PROJECT REPORT

FOR

Proposed Amendment in Environmental Clearance reg. Use of Fuel Mix in Existing Cement Plant

At
Village : Rawan, Tehsil : Balodabazar,
District : Balodabazar - Bhatapara (Chhattisgarh)

APPLICANT

M/s. Ambuja Cements Ltd.
(Unit : Bhatapara)
Village - Rawan, Tehsil - Balodabazar,
District - Balodabazar-Bhatapara (Chhattisgarh) - 493331
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April, 2015
1.0 Introduction

M/s. Ambuja Cements Limited (ACL) under the brand name of ‘Ambuja Cement’ is a leading manufacturer of various types of cements in India. ACL has always been in the forefront to undertake environmental safeguard & improvement initiatives in all units and facilities.

Eco-friendly operations & mining practices, 100% restoration of mined area, recycling of sewage, zero discharge of waste water, emissions well below prescribed norms are only a few of these measures. All units of ACL are certified to Environment Management System (ISO-14001).

The Bhatapara Unit of Ambuja Cements Ltd. was originally established in 1987 under Management of M/s. Modi Cement Ltd. It was having a capacity of 1.8 MTPA cement. In 1998, Ambuja Cements Ltd. took over the management control of the unit which was subsequently taken over by Holcim, Switzerland in 2005.

In 2009, a new clinkerization line of 2.72 MTPA was commissioned and captive power plant was expanded to 63 MW. This unit is presently having a clinker manufacturing capacity of 4.42 MTPA & cement manufacturing capacity of 3.5 MTPA.

2.0 Location Details

Village: Rawan

Tehsil: Balodabazar

District: Balodabazar - Bhatapara

State: Chhattisgarh

Latitude: 21° 39' 57.25'' N to 21° 41' 4.41''N

Longitude: 82° 04' 22.02''E to 82° 05' 46.15''E

Toposheet No.: 64 G-14, 64K/1 & 64K/2

Location Map of the Plant site has been shown below:
Proposed Amendment in Environmental Clearance reg. Use of Fuel Mix in Existing Cement Plant
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M/s. Ambuja Cements Limited
(Unit: Bhatapara)

Figure - 1: Location Map
3.0  Project Proposal
M/s. Ambuja Cements Ltd. (Unit - Bhatapara) have obtained Environmental clearance for clinker production capacity of 2.72 MTPA (Line - II) from MoEF, New Delhi, vide MoEF letter no. J-11011/355/2005-IA-II (I) dated 13th April, 2007.
ACL is now proposing amendment in EC reg. use of Fuel Mix (Petcoke along with coal in different proportion) in existing Cement Plant (Clinkerization Unit of 2.72 MTPA capacity - Line II).
Details of the same have been given in table below:

Table - 1.1
Proposed Amendment

<table>
<thead>
<tr>
<th>Category</th>
<th>Existing</th>
<th>After Proposed Amendment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel for Cement Plant (Kiln)</td>
<td>Coal</td>
<td>Coal : Petcoke</td>
</tr>
<tr>
<td>Fuel</td>
<td>100%</td>
<td>Proportion to be designed for “S” content not exceeding 7.5 % in fuel mix</td>
</tr>
<tr>
<td>Proportion in mix fuel</td>
<td>100%</td>
<td>As per proportion</td>
</tr>
<tr>
<td>Fuel Consumption (TPD)</td>
<td>1485</td>
<td></td>
</tr>
</tbody>
</table>

4.0  Combustion Mechanism

Coal Burning
During the course of combustion, the following sequence of events takes place.

1. Drying: Initially, the fuel moisture is driven off. As a result, surface temperature of coal particle rise.
2. De-volatilization: It follows in the wake of drying. As the fuel particles receive heat from surroundings through convection and radiation, de-volatilization sets in whereupon the volatile matter tied to the fuel commence to be liberated as combustible vapors which burn as a diffusion flame surrounding the fuel particle. The volatiles burn as a diffusion flame surrounding the fuel particle.
3. Burnout: During the Coal burning process, the exothermic reactions, i.e. burning of carbon, hydrogen and sulphur in the fuel:

\[
\begin{align*}
C + O_2 & \rightarrow CO_2 + 408.86 \text{ KJ/mole} \\
2H + O_2 & \rightarrow 2H_2O + 286.22 \text{ KJ/mole} \\
S + O_2 & \rightarrow SO_2 + 292.25 \text{ KJ/mole}
\end{align*}
\]

At higher temperature, i.e. in the flame core some endothermic reactions may occur

\[
\begin{align*}
N_2 + O_2 & \rightarrow 2NO \cdot 180 \text{ KJ/mole} \\
C + CO_2 & \rightarrow 2CO \cdot 7.25 \text{ MJ/Kg}
\end{align*}
\]

The last reaction takes place on the incandescent surface of the carbon particles under conditions of the carbon particles under conditioned oxygen deficiency.
**Petcoke burning**

Combustion involves a series of complex chemical reactions. The general approach is to break down the carbonaceous material into a series of equivalent simple reactions. These reactions take place in a systematic way involving following steps.

1. De-volatilization and volatile combustion
2. Char (C) Combustion
3. NOx formation
4. SO2 absorption in limestone, forming calcium sulfate

**De-volatilization and Volatile Combustion**

When Pet coke is fed into kiln & calciner, it decomposes into two main components: Hydrogen-rich volatile fuel and Carbon. The moisture content present in the feedstock after drying evaporates during the de-volatilization process. Since the reaction is fast enough to achieve equilibrium at small residence times, ACL modeled it with equivalent simple reactions involving combustion of elemental components using equilibrium reactors. The steps involved in this modeling of combustion chamber include:

1. Decomposition of Pet coke into elemental components
2. Volatile combustion

Combustion of carbonaceous feedstock always involves complex reactions that are very difficult to model, since the kinetic constants for various series and parallel reactions are unknown. To simplify, the feedstock is decomposed into elemental components based on the ultimate analysis of the feedstock.

Volatile combustion can be written as,

\[ \text{Volatiles (HC)} + \frac{3}{2} \text{O}_2 \rightarrow \text{CO} + \text{H}_2\text{O} \]  

The main reactions considered in the modeling volatile combustion process are

\[ \text{C} + \frac{1}{2} \text{O}_2 \rightarrow \text{CO} \quad -111 \text{ MJ/kmol} \]  
\[ \text{S} + \text{O}_2 \rightarrow \text{SO}_2 \quad -296 \text{ MJ/kmol} \]  
\[ \text{H}_2 + \frac{1}{2} \text{O}_2 \rightarrow \text{H}_2\text{O} \quad -241 \text{ MJ/kmol} \]

Exothermic volatile combustion reaction, mainly produce CO and H2O and SO2 release rate is proportional to the char combustion rate.

**Char Combustion**

Char Combustion mainly involves the formation of carbon dioxide and carbon monoxide. The char combustion mechanism proposed by Gordon and Amundson takes into consideration two main reactions. They are,

\[ \text{CO} + \frac{1}{2} \text{O}_2 \rightarrow \text{CO}_2 \quad -283 \text{ MJ/kmol} \]  
\[ \text{C} + \text{CO}_2 \rightarrow 2\text{CO} \quad +172 \text{ MJ/kmol} \]
The reactions involve combustion of Char (C) are heterogeneous, whereas the carbon dioxide formation reaction takes place in homogenous phase. The reaction rates depend mainly on physical and chemical properties of char and modeling it is considered to take place at equilibrium conditions with fast reaction rates. Temperature is a main criterion for the first four reactions. At temperatures below 350 °F, those reactions are predominant and above the temperature range reactions the last two are predominant.

**NOx Formation**

During combustion with air, nitrogen present in fuel or air reacts with oxygen to form nitric oxide (NO), which reacts further to form nitrogen dioxide (NO2). In addition, small amounts of N2O may be formed during the combustion process. The main reactions involved in the formation of nitrogen oxides are given as,

\[
\begin{align*}
\frac{1}{2} \text{N}_2 + \frac{1}{2} \text{O}_2 & \rightarrow \text{NO} + 34 \text{ MJ/kmol} \quad (7) \\
\frac{1}{2} \text{N}_2 + \text{O}_2 & \rightarrow \text{NO}_2 - 57 \text{ MJ/kmol} \quad (8) \\
\text{N}_2 + \frac{1}{2} \text{O}_2 & \rightarrow \text{N}_2\text{O} + 82 \text{ MJ/kmol} \quad (9)
\end{align*}
\]

**SO2 Absorption in Limestone Forming Calcium Sulfate**

Raw meal rich in Limestone, which is the main raw material for manufacturing of clinker fed into the pre-heater. At elevated temperatures, limestone decomposes to calcium oxide, which reacts with sulfur-dioxide formed during combustion to form calcium sulfate. The reactions are given as:

\[
\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2 - 178 \text{ KJ/mol} \quad (10)
\]

\[
\text{CaO} + \text{SO}_2 + \frac{1}{2} \text{O}_2 \rightarrow \text{CaSO}_4 + 15141 \text{ KJ/Kg of Sulphur} \quad (11)
\]

Conversion of SO2 is greatly influenced by the properties of CaCO3 and for simplicity in the modeling a conversion of 99% of SO2 to CaSO4 is assumed. This assumption is valid if the particle size distribution of CaCO3 is fine. In our modeling, the CaCO3 particle size distribution is assumed to be same as that of pet coke, modeled within the range of 1 to 50 microns to avoid heterogeneity effects in the reactions 10 and 11.

### 4.1 Control Measures for reducing SO2 emissions after proposed amendment project in Cement Plant

1. **Equipment Selection to reduce SO2 emission:**
   - a) Equipped with a good burner system that provides improved combustion efficiency of the fuel and also avoid flame impingement on the raw materials.
   - b) A dual-string multistage pre-heater tower adjusts the kiln feed distribution in the riser duct which more nearly equalizes the material flow rates and gas temperatures between the two bottom-stage cyclones.

2. **An easier-burning mix will result in lower sulfur volatility from the clinker.**

*Bhatapara Unit is having very good burnability of Raw Mix.*
3. **Sox absorption on process & system:**
   a) Raw material grinding and drying systems that use all or a portion of kiln gases for drying accomplish substantial SO2 removal because of the nature of the process.
   b) Due to the interaction of raw materials and kiln gases, the preheater have inherent SO2 removal efficiencies. Literature indicates suspension pre-heater of pre-calciner kiln acts as 100% SO2 Barriers.
   c) The Sulphur from Petcoke will not add to SO2 emission level since it is non-pyritic. Sulphur present reacts with lime & alkali & form CaSO4, K2SO4, Na2SO4 during clinker formation Process.

4. **Pyro-Process is an inherent removal process of SO2:**
   Pyro-process itself acts as a long SO2 scrubber. Kiln with pre heater /Calciner removes 70-95% SO2 emissions. In line raw mill again scrubs 50-70% of SO2.

4.2 **Methods to prevent formation of SO2 in various Zones**
   Sulfur present in the fuel will be in the form of sulfates, sulfides & organic sulfur. SO2 produced are scrubbed in calcining zone (combined with CaCO3 & CaO) & in the burning zone (combined with alkalis).

   1) Pre-heater:
      - At calciner high temperature & CaO are effective to scrub SO2.
      - In presence of dry CaO below reaction takes place:
        \[ \text{CaO} + \text{SO}_2 = \text{CaSO}_4 \]
      - Small amount of CaO is carried back (To top stages of PH) again help to scrub small amount of SO2.

   2) Calcining zone:
      - CaO is highly reactive to SO2.
      - Reaction rate and equilibrium are optimum at 800 – 950 °C.
        \[ 2\text{CaO} + \text{SO}_2 = 2 \text{CaSO}_4 \]
      - SO2 scrubbing in this zone is effected by excess oxygen & conversely by CO concentration.
      - SO3 content at top stage discharge material is function of burning zone temperature, back end supply of oxygen and CO.
      - V. good distribution of hot meal in the riser duct & cyclones at bottom of PH make more effective of SO2 scrubbing
      - In this zone the sulphur cycle formation and scrubbing mainly depends on the time it takes for the meal to pass through a narrow temperature range & its contact with flue gases containing SO2.
3) Upper transition zone:
   - Increasing temperature is more favorable and sulfides absorb in clinker.
   - As oxygen partial pressure increases sulfites become more stable. Thus SO2 remains in vapor phase.
   - As oxygen further increases sulfate solid, molten sulfate & SO3 are stabilized.

4) Burning zone:
   - Alkali sulfates are most stable & will leave kiln with clinker.
   - When alkalies are excess SO2 emission is low and vice versa.
   - Controlling temperature in burning zone helps to stabilize SO2.
   - If anhydrite is left in kiln at 1250 °C decomposes rapidly to increase SO2 and decrease O2 level.
   - However presence of SO2 and O2 in kiln suppresses these reactions and even short residence time helps suppress anhydrite reactions.

5) Raw mill:
   - SO2 reacts with limestone (CaCO3) surface to form Ca(SO4)2 in presence high content of water vapor.
   - At around 200°C temp & relatively high humidity favors calcium bisulfate formation.
   - Calcium bisulfate oxidized to H2SO4 and CaSO4 in kiln.

<table>
<thead>
<tr>
<th>Pre-heater</th>
<th>Sulfides + O2 = Oxides + SO2</th>
<th>CaCO3 + SO2 = CaSO4+CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel + O2 = SO2</td>
<td>CaO + SO2 = CaSO4</td>
<td>- SO2 removal as fresh surface available</td>
</tr>
<tr>
<td>CaSO4 + C = SO2 + CO</td>
<td>CaSO3 + 0.5O2 = CaSO4</td>
<td>- Addition of calcium hydroxide would help increase absorption as SO2</td>
</tr>
<tr>
<td>Burning</td>
<td>Fuel + O2 = SO2</td>
<td>Na2O + SO2 + 0.5O2 = Na2SO4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>K2O + SO2 + 0.5O2 = K2SO4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CaO + SO2 + 0.5O2 = CaSO4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Depends on O2 con and partial pressure of SO2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- High SO2 more stability SO compounds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Temp &gt;1400°C may cause Na2SO4, K2SO4 to decompose</td>
</tr>
<tr>
<td>Raw mill</td>
<td>NO SO2 formation</td>
<td>SO2 absorption</td>
</tr>
<tr>
<td></td>
<td>CaCO3 + SO2 = CaSO4 + CO</td>
<td>- As more fresh CaCO3 surface available more absorption</td>
</tr>
<tr>
<td>Others</td>
<td>SO2 + 0.5O2 = SO3 (750°C)</td>
<td>Reaction is very slow so not formed usually</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SO3 neutralized by alkaline materials such as CaO</td>
</tr>
</tbody>
</table>
5.0 Project Benefits

✓ **Less fuel consumption** to produce the same amount of energy as pet coke has higher calorific value.

✓ **More Fuel Alternatives** for plant operation.

✓ **Natural Resource Conservation**, as the pet coke is the waste product from the petroleum refinery thereby helps conserving virgin natural resource.

✓ **Lesser Air pollution**
  
  o Low particulate matter & fugitive emission as the ash content in the pet coke is negligible.
  
  o No SO2 emissions from kiln due to change in fuel mix as limestone is the main component of the kiln feed and sulphur in fuel gets absorbed in the process.