AFR AND ITS RELEVANCE TO INDIAN CEMENT INDUSTRY

By

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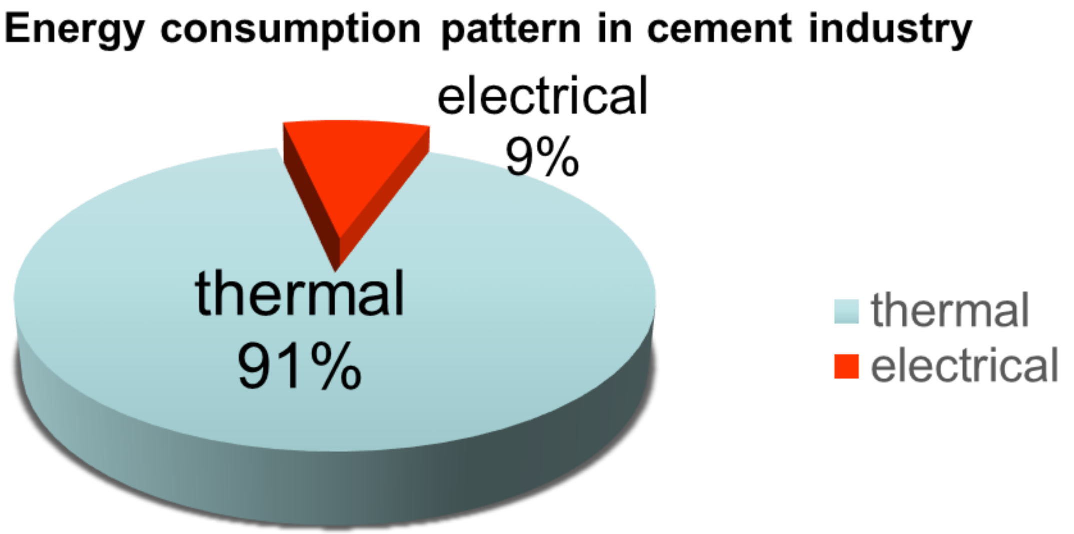
ENERGY CONSUMPTION IN CEMENT INDUSTRY

- **Cement industry is highly energy intensive with energy cost as high as 50-70% comprising of both thermal and electrical energy of total cost of production.**
- **The energy distribution is given as**

Target is to conserve this 91 % energy

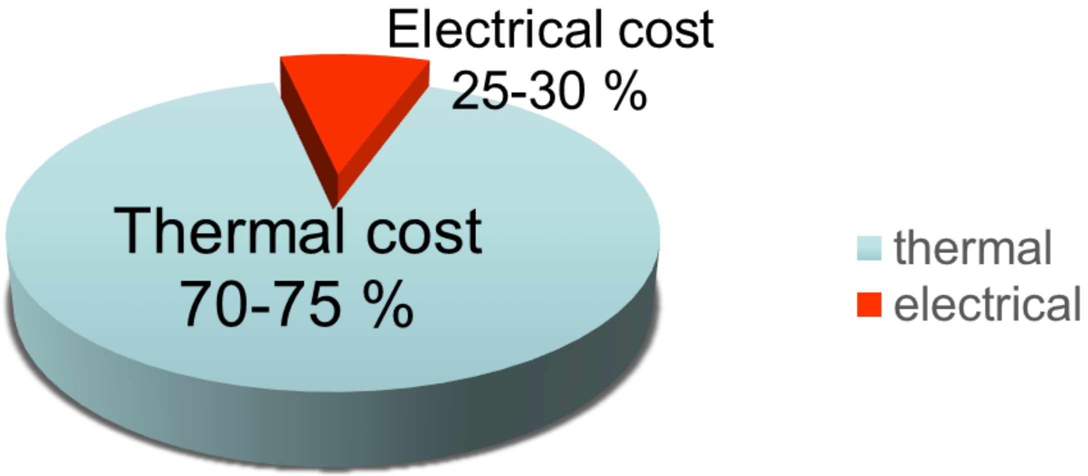


The conservation of energy and use of cheaper renewable alternate fuel have assumed greater importance for improving productivity and reducing thermal energy consumption.

ENERGY COST COMPARISON

- **Out of 50-70% of energy cost from total cost of production, major portion is of thermal energy.**
- **The energy cost distribution is given as**

Target is to reduce this 75 % energy cost



MAJOR CHALLENGES

- **High cost of fuel due to shortfall in coal linkages**
- **Insecurity in indigenous fuel availability.**
- **Perennial constraints like higher ash content and erratic variations in quality of indigenous coal.**

Keeping these challenges in view, cement industry is striving for energy conservation and exploring cheaper alternate materials which are renewable and environmentally friendly.

OPTIONS FOR MEETING THE FUEL REQUIREMENT FOR CEMENT INDUSTRY

- **Increased usage of alternative fuels for enhancing the Thermal Substitution Rate (TSR)**
- **Equal priority to cement sector in the grant of Coal linkage vis-a-vis other sectors**
- **Reserving sufficient coal blocks for cement industry**
- **Incentives for power generated by Waste Heat Recovery Plants**

WHY AFR ?

- Conservation of fossil (non-renewable) fuels.
- Reduction in energy costs for cement manufacture
- Complete destruction of waste
- Effective method of waste disposal
- Reduction in greenhouse gas emissions leading to alleviation of global warming
- Prevention of environmental degradation
- Minimizing environmental impact due to reduced load on coal mining
- Achieving PAT targets

The global average alternate fuel use in the cement industry is currently 4.3% of total thermal energy consumption. In some countries, the average use is as high as 34%, whereas in India the average is below 1 %.

CO-PROCESSING

Co-processing is use of waste as energy resource or mineral resource, or both to replace fossil fuels such as coal, petroleum and gas (for energy recovery) and natural mineral resources (for material recycling) in energy intensive industries such as cement, steel, thermal power plants etc.

Waste materials used for co-processing are referred to as alternative fuels and raw materials (AFR)

"One industry's waste becomes another industry's resource"

LIST OF ALTERNATE FUELS USED IN CEMENT KILNS WORLD WIDE

S. No.	Alternate Fuels
1.	RDF from Municipal Solid Waste (MSW)
2.	Hazardous Waste (including Industrial Plastic Waste)
3.	Biomass
4.	Used Tyres
5.	Poultry Litter
6.	Slaughter House and Dead Animals
7.	Dried Sewage Sludge

ENERGY CONTENT (CALORIFIC VALUE)

S. No.	Alternate Fuels	Average Net Calorific Value [kcal/kg]
1.	RDF from Municipal Solid Waste (MSW)	2,200
2.	Hazardous Waste (including Industrial Plastic Waste)	4,000
3.	Biomass	3,000
4.	Used Tyres	7,500

NCB INVESTIGATIONS ON CO-PROCESSING ON ALTERNATE FUELS

- **Materials Studied**
  - **Spent Wash**
  - **ETP Sludge**
  - **CETP Sludge**
  - **Bottom Ash from Crude Processing**

SPENT WASH CHARACTERIZATION

Sl. No.	Constituent	Value, %
1	Moisture Content	47.01
2	Volatile Matter	35.69
3	Ash Content	10.59
4	Fixed Carbon	6.71
5	Calorific Value (kcal/kg)	2000

- The analysis of the spent wash sample indicates the concentration of Na_2O at 2.08%, K_2O at 3.49% and chloride at 1.54%.

OUTCOMES OF SPENT WASH CO-PROCESSING

- Proposed to feed spent wash to replace coal up to 5% through main kiln firing
- No kiln operational and quality problems observed during trials at 1000 LPH feed of spent wash (3.5% SUBST.)
- Chloride content in hot meal increased to 0.6% with spent wash from 0.3% with coal
- Volatile matter increased to 3% from 2.0-2.5% (3.5% limit for hard coating)
- Chloride content in spent wash be restricted to 1.5% and below 0.35% in hot meal at kiln inlet

OUTCOMES OF ETP SLUDGE CO-PROCESSING

- The ETP sludge consumption was found to be varying from 4% to 6.5% (on dry basis) of total fuel used during the period of trials
- With proper handling and feeding higher quantity of ETP sludge can be used up to 10%.
- The laboratory results for chemical analysis and heavy metals in the clinker indicate that ETP sludge has negligible impact on the quality of clinker
- The results of leachability tests from all the clinker samples are also found within narrow variation indicating no adverse impact on use of ETP sludge.

CETP Sludge Characterization

- CETP sludge is a mixture of fine powder, granules and lumps which has significant and varying amount of moisture (35-50%). On sun drying, the sludge turns from sticky into brittle and non - sticky and becomes soft which is considered suitable for grinding.

Sl. No.	Constituent	Value (ADB)
1	Moisture Content (%)	6.09
2	Volatile Matter (%)	35.32
3	Ash Content (%)	55.76
4	Fixed Carbon (%)	2.83
5	Calorific Value (kcal/kg)	1621

OUTCOMES OF CETP SLUDGE CO-PROCESSING

- **CETP could be used to the extent of 5% only along with fuels**
- **No significant Impact on product quality and environment.**
- **The laboratory results for chemical analysis, heavy metals in the clinker, stack emissions data, leachability test and kiln parameters indicate that the use of CETP sludge has no adverse impact on clinker quality and environment at 5 %.**
- **SO_3 content was on the higher side and requires attention to limit the same below the permissible limits of 3.5% in cement.**

BOTTOM SLUDGE FROM REFINERY

S. No.	Constituent	Value
1	Moisture Content	4.26%
2	Volatile Matter	87.13%
3	Mineral Matter	0.07%
4	Fixed Carbon	8.54%
5	Calorific Value	10900 kcal/kg

Outcome of the study

Determination of heavy metals in bottom sludge were found low and hence expected to have insignificant impact on environment and clinker quality.

ALTERNATE BLENDING MATERIALS

- **Various ferrous & non-ferrous industries generate industrial wastes that are unutilized, and thus occupy large tracts of valuable land, posing serious environmental and health hazards.**
- **Initial studies have shown that these materials have the potential to be used as blending materials at the clinker grinding stage during cement manufacture**
- **Substantially reduce heat consumption and mitigate CO2 emission levels to the extent of the additional levels used.**

FLY ASH PRODUCTION AND UTILIZATION LEVELS IN INDIA

- **2010-11 : 190 million tonnes (generation)**
- **2020-21 : 450 million tonnes (estimated)**
- **2031-32 : 900 million tonnes (estimated)**
- **At present, about 100 million tonnes is being utilized in cement and other building materials**

PROPERTIES OF INDIAN FLY ASH

- **Glass content : 15-45 %**
- **Lime reactivity: 2.0-7.0 MPa**
- **Role of fly ash in PPC is attributed to the pozzolanic action**
- **Fine fraction of fly ash, below 45 micron, contributes predominantly to the Performance of PPC**
- **Fly ash conforming to standard IS: 3812 (1) 2003 can be used (up to 35% maximum) in the manufacture of PPC as per IS: 1489 (part 1) 1991.**

NCB STUDIES ON MAXIMUM FLY ASH UTILIZATION

- **Mechanical activation (by screening, fine grinding and separation)**
- **Chemical activation (addition of suitable chemical compounds)**
- **Thermal activation (low temperature heating)**

ANTICIPATED BENEFITS

- **Thermal savings: saving potential: 180 - 235 kcal /kg cement**
- **PPC (27 - 35% fly ash replacement)**
- **Electrical savings: saving potential: 13 - 17 kWh/t PPC.**
- **CO_2 reduction (direct): 220-280 kg CO_2/t PPC (for cement with 27 - 35% by mass fly ash).**
- **CO_2 reduction (indirect): reduction in CO_2 emission is expected to be 13 – 17kg/t PPC (for cement with 27 - 35% by mass fly ash.)**

CONSTRAINTS IN FLY ASH UTILIZATION AND REMEDIAL MEASURES

- Provision of transportation of dry fly ash in closed wagons to prevent high transit losses and fugitive emissions as it is a fine powder.
- As the bulk of fly ash is disposed of in a wet state, arrangements have to be made for extraction and supply of fly ash in a dry state.
- Provision of marketing of standard quality fly ash in bags or any other packing such as drums, etc
- Tax relief and fly ash utilization subsidy will go a long way to promote increased utilization

STANDARD ON SLAG UTILIZATION

IS: 12089-1987 is for quality of GBFS to be used in manufacture of PSC

- Glass content (by OM) : 85 %
- Manganese Oxide : < 5.5 %
- Magnesium Oxide : < 17.0%
- Sulfide Sulfur : < 2.0 %
- The quality and performance of PSC is governed by the Indian standard specification IS:455-1989, which allows use of GBFS in the range of 25-70% (4th amendments).
- The European standard (EN-197) for blast furnace slag cement type III/B and III/C allows addition of ground GBFS in the range of 66-80% and 81-95% respectively
- At present, the steel industry is able to granulate about 10 million tonnes of usable GBSF out of an approximate 22 million tonnes generated.
- Estimated generation of (GBFS) will be around 43.9 mtpa in 2020 and about 95 mtpa in 2030.
- At present, total amount of GBFS is used in PSC in India.

ANTICIPATED BENEFITS

- **Thermal savings: 270 - 475 kcal/kg PSC**
- **Electrical savings: 18 - 34 kWh/t PSC (from current substitution rate of 40% to allowed/potential level of 70%)**
- **CO_2 reduction (direct): Reduction in CO_2 emission up to 325 to 570 kg CO_2/t PSC (assuming GBFS as CO_2 free)**
- **CO_2 reduction (indirect): 1 kWh reduction in specific power consumption reduces CO_2 emission by 1kg hence, reduction in CO_2 emission is expected to be 18 - 34 kg/t PSC (for cement with 40 - 70% by mass of slag)**

CONSTRAINTS AND REMEDIAL MEASURES

- **Inadequate infrastructure for granulation of slag**
- **Inadequate quality of clinker to absorb additional slag**
- **Rationalizing the cost input on grinding of slag**
- **New steel plants to be set up in 100% slag granulation facility**
- **Technology upgrades to improve clinker quality**
- **Economic activation of non-granulated blast furnace slag is not available at present.**
- **Transportation and consumer awareness on quality of slag cement.**

PRODUCTION LEVELS OF VARIOUS TYPES OF INDUSTRIAL WASTES AND BY-PRODUCTS

- **lead-zinc slag ~ 1.0 MTPA**
- **Copper slag ~ 0.8 MTPA**
- **'LD' / Blast Oxygen Furnace Slag (BOF) ~ 4.0 MTPA**
- **Equilibrium catalyst ~ 15,000 TPA**
- **Jarosite ~ 0.3 MTPA**
- **Kimberlite ~ 0.6 MTPA**
- **Marble slurry ~ 5 MTPA**

Lead-Zinc Slag as Performance Improver

Properties	OPC-C	OPC-BF	OPC-Zn-Slag
Fineness (m2/kg)	309	307	307
Consistency,%	26.0	26.0	26.0
Setting time (minutes			
Initial	130	120	125
Final	185	180	180
Compressive Strength (MPa)			
3 days	41.0	41.0	42.0
7 days	51.5	51.0	50.0
28 days	62.0	62.0	62.0
Soundness			
Le-chat, mm	1.0	1.0	1.0
Autoclave,%	0.02	0.02	0.03

LD Slag as Performance Improver

Property	OPC-C	OPC-BF	OPC-LD-1	OPC-LD-2	OPC-LD-3
BF (m2/kg)	**321**	**316**	**318**	**316**	**318**
Consist,%	**28.0**	**27.0**	**27.0**	**28.0**	**27.0**
Setting time (minutes)					
Initial	**95**	**100**	**100**	**105**	**100**
Final	**145**	**155**	**155**	**155**	**160**
Compressive strength (Mpa)					
3 days	**35.0**	**34.0**	**35.0**	**33.0**	**34.0**
7 days	**42.5**	**43.0**	**42.5**	**42.0**	**42.5**
28 days	**51.0**	**51.0**	**50.5**	**50.5**	**51.0**
Soundness					
Le-chat,mm	**1.0**	**2.0**	**1.0**	**1.0**	**1.0**
Auto,%	**0.03**	**0.03**	**0.04**	**0.04**	**0.02**

PERFORMANCE EVALUATION OF CEMENT BLENDS CONTAINING PANIPAT SPENT CATALYST WASTE

Properties	Control	S C 1 %	S C 5 %	S C 10 %	S C 15 %	S C 20 %
Fineness (m^2/kg)	321	310	322	325	313	323
Consistency (%)	25	25.4	26.8	28.8	30.4	31.6
Setting Time (mnts)						
Initial	134	120	105	98	93	79
Final	213	178	167	180	146	129
Comp. Strength (MPa)						
3d	25.2	32.0	31.3	26.5	23.1	18.5
7d	36.2	38.9	38.1	32.5	28.0	26.1
28d	42.1	46.7	46.4	44.1	37.2	36.6

S C – Spent Catalyst

Copper Slag as Performance Improver

Property	OPC-C	OPC-BF	OPC-Cu-1	OPC-Cu-2	OPC-Cu-3
BF (m2/kg)	**310**	**308**	**309**	**310**	**308**
Consist,%	**26.5**	**26.3**	**26.4**	**26.2**	**26.4**
Setting time (minutes)					
Initial	**130**	**140**	**135**	**132**	**136**
Final	**195**	**205**	**204**	**205**	**202**
Compressive strength (Mpa)					
3 days	**36.0**	**36.0**	**36.0**	**36.0**	**36.0**
7 days	**47.5**	**47.0**	**47.5**	**47.5**	**47.0**
28 days	**59.0**	**60.0**	**61.0**	**60.0**	**60.0**
Soundness					
Le-chat,mm	**1.0**	**2.0**	**2.0**	**1.0**	**2.0**
Auto,%	**0.02**	**0.02**	**0.03**	**0.05**	**0.04**

E-Cat as Performance Improver

Properties	OPC-C	OPC-EC-1
Fineness (m2/kg)	320	318
Consistency,%	25.0	26.4
Setting time (minutes		
Initial	134	88
Final	213	153
Compressive Strength (MPa)		
3 days	25.0	28.0
7 days	36.0	32.0
28 days	42.0	47.0
Soundness		
Le-chat, mm	1.0	1.0
Autoclave,%	0.02	0.02

PROGRESS IN THE USE OF INDUSTRIAL WASTE IN CEMENT MANUFACTURE

- **Based on detailed investigation carried out at NCB, waste materials namely Lead-Zink Slag, Copper slag and E-Cat have already been recommended by the Working Group of BIS for use as performance improver in OPC.**
- **BIS draft considering above recommendations is presently under wide circulation.**

REDUCE CO_2 EMISSIONS AND ENERGY CONSUMPTION BY USE OF LOW GRADE LIMESTONE

- **Percentage of clinker in cement blends can also be reduced by using various materials, such as limestone, low grade/dolomitic limestone**
- **Globally, three types of blended cements, namely Portland Slag Cement (PSC), Portland Pozzolana Cement (PPC) and Portland Limestone Cement (PLC) are being produced**
- **PPC, PSC are commonly produced in India and PLC yet to be standardized and produced**

NCB STUDIES ON POTENTIAL ALTERNATE RAW MATERIALS

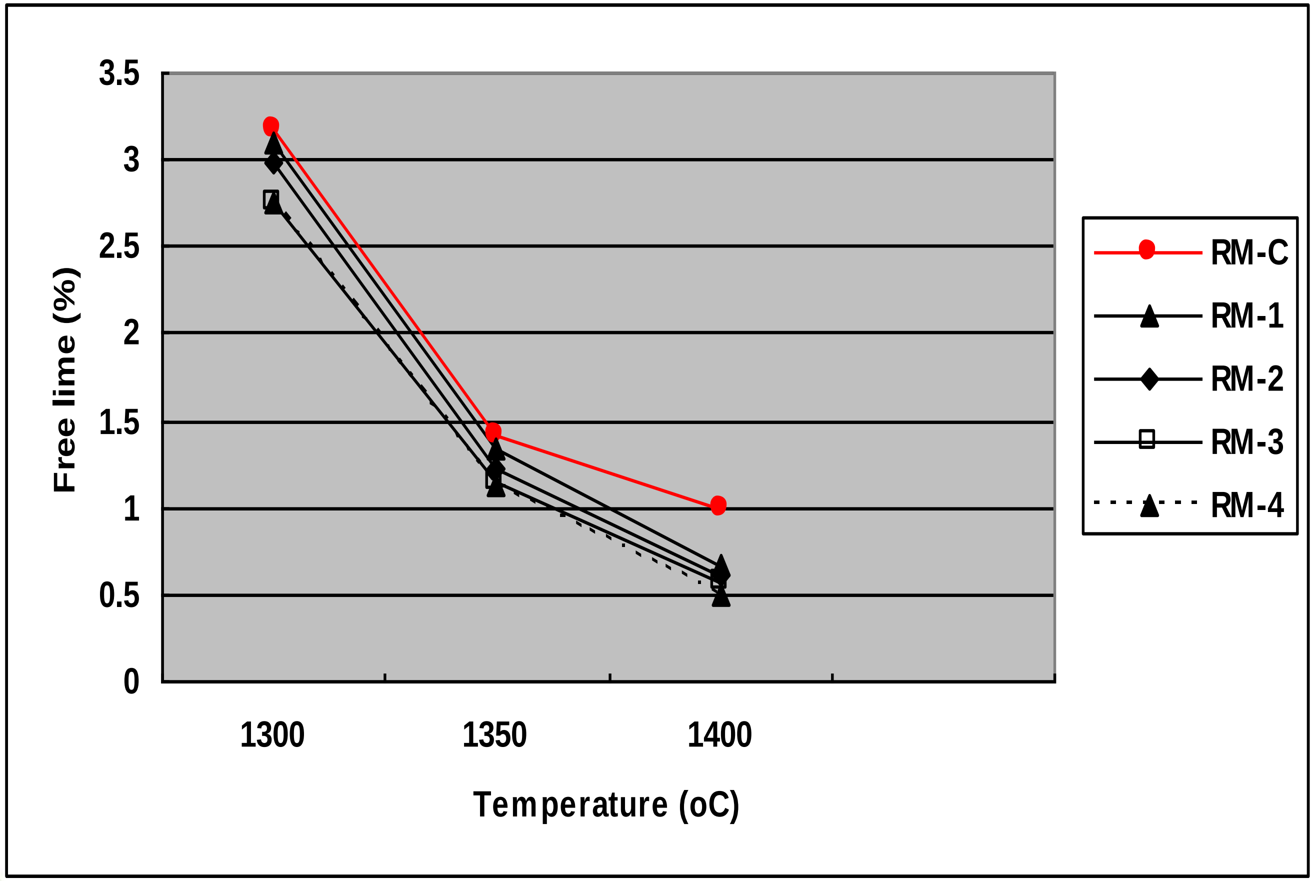
Potential materials	Current estimated generation (MTPA)	Range of addition as raw mix component (%)
Fly ash	190	1 - 3
Blast furnace slag	22	10 - 15
Steel slag	6	10
Carbide sludge	0.2	10 - 17
Phospho-gypsum	5 - 6	Not available
Pb-Zn slag	1.0	5 - 6
Flue dust from blast furnace	Not available	1 - 2
Dolochar waste	Not available	1 - 3

- Level of utilization will depend upon overall compatibility with other raw materials, and the desired quality in the resultant clinker

COPPER SLAG AS MINERALISER

- **The chemical analysis of the copper slag indicated the presence of 68.29% Fe_2O_3 and 1.20% CuO and was found to be compatible for use in cement raw mix.**
- **Studies conducted on the burnability of cement raw mixes containing 1.5-2.5% copper slag showed clinker formation at ~50^{o}C lower temperature as compared to control raw mix.**
- **Clinker mineral phases developed in presence of up to 2.5% copper slag were equally good indicating mineralizing effect of copper slag. In presence of copper slag, the clinker mineral phase formation is also reported to be increased.**
- **Performance characteristics of cement prepared from mineralized clinker were found to be comparable to control cement.**

BURNABILITY RESULTS USING COPPER SLAG AS MINERALISER



Free CaO content in RM-C at 1400°C : 1.0% and at 1450°C : 0.50%
Free CaO content in RM-1 to RM-4 at 1400°C : 0.5-0.6%

IMPACT OF AFR ON PROCESS PARAMETERS

- **Impact of AFR on total electrical and thermal energy consumption can be hard to quantify.**
- **Plant operation with alternate fuels may result in minor increase in overall specific heat consumption and loss of production.**
- **There are mainly six factors contributing to increased heat consumption i.e. moisture content of AF, ash content, poor combustion, fluctuating AF feed and its quality, introduction of cold air and circulation phenomenon.**
- **However there are various measures to compensate or alleviate negative impacts of alternate fuels on production .**
- **It can be inferred that negative impacts of AF utilization such as increased specific heat consumption and production loss will lead to reduction in the benefits to a certain extent obtained under PAT scheme.**

CONCLUSION

- Substituting conventional fuels with alternate/waste derived fuels (WDF) including hazardous combustible wastes (HCW) shall cut down the energy costs in cement plants.
- Use of alternate waste as blending material
- Moreover it is an effective tool for cement plants to achieve a reduction in specific energy consumption to fulfill the PAT targets and acquire certificates of energy savings which could be traded.
- This will help in achieving CO_2 emissions intensity targets in Indian cement industry and lead to significant environmental impact in global scenario
- Swachh Bharat Abhiyan directs the nation to solve its waste management issues and AFR Co-processing in cement plants will prove to be an asset.


THANK
YOU