Cleaner Production Assessment

in Ceramic Sector

सत्यमेव जयते

Department of Forests and Environment
Government of Gujarat

Submitted by:

Gujarat Cleaner Production Centre
(Established by Industries & Mines Department, Government of Gujarat)

March, 2016

The document is intended to provide guidance to the Industries in developing approaches for Cleaner Production. Compliance with environmental regulations is the responsibility of each individual business and is not the focus of this document. Any use made of this report, or reliance on, or any decision to be made based on it, is the responsibility of such user. The GCPC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this document.

Title*: Cleaner Production in Ceramic Sector*
Published in: *March, 2016*

Publishing Committee:

Dr. Bharat Jain*, Member Secretary*
Mr. P. R Rathod*, Senior Project Engineer*
Mr. Paras Gojiya*, Assistant Project Engineer*
Mr. Abhi Patel*, Assistant Project Engineer*
Mr. K. D. Sanghavi*, External Expert*

Gujarat Cleaner Production Centre
(Established by: Industries & Mines Department, Govt. of Gujarat)

3rd Floor, Block No. 11, 12
Udhyog Bhavan, Sector – 11
Gandhinagar, Gujarat – 382017

Tel: +91 79 232 44147
Email: gcpc11@yahoo.com
Website: www.gcpcgujarat.org.in

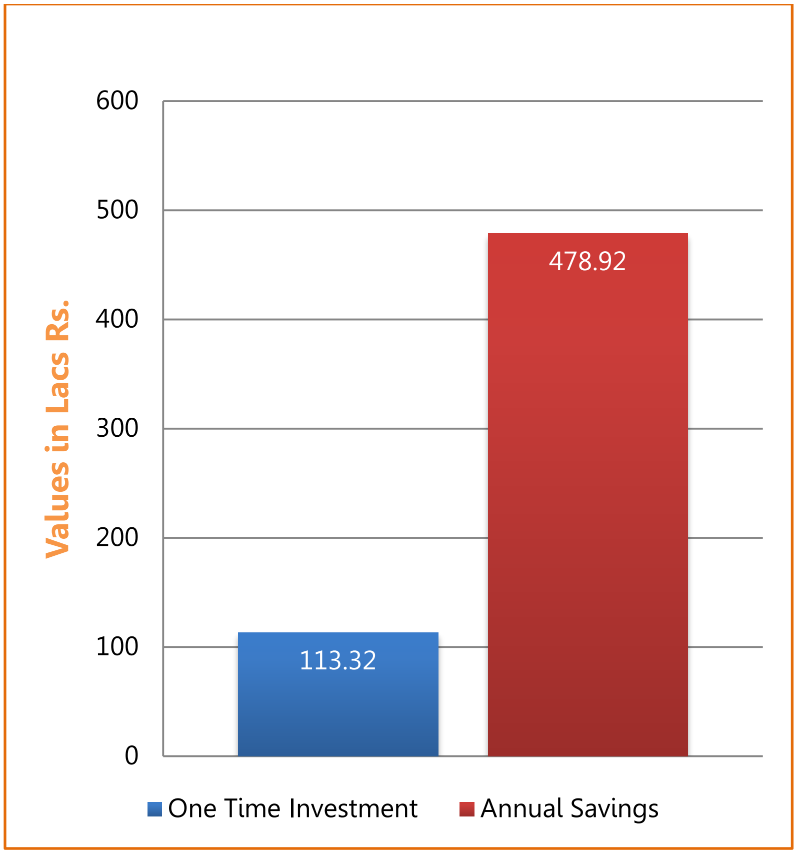
Executive Summary

EXECUTIVE SUMMARY

Overall Achievable Financial Benefit from

‘Cleaner Production Assessment in Ceramic Sector’

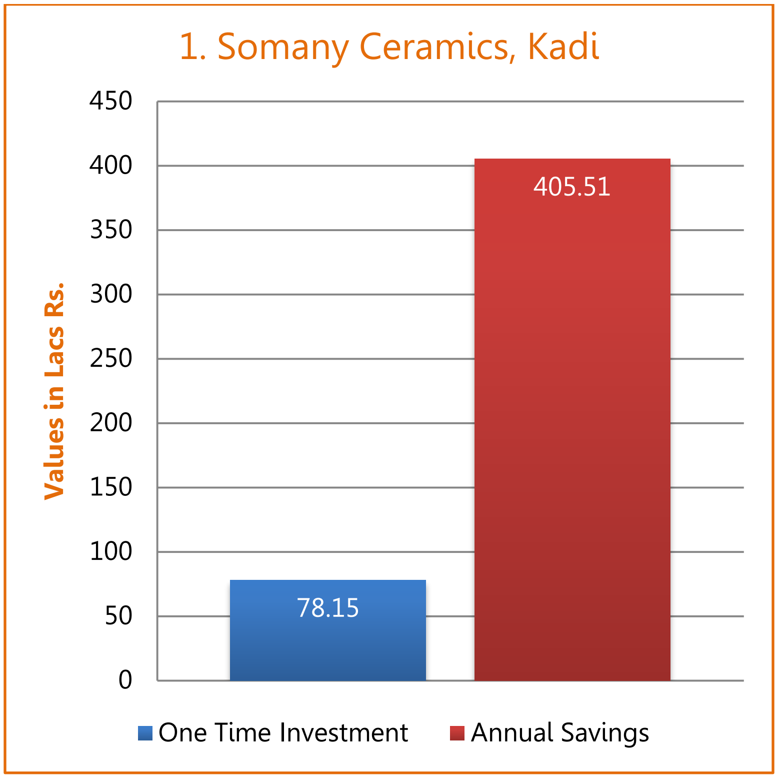
(One Time Investment vs. Annual Savings Indicator)



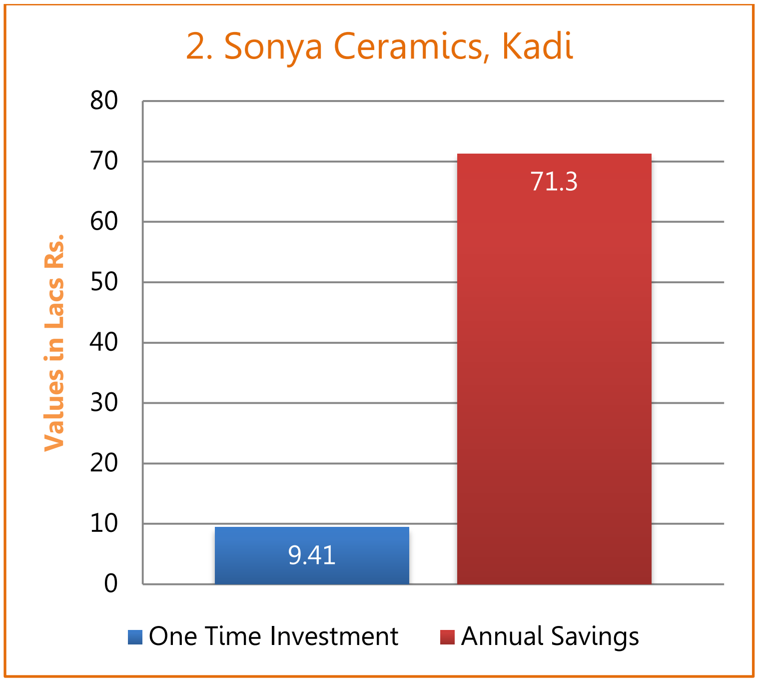
One time investment: Rs. 113.32 Lacs Savings: Rs. 478.92 Lacs Simple Payback: 3 Months

Industry wise achievable financial benefits

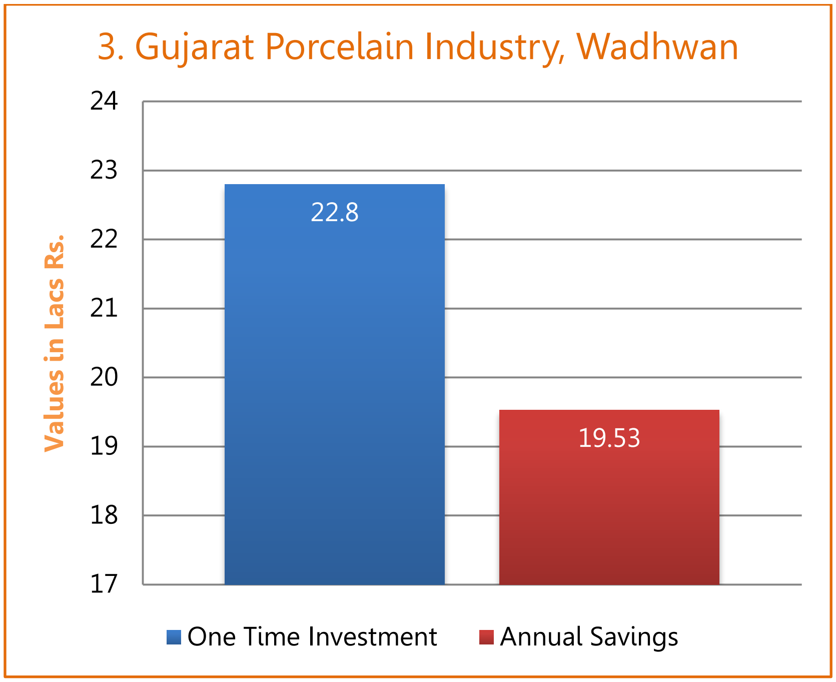
(One Time Investment vs. Annual Savings Indicator)



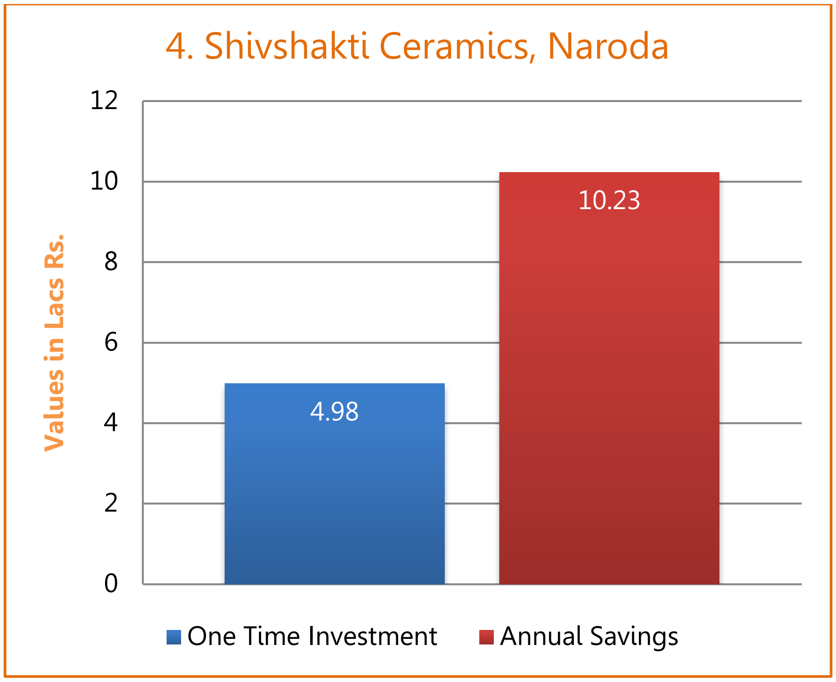
One time investment: Rs. 78.15 Lacs Savings: Rs. 405.51 Lacs Simple Payback: 3 Months



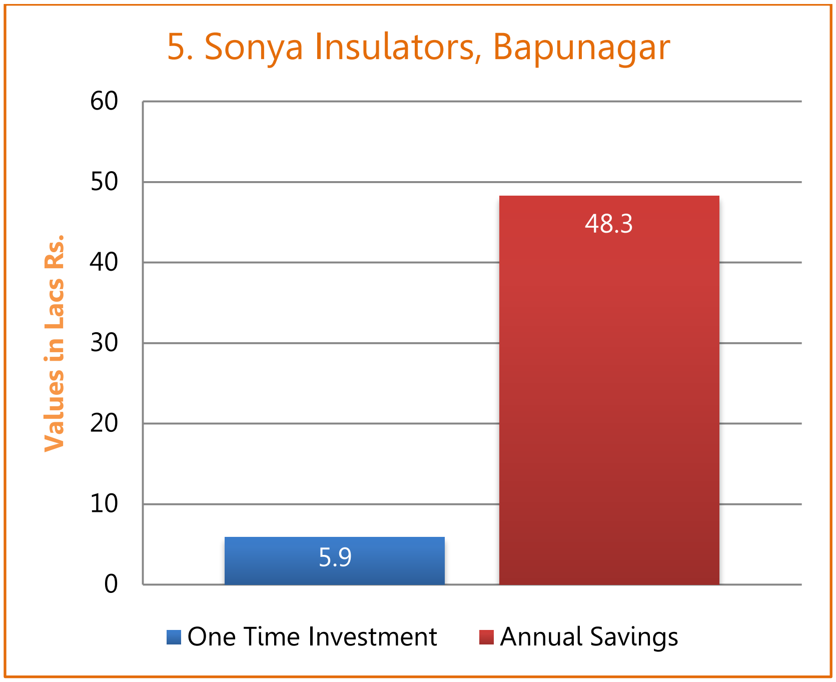
One time investment: Rs. 9.41 Lacs Savings: Rs. 71.3 Lacs Simple Payback: 2 Months



One time investment: Rs. 22.8 Lacs Savings: Rs. 19.53 Lacs Simple Payback: 14 Months



One time investment: Rs. 4.98 Lacs Savings: Rs. 10.23 Lacs Simple Payback: 6 Months



One time investment: Rs. 5.9 Lacs Savings: Rs. 48.3 Lacs Simple Payback: 2 Months

Industry wise Regression Analysis of expected saving of resources from this Project

1. Somany Ceramics, Kadi

Sr. No.	Suggested CP Option	Resource Saved	Quantity of Savings per annum (with unit)	One Time Investment (in INR)	Annual Savings (in INR)	Payback Period (in Months)	Reduction in Waste (Solid, Liq. or Gas) annually
1	Optimization of Combustion Efficiency at Spray Dryer Furnaces	Coal	5076 MT	75,00,000	2,38,00,000	4	8100 MT GHG
2	Optimization of Combustion Efficiency at Kilns and Dryers	Natural Gas	1,82,500 SCM	Nil	53,50,000	Immediate	342 MT GHG
3	Avoid Compressed air usage for cleaning purposes	Electricity	14,000 KWh	15,000	1,05,000	4	12.04 MT GHG
4	Reusing of 100% of sludge generated from Effluent Treatment Plant during process in tile body preparation	Processed material and Water	385 MT	Nil	U/A	Immediate	385 MT Solid Waste Recovery
5	Reusing of 100% treated waste water back into the process (Zero Liquid Discharge)	Water	48,000 KL	Nil	U/A	Immediate	48,000 KL Waste Water Reuse
6	Modification in the dust feeding system in press machine to decrease the loss of material in the form of dusting	Processed Material	4,000 MT	1,00,000	51,12,000	1	4,000 MT Solid Waste Recovery
7	Reuse of glaze scrubbed from the sides of wall tiles to use in preparation of engobe in floor tiles	Processed Material	78 MT	1,00,000	14,14,000	1	78 MT Solid Waste Recovery
8	Solar Drying of Coal to reduce the moisture Content	Coal	1,060 MT	1,00,000	47,70,000	1	1700 MT GHG

2. Sonya Ceramics, Kadi							
9	Reusing 100% of waste water into the process (Zero Liquid Discharge)	Water	2,700 KL	Nil	U/A	Immediate	2700 KL Waste Water Reuse
10	Installation of dust collector system to recover the waste material in form of dust	Processed Material	65 MT	60,000	72,000	10	65 MT Material Recovery
11	Reduction in loss of glaze material by installing closed chamber glazing spray machine	Processed Material	14.4 MT	2,50,000	5,10,000	6	14.4 MT Material Recovery
12	Modification in kiln car furniture design and loading pattern to reduce the weight of kiln car (Low Thermal Mass Kiln)	Natural Gas	2,19,000 SCM	2,20,000	46,14,000	1	410 MT GHG
13	Installation of Variable Frequency Drive (VFD) In Ball Mill Motor	Electricity	5,500 KWh	40,000	41,300	12	4.73 MT GHG
14	Installation of Variable Frequency Drive (VFD) in Motors of Ball Mill (Individual Connection)	Electricity	1,120 KWh	10,000	8,400	15	0.96 MT GHG
15	Installation of ON - OFF Controller (10 minutes ON and 5 minutes OFF) for Agitation Motors	Electricity	1,760 KWh	8,000	13,200	8	1.51 MT GHG
16	Power factor improvement to unity through installation of capacitors	Electricity	Reactive Power in transportation	25,000	32,000	10	3.66 MT GHG
17	Optimize Power Consumption at Ball Mill Motor by Installing Timer Based ON-OFF Controller	Electricity	4520 KWh	25,000	33,900	9	3.89 MT GHG
18	Improvement in Kiln Insulation	Natural Gas	7,200 SCM	3,00,000	1,60,000	23	13.5 MT GHG
19	Optimization of Combustion Efficiency of Kiln	Natural Gas	85,540 SCM	Nil	16,25,000	Immediate	160 MT GHG

20	Avoid Compressed air usage for cleaning purposes	Electricity	2,800 KWh	3,000	21,000	3	2.41 MT GHG
3. Gujarat Porcelain Industries, Wadhwan, Surendranagar							
21	Reusing 100% of waste water into the process (Zero Liquid Discharge)	Water	720 KL	Nil	U/A	U/A	720 KL Waste Water Reuse
22	Reduction in loss of glaze material by installing closed chamber glazing spray machine	Processed Material	24 MT	2,50,000	4,40,000	7	24 MT Material Recovery
23	Modification in kiln car furniture design and loading pattern to reduce the weight of kiln car (Low Thermal Mass Kiln)	Natural Gas	20,700 SCM	14,70,000	8,30,000	21	38.8 MT GHG
24	Installation of Variable Frequency Drive (VFD) in Ball Mills	Electricity	4,080 KWh	35,000	30,600	14	3.51 MT GHG
25	Installation of Variable Frequency Drive (VFD) in Motors of Agitation Section	Electricity	1,120 KWh	10,000	8,400	15	0.96 MT GHG
26	Implementation of ON - OFF Controller (10 minutes ON and 5 minutes OFF) for Agitation Motors	Electricity	1,760 KWh	8,000	13,200	8	1.51 MT GHG
27	Power factor improvement to unity through installation of capacitors	Electricity	Reactive Power in transportation	7,000	10,000	9	1.14 MT GHG
28	Improvement in Kiln Insulation	Natural Gas	7,200 SCM	5,00,000	2,00,000	30	13.5 MT GHG
29	Optimization of Combustion Efficiency of kiln	Natural Gas	13,000 SCM	Nil	4,21,000	Immediate	24 MT GHG
4. Shivshakti Ceramics, Naroda							
30	Installation of Variable Frequency Drive (VFD) In Ball Mill Motor	Electricity	2,500 KWh	20,000	19,300	13	2.15 MT GHG

31	Avoid Compressed air usage for cleaning purposes	Electricity	2,800 KWh	3,000	21,000	3	2.41 MT GHG
32	Improvement in Tunnel Kiln & Decoration Kiln Insulation	Natural Gas	10,000 SCM	4,75,000	3,50,000	16	18.7 MT GHG
33	Optimization of Combustion Efficiency of Kiln	Natural Gas	19,700 SCM	Nil	6,33,000	Immediate	37 MT GHG
5. Sonya Insulators, Bapunagar							
34	Reusing 100% of waste water into the process (Zero Liquid Discharge)	Water	3,300 KL	Nil	U/A	U/A	3,300 KL Waste Water Reuse
35	Installation of Variable Frequency Drive (VFD) In Ball Mill Motor	Electricity	2,800 KWh	40,000	21,000	23	2.41 MT GHG
36	Implementation of ON - OFF Controller (10 minutes ON and 5 minutes OFF) for Agitation Motors	Electricity	4,600 KWh	10,000	34,700	4	3.96 MT GHG
37	Optimize Power Consumption at Ball Mill Motor by Installing Timer Based ON-OFF Controller	Electricity	2,900 KWh	20,000	21,800	12	2.49 MT GHG
38	Improvement in Kiln Insulation	Natural Gas	12,500 SCM	5,00,000	3,00,000	20	23.4 MT GHG
39	Optimization of Combustion Efficiency of Kiln	Natural Gas	1,03,000 SCM	20,000	44,52,000	Immediate	193 MT GHG

Abbreviations:

CP: Cleaner Production
INR: Indian Rupees
MT: Metric Ton
SCM: Standard Cubic Meter
KWh: Kilo Watt Hour
KL: Kilo Liter
U/A: Unaccountable
N/A: Not Applicable
GHG: Green House Gas (CO_2)

TOTAL EXPECTED OUTCOME OF THE PROJECT

Cleaner Production Assessment in Ceramic Sector

Sr. No.	Resource Saved	Quantity of Savings per annum (with unit)	One Time Investment (in INR)	Annual Savings (in INR)	Average Payback Period (in Months)	Reduction in Waste (Solid, Liq. or Gas) annually
1	Coal	6,136 MT	76,00,000	2,85,70,000	4	9800 MT GHG
2	Natural Gas	6,80,340 SCM	34,85,000	1,89,35,000	3	1274 MT GHG
3	Electricity	52,260 KWh	2,47,000	3,87,400	8	45 MT GHG
4	Water	54,720 KL	Nil	U/A	U/A	54,720 KL Waste Water Reuse
5	Raw/ Processed Material	4570 MT	U/A	U/A	U/A	4570 MT Solid Waste Recovery

TABLE OF CONTENTS

Chapter – 1

About the Project

ABOUT THE PROJECT

Name of Project:	Cleaner Production Assessment in Ceramic Sector
Project Target:	Cleaner Production Assessment in 5 different industries from Ceramic Sector

Description:

Ceramic Industry is an inseparable part of the Indian Industrial Sector. Its contribution to the growth of state as well as the nation is noteworthy. The success stories are many, but the sector has still a long way to pass through for achieving a sustainable growth.

The Department of Forests and Environment, Government of Gujarat has awarded a Project "Cleaner Production Assessment in Ceramic Sector" to the Gujarat Cleaner Production Centre (GCPC), Gandhinagar, Gujarat, for carrying out Cleaner Production Assessment in the Ceramic Sector of Gujarat.

The objective of the project is to create Cleaner Production opportunities for improving resource efficiency and preventing the emissions to the air, water and land. The target of the project is Cleaner Production Assessment in 5 different industries from Ceramic Sector; hence preparing sector specific guidelines.

In order to achieve the above mentioned objective, the activities undertaken so far are mentioned in the forthcoming part of the document.

Chapter – 2

Objective of the Project

Cleaner Production Assessment in Ceramic Sector

OBJECTIVE OF THE PROJECT

The purpose of Cleaner Production Assessment Project is to raise awareness of the environmental impacts associated with industrial and manufacturing processes, and to highlight the approaches that industry and government can take to avoid or minimize these impacts by adopting a Cleaner Production approach for achieving multiplier effects.

The major focus area of CP studies will be reduction of the emissions to air, water and land. Cleaner production is an ongoing, comprehensive examination of the operations of a facility; with the goal of minimizing all types of wastes. This enhances economic growth and allows the industries to concentrate on providing better goods and services.

Ceramic industry has a huge scope of implementing cleaner production techniques. The increasing demand of ceramic products at global level has triggered the production rate of ceramic products in last a few years. To sustain in a global competitive market along with keeping environmental impacts in mind, industries have to implement techniques that may reduce the production cost, improve the production rate and most importantly, avoid waste generation.

The major concern of the ceramic industry is the solid waste generated at the end of the process. A practice has been followed to recycle a small part of it, but that is not sufficient because, a major part of it is disposed off in the landfill. With that, ceramic industry also emits pollutants to air and water, a huge amount of inorganic material and harmful metal particles are found in the waste water. Dust particles and oxides of Nitrogen, Sulphur and Carbon released in the air during the manufacturing process are far more than recommended by the regulatory bodies, which is equally harmful to the environment and the human health. Implementation of CP techniques can reduce the waste generated in the process and can help saving a handsome amount of capital, ultimately benefitting manufacturers as well as nature.

Cleaner Production is an attractive approach to tackle environmental problems associated with industrial production and poor material efficiency. The cleaner production approaches were successfully implemented in other sectors also. It shows that significant financial saving and environmental improvements can be made by relatively low-cost and straightforward interventions. This improves the quality of products and minimizes the cost of production, enabling the industry to compete in the global market. Moreover, Cleaner Production also improves the company’s public image by highlighting the steps it has taken to protect the environment.

The objectives specifically are as mentioned:

1. To perform cost saving through reduced wastage of both energy and materials
2. To perform cost saving on End-of-Pipe waste treatment
3. To improve operating efficiency of the plant
4. To increase product quality and consistency
5. To recover waste materials
6. To improve the work environment (Health and Safety of the workers)
7. To build capacity of industrial floor personnel
8. To develop new and improved market opportunities through waste exchange

Chapter – 3

Project Activities

Cleaner Production Assessment in Ceramic Sector

PROJECT ACTIVITIES

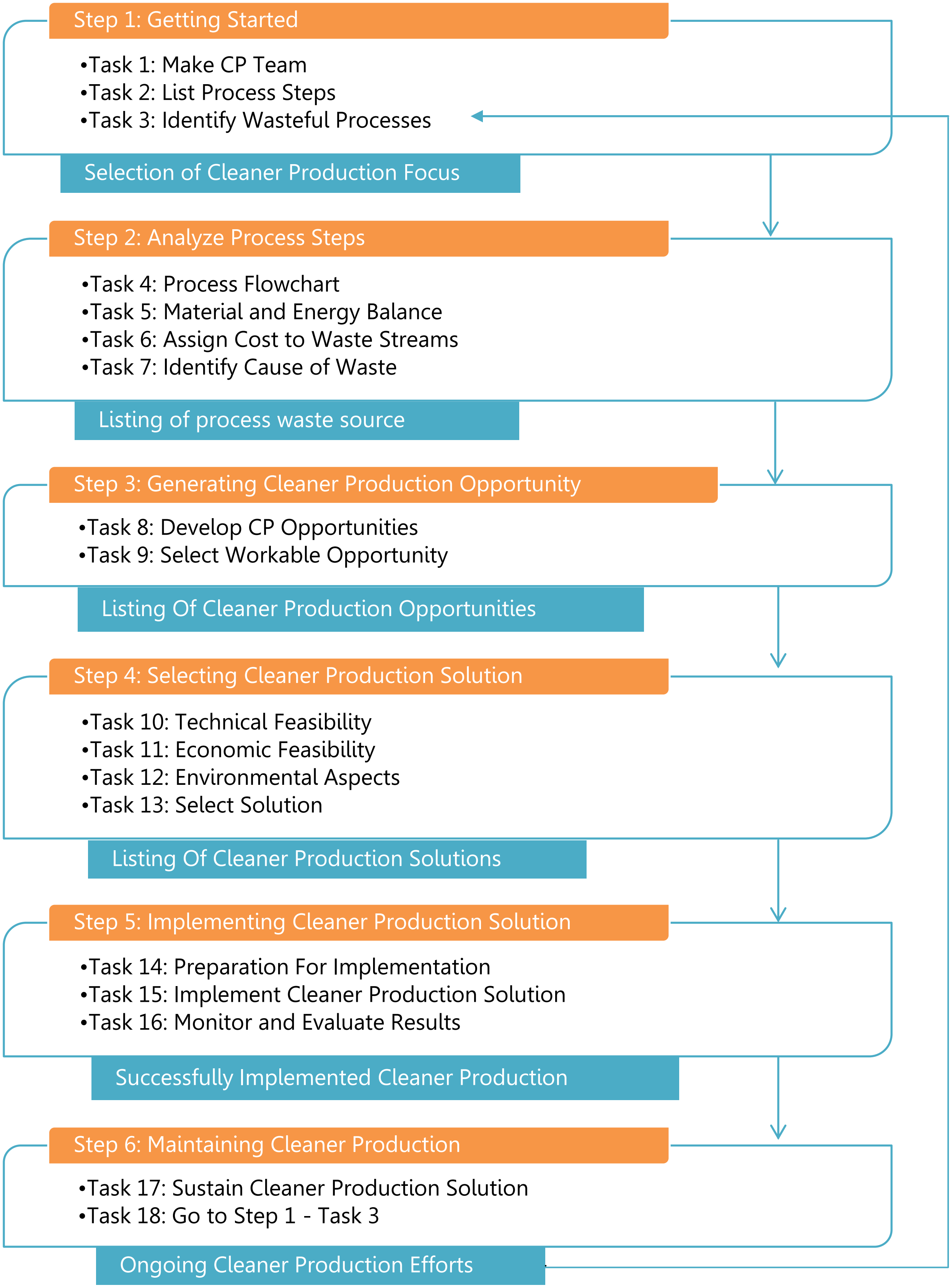
Scope of Work

Sr. No.	Activities
1.	Selection of industrial estate having ceramic sector
2.	Identification of sub-sectors in ceramic industries
3.	Introductory meeting with Associations/Industries and identification of willing pilot industries for CP assessment
4.	Baseline Survey / Data Collection
5.	Detailed Cleaner Production Assessment
6.	Submission of Draft Assessment Report
7.	Submission of Final Report
8.	Dissemination of results

Chapter – 4

Methodology for Cp Assessment

Methodology for Cleaner Production Assessment



Step 1: Getting Started

- Task 1: Make CP Team
- Task 2: List Process Steps
- Task 3: Identify Wasteful Processes

Selection of Cleaner Production Focus

Step 2: Analyze Process Steps

- Task 4: Process Flowchart
- Task 5: Material and Energy Balance
- Task 6: Assign Cost to Waste Streams
- Task 7: Identify Cause of Waste

Listing of process waste source

Step 3: Generating Cleaner Production Opportunity

- Task 8: Develop CP Opportunities
- Task 9: Select Workable Opportunity

Listing Of Cleaner Production Opportunities

Step 4: Selecting Cleaner Production Solution

- Task 10: Technical Feasibility
- Task 11: Economic Feasibility
- Task 12: Environmental Aspects
- Task 13: Select Solution

Listing Of Cleaner Production Solutions

Step 5: Implementing Cleaner Production Solution

- Task 14: Preparation For Implementation
- Task 15: Implement Cleaner Production Solution
- Task 16: Monitor and Evaluate Results

Successfully Implemented Cleaner Production

Step 6: Maintaining Cleaner Production

- Task 17: Sustain Cleaner Production Solution
- Task 18: Go to Step 1 - Task 3

Ongoing Cleaner Production Efforts

Chapter – 5

Primary Introduction: Ceramic Sector

PRIMARY INTRODUCTION: CERAMIC SECTOR

A Brief Technical Background of Ceramic Sector

Ceramic industry mainly deals with different types of clays and minerals and other natural earthen material, with different composition for different type of categories and the basis of their composition; they are divided into different sub-sectors. They can be understood as follows.

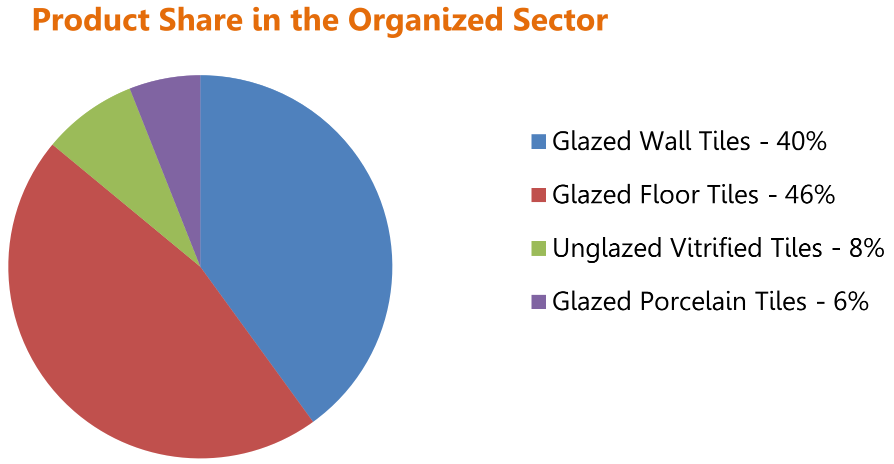
- Wall and Floor Tiles
- Refractory Products
- Table and Ornamental Ware (Household Ceramics)
- Sanitaryware
- Technical Ceramics
- Low tension and high tension insulators

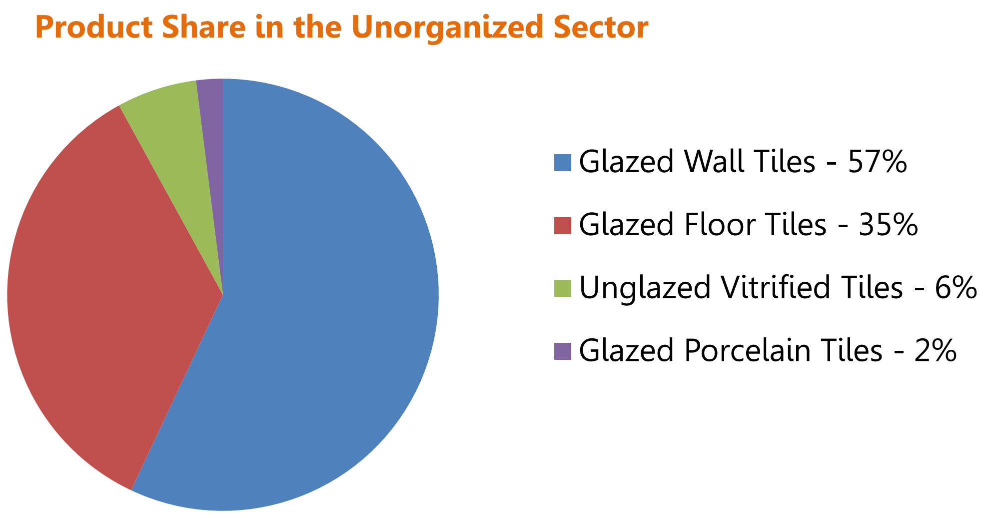
❖ Wall and Floor Tiles

Ceramic tiles are thin slabs made from clays and/or other inorganic materials, generally used as coverings for floors and walls. Ceramic tiles are usually shaped by extrusion or dust pressing at room temperature, then dried and subsequently fired at temperatures sufficient to develop the required properties.

By basic product variation, the tiles market has three component segments: mosaic, ceramic, and natural stones. Mosaic tiles claim a 50 to 60% share. The ceramic tiles and natural stones share the rest almost equally. Natural stones also have three segments: granites, marbles and other stones, including Kota stone.

The main product segments are the Wall Tiles, Floor Tiles, Vitrified and Industrial Tiles. The market shares (in value term) are 20%, 30%, 50% and 70% respectively. They are available in a wide variety of designs, textures and surface effects.





Source: Widening the coverage of PAT scheme – sector manual by TERI and Shakti Foundation

These tiles are differentiated also by the technology used for the firing, viz.Double Firing (older system), Single Firing (newer technology) and Double Face Firing. Single firing is used for floor tiles while double firing continues to be used for wall tiles. Roller technology is more suitable for larger tiles and tunnel technology for smaller ones.

The vitrified tiles are abrasion and acid resistant and do not absorb any moisture. They are suitable for subject to heavy wear and tear like industrial and chemical plants, hotel lobbies, banks, special pavements.

Over the last two decades, the technical ceramics segment has recorded an impressive growth propelled by the demand for high-alumina ceramics, cuttings tools and structural ceramics from the industry. Overall, the Indian ceramics industry has emerged as a major manufacturer and supplier in the global market.

The industry also enjoys the unique distinction of being highly indigenous with an abundance of raw material, technical skill, infrastructural facilities despite being fairly capital intensive. The potential is huge considering the per capital consumption of ceramic tile in India.

The most common tile shapes are squares and rectangles, but other polygonal shapes (hexagons, octagons, etc.) are also available. As for size, tile sides range from only a few centimeters (Mosaics) to slabs with 60–100 cm sides. The thickness ranges from 5 mm for wall tiles to over 25 mm for some extruded tiles.

Ceramic wall and floor tiles are important wall and floor covering products used in the building and housing industry and, therefore, the maintenance and renovation market is of special importance to these products. Other applications are the use of tiles for external facades, swimming pools and public areas.

❖ Bricks and Roof Tiles

Brick products are produced in large quantities, which are used as materials in numerous branches of building and contracting. For the most part, bricks and tiles are not designated according to the shaping technique used, but according to the intended application:

- Building bricks (e.g. clay blocks, facing bricks, engineering bricks/clinker bricks and lightweight bricks)
- Roof tiles (e.g. extruded tiles, pressed tiles)
- Paving bricks
- Chimney bricks (e.g. chimney pipes).

Due to the different techniques of manufacturing, different types of brickyards are specialized in various groups of products, e.g. clay roof tile works and building bricks works.

❖ Vitrified Clay Pipes

Vitrified clay pipes and fittings are used for drains and sewers, also for making tanks for acids and products for stables.

❖ Refractory Products

Refractory products are ceramic materials capable of withstanding temperatures above 1500 °C. Numerous refractory products in a wide variety of shapes and forms are used in many industrial applications of the steel, iron, cement, lime, glass, ceramic, aluminium, and copper industries; with that also in petrochemical industries, in incinerators, in power plants, and in house heating systems.

They are vital to high temperature processes and resist all types of stresses (mechanical, thermal, chemical) such as erosion, creeping deformation, corrosion and thermal shocks. The resistance of refractory materials to high temperatures is defined so that their softening point is not less than 1500 °C. A classification of ‘refractory materials’ with a softening point of 1500 - 1800 ºC and 'high refractory materials' with a softening point of more than1800 ºC is commonly used.

❖ Expanded Clay Aggregates

Expanded clay aggregates are porous ceramic products with a uniform pore structure of fine, closed cells and with a densely sintered, firm external skin. They are manufactured from raw materials containing clay minerals. The raw material is prepared, moulded and then subjected to a firing process at temperatures between 1100 and 1300 ºC, resulting in a significant increase in volume due to expansion.

The products can be manufactured in any quantity and with precisely adjustable grain size and characteristics to meet a wide range of technical requirements for numerous areas of application.

They are used as loose or cement bound material for the construction industry; for instance loose fillings, lightweight concrete, blocks and other refabricated lightweight concrete components, structural lightweight concrete for on-site processing and also loose material in garden and landscape design (e.g. embankment fillings in road construction, substrates for green roofs, filter and drainage fillings).

The diverse range of industrially produced lightweight aggregates (LWA) covers a wide spectrum of technical characteristics. Properties such as grain size, porosity, weight and grain strength can be controlled during the manufacturing processes. Aggregates with grain densities between 0.15 to 1.7 kg/dm³ are available to suit a wide range of requirements and applications. These lightweight aggregates have excellent insulating characteristics. This is due to the large number of finely distributed pores inside the material. Thermal conductivity values for loose fills of industrially produced lightweight aggregates range from 0.07 to 0.18 W/mK, depending on the grain size and density of the respective material

In addition to expanded clay aggregates, industrially produced lightweight aggregates also include expanded slate and shale, bottom ash, sintered hard coal flue dust and expanded glass.

❖ Tableware

The manufacture of household ceramics covers tableware, artificial and fancy goods made of porcelain, earthenware and fine stoneware. Typical products are plates, dishes, cups, bowls, jugs and vases. Tableware conforms to the general description of processes which apply to all the ceramics.

India has been exporting Bone China tableware to all the European countries, Canada, Australia and Egypt etc. At present production capacity of Bone China tableware in India is 200 MTPD and nearly 25% of total production is exported.

The intrinsic fundamentals of this fast growing segment are estimated to give around 8% to10% growth for the next decade. Though selected players, especially new entrants who came in with the right strategy to tap such a highly fragmented market, can look at more than 15% growth for at least 3 to 4 years over existing base. The key point is also that though the market is not nascent it has huge untapped potential. Growth is more in the organized retail segment though on a much smaller base but its share of the market is around 9.5% and growing. Almost 50% of the market is comprised of organized players, with brands like Yera, Ocean, Luminarc, La Opala, JCPL, Bharat, Corelle, Treo and others.

❖ Sanitary ware

The sanitary ware is estimated to be valued approximately Rs. 780 crores in 2014 while the bathroom fitting segment is estimated at approximately Rs. 1900 crores.

The manufacture of sanitary ware follows processes similar to those which apply to all the other ceramic products. Sanitary ware is one of the biggest sectors at present. Ceramic sanitary ware is used for sanitation purposes. Sanitary ware products range from wash basins, closets, urinals, sinks to bath tubs etc. Because of its good properties like good corrosion resistance, glazy surface with different appealing colours, the use of sanitary ware for sanitation purpose has not yet been remarkably replaced by other materials like steel, fiber etc. The ceramic sanitary wares are rather cheap, easy to clean and are available in various colours.

The population has been increasing day by day and the living standards of people are also increasing. The demand of sanitary ware is also increasing the same way. The market is very bright in that concern. With the improved living standard of people, these items are essential and an integral part of consumer sectors. As these items are not repairable or re-usable after every installation, its demand also increases by the renovation and modernization of the existing systems of the sectors mentioned above.

❖ Technical ceramics

Technical ceramics are applied in many industries and cover both, established products like insulators and new applications. They supply elements for the aerospace and automotive industries like engine parts, catalyst carriers; electronics like capacitors, piezo-electrics; biomedical products like bone replacement; environment protection like filters and many others.

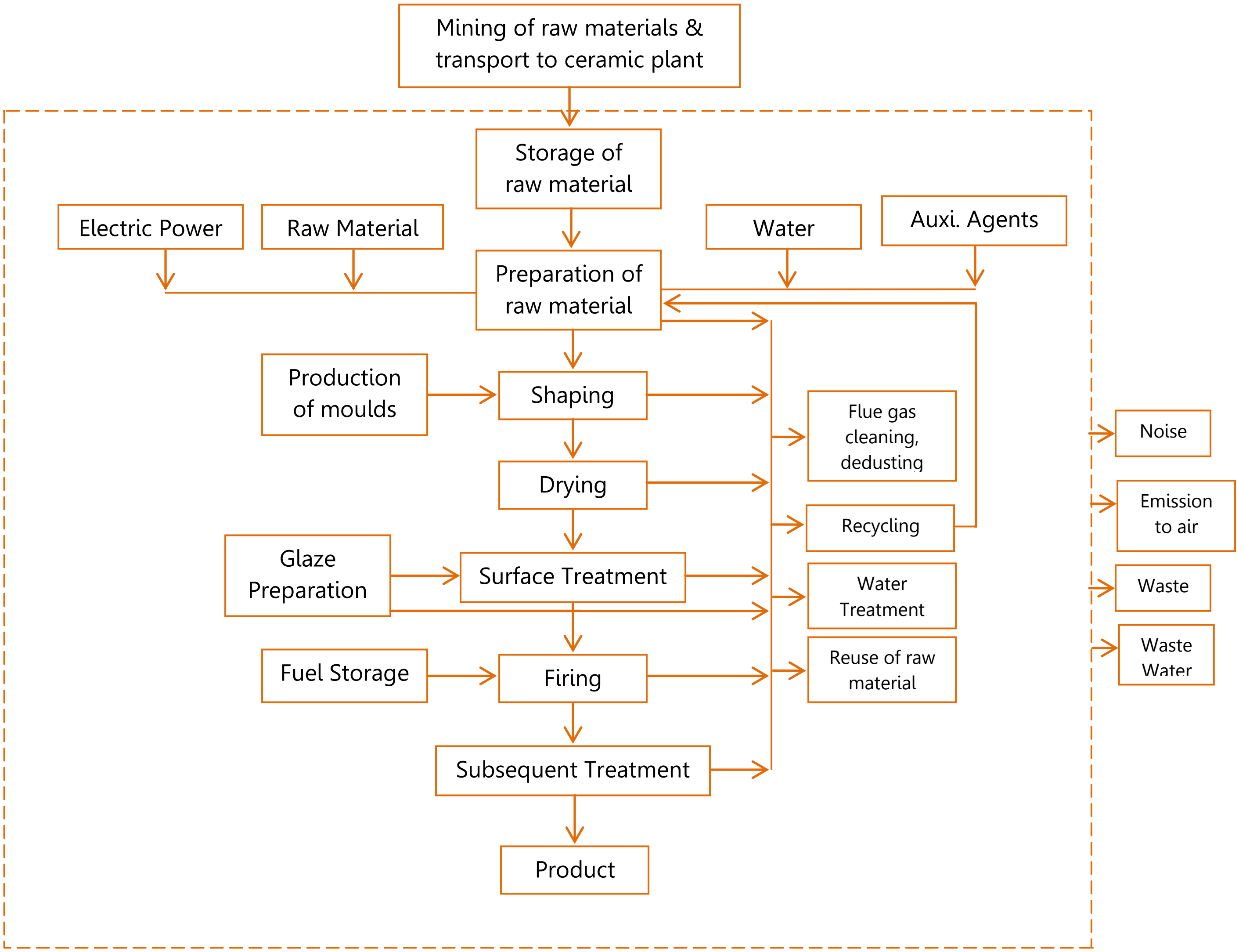
❖ Inorganic bonded abrasives

Abrasive products are the tools widely used for cutting and grinding kind of functions. They are also useful for cutting-off, polishing, dressing, sharpening, etc operations for metals, plastics, wood, glass and stones.

Basically, a distinction can be made between bonded abrasives (grinding wheels) and coated abrasives (abrasive paper and tissues). Furthermore, loose abrasives also exist, which do not have any solid linkage to a backing (like polishing pastes).

An inorganic bonded abrasive (or vitrified bonded grinding wheel) is a tool made up of synthetic abrasive materials, special fused alumina, synthetic corundum, silicon carbide, Cubic Boron Nitride (CBN) or diamond, pre-screened in uniform grit size.

General Ceramic Manufacturing Process



Stages in the manufacturing of Ceramic Products

Body Preparation

Many of the traditional methods of manufacture are used, particularly for Clay based bodies, but modifications are necessary for dealing with non-clay bodies. Several techniques entirely new to ceramics have had to be developed, some adapted from those used in other industries, particularly the food, pharmaceutical and metal industries, in order to fabricate many of the newer materials and to obtain the special properties required. The special methods will be described in later sections.

Familiar body preparation methods used include wet and dry rotary or vibratory grinding in cylindrical pebble mills to reduce raw materials to precisely controlled fineness; blunging by rotating paddles in octagonal-section vessels to disperse clays and to blend the body constituents (thorough homogenizing is essential in technical ceramics generally); dry and semi-wet mixing in pan-mills; filter-pressing; de-airing pug extrusion; and, less frequently. Slip mixing for slip casting. Magnetting is also an important step, to remove traces of metallic iron.

Shaping techniques used for clay-based bodies are also similar to the traditional ones. For example, plastic methods are widely used, such as jollying-that is beating the plastic body into a plaster mould to provide the external shape, and shaping the inside by applying a metal tool with the mould rotating. Pressing in steel moulds, either in the plastic or semi-dry state is also very common, although for the latter the conditions are somewhat different from those used in tile pressing. Slip casting is only rarely used.

Firing methods are generally similar to those used for the more conventional types of ware, but have to be modified for certain materials and in some cases new techniques have had to be devised for example hot pressing.

Blending: It will be assumed that the raw materials have been ground to the correct particle size either by the supplier or the user, and are ready to be mixed, e.g. quartz and felspar.

There are three essentials in mixing bodies for high quality technical ware: accuracy in batching, homogeneity, and freedom from contamination. Accuracy in making up a body is vital to the whole manufacture, and an error might be detected only after firing, in which case serious losses could result. For this reason, as well as to economize in labour, the trend is to introduce automatic batching systems, of which there is a variety. One recently marketed device consists of a “load-cell” placed under each leg of a ball mill, tank or blunger, this transmits a pneumatic signal to a meter; the weight of material introduced or discharged being thereby regulated.

Mixing is done either dry or wet. If the former, the raw materials, particularly clays, must be in a thoroughly disintegrated condition (usually less than 300 mesh size) as received, or else they must be passed through a disintegrator before use. Whichever type of disintegrator is used-pin, swinging hammer, etc.-it is most important to ensure, perfectly by putting through a trial batch of material, that it will resist abrasion by that particular material.

For most technical ceramics wet mixing is preferred, as it is more thorough than dry mixing. This is important in ensuring the maximum homogeneity for high quality products, such as high tension porcelain, which will be subjected to high electrical or mechanical stress. It also minimizes specking and localized structural weakness, caused by even a small number of particles of foreign matter. The procedure is generally similar to that used for high grade domestic ware.

On the other hand some products made in large quantities, like pressed low tension porcelain and steatite are not so demanding, and for these dry mixing is adequate. This method is cheaper, since no de-watering is necessary. For materials that are free-pouring and do not tend to aggregate, dry mixing presents no problem, and several types of equipment are available. For example, there are rotary batch mixers, consisting of a drum with internal baffles in the form of blades or scoops.

Whatever methods of mixing-wet or dry- are used, contamination by metal must be guarded against, and magnetting plays an important part in removing small, and occasionally large, pieces of iron, both from slips and also from dry material that has passed through attritions. Permanent magnets may be used, but electromagnets are far more powerful.

De-watering

In preparing materials for all methods of shaping except slip casting it is necessary to remove part of the water from wet-mixed bodies, to a carefully controlled extent, or to dry them off completely.

The traditional method-filter pressing-is widely used. Careful attention to the operating conditions is necessary to ensure a uniform product. Control is necessary over specific gravity, viscosity and degree of deflocculation of the slip, and the pressure time cycle. Comparatively soft centres of the filter cake are cut out and returned to the mill or blunger. Binders or plasticizers may have to be added to low-clay bodies, this is sometimes done in the mill, so that the additives become adsorbed on the solids, to give uniform distribution in the filter cakes.

After checking moisture and hardness, the filter cakes are either stored in a humidity chamber or used directly. Formerly it was the custom to store filter cakes over a long period to mature, and it was known for a clay worker to lay down stocks of filter cakes for use by the next generation. This gave a homogeneous body with high plasticity, but long storage is now generally considered unnecessary, with the almost universal use of the de-airing pugmill. If required for pressing, the cakes are partially or completely dried and disintegrated.

Granulation

When fine materials are to be shaped by pressing in steel dies they must first be made free-pouring by compacting in one way or another, followed by breaking down the aggregates in to granules, which will then pour easily and evenly into the die cavity.

For semi-wet pressing, as used for low tension porcelain (moisture content about 15-17%) the usual method is to crush the partially dried filter cakes in a pan mixer (unless dry mixing has been used), the necessary extra water and the lubricants then being added. These consist of paraffin and a water-soluble oil, such as those used as coolants in machining metals. Other cheap oils, such as burnt diesel oil, with an emulsifier, are also used. The proportions vary widely, a typical mixture being one part by weight of oil and two of paraffin to 10 parts of water in the body. Some manufacturers claim that it is better to add the water and oil first, followed by the paraffin, which “breaks” the oil-water emulsion and frees the oil for lubricating the die, during pressing: others, however, consider that the order of mixing is immaterial.

For dry pressing the essential conditions are that the granules shall be strong enough to resist disintegration during handling, including automatic hopper feeding, but shall be soft enough to deform easily during pressing. Suitable bonds or lubricants, or both, must be incorporated, or added after granulation to give good pressed strength and to facilitate-pressing and ejection, as well as to minimize die abrasion. Free –pouring characteristics are even more essential than for semi-wet pressing as there is no plastic flow other than in the direction of pressing. There are three commonly used methods:-

a. Wet granulation, in which the semi-plastic mix is forced through a woven screen of say 16-mesh by means of a rocking arm granulator.

b. Dry granulation, where the dry or nearly dry material is pre pressed in a steel die, and the pressings then broken down and the granules graded as for semi-wet press material.

c. Spray drying. This technique was originally developed for the production of dried milk and other food products, and for pharmaceuticals. It was first used in ceramics for producing pressing material for very small ferrite rings and was later used for porcelain, steatite and other ceramics. The method consists in pumping the slip into a stream of hot air. The spray droplets become dried to an extent that is easily controlled, and the material in granular form is collected at the bottom of the vessel. The hot air enter from the top and follows a spiral flow pattern. Atomization is either (i) by a nozzle in the lower part of the drying chamber, pointing vertically upwards, or (ii) by centrifugal atomization using a rotating vaned disc fabricated with abrasive-resistant inserts, and which projects the spray radially. The former will give smaller granules ,e.g. 55% between 60120μ: the latter is used for larger sizes, e.g. 65% between 250 and 500μ. The larger the size of the drying chamber the larger the granule size obtainable: using a disc atomizer a laboratory unit will give granules between 5 and 50μ, a 7-10ft. unit 75 to 100μ and a larger units 200 to 500μ granules. The apparent density of the granules is less than that obtained by conventional methods, and the choice of binders is sometimes found to be critical.

The advantages of spray drying are:

a. It can be used for batch or continuous production.
b. Drying and granulation are achieved simultaneously.
c. Spherical, free-pouring granules of very small size and narrow size range are obtained.
d. Control of final moisture content and of granule size as well as of bulk density of the granulated material is simple.
e. Substantial saving in labour costs is possible owing to the elimination of filter-pressing etc.
f. Saving of floor spaces is considerable.

In deciding whether to use spray drying in a particular case, the technical advantages may be the dominant factor, but from the economic point of view the capital outlay and cost of providing hot air (at say 250·C.) have to be set against the saving in labour. Regarding the hot air, which of course has to do the whole of the de-watering required, the solids concentration of the slip is of the greatest importance. It has been shown, for example, that in a plant producing granules at the rate of 3000kg. per hour, a reduction of 50% in the thermal energy necessary could be achieved by increasing the feed solids concentration from 50 to 65%.

Throwing

Although obsolescent, throwing on a potter’s wheel is still in use to a limited extent for pre-shaping extruded blanks for high tension insulators, before the final turning operation. It is also said to help to homogenize the plastic body and to destroy the orientation patters produced by pug extrusion. However these advantages have to be weighed against the cost of this skilled extra operation.

Jollying

This is widely used, in conjunction with turning, for making high tension insulators. The technique is basically the same as that used for domestic ware. Modifications are made for shaping particular types of insulators; for example, provision has to be made for horizontal movement of the tool, for jollying deep cavities with undercuts or tapers. Great care has to be taken to avoid introducing strains, which may give rise to local dielectric weaknesses in the fired article, and for this reason stock is removed in small amounts at a time.

Wet pressing

This method is similar to that used for the automatic shaping of mass-produced domestic hollowware. A piece of pugged, de-aired body is pressed into a plaster mould to form the external shape, as in jolleying and hot pressing, but the moulds have to be reinforced to enable them to withstand the higher forming pressure used; this is done by embedding steel plates in the plaster. The moulds are provided with air ducts in order to avoid trapping air, and so that after pressing, compressed air can be blown in to release the piece. Although economical in die costs, the method is only suitable for a few types of low tension porcelain parts where the dimensions are not critical; the quality obtainable is not good enough for making high tension ware, and appears to be used only in certain American factories.

Semi-wet pressing

This is the main shaping method used for a great variety of low tension porcelain parts. It is included under plastic shaping methods because, unlike dust pressing as used in the tile industry, for which a moisture content around 8% is typical, and where no bulk plastic flow takes place, the moisture content for semi-wet pressing is around 16% and the method depends on plastic flow in order to fill small cavities in quite complicated steel moulds. (For some products a split mould, or one with movable inserts, may be necessary in order to allow the piece to be ejected.) The body is used in granular form to facilitate uniform die filling.

Manually operated fly (Screw) presses are still used, but the trend is towards automatic hydraulic presses. The filling of the dies may be manual or automatic and again the trend is towards the latter, which avoids relying on the judgment of the operator in achieving correct filling, but requires more attention to granulation. Difficulties are sometimes experienced in obtaining clean ejection of the pressed piece from the die without “plucking”, i.e. sticking to the upper punch; moisture content is critical, and the correct amount to provide sufficient plastic flow without stickiness has to be found by trial and error, for particular bodies and die shapes. Careful choice of die lubricant helps to give a good surface; paraffin is the most usual lubricant, sometimes with the addition of a small amount of olein or other oils, and is applied to the die parts between each pressing. Correct granulation is of course essential.

Drying

Depending upon the technological requirement the dryer is used. The type of the dryer, the temperature of drying, and the time required to do the drying -all depends upon the requirement of a particular product and the process.

Mangle Dryer- Tunnel dryer, the natural Drying and Intermittent drying are some of the method of drying used by the industries.

Glazing

Many technical ceramics are glazed, particularly if they are to be used in damp or contaminated atmospheres. For example porcelain insulators, although there are many applications for which glazing is unnecessary. Most glazes used are of the raw. Once-fired, felspathic type, applied to the ware before firing. Other types are also used, such as lead glazes, the ware then being twice fired. Application is by dipping or spraying. The former tends to be used for large articles; for instance, 10-ft. high tension bushings are sometimes dipped in a tank of glaze slip and are handled by two men by means of a pole or pipe passing through the bushings and clamped rigidly to it. Smaller pieces, such as tubes a few inches in length lend themselves to automatic spraying followed by drying, in circular booths in which they are carried round on rotating spigots. The composition and other details of the various glazes used will be dealt with under the section on porcelain.

Firing: Types of kiln

A wide variety of types and sizes of kilns are used: tunnel, intermittent (including the “top hat” type,) and various small and special kilns. In the case of tunnel kilns the size varies from about 400-ft. long, with a setting width of 5ft 8in. and setting height of 5 ft 2in, used for large high tension insulators, down to miniature tunnels in the form of tubes of 1 or 2 in. diameter and 1 or 2ft. long, for very small articles. The points to be considered are:

a. The final firing temperature and the firing schedule are often critical, particularly with non-clay ceramics:
b. temperatures tend to be higher and to cover a much wider spread than with the more conventional ware;
c. occasionally , controlled atmospheres are necessary- for example, inert atmospheres are for some ferrites, and reducing atmospheres for high temperature metalizing;
d. There is a great variety of sizes and shapes of ware.

The choice of kiln naturally depends a great deal upon the volume of production, as well as on the price and availability of fuels and type of ware and precision required in the control of temperatures and atmospheres. For small orders for special types of product, batch kilns are generally more convenient, and avoid interruption of normal tunnel kiln flow. If one tunnel kiln is used for all ware the schedule must be appropriate to the largest sizes; this is not always a disadvantage provided that the relative output of the various sizes allows the spaces between the larger ware to be filled up to give high setting density. Ideally body composition would be adjusted to allow all ware to be fired at the same temperature, but this is not always possible, in which it is difficult to make efficient use of a single tunnel kiln.

For very small pieces such as tubular, capacitor dielectrics 10mm. or so long, which can be fired very quickly, a miniature tunnel kiln may be used. One which is easily constructed is heated by silicon carbide rod elements placed around a muffle tube schedules as short as 30 min. are sometimes used. It may be noted here that the non-clay types of ware do not course require particular care in passing through temperatures around 600°C, and indeed certain types must be cooled rapidly in order to develop the required properties.

For temperature from about 1500 - 1800°C there are number of alternatives. Gas or oil-fired tunnel kilns, directly heated or muffle type, are used, the combustion air being preheated (maximum flame temperature of a coal gas-air mixture is only 2040°C. if the air is not preheated.) High temperature gas-fired intermittent kilns are also used, and molybdenum wire-wound muffles, requiring an atmosphere of hydrogen or cracked ammonia, are used both experimentally and for the high temperature metalizing of ceramics, particularly of alumina, at temperatures up to 1700-1800°C. A recent modification of the molybdenum element furnace is the replacement of the wire-wound muffle by a number of independent wire elements which are sealed into crystallized alumina sheaths; furnaces of various sizes can be built up from an appropriate number of these elements.

ENVIRONMENTAL ISSUES ASSOCIATED WITH CERAMIC SECTOR

The ceramic industry of Gujarat faces many problems related to Environment, Health and Safety, Production Inputs, Managerial Skills, Finance and Marketing. Production, Pollution and Protection terms are inter-related. The ceramic industry is no exception to this nexus.

Air Pollution:

Particulate matter/dust can arise from the handling or processing of raw materials or product finishing and also soot can arise from firing fuel oil or different solid fuels. Gaseous emissions arise during the firing or spray-drying of ceramics and may be derived from the raw materials and/or from the fuels employed. Carbon oxides, nitrogen oxides, sulphur oxides, inorganic fluorine and chlorine compounds, as well as organic compounds are of particular importance among the gaseous emissions. Due to the use of substances for decorative purposes which contain heavy metals, or due to the usage of heavy oil as fuel, heavy metals can also be emitted.

The amount of flue gas produced during firing in the furnace kiln depends on the fired product and the type of fuel used. Volatile components are emitted from the product mass and from the fuel.

Airborne dust concentration at various sections of major units happens to be higher than recommended in both urban and rural factories, with higher level of that in urban area. A high dust concentration is found in the grinding and glaze spray department. Airborne dust consists of 25% free silica particles which is a high risk to the respiratory system of the workers.

Air pollution arising out of ceramic production is in the form of suspended dust particles. This kind of air pollution not only affects the health of ceramic workers but also the other citizens of the town as well as micro urban climate. Thus, the health hazard of ceramic workers is due to the nature of raw material, its handling and storage, and techniques of production, nature of energy resource and micro-environmental degradation.

Water Pollution:

These mainly occur during the manufacturing processes of ceramic products, especially during the manufacture of traditional ceramics, and the resulting process waste water mainly contains mineral components (insoluble particulate matter). Depending on the production method, the process waste water also contains further inorganic materials, small quantities of numerous organic materials as well as some heavy metals. Apart from process water, which often is cleaned and re-used in closed circuits, also cooling water, rainwater and sanitary waste water may contribute to the emission to water from the plant

Soil Pollution:

The quarrying of various raw materials of ceramic industry creates bad land topography with numerous depressions of different shapes and depths. Many of them are filled with environmentally unfriendly and non-degradable ceramic waste materials and some of them tend to collect rain water and await accidents to happen. Also the collected water remains mosquito breeding pockets; spreading pathogenic diseases.

However, soil is little impaired by the spoil from ceramic works, if the waste generated during production is reused in the plant's own production or in other ceramic works, but in case when the spoil dumps are formed where the plant is operated inefficiently, soil pollution becomes the major concern. The biggest problem related to the ceramic industry is the generation of the solid waste which needs to be disposed off in the landfills. Another misuse of land resource is the open storage of raw materials creating unhygienic dusty environment; leading to the air pollution.

Process Losses:

Process losses originating from the manufacture of ceramic products mainly consist of the following:

- Different kinds of sludge (sludge from process waste water treatment, glazing sludge, plaster sludge, grinding sludge)
- Broken ware from shaping, drying, firing and refractory material
- Dust from flue-gas cleaning and de-dusting units
- Used plaster moulds
- Used sorption agents (granular limestone, limestone dust)
- Packaging waste (plastic, wood, metal, paper, etc.)
- Solid residues, e.g. ashes arise from firing with solid fuels.

Parts of the accumulated process losses mentioned above, can be recycled and reused within the plant as per product specifications or process requirements. Materials, which cannot be recycled internally, leave the plant as waste and are supplied to external recycling or disposal facilities.

Energy Consumption/CO_2 Emissions:

All sectors of the ceramic industry are energy intensive, as a key part of the process involves drying followed by firing to temperatures between 800 to 2000 ºC. For the manufacture of porcelain, energy accounts for at least 10 to 18% of the total cost. For the manufacture of bricks, the share of the energy cost varies between 17 and 25% with maximum up to 30%.

Health and Safety:

Many of the units have poor, unhygienic conditions both within their premises and outside their premises. Most of the units have dusty working environment and unbearable thermal condition around the kiln. In colour, dyes and paint section; hazardous chemical spray particles in the air affect the workers' health and working condition. Plant design including exhaust system, sanitary facilities and overall maintenance of cleanliness is sometimes far below the standards set by the industrial safety, security, health, hygiene and environment regulation acts.

Thermal and Chemical Exposure:

Urban ceramic unit workers show more thermal stress than the rural unit workers. Many a times, in urban and rural units Wet Bulb Globe Temperature levels have been observed upto 55°C and 48°C respectively which is far more than recommendations by Occupational Safety and Health Administration (1974). This clearly shows that Kiln section is found to be very hot and workers are exposed to severe heat. The glaze used in the paints and dyes for the ceramic products contains Lead which is severely harmful for the human health. Presence of silica also leads to diseases like Silicosis and Tuberculosis and many types of lung disorders.

Industry Specific Standards – Ceramic Industry (Source: Central Pollution Control Board)

Category of industries as per Central Pollution Control Board:

- Ceramic and refractories: RED
- Ceramic, earthen pottery and tile manufacturing using oil or gas fired kiln, producer gas plant using conventional up-drift coal gasification: ORANGE
- Ceramic colour manufacturing (not using boiler and wastewater recycling process), decoration of ceramic cups & plates by electric furnace, ceramic, earthen pottery, tile manufacturing using electrical kiln or not involving fossil fuel kilns: GREEN

Following are the standards of emissions of Ceramic Industry.

Particulars	EMISSIONS	(Concentration in mg/Nm^3)
A) Kilns		
(a) Tunnel, Top Hat, Chamber	Particulate Matter	150
	Fluoride	10
	Chloride	100
	Sulphur dioxide	**
(b) Down-draft	Particulate Matter Fluoride	1200
	Chloride	10
	Sulphur dioxide	100
		**
	Particulate Matter Fluoride	
(c) Shuttle	Chloride	150
	Sulphur dioxide	10
		100
	Particulate Matter Fluoride	**
	Sulphur dioxide	
(d) Vertical Shaft Kiln		250
	Particulate Matter	10
	Fluoride	**
	Sulphur dioxide	
(e) Tank furnace		150
		10
		**
B) Raw material handling, Processing and operations		
(a) Dry raw materials handling and processing operations	Particulate Matter	150
(b) Basic raw material and processing operations	Particulate Matter	*
(c) Other sources of air pollution Generation	Particulate Matter	*

C) Automatic Spray Unit (a)Dryers (i)Fuel fired dryers (ii)For heat recovery dryer	Particulate Matter	150
(b)Mechanical finishing operation	Particulate Matter	*
(c) Lime/Plasters of Paris manufacture	Particulate Matter	*

∗ Standards notified at Sr. No. 2 may also be referred.

1 Substituted by Rule 2 of the Environment (Protection) Amendment Rules, 1996 notified by G. S. R. 176(E), dated 2. 4. 1996 may be read as BOD (3 days at 27°C) wherever BOD 5 days 20°C occurred.

Sr. No.	Industry	Parameter	Standards
1	Capacity :		
	Upto 5T/day	Stack Height	A. Hood should be provided with a stack of 30 meter height from ground level (including Kiln height)
	Above 5T/day	- do –	H=14(Q)0.3 Where Q is emission rate of SO2 in kg/hr and H=Stack in meters
	More than 5T/day	Particulate matter	500 mg/NM^3
	and utp 40 T/day	Particulate matter	500 mg/NM^3

Note: Oxygen reference level for particulate matter concentration calculations for kilns mentioned at A(c) is 18% and for those at A(b), A(d) and A(c) is 8%.

* All possible preventive measures should be taken to control pollution as far as practicable.

** The standard for sulphur dioxide in terms of stack height limits for kilns with various capacities of

Coal consumption shall be as indicated below:

Coal consumed per day	Stack height
Less than 8.5 MT	9 m
More than 8.5 to 21 MT	12 m
More than 21 to 42 MT	15 m
More than 42 to 64 MT	18 m
More than 64 to 104 MT	21 m
More than 104 to 105 MT	24 m
More than 105 to 126 MT	27 m
More than 126 MT	30 m or using formula

Standards of emissions to air (CPCB)

Pollutants	Time-weighted average	Concentration in ambient air			Method of measurement
		Industrial Areas	Residential Rural & other Areas	Sensitive Areas	
Sulphur Dioxide (SO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3	-Improved West and Geake Method - Ultraviolet Fluorescence
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	
Oxides of Nitrogen as (NO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3	-Jacob & Hochheiser Modified (Na-Arsenite) Method -Gas Phase Chemi-luminescence
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	
Suspended Particulate Matter (SPM)	Annual Average*	360 µg/m^3	140 µg/m^3	70 µg/m^3	- High Volume Sampling, (Average flow rate not less than 1.1 m3/minute).
	24 hours**	500 µg/m^3	200 µg/m^3	100 µg/m^3	
Respirable Particulate Matter (RPM) (size less than 10 microns)	Annual Average*	120 µg/m^3	60 µg/m^3	50 µg/m^3	- Respirable particulate matter sampler
	24 hours**	150 µg/m^3	100 µg/m^3	75 µg/m^3	
Lead (Pb)	Annual Average*	1.0 µg/m^3	0.75 µg/m^3	0.50 µg/m^3	-ASS Method after Sampling using EPM 2000 or equivalent Filter paper
	24 hours**	1.5 µg/m^3	1.00 µg/m^3	0.75 µg/m^3	

Ammonia1	Annual Average*	0.1 mg/ m^3	0.1 mg/ m^3	0.1 mg/m^3	
	24 hours**	0.4 mg/ m^3	0.4 mg/m^3	0.4 mg/m^3	
Carbon Monoxide (CO)	8 hours**	5.0 mg/m^3	2.0 mg/m^3	1.0 mg/ m^3	- Non Dispersive Infra Red (NDIR) Spectroscopy
	1 hour	10.0 mg/m^3	4.0 mg/m^3	2.0 mg/m^3	
Note: * Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval. ** 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.					

Chapter – 6

Data Collection & Detailed Assessment

Cleaner Production Assessment in Ceramic Sector

DATA COLLECTION AND DETAILED ASSESSMENT

For conducting the detailed Cleaner Production Assessment, Four of the sub-sectors were identified to cover a wider scope of assessment. They are –

1. Wall and Floor Tiles
2. Low Tension Insulators
3. Technical Ceramics
4. Table ware

Industrial estates consisting of Ceramic units were identified. Major of the ceramic units are located around Morbi, Thangarh, Surendranagar, Naroda, Himmatnagar, Kadi, Panchmahal etc. various units were invited to participate in the project through letters, emails and telephonic conversations, out of which following units were selected to conduct the detailed Cleaner Production Assessment –

1. Somany Ceramics, Kadi – Manufacturer of wall and floor tiles
2. Sonya Ceramics, Kadi – Manufacturer of low tension ceramic insulators
3. Gujarat Porcelain Industry, Wadhwan – Manufacturer of LT Porcelain ware
4. Shivshakti Ceramics, Naroda – Manufacturer of cups, saucers and tableware
5. Sonya Insulators, Bapunagar – Manufacturer of technical ceramics

A detailed exercise was carried out using the methodology of data collection and detailed assessment, including on-site observations, waste stream identification, quantification, generation of Cleaner Production Scope, Suggestions to implement CP and possible outcomes of implementation. After suggesting the options, many of them have been taken under implementation, many of them are being planned to be implemented and many of them are implemented successfully. The detail of the same is mentioned in the next parts of the document.

Selection of CP Assessment Focus

The focus of the project is generating Cleaner Production Scope by –

- Study of raw material to final product (Mass Balance)
- Study of usage of process water in overall processes (Water Balance)
- Study of source of waste water generation with its physical form and balancing the quantity from individual waste water generation to final effluent discharge/recycle from the industry

- Study of source of solid waste generation with its physical form and balancing the quantity from individual solid waste generation to final solid waste discharge/recycle from the industry
- Study of source of air and gaseous emission from the different processes and identifying the impacts and losses for the industries.

General description of information:

The details required for carrying out the assessment is presented in the following table:

Details	**Purpose**
Company profile	For general status and growth of industry
Plant layout	To gain an overview of plant design and equipment positions
Fuel (PNG) consumption data	To correlate fuel consumption with the production output
Electricity consumption	To correlate electricity consumption with the production output
Process flow sheet	To identify the individual process and relation between the processes
Material consumption data	To track the actual quantity of raw and auxiliary materials converted into final product.
Water consumption data	To track the water consumption in different processes and role of water in the process
Waste water generation data	To determine the quantity & quality of waste water generated in the process
Air & gaseous emission data	To determine air & gaseous emission sources

List of data source, authentication & reliability

All the data necessary for carrying out this activity was obtained from the industry employees at the discretion of the owner.

Data	Authentication	Reliability
Company profile	Industry personnel	High
Plant layout	Industry personnel	High
Fuel consumption data	Installed meter readings	High
Electricity consumption	Electricity bills from State Electricity Board	High
Process flow sheet	Industry personnel & verified in visit	High
Material consumption data	Industry personnel	Medium
Water consumption data	Industry personnel & verified by process parameters	High
Waste water generation data	Industry personnel	Medium
Air & gaseous emission information	Visual during visit	Medium
Environment Consent	Gujarat Pollution Control Board	High
Domestic water consumption data	Industry personnel	Medium

Methodology of Data Collection

- Data collection, verification by visit to the industry and interaction with industry personnel.
- Study of collected data to assess how well the process systems and pollution control systems are performing, and identifying the operations of poor performance.
- Identifying potential cost savings which can be accrued through reduction in raw material consumption by way of waste minimization and adoption of recycle/recovery/reduction in pollution load.
- To identify the measures in order to enabling industry discharge in compliance with environmental laws and regulations.
- To make proper format of up-to-date environmental data base for use in-plant modifications, emergencies etc.

- Unraveling surprises and hidden liabilities due to which regulatory risk and exposure to litigation can be reduced and providing timely warning to management on potential future problems, and
- Providing inputs for strengthening environmental management structures within the industry.

Limitations

Some limitations were also faced by the team during the environmental assessment project. These are as below:

- Lack of data related to actual consumption of resources to verify and made calculations on actual consumption figures.
- Hesitation/reluctance on the part of industry persons to provide typical problem in the process resulting in loss of resources and generation of undesirable waste.
- Limitation of technical staff in the industries.
- Unavailability of technical details and process parameters.
- Lack of metering & data at critical processes.

Chapter – 7

Case Studies of Cleaner Production Implementation

SOMANY CERAMICS, KADI

Introduction – Somany Ceramics

Established in 1969, Somany Ceramics Ltd. has been involved in manufacturing of world class quality ceramic products. The company is a complete solutions provider in terms of décor solutions with widest product range of wall tiles, floor tiles, polished vitrified tiles, glazed vitrified tiles, digital tiles, sanitaryware and bath fittings. It has manufacturing units at Kadi (Gujarat) and Kassar (Haryana) and joint venture plants at Morbi, with a total manufacturing of 41 million Sq. Meters of tiles annually.

The company has its marketing sphere of influence spanning India, Africa, the Middle East, United Kingdom and Russia and has over four decades of spearheading industry innovation experience in ceramics and allied products segment. Somany Ceramics has established its presence as a leading and formidable force in the Indian tiles sector. The company is renowned for implementing the newest technological advancements and practice of lateral thought and trend-setting tenets, also for pioneering several first of its kind designs and styles in tiles segment of India. The CP assessment project was carries out at the Kadi based manufacturing plant of Somany Ceramics Ltd.

Cleaner Production Assessment Team

The team for conducting Cleaner Production Assessment includes the following members.

Name	Designation
Dr. Bharat Jain	Member Secretary, GCPC
Mr. Punamchandra Rathod	Senior Project Engineer, GCPC
Mr. Paras Gojiya	Assistant Project Engineer, GCPC
Mr. Abhi Patel	Assistant Project Engineer, GCPC
Mr. K. D. Sanghavi	Technical Expert, GCPC
Mr. Sandeep Suthar	DGM, Engineering, Somany Ceramics
Mr. Dipesh Pandya	Senior Manager, Engineering, Somany Ceramics
Mr. Rakesh Shah	Senior Manager, Maintenance, Somany Ceramics

Manufacturing Process

Somany Ceramics Ltd, Kadi manufacturing plant, manufactures two types of products, viz. wall tiles and floor tiles. Apart from some variations, the major parts of the manufacturing processes of both types of products are same. Ceramic tiles manufacturing is a continuous process in Somany Ceramics Ltd.

A. Raw Material Storage

Different types of clays are transported to the plant via trucks and unloaded manually to store in the storage yard with separate compartments for each type of clay.

B. Slip Preparation

The slip is the wet slurry formed by mixing the tile body raw materials. The raw materials used for the slip preparation are Clay, Lime powder, dolomite powder, quartz powder, de flocculants, powdered soda, sodium silicate, talc powder, potash feldspar powder, Sodium Meta Silicate and water.

The main raw materials are fed to the ball mill using mechanical crane and hoppers and are mixed and wet ground to get desired level of slip density. The slip so formed is passed through a 40 mesh size sieve, followed by 60 mesh size sieve. The underflow of the 60 mesh is stored in storage tank, while the overflow is reused for slip preparation with the next batch.

C. Spray Drying

The final slip is fed to the spray dryer where dust with desired particle size and moisture is obtained to produce tiles from dust. The dust so formed is conveyed via belt conveying system to the press machines, passing through various size meshes.

D. Pressing and drying

An automatic pneumatic machine feeds the dust to the press machine with desired particle size and moisture (5.5 – 5.6%) and an average of 200 bars pressure is applied to convert the dust into a green tile shape. Tiles are dried up in the dryer before being fed to the glazing line.

Till this stage, the process for Wall tiles and Floor tiles is similar; further, there are some variations in manufacture processes of wall and floor tiles, mentioned as below.

Floor Tiles:

E. Engobe, Glaze and Colour paste preparation

The materials used for the engobe and glaze preparation are Opaque frit, transparent frit, matt frit, china clay & ball clay, minerals soda feldspar, calcite, zircolite, quartz, calcite alumina, barium carbonate, volestonite, dolomite, mullite dust, deflocuulants. The raw materials are wet grinded, screened with desired particle size and stored with required density. Also, colour paste is prepared by the similar raw material and with similar wet grinding method.

F. Engobe, glaze and print Application

Engobe operation is carried out over tiles in glaze line. A primary sprinkle of water is applied on the tiles, followed by bell shaped glaze application mechanism. The engobe is poured continuously in a container in conveyor line through a bell shaped laminar flow. The tile bodies pass under it. After a fixed distance from engobe application, the glaze is applied by the same mechanism. The glaze on the sides of tiles is scrapped off using rubber scrappers.

Post to that, a design is printed on the tile by either drum printing mechanism or in a digital printer machine. The printed tiles are stored in specially designed cars whose movement is controlled by laser guided vehicles, which transport them to the pre-drying zone of the kiln.

G. Firing in the kiln

The kilns in Somany are roller type fast firing kilns. There are total 3 plants for floor tile making, FTP – 1, FTP – 2 and FTP – 3, hence three kilns for firing the tiles. The green glazed tiles are fed into the roller kiln after passing through the pre-drying zone.

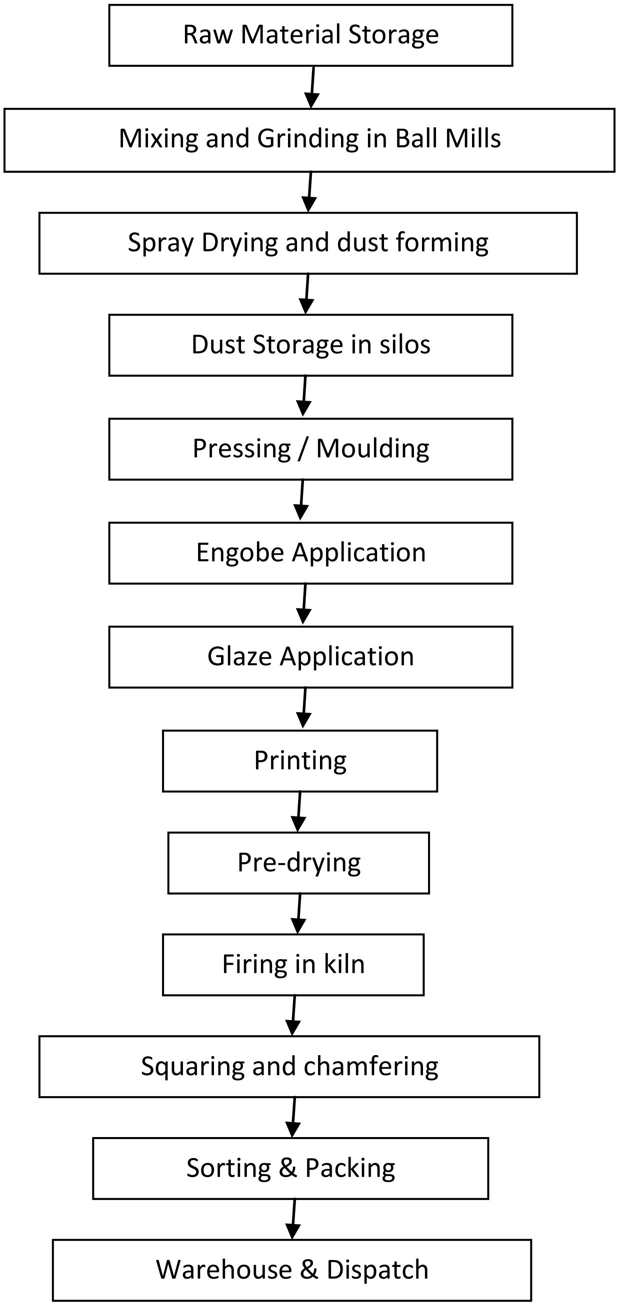
The temperature inside the kiln ranges to 1180^o C in the firing zoneto lower upto 250^o C in drying zone and still lower in the cooling zone. The thermal energy is provided to the kiln by combustion of natural gas or LNG, which is the most favourable fuel for ceramic industries in the present days. The tiles coming out of the kiln goes further for quality sorting and sizing.

H. Sizing, sorting and packing

Fired tiles are sent to sizing and chamfering machine for making exact size of the tile by side grinding through online conveyor system, which is a source of dust generation. After that, visual checks for quality grading passes the acceptable tiles and are packed in kraft paper corrugated boxes, and are dispatched for shipping.

The rejected tiles are checked for the fault in detail and possible steps are taken to reduce the loss due to that defect.

Manufacturing Process Flow Diagram of Floor Tiles



Wall Tiles:

In wall tiles plant, the process is different from floor tiles plant after pressing stage.

E. Body firing in Biscuit Kiln (Double Fast Firing)

In wall tile pants, also known as Double Fast Firing (DFF), the green biscuit is sent for drying and firing directly after the pressing section. The reason it is called as double fast firing is because the thermal application is done booth in upper and lower side simultaneously, to a temperature of 1140^{o} C so as to bake the tiles equally from both the sides. The tiles after exiting the kiln are passed for glaze application using a roller car.

F. Engobe, glaze and print Application

Same as the way in floor tile plant, the baked tiles body undergo engobe operation in the conveyor line. A primary sprinkle of water is applied on the tiles depending upon the temperature of the tiles body, followed by bell shaped glaze application mechanism. The engobe is poured continuously in a container in conveyor line through a bell shaped laminar flow. Glost biscuits pass under it. After a fixed distance from engobe application, the glaze is applied by the same mechanism. The glaze on the sides of tiles is scrapped off using rubber scrappers.

Post to that, a design is printed on the tile by either drum printing mechanism or in a digital printer machine, the same way as in floor tile plant. The printed tiles are stored in specially designed cars whose movement is controlled by laser guided vehicles, which transport them to the pre-drying zone of the kiln.

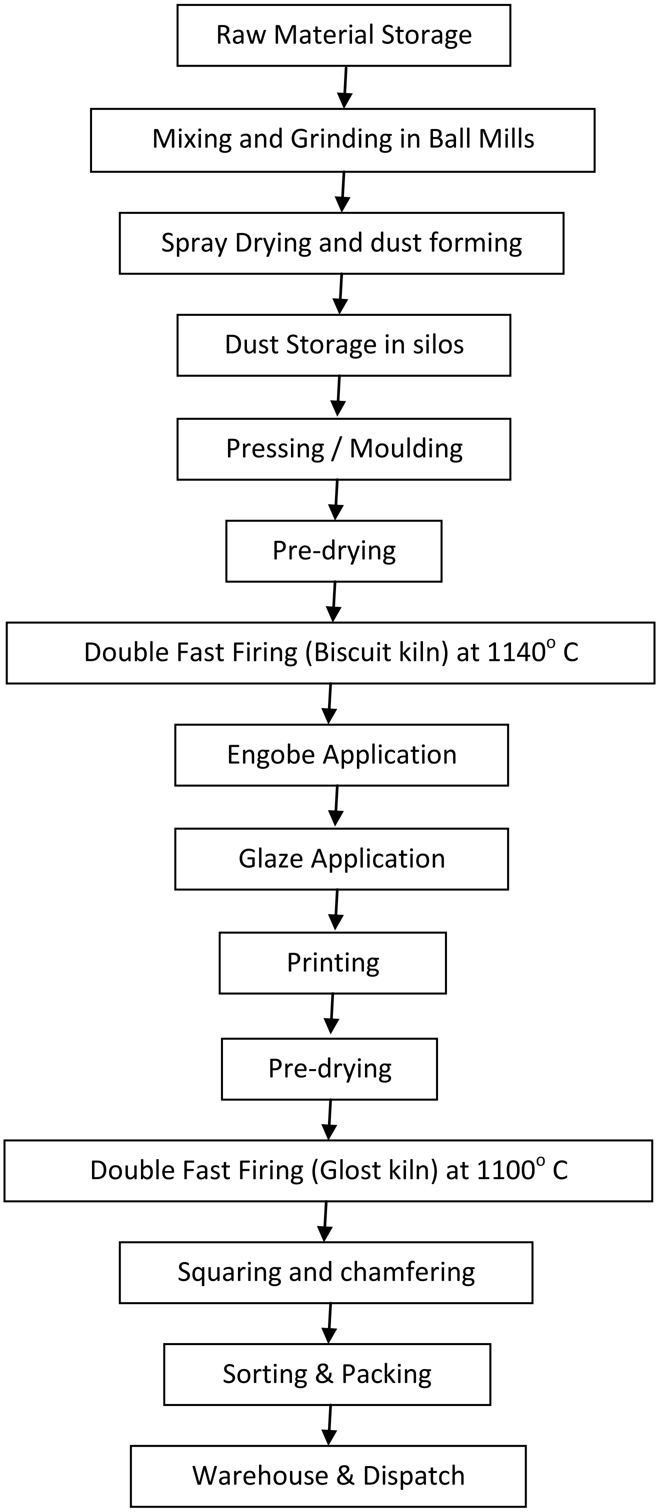
G. Tiles Firing in Glost Kiln

The tile after application of glaze and printing are again sent for firing in the kiln. The double firing in the wall tiles manufacturing is necessary for proper adhesion of the glaze and printed colours on the tile body. The temperature is as high as 1100^{o} C. The tiles coming out of the kiln goes further for quality sorting and sizing.

H. Sizing, sorting and packing

As the way in floor tiles manufacturing, fired tiles are sent to sizing. After that, visual checks for quality grading passes the acceptable tiles and are packed in kraft paper corrugated boxes, and are dispatched for shipping. The rejected tiles are checked for the fault in detail and possible steps are taken to reduce the loss due to that defect.

Manufacturing Process Flow Diagram of Wall Tiles



Production Inputs

Annual Production of tiles

Sr. No.	Name of Products	Production (in Sq. Meters)				
		2011 – 12	2012 – 13	2013 – 14	2014 – 15	2015 (Oct)
1	WTP (Wall Tiles)	2316886	2278326	2348511	2107101	1097142
2	Single Fast Fire (FTP – 2) Wall tiles	1621333	1831845	1875761	1915007	869227
3	FTP – 1 (Floor Tiles)	1899479	1897852	2095940	2114174	875487
4	FTP – 3 New	0	0	0	316378	1074131
5	**TOTAL**	**5837697**	**6008023**	**6320212**	**6452660**	**3915987**

Annual Raw Material Consumption

Sr. No.	Name of Raw Material	Raw Material consumption (in MT)				
		2011 – 12	2012 – 13	2013 – 14	2014 – 15	2015 (Oct)
1	Body Raw Material	110367	119360	125145	128122	77483
2	Glaze Raw Material	6891	7073	7074	7172	4526
3	**TOTAL**	**117258**	**126397**	**132192**	**135294**	**82008**

Fuel Consumption per square meter of products

Sr. No.	Name of Products	Fuel consumption (in MT)				
		2011 – 12	2012 – 13	2013 – 14	2014 – 15	2015 (Oct)
1	Power (KWh)	2.09	2.18	2.16	2.10	2.22
2	Gas (Std. Cubic Meter)	2.23	1.59	1.45	1.47	1.55
3	Coal (Kg)	0.66	2.49	2.83	3.06	2.87

Water Consumption Analysis

Fresh Water Consumption	
Water requirement (in Kiloliters per Day)	Domestic use: **90 KLD**
	Process use: **232 KLD**
	Cooling purposes: **10 KLD**
	Washing purpose: **217 KLD**
	Gardening purpose: **25 KLD**
	Total: **574 KLD**
Waste Water Generation	
Waste water generated (in KLD)	Domestic use: **75 KLD**
	Process use: **0 KLD**
	Cooling purposes: **2 KLD**
	Washing purpose: **248 KLD**
	Others (specify): **0 KLD**
	Total: **325 KLD**
With that, 134.13 KLD of waste water is reused directly in the process.	
Storm water drainage	Availability of storm water drainage? – **No**

TOTAL FRESH WATER CONSUMPTION

COOLING FRESH WATER CONSUMPTION APPROX. (IN LITERS)

Cooling Water	1000
Total	1000

PROCESS FRESH WATER CONSUMPTION (IN LITERS)

SLIP PREPARATION FTP-1 & 2 BALL MILL	104900
GLAZE PREPARATION FTP-1 & 2 BALL MILL	11700
SLIP PREPARATION WTP BALL MILL	30000
GLAZE PREPARATION WTP BALL MILL	2400
SLIP PREPARATION FTP-3 BALL MILL	80000
GLAZE PREPARATION FTP-3 BALL MILL	3000
TOTAL	232000

WASHING FRESH WATER CONSUMPTION (IN LITERS)

SACMI SPRAY DRYER CLEANING	3000
FTP-1 & 2 DIPPING	80000
FTP-1 & 2 BALL MILL CLEANING	4000
SAKA SPRAY DRYER CLEANING	3000
LABORATORY	10000
WTP DIPPING	35000
WTP BALL MILL CLEANING	2000
NEW SPRAY DRYER CLEANING	3000
FTP-3 DIPPING	75000
FTP-3 BALL MILL CLEANING	2000
TOTAL	217000

TOTAL FRESH WATER CONSUMPTION - APPROX. (IN LITERS)

SOAKPIT	90000
GARDENING	25000
SLIP PREPARATION FTP-1 & 2 BALL MILL	104900
SACMI SPRAY DRYER CLEANING	3000
FTP-1 & 2 DIPPING	80000
COOLING TOWER	10000
GLAZE PREPARATION FTP-1 & 2 BALL MILL	11700
SLIP PREPARATION- WTP BALL MILL	30000
FTP-1 & 2 BALL MILL CLEANING	4000
SAKA SPRAY DRYER CLEANING	3000
LABORATORY	10000
WTP DIPPING	35000
GLAZE PREPARATION-WTP BALL MILL	2400
WTP BALL MILL CLEANING	2000
SLIP PREPARATION FTP-3 BALL MILL	80000
NEW SPRAY DRYER CLEANING	3000
FTP-3 DIPPING	75000
GLAZE PREPARATION FTP-3 BALL MILL	3000
FTP BALL MILL CLEANING	2000
TOTAL	574000

TOTAL WASTE WATER INPUT TO ETP

TOTAL INPUT COOLING - APPROX. (IN LITERS)

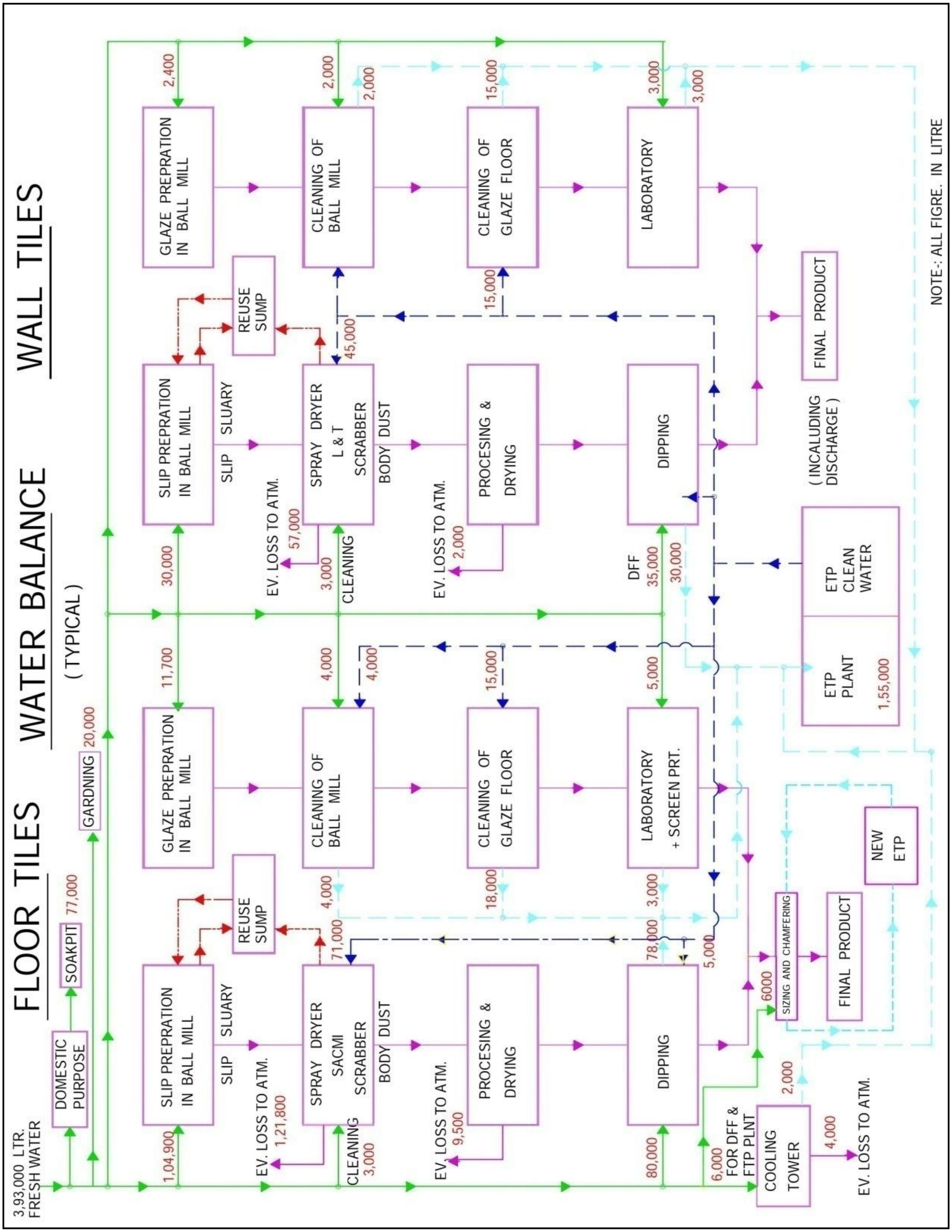
COOLING TOWER	2000

WATER INPUT WASHING - APPROX. (IN LITERS)

FTP-1 & 2 BALL MILL CLEANING	6000
FTP-1 & 2 GLAZE FLOOR CLEANING	40000
LABORATORY	9000
FTP-1 & 2 DIPPING	78000
WTP DIPPING	30000
WTP BALL MILL CLEANING	2000
WTP GLAZE FLOOR CLEANING	14000
FTP-3 DIPPING	70000
FTP-3 BALL MILL CLEANING	11000
FTP GLAZE FLOOR CLEANING	14000
TOTAL	248000

TOTAL ETP WATER OUTPUT-APPROX. (IN LITERS)

SACMI SPRAY DRYER	71000
FTP-1 & 2 BALL MILL CLEANING	4000
FTP GLAZE FLOOR CLEANING	15000
L&T SPRAY DRYER	45000
WTP GLAZE FLOOR CLEANING	15000
WTP DIPPING	5000
NEW SPRAY DRYER	70000
FTP-3 BALL MILL CLEANING	10000
FTP-3 GLAZE FLOOR CLEANING	15000
TOTAL	250000


FLOOR TILES
WATER BALANCE
(TYPICAL)
WALL TILES
3,93,000 LTR. FRESH WATER
DOMESTIC PURPOSE
SOAKPIT
77,000
GARDNING
20,000
SLIP PREPRATION IN BALL MILL
SLIP
SLUARY
1,04,900
REUSE SUMP
GLAZE PREPRATION IN BALL MILL
11,700
SPRAY DRYER SACMI SCRABBER
BODY DUST
EV. LOSS TO ATM.
1,21,800
CLEANING
3,000
71,000
4,000
CLEANING OF BALL MILL
4,000
4,000
PROCESING & DRYING
EV. LOSS TO ATM.
9,500
CLEANING OF GLAZE FLOOR
18,000
15,000
DIPPING
80,000
78,000
5,000
LABORATORY + SCREEN PRT.
3,000
5,000
FOR DFF & FTP PLNT
6,000
COOLING TOWER
4,000
EV. LOSS TO ATM.
2,000
6000
SIZING AND CHAMFERING
FINAL PRODUCT
NEW ETP
ETP PLANT
1,55,000
ETP CLEAN WATER
SLIP PREPRATION IN BALL MILL
SLIP
SLUARY
30,000
REUSE SUMP
GLAZE PREPRATION IN BALL MILL
2,400
SPRAY DRYER L & T SCRABBER
BODY DUST
EV. LOSS TO ATM.
57,000
3,000
CLEANING
45,000
CLEANING OF BALL MILL
2,000
2,000
PROCESING & DRYING
EV. LOSS TO ATM.
2,000
CLEANING OF GLAZE FLOOR
15,000
15,000
DIPPING
DFF
35,000
30,000
LABORATORY
3,000
3,000
FINAL PRODUCT
(INCALUDING DISCHARGE)
NOTE-: ALL FIGRE. IN LITRE

Cleaner Production Opportunities

Intervening Technique	Optimisation of Combustion Efficiency at Spray Dryer Furnaces

Implementing the technology

Plant is operating 3 nos. spray driers for material processing for which hot flue gases are being generated through respective fluidised bed furnaces with coal as fuel. The operating parameters of the furnaces are mentioned in following table:

Table: Furnace Operating Parameters

Parameters	SACMI	SAKA	BORA
Set Temperature Value (^{0}C)	600	575	610
Fuel Feeder Motor Frequency (Hz) – Auto	10-23	10-16	8-30
FD Fan Motor Frequency (Hz) - Fixed	41.6	36.5	38

As it is evident that the frequency of fuel feeding is varying as per temperature requirement but the supply air and draft control is constant thus affecting the combustion efficiency of the furnaces resulting in excess fuel consumption. Thus, the flue gas analysis for the furnaces were carried out at the exhaust of individual furnaces, the measured parameters are shown in table below:

Table 1: Flue Gas Monitoring Parameters at Furnaces

Parameter	Unit	SACMI	SAKA	BORA
Net Temperature	^{0}C	592	560	495
O_2	%	13.6	O_2 > 20%	O_2 > 20%
CO	ppm	58	O_2 > 20%	O_2 > 20%
Combustion Efficiency	%	38	O_2 > 20%	O_2 > 20%
CO_2	%	6.1	O_2 > 20%	O_2 > 20%
Flue Gas Temperature	^{0}C	619	592	525
Ambient Temperature	^{0}C	26.4	33.1	30
Excess Air	%	216.6	O_2 > 20%	O_2 > 20%
Pressure	mbar	0.09	0.06	0.07

Combustion Efficiency Indicator:

	1. As a rule, the most efficient and cost-effective use of fuel takes place when CO_2 concentration in the exhaust is maximized. Theoretically, this occurs when there is just enough O_2 in the supply air to react with all the carbon in the fuel. 2. The absence of any O_2 in the flue gas directly indicates deficient combustion air while presence indicates excess air. Ideally, the O_2 level shall be maintained 6 % to 8 %, CO_2 level shall be maintained 10 % to 13 %, CO level shall be maintained 80 ppm - 100 ppm and excess air shall be maintained 15 % to 20 % for pulverized coal. 3. Carbon monoxide (CO) is a sensitive indicator of incomplete combustion; its levels should range from 0 to 400 ppm by volume. The presence of a large amount of CO in flue gas is a certain indicator of deficient air. Thus, it is recommended to operate the furnaces at optimum efficiency by controlling (manual/auto) air fuel ratio so that to get maximum combustion efficiency, the fluidised bed furnaces are known for generating maximum combustion efficiency in principal more than 80 %, thus plant should target to achieve the same initially manual adjustment through frequency adjustment and monitoring oxygen percentage in flue gases and then putting the drives in auto with online O_2 sensor in exhaust and feedback to supply air, although caution need to be considered with setting of minimum air requirement for bed generation within furnace, if the required bed height is not achieved after reduction in air supply and there is still less combustion efficiency achieved, then the design of furnace need to be modified accordingly.
Benefits	
Environmental	• Reduction in the coal consumption by **5076 Tons per Annum** • Reduction in the emission of green house gases and air pollution
Economical	Investment: **Rs. 75,00,000/-** (For 3 furnaces) Savings: **Rs. 2,38,00,000/-** per annum Payback period: **4 months**

Intervening Technique	Optimisation of Combustion Efficiency at Kilns and Dryers

Implementing the technology

Flue gas exhaust at the kilns & dryers was monitored. The flue gas analysis for the kilns & dryers were carried out at the exhaust of individual furnaces, the measured parameters are shown in tables below:

Table: Flue Gas Monitoring Parameters at Modena Kiln

Parameter	Unit	Initial	Reduced Combustion Air
Net Temperature	^{0}C	168	160
O_2	%	15	12.7
CO	ppm	107	120
Combustion Efficiency	%	71.6	76.6
CO_2	%	3.5	4.7
Flue Gas Temperature	^{0}C	198	194
Ambient Temperature	^{0}C	30.2	33.8
Excess Air	%	231	164
Pressure	mbar	0.08	0.40

Table: Flue Gas Monitoring Parameters at Modena 5 Layer Dryer

Parameter	**Unit**	**Initial**	**Reduced Combustion Air**
Net Temperature	^{0}C	88	88
O_2	%	19.9	19.7
CO	ppm	22	24
Combustion Efficiency	%	37.9	44.7
CO_2	%	0.6	0.7
Flue Gas Temperature	^{0}C	119	120
Ambient Temperature	^{0}C	30.7	31
Excess Air	%	1990	1642
Pressure	mbar	0.04	0.05

Table: Flue Gas Monitoring Parameters at FTP Kiln No. 2

Parameter	Unit	Initial	Reduced Combustion Air
Net Temperature	^{0}C	226	204
O_2	%	17.2	14.5
CO	ppm	79	180
Combustion Efficiency	%	50.2	68.2
CO_2	%	2.0	3.6
Flue Gas Temperature	^{0}C	255	237
Ambient Temperature	^{0}C	29.5	33
Excess Air	%	480.5	221.5
Pressure	mbar	0.07	0.37

Table: Flue Gas Monitoring Parameters at DFF Plant Biscuit Kiln

Parameter	Unit	Initial	Dilution Blower Off
Net Temperature	^{0}C	246	260
O_2	%	17.1	16.7
CO	ppm	29	32
Combustion Efficiency	%	46.7	49.5
CO_2	%	2.1	2.4
Flue Gas Temperature	^{0}C	279	274
Ambient Temperature	^{0}C	32.6	32.6
Excess Air	%	464.8	397.6
Pressure	mbar	0.29	0.28

Table: Flue Gas Monitoring Parameters at DFF Plant Glost Kiln

Parameter	Unit	Initial
Net Temperature	^{0}C	150
O_2	%	15.3
CO	ppm	86

Combustion Efficiency	%	72.3
CO_2	%	3.2
Flue Gas Temperature	^{0}C	181
Ambient Temperature	^{0}C	82.4
Excess Air	%	273.2
Pressure	mbar	0.22

Table: Flue Gas Monitoring Parameters at Horizontal Dryer

Parameter	**Unit**	**Initial**
Net Temperature	^{0}C	144
O_2	%	19.2
CO	ppm	1
Combustion Efficiency	%	38.4
CO_2	%	1.0
Flue Gas Temperature	^{0}C	177
Ambient Temperature	^{0}C	33.1
Excess Air	%	1061
Pressure	mbar	0.29

Table: Flue Gas Monitoring Parameters at Vertical Dryer

Parameter	**Unit**	**Initial**
Net Temperature	^{0}C	127
O_2	%	17.9
CO	ppm	37
Combustion Efficiency	%	62.7
CO_2	%	1.7
Flue Gas Temperature	^{0}C	161
Ambient Temperature	^{0}C	34.3
Excess Air	%	620.6
Pressure	mbar	0.06

Combustion Efficiency Indicator:

	1. As a rule, the most efficient and cost-effective use of fuel takes place when CO_2 concentration in the exhaust is maximised. Theoretically, this occurs when there is just enough O_2 in the supply air to react with all the carbon in the fuel. 2. The absence of any O_2 in the flue gas directly indicates deficient combustion air while presence indicates excess air. Ideally, the O_2 level shall be maintained 2 % to 6 %, CO_2 level shall be maintained 8 % to 11 %, CO level shall be maintained 80 ppm - 100 ppm and excess air shall be maintained 5 % to 7 % (high pressure burner) for gas. 3. Carbon monoxide (CO) is a sensitive indicator of incomplete combustion, its levels should range from 0 to 400 ppm by volume. The presence of a large amount of CO in flue gas is a certain indicator of deficient air. The same can be maintained by regular monitoring of flue gas sample with the help of a portable flue gas analyzer or by installing O_2 sensor at the furnace exhaust for flue gases and a modulating motorized damper or RPM of combustion air blower through VFD for combustion air control. The sensor will provide constant feedback of O_2% to the damper / VFD which will in turn regulate the flow of combustion air to maintain the combustion efficiency at optimum level of 80 - 90% (Achievable combustion efficiency). It is suggested to control the combustion air through reducing the RPM of combustion air blower by 1-2 Hertz at a time by monitoring required temperature within kiln and set the appropriate frequency and monitoring the required O_2 percentage in flue gas to optimize the air fuel ratio and thus combustion efficiency at the kiln. Excessive draft allows increased volume of air into the furnace. The large amount of flue gas moves quickly through the furnace, allowing less time for heat transfer to the material side. The result is that the exit temperature decreases with increase in heat quantity along with larger volume of flue gas leaving the stack contributes to higher heat loss.
Benefits	

Environmental	• Reduction in the gas consumption by **500 SCM** per day • Reduction in the emission of green house gases and air pollution
Economical	Investment: **NIL** Savings: **Rs. 53,50,000/-** per annum Payback period: **Immediate**

Intervening Technique	Avoid Compressed air usage for cleaning purposes
Implementing the technology	▪ During the visit it was observed that compressed air is used for cleaning purposes at some workstations to clean the components with open hose of 5 mm diameter and at 6 kg/cm²g pressure. ▪ Usually, cleaning can be done at lower pressure (around 2-3 kg/cm²g). So, the first step would be to reduce the pressure and energy saving would be around 8% at drop of each bar for that hose if generated separately. From our past experience the company can save Rs. 21,000 per year (from one workplace) by installing compressed air saving gun.  ▪ The compressed air is a costly utility and the less critical purposes like cleaning can be achieved by installing air saver nozzles at the tip of these cleaning devices or shall be replaced with new one. The special design of these improved cleaning nozzles allows ambient air to get entrained in the path due to vacuum created by compressed air and delivers the air with similar velocity and thrust giving to desired cleaning effect. However, the amount of compressed air uses is only 20-25%

	which reduces the compressed air requirement and thus resulting in energy savings. In addition, these nozzles also reduce the noise level.
Benefits	
Environmental	• Reduction in leakage of compressed air, hence reduction in electricity to generate the compressed air • Reduction in Noise Pollution in surrounding area, thereby making the site area comfortable to work
Economical	Investment: (3000 * 5 sites): **Rs. 15,000/-** Savings: **Rs. 1,05,000/-** per annum Payback period: **4 Months**

Intervening Technique	Reusing of 100% of sludge generated from Effluent Treatment Plant during process in tile body preparation.
Implementing the technology	Before: • The effluent generated in the plant was sent for treatment in the Effluent Treatment Plant and the sludge generated after the treatment was sent for disposal in TSDF. The sludge did not have much impurity, but the recyclable value of the sludge was not being considered.  After: • The sludge generated after the treatment in ETP is stored open to environment for evaporation, and after drying, the sludge is reused in the manufacture of tile body as a raw material along with the fresh raw material.

- After taking this step, industry is now mixing the sludge formed from the ETP in small quantum to mix it with the raw material formation in the slip preparation stage.

- The wall and floor tiles are completely natural products with only physical operations involved in the manufacturing; hence the addition of small quantum of ETP sludge in the slip preparation for the tile body along with the virgin raw material does not alter the quality of the tile body.

- The sludge is wet grinded in the ball mill along with the raw materials.

Benefits		
Environmental	Before: • The sludge of ETP was sent to the TSDF for disposal, increasing the load of solid waste in the environment. • The major part of the sludge contained the waste glaze, containing chemicals used for glaze preparation, harmful for the environment as well as human health • Total sludge disposal was **32.14 tons/month**	After: • As the sludge is being recycled in the process, the load of solid waste disposal on the environment decreased considerably • Also leading to decreased health harms to the associated people

Economical	Before: - Considerable amount of the economy was lost in the sludge, as it contained processed raw material. - Company had to pay fees for the disposal to the TSDF After: - Recycling of sludge leaded to decrease in the raw material consumption - Company had to pay Zero amount for the disposal of sludge

<table>
<tr><td>Intervening Technology / Technique</td><td colspan="2">Zero discharge of treated effluent, as 100% treated water is reused in process in wet grinding.</td></tr>
<tr><td>Implementing the technology</td><td colspan="2">Before:
- The effluent generated in the plant was sent for treatment in the Effluent Treatment Plant and the waste water generated was not recycled/reused anywhere.
After:
- The waste water after the primary treatment of the effluent is pumped back into the plant for utilizing in the slip preparation (wet grinding) operation.

Flow diagram of the Zero Discharge waste water recycle plant (ETP)</td></tr>
<tr><td>Benefits</td><td colspan="2"></td></tr>
<tr><td>Environmental</td><td>Before:</td><td>After:</td></tr>
</table>

	• High consumption of fresh water • Waste of water in the disposal of the effluent	• Conservation of fresh water by recycling of waste water back into the process, hence saving the same amount of fresh water • Zero discharge of liquid from the industry
Economical	Industry had to buy more amount of water from the GIDC water supply system.	Reduced amount of purchase for fresh water due to recycling **134.13 KL/Day** of waste water.

Intervening Technology / Technique	Recovery of heat from waste gas and utilization for pre-drying of biscuit tiles body
Implementing the technology	Before: • Hot gases are generated in the firing stage in kilns. Earlier the heat of the flue gases was lost to the environment as the gases escaped via chimneys, leading to considerable wastage of energy and fuel. • Also, the ambient temperature in the flue gases emission area was higher. After: • The industry developed a heat recovery system by installing indirect fan exhausts from its kilns and diverted the flue gases generated towards the pre-drying zone before the kiln. • After installing the above mentioned equipments, it was possible to maintain about 125° C temperature in pre-dryer
Benefits	
Environmental	• Reduction in the emission of flue gases to the environment, leading to decrease in the load of air pollution • Reduction in the fuel consumption • Decrease in the ambient temperature, leading to better work environment for the workers.

Intervening Technology / Technique	Modification in the dust feeding system in press machine to decrease the loss of material in the form of dusting
Implementing the technology	Before: • The press machine in the industry are hydraulic type press machines, which feed the dust inside the press chamber with a very high pressure, followed by the pressing of hammer on the dust with an approximate pressure of 200 bars. • Due to such drastic conditions, the dust inside the pressing chamber came out from the void spaces in the machine with a high velocity, leading to the loss of valuable processed material as well as forming air borne particles aiding to the air pollution and health hazards to the working personnel in the plant. After: • Industry modified the dust feeding system, changing the set limit of the movement of the filler plates according to the requirement of size of tiles to be pressed. • A plate was installed inside the moving area of the feeding platform, which covered the maximum void space to avoid excess dust losses. However, there is still a scope of preventing the dust spreading form the press. • With that, all the possible compressed sir leakages are arrested and ceased. 

	
Benefits	
Environmental	• The direct benefit to the environment is reduction in the air pollution formed by the air borne dust particles. • Reduction in the health hazard to the working personnel in the plant
Economical	• Direct saving of the processed raw material, which was lost before implementation of Cleaner Production.
	Total investment: Rs. 1,00,000/- Savings: Rs. 51,12,000/- (Annually) Payback Period: 7 days

Intervening Technology / Technique	Installation of roller machine for direct reuse of granules, first of its kind in ceramic industries of India
Implementing the technology	Before: • In the dust storage silos, bigger size lumps were formed due to moisture and humidity in the surrounding area. • Those big lumps remained on the vibro-screen before the press application and were sent to the scrap blunging tank for recycling. It was a considerable loss of raw material dust. After: • The industry designed and installed an in-house online roller machine for direct reuse of higher size granule lumps. It is first of its kind in the ceramic industries in India.

Benefits	
Environmental	• Reduction in the consumption of energy to recycle the large sized particles in the blunging tank and pass through all the operations again in the process.
Economical	• Elimination of loss of dust from vibro-screen to the press dust conveyor

Intervening Technology / Technique	Reuse of used low cost rubber tyre for sealing the lid of wet grinding ball mill, to prevent the spillage.
Implementing the technology	Before: • There was a spillage of wet raw material from the ball mill in the slip house area during the wet grinding operation. After: • The leakage was sealed by using a low cost used rubber tyre, preventing the spillage of wet slurry.
Benefits	
	• Savings of considerable amount of raw material and water

Intervening Technology / Technique	Modification in raw material composition for reduction in overall manufacturing cost
Implementing the technology	Before: • The industry used 7 types of clays with a fixed composition for making the body of the tiles. After: • The composition was modified, now using only 4 types of clays, and the changed composition could save a considerable amount of the raw material per ton of the product formed.
Benefits	

Environmental	• Reduction in the raw material consumption: 11.3 Kg/ton of product
Economical	• Reduction in the overall cost of product: Rs. 69.12 Lacs/annum

Intervening Technology / Technique	Reuse of glaze scrubbed from the sides of wall tiles to use in preparation of engobe in floor tiles.
Implementing the technology	Before: • The engobe and glaze application in the plant is an inverted bell type application, as shown here.  • During the application, the glaze and the engobe is applied on the side wall of the tile body, which was a waste of the valuable process material. After: • Side wall glaze scrappers were installed in the conveyor line to scrap off the extra glaze material from the sides of tiles body • Reuse of the glaze scrubbed from the sides of floor tiles to use in preparation of body of floor tiles plant. • Reuse of glaze scrubbed from the sides of wall tiles to use in

	preparation of engobe in floor tiles plant.
Benefits	
Environmental	• The reuse of the scrubbed glaze material led to the savings of processed raw material, along with reduction in the energy and material consumption for preparing new material.
Economical	Saving of material: • 48.72 ton/annum (wall tiles plant) and • 29.94 ton/annum (floor tile plant)
	Total investment: Rs. 1,00,000/- Savings: Rs. 14,14,000/- Per Annum Payback: 26 days

Intervening Technology / Technique	Minute bad printed green biscuits sent for firing in kiln and sold as second and third quality tiles.
Implementing the technology	Before: • Green Glazed Pitchers were sent to scrape recycling, but it was realized that recycling, being an environment friendly activity, also costs a lot, six times higher than input raw material. After: • Very minute bad printing tiles sent for firing and sold under second and third grade quality tiles.
Benefits	
Environmental	• Reduction in the energy to recycle the broken pitchers to form slurry
Economical	Total investment: Negligible Savings: Rs: 25,00,000/- Per annum Payback Period: Immediate

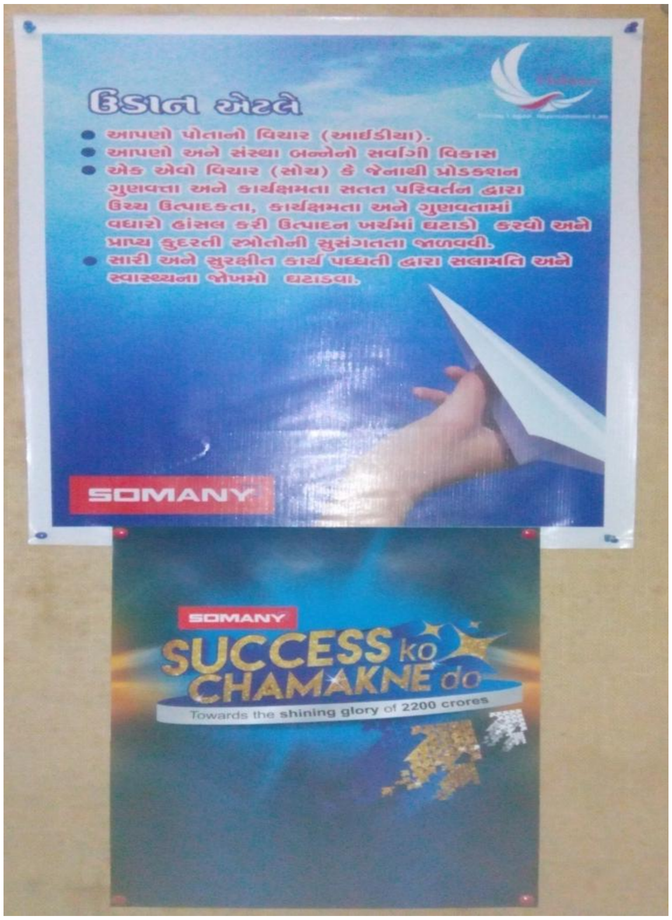
Other activities initiated by the industry towards Cleaner Production

Intervening Technique	'Udaan' – A Continuous improvement programme
Description	The industry has started a Continuous Improvement drive, called 'Udaan', under which the industry invites suggestions for improvement from all the company staff, including grass root level personnel, for the scope of improvement in each and every part of the plant operations

and functions.

Many of the staff members from workers to top level officers have suggested many improvements in the process and the industry has welcomed them all and implemented the suggestions as soon as possible.

With that, the company has awarded cash prizes also to those suggestions which considerably saved a good amount of revenue and the environment.



Intervening Technique	Continuous monitoring and control of quality of defected pieces
Description	Defected tiles at kiln exit were collected in closed boxes earlier and were sent to ware house as second quality and third quality products, now they are collected on pallets for defect analysis to reduce glost pitcher loss monitoring and control.

Intervening Technique	Installation of ‘Robotic’ carrier vehicle ‘LGV’ (Laser Guided Vehicle) for transporting green glost tiles from assembly line to the kiln
Description	The industry installed ‘LGV’ (Laser Guided Vehicle) to transport the green glost tiles from the assembly line to load into kiln. This vehicle automatically loads the glost tiles from the assembly line, by the guideline of sensors, and transports the stack through the pre-decided guided path. This technology decreased the glost pitchers loss during loading transportation, and unloading, especially due to human errors. This also led to saving of manpower, time and quality of work.

Intervening Technique	Savings the loss of heat in off time by increasing the storage capacity of processed material storage
Description	**Before:** A few times, when plant is not running, the heat generating equipments (Furnace and spray dryers) are switched off, leading to the loss of generated heat during working time. **After:** Increased the number of dust storage silos so as to run the spray dryers continuously with FBC, to avoid fuel and energy loss during repetitive starts.

Intervening Technique	Raw water wastage in domestic area was taken under control by half closing the main valve.
Description	Before: The industry has a residential area to accommodate the staff members. The water for the domestic use in the industry as well as the residential colony is supplied from the main input of water to the industry. The controlling valve for the domestic was fully open before, so as to get maximum flow rate. It was observed that knowingly or unknowingly, water was wasted in a huge amount.

	After: The industry implemented a habit to open only half of the valve to initiate the water supply for domestic use.

Intervening Technique	Other various options having direct or indirect benefit to the environment
Description	• Installation of Cyclones and wet scrubber units to control the fine dust escape from spray dryers • Pulse jet dust collector units are installed for collecting the flying dust near pressing, dry sizing and chamfering area • Installation of hydro filter units to collect flying dry glaze particles during applications • Installation of energy and fuel consumption meters on every equipment • Setting up and optimization of machine for speed and control to reduce the bad printing defects, leading to reduction in green glazed pitchers loss • Installation of stack at height according to pollution control norms guided by Central Pollution Control Board for Kilns, Spray dryers and D. G. Set • Waste plastic containers and used oil are sold to registered re-processors and recyclers • Preparation of loss on ignition report and finished product weight per box report on monthly basis, for calculation of actual amount of loss

Waste Stream	Moisture Control of Coal

Description

Before:

The moisture limit of the coal used for firing is 25%; however, most of the time, the coal has a moisture of more than 35%. There was no facility for preheating of coal. The coal storage area is open to environment which leads to increase in the moisture especially in winter and monsoon seasons.

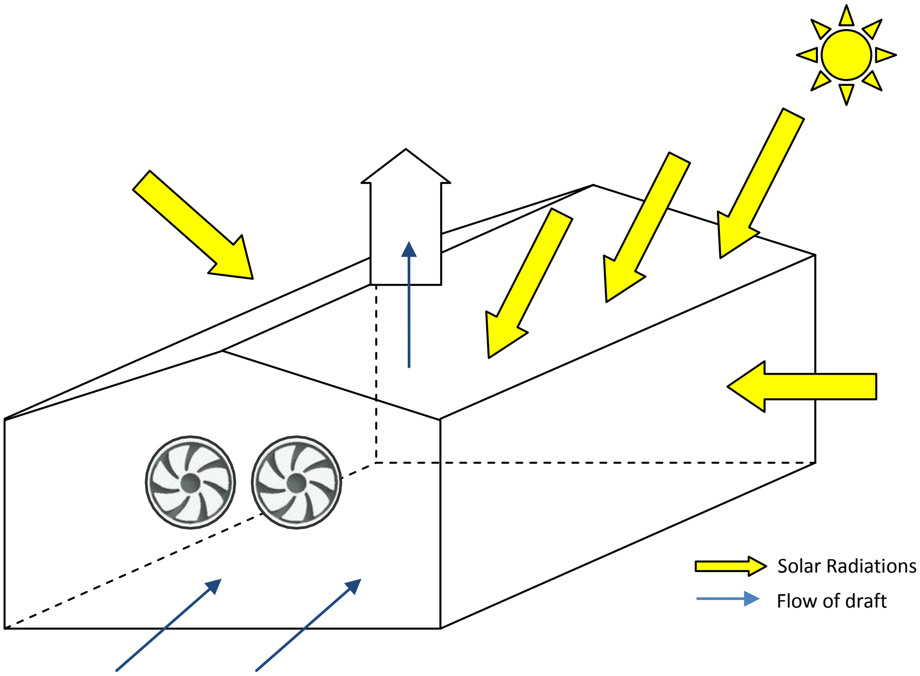
Also the loss due to wind flow is significant. There was a huge hole in the back side wall of the yard, leading to the loss of coal by wind, also generating air borne particles, polluting the air.

After:

- The most appropriate suggestible option for natural drying is 'Solar Drying'
- The average incidence of solar radiations on earth on an average sunny day in subtropical areas like India is around 800 – 1000 W/M^2(especially in regions like Gujarat, which falls on 'Tropic of Cancer'
- The energy obtained from the Sun in form of radiations can be utilized for drying purpose.

- The space dedicated for coal storage can be modified in the form of Solar Drying area by simply using easily available and low cost materials.

- As depicted in the following graphics, with the help of metallic supports, strong plastic sheets can be arranged in the form of roofs and sides of the area, in which the coal can be stored.



- The arrangement contains, as shown in the graphics, a toughened plastic sheet arranged on roofs and sides with metallic supports, with fans arranged at the inlet side of the drying area. An exhaust chimney is provided for creating a suction draft inside the drying area.

- The drying principle is based on four factors:

1. **Temperature:** It is directly proportional with the rate of drying. More the temperature of drying area, rapid will be the drying. Here, sufficient temperature will be available due to the combined effect created by the plastic sheets and solar radiations.

2. **Air draft velocity:** It is also directly proportional with the rate

of drying. More the velocity of wind/drying air, faster will be the drying. In this case, it will be provided using small fans from inlet side of drying area.

3. **Moisture:** It is inversely proportional with the rate of drying. In this case, we have to decrease the moisture from 25% to 18%.

4. **Surface area:** More the surface area of contact between the object and the air, faster will be the drying. This can be achieved by spreading the coals on the ground and not stacking one on the other. However, lack of more space available is a constraint in this situation, which reduces the scope of utilizing this advantage.

The working of this operation can be explained as below.

- The coals can be arranged in the drying chamber, utilizing maximum surface area available.
- The plastic sheets create Greenhouse Effect inside the drying chamber, which absorbs solar radiations inside the chamber but allows only partial radiations to reflect out in atmosphere, hence increasing the temperature inside the chamber.
- The increased temperature heats up the inside air, which is naturally drafted upwards. The fans regulate the draft direction and velocity. The hot air has more absorption capacity than the cold air; hence it absorbs the moisture of coal and moves outside the chamber through the small chimney provided at the top, creating a suction pressure inside to draw the hot air. This continues the process ahead.

- The objective of the dryer is to supply the coal with more heat than is available under ambient conditions, thereby increasing sufficiently the vapour pressure of the moisture held within the coal and decreasing significantly the relative humidity of drying air and thereby increasing its moisture carrying capacity and ensuring sufficiently low equilibrium moisture content.

	 
Benefit (Environmental)	• The drying would be made very faster and efficient • Removal of moisture in totally natural way, decreasing the moisture by 15%. • Coal would dry to less than 20% moisture within 4 hours • In winter and monsoon season also, much efficient drying can be obtained • Decreased moisture will generate less water vapour during combustion, thereby reducing emission to air • Complete combustion would be obtained, reducing emission of carbon monoxide.
Benefit (Economic)	• Combustion efficiency would increase to almost 10%, thereby reducing the coal consumption by 5% approx. • Investment: Rs. 1,00,000/- approx. • Savings of coal: 1060 MT / Year • Savings of finance: Rs. 47,70,000/- per year • Payback Period: Less than 1 month

SONYA CERAMICS, KADI

Introduction

Since 1960, Sonya has been a progressive leader in the ceramic industry earning a reputation for quality, service & dependability. Sonya group employs more than 400 long term experienced people at two different sites i.e. at Kadi& Ahmedabad.

Sonya manufactures L.T. Insulators & Technical Ceramics, which are related to Electrical Industries & Heater Industries, whereas their other products are Wall, Roof & Paving Tiles, which are used in niche market & by high end builders. The ceramics are made from Normal Porcelain, Steatite, Cordierite, Cordierite Porcelain, High Alumina Refractory, Cordierite Refractory, Cordio-Sillimanite, Hard Porcelain and Alumina Ceramics. The industry also makes ceramic products as per the design/drawing of the customer.

Cleaner Production Assessment Team

The team for conducting Cleaner Production Assessment includes the following members.

Name	Designation
Dr. Bharat Jain	Member Secretary, GCPC
Mr. Punamchandra Rathod	Senior Project Engineer, GCPC
Mr. Paras Gojiya	Assistant Project Engineer, GCPC
Mr. Abhi Patel	Assistant Project Engineer, GCPC
Mr. K. D. Sanghavi	Technical Expert, GCPC
Mr. Rupeshbhai Shah	MD, Sonya Ceramics, Kadi
Mr. Urmish Patel	Manager, Sonya Ceramics, Kadi Plant
Mr. Hemant Gajjar	QC/QA Dept, Sonya Ceramics, Kadi Plant

Manufacturing Process

1. Raw Material Storage

Different types of clays are transported to the plant via trucks and unloaded manually to store in the storage yard with separate compartments for each type of clay.

2. Slip Preparation

The slurry is formed by mixing various types of raw materials in a fixed composition manually in the ball mill. A batch of ball mill contains equal proportion each of (800 Kg) raw material, water and river bed stone pebbles. (Total: 2400 Kg). The ball mill grinds the raw material for more than 8 hours to form slurry, which is passed through a 40 mesh size sieve, so as to reject the oversized particles.

3. Filtration

The slurry after passing the sieve is stored in three slurry storage tanks, to which three press and frame filters are connected. More 2 filters are there on standby basis. The press filters intake the slurry with high pressure and give the wet cakes of the material. The large size press filters can give out 24 cakes in a batch while the smaller size press filters can give out 18 cakes in a batch. The output moisture of wet cakes is 22 – 24% approximately.

4. Wet cake drying

The wet cakes are put on a trolley manually and are stacked on the ground for environmental drying. After some time, when the cakes become dry such that they can be handled easily, they are cut into slices and are again spread on the ground for more drying. A fan is installed to throw air on the wet pieces.

5. Pulverizing and granulating

The sliced pieces of cakes, when the moisture reaches less than 18 – 20%, are grinded in a pulverizing machine to form wet granules, collected in a chamber below. It is necessary to form fixed size granules of the material before sending it to mould, hence a manually operated self designed vibro-screening machine is installed, which forms the required sized granules, sent for press moulding.

6. Press Moulding

There are manually operated press mould machines for casting the shape out of the material. Operators fill in the material into the dye of the press using their hands, followed by pressing the mechanical handle to cast out the shape. The casted moulds are sent of natural drying.

7. Drying

The casted moulds are stacked on a wooden board and are put on a rack for natural drying. Some stacks are also put on and near the kiln wall, so as to fasten the drying process due to the ambient hot air. After a considerable removal of moisture, the moulds are sent for finishing operation.

8. Finishing

The workers of the plant finish the sides of the dried moulds by removing off the extra material from the edges of the moulds. The industry claims that the material removed from the moulds are recycled back into the raw material formation operation.

9. Glazing

The finished moulds are subjected to the glazing operation. The glaze is sprayed on the moulds using a spray gun, which leads to a considerable amount of waste of glaze, also an irregular spray of glaze leads to further losses of the product.

10. Firing

The glazed products are arranged on the kiln cars. There are many errors by the workers while arranging the moulds on the kiln cars, leading to further losses. The moulds are arranged in 3, 4 or 5 lines vertically, depending upon the size of the moulds loaded. The workers do not load much pieces at the bottom most line, as no proper firing is done in the lower parts of the car.

The loaded cars are sent in the tunnel kiln for firing in the cycle of 40 minutes. The maximum temperature range is upto 1160°C, with a total time inside kiln being 18 hours for an average kiln. There is no temperature and cycle time change for different products.

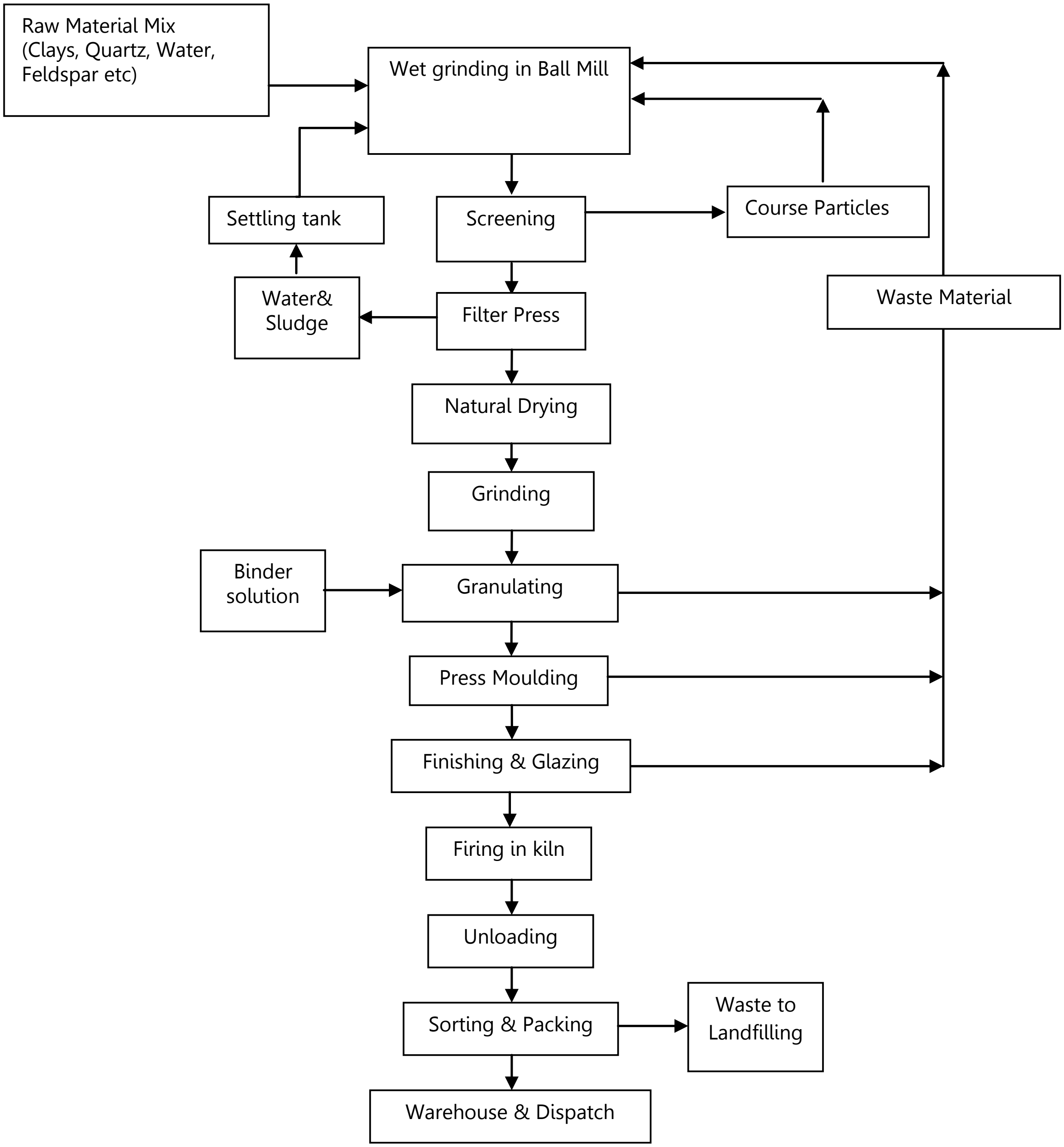
11. Sorting

The final products coming out of the kiln are very hot to handle, and are subjected to cooling using ceiling fans, followed by sorting. The QA/QC department checks and verifies the size and shape with the standards and separates the acceptable and rejected products.

12. Packing and dispatching

The acceptable quality products are packed in grass packing and then plastic bags and transported to the market via trucks.

Manufacturing Process Flow Diagram of L. T. Porcelain Insulators



Sources of waste generation

Sr. No.	Waste	Source	Remarks
1	Raw material	During transportation and Unloading from trucks	Generation of air borne particles
2	Raw material	At storage area, carrying away of material with wind	Generation of air borne particles
3	Raw material	Loading the material into ball mills	Generation of air borne particles
4	Processed material	Spillage of slip in the collection pit and deposition of material after drying	Material wastage, also chocking of flow through nick
5	Water	Filtrate of press and frame filter	Recycled into the process
6	Water	Moisture loss in form of Evaporation in drying	Lost to the atmosphere
7	Processed raw material	Spillage of granules formed from the granulator, mixing with impurities	Sent for scrap recycling in ball mill
8	Processed material	Material wastage at press mould, falling on ground	Sent for scrap recycling in ball mill
9	Moulded pieces	Broken pieces from toggle & press moulding machine	Sent for scrap recycling in ball mill
10	Glaze Material	Wastage of material at glaze spraying application on the moulded pieces	Major source of airborne particles in the plant
11	Moulded pieces	Rejected pieces in Quality checking before loading on the kiln car	Sent for scrap recycling in ball mill
12	Compressed Air	Air spray on moulded pieces to remove dust from surface	Generation of airborne particles
13	Final Product	Rejected piece in quality checking after firing	Sent to the cement industry for recycle
14	Water	Loss of moisture due to evaporation	Lost to the atmosphere

Waste Stream Observation and Probable Solutions:

Observation	Loss of Precious Raw Material at Storage Yard
Before CP	• The industry receives the different types of clays and powdered material in loose, transported by trucks. Material is carried away along with the wind during transportation. Also, the moisture and quality control of received material is a liability to the industry. • The unloading of material is a manual operation, leading to generation of air borne particles of the material, aiding to the air pollution. • The material received in bags is also stored in open and bulk, allowing wind to carry away a mass quantity of material with it. • The Raw material storage yard is open to the wind. The material is lost in the form of air borne particles. Also, the material fallen on the ground mixes with the impurities, leaving no scope to recollect and reuse in the process. • Quantity of such loss is unaccountable. • Damage to the material in Monsoon season will be dramatically high.
Suggestions for implementing CP	• The raw material can be purchased in packed bags, which adds negligible cost to the purchase department. • Transportation of material can be done by covering the truck from all sides. • Storage yard can be improved in terms of design and construction. The yard should be covered fully with walls from all sides and top, with a door (preferably sliding) for unloading and loading of material. • Material should be stored in bags itself. • The door must be opened at the time of application only. • The flooring should be done using cement concrete, preferably with cement plaster. • A typical storage unit is shown here (for symbolic reference only)

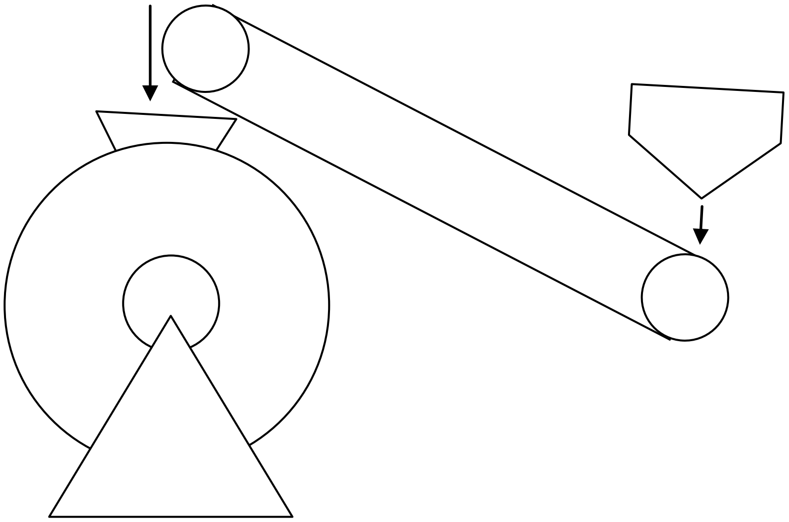
	   
After CP	• No loss of material during transportation • The quality and moisture will be reliable when the material will be purchased in packed bags • No loss of material during unloading and loading operations • No loss of material in the Monsoon season
Benefit	Benefit of implementing these options is both economic and environmental. The loss of precious raw material would come to the halt, leading to savings in purchase cost. Also, the reduction in the airborne particles will decrease the air pollution to an appreciable level.

Observation	Spillage of material and risk to men while loading material into the ball mill
Before CP	• The weighed quantity of material is filled in the ball mill by directly dumping the material into the lid hole. • While loading, the material is spilled on the ground and in air due to poor handling of workers, leading to loss of material and generation of airborne particles. • The worker has to climb over the ball mill and dump the material into it, which is an accident prone operation.

Suggestions for implementing CP

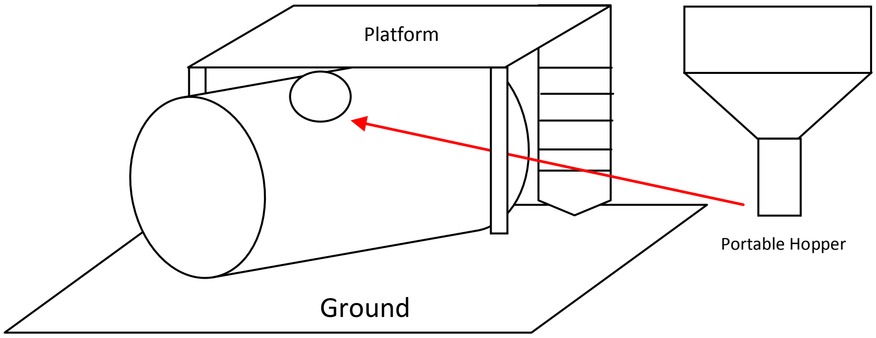
Option A:

- The whole raw material handling system could be made automatically or semi-automatically operated.
- A conveyor system can be designed to feed the raw material directly into the ball mill. The required quantity to be fed and the batch time schedule can be programmed accordingly.
- The conveyor belt's beginning part could be in the storage area, where automatically or manually required material can be loaded on the conveyor belts and at the second end the material is unloaded directly into the ball mill.
- The whole transmission path could be covered from top and sides so as to prevent the loss of material in transmission due to carriers like wind.



Option B:

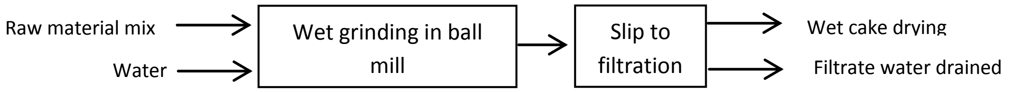
- A platform can be built near all ball mills, so that the worker can easily climb over the platform to load the material.

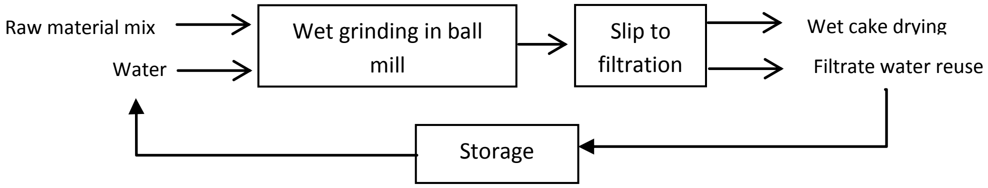


	• One advanced option could be installation of an electrical lift also, which may lift the material to the level of platform. • A portable hopper should be used while dumping the material inside the ball mill
After CP	• Complete reduction in the spillage of material, hence reduction in generation of airborne particles in both of the cases. • Reduction in the man-power needed for the operation in the first case. • Comfortable handling of material and safe operability for the workers in the second case.
Benefit	The benefit of implementing above options will be directly to the reduction in the air pollution in the surrounding area. Also, the reduced loss of material will lead to reduced expenses of revenue. The most important part is the reduced chances of accidents or near miss occurrences.

Clean Technology Option	It is recommended to purchase a 'Digital Moisture Meter' which readily measures the moisture and pH, may cost around Rs. 8,000 – 10,000 (one time investment) to regularly measure the moisture of incoming raw material. The direct benefit of the equipment is to check the quality of clay on spot at the time of receiving, and ensuring the best quality of the material before proceeding for further grinding operation. A symbolic reference of the device is given.  

Observation	Spillage and deposition of slurry while unloading from ball mill after wet grinding
Before CP	• After wet grinding, the slip so formed is unloaded from the ball mill using a suction valve, from where the slip is drained on the collection pit. From the pit, small channels are built which transfer the slip to the storage tank with the help of gravity. • In doing so, the viscous slurry is spilled around and deposited on the walls of pit in the form of scale after drying. • The deposited quantity is a loss of processed material and imparts poor housekeeping to the plant. • The dried scale creates problem of chocking of channels, which adds to the spillage of material. • Also, the open transportation of the slurry aids to the addition of surrounding impurities to it.
Suggestions for implementing CP	• A pipe can be used while unloading the slip from ball mill. It may be connected to the valve used for unloading, and the outlet can be given to the storage tank.
After CP	• Complete reduction on spillage and deposition of slip • No need of flow channels, hence complete reduction in chocking issues • No addition of impurities in closed transportation
Benefit	The economic benefit of implementing the option is savings in the loss of material, its quality and improving the housekeeping status of the slip house area

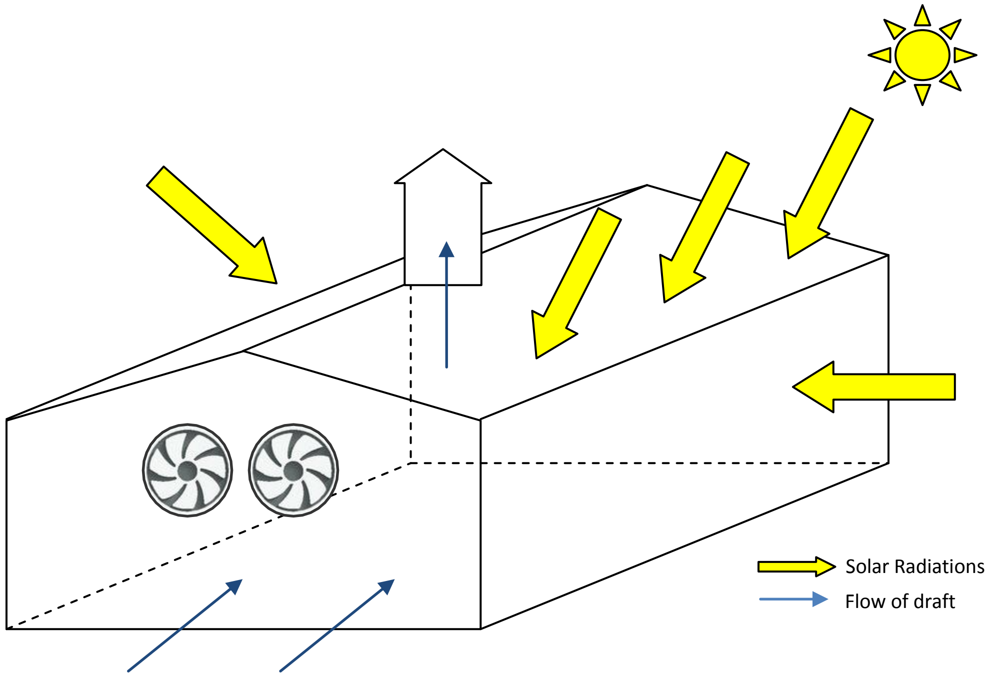
Observation	Reusing 100% of waste water into the process
Before CP	• From the storage tank, the slip is sent to the press and frame filter for wet cake formation. • The water removed from the slip in form of filtrate was drained out from the plant earlier, which was a major loss of water from the plant. • Approximate quantity of water wasted: **7.48 KLD** 

Suggestions for implementing CP	• All of the filtrate water can be reused in the process, at the wet grinding stage in ball mill. • The industry has already implemented this option.
After CP	• The plant is a Zero Discharge Plant, all the water is reused in the process. • Reduction in the cost of purchasing water from GIDC 
Benefit	• Savings in the natural resource by reusing 100% water • Approximate reduction in the fresh water demand: **7.48 KLD**

Observation	Inefficient drying of wet cake
Before CP	• The wet cake formed from the press and frame filter are loaded on trolley and stacked on ground for natural drying • However, the drying operation was found inefficient, as the surrounding area is closed from 3 sides and top, allowing very less air to ventilate and minimal solar radiations to fall upon. • Also the wet cake is stacked one on the other, allowing very less area for wind and material contact. • The industry carries out filtering operation in an amount to have a stock of wet cakes for at least 5 days to upto a month sometimes. In those conditions, the available space is fully occupied with the stacked wet cakes. • Many a times, a fan portable is used to blow air for drying cakes, adding to the electricity consumption.
Suggestions for implementing CP	• The most appropriate suggestible option for natural drying is 'Solar Drying' • The average incidence of solar radiations on earth on an average sunny day in subtropical areas like India is around 800 – 1000 W/M^2(especially in regions like Gujarat, which falls on 'Tropic of Cancer' • The energy obtained from the Sun in form of radiations can be

utilized for drying purpose.

- The space dedicated for wet cake drying can be modified in the form of Solar Drying area by simply using easily available and low cost materials.
- As depicted in the following graphics, with the help of metallic supports, strong plastic sheets can be arranged in the form of roofs and sides of the area, in which the wet cakes can be arranged for drying.



- The arrangement contains, as shown in the graphics, a toughened plastic sheet arranged on roofs and sides with metallic supports, with fans arranged at the inlet side of the drying area. An exhaust chimney is provided for creating a suction draft inside the drying area.

The drying principle is based on four factors:

1. **Temperature:** It is directly proportional with the rate of drying. More the temperature of drying area, rapid will be the drying. Here, sufficient temperature will be available due to the combined effect created by the plastic sheets and solar radiations.

2. **Air draft velocity:** It is also directly proportional with the rate of drying. More the velocity of wind/drying air, faster will be the drying.

In this case, it will be provided using small fans from inlet side of drying area.

3. **Moisture:** It is inversely proportional with the rate of drying. In this case, we have to decrease the moisture from 25% to 18%.

4. **Surface area:** More the surface area of contact between the object and the air, faster will be the drying. This can be achieved by spreading the wet cakes on the ground and not stacking one on the other. However, lack of more space available is a constraint in this situation, which reduces the scope of utilizing this advantage.

The working of this operation can be explained as below.

- The wet cakes can be arranged in the drying chamber, utilizing maximum surface area available.
- The plastic sheets create Greenhouse Effect inside the drying chamber, which absorbs solar radiations inside the chamber but allows only partial radiations to reflect out in atmosphere, hence increasing the temperature inside the chamber.
- The increased temperature heats up the inside air, which is naturally drafted upwards. The fans regulate the draft direction and velocity. The hot air has more absorption capacity than the cold air; hence it absorbs the moisture of wet cake and moves outside the chamber through the small chimney provided at the top, creating a suction pressure inside to draw the hot air. This continues the process ahead.

- The objective of the dryer is to supply the wet cake with more heat than is available under ambient conditions, thereby increasing sufficiently the vapour pressure of the moisture held within the wet cake and decreasing significantly the relative humidity of drying air and thereby increasing its moisture carrying capacity and ensuring sufficiently low equilibrium moisture content.

- The difference needed in the moisture, here, is from 25% to 18%, i.e., difference of 7%. So to dry 1 ton wet cake, 70 kg water must be removed. At 40°C temperature, the moisture carrying capacity of air is 49.8 gram/kg of air. So, the time required to reduce the moisture of wet cake will be less than 2 hours. A symbolic reference is shown here.

	 
Benefit After CP	• The drying would be made very faster and efficient • Wet cakes would dry within 2 hours to the required moisture level • In winter and monsoon season also, much efficient drying can be obtained • Indirect benefit will be the increase in the productivity, as due to rapid drying, per day almost double amount of material can be processed.

Observation	Loss of processed raw material due to poor handling at various steps in process
Before CP	• An unaccountable quantity of processed material (which has passed through various operations like – ➢ Transportation to plant (incurring transportation charges) ➢ Wet grinding (incurring electricity charges for ball mill) ➢ Slip storage (incurring electricity charges for stirring) ➢ Filter press (incurring electricity charges for compression) ➢ Disintegration (incurring electricity charges for motor) – is being wasted at various steps during the process due to poor handling practices of the manpower involved. The wastage of the material is observed at following steps. • The pieces of wet cake are spread on the ground of drying and feeding to the disintegrator, where they mix with the impurities. Also, some amount of material is broken down and mixes with the dirt due to human movements on it.

Major Concerns: 1. Loss of processed material(quantity unaccountable)

- The wet cakes are fed to the disintegrator. Its outlet is in the moist powder form. The powdered material directly falls on the ground, mixes with impurities. Workers have to again collect it to send to granulators.

Major Concerns: 1. Loss of processed material (quantity unaccountable)
2. Addition of impurities to material
3. Unnecessary usage of man-power

- The powdered material is fed to the in-house-designed granulator, which converts the powdered material into the granules of required size. Again, the granulated material from the outlet falls directly on the ground; mixes with impurities. Workers have to recollect the material to send for moulding.

Major Concerns: 1. Loss of processed material (quantity unaccountable)
2. Addition of impurities to material
3. Unnecessary usage of man-power

- The granulated material, collected from ground, is sent for 'toggle and press' moulding. The workers present there feed the approximate quantity of granulated material into the dyes of the press machine with their bare hands, which is purely based on their experience. Also, while performing this operation, material falls down from their hands on the ground, again mixes with impurities.

Major Concerns: 1. Uncertainty in the amount of material fed into dye
2. Uneven pressing may lead to improper moulding and may cause dimensional errors, granules and hair cracks in moulded piece
3. Loss of processed material (quantity unaccountable)
4. Addition of impurities to material
5. Risk to health of workers for handling such material with their bare hands

- The moulded pieces are sent to finishing operation, where the workers (majority of them being female) finishes the edges of moulds and remove extra material from edges to make it smooth. Again, the operation is carried out bare handed. The material removed from moulds is let fall down on ground and rarely being

	recollected. **Major Concerns:** 1. Loss of processed material (quantity unaccountable) 2. Addition of impurities to material 3. Risk to health of workers for handling such material with their bare hands • The finished pieces are internally transported by workers by loading on wooden boards with their hands, which invite chances of accidental falling down and breakage of finished pieces. **Major Concerns:** 1. Loss of moulded and finished pieces • All the above mentioned observations represent Poor Housekeeping of the unit. The total amount of material wasted in the green stage in year 2015 (January – December) was approximately 223.6 MT, with an average of 620 Kg per day. • The industry claims that all the waste material at green stage is recycled back to the process by wet grinding. It is a matter of fact that recycling is NOT ALWAYS the suitable option, as the recycling consumes 6 times more energy than regular operations. Also, in continuous recycling operation, a quantum of material never comes out of the recycling cycle and never converts to the final product. • The industry used 344 ball mills to recycle the green stage waste in year 2015 (Jan – Dec), consuming additional electricity of 4626 units (an amount of Rs. 34,700/- approx.), excluding many other factors. • The raw material of ceramic sector is comparatively cheaper, hence attracts very less attention of the associated people as far as material saving is concerned. However, the facts are not like that. The material itself passes through many steps from receiving to finally firing and involves many energy intensive operations and manpower costs. Hence, the material loss (i. e. Poor Housekeeping) should never been taken lightly.
Suggestions for implementing CP	• The best possible suggestion in the scope of this exercise for drying the wet cake is solar drying, which has been already mentioned in the previous part. It indirectly also helps in the saving of material from loss. • However, the second viable option here could be, use of 300 – 500 gauge plastic sheets for laying on the ground and on that the wet cake

can be spread to dry.

- The powdered material from the disintegrator can be directly supplied to the granulator using a semi-cylindrical pipe / channel, so that leaving no scope of waste of material by spilling on ground.

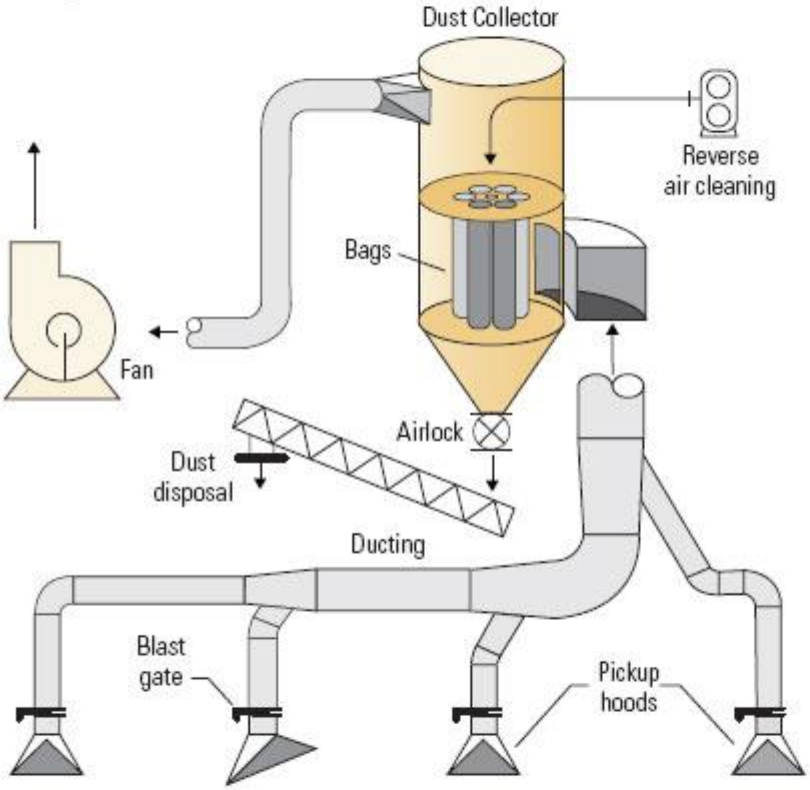
If this option is difficult to implement, another possible option is to collect the powdered material in a mechanical trolley / collection bin and convey it to the inlet of granulator manually, thereby leaving less scope of spillage.

- Same way, there should be also a mechanical trolley / collection bin at the outlet of granulator to collect granules and send for pressing machines.
- It is highly recommended to use mechanical / hydraulic jacks or trolleys to transport moulded and finished pieces loaded on wooden pallets, as it provides smooth and accident free transportation of material internally in the plant area. (Symbolic reference provided here)

	• For the loss of material during pressing in 'toggle and press' machines, it is recommended to install automatic material feeding equipment, which feeds the exactly programmed weighed material, called as **'Load Cell'**, into the pressing machine at a projected site only, thereby reducing spillage of material to the ground. • It is also highly recommended to install automatic press machines. The trend of automatic pressing machine started into the tiles manufacturing machine but it is an old thing for porcelain industries also in the present scenario. Press machines with removable and multi-designed dyes are available in the market. (Symbolic representation is shown here) 
After CP	• Installation of plastic sheets on ground would drastically reduce the loss of material; also it would be easy to recollect the material. Protection from impurities is the additional advantage. • Installation of semi-cylindrical pipe for transportation will reduce the spillage of material to zero. Also, the slope and gravity will do their work, hence requiring no energy to transport the material. Decrease in the man-power dependency will is the additional advantage.

<table>
<tr><td></td><td colspan="2">• Installation and practice of using mechanical / hydraulic trolley has got its own advantages of smooth transportation internally inside the plant premises. The powdered or granulated material is best transported in basket trolley, which reduces the material loss by spillage to zero.
• The moulded pieces must be transported wooden pallets stacked on the hydraulic lifting trolley. It guarantees zero accidental falling and breakage of material. Smooth handling, smooth transportation and reduction in man-power dependency are additional advantages.
• Installation of 'Load Cell' will decrease all possible loss of material by spillage at the pressing area. As fixed quantity of material will be fed to the dye, the uniformity of mould volume will be assured, thereby decreasing the dimension errors and such kind of losses. Decrease in the man-power dependency will is the additional advantage.
• Installation of automatic press machines will drastically reduce all kinds of material loss prior as well as post pressing and moulding during the application. Also, it assures uniform volume of mould, proper and uniform pressing on all sides, and uniform dimensions of the product. It would decrease the rejection of pieces drastically.</td></tr>
<tr><td>Benefit</td><td>Before CP
• Loss of material at every operation (approx. 223.6 MT in year 2015)
• Incurring electricity cost for recycling the waste material (approx. Rs. 34,700/- P. A.)
• Complete dependency on manpower for material handling
• Poor housekeeping</td><td>After CP
• Reduced loss of material (from 80% to 100% - depending upon implementation of options)
• Reduction in recycling costs (both electrical and man-power) amount of money depending on amount of implementation
• Reduced to zero dependency on manpower for material handling
• Good housekeeping</td></tr>
</table>

Observation	Frequent Air Spraying on material, causing to loss of material in form of dust, also leading to increased risks of health hazards to the associated people
Before CP	• In the manufacturing process, after the finishing operation, it is necessary to remove dust and impurities from the moulded pieces, before the glazing application. • The workers have developed a habit of spraying pressurized air on the moulded pieces to remove the dust. This operation generates a huge quantity of air-borne particles in the surrounding, which may critically increase the chances of breathing related diseases in the associated people as the particles go into their respiratory system. • Also, this is again a loss of processed material which has gone through many energy (ultimately economy) intensive steps. The quantity of loss is unaccountable. Also, as the dust particles are heavier than air, they tend to settle down back; hence they will again sit on the nearby products. This will be a never ending process, until the dust from the air is not filtered.
Suggestions for implementing CP	• It is highly recommended to make the workers aware about possible damages of dusting. They must be motivated to use **Personal Protective Equipment** like '**Face Masks'**. • A dust collecting set-up can be built using a suction blower associated with a collection hood at the spot of air-cleaning operation. A schematic representation of dust collection set-up is shown here.

<table>
<tr><td></td><td colspan="2">
</td></tr>
<tr><td>After CP</td><td colspan="2">After the implementation of above mentioned technique –
• All the dust spreading into the atmosphere will be collected back into the collection tank, can be reused into the process by just passing through granulation operation.
• Also, due to reduction of air-borne particles in the surrounding, work-place will become clean and comfortable to work. With that, face mask will prevent the dust particles to go into the breathing system of associated people.</td></tr>
<tr><td>Benefit</td><td>Before CP
• Loss of processed material in form of dust
(Approx. 20 Kg per day)
• Generation of air-borne particles in the surrounding atmosphere, aiding to deterioration in the ambient air quality</td><td>After CP
• Complete reduction in the dust loss of material
(Approx. 600 Kg material per month)
• Compete reduction in air pollution of the surrounding atmosphere
• Reduction in the possible</td></tr>
</table>

	• Intensive chances of breathing related diseases, may cause various lugs diseases to workers	health hazard to the associated people
	Total Investment: From Rs. 10,000/- to 50,000/- (depending upon size of setup) Savings: Rs. 4,000/- per month Payback Period: 3 months to 12 months	

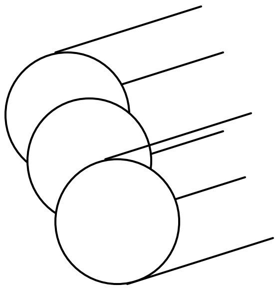
Observation	Waste of Precious Glaze material in form of dusting during glazing application, also aiding to generation of air-borne particles
Before CP	• Glazing is one of the most important parts of any ceramic manufacturing industry. Glaze is an impervious layer or coating of a vitreous substance which has been fused to a ceramic body through firing. Glaze can serve to color, decorate or waterproof an item. • The preparation of glaze is a costlier operation. It includes wet grinding of various heavy minerals, heavy metals and clays for 40 to 55 hours in ball mills, depending upon their composition and concentration. • It was observed during the field visit that the glazing application is carried out using the 'Paint Spray Gun' on the dried moulded piece in a practically open area. In doing so, the glaze material is being wasted in a huge quantity. Approximately 45 – 55% of material is lost in the surrounding area in form of aerosol. Workers are also habituated of using the spraying method and are not ready to change it. Also, the uniformity and thickness of layer sprayed on the material cannot be assured. • Apart from glaze loss, the aerosol is generating air-borne particles in the surrounding atmosphere. The particles are heavier than air, hence tend to settle down on the ground, aiding to air pollution. The glaze material contains many harmful heavy metals and minerals.
Suggestions for implementing CP	**Option – A** • It is recommended to install a semi-automatic glazing machine. • The glazing machine contains a conveyor which carries the subject material through the glazing chamber. In the completely closed chamber, glaze is sprayed from all sides using the atomizer, as per the requirement. The uniformity and precision of the spray is very high,

giving an even thickness of layer on the pieces.

- No particles of glaze could come out of the chamber. Also, the extra glaze remained on the walls of chamber would be collected in a drum and reused at the spot.

- It is very easy to operate the equipment. There will be no requirement of skilled labour.

- The industry has installed the machine but the workers are not interested to use it despite having such huge advantages. The reason could be understood as follows. The diagrammatic representation of the conveyor belt is shown below.

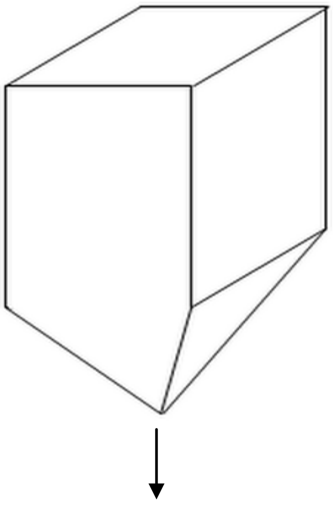


- In the above mentioned graphic, the design of conveyor belt has a scope of improvement. The belt is in the form of narrow strips made up of rubber, with gap between them. The piece is mounted between the gaps and conveyed further. The problem here is that, the pieces with smaller size than the gaps cannot be properly mounted on it. The proposed solution for the same is mentioned in the next column.

Option – B

- It is recommended that if the Spray Gun is the option the industry wishes to continue with, then the wastage of glaze can be minimized by creating an in-house glazing chamber, closed from all sides, having a conical bottom.

- The pieces subject to glazing can be stacked inside and spraying can be carried out by the trained worker only. A graphical representation is shown here.

<table>
<tr><td></td><td>
Extra glaze recovery</td></tr>
<tr><td>After CP</td><td>**Option – A**
• By installation of glazing machine (which has been installed already) and using the machine thoroughly for all type of products, the glaze will be applied uniformly and evenly on each product. The new design of conveyor which would be suitable for all type and size of products is shown here (for symbolic reference only)

• As the glazing application occurs in a completely closed chamber, hence no glaze particles are carried out with air, leading to reduction in air pollution of the surrounding area.</td></tr>
</table>

- Also, the glaze losses will be reduced completely as no glaze will be wasted. The spray application occurs under fully controlled manner and the extra glaze remained on the internal walls of the chamber is reused at the spot, leading to a dramatic savings in glaze material and its manufacturing utilities.

- With that, the productivity per day will also increase dramatically; it will be possible to glaze **11,000 pieces** of products per day.

- With that, one more benefit is that, even unskilled workers can also operate this equipment; hence there will be no requirement of skilled manpower. This will also reduce the losses due to human error.

Option – B

- In case the first option does not seem viable, the second option will be also useful to reduce the glaze material consumption. In the closed chamber, the loss of particles in form of aerosol will reduce completely. The glaze remained on the walls of chamber can be collected at the conical bottom.

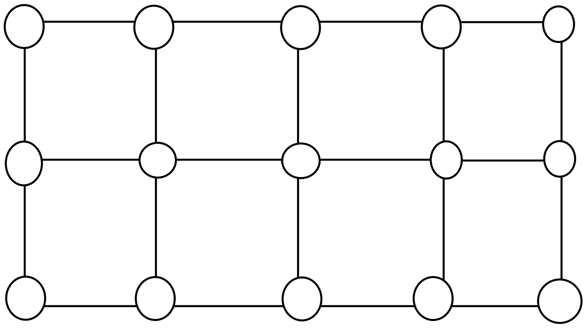
- With that, the reduction in air pollution of surrounding area is the additional advantage, as no particle would go out of the chamber.

- The drawbacks associated with this option are –
  1. Dependency on man power, as the application will be still carried out by the skilled worker only.
  2. The recollected glaze material will have to pass through recycle application (wet grinding) consuming more utilities.

Benefit		
Environmental	Before CP: • **Material and energy waste:** A lot of processed material and energy is wasted in uneven spray • **Air Pollution:** The air borne particles are aiding to the air pollution of the surrounding	After CP: • **Saving of material& energy:** Material remains completely inside the spraying chamber, and complete recycle at spot • **No Pollution:** No particles of glaze flow out of the equipment, hence complete

	area	reduction of air pollution
Economical	• **Glaze manufacturing cost per month:** ✓ Glaze required: Approx. 4000 Kg/month (7 Ball Mills per Month) ✓ Cost of glaze: Rs. 15/Kg approx. ✓ Total Cost = (4000*15) **= Rs. 60,000/- monthly**	• **Glaze manufacturing cost per month:** ✓ Glaze Required: 1800 Kg/month (3 Ball Mills per Month) ✓ Cost of Glaze: Rs. 15/Kg approx. ✓ Total Cost = (1800*15) **= Rs. 27,000/- monthly** ✓ Savings: **Rs. 33,000/month**
	• **Electricity cost** (5 HP Motor * 52 hours * 7 ball mills per month) 1372 units per month Rs. 10,292/- per month	• **Electricity cost** (5 HP Motor * 52 hours * 3 ball mills per month) 588.2 units per month Rs. 4,410/- per month Savings: **Rs. 5,852 per month**
	• **Productivity:** 6,745/day • Skilled worker required • Non-uniform thickness of glaze	• **Productivity:** 10,600 Kg/day • No skilled worker required • Uniform thickness of glaze
	Total investment: **Rs. 6,000/-** (Changing belt of conveyor) Direct Savings: Rs: 36,670 + Rs. 5,852 + Increased productivity **= Rs. 42,522/- P.M.** Payback Period: Less than **1 Month**	

Observation	Requirement of modification in kiln car furniture design and loading pattern to reduce the weight of kiln car (Low Thermal Mass Kiln)
Before CP	• The heavier the material on kiln car more will be the gas consumption of the kiln. Furniture of the car consists of the shelves for loading the moulded pieces, supports to withstand the shelves and refractory bricks platform to withstand the whole assembly. • This kind of arrangement makes the kiln car very heavy, aiding to heat absorption and increase the gas consumption. • The diagrammatic representation of kiln car at Sonya Ceramics is shown here.



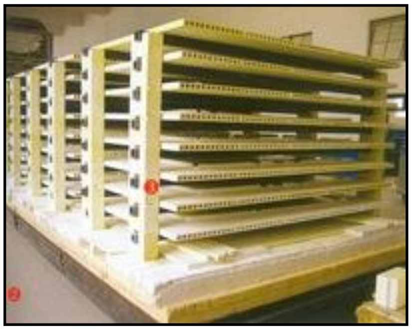
The size of the kiln	104′ (31.69 meters) approx.
Car capacity of kiln	27 Cars
Dimensions of the kiln car	(46″ * 20″ * 30″) (L * W * H)
Cycle time	40 Min
Total time inside kiln per car	18 Hours
Material of car furniture	• The shelves are made of Pressed Cordierite and • The platform is made up of heavy refractory bricks with ceramic fibre as filling
Dimension of cordierite plates	11″ * 10″ * 1″ (280mm * 254 mm * 25mm)
Loaded product per kiln car	150 Kg
No. of layers of sagger per car	4 to 6 (depending upon size of product)
Average gas consumption	287.35 SCM/Ton of product

A typical cordierite plate is shown here (For Symbolic reference only)

Suggestions for implementing CP

- As per the thumb rule, the gas consumption will be reduced dramatically by reducing the weight of the kiln car. The option to reduce the kiln car weight is by changing the design of shelves in the kiln car

- It is highly recommended to replace the Solid Cordierite Shelves with light weight 'Extruded Cordierite Batts'. The structure can be visualized in the picture given below.

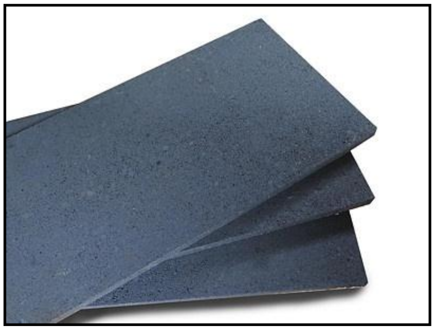


- The specific gravity of the extruded cordierite batts is 2.57 – 2.66 with better thermal efficiency and thermal shock resistance and proven to reduce the gas consumption than the solid cordierite plates.

- The only drawback associated with using such plates is that the thickness required for carrying heavy load is around 25 mm. However, it is still the better condition, because after deducting the internal hollow portion, the solid portion thickness still reduces to 12 mm.

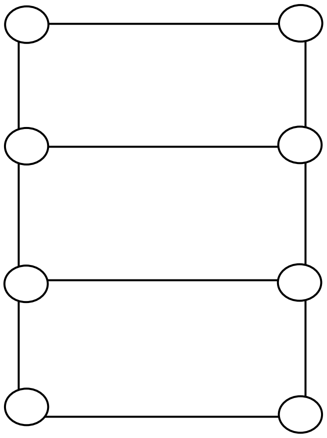
- The second option; however much costlier one, is to use oxide bonded Silicon Carbide plates in place of solid cordierite. Actually it is heavier than the former one (Specific Gravity: 2.9 – 3.4) but has got even better load carrying capacity at elevated temperatures (say 1200o C). Also, its porosity is far less than cordierite.

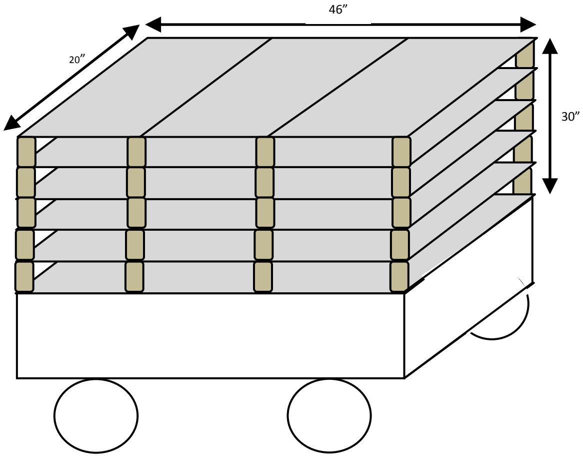
- The advantage with the oxide bonded silicon carbide plate is that, it requires a thickness of 8 mm to 10 mm for carrying the same load at same temperature that can be withstood by the cordierite plate of 25 mm thickness. This can significantly reduce the gas consumption. Also, the life of this plate is significantly more compared to the former one.



- It is left to the industry to decide the appropriate option out of the two suggested here, as it is well understood that financial implications are one of the most important factors while deciding any modification in the process.

- By using either of the two, the number of plates required for loading would reduce considerably. The modified design is shown here.





After CP	• Size of one shelve: 20″ * 15″ * 1″ (0.508 * 0.381 * 0.025 meter) • Volume of one shelve: 0.0048 m^3 • Density of one extruded batt: 2100 Kg/m^3 * 60% (as 40% space is hollow) • **Weight of one extruded batt: (0.0048 * 2100 * 0.6) = 6.048 Kg** • Each layer of car will contain 3 shelves of extruded batt • Each car may contain 5 layers of such batts • Total no. of batts per car: (5 * 3) = 15 • Total weight of 15 batts: (15 * 6.05) = 90.72 Kg • **Total weight of batts for 36 cars: = 3265.92 Kg** • Current weight of shelves on 36 cars: 5443.2 Kg • After modification, weight of shelves on 36 cars: 3265.92 Kg • Reduction in weight of cars: (5443.2 – 3265.92) = 2177.28 Kg • **% Reduction in weight: 40%** • % Reduction in Gas Consumption: **40% approx. (2,19,746 SCM P. A.)**
Benefit	
Economical	Investment: Rs. 2,20,000/- (for 540 batts @ Rs. 100/Kg of batt) Savings: Rs. 46,14,000/- per annum Simple Payback Period: 1 month
Environmental	Reduction in natural gas consumption by 2,19,746 SCM per annum, thereby reducing the emission of green house gases to a larger extent.

Intervening Technique	Installation of Variable Frequency Drive (VFD) In Ball Mill Motor

Before CP

Plant is operating 5 nos. ball mills, with common connection to single 30 HP motor. The motor load test conducted while operating all 5 nos. ball mill simultaneously is shown in table below:

Table: Electrical Parameters Measured at Ball Mill Motor (5 nos. Motor)

Parameter	O/P from the panel (to ball mill)			I/P to the panel	
	Reading 1	Reading 2	Reading 3	Reading 1	Reading 2
Voltage (V)	408	409	410	409	408
Ampere (A)	22.5	20.0	21.1	15.6	16.6
Power (kW)	9.71	6.90	8.35	6.10	7.27
Power Factor (Cos Ø)	0.61	0.49	0.56	0.55	0.62

The load survey conducted on the ball mill shows that the maximum loading on ball mill motor is 43%. The load variation recorded during normal operation of ball mill motor is 6.10 kW to 9.71 kW, while the rated capacity of motor is 22.4 kW.

The load survey during single ball mill operation is shown in table below:

Table: Electrical Parameters Measured at Ball Mill Motor (Individual Motor)

Parameter	Reading 1	Reading 2	Reading 3	Reading 4
Voltage (V)	417	416	417	417
Ampere (A)	7.03	6.95	7.00	7.20
Power (kW)	2.83	2.71	2.78	3.02
Power Factor (Cos Ø)	0.56	0.54	0.55	0.58

Thus even if less than 5 nos. ball mill(s) operate, the loading on motor will be less than 40 % and thus resulting in higher efficiency losses at motor.

Ball mill/Blunger is a batch grinding process. As per the process requirement the motor should run at full speed during the start of batch, however after a particular time the ball mill or Blunger can be rotated at less speed (RPM).

After CP	The speed of the motor can be reduced by installing variable frequency drive on Ball Mill/Blunger motor and operating speed can be programmed based on time. This will result in reduction in electricity consumption to the tune of 15% saving in electricity consumption in ball mills and blunger. This concept is applicable to glaze preparation ball mill in glaze section also.
Benefit	
Environmental	Reduction in the electricity consumption by 5500 units per year, ultimately reducing the carbon footprints to the environment.
Economical	Investment: Rs. 40,000/- (for 40 HP VFD) Approx. Annual Savings: Rs. 41,300/- per annum Payback Period: 12 months

Intervening Technique	Installation of Variable Frequency Drive (VFD) in Motors of Ball Mill (Individual Connection)
Before CP	• It is observed that the loading on individual ball mill motors is in between 30% to 65%. • Also the speed of the motors is higher than required for most of the time during the operation. For most of the time motor keeps on rotating at higher speed than the required.

After CP	• Installation of the variable frequency drive (VFD) on agitator motors can saves electricity consumption in agitation section by 15 %. • Though this measure is techno-economically viable, but overall saving potential is low as % energy consumption for agitation itself is low.
Benefit	
Environmental	Reduction in the electricity consumption by 1120 units per year, ultimately reducing the carbon footprints to the environment.
Economical	Investment: Rs. 10,000/- (for 5 HP VFD) Approx. Annual Savings: Rs. 8,400/- per annum Payback Period: 15 months

Intervening Technique	Implementation of ON - OFF Controller (10 minutes ON and 5 minutes OFF) for Agitation Motors
Before CP	In agitation section, agitators are provided in underground tanks to maintain theuniformity of the slurry. These motors operate for about 24 hours in a day. Agitation in a necessary operation to maintain the quality of the slurry and not to let it settle down and deposit as dry, however, there is a scope to save energy in it.
After CP	Installation of automatically ON - OFF system on the agitator motors do not affect the uniformity (quality) of slurry but gives saving in electricity consumption in agitator motors. This system automatically switches ON agitator motors for about 10 minutes and then switches OFF for about 5 minutes. This means that in one hour agitator motors operate for about 40 minutes and remain switch off for about 20 minutes. This could result in approximately 30% saving in electricity consumption of agitator motors. Though this measure is techno-economically viable, but overall saving potential is low as % energy consumption for agitation process itself is low.
Benefit	
Environmental	Reduction in the electricity consumption by 1760 units per year, ultimately reducing the carbon footprints to the environment.
Economical	Investment: Rs. 8,000/- (for ON-OFF Timers) Approx. Annual Savings: Rs. 13,200/- per annum Payback Period: 8 months

Intervening Technique	Power factor improvement to unity through installation of capacitors

Before CP	The source of outside power for the plant is from UGVCL (Uttar Gujarat Vij Company Ltd.) grid at 11 kV. The 11 kV supply is stepped down through common discom transformer and supplied to the plant at 420 V. The total amount paid to UGVCL against reactive power consumption by the plant during January 2015 to December 2015 was Rs. 32,190
After CP	Through power factor maintained near to unity, plant can reduce the reactive power consumption which will save additional charges in electricity bill. Power factor is improved by the installation of capacitors and replacement of the de-rated existing capacitors.
Benefit	
Economical	Investment: Rs. 25,000/- (for capacitors) Approx. Annual Savings: Rs. 32,000/- per annum Payback Period: 10 months

Intervening Technique	Optimize Power Consumption at Ball Mill Motor by Installing Timer Based ON-OFF Controller
Before CP	The ball mills are one of the major electricity consuming equipment, since the batch time for the material preparation varies from 5 to 6 hours; the plant is operating 5 nos. of ball mill and since the material processing require 5 hours operation for required material properties, the manual dependency on operator results in additional operation of ball mill motors.
After CP	In order to reduce unnecessary operation of ball mills, a simple programmable timer based ON-OFF controller will automatically switch OFF the motor of ball mill on completion of programmed time.
Benefit	
Environmental	Reduction in the electricity consumption by 4520 units per year, ultimately reducing the carbon footprints to the environment.
Economical	Investment: Rs. 25,000/- (for ON-OFF Timer) Approx. Annual Savings: Rs. 33,900/- per annum Payback Period: 9 months

Intervening Technique	Improvement in Kiln Insulation
Before CP	One of the heat losses in the kiln is due to the radiationloss from the surface of the kiln The surface temperature measured around the kiln firing zone was recorded from 78 ^{0}C to 140 ^{0}C at different locations, while surface near burners were found at 257 ^{0}C to 379 ^{0}C.
After CP	The radiated heat loss can be minimized by improving the insulation in kiln,recuperators and other hot surfaces. This reduces the surfacetemperature and thereby reduces fuel consumption.

The proposed insulation is ceramic fibre blanket supported by asbestos cladding. It is available in roll form in a wide variety of densities and thicknesses. It has excellent strength before and after heating. It has excellent chemical resistance unaffectedby all chemicals except hydrofluoric acids and strongalkalis.

Its specifications are –

- Thermal Capacity: 1260°C
- Alumina Content (Al_2O_3): 37%
- Silica (SiO_2): 52%
- Zirconia (ZrO_2): 17%
- Density: 96 Kg/m^3

Benefit

Environmental

- Reduction in the natural gas consumption by 7200 SCM per year
- Thereby, reduction in the green-house gases in the atmosphere due to combustion of the fuel

Economical

Investment: Rs.3,00,000/- (for insulation) Approx.
Annual Savings: Rs. 1,60,000/- per annum
Payback Period: 23 months

Intervening Technique

Optimization of Combustion Efficiency of Kiln

Before CP

Flue gas exhaust at the tunnel kiln furnace was monitored. %O_2 in flue gas varies from 5.1% to 15.6%.

Flue gas temperature also varies from169°C to 200°C.% O2 in flue gases should be between 2 – 6%.

Parameter	Unit	Exhaust (Flue Gas)		Firing Zone
O2	%	14.1	12.0	20.3
CO	ppm	1266	1137	20
Combustion Efficiency	%	45.2	57.5	O2> 20%
CO2	%	3.01	5.0	O2> 20%
Excess Air	%	344.6	137.5	O2> 20%
Pressure	mbar	0.05	0.08	0.24

After CP

The same can be maintained by regular monitoring of flue gas sample with the help of a portable flue gas analyzer or by installing O_2sensor at the furnace exhaust for flue gases and a modulating motorized damper for combustion air control.

	The sensor will provide constant feedback of O_2% to the damper which will in turn regulate the flow of combustion air to maintain the combustion efficiency at optimum level of 80 - 90% (Achievable combustion efficiency). It is suggested to control the combustion air through reducing the RPM of combustion air blower by 1-2 Hertz at a time by monitoring required temperature within kiln and set the appropriate frequency and monitoring the required O_2 percentage in flue gas to optimize the air fuel ratio and thus combustion efficiency at the kiln. Excessive draft allows increased volume of air into the furnace. The large amount of flue gas moves quickly through the furnace, allowing less time for heat transfer to the material side. The result is that the exit temperature decreases with increase in heat quantity along with larger volume of flue gas leaving the stack contributes to higher heat loss. The proper control of air to fuel ratio can result in combustion efficiency more than 75 % with old burners as well. Thus increase in 15 % combustion efficiency will result in saving of approximately 85540 SCM gas per annum.
Benefit	
Environmental	▪ Reduction in the natural gas consumption by 85,540 SCM per year ▪ Thereby, reduction in the green-house gases in the atmosphere due to combustion of the fuel
Economical	Investment: **NIL** Annual Savings: **Rs. 16,25,000/-** per annum Payback Period: **Immediate**

Intervening Technique	Avoid Compressed air usage for cleaning purposes
Before CP	During the visit it was observed that compressed air is used for cleaning purposes at some workstations to clean the components with open hose of 5 mm diameter and at 6 kg/cm^{2}g pressure.
After CP	Usually, cleaning can be done at lower pressure (around 2-3 kg/cm^{2}g). So, the first step would be to reduce the pressure and energy saving would be around 8% at drop of each bar for that hose if generated separately. From our past experience the company can save Rs. 21,000 per year (from one workplace) by installing compressed air saving gun.

	 The compressed air is a costly utility and the less critical purposes like cleaning can be achieved by installing air saver nozzles at the tip of these cleaning devices or shall be replaced with new one. The special design of these improved cleaning nozzles allows ambient air to get entrained in the path due to vacuum created by compressed air and delivers the air with similar velocity and thrust giving to desired cleaning effect. However, the amount of compressed air uses is only 20-25% which reduces the compressed air requirement and thus resulting in energy savings. In addition, these nozzles also reduce the noise level.
Environmental	Reduction in the electricity consumption to generate the compressed air, with that, also reducing Noise Pollution of the surrounding, making the site easy to work
Economical	Investment: **3,000/-** per gun Annual Savings: **Rs. 21,000/-** per station Payback Period: **3 months**

GUJARAT PORCELAIN INDUSTRY, WADHWAN, SURENDRANAGAR

Introduction – Gujarat Porcelain Industry

Gujarat Porcelain Industries, located at Wadhwan City Industrial Estate, Surendranagar district, is a well-known manufacturer of Low Tension Porcelain ware (Electrical and Industrial). It was established in 1977 under New Entrepreneur Scheme, and started its production in 1978. It started manufacturing of electrical fuses, electrical accessories, holders, switches and sockets with a conventional down-draft coal fired kiln in the same year. Thereafter, the firm employed LDO fired kiln and finally switched to PNG (Pressurized Natural Gas) since 2007, with enhanced production capacity from 20MT to 60 MT per month. There are 18 registered workers in the plant. Additional workers may be employed by the company on contractual basis, as per requirement. The industry is spread in 3700 sq. meters with a built up area of around 750 sq. meters.

Cleaner Production Assessment Team

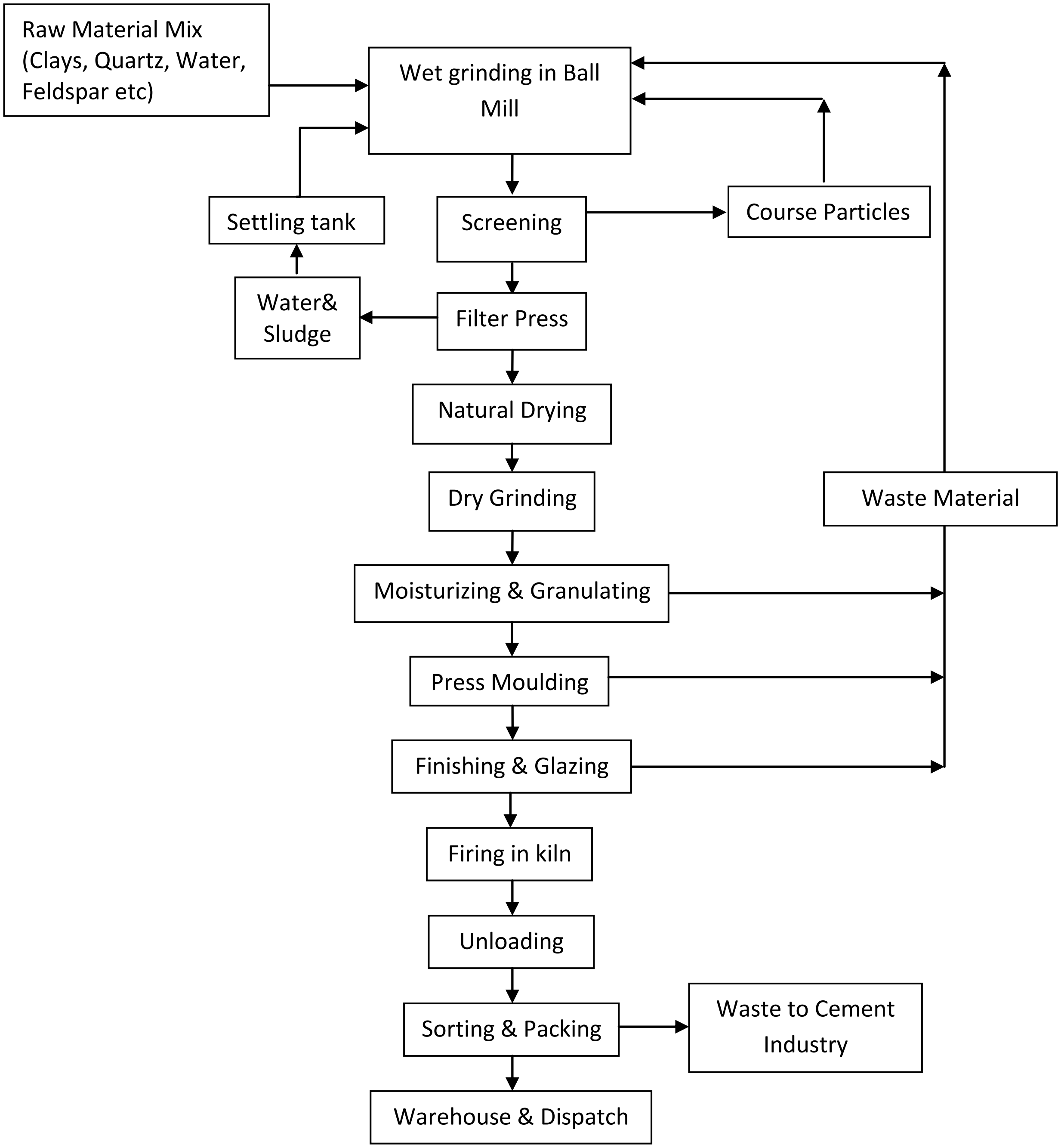
The team for conducting Cleaner Production Assessment includes the following members.

Name	Designation
Dr. Bharat Jain	Member Secretary, GCPC
Mr. Punamchandra Rathod	Senior Project Engineer, GCPC
Mr. Paras Gojiya	Assistant Project Engineer, GCPC
Mr. Abhi Patel	Assistant Project Engineer, GCPC
Mr. K. D. Sanghavi	Technical Expert, GCPC
Mr. Hasmukhbhai Shah	Partner, Gujarat Porcelain Industries
Mr. Chiragbhai Shah	MD, Gujarat Porcelain Industries

Manufacturing Process

Gujarat Porcelain Industries Ltd., Wadhwan manufacturing plant manufactures Low Tension electrical and industrial porcelain ware. The manufacturing process flow chart is as depicted below.

Manufacturing Process Flow Diagram



1. Raw Material Storage

   Different types of clays and minerals are transported in **'plastic packing'** to the plant via trucks and unloaded manually to store in the storage yard with separate compartments for each type of clay.

2. Slip Preparation

   The slip is formed by mixing various types of raw materials in a fixed composition manually in the ball mill. A batch of ball mill contains 2500 Kg of raw material, 2000 litres of water and high alumina pebbles. The ball mill grinds the raw material for 5 hours to form slurry, which is passed through a 80 mesh size 3 layered vibro-screens, so as to reject the oversized particles.

3. Filtration

   The slurry after passing the sieve is stored in an underground slurry storage tank, to which a press and frame filter is connected. The press filter intakes the slurry with high pressure and gives the wet cakes of the material.

4. Wet cake drying

   The wet cakes are manually stacked on the ground for atmospheric drying. They are stacked in such a manner that maximum amount of solar radiations can be utilized to dry them. Advance stock of around 5 days is kept for drying, keeping separate locations of each day's stacks.

5. Dry Grinding

   When the moisture of the cakes reaches to less than 5%, they are fed to disintegrator machine where dry grinding of the cake occurs. The dry powder is obtained at the bottom of the machine. This operation is a dust intensive one. As the grinding is a dry operation, the powdered particles are spread in the air.

6. Moisturizing and Granulating

   Water is sprinkled on the dry powder to moisturize it upto 18 – 20% and is fed to the granulating machine. The granulating machine is a modified disintegrator which creates granules of the moist slurry fed to it. The granules so formed are sent to toggle and press machines for moulding.

7. Press Moulding

   There are manually operated 'toggle and press' moulding machines for casting the shape out of the material. Operators fill in the material into the dye of the press using their hands, followed by toggling and pressing the mechanical handle to cast out the shape.

8. Drying

The casted moulds are stacked on wooden blocks and transported for natural drying via using a manually operated 'hydraulic jack'. Maximum utilization of solar radiation is done. The drying area is protected using roofs from top. Some stacks are also put on near the kiln wall, so as to fasten the drying process due to the ambient hot air. After a considerable removal of moisture, the moulds are sent for finishing operation.

9. Finishing

The workers of the plant finish the sides of the dried moulds by removing off the extra material from the edges of the moulds. The material removed from the moulds is recycled back into the slip formation operation (wet grinding).

10. Glazing

The finished moulds are subjected to the glazing operation. Previously, the glazing operation was carries out by spraying on the moulds using a spray gun, which led to a considerable amount of glaze loss.

Now the industry has installed a glazing machine, which automatically sprays the glaze in a closed chamber, leading to no wastage of the glaze material, as well as less generation of air borne particles.

11. Firing

The glazed products are arranged on the kiln cars. Care is taken while stacking the products on the kiln car. The moulds are arranged in 5 or 6 lines vertically, depending upon the size of the moulds loaded. Total number of cars that can be accommodated in kiln is 27.

The loaded cars are sent in the tunnel kiln for firing in the cycle of 80 minutes. The maximum temperature range is upto 1150^{o}C, with a total time inside kiln being 38 hours for an average kiln car. There is no temperature and cycle time change for different products.

The cooling zone of the kiln is considerably long, which is good for maximum utilization of the hot gases inside the kiln. Also, temperature of the products coming out the kiln is considerably low such that they can be handled easily.

12. Sorting

The workers present in the sorting department check and verify the size and shape with the standards and separate the acceptable and rejected products. The rejected products are collected in the ware house, where they are sold to cement manufacturing industries for recycle.

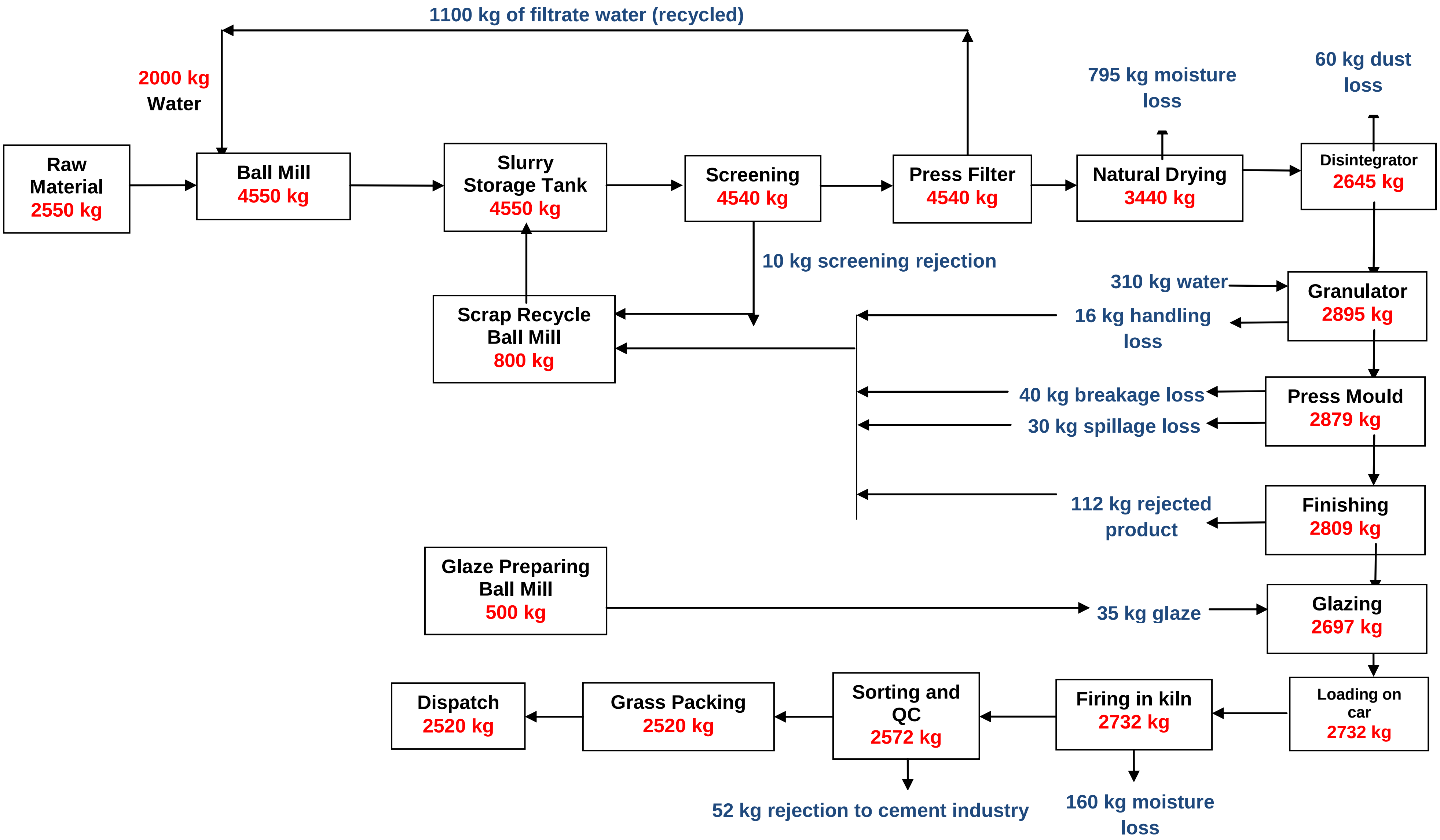
13. Packing and dispatching

The acceptable quality products are packed in grass packing and then plastic bags and transported to the market via trucks.

Sources of waste generation, quality and approximate quantity

Sr. No.	Waste	Source	Quantity	Remarks
1.	Raw material	Loading in the ball mill	Negligible	Generation of air borne particles
2.	Water	Filtrate of press and frame filter	1100 Kg / batch	Recycled into the process
3.	Water	Moisture loss in form of Evaporation in drying	795 Kg / batch	Lost to the atmosphere
4.	Processed raw material	Material is lost in the form of dusting at disintegrator	60 Kg / batch	Major source of air borne particles
5.	Processed material	Granules formed in the granulator fall on the ground and mix with impurities	16 Kg / batch	Sent for scrap recycling in ball mill
6.	Processed material	Material wastage at press mould, falling on ground	30 Kg / batch	Sent for scrap recycling in ball mill
7.	Moulded pieces	Broken pieces from toggle & press moulding machine	40 Kg / batch	Sent for scrap recycling in ball mill
8.	Moulded pieces	Rejected pieces in Quality checking before loading on the kiln car	112 Kg / batch	Sent for scrap recycling in ball mill
9.	Final Product	Rejected piece in quality checking after firing	52 Kg / batch	Sent to the cement industry for recycle
10.	Water	Loss of moisture due to evaporation	160 Kg / batch	Lost to the atmosphere

Material Balance of the Process



Cleaner Production Opportunities

Intervening Technique	Decrease in wet grinding time by change in the quality and granule size of raw material purchasing
Implementing the technology	**Before CP:** • The industry purchased different types of clays and other raw materials (minerals such as quartz, feldspar, frit etc) in a bigger granule size. Clays were in bigger lumps form and other minerals were in granules of irregular size. • They were fed to the ball mills of capacities 0.8 MT and 1 MT and were wet ground for **24 hours.**  **After CP:** • Industry has started to purchase the raw material with a smaller granule size. • Clays are purchased in smaller lumps and all the minerals are purchased with 200 mesh size only. They are fed to a ball mill with capacity 2.5 MT and now the grinding time is decreased to **5 hours.**

		
Benefits		
Environmental	**Before CP:** • The wet grinding was done for **24 hours**, consuming more electricity.	**After CP:** • Reduction in the electricity consumption, as the grinding time reduced to **5 hours**.
Economical	**Before CP:** • Electricity Charges: 0.8 MT ball mill motor: 53.7 unit 1 MT ball mill Motor: 89.5 unit Total electricity per batch: 143.2 unit Total charges per batch: Rs. 1976/-	**Before CP:** • Electricity Charges: 2.5 MT ball mill motor: 93.21 unit Total electricity per batch: 93.21 unit Total charges per batch: Rs. 1286/-
	Savings: Rs. 690 per batch Rs. 20,700 per month (approx.)	

Intervening Technique	Reduction in material handling loss by purchasing the raw material in packed bags.
Implementing the technology	**Before CP:** • The industry purchased different types of clays and other raw materials (minerals such as quartz, feldspar, frit etc) in loose. The material arrived at the industry in open trucks, leading to loss of material in transportation. • At the storage area also, the material was stored on ground, open from all sides, allowing wind to carry the material with it. • It also gave rise to the dusting and air borne particles, leading to air pollution.

After CP:

- Industry has started to purchase the raw material in plastic bags from the supplier with a negligibly more cost per ton.

- Storage yard is covered with wall from 3 sides and a roof is built over it.

		
Benefits		
Environmental	**Before CP:** • Loss of material by dusting and air pollution due to air borne particles • No control of raw material quality	**After CP:** • Prevention of material loss by dusting • Prevention of air pollution caused by air borne particles • Control of raw material quality

Intervening Technique	Installation of hydraulic lift for unloading the raw material into the ball mill
Implementing the technology	**Before CP:** • In the slip house area, a temporary ladder was installed to unload the raw material in the ball mill. • The workers climbed the ladder with the bag of the material and unloaded the bag inside the ball mill. • The time required for the whole movement (climbing through ladder, unloading and returning) was considerably high and risky to the worker. **After CP:** • The industry has installed a hydraulic lift in the ball mill area. • The workers now put the bags of raw material on the lift, which carries it to the height. A platform is also built on the top where other workers can unload the material in the ball

mill.

- The overall time of the movement also reduced considerably.

Benefits		
Environmental	**Before CP:** • Time consuming operation • Risk to involved workers • Spillage of raw material	**After CP:** • Reduction in time consumed • Reduction in risk to workers • Reduction in material spillage

Intervening Technique	Making cement concrete/Kota stone furnished flooring in the factory premises
Implementing	**Before CP:**

the technology	• The factory premise was dust intensive as all the spillage of material from all operations fell on the ground, where the natural impurities aided to it. • Also, due to addition of impurities, industry did not reuse the material falling on the ground. • The internal transportation of material and utilities was difficult and it aided to accidental break down of moulded green products frequently. **After CP:** • All the area in the factory premise is now solidified with cement concrete. Some of the areas, (such as pressing section) are furnished with Kota stones. • Internal transportation of material and utilities has become very easy. Accidental break down and losses of product does not occur now. 

		
Benefits		
Environmental	**Before CP:** • Dust intensive factory premise • Difficult to transport material and utilities internally in the factory premise	**After CP:** • All the major parts of the factory premise are now dust free • Easy internal transportation of material and utilities
Economical	**Before CP:** • Accidental falling and breaking of green products frequently • Addition of impurities to the products fallen on the ground	**After CP:** • Complete reduction in accidental losses of products • The material fallen on ground can be reused now in the process after wet grinding

Intervening Technique	Using a hydraulic jack for transporting green stage products
Implementing the technology	**Before CP:** • The workers used to carry the green stage products on their shoulders, stacked on wooden blocks, leading to falling and breaking of products sometimes. **After CP:** • Industry has now started using a hydraulic jack to carry the products, stacked on modified wooden carriers.

Benefits

Before CP:	**After CP:**
• Accidental loss of products	• No loss due to accidental breaking of products
• Difficulty in transportation for workers	• Easy internal transportation
• Also, the efficient of carrying weight for a human being was less.	• Efficiency of carrying weight for the hydraulic jack is considerably more than human being

Intervening Technique

Zero discharge of process waste water, as 100% treated water is reused in process in wet grinding, also utilizing 100% sludge generated in settling tank back to the wet grinding operation.

Implementing the technology

Before CP:

- The process waste water generated in the plant (from press and frame filter during formation of wet cake) was disposed off and was not recycled/reused anywhere.

- The waste water also contained processed raw material filtered from the press filter machine, which was also a considerable loss to the industry.

After CP:

- Industry has built two waste water storing and settling tanks in which all the waste water from the press and filter section is stored.

- After settling of the solid particles/sludge, 100% of water from the tank is pumped back to the ball mill, in the wet

	grinding operation, leading to Zero discharge of water. • Also, the sludge remained after the settling of solid particles, is removed from the tank regularly and is used along with the fresh raw material in wet grinding operation. 	
Benefits		
Environmental	**Before CP:** • Wastage of water in the drainage, approximately **2 KLD** • Wastage of solid material along with the drained water	**After CP:** • Recycle of 100% of waste water into the process, conserving **2.5 KL/Day** • Recycle of sludge along with the fresh raw material in wet grinding, approximately, **2 MT per month.**

Intervening Technique	Saving of glaze by installation of Glazing machine, thereby reduction in air pollution
Implementing the technology	• Glazing operation is an important part of the ceramic industry. It provides a shiny and smooth texture to the ceramic material. • The composition and properties of glaze used for different types of ceramic products are different. The glaze used for Low Tension Insulators are of low density type. • Because of that reason, they can be applied on the material

by spraying with any atomizer equipment.

Before CP:

- Industry used a spray gun painting mechanism to apply glaze on the green products.
- The green stage products which were subjected to glaze application were put on wooden blocks and the glaze was sprayed on it.
- Spray gun mechanism needs a highly skilled worker to operate it, because a major part of the glaze sprayed was lost to the surrounding part, dried and converted to powder form and due to the addition of impurities, industry did not recycle it. Also, many a times, the glaze was applied irregularly due to human errors and glaze related losses were considerable high.
- Also, the spray of glaze led to generation of air borne particles and could affect harmfully to the surrounding people.

After CP:

- Industry installed a glazing machine to apply glaze on the green stage products. Using the machine, the glaze is applied uniformly and evenly on each product.
- The equipment works on the same mechanism as that of the spray gun. A Conveyor belt carries the ceramic products on it towards a closed chamber, where glaze is sprayed from 3 sides using atomizers.
- Prior to glazing chamber, an air suction pump is installed, which sucks all the dust particles from products
- The glazing application occurs in a completely closed chamber, hence no glaze particles are carried out with air, leading to reduction in air pollution of the surrounding area. The glaze related losses are reduced completely. Also, no need of skilled worker is there in operating the equipment, anybody can easily operate it.
- No glaze is wasted, as the spray application occurs under fully controlled manner and the extra glaze remained on the

internal walls of the chamber is reused at the spot, leading to a dramatic savings in glaze and its manufacturing utilities. With that, the productivity per day also increased dramatically, from **7000 pieces** of products to **11000 pieces** of products.

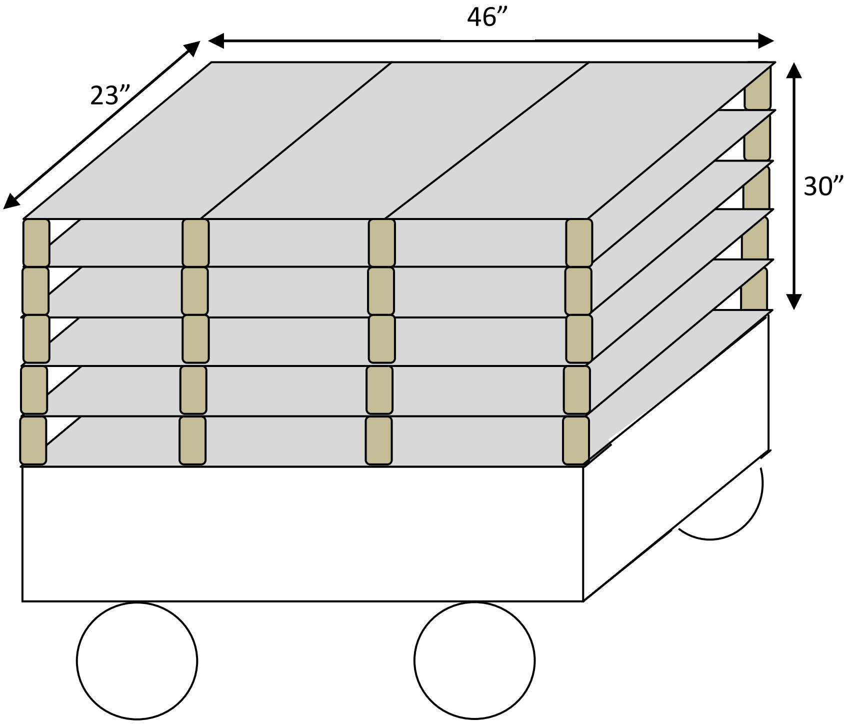
Benefits		
Environmental	**Before CP:** • **Material and energy waste:** A lot of processed material and energy was wasted in uneven spray • **Air Pollution:** The air borne particles were aiding to the air	**After CP:** • **Saving of material& energy:** Material remains completely inside the spraying chamber, and complete recycle at spot • **No Pollution:** No particles of

	pollution of the surrounding area • **Risk to Humans:** The glaze particles in the air could cause various breathing and lungs related diseases to associated workers	glaze flow out of the equipment, hence complete reduction of air pollution • **Reduction in health hazard:** Reduction in the air borne particles also reduced the risk of breathing related diseases to workers associated
Economical	• **Glaze manufacturing cost per month:** ✓ Glaze required: 3500 Kg/month (7 Ball Mills per Month) ✓ Cost of glaze: Rs. 15/Kg ✓ Total Cost = (3500*15) **= Rs. 52,500/- monthly**	• **Glaze manufacturing cost per month:** ✓ Glaze Required: 1500 Kg/month (3 Ball Mills per Month) ✓ Cost of Glaze: Rs. 15/Kg ✓ Total Cost = (1500*15) **= Rs. 22,500/- monthly** ✓ Savings: **Rs. 30,000/month**
	• **Electricity cost** (3 HP Motor * 54 hours * 7 ball mills per month) 875.6 units per month Rs. 11,670/- per month	• **Electricity cost** (3 HP Motor * 54 hours * 3 ball mills per month) 362.4 units per month Rs. 5,000/- per month Savings: **Rs. 6,670 per month**
	• **Productivity:** 7000 pieces/day • Skilled worker required • Non-uniform thickness of glaze	• **Productivity:** 11000 pieces/day • No skilled worker required • Uniform thickness of glaze
	Total investment: **Rs. 2,50,000/- (equipment cost)** Direct Savings: **Rs: 36,670/- Per month + Increased productivity** Payback Period: Less than **7 Months**	

Intervening Technique	Reduction in the fuel consumption of kiln by modification in kiln car platform material and design
Implementing the technology	• The kiln used at Gujarat Porcelain Industries is a tunnel kiln, made up of ceramic fibre walls with asbestos covering outside. • Its capacity to bake the material is **3300 Kg/day.** • Average fuel consumption: **475 SM^3/day** (144 SM^3/ton

product)

- Car capacity of kiln: **27 Cars**
- Kiln Car Dimensions: **(46” * 23” * 30”)** (Length * Width * Height)



A kiln car at Gujarat Porcelain Industries

- Cycle Time: **80 Minutes**
- Total time inside kiln for a car: **37.5 Hours**
- Average material loading per car: **165 Kg**
- Temperature Pattern of kiln:**450° C –1150° C – 220° C**

Before CP:

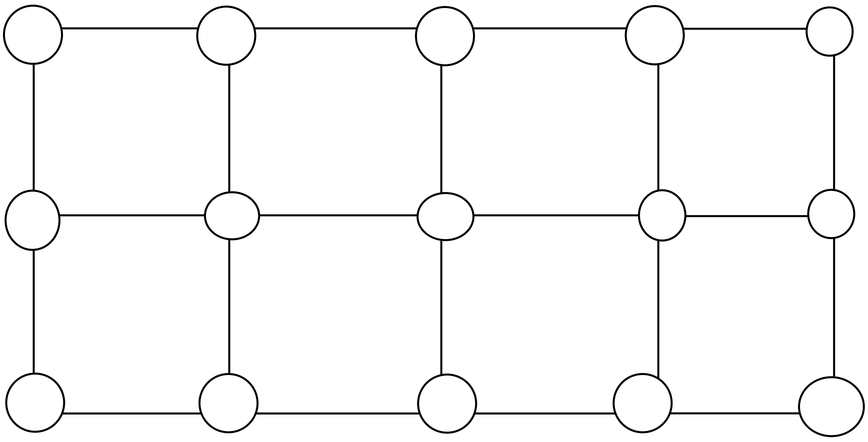
- The kiln car size is 46” * 23” * 30” (Length * Width * Height)

- The platforms used to hold the moulded insulators were made up of ‘Cordierite’

- Dimension of cordierite plates: 11”*11”* 1”
(280mm * 280 mm * 25mm)

- Each layer of car contained 8 plates.

- The graphical design (Top View) of the kiln car is as shown here.



- With this structure, approximately 24 Kg of product could be loaded on one layer

- Each car contained approx 5 layers of cordierite plates.

- Total weight of products loaded on car with above structure: (24Kg * 5 layers) = 120 Kg approximately.

- As the car loading cycle time is 80 minutes,
  Per day car sent for baking: 18 cars
  Per day firing of products: 2160 Kg approximately

- Average gas consumption per day: 545 SM^3/Day approximately
  Gas consumption per ton of product: (545 SM^3 / 2160 Kg)
  = 252 SM^3 /MT

After CP:

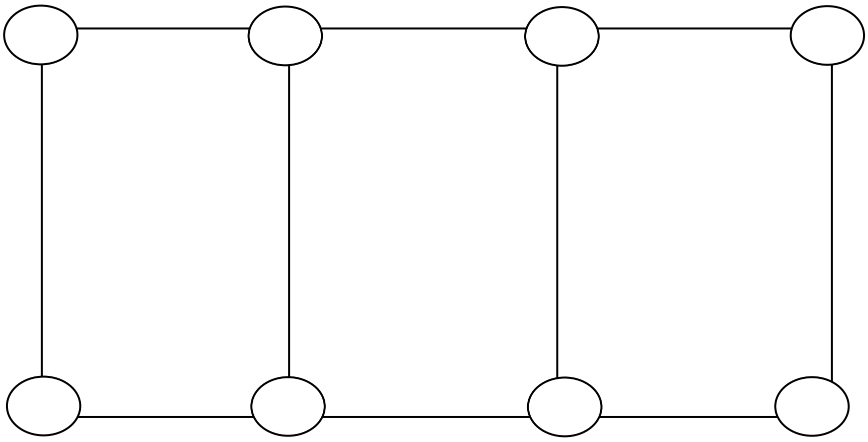
- The kiln car size is 46” * 23” * 30” (Length * Width * Height)

- The platforms used to hold the moulded insulators are made up of ‘Oxide Bonded Silicon Carbide’

- Dimension of SiC plates: 15”* 22”* 0.6”
  (381mm * 560mm * 15mm)

- Each layer of car contained 3 plates.

- The graphical design (Top View) of the kiln car is as shown here.



- With this structure, approximately30 Kg of product could be loaded on one layer
- Each car contained approx 6 layers of oxide bonded silicon carbide plates.
- Total weight of products loaded on car with above structure: (30 Kg * 6 layers) = 180 Kg approximately.
- As the car loading cycle time is 80 minutes,
  Per day car sent for baking: 18 cars
  Per day firing of products:3240 Kg approximately
- Average gas consumption per day:488 SM^3/Day approximately
  Gas consumption per ton of product: (488 SM^3 / 3240 Kg)
  = 150 SM^3 /MT

Benefits		
Environmental	**Before CP:** • Per Day Consumption of fuel: 545.984 SM^3/Day	**After CP:** • Per Day Consumption of fuel: 488.371 SM^3/Day • Reduction in fuel consumption: = (545.984 – 488.371) = 57.61 SM^3/Day and = 1728.31 SM^3/Month • Percentage reduction of fuel consumption: 10.55% • Conservation of considerable amount of natural resources

Economical	• Fuel expense per day = (Rs. 40/SM^3) * (545.984) = Rs. 21,839/Day	• Fuel expense per day = (Rs. 40/SM^3) * (488.371) = Rs. 19,534/Day • Savings of Rs. 2,305/Day Rs. 69,150/Month
	• Average Productivity per day: 2160 Kg	• Average Productivity per day: 3240 Kg • Increase in productivity: 1080 Kg/Day • % increase in productivity: 50%
	Total Investment: **Rs. 14,70,000/-** (One time) Total Savings: **Rs. 69,150 per month** Payback Period: **21 Months**	

Intervening Technique	Good Housekeeping Practices
Implementing the technology	**Before CP:** • The unloading of slip from ball mill after wet grinding was done on the ground of Collection Pit. The material was deposited on the floor and sides of the pit and dried, leading to loss of material and poor housekeeping of slip preparation area. • The moulds prepared in the toggle and press machine were kept for drying. The area was open to the atmosphere, allowing impurities and dust particles to fall upon it. • The broken moulds (green stage) were thrown on the ground and at the end of the day workers had to collect them all by grooming. Also, ground impurities were added to it **After CP:** • Industry has installed a hose pipe to unload the material from the ball mill and convey it for vibro-screening and storage tank. The spillage is stopped and the surrounding area is very clean now.

- The industry has installed roofs throughout the plant, including the moulds drying area and the final product storage area.

- The industry has started to put ‘scrap collection bins’ at all possible spots to collect the broken and damaged pieces on the spot.

- The collected waste from all the bins is stored in a scrap storage area, from where it is wet ground to recycle in the process.

		
Benefits		
	Before CP: • Spillage of slurry on the ground and deposition and drying on the sides of pit, ultimately loss of material to the industry.	**After CP:** • No spillage of a single drop of slurry, leading to no loss of material and money.
	• Falling of dust particles and impurities on the moulds kept for drying, those impurities persist in glazing and firing application, forming bulged parts on the body.	• By installation of rooftops in mould storage area, complete reduction in rejections due to impurities falling on the green stage moulds.
	• The broken pieces fell on the ground, impurities were added to it. Workers had to groom the ground regularly.	• The scrap pieces are now collected at the spot in the waste collection bin, and sent for recycling.

Intervening Technique	Installation of Variable Frequency Drive (VFD) in Ball Mills
Before CP	Ball mill/Blunger is a batch grinding process. As per the process requirement the motor should run at full speed during the start of batch, however after a particular time the ball mill or Blunger can be rotated at less speed (RPM). The load survey conducted on the ball mill shows that the average loading on ball mill motor is 58.1 %. The load variation recorded during normal operation of ball mill motor is 8 kW to 16 kW.

After CP	The speed of the motor can be reduced by installing variable frequency drive on Ball Mill/Blunger motor and operating speed can be programmed based on time. This will result in reduction in electricity consumption to the tune of 15% saving in electricity consumption in ball mills and blunger. This concept is applicable to glaze preparation ball mill in glaze section also.
Benefit	
Environmental	Reduction in the electricity consumption by 4080 units per year, ultimately reducing the carbon footprints to the environment.
Economical	Investment: Rs.35,000/- (for 25 HP VFD) Approx. Annual Savings: Rs. 30,600/- per annum Payback Period: 14 months

Intervening Technique	Installation of Variable Frequency Drive (VFD) in Motors of Agitation Section
Before CP	It is observed that the loading on agitator motors is in between 30% to 65%. Also thespeed of the motors is higher than required for most of the time during agitation process.It is to be noted that agitation is a variable load process. Initially when the fresh chargecomes from Ball Mill/Blunger, loading on motor is in between 65 % to 72%. Howeverafter some time as the raw material become uniform then the loading on motor decreases.For most of the time motor keeps on rotating at higher speed than the required.
After CP	Installation of the variable frequency drive (VFD) on agitator motors can saves electricityconsumption in agitation section by 15 %. Though this measure is techno-economically viable, but overall saving potential is low as % energy consumption for agitation process itself is low.
Benefit	
Environmental	Reduction in the electricity consumption by 1120 units per year, ultimately reducing the carbon footprints to the environment.
Economical	Investment: Rs.10,000/- (for 3 HP VFD) Approx. Annual Savings: Rs. 8,400/- per annum Payback Period: 15 months

Intervening Technique	Implementation of ON - OFF Controller (10 minutes ON and 5 minutes OFF) for Agitation Motors
Before CP	In agitation section, agitators are provided in underground tanks to maintain theuniformity of the slurry. These motors operate for about 24 hours in a day. Agitation in a necessary operation to maintain the quality of the slurry and not to let it settle down and deposit as dry, however, there is a scope to save energy in it.
After CP	Installation of automatically ON - OFF system on the agitator motors do not affect the uniformity (quality) of slurry but gives saving in electricity consumption in agitator motors. This system automatically switches ON agitator motors for about 10 minutes and then switches OFF for about 5 minutes. This means that in one hour agitator motors operate for about 40 minutes and remain switch off for about 20 minutes. This could result in approximately 30% saving in electricity consumption of agitator motors.
Benefit	
Environmental	Reduction in the electricity consumption by 1760 units per year, ultimately reducing the carbon footprints to the environment.
Economical	Investment: Rs.8,000/- (for timer based ON-OFF controller) Approx. Annual Savings: Rs. 13,200/- per annum Payback Period: 8 months

Intervening Technique	Power factor improvement to unity through installation of capacitors
Before CP	The source of outside power for the plant is from PGVCL (Paschim Gujarat Vij Company Ltd.) grid at 11 kV. The 11 kV supply is stepped down through common discom transformer and supplied to the plant at 420 V. For the type of connection plant has PGVCL do not have clause for power factor penalty or rebate, but PGVCL charges Rs. 0.10 per kVArh which is recorded due to low power factor maintained within plant. The total amount paid to PGVCL against reactive power consumption by the plant during April 2014 to March 2015 was Rs. 10,924/-
After CP	Through power factor maintained near to unity, plant can reduce the reactive power consumption which will save additional charges in electricity bill. Power factor is improved by the installation of capacitors and replacement of the de-rated existing capacitors.
Benefit	
Economical	Investment: Rs.7,000/- (for installing capacitors) Approx. Annual Savings: Rs. 10,000/- per annum Payback Period: 9 months

Intervening Technique	Improvement in Kiln Insulation
Before CP	One of the heat losses in the kiln is due to the radiationloss from the surface of the kiln The surface temperature measured around the kiln firing zone was recorded from 78 ^{0}C to 140 ^{0}C at different locations, while surface near burners were found at 257 ^{0}C to 379 ^{0}C.
After CP	The radiated heat loss can be minimized by improving the insulation in kiln, recuperators and other hot surfaces. This reduces the surface temperature and thereby reduces fuel consumption. The proposed insulation is ceramic fibre blanket supported by asbestos cladding. It is available in roll form in a wide variety of densities and thicknesses. It has excellent strength before and after heating. It has excellent chemical resistance unaffectedby all chemicals except hydrofluoric acids and strongalkalis. Its specifications are – ▪ Thermal Capacity: 1260°C ▪ Alumina Content (Al_2O_3): 37% ▪ Silica (SiO_2): 52% ▪ Zirconia (ZrO_2): 17% ▪ Density: 96 Kg/m^3
Benefit	
Environmental	▪ Reduction in the natural gas consumption by 7200 SCM per year ▪ Thereby, reduction in the green-house gases in the atmosphere due to combustion of the fuel
Economical	Investment: Rs.5,00,000/- (for insulation) Approx. Annual Savings: Rs. 2,00,000/- per annum Payback Period: 30 months

Intervening Technique	Optimization of Combustion Efficiency of Kiln

Before CP

Flue gas exhaust at the tunnel kiln furnace was monitored. %O_2 in flue gas varies from 5.1% to 15.6%.
Flue gas temperature also varies from169°C to 200°C.% O2 in flue gases should be between 2 – 6%.

Parameters	At Kiln Exhaust	At Furnace Exhaust
O2 (%)	17.3	10.2
CO (ppm)	131	65
CO2 (%)	2.4	6.1
Efficiency (%)	67.5	64.1
Excess Air (%)	364.3	95.3
Pressure (mbar)	0.12	0.20

After CP

It is suggested to control the combustion air through reducing the RPM of combustion air blower by 1-2 Hertz at a time by monitoring required temperature within kiln and set the appropriate frequency and monitoring the required O_2 percentage in flue gas to optimize the air fuel ratio and thus combustion efficiency at the kiln.

Excessive draft allows increased volume of air into the furnace. The large amount of flue gas moves quickly through the furnace, allowing less time for heat transfer to the material side. The result is that the exit temperature decreases with increase in heat quantity along with larger volume of flue gas leaving the stack contributes to higher heat loss.

The proper control of air to fuel ratio can result in combustion efficiency more than 75 % with old burners as well. Thus increase in 10 % combustion efficiency will result in saving of approximately 12971 SCM gas per annum.

Environmental

- Reduction in the natural gas consumption by 13,000 SCM per year
- Thereby, reduction in the green-house gases in the atmosphere due to combustion of the fuel

Economical

Investment: **NIL**
Annual Savings: **Rs. 4,21,000/-** per annum
Payback Period: **Immediate**

SHIVSHAKTI CERAMICS, NARODA, AHMEDABAD

Shivshakti Ceramics Ltd.

Shivshakti Ceramic Industries is a well-known manufacturer of Ceramic tableware. It was established in 1983. It started manufacturing Cup & Saucers with conventional coal fired kiln in the same year. Thereafter, the firm employed LDO fired kiln and finally switched to PNG (Pressurized Natural Gas) since 2005 with enhanced production capacity from 36 MT to 72 MT per month. There are 25 registered workers in the plant. Additional workers may be employed by the company on contractual basis, as per requirement. The annual turnover of the company is Rs. 14 crores.

Cleaner Production Assessment Team

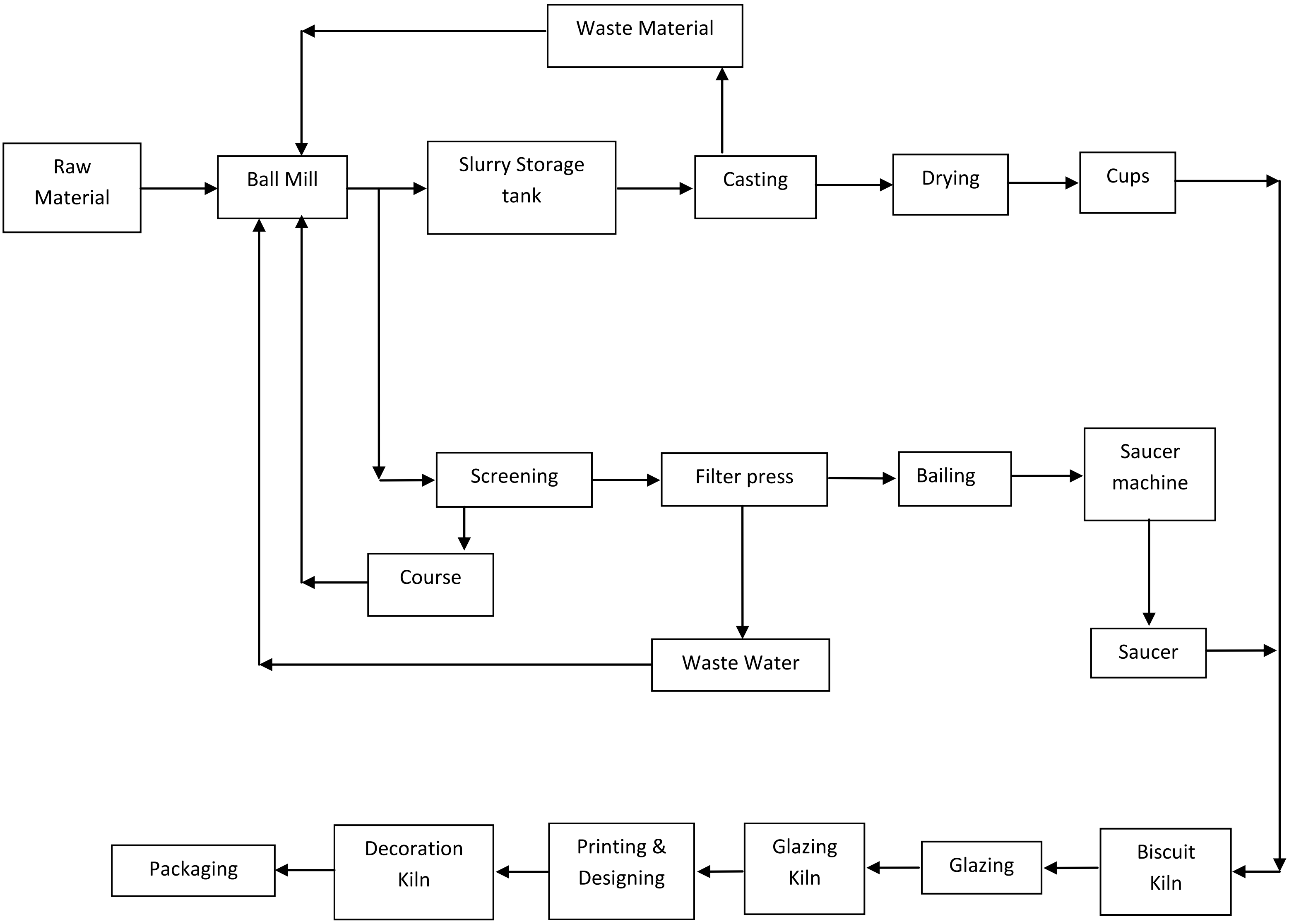
The team for conducting Cleaner Production Assessment includes the following members.

Name	Designation
Dr. Bharat Jain	Member Secretary, GCPC
Mr. Punamchandra Rathod	Senior Project Engineer, GCPC
Mr. Paras Gojiya	Assistant Project Engineer, GCPC
Mr. Abhi Patel	Assistant Project Engineer, GCPC
Mr. K. D. Sanghavi	Technical Expert, GCPC
Mr. Dineshbhai Patel	Partner, Shivshakti Ceramics

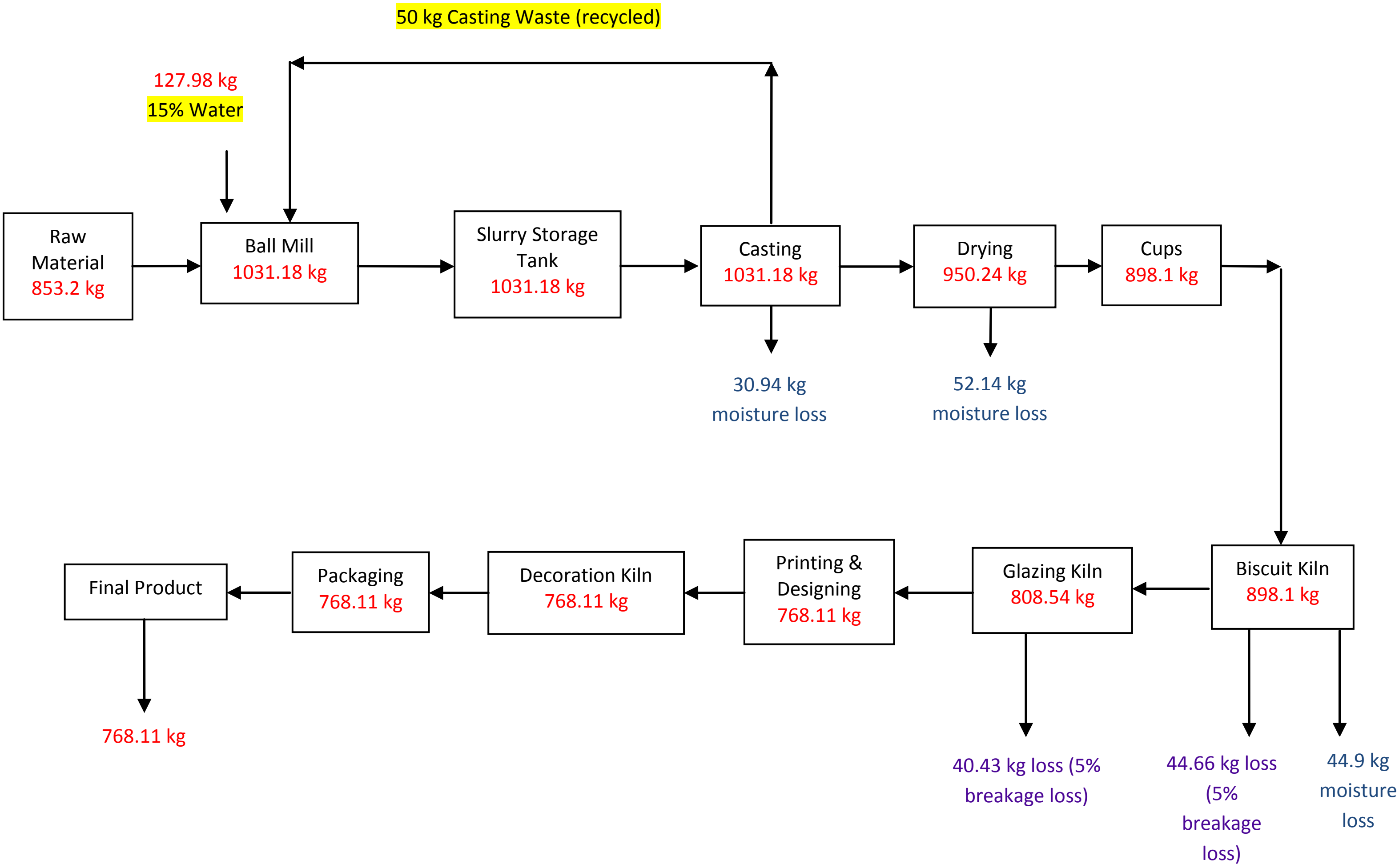
Manufacturing Process

Shivshakti Ceramics Ltd, Naroda manufacturing plant, manufactures two types of products, viz. ceramic cups and saucers. Apart from some variations, the major parts of the manufacturing processes of both types of products are same.

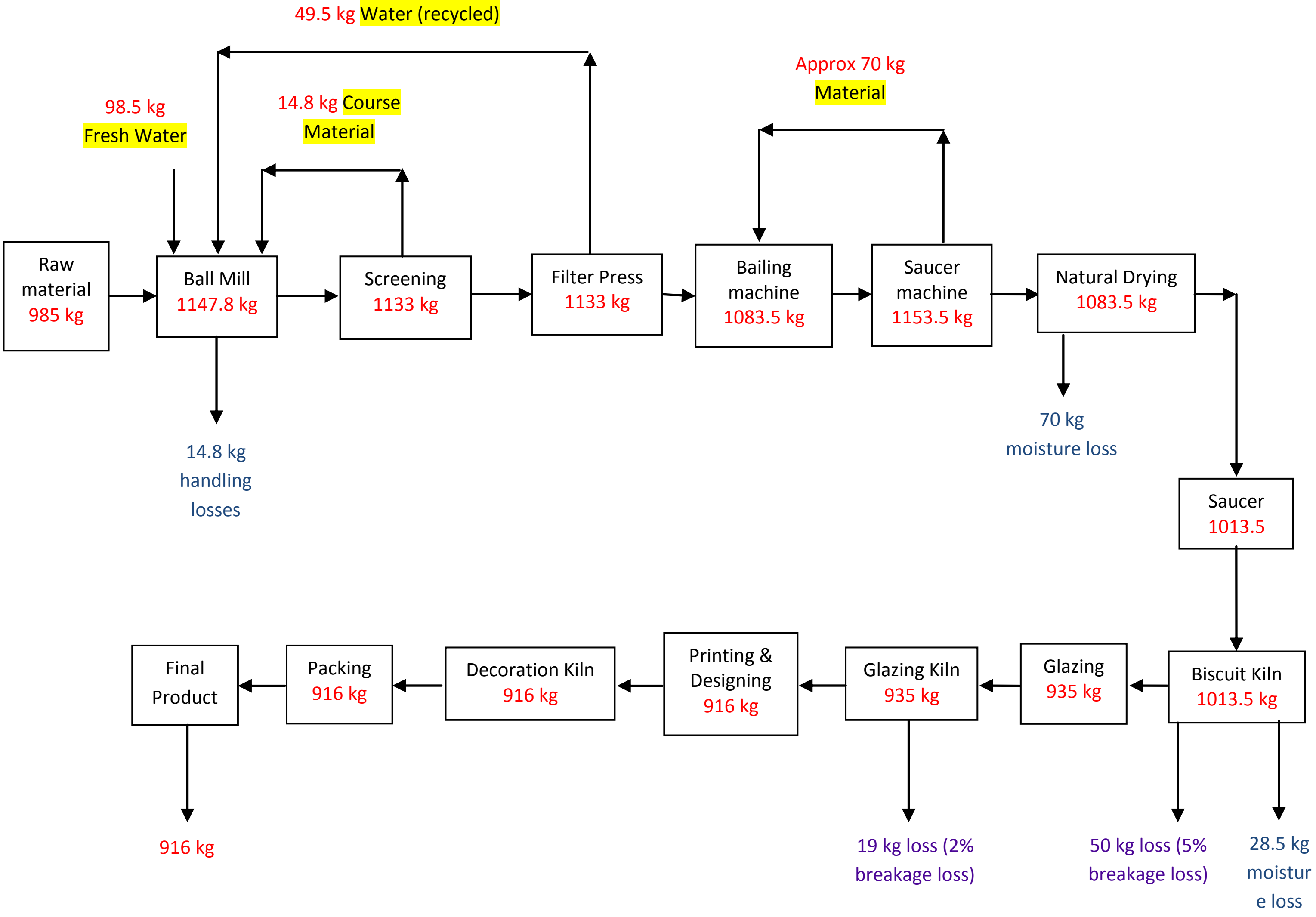
Manufacturing Process Flow Diagram



Material Balance of Cups



Material Balance of Saucers


49.5 kg Water (recycled)
Approx 70 kg Material
98.5 kg Fresh Water
14.8 kg Course Material
Raw material 985 kg
Ball Mill 1147.8 kg
Screening 1133 kg
Filter Press 1133 kg
Bailing machine 1083.5 kg
Saucer machine 1153.5 kg
Natural Drying 1083.5 kg
14.8 kg handling losses
70 kg moisture loss
Saucer 1013.5
Final Product
Packing 916 kg
Decoration Kiln 916 kg
Printing & Designing 916 kg
Glazing Kiln 935 kg
Glazing 935 kg
Biscuit Kiln 1013.5 kg
916 kg
19 kg loss (2% breakage loss)
50 kg loss (5% breakage loss)
28.5 kg moisture loss

Cleaner Production Opportunities

Sources of waste generation, quality and approximate quantity

S. No.	Process	Waste	Source	Quantity
1.	Cup manufacturing	Raw material	Ball mill (loading & unloading)	Unaccounted
2.	Cup manufacturing	Semi processed material (Runner or flash)	Casting (cutting waste)	Negligible
3.	Cup manufacturing	De moisture cup material	Biscuit kiln (broken cups)	44.7 kg/batch
4.	Cup manufacturing	Glazed cup material	Glazing kiln (broken cups)	40.3 kg/batch
5.	Saucer manufacturing	Raw material	Ball mill (loading/unloading)	14.8 kg/batch
6.	Saucer manufacturing	De moisture cup material	Biscuit kiln (broken cups)	50 kg/batch
7.	Saucer manufacturing	Glazed cup material	Glazing kiln (broken cups)	19 kg/batch

Company is maintaining material wastage (Dry) of 10 % for cups and 7 % for saucers (these figures have to be checked with material inventory and output product for average of total batches in the study month).
If there is significant difference thus we need to cross check the material balance at individual process step to get exact figures of material wastages generated in the process.

Observation

- The team has observed material losses during various stages of the process viz. loading, casting, screening etc. But, the industry persons claimed that all these material losses were eventually recovered and were being reused at the ball mill stage.

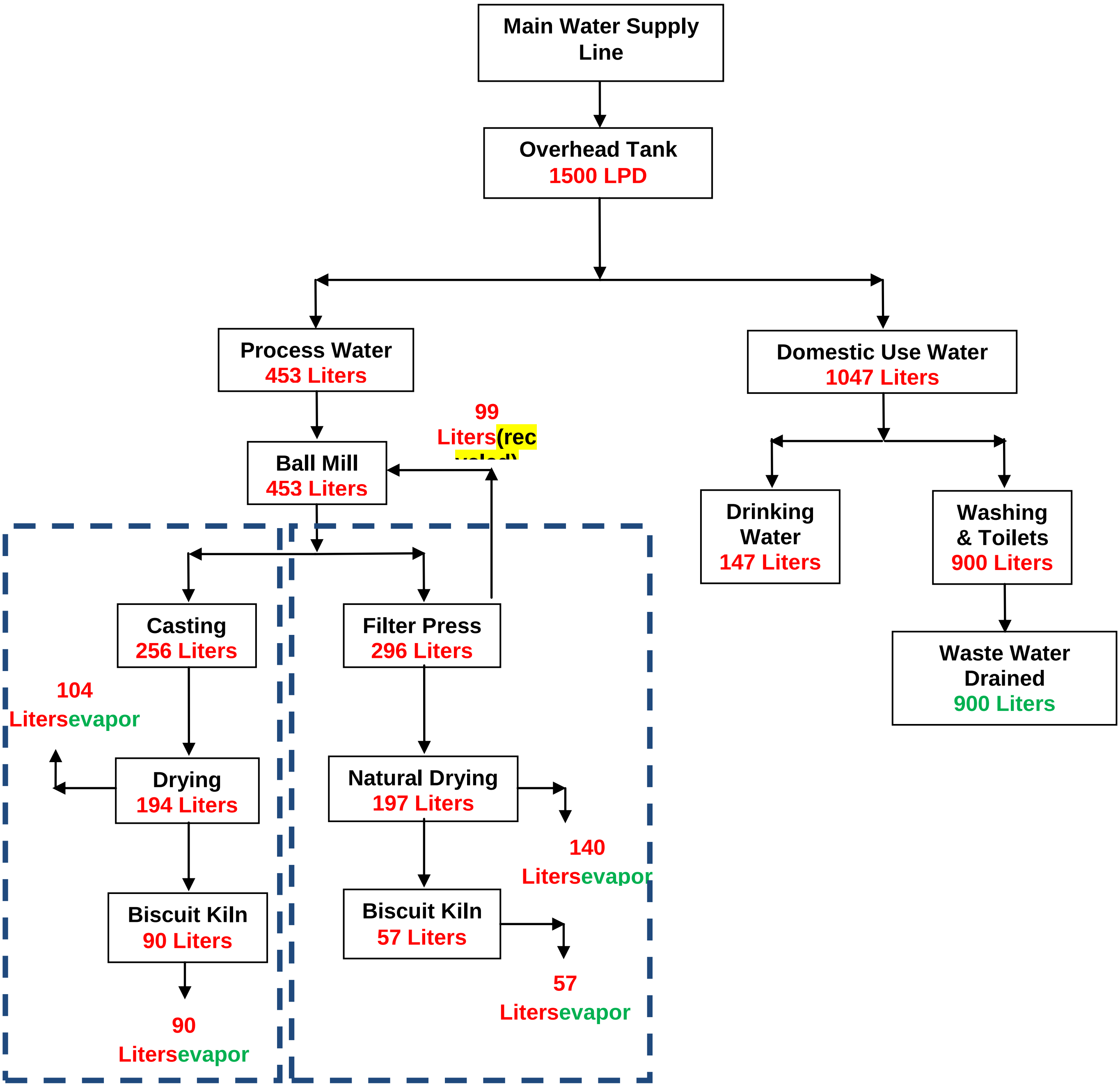
- In the *cup finishing* area, rejections were found to occur during the casting operation. The team observed that those rejections were just let down to fall on the surface and were forming a heap like structure which seemed to cause some material to mix with the floor particles and thus contribute towards losses.

Recommendations

- In the casting area, if a small collection pit is made or a plastic trolley with wheels (for better movability) could be placed, it could result in better recovery with lesser adulteration with unwanted materials.

Water Balance

Water flow layout and Balancing (On the basis of 1.5 KLPD consumption, considering production of 2 batches per day)



Sources of waste water generation& water losses

S. No.	Process / Application	Waste / Loss	Source	Quantity
1.	Cup manufacturing	Water vapours	Drying	104 liters/day
2.	Cup manufacturing	Water vapours	Biscuit kiln	90 liters/day
3.	Saucer manufacturing	Water vapours	Natural drying	140 liters/day
4.	Saucer manufacturing	Water vapours	Biscuit kiln	57 liters/day
5.	Domestic use	Waste water	Toilets & washing	900 liter/day

Observations

- The team did not observe any separate stream for waste water. The water which is drained after domestic usage was being collected in an underground tank.
- There is no waste water treatment facility available to treat the waste water and reuse the treated water for domestic purposes except drinking.
- Also, the team did not observe any storm water drainage system around the plant.

Recommendations

- It is recommended to have a storm water drainage system in order to avoid material losses caused by water especially during the rainy season.
- **STEPS Grey Water Purification System** is an effective and economical solution for conservationof water. This is a liquid catalyst system to purify the domestic grey water using an In-linedevise which not only treats water, but also purifies it. The purity is up to such a high level thatthe treated water can be re-used for domestic washing and cleaning needs.The treated water removes bacteria, odours,

turbidity, colour, sulphides and other contaminants,organic matter, oil and grease. After treatment, this water becomes crystal clear and pure forreuse in domestic, horticulture or agricultural purposes. **STEPS proprietary chemicals** are safer than most others being used in water treatment today. This system comprises a filtering system surrounded by dual chambers in which specific chemicalsare introduced into the filtered water. The device can be scaled in size to meet user needs.Its size is small enough to be installed as part of a residential plumbing system.The in-line catalyst devise will re-cycle more than 65% of the water that goes into the sewagesand makes the water available for domestic use without having to depend on the public supplyfrom government bodies. The cost of such purification is similar or less than the water treatmentcharges we pay. Besides, the 65% saving of water will put less pressure on our water resourcesand allow the aquifers to recharge in the natural replenishment speeds.

Air Emissions

Source of air emissions & quality

S. No.	Process Area	Air Emission Type	Source	Quantity	Recommended Quantity
1.	Material Storage	Feldspar & Quartz	Material loading &unloading	Not available	1 – 10 mg/m^3
2.	Glazing	Dust	Cleaning	Not available	1 – 10 mg/m^3
3.	Glazing	Feldspar, Zirconium & Quartz	Glaze coating	Not available	1 – 20 mg/m^3 as daily average
4.	Heat treatment	Fluoride stated as HF	Kilns	Not available	1 – 10 mg/m^3 as daily average
5.	Heat treatment	Chloride stated as HCl	Kilns	Not available	1 – 30 mg/m^3 as daily average
6.	Heat treatment	Chloride stated as HCl	Kilns	Not available	1 – 30 mg/m^3 as daily average
7.	Heat treatment	SO_X stated as SO_2 Sulphur content in raw material ≤ 25 %	Kilns	Not available	< 500 mg/m^3 as daily average
8.	Heat treatment	SO_X stated as SO_2 Sulphur content in raw material >0.25 %	Kilns	Not available	500 - 2000 mg/m^3 as daily average
9.	Heat treatment	NO_X from flue-gases stated as NO_2, for kiln gas temperatures < 1300 °C	Kilns	Not available	250 mg/m^3 as daily average

10.	Heat treatment	NO_X from flue-gases stated as NO_2, for kiln gas temperatures ≥ 1300 °C	Kilns	Not available	500 mg/m^3 as daily average

Observations

The team observed the *area around the glaze tank*, the raw materials for glazing operation viz. feldspar, china clay etc were spilt on the floor space and were forming air borne particles.

Recommendations

- The air borne fine particles which were felt around glaze tank area can be prevented by proper segregation and careful handling of materials.
- Reduce channelled dust emissions from spray glazing processes to 1 – 10 mg/m^3, as the halfhourly average value, by applying bag filters or sintered lamellar filters.

Energy Management

Energy balance of biscuit kiln furnace

Heat	Source	Theoretical		Actual	
		Percentage (%)	Value (kcal/hr)	Percentage (%)	Value (kcal/hr)
Input	Heat from combustion of fuel	98.5	83962.39	85	72454.85
	Heat from pre firing goods & kiln furniture	0.7	587.74	1.2	867
	Heat from kiln car	0.8	671.70	2	1620
	Total	**100**	**85221.82**	**88**	**74941.85**

Output	Heat losses from firing goods & kiln furniture	6.9	5880.31	9	6936
	Heat losses from kiln car	10	8522.18	17	12960
	Heat losses from waste heat	7	5965.53	3	2438
	Heat losses from combustion gas (flue gas)	21	17896.58	15.00	11241.28
	Heat losses with moisture in the product	N/A	N/A	3.00	2248.26
	Heat losses from radiation & convection	55.1	46957.22	51.00	38220.34
	Unaccounted losses	N/A	N/A	1.20	897.77
	Total	**100**	**85221.82**	**100**	**74941.85**

Observations

On the basis of the data available and close approximations the above summary table is being created, it shows comparison between the theoretical values and actual values for the same calculations.

- It is found that the heat losses due to kiln furniture are 3 % excess than the theoretical value which accounts for 1055 kcal/hr.
- The heat losses due to kiln car are 7 % excess than the theoretical value which accounts for 4437 kcal/hr.
- The heat losses due to radiation and convection are although lesser than the theoretical value but still at higher side of 51 % of the total input heat.

Recommendations

- It is recommended to apply insulating (ceramic) paint coating from inside the furnace walls to reduce the convective heat losses.
- Also it is recommended to apply similar paint coatings on the surface of kiln furniture as well as kiln car to reduce the heat losses due to heat absorbed by these accessories used in the kilns.

Scope of Cleaner Production

Intervening Technique	Installation of Variable Frequency Drive (VFD) In Ball Mill Motor
Before CP	Plant is operating 1 nos. glaze ball mill, with 7.5 HP motor. The motor load test conducted while operating ball mill is shown in table below: The load survey during single ball mill operation is shown in table below: **Table: Motor Load Parameters of Glaze Ball Mill** (table below) It is evident that the motor load is varying from 75 % to 53 %,

Table: Motor Load Parameters of Glaze Ball Mill

Parameter	Reading 1	Reading 2
Voltage (V)	435	435
Ampere (A)	6.31	4.77
Power (kW)	4.18	2.96
Power Factor (Cos Ø)	0.88	0.82

	the glazing ball mill operates for 40 hrs per batch and total of 10 nos. batch per month is generated. Ball mill/Blunger is a batch grinding process. As per the process requirement the motor should run at full speed during the start of batch, however after a particular time the ball mill or Blunger can be rotated at less speed (RPM).
After CP	The speed of the motor can be reduced by installing variable frequency drive on Ball Mill/Blunger motor and operating speed can be programmed based on time. This will result in reduction in electricity consumption to the tune of 15% saving in electricity consumption in ball mills and blunger. This concept is applicable to slip preparation ball mill in sliphouse also.
Benefit	
Environmental	Reduction in the electricity consumption by 2500 units per year, ultimately reducing the carbon footprints to the environment.
Economical	Investment: Rs. 20,000/- (for 7.5 HP VFD) Approx. Annual Savings: Rs. 19,300/- per annum Payback Period: 13 months

Intervening Technique	Avoid Compressed air usage for cleaning purposes
Before CP	During the visit it was observed that compressed air is used for cleaning purposes at some workstations to clean the components with open hose of 5 mm diameter and at 6 kg/cm^{2}g pressure.
After CP	Usually, cleaning can be done at lower pressure (around 2-3 kg/cm^{2}g). So, the first step would be to reduce the pressure and energy saving would be around 8% at drop of each bar for that hose if generated separately. From our past experience the company can save Rs. 21,000 per year (from one workplace) by installing compressed air saving gun. The compressed air is a costly utility and the less critical purposes like cleaning can be achieved by installing air saver nozzles at the tip of these cleaning devices or shall be replaced with new one. The special design of these improved cleaning nozzles allows ambient air to get entrained in the path due to vacuum created

	by compressed air and delivers the air with similar velocity and thrust giving to desired cleaning effect. However, the amount of compressed air uses is only 20-25% which reduces the compressed air requirement and thus resulting in energy savings. In addition, these nozzles also reduce the noise level. 
Environmental	Reduction in the electricity consumption to generate the compressed air, with that, also reducing Noise Pollution of the surrounding, making the site easy to work
Economical	Investment: **3,000/-** per gun Annual Savings: **Rs. 21,000/-** per station Payback Period: **3 months**

Intervening Technique	Improvement in Tunnel Kiln & Decoration Kiln Insulation
Before CP	One of the heat losses in the kiln is due to the radiation loss from the surface of the kiln. The surface temperature measured around the tunnel kiln firing zone was recorded from 76 ^{0}C to 116 ^{0}C at different locations, while surface near burners were found at more than 188 ^{0}C. The surface temperature at decoration kiln firing zone was recorded from 170 ^{0}C to 222 ^{0}C.
After CP	The radiated heat loss can be minimized by improving the insulation in kiln,recuperators and other hot surfaces. This reduces the surfacetemperature and thereby reduces fuel

	consumption. The proposed insulation is ceramic fibre blanket supported by asbestos cladding. It is available in roll form in a wide variety of densities and thicknesses. It has excellent strength before and after heating. It has excellent chemical resistance unaffectedby all chemicals except hydrofluoric acids and strongalkalis. Its specifications are – ▪ Thermal Capacity: 1260°C ▪ Alumina Content (Al_2O_3): 37% ▪ Silica (SiO_2): 52% ▪ Zirconia (ZrO_2): 17% ▪ Density: 96 Kg/m^3
Benefit	
Environmental	▪ Reduction in the natural gas consumption by 10,000 to 12,000 SCM per year combined from both the kilns ▪ Thereby, reduction in the green-house gases in the atmosphere due to combustion of the fuel
Economical	Investment: Rs. 4,75,000/- (for insulation in both kilns) Approx. Annual Savings: Rs. 3,50,000/- per annum Payback Period: 16 months

<table>
<tr><td>Intervening Technique</td><td>Optimization of Combustion Efficiency of Kiln</td></tr>
<tr><td>Before CP</td><td>Flue gas exhaust at the tunnel kiln furnace & decoration kiln was monitored. % O_2 in flue gas is more than 11 % in tunnel kiln and more 9 % in decoration kiln. % O_2 in flue gases should be between 2 – 6%. The same can be maintained by regular monitoring of flue gas sample with the help of a portable flue gas analyzer or by installing O_2sensor at the furnace exhaust for flue gases and a modulating motorized damper or RPM of combustion air blower through VFD for combustion air control. The sensor will provide constant feedback of O_2% to the damper / VFD which will in turn regulate the flow of combustion air to maintain the combustion efficiency at optimum level of 80 - 90% (Achievable combustion efficiency).
Table: Flue Gas Monitoring Parameters at Tunnel Kiln
<table>
<tr><th>Parameter</th><th>Unit</th><th>At Kiln Exhaust</th><th>Firing Zone</th></tr>
</table>
</td></tr>
</table>

Net Temperature	0C	215	482
O2	%	14.2	11.9
CO	ppm	11	53
Combustion Efficiency	%	69	55.2
CO2	%	3.9	5.2
Flue Gas Temperature	0C	233	507
Ambient Temperature	0C	20.6	25
Excess Air	%	198.5	127.1
Pressure	mbar	0.06	0.29

Table: Flue Gas Monitoring Parameters at Decoration Kiln

Parameter	Unit	Firing Zone
Net Temperature	0C	502
O2	%	10
CO	ppm	0
Combustion Efficiency	%	57.3
CO2	%	6.0
Flue Gas Temperature	0C	534
Ambient Temperature	0C	29.5
Excess Air	%	100.9
Pressure	mbar	0.02

After CP

It is suggested to control the combustion air through reducing the RPM of combustion air blower by 1-2 Hertz at a time by monitoring required temperature within kiln and set the appropriate frequency and monitoring the required O_2 percentage in flue gas to optimize the air fuel ratio and thus combustion efficiency at the kiln.

Excessive draft allows increased volume of air into the furnace. The large amount of flue gas moves quickly through the furnace, allowing less time for heat transfer to the material side. The result is that the exit temperature decreases with increase in heat quantity along with larger volume of flue gas leaving the stack contributes to higher heat loss.

The proper control of air to fuel ratio can result in combustion efficiency more than 75 % with old burners as well. Thus increase in 10 % combustion efficiency will result in saving of

	approximately 19,782 SCM gas per annum.
Benefit	
Environmental	▪ Reduction in the natural gas consumption by 19,782 SCM per year ▪ Thereby, reduction in the green-house gases in the atmosphere due to combustion of the fuel
Economical	Investment: **NIL** Annual Savings: **Rs. 6,33,000/-** per annum Payback Period: **Immediate**

SONYA INSULATORS, BAPUNAGAR, AHMEDABAD

Introduction

Since 1960, Sonya has been a progressive leader in the ceramic industry earning a reputation for quality, service & dependability. Sonya group employs more than 400 long term experienced people at two different sites i.e. at Kadi & Ahmedabad.

Sonya manufactures L.T. Insulators & Technical Ceramics, which are related to Electrical Industries & Heater Industries, whereas their other products are Wall, Roof & Paving Tiles, which are used in niche market & by high end builders. The ceramics are made from Normal Porcelain, Steatite, Cordierite, Cordierite Porcelain, High Alumina Refractory, Cordierite Refractory, Cordio-Sillimanite, Hard Porcelain and Alumina Ceramics. The industry also makes ceramic products as per the design/drawing of the customer.

The industry has trade relations to more than 45 countries including 500 companies of the World. It was the first industry in insulators sector to obtain ISO certification in 2000. It has achieved National Awards for:

- Best performance in Technical Ceramics award from Ex-Prime Minister Dr. Manmohan Singh
- Quality and General Performance from ex-president Dr. A. P. J. Abdul Kalam
- Consistent High Quality Performance award from, Ex-chief Minister of Gujarat and Current Prime-Minister Mr. NarendraModi

The industry has also achieved export awards for 5 consecutive years from Government of Gujarat and product excellence award from Indian Ceramic Society.

Cleaner Production Assessment Team

The team for conducting Cleaner Production Assessment includes the following members.

Name	**Designation**
Dr. Bharat Jain	Member Secretary, GCPC
Mr. Punamchandra Rathod	Senior Project Engineer, GCPC
Mr. Paras Gojiya	Assistant Project Engineer, GCPC
Mr. Abhi Patel	Assistant Project Engineer, GCPC
Mr. K. D. Sanghavi	Technical Expert, GCPC
Mr. Rupeshbhai Shah	MD, Sonya Insulators, Bapunagar
Mr. J. K. Shah	CEO, Sonya Insulators, Bapunagar
Mr. Kashyap Pandya	Senior Engineer, Sonya Insulators, Bapunagar

Manufacturing Process

1. Raw Material Storage

Different types of clays are transported to the plant via trucks and unloaded manually to store in the storage yard with separate compartments for each type of clay.

2. Slip Preparation

The slurry is formed by mixing various types of raw materials in a fixed composition manually in the ball mill. A batch of ball mill contains equal proportion each of (800 Kg) raw material, water and river bed stone pebbles. (Total: 2400 Kg). The ball mill grinds the raw material for more than 8 hours to form slurry, which is passed through a 40 mesh size sieve, so as to reject the oversized particles.

3. Filtration

The slurry after passing the sieve is stored in three slurry storage tanks, to which three press and frame filters are connected. More 2 filters are there on standby basis. The press filters intake the slurry with high pressure and give the wet cakes of the material. The large size press filters can give out 24 cakes in a batch while the smaller size press filters can give out 18 cakes in a batch. The output moisture of wet cakes is 22 – 24% approximately.

4. Wet cake drying

The wet cakes are put on a trolley manually and are stacked on the ground for environmental drying. After some time, when the cakes become dry such that they can be handled easily, they are cut into slices and are again spread on the ground for more drying. A fan is installed to throw air on the wet pieces.

5. Pulverizing and granulating

The sliced pieces of cakes, when the moisture reaches less than 18 – 20%, are grinded in a pulverizing machine to form wet granules, collected in a chamber below. It is necessary to form fixed size granules of the material before sending it to mould, hence a manually operated self designed vibro-screening machine is installed, which forms the required sized granules, sent for press moulding.

6. Press Moulding

There are manually operated press mould machines for casting the shape out of the material. Operators fill in the material into the dye of the press using their hands, followed by pressing the mechanical handle to cast out the shape. The casted moulds are sent of natural drying.

7. Drying

The casted moulds are stacked on a wooden board and are put on a rack for natural drying. Some stacks are also put on and near the kiln wall, so as to fasten the drying process due to the ambient hot air. After a considerable removal of moisture, the moulds are sent for finishing operation.

8. Finishing

The workers of the plant finish the sides of the dried moulds by removing off the extra material from the edges of the moulds. The industry claims that the material removed from the moulds are recycled back into the raw material formation operation.

9. Glazing

The finished moulds are subjected to the glazing operation. The glaze is sprayed on the moulds using a spray gun, which leads to a considerable amount of waste of glaze, also an irregular spray of glaze leads to further losses of the product.

10. Firing

The glazed products are arranged on the kiln cars. There are many errors by the workers while arranging the moulds on the kiln cars, leading to further losses. The moulds are arranged in 3, 4 or 5 lines vertically, depending upon the size of the moulds loaded. The workers do not load much pieces at the bottom most line, as no proper firing is done in the lower parts of the car.

The loaded cars are sent in the tunnel kiln for firing in the cycle of 40 minutes. The maximum temperature range is upto 1160^{o}C, with a total time inside kiln being 18 hours for an average kiln. There is no temperature and cycle time change for different products.

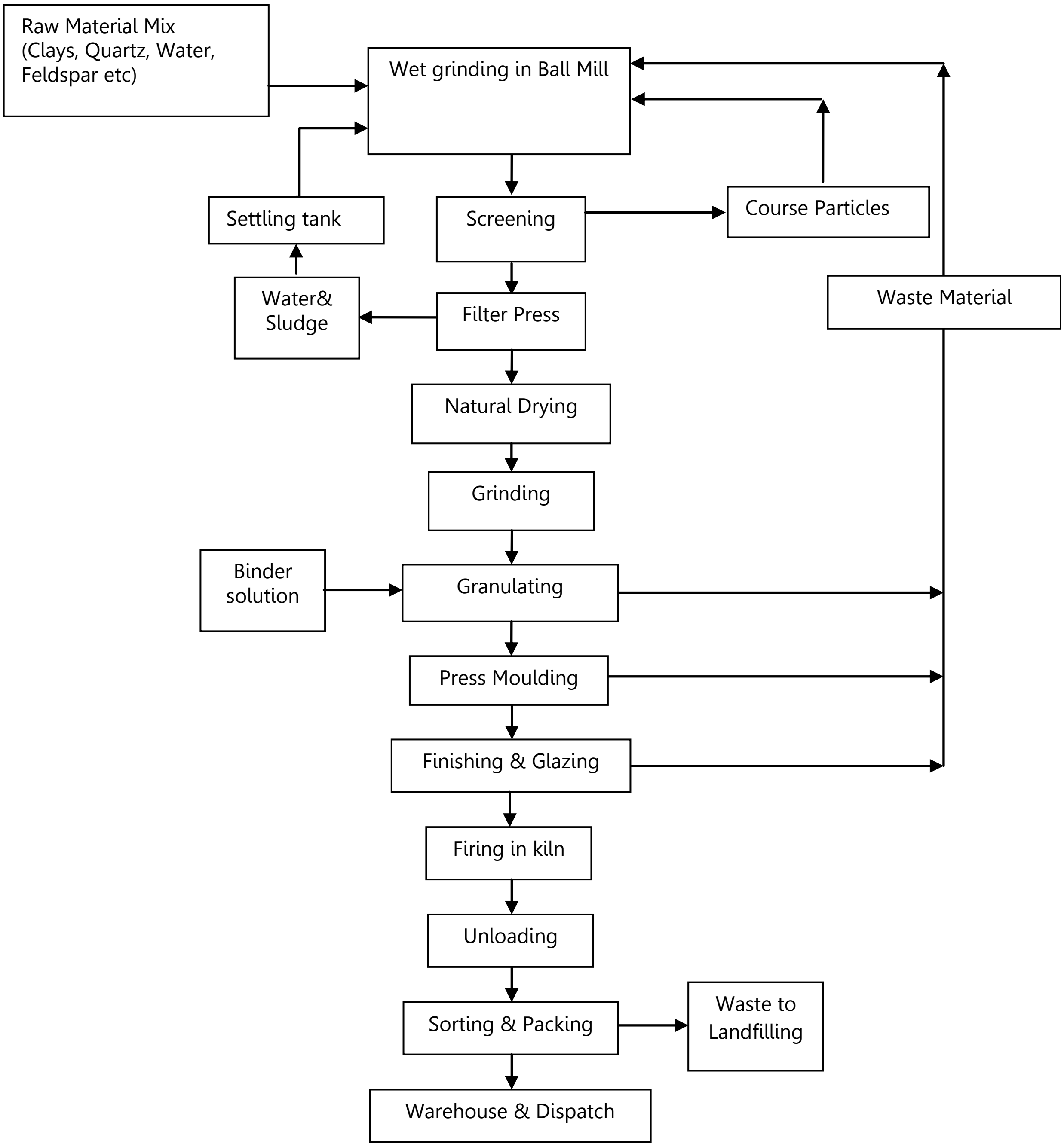
11. Sorting

The final products coming out of the kiln are very hot to handle, and are subjected to cooling using ceiling fans, followed by sorting. The QA/QC department checks and verifies the size and shape with the standards and separates the acceptable and rejected products.

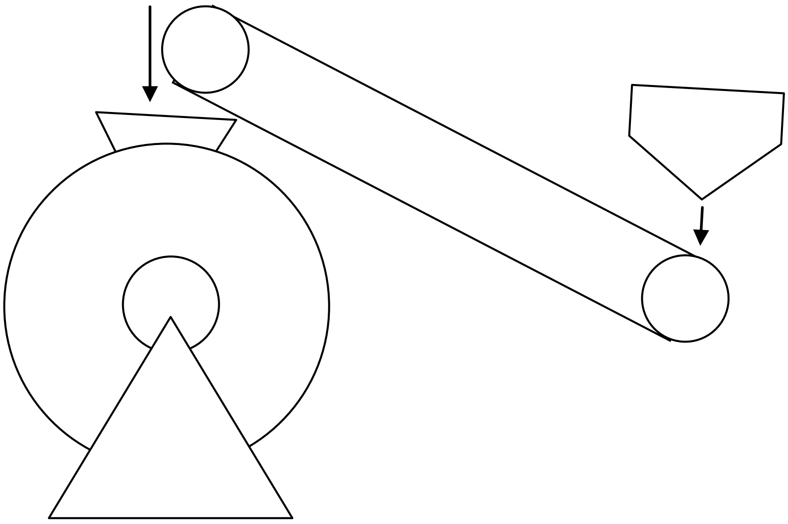
12. Packing and dispatching

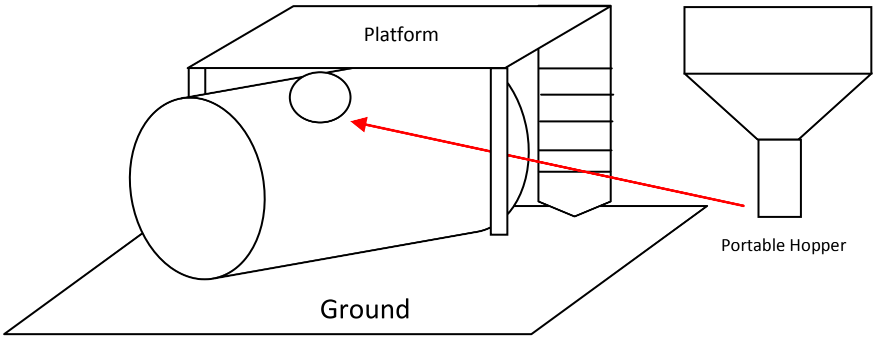
The acceptable quality products are packed in grass packing and then plastic bags and transported to the market via trucks.

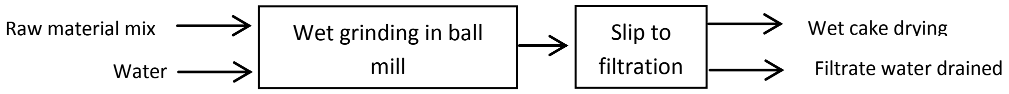
Manufacturing Process Flow Diagram of L. T. Porcelain Insulators

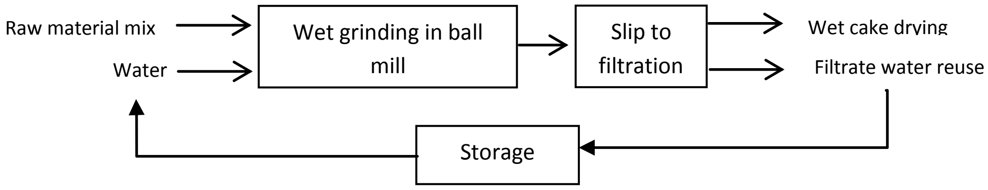


Cleaner Production Opportunities

Observation	Spillage of material and risk to men while loading material into the ball mill
Before CP	• The weighed quantity of material is filled in the ball mill by directly dumping the material into the lid hole. • While loading, the material is spilled on the ground and in air due to poor handling of workers, leading to loss of material and generation of airborne particles. • The worker has to climb over the ball mill and dump the material into it, which is an accident prone operation.
Suggestions for implementing CP	Option A: • The whole raw material handling system could be made automatically or semi-automatically operated. • A conveyor system can be designed to feed the raw material directly into the ball mill. The required quantity to be fed and the batch time schedule can be programmed accordingly. • The conveyor belt's beginning part could be in the storage area, where automatically or manually required material can be loaded on the conveyor belts and at the second end the material is unloaded directly into the ball mill. • The whole transmission path could be covered from top and sides so as to prevent the loss of material in transmission due to carriers like wind.  Option B: • A platform can be built near all ball mills, so that the worker can easily climb over the platform to load the material.

	 • One advanced option could be installation of an electrical lift also, which may lift the material to the level of platform. • A portable hopper should be used while dumping the material inside the ball mill
After CP	• Complete reduction in the spillage of material, hence reduction in generation of airborne particles in both of the cases. • Reduction in the man-power needed for the operation in the first case. • Comfortable handling of material and safe operability for the workers in the second case.
Benefit	The benefit of implementing above options will be directly to the reduction in the air pollution in the surrounding area. Also, the reduced loss of material will lead to reduced expenses of revenue. The most important part is the reduced chances of accidents or near miss occurrences.

Observation	Reusing 100% of waste water into the process
Before CP	• From the storage tank, the slip is sent to the press and frame filter for wet cake formation. • The water removed from the slip in form of filtrate was drained out from the plant earlier, which was a major loss of water from the plant. • Approximate quantity of water wasted: **9.3 KLD** 
Suggestions for implementing CP	• All of the filtrate water can be reused in the process, at the wet grinding stage in ball mill. • The industry has already implemented this option.

After CP	- The plant is a Zero Discharge Plant, all the water is reused in the process. - Reduction in the cost of purchasing water from GIDC 
Benefit	- Savings in the natural resource by reusing 100% water - Approximate reduction in the fresh water demand: **9.3 KLD**

Observation	Loss of processed raw material due to poor handling at various steps in process
Before CP	- An unaccountable quantity of processed material (which has passed through various operations like – ➢ Transportation to plant (incurring transportation charges) ➢ Wet grinding (incurring electricity charges for ball mill) ➢ Slip storage (incurring electricity charges for stirring) ➢ Filter press (incurring electricity charges for compression) ➢ Disintegration (incurring electricity charges for motor) – is being wasted at various steps during the process due to poor handling practices of the manpower involved. The wastage of the material is observed at following steps. - The pieces of wet cake are spread on the ground of drying and feeding to the disintegrator, where they mix with the impurities. Also, some amount of material is broken down and mixes with the dirt due to human movements on it. **Major Concerns:** 1. Loss of processed material(quantity unaccountable) - The wet cakes are fed to the disintegrator. Its outlet is in the moist powder form. The powdered material directly falls on the ground, mixes with impurities. Workers have to again collect it to send to granulators. **Major Concerns:** 1. Loss of processed material (quantity unaccountable) 2. Addition of impurities to material 3. Unnecessary usage of man-power

- The powdered material is fed to the in-house-designed granulator, which converts the powdered material into the granules of required size. Again, the granulated material from the outlet falls directly on the ground; mixes with impurities. Workers have to recollect the material to send for moulding.

Major Concerns: 1. Loss of processed material (quantity unaccountable)
2. Addition of impurities to material
3. Unnecessary usage of man-power

- The granulated material, collected from ground, is sent for 'toggle and press' moulding. The workers present there feed the approximate quantity of granulated material into the dyes of the press machine with their bare hands, which is purely based on their experience. Also, while performing this operation, material falls down from their hands on the ground, again mixes with impurities.

Major Concerns: 1. Uncertainty in the amount of material fed into dye
2. Uneven pressing may lead to improper moulding and may cause dimensional errors, granules and hair cracks in moulded piece
3. Loss of processed material (quantity unaccountable)
4. Addition of impurities to material
5. Risk to health of workers for handling such material with their bare hands

- The moulded pieces are sent to finishing operation, where the workers (majority of them being female) finishes the edges of moulds and remove extra material from edges to make it smooth. Again, the operation is carried out bare handed. The material removed from moulds is let fall down on ground and rarely being recollected.

Major Concerns: 1. Loss of processed material (quantity unaccountable)
2. Addition of impurities to material
3. Risk to health of workers for handling such material with their bare hands

- The finished pieces are internally transported by workers by loading on wooden boards with their hands, which invite chances of accidental falling down and breakage of finished pieces.

Major Concerns: 1. Loss of moulded and finished pieces

- All the above mentioned observations represent Poor Housekeeping of the unit. The total amount of material wasted in the green stage in year 2015 (January – December) w as approximately 223.6 MT, with an

	average of 620 Kg per day. • The industry claims that all the waste material at green stage is recycled back to the process by wet grinding. It is a matter of fact that recycling is NOT ALWAYS the suitable option, as the recycling consumes 6 times more energy than regular operations. Also, in continuous recycling operation, a quantum of material never comes out of the recycling cycle and never converts to the final product. • The industry used 344 ball mills to recycle the green stage waste in year 2015 (Jan – Dec), consuming additional electricity of 4626 units (an amount of Rs. 34,700/- approx.), excluding many other factors. • The raw material of ceramic sector is comparatively cheaper, hence attracts very less attention of the associated people as far as material saving is concerned. However, the facts are not like that. The material itself passes through many steps from receiving to finally firing and involves many energy intensive operations and manpower costs. Hence, the material loss (i. e. Poor Housekeeping) should never been taken lightly.
Suggestions for implementing CP	• The best possible suggestion in the scope of this exercise for drying the wet cake is solar drying, which has been already mentioned in the previous part. It indirectly also helps in the saving of material from loss. • However, the second viable option here could be, use of 300 – 500 gauge plastic sheets for laying on the ground and on that the wet cake can be spread to dry. • The powdered material from the disintegrator can be directly supplied to the granulator using a semi-cylindrical pipe / channel, so that leaving no scope of waste of material by spilling on ground. If this option is difficult to implement, another possible option is to collect the powdered material in a mechanical trolley / collection bin and convey it to the inlet of granulator manually, thereby leaving less scope of spillage. • Same way, there should be also a mechanical trolley / collection bin at the outlet of granulator to collect granules and send for pressing machines. • It is highly recommended to use mechanical / hydraulic jacks or trolleys to transport moulded and finished pieces loaded on wooden pallets, as it provides smooth and accident free transportation of

material internally in the plant area. (Symbolic reference provided here)

- For the loss of material during pressing in 'toggle and press' machines, it is recommended to install automatic material feeding equipment, which feeds the exactly programmed weighed material, called as **'Load Cell'**, into the pressing machine at a projected site only, thereby reducing spillage of material to the ground.

- It is also highly recommended to install automatic press machines. The trend of automatic pressing machine started into the tiles manufacturing machine but it is an old thing for porcelain industries also in the present scenario. Press machines with removable and multi-designed dyes are available in the market. (Symbolic representation is shown here)

	
After CP	• Installation of plastic sheets on ground would drastically reduce the loss of material; also it would be easy to recollect the material. Protection from impurities is the additional advantage. • Installation of semi-cylindrical pipe for transportation will reduce the spillage of material to zero. Also, the slope and gravity will do their work, hence requiring no energy to transport the material. Decrease in the man-power dependency will is the additional advantage. • Installation and practice of using mechanical / hydraulic trolley has got its own advantages of smooth transportation internally inside the plant premises. The powdered or granulated material is best transported in basket trolley, which reduces the material loss by spillage to zero. • The moulded pieces must be transported wooden pallets stacked on the hydraulic lifting trolley. It guarantees zero accidental falling and breakage of material. Smooth handling, smooth transportation and reduction in man-power dependency are additional advantages. • Installation of 'Load Cell' will decrease all possible loss of material by spillage at the pressing area. As fixed quantity of material will be fed to the dye, the uniformity of mould volume will be assured, thereby decreasing the dimension errors and such kind of losses. Decrease in the man-power dependency will is the additional advantage.

	• Installation of automatic press machines will drastically reduce all kinds of material loss prior as well as post pressing and moulding during the application. Also, it assures uniform volume of mould, proper and uniform pressing on all sides, and uniform dimensions of the product. It would decrease the rejection of pieces drastically.	
Benefit	Before CP	After CP
	• Loss of material at every operation (approx. 223.6 MT in year 2015)	• Reduced loss of material (from 80% to 100% - depending upon implementation of options)
	• Incurring electricity cost for recycling the waste material (approx. Rs. 34,700/- P. A.)	• Reduction in recycling costs (both electrical and man-power) amount of money depending on amount of implementation
	• Complete dependency on manpower for material handling	• Reduced to zero dependency on manpower for material handling
	• Poor housekeeping	• Good housekeeping

Observation	Spillage and deposition of slurry while unloading from ball mill after wet grinding
Before CP	• After wet grinding, the slip so formed is unloaded from the ball mill using a suction valve, from where the slip is drained on the collection pit. From the pit, small channels are built which transfer the slip to the storage tank with the help of gravity. • In doing so, the viscous slurry is spilled around and deposited on the walls of pit in the form of scale after drying. • The deposited quantity is a loss of processed material and imparts poor housekeeping to the plant. • The dried scale creates problem of chocking of channels, which adds to the spillage of material. • Also, the open transportation of the slurry aids to the addition of surrounding impurities to it.
Suggestions for implementing CP	• A pipe can be used while unloading the slip from ball mill. It may be connected to the valve used for unloading, and the outlet can be given to the storage tank.
After CP	• Complete reduction on spillage and deposition of slip

<table>
<tr><td></td><td>• No need of flow channels, hence complete reduction in chocking issues
• No addition of impurities in closed transportation</td></tr>
<tr><td>Benefit</td><td>The economic benefit of implementing the option is savings in the loss of material, its quality and improving the housekeeping status of the slip house area</td></tr>
</table>

<table>
<tr><td>Intervening Technique</td><td>Installation of Variable Frequency Drive (VFD) In Ball Mill Motor</td></tr>
<tr><td>Before CP</td><td>Plant is operating 6 nos. ball mills, with common with individual 5 HP motor. The motor load test conducted while operating ball mill is shown in table below:

Table: Electrical Parameters Measured at Ball Mill Motor (5 nos. Motor)

<table>
<tr><th>Parameter</th><th>Reading 1</th><th>Reading 2</th><th>Reading 3</th></tr>
<tr><td>Voltage (V)</td><td>396</td><td>396</td><td>397</td></tr>
<tr><td>Ampere (A)</td><td>3.38</td><td>3.56</td><td>3.69</td></tr>
<tr><td>Power (kW)</td><td>0.95</td><td>1.29</td><td>1.42</td></tr>
<tr><td>Power Factor (Cos Ø)</td><td>0.42</td><td>0.53</td><td>0.56</td></tr>
</table>

The load survey conducted on the ball mill shows that the maximum loading on ball mill motor is 38 %. The load variation recorded during normal operation of ball mill motor is 0.95 kW to 1.42 kW, while the rated capacity of motor is 3.75 kW.

Ball mill/Blunger is a batch grinding process. As per the process requirement the motor should run at full speed during the start of batch, however after a particular time the ball mill or Blunger can be rotated at less speed (RPM).</td></tr>
<tr><td>After CP</td><td>The speed of the motor can be reduced by installing variable frequency drive on Ball Mill/Blunger motor and operating speed can be programmed based on time.

This will result in reduction in electricity consumption to the tune of 15% saving in electricity consumption in ball mills and blunger. This concept is applicable to glaze preparation ball mill in glaze section also.</td></tr>
<tr><td colspan="2">Benefit</td></tr>
<tr><td>Environmental</td><td>Reduction in the electricity consumption by 2800 units per year, ultimately reducing the carbon footprints to the environment.</td></tr>
<tr><td>Economical</td><td>Investment: Rs. 40,000/- (for 4 Nos. of 5 HP VFD) Approx.
Annual Savings: Rs. 20,900/- per annum
Payback Period: 23 months</td></tr>
</table>

Intervening Technique	Implementation of ON - OFF Controller (10 minutes ON and 5 minutes OFF) for Agitation Motors
Before CP	In agitation section, agitators are provided in underground tanks to maintain theuniformity of the slurry. These motors operate for about 24 hours in a day. Agitation in a necessary operation to maintain the quality of the slurry and not to let it settle down and deposit as dry, however, there is a scope to save energy in it.
After CP	Installation of automatically ON - OFF system on the agitator motors do not affect the uniformity (quality) of slurry but gives saving in electricity consumption in agitator motors. This system automatically switches ON agitator motors for about 10 minutes and then switches OFF for about 5 minutes. This means that in one hour agitator motors operate for about 40 minutes and remain switch off for about 20 minutes. This could result in approximately 30% saving in electricity consumption of agitator motors.
Benefit	
Environmental	Reduction in the electricity consumption by 4600 units per year, ultimately reducing the carbon footprints to the environment.
Economical	Investment: Rs.10,000/- (for timer based ON-OFF controller) Approx. Annual Savings: Rs. 34,700/- per annum Payback Period: 4 months

Intervening Technique	Optimize Power Consumption at Ball Mill Motor by Installing Timer Based ON-OFF Controller
Before CP	The ball mills are one of the major electricity consuming equipment, since the batch time for the material preparation varies from 8 to 9 hours, the plant is operating 6 nos. of ball mill and since the material processing require 8 hours operation for required material properties, the manual dependency on operator results in additional operation of ball mill motors.
After CP	In order to reduce unnecessary operation of ball mills, a simple programmable timer based ON-OFF controller will automatically switch OFF the motor of ball mill on completion of programmed time.
Benefit	
Environmental	Reduction in the electricity consumption by 2900 units per year, ultimately reducing the carbon footprints to the environment.
Economical	Investment: Rs. 20,000/- (for ON-OFF Timer) Approx. Annual Savings: Rs. 21,800/- per annum Payback Period: 12 months

Intervening Technique	Improvement in Kiln Insulation
Before CP	One of the heat losses in the kiln is due to the radiationloss from the surface of the kiln The surface temperature measured around the kiln firing zone was recorded from 105 ^{0}C to 174 ^{0}C at different locations, while surface near burners were found at 190 ^{0}C to 223 ^{0}C.
After CP	The radiated heat loss can be minimized by improving the insulation in kiln,recuperators and other hot surfaces. This reduces the surfacetemperature and thereby reduces fuel consumption. The proposed insulation is ceramic fibre blanket supported by asbestos cladding. It is available in roll form in a wide variety of densities and thicknesses. It has excellent strength before and after heating. It has excellent chemical resistance unaffectedby all chemicals except hydrofluoric acids and strongalkalis. Its specifications are – ▪ Thermal Capacity: 1260°C ▪ Alumina Content (Al_2O_3): 37% ▪ Silica (SiO_2): 52% ▪ Zirconia (ZrO_2): 17% ▪ Density: 96 Kg/m^3
Benefit	
Environmental	▪ Reduction in the natural gas consumption by 7500 to 8000 SCM per year ▪ Thereby, reduction in the green-house gases in the atmosphere due to combustion of the fuel
Economical	Investment: Rs.5,00,000/- (for insulation) Approx. Annual Savings: Rs. 3,00,000/- per annum Payback Period: 20 months

Intervening Technique	Optimization of Combustion Efficiency of Kiln

<table>
<tr>
<td>Before CP</td>
<td>
Flue gas exhaust at the tunnel kiln furnace was monitored. %O$_2$ in flue gas varies is more than12 %.Flue gas temperature at exhaust of kiln (at charging end) was also at 378 ^{0}C.% O$_2$ in flue gases should be between 2 – 6%. The same can be maintained by regular monitoring of flue gas sample with the help of a portable flue gas analyzer or by installing O$_2$sensor at the furnace exhaust for flue gases and a modulating motorized damper or RPM of combustion air blower through VFD for combustion air control. The sensor will provide constant feedback of O$_2$% to the damper / VFD which will in turn regulate the flow of combustion air to maintain the combustion efficiency at optimum level of 80 - 90% (Achievable combustion efficiency).

Table: Flue Gas Monitoring Parameters at Kiln
<table>
<tr><th>Parameter</th><th>Unit</th><th>Firing Zone</th></tr>
<tr><td>O2</td><td>%</td><td>14.3</td></tr>
<tr><td>CO</td><td>ppm</td><td>0</td></tr>
<tr><td>Combustion Efficiency</td><td>%</td><td>45</td></tr>
<tr><td>CO2</td><td>%</td><td>3.9</td></tr>
<tr><td>Excess Air</td><td>%</td><td>124.8</td></tr>
<tr><td>Pressure</td><td>mbar</td><td>0.11</td></tr>
</table>
</td>
</tr>
<tr>
<td>After CP</td>
<td>
It is suggested to control the combustion air through reducing the RPM of combustion air blower by 1-2 Hertz at a time by monitoring required temperature within kiln and set the appropriate frequency and monitoring the required O$_2$ percentage in flue gas to optimize the air fuel ratio and thus combustion efficiency at the kiln.

Excessive draft allows increased volume of air into the furnace. The large amount of flue gas moves quickly through the furnace, allowing less time for heat transfer to the material side. The result is that the exit temperature decreases with increase in heat quantity along with larger volume of flue gas leaving the stack contributes to higher heat loss.

The proper control of air to fuel ratio can result in combustion efficiency more than 75 % with old burners as well. Thus increase in 30 % combustion efficiency will result in saving of approximately 1,03,543 SCM gas per annum.
</td>
</tr>
<tr>
<td colspan="2">Benefit</td>
</tr>
<tr>
<td>Environmental</td>
<td>▪ Reduction in the natural gas consumption by 1,03,543 SCM per year</td>
</tr>
</table>

	▪ Thereby, reduction in the green-house gases in the atmosphere due to combustion of the fuel
Economical	Investment: **Rs. 20,000/-** (For VFD) Annual Savings: **Rs. 44,52,000/-** per annum Payback Period: **Immediate**

^^^^^^^^^

For More Details:

Gujarat Cleaner Production Centre

(Established by Industries & Mines Department, Government of Gujarat)

Block No: 11-12, 3rd Floor, Udhyog Bhavan, Gandhinagar
Phone: + 91 79 2324 4147 **Email:** gcpc11@yahoo.com
Web: www.gcpcgujarat.org.in