installed capacity of incinerators, part of Incinerable HW generated is being dumped illegally. Co-processing of such waste can prevent illegal disposal practices. Moreover, many incinerators do not have energy recovery feature and have significantly high emissions.

Burning of used tyres in brick kilns and boilers at low temperatures releases toxics such as dioxins and furans. The toxics released into the atmosphere through such activities are carcinogenic in nature. Such practices are issues of environmental concern and need to be addressed. Cement kilns operate at high temperatures and used tyre in chipped form may be effectively burnt with significantly lower release of such harmful toxics.

With continuous population growth in urban areas, disposal of MSW is becoming a formidable task. Co-processing offers a sustainable solution for MSW disposal through usage of RDF in cement kilns.

Co-processing of biomass as an AF in cement industry makes better utilization of the heat content of such wastes as compared to their utilization for power generation in Biomass based Waste to Energy (WTE) power plants. Similarly, industrial plastic wastes which have significantly good heat content can also be co-processed in cement kilns in an environment friendly manner.

Generally, wastes such as biomass, RDF etc have a significant percentage of ash content. Power generation through WTE based power plants leads to generation of significant quantities of ash, disposal of which is task in itself. On the other hand, co-processing of such wastes in cement plants does not lead to such ash disposal concerns.

5. BARRIERS TO INCREASING TSR IN INDIAN CEMENT INDUSTRY

Co-processing of wastes is a sustainable method of disposing large volumes of waste without impacting the environment. However various policy, technical and financial barriers jeopardise this effort.

Major barriers which hamper the increase in TSR levels in Indian cement industry are outlined below:

- Expensive and time consuming trial runs required for each stream of HW.
- Lack of pre-processing facilities for using HW.
- Lack of information on availability and quality of AF in public domain.
- Huge competition for HW adversely impacting gate fee, making co-processing economically unattractive.
- Restrictions on Interstate movement of HW by some Indian states
- No policy measure to promote highly energy efficient and environmentally sound co-processing process over other means of disposal
- Biomass is reserved for WTE power plants in several states.
- Cumbersome transportation and logistics for low density wastes such as RDF
- Restrictions on import of AF such as tyre chips and Solid Recovered Fuel (SRF).
- Huge competition for used tyres from recycling and small scale industries resulting in exhorbitant prices for used tyres.
- Complicated and time consuming permit process for co-processing.
- No proper waste segregation at source in case of MSW and plastic waste.

6. ACTION PLAN

Following action plans are recommended for enhancing the TSR levels in Indian cement industry.

6.1 Hazardous Waste

- Eliminate need for emission trials for specific categories of HW.
- Increase availability of HW by including part of land-fillable HW under incinerable category.
- Develop guidelines for HW pre-processing units for cement industry.
- Making available HW inventory data base on software platform in all relevant states.
- Provision of central/ state government subsidy for setting up HW pre-processing units.

6.2 RDF from MSW

- Demo project for RDF in a proactive state in public private partnership mode.
- Encouragement to RDF co-processing by Ministry of New and Renewable Energy (MNRE) under their waste to energy scheme.
- Cement industry should take RDF use as Corporate Social responsibility (CSR) activity. Develop source segregated non recyclable plastic waste from neighbourhood for co-processing.

6.3 Used Tyres

- Ban on burning of tyres in brick kilns and boilers to prevent air pollution by toxics such as dioxins and furans.
- Allow free import of tyre chips and rubber waste for co-processing.

6.4 Biomass

- Ministry of New and Renewable Energy (MNRE) to include biomass co-processing in cement plants in their plan to use surplus biomass as green fuel.
- Captive/ neighbourhood energy crop plantation should be carried out by cement industry as Corporate Social Responsibility (CSR) activity.

6.5 Industrial Plastic Waste

- Replicate Gujarat model of co-processing plastic waste from waste paper based paper mills in other states having such paper mills.

7. CASE STUDY

7.1 Objective

The study was conducted for a client to access the availability of various AF in the vicinity of the upcoming Greenfield integrated cement project located in the southern part of India. The study encompassed the selection of potential AF, and an assessment of the technical and financial viability of setting up a facility for co-processing of AF.

7.2 Methodology

- The activities included development of a questionnaire followed by the site visit comprising of a two member specialist team from HOLTEC.
- Government bodies including the State Pollution Control Boards, State Agricultural Department, Department Of Renewable Energy and District Municipal Bodies were visited.
- Discussions were held with the concerned officials. Data on availability of various AF was collected.
- The project site was visited to access the availability of locally available AF.

 

Pictures taken during site visit to waste segregation centre

Based on these visits, data collected, and HOLTEC's experience in AF, a Techno-Economic Feasibility Report on Co-processing of AF was submitted.

7.3 Findings of the Study

7.3.1 AF Availability Assessment

The cement project envisages the use of South African coal as primary fuel. (NCV: 6,200 kcal/kg). The potential AF along with the estimated available quantities in tpa and their NCV are given in the **Table 4** below:

Table 4
Estimated potential availability and NCV of short listed AF

Alternate Fuel	Estimated Potential Availability (in tpa)	NCV (kcal/kg)
Local RDF	5,000	2,500
Sugarcane trash	10,000	3,200
Hazardous waste	4,000	3,000
Tyre chips	1,000	7,500

7.3.2 AF Compatibility with Clinker Quality and Kiln Operation

Based on the typical properties of the short listed AF for the study, the total chlorideinput was found well within the limit. High chloride input related preheater blockage issues are not expected for the above quantities of fuel substitution.

Sulphur content in the raw material as well as South African coal was found to be low, hence, no issues with respect to excess sulphur and its subsequent impact on clinker quality and kiln operations are foreseen.

Ash absorption in clinker by using 100% South African coal was calculated as 1.7%. Use of AF may marginally increase the ash absorption in clinker. The theoretical ash absorption was 1.9% which is only marginally higher and not expected to impact clinker quality.

7.3.3 Cost Economics

The investment cost towards setting up a co-processing facility in the cement plant was estimated to be about INR 100 million. The table below illustrates the quantities of various AF considered for co-processing and the financial indicators for the above investment to evaluate the feasibility of setting up a co-processing system.

Table 5
Quantities of AF considered and financial indicators

Parameter	Units	Quantity
Imported SRF	tpa	20,000
Local RDF	tpa	5,000
Sugarcane trash	tpa	10,000
Hazardous waste	tpa	4,000
Tyre chips	tpa	1,000
Total alternate fuels	**tpa**	**40,000**
Financial indicator	**Units**	**Value**
TSR	%	11.08
IRR	%	39.1
Payback period		2 yrs 6 onths

7.4 Conclusion

The financial results indicate that the project is financially attractive with high IRR and a low pay back period, considering adequate availability of alternative fuels.

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