# PROJECT REPORT

# ON

# PROPOSED AMENDMENT IN EC REGARDING USE OF FUEL MIX IN EXISTING CEMENT PLANT AND CAPTIVE POWER PLANT

## By


## M/s UltraTech Cement Ltd.
## (Unit : Rawan Cement Works)

## At

## PO- Grasim Vihar,Village Rawan, Tehsil- Simga, District – Balodabazar Bhatapara (Chhattisgarh).

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# PROJECT REPORT

## *1.0 Introduction*

M/s. UltraTech Cement Limited is the largest cement company in India and among the leading producers of cement globally. It is also the country's largest manufacturer of white cement and Ready Mix Concrete. UltraTech Cement has been selected as Superbrand and Powerbrand by the Superbrands Council and Powerbrand India respectively.

Rawan Cement Works is a unit of UltraTech Cement Limited, one of the flagship organizations of Aditya Birla Group.

Rawan Cement Works is located at Po-Grasim Vihar, Village: Rawan, Dist. Baloda Bazaar in Chhattisgarh State; having Clinker Production Capacity of 6.5 MTPA, Cement Production Capacity of 6.5 MTPA along with Captive Power Plant (80 MW), DG Set (15 MW) and Captive limestone Mine with production capacity of 7.5 MTPA.

Presently, Rawan Cement Works is using coal as fuel in Kiln and CPP; to save natural resources (coal), Rawan Cement Works has proposed to use Petcoke in proportionate blending with Coal *(as given in Tables below)*, which will reduce coal consumption. Existing infrastructure facilities will be used for the proposed Fuel Mix activity.

## *2.0 Location details*

| | |
|---|---|
| Village | Rawan |
| Tehsil | Simga |
| District | Balodabazar -Bhatapara |
| State | Chhattisgarh |
| Latitude | 21°35'2.34"N to 21°33'40.47"N |
| Longitude | 82° 0'47.90"E to 82° 1'57.81"E |
| Toposheet No. | 64 G-14, 64 G-15, 64 K/2 & 64K/3 |

*Location Map of the Plant site has been shown below:*

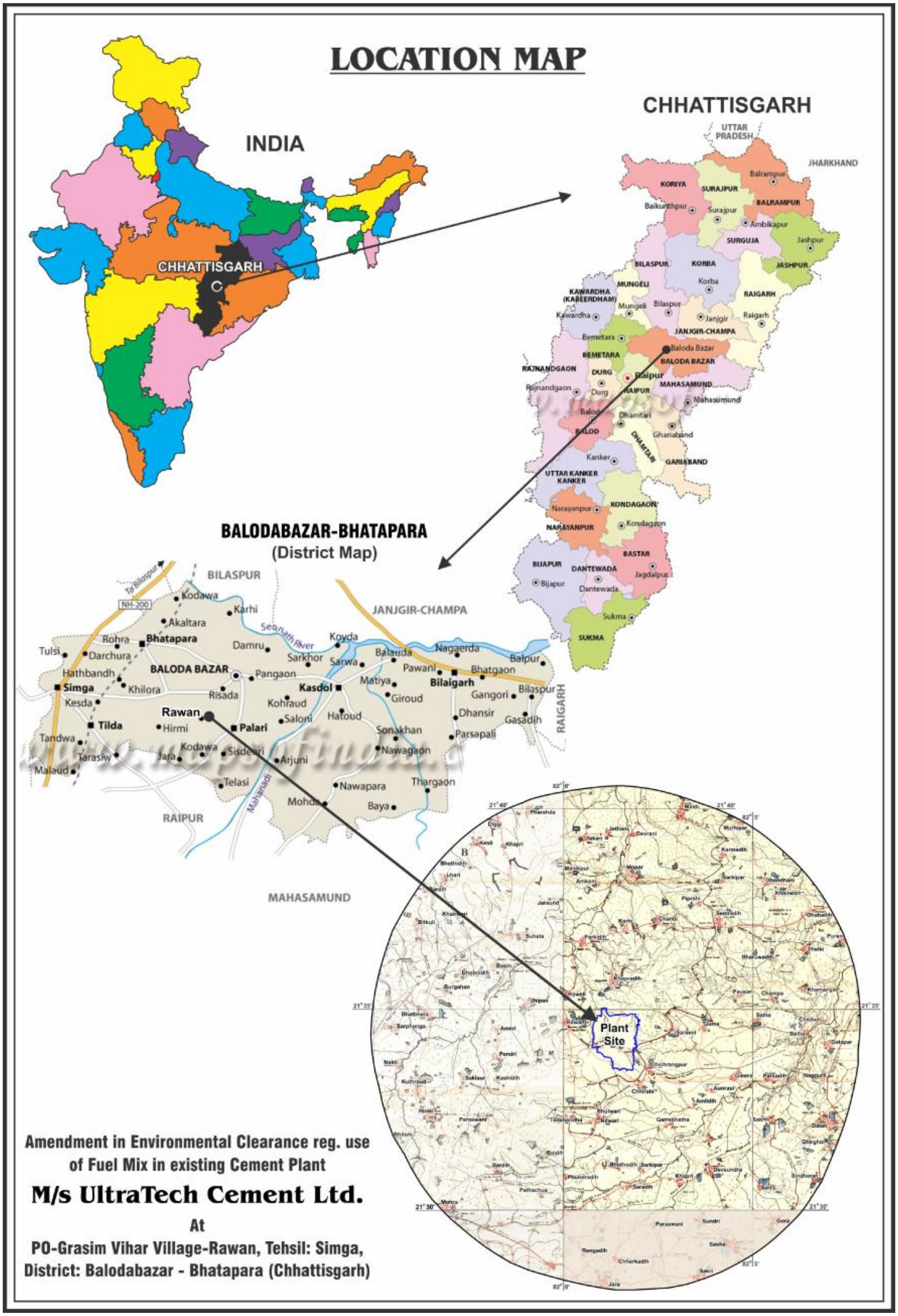


**Figure - 1: Location Map**

## 3.0 Project Proposal

M/s UltraTech Cement Limited (Unit- Rawan Cement Works) has obtained Environmental Clearance for the existing Cement Plan and Captive Power Plant vide MoEF letter no. J-11011/262/2009-IA II (I) dated 17/03/2011. M/s. UTCL is now proposing amendment in EC regarding use of fuel mix in the existing Cement Plant and Captive Power Plant.

Details of the same have been given in table below:

***Table - 1***

***Proposed Amendment***

| Category | Existing | After Proposed Amendment |
|---|---|---|
| ***Fuel for Cement Plant (Kiln)*** | | |
| Fuel | Coal | Coal/Petcoke |
| Proportion in Mix Fuel % | 100% | Either 100 % Coal or 100 % Petcoke |
| Fuel Consumption (TPD) | 2609 | 2609/1691 |
| ***Fuel for Captive Power Plant*** | | |
| Fuel | Coal | Coal : Petcoke |
| Proportion in Mix Fuel | 100% | 100 : 0<br>09 : 91<br>0 : 100 |
| Fuel Consumption (TPD) | 1204 | 1204 : 0<br>109 : 465<br>0 : 512 |

**Table - 2**

**Existing & Proposed Fuel Mix Quality**

| S. No. | Category | Calorific Value (kcal / Kg) | | % Ash | | % Sulphur | |
|---|---|---|---|---|---|---|---|
| | | Existing | After Proposed Amendment | Existing | After Proposed Amendment | Existing | After Proposed Amendment |
| ***Fuel for Cement Plant (Kiln)*** | | | | | | | |
| 1. | Coal | 3800-6500 | 3800-6500 | 28-40 | 28-40 | 0.40-0.70 | 0.40-0.70 |
| 2. | Petcoke | NA- | 7600-8400 | NA | 1.0-5.0 | NA | 6.0-7.0 |
| ***Fuel for CPP*** | | | | | | | |
| 1. | Coal | 3400 | 3400 | 45 | 45 | 0.8 | 0.8 |
| 2. | Petcoke | NA | 8000 | NA | 0.70-1.0 | NA | 6.0-7.0 |

## 4.0 *Fuel Logistic*

| S. No. | Category | Source | Agreement / MoU | Mode of Transportation |
|---|---|---|---|---|
| 1. | Coal | SECL and South Africa | Agreement/Purchase Order | Road cum Rail |
| 2. | Petcoke | USA and Reliance/Essar | Purchase Order | Rail |

## 5.0 *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 librated 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:

$$C + O2 \longrightarrow CO_2 + 408.86 \text{ KJ/mole}$$

$$2H + O2 \longrightarrow 2H_2O + 286.22 \text{ KJ/mole}$$

$$S + O2 \longrightarrow SO_2 + 292.25 \text{ KJ/mole}$$

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

$$N_2 + O2 \longrightarrow 2NO - 180 \text{ KJ/mole}$$

$$C + CO2 \longrightarrow 2CO - 7.25 \text{ MJ/Kg}$$

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

*De-volatilization and Volatile Combustion*

When Petcoke is fed into reactor, 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. De-volatilization and combustion are very fast in CFBC, with mean residence time from 0.4 to 0.5 seconds. Since the reaction is fast enough to achieve equilibrium at small residence times, we 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 Petcoke 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,

$$\text{Volatiles (HC)} + O_2 \longrightarrow CO + H_2O \qquad (1)$$

The main reactions considered in the modeling volatile combustion process are

$$C + \frac{1}{2} O_2 \longrightarrow CO \qquad -111\ \text{MJ/kmol} \qquad (2)$$

$$S + O_2 \longrightarrow SO_2 \qquad -296\ \text{MJ/kmol} \qquad (3)$$

$$H_2 + \frac{1}{2} O_2 \longrightarrow H_2O \qquad -241\ \text{MJ/kmol} \qquad (4)$$

Exothermic volatile combustion reaction, mainly produce CO and $H_2O$ and $SO_2$ 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,

$$CO + \frac{1}{2} O_2 \longrightarrow CO_2 \qquad -283\ \text{MJ/kmol} \qquad (5)$$

$$C + CO_2 \longrightarrow 2CO \qquad +172\ \text{MJ/kmol} \qquad (6)$$

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 ($NO_2$). In addition, small amounts of $N_2O$ may be formed during the combustion process. The main reactions involved in the formation of nitrogen oxides are given as,

$$\frac{1}{2} N_2 + \frac{1}{2} O_2 \longrightarrow NO \qquad +34\ MJ/kmol \qquad (7)$$

$$\frac{1}{2} N_2 + O_2 \longrightarrow NO_2 \qquad -57\ MJ/kmol \qquad (8)$$

$$N_2 + \frac{1}{2} O_2 \longrightarrow N_2O \qquad +82\ MJ/kmol \qquad (9)$$

*$SO_2$ Absorption in Limestone Forming Calcium Sulfate*

Limestone is fed into the rector with coal. 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:

$$CaCO_3 \longrightarrow CaO + CO_2 \qquad -178\ KJ/mol \qquad (10)$$

$$CaO + SO_2 + \frac{1}{2} O_2 \longrightarrow CaSO_4 \qquad +15141\ KJ/Kg\ of\ Sulphur \qquad (11)$$

Conversion of $SO_2$ is greatly influenced by the properties of $CaCO_3$ and for simplicity in the modeling a conversion of 99% of $SO_2$ to $CaSO_4$ is assumed. This assumption is valid if the particle size distribution of $CaCO_3$ is fine in the range of 1 to 50 microns. In our modeling, the $CaCO_3$ particle size distribution is assumed to be same as that of Petcoke, modeled within the range of 1 to 50 microns to avoid heterogeneity effects in the reactions 10 and 11.

## 6.0 *Impact of Proposed Amendment Project On Air Quality*

There will be no major impact of the proposed amendment project on the air quality. Details have been given in Table - 3.

**Table - 3**
**Impact on Air Quality**

| S. No. | Fuel Characters | Cement Plant | | CPP | |
|---|---|---|---|---|---|
| | | Existing | After Amendment | Existing | After Amendment |
| 1. | Coal Consumption (TPD) | 2609 (Coal) | Coal/Petcoke 2609/1884 | 1204 (Coal) | Coal/Petcoke 1204 : 0<br>109 : 465<br>0 : 512 |
| 2. | Sulphur (%) | 0.4-0.70 | 0.4-0.7/6.0-7.0 | 0.3-0.7 | 0.3-0.7/6.0-7.0 |
| 3. | Ash (%) | 28-40 | 28-40/1.0-5.0 | 48 | 48/0.3-0.7 |
| 4. | Dust Load* (kg/hr.) | 88.34 | 88.34 | 0.109 kg/MwH | 0.109 kg/MwH |
| 5. | $SO_2$ Emission Rate (g/sec) | 14.96 | 54.8 | 15.42 | 41.44 |

**Calculated at max. Value*

## 7.0 *Control Measures For Reducing So2 Emissions After Proposed Amendment Project*

### 7.1 Cement Plant

The SO2 emission shall be reduced / controlled below norms with the addition of limestone powder. The technical aspects are as under,

- Petcoke burns above 700 C.
- Petcoke contains 9%-11% of VM and domestic coal contains 20%-25%
- Fluidized bed gives a sufficient residence time for combustion of the fixed carbon.
- Cinder recovery and reinjection system enhances residence time further and ensures complete combustion of the Petcoke.
- Petcoke is similar to anthracite with low volatiles and High Sulphur.
- Petcoke contains very little ash and moisture content, so the heat carried away is less which increases bed temperature.
- Chances of spontaneous combustion is less due to low volatile content.
- Homogenous mixing of coal and Petcoke has a better result.
- Petcoke contains high sulphur and separate care to be taken to control sulphur emission to atmosphere by adding limestone.
- Petcoke readily available in small sizes and no sizing or screening is required.
- The reaction of Sulphur with Lime stone for desulfurization is occurs after the calcinations process as:

Calcination reaction starts above 850 °C temperature

- $CaCO_3$ Heat = $CaO + CO_2$ (g) ↑

100 g = 56 g + 44 g

Desulfurization reaction above 850 °C temperature

- $CaO + SO_2 + ½ O_2$ Heat $CaSO_4$

56 g + 64 g + 16 g = 136 g

From above reaction we found that 0.875gms of CaO & 0.25gms of $O_2$ required to desulfurization of 1gm of sulphur Dioxide ($SO_2$) and produce 2.125gms of $CaSO_4$.

**SO2 Formation and Absorption in Pyro Process**

*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.

- **Methods to prevent formation of SO2 in various Zones**

Sulphur present in the fuel will be in the form of sulphates, sulfides & organic sulphur. 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 $SO_2$.
- In presence of dry CaO below reaction takes place:

  $CaO + SO_2 = CaSO_4$

- Small amount of CaO is carried back (To top stages of PH) again help to scrub small amount of $SO_2$.

2) Calcining zone:

- CaO is highly reactive to $SO_2$.
- Reaction rate and equilibrium are optimum at 800 – 950 $^{o}$C.

  $2CaO + SO_2 = 2\ CaSO_4$

- $SO_2$ scrubbing in this zone is effected by excess oxygen & conversely by CO concentration.
- $SO_3$ content at top stage discharge material is function of burning zone temperature, back end supply of oxygen and CO.
- $SO_2$ scrubbing is made more effective distribution of hot meal in the riser duct & cyclones at bottom of PH.
- 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 $SO_2$.

3) Upper transition zone:

- Increasing temperature is more favorable and sulfides absorb in clinker.
- As oxygen partial pressure increases sulfites become more stable. Thus $SO_2$ remains in vapor phase.
- As oxygen further increases sulfate solid, molten sulfate & $SO_3$ are stabilized.
- Alkali sulfates & alkali/calcium sulfates are stable. In this region $SO_2$ combines with alkalies to form $K_2SO_4$, $Na_2SO_4$ & $2CaSO_4.K_2SO_4$ (calcium langbeinite) & $3K_2SO_4.NaSO_4$ (aphthitalite).

4) Burning zone:

- Alkali sulfates are most stable & will leave kiln with clinker.
- When alkalis are excess $SO_2$ emission is low and vice versa.
- Controlling temperature in burning zone helps to stabilize $SO_2$.
- If anhydrite is left in kiln at 1250 $^{o}$C decomposes rapidly to increase $SO_2$ and decrease $O_2$ level. However presence of $SO_2$ and $O_2$ in kiln suppresses these reactions and even short residence time helps suppress anhydrite reactions.

5) Raw mill:

- $SO_2$ reacts with limestone ($CaCO_3$) surface to form Ca $(SO_4)_2$ in presence high content of water vapor.
- At around 200$^{o}$C temp & relatively high humidity favors calcium bisulfate formation.
- Calcium bisulfate oxidized to $H_2SO_4$ and $CaSO_4$ in kiln.

| | | |
|---|---|---|
| Pre-heater | Sulfides + $O_2$ = Oxides + $SO_2$<br>Organic Sulphur + $O_2$ = $SO_2$ | $CaCO_3 + SO_2 = CaSO_4 + CO_2$<br>- Less removal as less fresh surface available<br>- Addition of calcium hydroxide would help increase absorption as $SO_2$<br>- Top stages are less effective. |
| Calcining | Fuel + $O_2$ = $SO_2$<br>$CaSO_4 + C = SO_2 + CO$ | $CaO + SO_2 = CaSO_4$<br>$CaSO_3 + 0.5O_2 = CaSO_4$<br>- Depends upon mainly $O_2$ and CO concentration<br>- $CaSO_4$ causes recirculation of sulfur volatilities causing choking problems. |
| Burning | Fuel + $O_2$ = $SO_2$ | $Na_2O + SO_2 + 0.5O_2 = Na_2SO_4$<br>$K_2O + SO_2 + 0.5O_2 = K_2SO_4$<br>$CaO + SO_2 + 0.5O_2 = CaSO_4$<br>- Depends on $O_2$ con and partial pressure of $SO_2$.<br>- High $SO_2$ more stability SO compounds<br>- Temp >1400°C may cause $Na_2SO_4$ , $K_2SO_4$ to decompose |
| Raw mill | NO $SO_2$ formation | $SO_2$ absorption<br>$CaCO_3 + SO_2 = CaSO_4 + CO_2$<br>- As more fresh $CaCO_3$ surface available more absorption |
| others | $SO_2 + 0.5O_2 = SO_3$ (750°C) | Reaction is very slow so not formed usually<br>$SO_3$ neutralized by alkaline materials such as CaO. |

## 7.2 Captive Power Plant

*Process & Control Philosophy of proposed Multi Fuel Feeding (i.e. Indg.Coal+Petcoke with cap of Sulphur Content max. 7%) along with Crushed Lime Stone, as desulphurising agent, for Generation of 80 MW in CFBC Boilers of Captive Power plant at UltraTech Cements Ltd. (Unit: Rawan Cement Works) is given below:*

CFBC Boilers are suitable for firing various types of Fuels, such as Coal, Petcoke, Lignite etc; even with high Sulphur content along with Crushed Limestone, which results in $SO_2$ absorption compatibility upto 85 - 90%. CFBC Technology also conforms to low NOx generation for maintaining low combustor temperature, less that 900 - 950 Deg.C.

In this process, each type of fuel is fed from separate bunker-chambers through variable frequency driven (VFDs) Rotary Airlock Valves (for maintaining desired percentage of each fuel in fuel-mix) to one common Drag-Chain fuel feeder for feeding to Boiler, also driven by variable frequency drive (VFD) to control fuel-mix feed, as per the load requirement.

For capturing sulphur to optimal level in CFBC Boilers (absorption min.85%), Lime Stone Feeding is suitably controlled through Rotary Air Lock Valve, driven by variable frequency drive (VFD) and control-system is actuated, based on real time $SO_2$ generation figure signals, received from on-line Boiler Stack Flue-Gas Sox Analyser.

The lime-stone dust also works as a sorbent agent, to maintain desired dust inventory in the boiler combustor (prime requsite for FBC-Fluidised Bed Combustion Technology) for efficient combustion of fuel-mix, resulting in minimising consumption of other sorbents, like crushed refractory, sand etc.

*The Single Fuel (Indg.Coal) Feeding Arrangement in CFBC Boiler is shown in Figure - 3:* without limestone feeding with low Sulphur content (ranging from 0.5 to 1.0%) Indg.Coal - ***the existing system :***

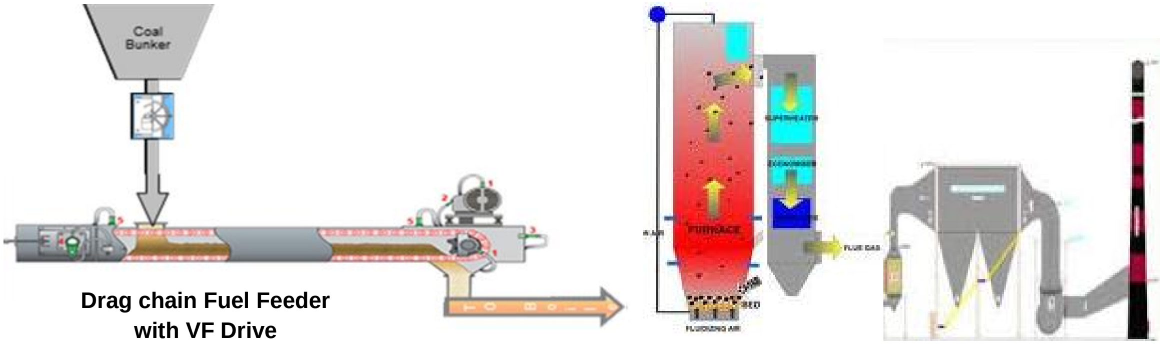


**Figure - 2: Single Fuel Feeding Arrangement in CFBC Boiler**

*Proposed Multi Fuel (Indg.Coal+Petcoke with Sulphur Cap in Fuel-Mix max.7%) Feeding Arrangement in CFBC Boiler is shown in Figure - 4:* along with Limestone feeding to capture sulphur (ensuring min.82%).

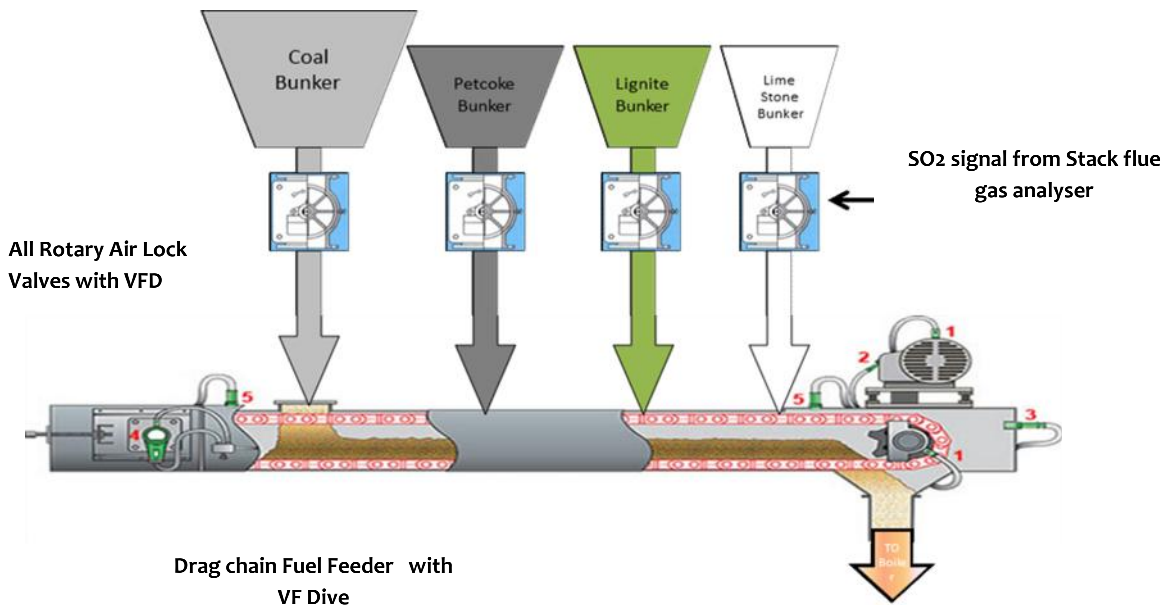


**Figure - 3: Multiple Fuel Feeding Arrangement in CFBC Boiler**

The final crushed lime stone is fed to the bunker for feeding to boiler as per the requirement depending upon SO2 in the flue gas.

**Proposed Multi-Fuel, fuel usage philosophy :** The Table indicates the present sulphur content in the fuel and in proposed fuel-mix along with SO2 in flue gas in gm/sec.

| Description | UOM | Existing | Proposed |
|---|---|---|---|
| **Fuel Mix - by Wt** | | | |
| **Cement Plant** | | | |

| | | | |
|---|---|---|---|
| Coal/Petcock | % | 100% Coal | Either 100 % Coal / 100 % Petcoke |
| **Sulphur** | | | |
| Coal/Petcock | % | 0.4-0.7 | 0.4-0.7/6.0-7.0 |
| Limestone Consumption | MT/Hr | 0 | 5.23 |

**Summary:**

1) Use of proposed Fuel-Mix (Coal + Petcoke), will not degrade the ambient air quality of the surrounding area and $SO_2$ Emission will be even less from the present condition.
2) UTCL has considered min. 82% Sulphur capture against CFBC Boiler Technology along with Lime-Stone dosing supports ~ 85-90% Sulphur capture.
3) Low Ash Generation, for low ash content in Petcoke and total ash generated will be used up in Cement Manufacturing.

## *8.0 Project Benefits*

- ✓ Less fuel consumption to produce the same amount of energy as Petcoke has higher calorific value.
- ✓ More Fuel Alternatives for plant operation.
- ✓ Natural Resource Conservation- as the Petcoke 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 Petcoke is negligible.
  - o No $SO_2$ 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.