TECHNO-FEASIBILITY REPORT
on Air Pollution Issues at
R. KAY GRINDING (JAMMU) PVT. LTD.

Submitted to

J&K Pollution Control Board
Government of J&K

A project by

A&A Infra

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About the Consultant:

This project/study is undertaken by the start-up A&A Infra, New Delhi under the mentorship of Prof. (Dr) P. Bose, Professor, Department of Civil Engineering, IIT Kanpur who has more than 25 years experience in the field of environmental engineering. Prof Mittal obtained MTech. in environmental Engineering from IIT Kanpur, PhD from University of Massachusetts, Amherst, USA and current is professor at the IIT Kanpur.

INTRODUCTION

M/s R. Kay Grinding (Jammu) Pvt. Ltd., Plot No. 36, Industrial Area, Hatli More, Tehsil & Distt. Kathua (J&K), is an existing industrial unit engaged in production of cement (grinding plant). The plant has installed production capacity of about 100 MT/day. Subsequently, the industrial unit added clinker making facility (as a part of backward integration), having installed capacity to produce about 80 MT/day of clinker, after obtaining the required statutory permissions.

As a proactive measure, the State Pollution Control Board, wants to ensure that the gaseous emissions from the cement kiln of the clinker unit complies with the applicable discharge standards, so that there is no damage to the surrounding environment as well as inhabitation
in the vicinity.

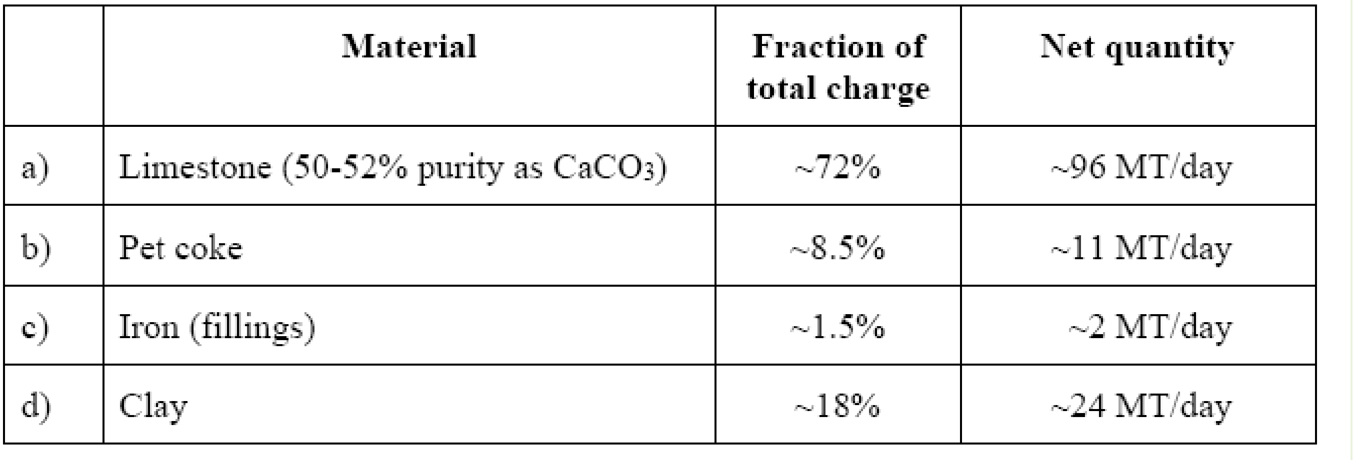
A&A Infra has carried out the suitability and adequacy of the air pollution control system (for cement kiln – vertical shaft) and suggesting suitable measures for overcoming the short comings (if any).

Objective of this study/project is to investigate the feasibility of making this unit a zero discharge entity. This report details the findings of the study.

The present report comprises of;
a) Industrial activity
b) Characterization and quantification of air emissions
c) Implementation philosophy
d) Recommendations for system improvement

THE INDUSTRY

The industrial unit is an existing cement manufacturing facility (grinding unit) having installed capacity to produce about 100 MT/day of cement. One of the major inputs – the clinker is presently being outsourced. As a part of backward integration – to produce clinker inhouse – the industrial unit augmented its existing setup by adding a clinker making unit after obtaining requisite statutory permissions from the competent authorities. The unit has installed capacity to produce ~80 MT/day of clinker. The basic inputs required for clinker unit are as typically as under:



	Material	**Fraction of total charge**	**Net quantity**
a)	Limestone (50-52% purity as $CaCO_3$)	~72%	~96 MT/day
b)	Pet coke	~8.5%	~11 MT/day
c)	Iron (fillings)	~1.5%	~2 MT/day
d)	Clay	~18%	~24 MT/day

Additionally, about 12-14% of water is added to the charge during palletization. Net yield of the process is about 60%.

The setup includes following machinery/equipment:

a) Jaw mill – for limestone crushing
b) Hammer mill – for further size reduction of limestone
c) Tunnel conveyor – for batching/proportioning of raw material inputs and conveying it to ball mill
d) Ball mill – for grinding/homogenization of raw material charge
d) Presence of lime around the pet-coke results in dry FGD of emissions at source (point of generation)
e) Slowing of emissions flow-through velocity, due to expanded area at the top as well as progressive emission cooling, during their up-flow through the kiln

The average SPM concentration, in the emissions from the VS kiln, is, typically, expected to be about 2000-3000 mg/Nm3. Most of the particles are likely to have size greater than 2 micron. The average specific gravity of the particulate matter is expected to be in the range of 0.8-1.2. Besides, the particulate matter will not be corrosive in nature.

Though, there will be SO_2 generation (due to high sulphur content in the pet coke), at source reaction with lime will significantly reduce the SO_2 concentration in the kiln emissions.

The emissions will have temperature between 50-80°C.

Ball mill at the R Kay

Filter

Kiln at R. Kay

Preheat Zone

While the raw mill is fairly effective in removing SO2 with CaCO3, the preheat zone of the kiln, particularly at the lower temperature end, is much less efficient. This is due to the combined effects of low relative humidity and temperature. No new limestone surface is being generated.

Also, as indicated above, the amounts of CaO or Ca(OH)2, both of which are more effective than CaCO3, are very small. Sprung [1964] ran a number of laboratory tests that showed that in the temperature range of 400-500°C (750-930°F), SO2 reacts with CaCO3 forming CaSO4. The degree of conversion increases with increasing temperature and increasing specific surface of the calcite (1,300-8,200 cm^2/g). The presence of water vapor enhances the conversion. The activation energy can be determined from the temperature dependence of the reaction rate constant. It is 27.9 kcal/mol for the conversion of SO2 to CaSO4 in dry atmospheres, but only 18.7 kcal/mol for an atmosphere with 2% water vapor by volume. It is clear that water vapor catalytically enhances the degree of reaction of SO2 with CaCO3. It has been however, point out that in the literature that temperature range of 300-600°C (570-1,110°F), in the top stages of the preheater, absorption conditions for SO2 generated from oxidation of pyrites are poor, due to low temperature and the presence of only calcium carbonate as a scrubbing medium.

It should not be concluded that the top preheater stages are totally ineffectual. Some experts have observed that the preheater scrubbed out 70% of the SO_2 liberated from the pyrite. The calcium sulfite that was the initial reaction product was effectively oxidized in the preheater and kiln above 450°C (840°F) so that SO2 levels from this source were minimal. Freshly generated free lime or alkali oxides effectively remove most of the SO2 that may be formed in the kiln and again carried back to the preheater. The effectiveness of the capture is reflected in the fact that a reduction in the ratio of alkali-to-sulfur from the normal value of at least 1.0 to only 0.4 only increased SO2 emissions by 8%. The advantage of preheater and calciner kilns, in this regard, is that the contact between flue gases and incoming material is much more efficient than in long kilns. Indeed, it is observed that the emissions should in fact be much less, and that the presence of pyrite in the raw mix is less problematic for preheater kilns. Although emissions from calciner kilns usually are lower than from long kilns, they may be higher than from preheater kilns because bypass gases will tend to be quenched (cooled rapidly), severely reducing the time (at favorable temperature) for the reaction of quicklime with SO^2 in the bypass.

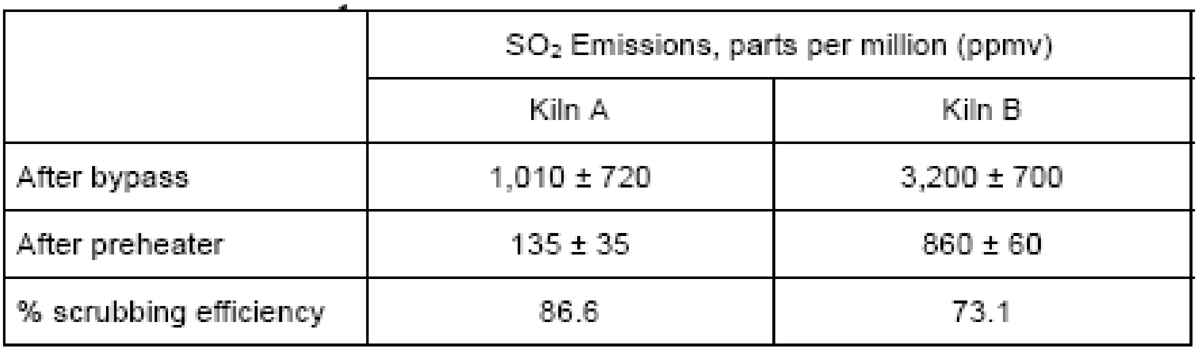
For SO2 removal, CaO should be more effective than CaCO3. SO2 reacts very readily with alkali or alkaline earth oxides in the presence of water to form salts. In the presence of dry CaO, the reaction reportedly occurs only above 300°C (570°F) in the following manner:

$CaO + SO2 \rightarrow \leftarrow CaSO_3$

In summary, in the preheat zone, sulfides in the feed are oxidized to SO2. Some of the SO2 generated in this zone and some of the SO2 from the burning process will be scrubbed out by the CaCO3 in the kiln feed, together with small amounts of free CaO that are carried back from hotter zones by the combustion flue gases.

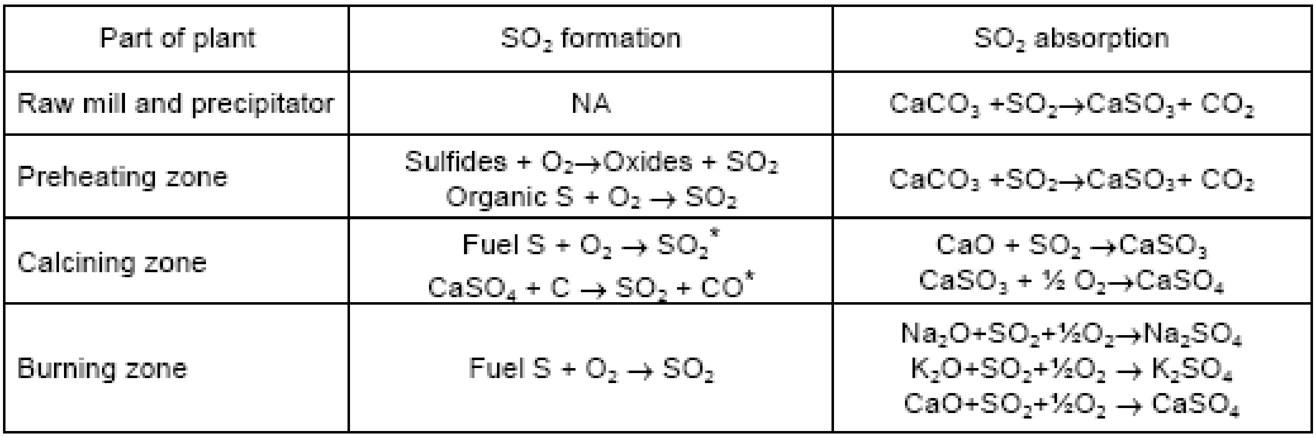
Calcining Zone

The calcining zone is the optimum place for dry scrubbing of SO_2 to occur. The newly generated CaO is very reactive toward SO2 in this region of high reaction rate and favorable thermodynamics. The reaction is optimum both with respect to rate and equilibrium in the 800-950°C range (1,470-1,740°F) typical of the lower preheater cyclone stages. Preheater and calciner kilns have much lower SO2 emissions than do long kilns, due in large part to the intimate contact between kiln exit gases and raw meal in the cyclones and riser ducts. In essence, the riser duct and the bottom cyclone stages reportedly act like fluidized beds. Data further confirming the high efficiency of the preheater in scrubbing SO2.



	SO_2 Emissions, parts per million (ppmv)	
	Kiln A	Kiln B
After bypass	1,010 ± 720	3,200 ± 700
After preheater	135 ± 35	860 ± 60
% scrubbing efficiency	86.6	73.1

Formation and recovery of So2 in various zones of the kiln are summarised below:



Part of plant	SO_2 formation	SO_2 absorption
Raw mill and precipitator	NA	$CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$
Preheating zone	Sulfides + $O_2 \rightarrow$ Oxides + SO_2 Organic S + $O_2 \rightarrow SO_2$	$CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$
Calcining zone	Fuel S + $O_2 \rightarrow SO_2^*$ $CaSO_4 + C \rightarrow SO_2 + CO^*$	$CaO + SO_2 \rightarrow CaSO_3$ $CaSO_3 + ½ O_2 \rightarrow CaSO_4$
Burning zone	Fuel S + $O_2 \rightarrow SO_2$	$Na_2O + SO_2 + ½O_2 \rightarrow Na_2SO_4$ $K_2O + SO_2 + ½O_2 \rightarrow K_2SO_4$ $CaO + SO_2 + ½O_2 \rightarrow CaSO_4$

Design considerations/requirements

The gas cleaning device needs to be designed/assessed on following:

a) Raw material feed = ~133 MT/day
b) Effective kiln operation time = ~24 hours/day
c) Material feed rate = ~5.5 MT/hour
d) Pet-coke feeding = ~470 kg/hour
e) Combustion air requirement = ~15.7 kg/kg of pet-coke
f) Combustion emission generation = ~13.9 Nm^3/kg of pet coke
g) Cooling/combustion air injection rate = ~9000 Nm^3/hour
h) Combustion emission generation = ~6500 Nm^3/hour
i) Gross emission generation (including process reaction gases/vapours) = <9000 Nm3/hour
j) Temperature of the emissions at the scrubber inlet = 50-80°C
k) The critical SPM levels in the emissions is less than 3000 mg/Nm3.
l) The kiln emissions follow ideal gas behaviour. Gas flow is incompressible.

Proposed Approach: Proposed concept is based on the 3R concept, i.e., Reduce, Reuse and Recycle with an objective of moving towards zero discharge.

Basically, air pollutants can be divided in 2 categories. Particulate and gaseous. Our approach is to del them separately to optimise each process.

Pollutants

- Particulate matter
- Gaseous
  - SO_2

Approach

Treat both stream separately to have an optimal solution

Useful product to incentive the industry

Particulate matter: It would be recycled back into the process after the Ball Mill to enter the manufacturing process. Basically, here we are utilising the particulates.

- *Particulate are fed ack in the production*

Gaseous Component:  Sulphur dioxide is the major pollutants which cases many problems in the environment. It is proposed to convert it into $CaSO_4$ which is a useful product. In fact, industry uses it as raw material. So, there is incentive for the industry to utilise it.

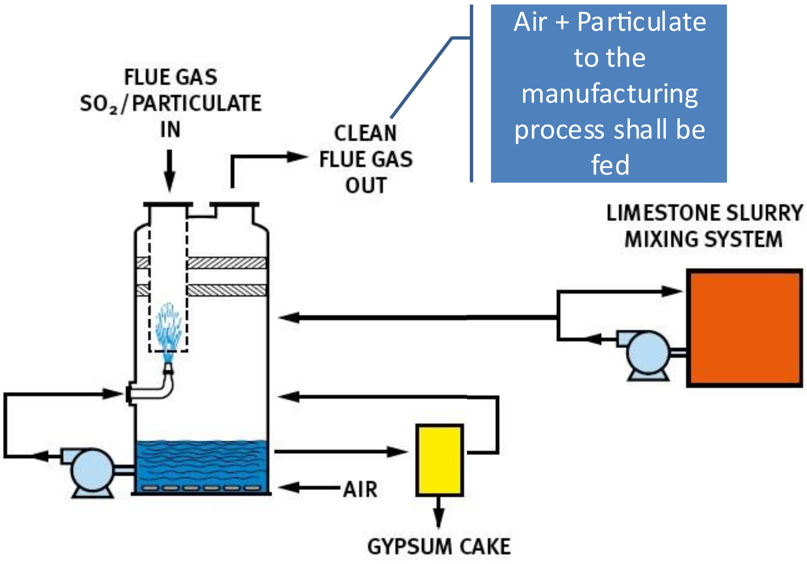
- *SO_2 is converted to Gypsum, $CaSO_4$*

$$CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$$

$$CaSO_3 + 2H_2O + \tfrac{1}{2}O_2 \rightarrow CaSO_4 \cdot 2H_2O_{(s)}$$

Conversion of SO_2 into $CaSO_4$

Recovery for Pollution Control

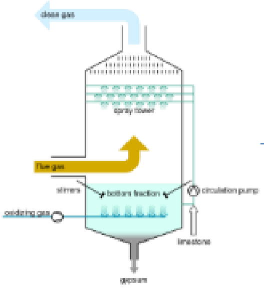


Air + Particulate to the manufacturing process shall be fed

Proposed Intervention:

Two phase scrubbers after the kiln to direct all (100 %) flue gasses through it as shown below:

Proposal



Fine Particles fed in the manufacturing process

Two Phase Scrubber

Innovative and Noble

- Materials already used in the factory are being used
- There is incentive for the industry to operate as a byproduct in the form of Gypsum is produced
- There shall be efforts to move in the direction of stack-less process in the vs based manufacturing of clinker, which would benefit state as a whole as there are many similar units in the area
- I see it as a contribution from the J&K Pollution Control Board

DESIGN AND SPECIFICATIONS OF PROPOSED MODIFICATIONS:

The modelling and design of the gas cleaning system, to satisfy the desired norms, is based on the following general considerations/assumptions.

a) The flue gas flow is expected to be ~9000 Nm^3/hour.
b) The critical SPM levels in the emissions will be less than 200 mg/Nm^3.
c) The maximum temperature of the emissions at the inlet of the APCD will be <80°C. The final temperature of the emissions, after treatment, will be in the range of 40-50°C.
d) Sufficient velocity will be maintained in the ducts/conduits in order to ensure that there is un-clogged flow.
e) All of the bends are recommended to have throat radius of, at least, 2 times the diameter of the duct. There are no sharp bends in the ducts/conduits.
f) The gaseous emissions follow ideal gas behaviour. Gas flow is incompressible.
g) Due consideration has been accorded to the change in gas properties and behaviour with changes in temperature.
h) There will not be any kind of leakage from any part of the duct, APCD, or machinery.
i) All inlets, outlets, and approaches are proper, so that there is no turbulence in the flow. The inner surfaces of the ducts and the APCD (coming in direct contact of flue gas) are reasonably smooth.
j) The sampling port will be provided in the stack, such that its height is, at least, 8 times the stack diameter, from the inlet to the stack. The emission shall be discharged into the atmosphere at a height, above the sampling port, at least 2 times the stack diameter.
k) While the specifications and operating parameters, being specified hereunder, represent theoretically optimised values, there may be some variation in any of these during actual