Enhancing Alternate Fuel in Cement Manufacturing Process:
A Sustainable Technological approach

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# Content

**Introduction**

AFR: Today’s Demand and Challenges

KHD Pyro Equipment for Burning AFR – PYROCLON® Calciner

KHD Pyro Equipment for Burning AFR – PYROJET® Kiln Burner

AFR: Alternative Raw materials

AFR: KHD’s References [India]

**Conclusion**
Indian Cement Industry is on 350 MTPA mark with more than 190 Large Plants and 350 small units.

Cement Despatch remains as consistent always except few slow-downs which gives thrust to cost competitiveness and subsequently innovative reforms.

Indian Cement Industry is operating at Lowest Specific Heat consumption of Average 725 Kcal/ kgcl against world Average 850 Kcal/ Kgcl.

Similarly Sp. Power consumption is Lowest in the world as 82 Kwh/T Cement against 100-110 Kwh/t Cement in World average.

Despite Efficient operation the average AFR Usage In Indian Cement Industry is below 2-3 % TSR which is far lower than Developed countries.

KHD continuously worked upon enhancement of Alternate fuels and Raw materials in the cement Plants Hence few important equipment invented/ developed to fulfil this requirement.

(Data from IBM & CII 2013-14 & 2014-15)
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</tbody>
</table>
AFR : Today’s Demand and Challenges

AFR Usages Comparison: Alternative Fuels (AF) utilization rate in the German Cement Industry.
## Waste Generation Statistics: India

<table>
<thead>
<tr>
<th>States</th>
<th>Generated (TPD)</th>
<th>Treated (TPD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh*</td>
<td>4760</td>
<td>6402</td>
</tr>
<tr>
<td>Chhattisgarh*</td>
<td>1896</td>
<td>168</td>
</tr>
<tr>
<td>Delhi</td>
<td>8370</td>
<td>3240</td>
</tr>
<tr>
<td>Gujarat</td>
<td>9988</td>
<td>2644</td>
</tr>
<tr>
<td>Haryana</td>
<td>3103</td>
<td>188</td>
</tr>
<tr>
<td>Jammu &amp; Kashmir*</td>
<td>1792</td>
<td>320</td>
</tr>
<tr>
<td>Jharkhand*</td>
<td>3570</td>
<td>65</td>
</tr>
<tr>
<td>Karnataka</td>
<td>8697</td>
<td>3000</td>
</tr>
<tr>
<td>West Bengal</td>
<td>9500</td>
<td>851</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>6678</td>
<td>-</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>22,570</td>
<td>5,927</td>
</tr>
<tr>
<td>Punjab*</td>
<td>4105</td>
<td>350</td>
</tr>
<tr>
<td>Rajasthan*</td>
<td>5037</td>
<td>490</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>14500</td>
<td>1607</td>
</tr>
<tr>
<td>Telengana</td>
<td>6740</td>
<td>3016</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>19180</td>
<td>5197</td>
</tr>
<tr>
<td>Other</td>
<td>10578</td>
<td>1287</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,41,064</strong></td>
<td><strong>34,752</strong></td>
</tr>
</tbody>
</table>

(Data of CPCB Annual Report 2013-14 & 2014-15)

Only 25% of Generated Waste is Treated,

Introduction - Alternative Fuel Availability in India
AFR : Today’s Demand and Challenges

Global Demands:

- Saving of natural resources
- Reduction of CO2 emissions (Emission trading)
- Thermal Recycling
- Material Recycling

Individual Demands:

- Earning of disposal fees
- Reduction of fuel costs “negative fuel costs”
- Stronger market position

Challenges:

- Identifying of new (fuel) sources for consistency in fuel supply.
- Preparing of waste to alternative fuel.
- Installation of AFR handling equipment.

(Data of CPCB Annual Report 2013-14 & 2014-15)
Challenges on energy balance, increase of specific heat consumption.

- Increased waste gas volumes (higher fuel moisture, fuel chemical composition, higher excess air demand, more fuel to maintain hot sintering zone).
- Higher amount of primary air (transport air) and leakage air, decrease of recuperation air from clinker cooler.
- Increased heat losses by radiation (shifting temperature profile of kiln to kiln inlet chamber).
- In case of Bypass System losses due to bypass gas extraction.

Challenges on plant operation stability

- High demands on fuel dosing equipment, continuous fuel feed.
- Formation of build-ups in case of Cl- and S-rich alternative fuels in the area kiln inlet, riser duct, bottommost cyclone. ➔ More manual cleaning efforts or Bypass System necessary

Challenges on clinker quality

- “Raining” of un-burnt fuel out of the kiln flame to the clinker bed => reduced burning conditions.
- Cooling down of the sintering zone.
- Possible enrichment of harmful elements in clinker, e.g. MgO, P2O5 (depending on Alternative Fuel ash composition).
- Adaption of raw mix, e.g. high Fe-content in Alternative Fuel.

Challenges on emissions

- Influence on avoiding NOx formation and / or NOx reduction.
- CO formation in case of inadequate calciner technology or unsuitable secondary fuels.
- Saving of primary fuel related CO2 emissions.
Introduction

AFR: Today’s Demand and Challenges

**KHD Pyro Equipment for Burning AFR – PYROCLON® Calciner**

KHD Pyro Equipment for Burning AFR – PYROJET® Kiln Burner

AFR: Alternative Raw materials

AFR: KHD’s References [India]

Conclusion
Challenges and Sustainable Innovative approach:

It’s not easy to add AFR without deeper analysis and knowledge as process related impacts can cause big problems!

KHD with 160 years of industrial history has the experience and process knowledge to identify and to solve these challenges to reach high and stable AFR firing rates.
Introduction – Feed points for Alternative Fuels and Raw Materials

Cement Mill:
- Synthetic Gypsum
- Gran. Blast Furn. Slag
- Fly Ash
- .......

Kiln Burner:
- Sorted municipal and industrial waste (RDF)
- Dried sewage sludge
- Liquid hazardous wastes, Solvents
- .......

Kiln Inlet:
- Whole Tires
- Pasty sludge
- .......

Calciner:
- Sorted municipal and industrial waste, low Quality
- Sewage Sludge
- Tire Chips
- .......

Raw Mill:
- Slag
- Fly Ash
- .......

KHD Pyro Equipment for Burning AFR – PYROCLON® Calciner

KHD PYROCLON® Calciner Technology – Overview

- PYROTOP® Mixing Chamber for complete fuel burn-out
- Design of Calciner length to reach suitable residence time (6-10 sec) for complete burn-out
- High velocity to ensure lifting of coarse fuels, avoidance of thick coatings
- Orifice to maintain gas balance and avoidance of coarse fuel fall through
- Tertiary Air Duct with Dust Settling Chamber or extended Kiln Hood to reduce clinker dust recirculation
Calciner - Pyroclon® Technology

- **Pyroclon-R**
  - In-line calciner (ILC)

- **Pyroclon-R LowNOx**
  - ILC with staged combustion

- **Pyroclon-R LowNOx AF**
  - ILC with staged combustion

- **Pyroclon-R with Combustion Chamber**
  - ILC with CC

Latest generation

![Diagram of Calciner - Pyroclon® Technology](image-url)
KHD Pyro Equipment for Burning AFR – PYROCLON® Calciner

KHD PYROCLON® Calciner Technology – Combustion Chamber

- Utilization of coarse fuels with extremely poor ignition and burning properties like coarse anthracite, petcoke and coarse secondary fuels or waste derived fuels.

- Ignition and start of combustion in pure air at high temperature (T > 1200°C).

- Calciner retention time > 7 sec.

- High efficiency and flexibility.

- Lower demand on fuel quality and preparation efforts.

→ Saving of alternative fuel costs.
PYROROTOR®

- Ø 3,4 m x 25 m or Ø 4,4 m x 18 m
- 0,2 - 1,0 U/min
- Filling degree max. 25%
- Meal for temperature control
- Auxiliary burner
- Oxidizing and reducing operation by TAD damper.
KHD Combustion Chamber: 60 % of total fuel (thermal)

- Coal / Petcoke / Animal Meal mix: 10 th-%
- Solid Hazardous Waste: 27 th-%
- Fluff RDF: 63 th-%

Typically 16 to 18 t/h of solid hazardous waste and Fluff RDF are fed into the KHD Combustion Chamber.

In 2014, after 10 years in operation

Calculation Example:
16 t waste/h → 384 t/d → assumed plant run time of 310 d/y
119 040 t/y → 1 190 400 t waste in 10 years.

Waste Density: 0,3 t/m³
Waste Volume: 3 968 000 m³ (in 10 years)

In Other Numbers
Storage Height: 5 m
Storage Area: 891 m x 891 m

Result = Stable feeding of approx. 90 th-% of alternative fuels to the calciner.
KHD Pyro Equipment for Burning AFR - PYROCLON® Calciner

KHD PYROCLON® Combustion Chamber – Latvia, 4 000 tpd

Result = Stable feeding of approx. **68 th-%** of **Alternative Fuels** to the kiln / calciner.

Main burner: **40 % of total fuel (thermal)**
- **Coal:** 78 th-%
- **Solid Residue Fuel, fine:** 22 th-% (= 2.5 t/h)

KHD Combustion Chamber: **60 % of total fuel (thermal)**
- **Coal (as stand-by for fast response):** 3 th-%
- **Solid Residue Fuel:** 70 th-%
- **Waste Wood Chips:** 2 th-%
- **Tyre Chips and Fluff:** 15 th-%
- **Neutralized Sulphuric Acid Tar:** 10 th-%

Typically **20 t/h** of Alternative Fuels are fed to the KHD Combustion Chamber.
Cemex Rüdersdorf, Germany – 6.000 tcl./d

Core equipment

- 5 Stage Cyclone Preheater WT PRZ 7648/3
- PYROCLON R® Low NOx Calciner w. PYROTOP
- 2-Pier Rotary Kiln, PYRORAPID® Ø 5,2 x 61 m
- 15% Bypass
- 3-Grate Cooler with hammer crusher

Result

- Since 1995 in operation
- Capacity proven for up to 6.500 t/d
- AFR ratio up to 85%
- WHR in connection with powerplant

Worlwide unique Plant Concept
Clinker Pyroline combined with CFBR

Circulating Fluidized Bed Reactor

A gasifyer operating on the principle of circulating fluidized bed to extent the options for using a wide range of different secondary materials.

The produced lean gas is burned in the calciner firing system while the reaction residues are discharged at the reactor floor and finally used in the raw mill.
Core equipment

- 1-String Pre-Heater, 4-stage. Type 7346/4
- PYROCLON® R LowNOx with PYROTOP®
- Tertiary Air Duct with Dust Setting Chamber
- Bypass system, design for 14 %
- 2-Station Rotary Kiln PYRORAPID® 4,2 x 50 m
- Kiln Burner PYROJET® HPJ/230
- Clinker Cooler IKN 3000/52/56/5/3 P, Grate Area 55 m²

Alternative Fuel Rate

<table>
<thead>
<tr>
<th>Kiln</th>
<th>15 % Animal Meal</th>
<th>85 % Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>LowNOx Calciner</td>
<td>70 % RDF</td>
<td>30 % Coal</td>
</tr>
<tr>
<td>Total</td>
<td>48 % Alt. Fuel</td>
<td>52 % Foss. Fuel</td>
</tr>
</tbody>
</table>

Result

- Since 1996 in operation
- Capacity proven for up to 2.500 t/d
- AFR ratio up to 50 %
### KHD Combustion Chamber – Reference List

<table>
<thead>
<tr>
<th>Customer</th>
<th>Country</th>
<th>Year</th>
<th>[t/d]</th>
<th>Preheater / Dimensions</th>
<th>Kiln</th>
<th>Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cimentos Liz S.A.</td>
<td>Brazil</td>
<td>2011</td>
<td>5000</td>
<td>PR 9067 / 5, PYROCLON R</td>
<td>5,0 x 69 PYRORAPID</td>
<td>Coal</td>
</tr>
<tr>
<td>Maras II</td>
<td>Turkey</td>
<td>2011</td>
<td>4500</td>
<td>PR 8864 / 5, PYROCLON R</td>
<td>4,6 x 54 PYRORAPID</td>
<td>Coal</td>
</tr>
<tr>
<td>Sengelejewski</td>
<td>Russia</td>
<td>2007</td>
<td>3000</td>
<td>PR 7950 / 4, PYROCLON R</td>
<td>4,4 x 52 PYRORAPID</td>
<td>Gas</td>
</tr>
<tr>
<td>Cimpor Yibitas Hasanoglan Plant</td>
<td>Turkey</td>
<td>2007</td>
<td>2500</td>
<td>PR 7648 / 5, PYROCLON R</td>
<td>4,2 x 50 PYRORAPID</td>
<td>Petcoke, Local Waste Derived Fuels</td>
</tr>
<tr>
<td>OAO Mordowzement, Komsomolski MORDOW 3</td>
<td>Russia</td>
<td>2006</td>
<td>6000</td>
<td>PRZ 7950 / 5, PYROCLON R</td>
<td>5,2 x 65</td>
<td>Gas</td>
</tr>
<tr>
<td>Holcim Campulung Cement</td>
<td>Romania</td>
<td>2006</td>
<td>4000</td>
<td>PR 8861 / 5, PYROCLON R</td>
<td>4,8 x 66</td>
<td>Coal / Petrol Coke, Natural Gas, Oil Sludge, Fluff RDF</td>
</tr>
<tr>
<td>Cemex Broceni Latvia plant, Broceni Line V</td>
<td>Latvia</td>
<td>2006</td>
<td>3500</td>
<td>PR 7650 / 4, PYROCLON R</td>
<td>4,6 x 54 PYRORAPID</td>
<td>Coal / Petrol Coke, Local Waste Fuels, Wood, Shredded tyres</td>
</tr>
<tr>
<td>Cimenterie National S.A.L.</td>
<td>Lebanon</td>
<td>2005</td>
<td>3800</td>
<td>PRZ 6442 / 4, PYROCLON R</td>
<td>4,4 x 64</td>
<td>Oil Petrol Coke Alternative Fuels</td>
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<tr>
<td>Guangzhou Heidelberg Yuexiu Cement</td>
<td>PR China</td>
<td>2003</td>
<td>6000</td>
<td>PRZ 7950/5, PYROCLON R</td>
<td>5,2 x 70 Pyrorapid</td>
<td>Hard Coal, Anthrazite, Sewage Sludge</td>
</tr>
<tr>
<td>Norcem A.S., Brevik Dalen plant Line VI</td>
<td>Norway</td>
<td>2003</td>
<td>3500</td>
<td>PRZ 5635/4, PYROCLON R Bypass</td>
<td>4,4 x 68</td>
<td>Coal Alternative Fuels, Waste Fuel</td>
</tr>
</tbody>
</table>
KHD PYROCLON® Combustion Chamber – Global Cemfuel Award

6th Global Cemfuels Conference 2012, in Aachen, Germany.

KHD wins the award for the most innovative technology for alternative fuel use.
Introduction

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AFR : Alternative Raw materials

AFR : KHD’s References [India]

Conclusion
Primary Air Amount:
Depending on fuel scenario
- Lower for primary fuels (⇒ Low NOx Burner)
- Higher for alternative fuels

KHD Pyro Equipment for Burning AFR - PYROJET® Kiln Burner
AFR Swirl Nozzle – Special Feature for higher AFR rates

- Retractable swirl element.
- No additional primary air necessary for AFR nozzle.
- Adjustable during operation.
- Fracturing, mixing of the AF flow shortly before entering the kiln (spraying angle).
- Improving the mixture within the flame core and with oxygen.
- Oxygen enrichment is also possible.

Increase of alternative fuel firing rate
KHD Pyro Equipment for Burning AFR - PYROJET® Kiln Burner

AFR Swirl element in front position ➔ Poor AFR distribution

AFR Swirl element in back position ➔ Good AFR distribution into the flame
## Reference List for Burner Modification with newly developed AFR Nozzle

<table>
<thead>
<tr>
<th>Plant</th>
<th>Company</th>
<th>Clinker Production [t/d]</th>
<th>AFR Rate Kiln Burner [%]</th>
<th>AFR Fuel Type</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burglengenfeld, D</td>
<td>Heidelberg Cement</td>
<td>2000</td>
<td>50-60</td>
<td>Plastic and paper foils</td>
<td>Existing Burner, retrofit with AFR Nozzle</td>
</tr>
<tr>
<td>Outão, PT</td>
<td>SECIL</td>
<td>3500</td>
<td>40-50</td>
<td>RDF, Sawdust, Wood Chips</td>
<td>Existing Burner, retrofit with AFR Nozzle</td>
</tr>
<tr>
<td>Erwitte, D</td>
<td>Spenner Zement</td>
<td>2000</td>
<td>Commissioning started</td>
<td></td>
<td>Existing Burner, retrofit with AFR Nozzle</td>
</tr>
<tr>
<td>Lampang, Thailand</td>
<td>Siam Cement</td>
<td>5500</td>
<td>Future intention to burn AFR</td>
<td></td>
<td>New Burner</td>
</tr>
</tbody>
</table>
AFR : Alternative Raw materials
Use of Alternative Raw Materials

Novotroizk, Russia, 2 x 3 000 t\text{cl}\cdot/d

Special Feature:

Up to 30% of raw material: Blast Furnace Slag
Fe-corrective component: Siemens Martin Slag

Source:

Slag dump from nearby steel works

Result:

Spec. Heat Consumption only \(\sim 600 \text{ kcal/kg}_{\text{cl}}\)

A successful project as an example of using Alternative Raw Materials.
AFR : KHD’s References [India]
<table>
<thead>
<tr>
<th>Plant</th>
<th>Type of Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTCL Reddipalayam</td>
<td>Tyre Chips, Municipal Waste, Paint Sludge, Agro Waste</td>
</tr>
<tr>
<td>UTCL Vikram Cement</td>
<td>Tyre Chips, Municipal Waste, Agro Waste</td>
</tr>
<tr>
<td>UTCL Tadipatri</td>
<td>Pharmaceutical Waste</td>
</tr>
<tr>
<td>Lafarge Sonadih</td>
<td>Agricultural Waste, Municipal &amp; Industrial Waste</td>
</tr>
<tr>
<td>UTCL Aditya Cement</td>
<td>Paint Sludge</td>
</tr>
</tbody>
</table>
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Conclusion
Conclusion

AFR - Alternative Fuels and Raw Materials

Utilization of alternative fuels is a state-of-the-art technology for cement plants.

Alternative fuels reduce fossil fuel consumption hence conservation of natural resources.

Broad variance in alternative fuels leads to many influences on the clinker process which have to be known and taken into account.

Different technical solutions exists for the utilization of secondary fuels in cement plants.

Due to steadily rising prices for primary fuels, the utilization of alternative fuels will become more and more a possibility for decreasing or maintaining the operational costs.

➡️ KHD’s 160 years of industrial history and experience helps our customers to implement alternative fuel projects into their process.
THANK YOU!