Use of 100% Unconventional Fuel in Cement Kiln - A Case Study

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1.0 Introduction

The cement industry, as high energy consumption activity, has always displayed interest in energy recovery & in alternate fuel [1]. The appropriate selection and use of a fuel has always been, and still is, a matter of great concern for cement industry. The current fierce competition in the cement market & the high impact of fuel costs in the final price of product is forcing industry to look for most economic mix to fire in the kiln.
Clinker kilns are listed as a methodology for re-use of almost all types of alternate fuel [2]. Cement kiln effectively traps the acid substances through basic material being baked inside at high temperature. This important capability to capture combustion products, with an effective de-dusting system, makes cement kilns suitable for alternate fuel [3], without the fear of adding to atmospheric pollution (4,5). There are a large variety of fuels that can be fired in cement kilns.

At Vikram cement, utilization of Indian coal or Import coal was not economical from any corner to the company due to its high landed cost. Various alternatives were evaluated. Pet coke (waste of Petroleum industry) from Reliance Industry Jamnagar was found to be most economical, among all available fuels.

2.0 Background

Use of alternate fuel especially Pet coke introduces sulfur in the cement kiln system, which enhances the formation of a varied range of volatile compounds. This volatile travels to cooler parts of the system & deposit there, resulting in blockage of path & ultimately plant stop. Therefore it becomes imperative to have careful understanding of the process and undertake remedial measures.

3.0 Remedial Measures

To counter this problem, various alternatives were brain stormed & implemented to achieve 100% use of Pet coke. Vikram cement started with 10% Pet coke along with normal coal gradually attaining 67% which at one point of time, looked to be optimal dose. But with concerted effort and further modification in the system resulted, in 100% utilization of Pet coke, which are described in following steps.

3.1 Step-I

Pet coke is having very low volatile matter, therefore poor burning material. Typical analysis of Pet coke verses other available coal is given in table-I

Description	Pet coke	India coal	Imported coal
Ash %	0.40-1.0	25-40	7.0-15.0
Inherent Moisture %	0.25-0.50	1.5-3.5	1.0-2.50
Volatile Matter %	9.50-11.00	24.0-30.0	25.0-31.0
Calorific Value (Calorie/gm)	8200-8300	4800-5800	6500-7000
Sulfur %	6.0-7.30	0.5-0.9	0.60-1.0

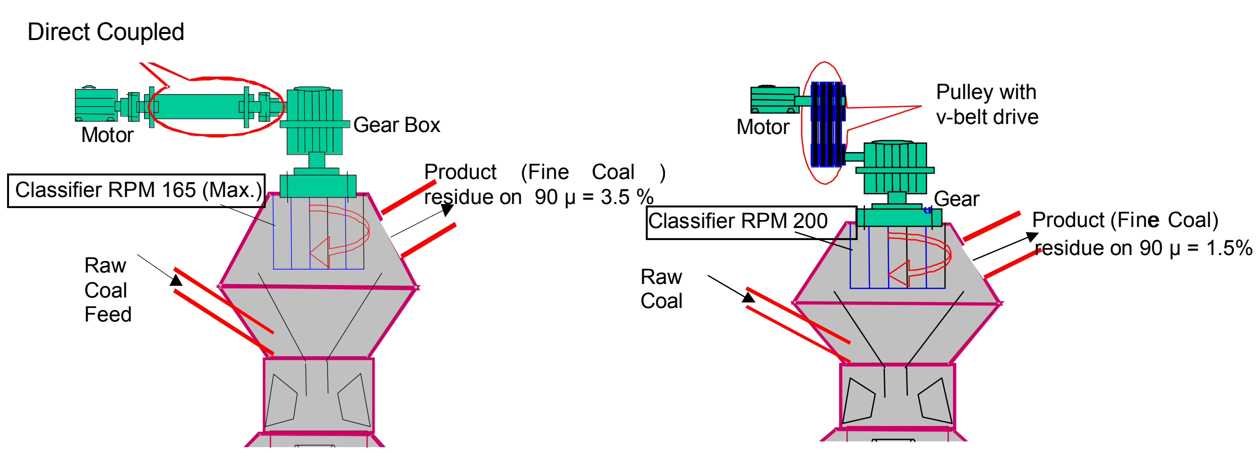
Normally volatiles help for initial ignition. Therefore to burn low volatile fuel, it needs more surface area (Finer grinding). After some trial, it was decided to keep fineness of firing coal 1.5% retention on 90 micron. But existing coal mill was capable of giving 5% max on 90 micron (design was 15% on 90 micron for Indian coal which is softer). Pet coke is very hard to grind (Hard grove Index 35-45) against 60-65 HGI (Hardgrove Index) in normal coal. Therefore without any modification, it was not possible to get targeted value of fineness in pet coke.

With Pet coke, we targeted 1.5 % residue on 90 micron, which was achieved by following action:

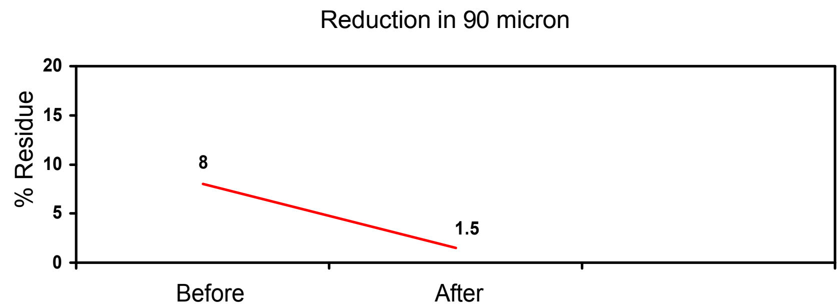
For 100 % combustion of pet coke at kiln & pyro it was decided to grind finer at level of 1.5 % retention on 90 micron sieve because due to poor burning characteristics of pet coke, it require more surface area.
Following improvement job's were carried out in-house for grinding at level of 1.5% residue on 90 microns.

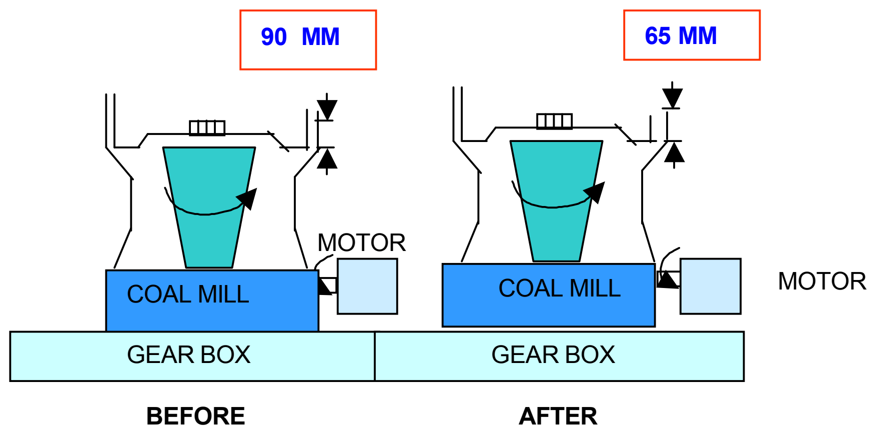
- In our coal mill, separator RPM was restriction beyond 150RPM, which was not allowing lower residue. V-belt pulley drive is installed in place of direct coupled which increases classifier RPM from 150 to 200.

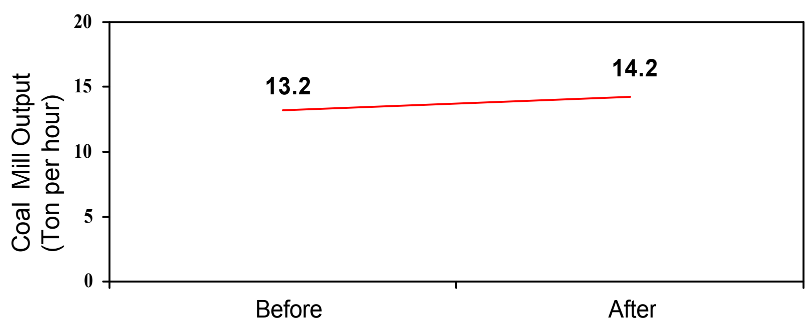
Before Modification | After Modification



Now at reduced residue, output of coal mill was also reduced resuting in less availability of ground coke so the less kiln output. But to maintain kiln output level, coal mill output level also required to be increased.
Reduction in coal mill internal diameter helped optimizing output at required particle size.







3.2 Step-II

Due to difficult burning characteristics of pet coke it is essential to have proper mixing of air with fuel other wise pet coke will burn on back side at inlet and shall cause jamming, due to more sulfur concentration at inlet, resulting in lower out put of kiln and poor quality of clinker. This was over come by increasing flame momentum. This was done by installing blower in place of primary air fan.

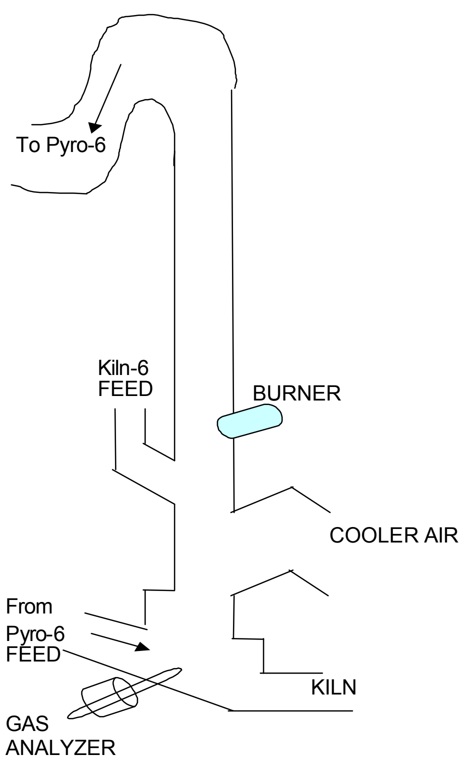
Resulting flame momentum was increased to 2300 % meter/second in Line-I & II and 2800 % meter/second in Line-III.

Description	**Before (Primary Air Fan)**	**After (Blower)**
	Flame Momentum (% Meter/Second)	
Unit-I & II	1200	2300
UNIT- III	1200	2800

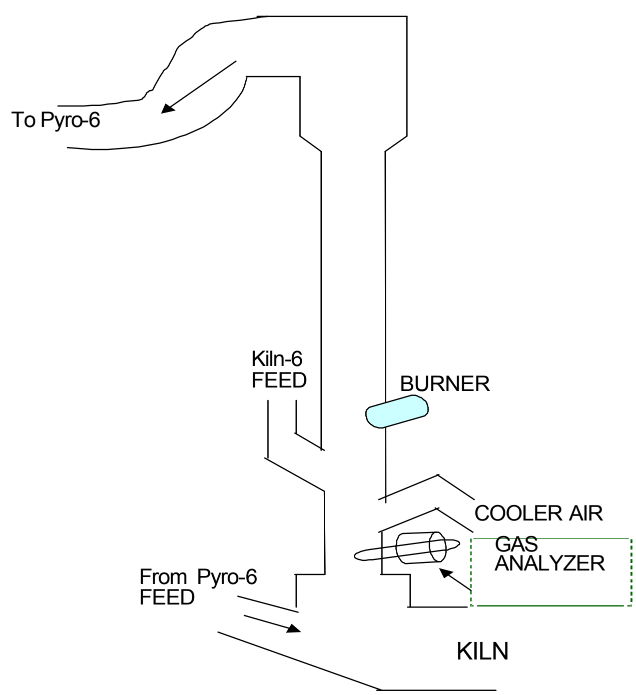
3.3 Step-III

For burning pet coke, Carbon monoxide (CO) has to be < 500 PPM at inlet. Earlier analyzer position at inlet was such that material was settling on the analyzer. Therefore area was getting restricted and causing deficiency of oxygen resulting in jamming. Further due to frequent jamming on analyzer, availability of analyzer was less so less availability of CO values, therefore kiln operation was inconsistent. To avoid this phenomenon and to monitor combustion in the process, high resolution & accurate monitoring system installed and relocated at new locations, as shown in the figures.

BEFORE MODIFICATION



AFTER MODIFICATION



(PYROCLONE)

Result: Smooth operation of kiln.

3.4 Step- IV

Volatile constituents like alkali oxides primarily K2O and Na2O through meal, and sulfate / chloride mainly from Pet coke forms a variety of volatile compounds. These volatile compounds condense in the comparatively cooler part of the pre-heater and make the jamming problem more severe. This problem not only reduces the life of the refractory but also exerts thermal as well as mechanical stress on the refractories. To overcome this problem, a kaizen has been taken in which the bricks of kiln riser duct & kiln inlet was replaced by silicon carbide based castable phase wise. This castable forms a vitreous layer on the surface having very low adherence properly. It helped remarkably less accumulation of coating.

Basically this volatile cycle is governed by sulpher to alkali ratio (Q):

Q = { SO3/80}/ {(Na2O/62)+(K2O/94)-(Cl/71)}

When Q= 1 Equilibrium (Medium hard coating).

Q= >1, Sulpher excess (Hard coating).

Q= <1, Alkali excess (Soft coating).

Q= Sulpher to Alkali ratio

SO3= Sulpher trioxide (%), Na2O = Sodium Oxide (%)

K2O = Potassium Oxide (%), Cl = Chloride (%)

Three actions were taken to reduce volatile cycle

(a) To reduce the sulfur cycle to avoid loss of productivity, combinability temperature must be reduced. Combinability temperature is the temperature at which oxides combine to form basic complexes required for cement clinker. This depends on oxides percentage and various moduli values. At high temperature sulfur again volatilize from clinker at burning zone & deposit in colder area of the system. At lower temperature sulfur comes out along with clinker. Combinability temperature (CT) was reduced at burning zone by redesigning the raw mix an using formula

Formula: CT (Combinability temperature) = 436+21 x AIR % + 10 x Clinker LSF + 3 x residue of raw meal on 150 microns + 32 x Clinker AM –20 x Clink SO_3% - 250 x Clinker fluoride

Modified raw mix design was as under

Description	LSF	SM	AM	Raw mill Residue on 212 micron
Before	96.2	2.14	0.94	2.7
After	93.5	2.00	1.08	2.4

(LSF : Lime Saturation Factor, SM: Silica Modulus, AM: Alumina Modulus)

LSF (Lime Saturation Factor) = (CaO % / 2.8 SiO2 % + 1.2 Al2O3 % + 0.65 Fe2O3 %)

SM (Silica Modulus) = (SiO2 % / Al2O3 % + Fe2O3 %)

AM (Alumina Modulus) = (Al2O3 % / Fe2O3 %)

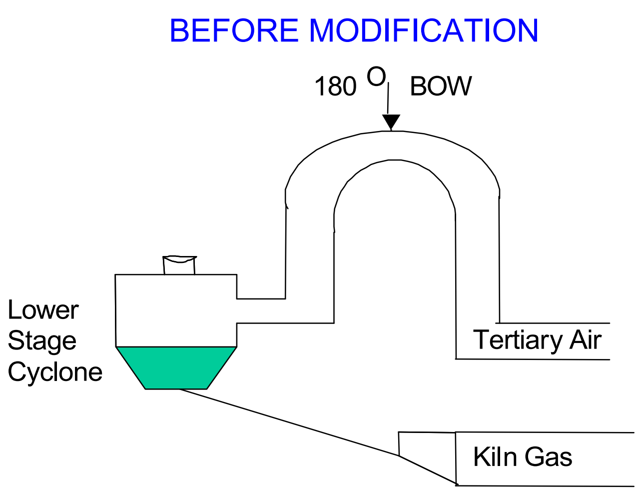
Results:	Before	After
Combinability Temperature (^{0}Celcius) -	1430	1400

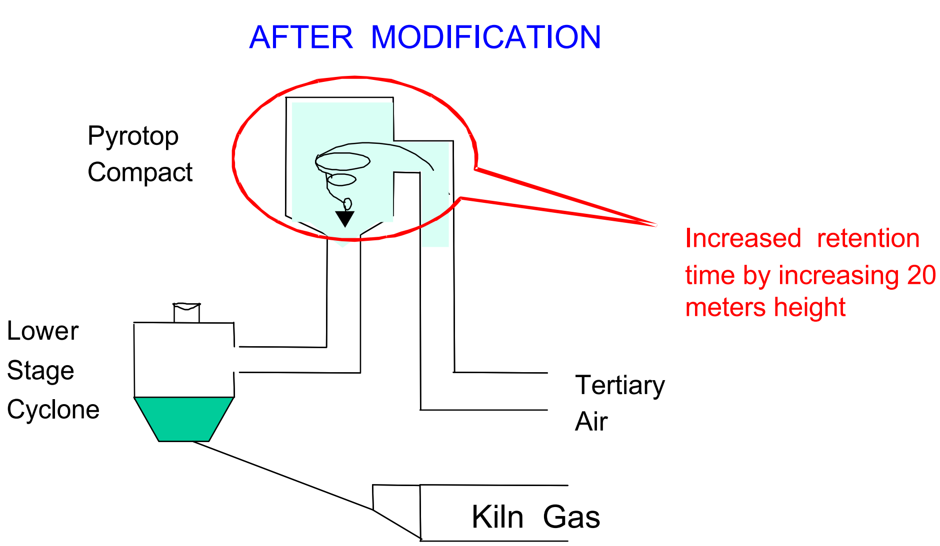
It was closely monitored.

(b) Further kiln speed was increased from 4.5 to 5.5 to help sulfur to combine as sulfates in clinker,& coming out of the system, so as to reduce further cycle in the system.

(c) Pet coke needs more time for proper combustion. In Pyroclone area, it was found that approx. 5 seconds time required for complete combustion to avoid CO (carbon monoxide) formation.

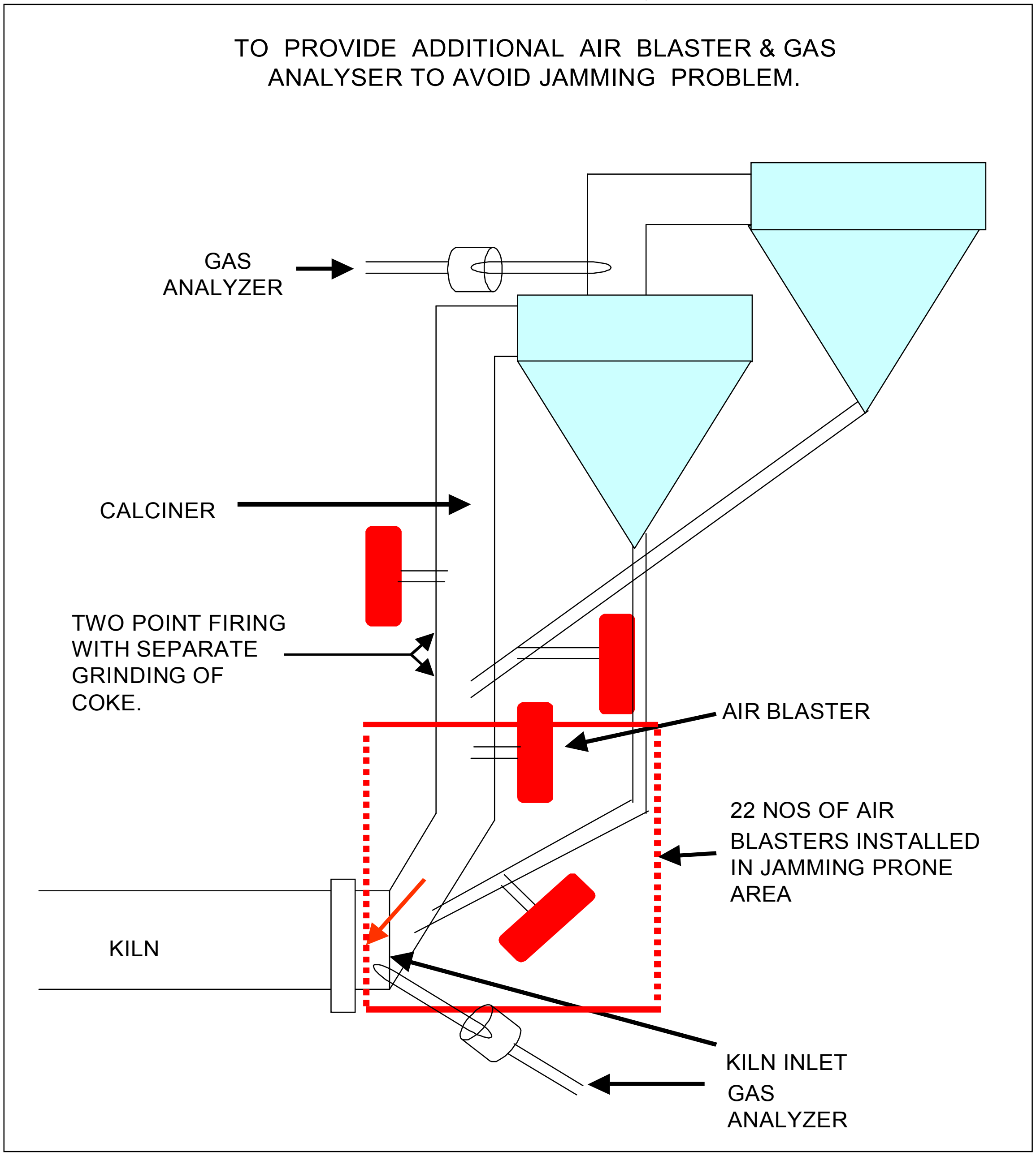
Retention time was enhanced by increasing pyro clone height by 20 meters. This has given enough time for pet coke to burn properly in the system to avoid any reducing atmosphere, as shown in the figure.





3.5 Step- V

Sulfur circulation by use of 100 % petcoke in the process may affect adversely due to higher sulfur in fuel, higher output or any process / raw mix variation.



These may cause jamming in the process path . It is necessary here to clean the area continuously . To avoid & control such happenings, following job was initiated Series of air blasters installed in jamming prone areas.

- High Pressure Pump installed for removing coating.

- Sulfur vaporization factor in the process is maintained below 2 % and it is monitored at increased frequency.

With all these changes and actions unit was able to implement 100 % pet coke with increased productivity and desired quality. Figure of pet coke consumption % is as under.

Description	% pet coke use
Year 2002-03	67.63
Year 2003-04	80.78
April'2004	89.67
May'2004	100.00
June'2004	100.00
July'2004	99.23
August'2004	100.00
September'2004	94.26
October'2004	87.84
November'2004	100.00
December'2004	88.83
January'2005	83.42
February'2005	100.00
March'2005	87.48
Year 2004-05	94.03

Due to strategic decision of using one Indian bituminous coal rake per month, percentage of pet coke was reduced from month of october'2004.

4.0 Savings

There was a huge tangible and intangible saving on use of petcoke, which is summarized as under:

Tangible:

Description	Year	
	2003-2004	2004-2005
Saving due to pet coke use (Indian Rs.In Lacs)	309.34	634.05

Intangible:

- Elimination of sweetner grade limestone usage in raw mix. Earlier sweetener grade limestone was bought to compensate quality while using high ash Indian bituminous coal.
- Enhancement of mine life reserve due to reduction in mines cut of grade quality.
- Conservation of natural resources like lime stone, Gypsum & Coal.
- Reduction in CO2 emission due to low carbonate limestone utilization

5.0 Conclusion

It is evident that in the present scenario where fossil fuel is becoming more scares raw material, use of alternative fuels is essential. Use of pet coke in the cement kiln creates lot of disturbances, effecting productivity & quality, if not used properly.

However paper clearly demonstrates that careful examination of problem and systematic implementation of remedial measures definitely absorb 100% Pet coke without affecting process and quality.

Apart from saving of fossil fuel, it further reduces use of natural resource like high grate limestone due to negligible ash in pet coke & gypsum consumption due to part of the sulfate coming out of fuel. Use of these fuels also protects our environment by less emission of greenhouse gases, thus saving our motherland.

6.0 Reference

[1] Cinti G : Utilizzo di residui combustibili nel forno rotante per la produzione di clinker da cemento. Proceedings "La gestione degli impianti di termontilizzazione dei rifiuti problemi e soluzioni Bolobna, 141-154, 1994, (In Italian)"
[2] M C Gregor M: Emerging Technologies for utilising waste in cement production, world cement, January 1994,49-51.
[3] Hansen E.R. : Tyre power is fire power, Rock Products, April 1992,29-31.
[4] Deussner M : Clinker burning with reduced Nox Emission. World cement, December 1995, 52-58.
[5] Rose , D & Brentrup L : Effective Emission reduction when using secondary Material at the seggenthal cement works in Switzerland . Zement - kalk - Gips,4,1995,204-214 .